Environmental Impact Assessment Report for the Installation and Operation of the Offshore Wind Farm in Lithuania's Marine Territory

The proposed economic activity is classified as public interest and is considered important for public security

Year of the document:	2022-2023
Organiser (Customer) of the proposed economic activity:	**Ministry of Energy of the Republic of Lithuania**
Developer of the Environmental Impact Assessment:	**Public Institution Coastal Research and Planning Institute**

Proposed economic activity:	**Installation and Operation of the Offshore Wind Farm** **The proposed economic activity is classified as public interest and is considered important for public security**
Site for the proposed economic activity location:	Baltic Sea area approved by the Resolution of the Government of the Republic of Lithuania No. 697 of 22 June 2020 "On the Identification of the Priority Parts of Lithuania's Territorial Sea and/or the Lithuanian Exclusive Economic Zone in the Baltic Sea Where a Tender (Tenders) for the Development and Operation of Power Plants Using Renewable Energy Sources is (are) Expedient and on the Measurement of the Installed Capacities of Such Power Plants"
Revision of the Environmental Impact Assessment Report no.	Rev. 1. For the public information
Year of the document:	2023

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ABBREVIATIONS

EPA	Environmental Protection Agency
RES	Renewable energy sources
MoE	Ministry of the Environment
IHPA	Important Habitat Protection Area
CPTRL	Comprehensive Plan of the Territory of the Republic of Lithuania
EC	European Commission
MSFD	Marine strategy framework directives
EEZ	Exclusive Economic Zone
LR	Republic of Lithuania
LRS	Seimas of the Republic of Lithuania
LRV	Government of the Republic of Lithuania
MW	Megawatts
PAH	Polynuclear aromatic hydrocarbon
IBPA	Important Bird Protection Area
EIA	Environmental Impact Assessment
PHIA	Public Health Impact Assessment
PEA	Proposed economic activity
SEA	Strategic Environmental Assessment
TS	Transformer substation
WT	Wind turbine

INTRODUCTION

The offshore wind farm in the Baltic Sea is one of the most important projects envisaged in the National Energy Independence Strategy[1], which will increase the production of local electricity from renewable energy sources (hereinafter referred to as RES) and reduce dependence on electricity imports. Clause 25.1.3 of the National Energy Independence Strategy provides that energy production from wind energy in the Baltic Sea after 2020 is to be conducted, taking into consideration, inter alia, the research carried out and other actions taken which are required for the adoption of decisions regarding territories which are appropriate for organisation of tenders and for identification of the installed capacity of power plants. The Resolution of the Government of the Republic of Lithuania No. 697 of 22 June 2020 "On the Identification of the Priority Parts of Lithuania's Territorial Sea and/or the Lithuanian Exclusive Economic Zone in the Baltic Sea Where a Tender (Tenders) for the Development and Operation of Power Plants Using Renewable Energy Sources is (are) Expedient and on the Measurement of the Installed Capacities of Such Power Plants" (hereinafter referred to as the LRV Resolution No. 697)[2] has defined the part of Lithuania's territorial sea where a tender (tenders) for the development and operation of power plants using renewable energy sources is (are) expedient until 2030, as well as the type of power plants to be developed, i.e. wind turbines.

The proposed economic activity, i.e. the installation and operation of wind farm, corresponds with the activity specified in Sub-Clause 3.6.1 of Annex 1 of the Law of the Republic of Lithuania on Environmental Impact Assessment of the Proposed Economic Activity (adopted by the Resolution of Seimas of the Republic of Lithuania No. I-1495 of 15 August 1996, hereinafter referred to as EIA Law): construction of WT in Lithuania's territorial sea and/or the Lithuanian Exclusive Economic Zone in the Baltic Sea, i.e. environmental impact of this proposed economic activity must be assessed. Pursuant to the EIA Law, the objectives of the EIA conducted are as follows:

- To determine, describe, and assess the potential direct and indirect impacts of the PEA, i.e. installation and operation of the offshore wind farm in the territorial sea approved by the LRV Resolution No. 697, on the following elements of the environment: land surface and subsurface, water, air, climate, landscape and biodiversity, with a special consideration of species and natural habitats of European Community interest, as well as on other species, material assets, immovable cultural heritage protected pursuant to the Law of the Republic of Lithuania on the Protected Species of Fauna, Flora and Fungi, and the interrelationship between these elements;
- To identify, describe and assess the potential direct and indirect impacts of PEA-induced biological, chemical and physical factors on public health, as well as on the interrelationship between the elements of the environment and public health;
- To determine the potential impact of the PEA on the elements of the environment and on public health by virtue of the risk of vulnerability of the PEA due to emergency cases and (or) potential emergency situations;
- To determine the measures to be taken in order to prevent envisaged significant adverse impact on the environment and public health, to reduce it or, if possible, to offset it;
- To define whether the PEA corresponds with the requirements of legislation regulating environmental protection, public health, immovable cultural heritage, fire and civil safety, after assessed its nature, location and (or) impact on the environment.

Participants of the EIA process are as follows:

- Organiser (Customer) of the PEA;

[1] Approved by the Resolution of the Seimas of the Republic of Lithuania no. No. XI-2133 "On Approval of the National Energy Independence Strategy" of 26 June 2012

2 Resolution of the Government of the Republic of Lithuania No. 697 of 22 June 2020 "On the Identification of the Priority Parts of Lithuania's Territorial Sea and/or the Lithuanian Exclusive Economic Zone in the Baltic Sea Where a Tender (Tenders) for the Development and Operation of Power Plants Using Renewable Energy Sources is (are) Expedient and on the Measurement of the Installed Capacities of Such Power Plants":
https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/90aa05b1b6bc11ea9a12d0dada3ca61b?jfwid=32wf7atk

- Drafter of the EIA documents;
- The public concerned;
- Entities of the EIA. Pursuant to Article 5 of the EIA Law, EIA entities are: the executive institution of the municipality in the territory whereof PEA is to be carried out, the institutions authorised by the Minister of Health, the institutions authorised by the Minister of the Interior responsible for fire and civil protection, the institutions authorised by the Minister of Culture responsible for the protection of cultural properties.

The PEA territory approved by the LRV Resolution No. 697 is outside the territories of the coastal municipalities and is located approximately 29.5 km from the coastal line. This IEA also does not cover the installation of electricity transmission joint bays. The EIA Report is submitted for coordination to the following entities of the EIA responsible for the administration of the coastal area territories neighbouring to the PEA territory:

- Palanga City Municipality Administration;
- Klaipėda District Municipality Administration;
- Klaipėda City Municipality Administration;
- Klaipėda Department of National Public Health Centre under the Ministry of Health;
- Klaipėda County Fire and Rescue Department;
- Department of Cultural Heritage under the Ministry of Culture, Klaipėda Division.

Pursuant to Article 5(2) of the EIA Law, entities of the EIA may also be other state institutions if, during the examination of the IEA documents, the competent authority, having regard to the nature, size or location of PEA, invites them in accordance with the procedure established by the Minister of Environment to participate in the process of environmental impact assessment. Additional IEA entities invited by the competent authority to participate in the IEA process:

- State Service for Protected Areas under the Ministry of Environment;
- SE Klaipėda State Seaport Authority;
- Lithuanian Geological Survey;
- Fisheries Service under the Ministry of Agriculture**.**

- The Competent Authority is the Environmental Protection Agency (EPA).

The EIA Report has been drawn up following the Regulations on Environmental Impact Assessment of the Proposed Economic Activity[3] (hereinafter referred to as the Regulations), coordinated and approved EIA Programme (Annex 1. Letter of Approval of the IEA Programme), conclusions of entities regarding the EIA Programme, and international consulting that took place on the EIA Programme stage.

The public is informed following Section 5 of the Regulations "Procedure for Provision of Information to the Public and Participation in the Process of Environmental Impact Assessment." During the EIA process of the PEA, the public concerned has the right to submit any proposals, comments, information, analysis, opinion regarding the PEA and EIA thereof to the drafter of the EIA documents, EIA entities, and EPA in accordance with the procedure referred to in Section 5 of the Regulations.

The Convention of the United Nations Economic Commission for Europe on Environmental Impact Assessment in a Transboundary Context (hereinafter - the Espoo Convention) determines that a transboundary EIA is carried out when the EIA is included in Annex I of the Espoo Convention. According to the second amendment of the Espoo Convention (Decision III/7 of 04.06.2004), large installations using WT for energy production are included in Annex I of the Convention. According to the resolution no. 900 (July 28, 2000) of Government of the Republic of Lithuania "Regarding the granting of powers to the Ministry of the Environment and its subordinate institutions", the cross-border EIA coordination and publicization process are coordinated by the Ministry of the Environment.

[3] Approved by the Order of the Minister of Environment of the Republic of Lithuania No. D1-885 of 2 October 2017 "On Approval of the Regulations on Environmental Impact Assessment of Proposed Economic Activities."

1. INFORMATION ON THE PROPOSED ECONOMIC ACTIVITY

The proposed economic activity is installation and operation of the offshore wind farm in the marine territory of the Baltic Sea approved by the LRV Resolution No. 697.

The technical specification for the procurement of document preparation services for the environmental impact assessment procedures for the wind turbines to be deployed in Lithuania's marine territory defines PEA as the totality of offshore WT, foundations thereof and electricity transmission system to the offshore substation, including the offshore transformer substation.

The electricity will be generated by the wind farm using the offshore WTs and transmitting the energy produced to the national grid.

1.1. Physical and Technical Characteristics

The PEA is related to a whole range of complex issues – impact on the environment and socio-economics, territorial planning, selection and integration of energy systems, engineering solutions, logistic and other related challenges both offshore and onshore. The key part of IEA is the technical project part, which solutions and technical parameters can have in impact on most sensitive environmental components.

The key parameters conditioning the physical impact of the proposed project are size of turbine, type of foundations, location of WT in the farm area, type of offshore TS and installation site, transmission cable system inside the farm.

Please note that the transmission joint bay between the offshore substation and onshore grid are not assessed in this report. Although the offshore WT part and its joint bay with the onshore national grid and the related infrastructure (hereinafter referred to as the Joint Bay) are an integral part of PEA, this EIA scope however includes the environmental impact assessment of installation of offshore WT farm and offshore TS with consideration of the fact that currently the site of offshore WT part joint bay corridor is still not defined. The above-mentioned site will be defined pursuant to the Law on Territorial Planning by developing a territorial planning document and conducting its strategic environmental assessment. Once the site of the Joint Bay corridor is defined, the selection for EIA will be conducted in accordance with the procedure stipulated by the EIA Law and enforcing legislation, followed by a full-scope environmental impact assessment conducted based on resolution adopted by the competent authority.

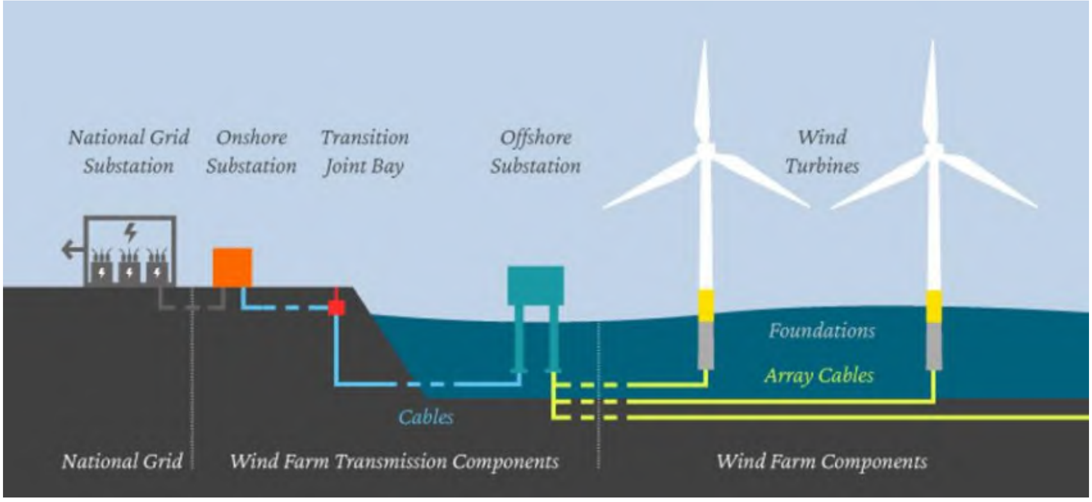


Fig. 1.1.1 Schematic presentation of offshore wind farm (source: https://www.northfallsoffshore.com/facts-Fig.s/).

Wind turbine (WT). Most WT designs have upwind, pitch controlled, variable speed rotors with three blades. Compared to onshore wind turbines, offshore turbines are much larger and there is an increased focus on reliability and maintainability. A new generation of 12MW+ turbines has been developed and operating reliably, and turbines with ratings at and over 14MW are offered by the main suppliers. The design life of an offshore turbine is approx. 25 years. The trend for longer design life on all turbines is due to the maturing of the industry – developers and WT farm developers now expect to operate wind farms for such periods without the technology becoming obsolete or unsupported by suppliers. Extreme loads due to storms, abnormal events and faults during operation can also be critical. Typically, an offshore turbine will turn for over 90% of the time. So, the design driver for many components is fatigue loading when generating.

Text and illustrations according to interactive OWT installation guide: https://guidetoanoffshorewindfarm.com/guide

Height of offshore WT tower is subject to the location wind category and environmental conditions. The best fitting WTs will be selected and WT physical and technical parameters, including capacity, will be verified during the development of the technical project according to the wind speed parameters measuring by the developer. WT consists of three main components: nacelle with integrated turbine, rotor and its blades, installed tower and foundation structures.

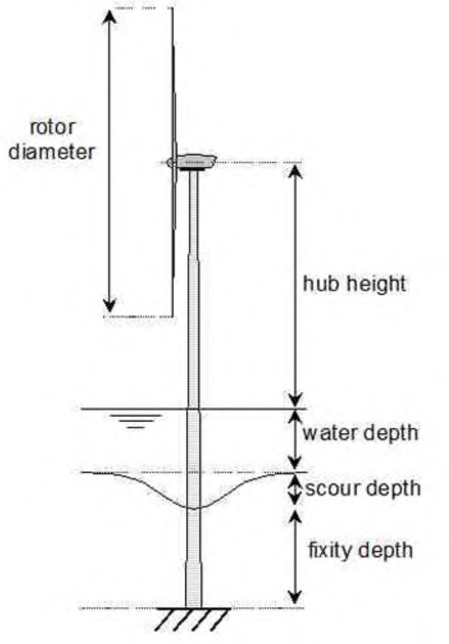
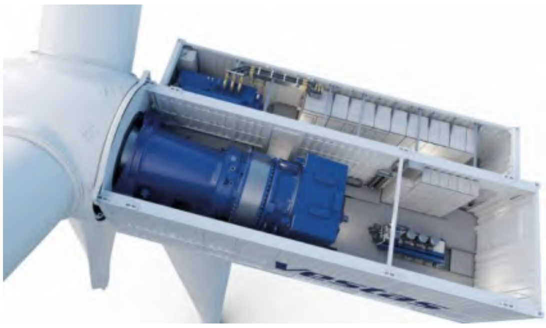


Fig. 1.1.2. WT height scheme (data by David Cerda Salzmann, Delft University of Technology).

Nacelle is assembled with the main turbine components (generator, gearbox, control system), which ensure the generator operation and convert the rotational energy into three-phase alternating electricity. For comparison, dimensions for a 10MW turbine are 20-25m long x 9-12m wide x 7-9m high, with mass 400-500t including hub. Nacelle mass is kept low to help with overall system dynamics and minimise logistics costs. To keep nacelle mass down, turbine designs may include the transformer and much of the power electronics in the tower base. There has been a move away from high-speed gearboxes for offshore turbines. Direct drive turbines are used instead.



The **rotor and its rotating blades** extracts kinetic energy from the wind and convert this into rotational energy in the drive train. The blades are connected to the turbine drive train via a central hub. In all offshore wind turbines, the blades are mounted on blade bearings to allow independent adjustment of the pitch angle of each blade. For comparison, a rotor for a 10MW turbine has a mass of about 150t and a diameter of 170-200m. There are no fundamental limits to the size of rotors for offshore turbines. New turbine designs report capacity factors of about 50% comparing with the nominal capacity factor. Rotor speeds are 5 to 12 r/min, resulting in a maximum tip speed of over 100 m/s. It is estimated that rotor clearance must be at least 22m above mean high water springs.

The **tower** is typically a tubular steel structure that houses a nacelle maintenance and power transmission shaft. It also houses transformer where alternating electricity is levelled and transmitted to the substation. For comparison, if the hub height is about 110m above sea level, so each tower is about 100m long and has a mass over 600 tonnes. About 90% of the mass is steel plate with forged steel flanges making up most of the rest. Towers are generally uniformly tapered, with a top diameter of the order of 5-6m and a base diameter of 7-8m.

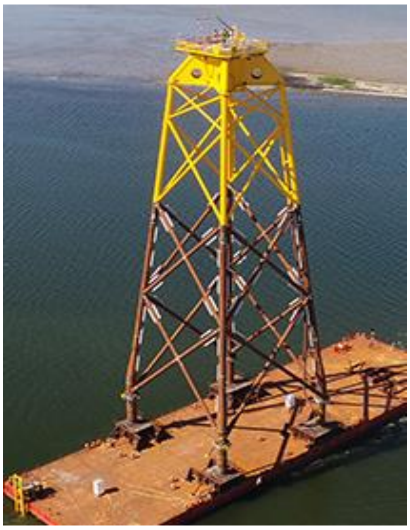
Text and illustrations according to interactive OWT installation guide*: https://guidetoanoffshorewindfarm.com/guide*

Wind turbine foundation structures

The foundation is typically around 20m above water level. Moreover, it provides support for the main WT structure, transferring a part of the loads from the turbine to the sea bed. The foundation also provides the conduit for the electrical cables, as well as access for personnel from vessels. It is estimated that over 80% of offshore WTs installed to date have been supported by monopiles driven into the sea bed, with jacket foundations representing approximately 15%. Gravity bases are the least common design and most examples were deployed at early offshore wind farms in water depths of less than 10m. For comparison, for a 10MW turbine at 30m water depth, indicative mass for a monopile (including transition piece) is around 1,650 tonnes. For a 10MW turbine at 40m water depth, indicative mass of a jacket (including pin piles) is 1,450 tonnes. Meanwhile, the gravity bases in waters of 36-42m report a mass of up to 15,000 tonnes.

Particular WT foundation design is subject to manufacturer requirements, including loads, frequencies, cable scheme, etc., as well as geological and hydrodynamical conditions of the proposed location, including potential ice impact and turbulence. The WT foundation design will be selected by the developer after considering the results of comprehensive geoengineering studies in the PEA area. The selected foundation design is conditioned by the area of natural substrate to be impacted during the foundation installation and defines the local change of hydrodynamical conditions in the selected area.

Monopile foundation structures are the most commonly used foundation type to date and are considered to be a proven technology by the offshore wind industry in water depths up to approximately 50m. Typically, for a 10MW turbine, the dimensions will be up to 10m diameter, 120m overall length and 2,000 tonnes. The monopile is a cylindrical steel tube that is usually driven into the sea bed. Monopiles need to withstand the impact of pile driving into the sea bed. The pile needs to be designed to account for these impact loads. As it is a simple cylindrical structure it is relatively easy to transport and move into its vertical orientation. The piles are driven into the sea bed until the required depth is reached subject to the WT turbine design, geological and hydrodynamical conditions. This foundation design reports an impact of the least sea bed area, yet produces a considerable underwater impulse noise during driving operations. A monopile will normally have a transition piece (typically around 20m above average water level) between it and the bottom of the turbine tower, allowing for a personnel access to ensure the turbine maintenance.



There are several different versions of **jacket structures**, including three legged and four legged. The structure itself is permeable, so it is well suitable for depth between 20 and 80 m. It shows lower wave loads as compared to monopole. It is a highly reliable yet expensive structure, which is widely used for the installation of offshore platforms. Contrary to monopile, A jacket foundation does not have a separate transition piece. The upper part of the jacket performs many of the functions of the transition piece. There are several different versions of jacket structures, three and four legged versions are currently the most widely used. Jacket foundations are used where ground conditions are too hard, or too soft, for monopiles. In addition, driving smaller diameter pin piles creates less noise than driving a single large monopile. Thus, in locations where underwater noise impact is great, a jacket may therefore be preferred over a monopole.

Offshore substation is used to collect the entire WT farm generating assets, transform and transmit to the onshore transmission grid. Its main function is to reduce electrical losses before export of power to shore. This is done by increasing the voltage, and in some cases converting from alternating current (AC) to direct current (DC). The main offshore substation components are transformers, switchgears, standby generator, staff premises, water reservoirs, cables, control and monitoring system, etc. An HVAC substation weighs up to 3,000 tonnes. An analogous HVDC substation weighs up to 18,000 tonnes. A typical OS is installed on the foundation design which is the same as WT. The platform is about 25m above the sea and has an area of 800m². A single HVAC offshore substation can support the input of about 700MW. Installation of several substations would make the power transmission per WT farm more efficient. Typically, a 1GW wind farm would only have one HVDC offshore substation but the PEA territory is rather close to the shore so a cheaper AC technology will most likely be used to support the proposed WT farm.

Text and illustrations according to interactive OWT installation guide*: https://guidetoanoffshorewindfarm.com/guide*

Subsea cables

Subsea cables ensure effective power delivery. Subject to their function, there are two main cable designs: array cables used to connect WTs inside the wind farm with the offshore substation and export cables that deliver power output from offshore farm to onshore grid.

Export cable comes in two types – HVAC and HVDC. An HVAC export cable is 3-core whereas a typical HVDC has a bipolar design with two single-core cables. HVAC cables suffer important losses over longer distances due to reactive power flow. HVDC is often used for long distance transmission.

AC export cables are typically rated between 132kV and 245kV, allowing export of 350-400MW per 3-core cable. The industry standard for projects is now 220kV for HVAC export cables. A 220kV three-core copper AC export cable has mass of approximately 90kg/m. A 320kV single-core DC copper export cable has mass of approximately 40kg/m.

Array cable

Each WT has of the order of 1.5km of array cable on either side associated with it, depending on turbine size and spacing. Array cables are now typically rated at 800 mm^2 66kV. High voltage enables more capacity to be connected on a single string, reducing the length of cable required and reducing the number of switchgear bays needed on the substation.

Text and illustrations according to interactive OWT installation guide: https://guidetoanoffshorewindfarm.com/guide

1.2. Installation of Wind Farm

The main stages of wind farm installation:

- Installation of foundation, tower and offshore substation;
- Installation of nacelle and blades;
- Installation of cables inside WT farm;
- Connection of WT to the power transmission system.

Foundation installation consists of the transport and fixing of foundation in position. Monopiles may be installed from a jack-up vessel or a floating vessel. Monopiles are generally moved into position using the main crane and held in position by a gripper tool. They are driven into the sea bed using a hammer and anvil system. When the monopile installation vessel has no useable deck space for transporting components, the monopiles are floated to site using tugs or transported using platform supply vessels. It is estimated that the full cycle time is 2-3 days per monopile. Under some unfavourable ground conditions (stones, boulders, solid moraine), monopiles are grouted into a pre-drilled rock socket.

Jacket foundations are installed into place over the pin piles and grouted. Post-piling, in which the pin piles are driven (or lowered into pre-drilled sockets) through a sleeve on the jacket legs, may alternatively be used. It is estimated that the full cycle time is 3-5 days per jacket.

WT installation. WT tower sections are typically preassembled onshore with any internal components and the completed structure, along with nacelle and blades, is transported vertically to site for final installation. Offshore tower installation is undertaken by jack-up vessels due to the need for a stable platform to perform offshore lifting operations and mating of components at height. It is estimated that the installation of a tower from positioning the vessel at the site to departure takes about 24 hours. The nacelles with placed on the assembled tower with the pre-assembled rotor in one peace. Then the hub and blades are mounted.

Text and illustrations according to interactive OWT installation guide: https://guidetoanoffshorewindfarm.com/guide

Offshore substation installation is typically carried out on the same foundation design as such of WT. Substation is floated by special vessels from crane / production site and transferred on pre-installed foundation structure. Offshore substation installation is a heavy lift operation, it is therefore typically floated on a barge and installed on foundation using high-capacity vessel cranes.

Cable installation is related to installation of power transmission system inside WT farm – array cables connecting WT to offshore substation and export cables connecting offshore and onshore substations. Cable installation activities are preceded with a survey to define the route and sea bed cleaning to eliminate any danger during excavation (UXO, other hazardous objects). All offshore cable installation involves the following activities: pre-trenching, cable lay, cable burial, cable pull-in to turbine, substation or shore. In engineering terms, pre-trenching and simultaneous lay and burial using a cable plough is often preferred if the soil is suitable as immediate burial and protection is obtained in a single pass. Cables are typically buried to 1-4m below sea bed.

Text and illustrations according to interactive OWT installation guide: https://guidetoanoffshorewindfarm.com/guide

1.3. Operation stage

The focus of activities during the operational phase of WT farm is to ensure proper conditions for the Project maintenance and efficient operation. This includes safety and security of operations related to the project management, staff training, power balancing of WT and TS operation, environment monitoring, issues related to generated electricity transmission, administration, supervision and organization of offshore operations, management of vessel and coastal infrastructure. Access to WT farm for maintenance operations can be achieved by small vessels that can directly approach and moor at WT and ensure safe transfer of the maintenance personnel to the WT maintenance platform. The period of the turbine defect warranty is usually five years. During this period, the wind turbine supplier takes care of WT maintenance and ensures smooth transfer of competences to the wind farm owner. Activity is divided into preventive maintenance (scheduled) and corrective service (unscheduled) works.

Text and illustrations according to interactive OWT installation guide*:* *https://guidetoanoffshorewindfarm.com/guide*

The bulk of preventive works will typically be carried out during periods of low wind speeds (usually the summer months) to minimise the impact on production. Corrective service is performed in response to unscheduled outages and is often viewed as more critical, due to accruement of downtime until the fault is resolved. Typical maintenance includes inspection, checking of bolted joints, and replacement of worn parts (with design life less than the design life of the project). In addition to electrical maintenance, foundation and cable inspection and assessment of state are carried out.

1.4. Decommissioning stage

At the end of the nominal design life of an offshore wind farm, to repower the wind farm site with new design turbines and likely meaning the update of foundations; or fully decommission the site. Turbine decommissioning will require complete removal of the structure. For turbine decommissioning, the process will be a reverse of the installation process, such as individual blades being removed, then hub and nacelle then finally tower and, partially, foundations (it is possible that some components could be left in position on the sea bed where they support secondary areas for biodiversity spread). For monopiles or jackets, all elements above the sea bed will need to be removed with piles cut off (typically about 1m). Removal of foundations is likely to involve the use of a range of cutting and drilling tools including guillotine saws, hydraulic hole cutting tools and abrasive waterjet cutting. The value, especially of the main conductor material in array and export cables, is such that it is likely to remain worth removing the cables for their use in secondary production. Cables will be disconnected each end then pulled from the sea bed and wound on to drums or chopped into short sections for storage on the decommissioning vessel. Like wind turbine, for substation decommissioning, the process is also to be a reverse of the installation process. If the remaining life of the substation structure and equipment is sufficient, the substation could be left in-situ and reused for a repowered wind farm of the same (or lower) capacity. All wind turbine components are to be transported onshore and handed over for reuse, recycling or disposal.

It is important to note that environmental studies in scopes as recommended in the section on PEA monitoring are required prior to and after decommissioning.

1.5. Materials to be used

Offshore WT construction will employ new, European Union certified products. The installation sites will only host the assembly and installation of individual devices. The use and storage of hazardous chemicals or compounds, radioactive agents; hazardous or non-hazardous wastes during PEA is not planned.

1.6. Waste generation and management

All wastes generating during WT farm construction and operation will be delivered to ports of service and handed over to waste management companies.

The engineering design for the WT farm will include the potential amount of waste generating during construction and operation and waste management plan.

Once WT farm is decommissioned, major part of its components will be handed over for reuse. When this is not possible, the components will be recycled or disposed in designated sites according to statutory requirements of the Republic of Lithuania. WT decommissioning project must include the generating waste management plan.

2. INFORMATION ON THE PROPOSED ECONOMIC ACTIVITY TERRITORY

The WTs are proposed to be installed in the marine territory of the Baltic Sea approved by the LRV Resolution No. 697 where a tender (tenders) for the development and operation of power plants using renewable
energy sources is (are) expedient by 2030.

The main characteristics of the territory:

– Area: 137.5 km^2;

– Average depth: 35 m;

– Distance from Klaipėda Seaport: from 38 km;

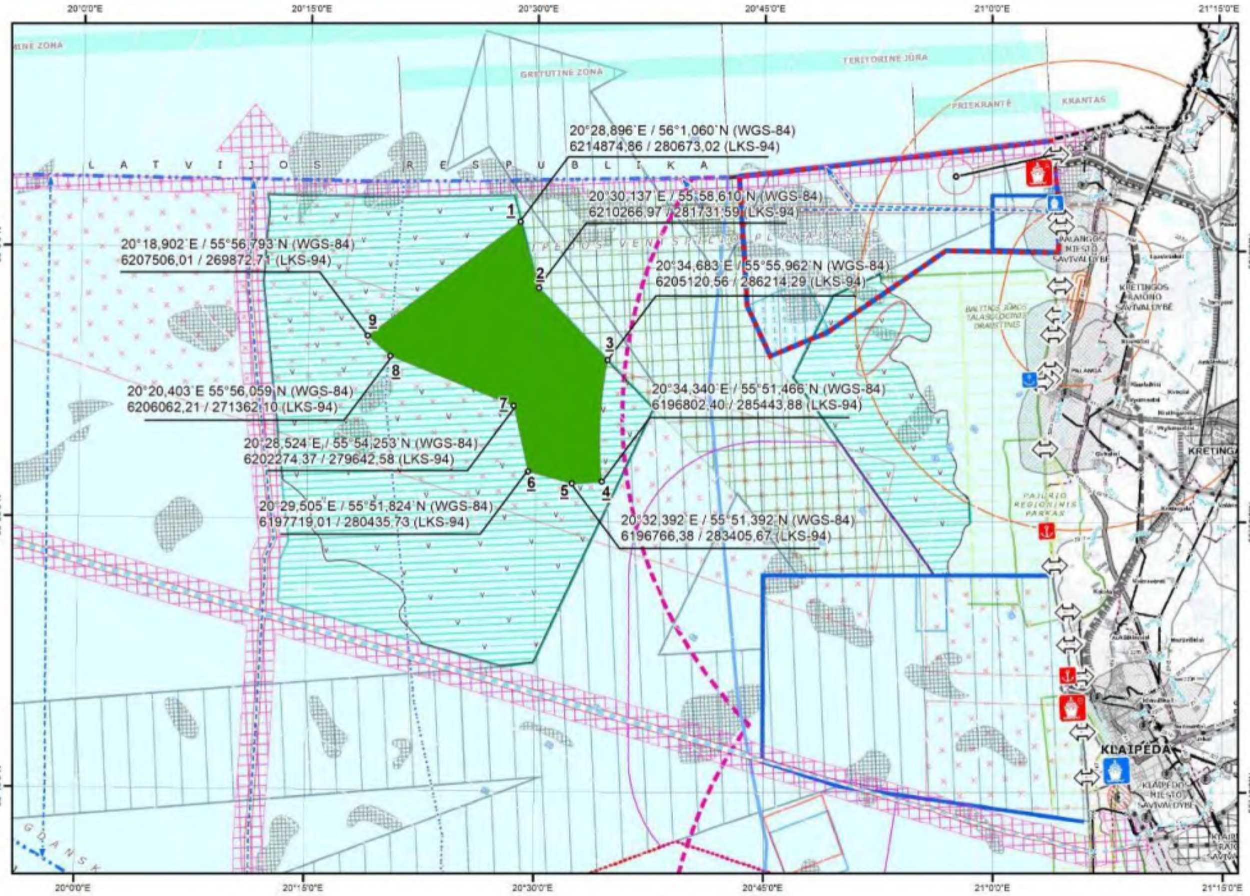


Fig. 2.1. The PEA territory in the Baltic Sea approved by the LRV Resolution No. 697.

Table 2.1. Coordinates of the territory approved by the LRV Resolution No. 697

Territory point no. (see Fig. 2.1)	Coordinates	
	according to the World Geodetic System 1984 (WGS–84)	according to the Lithuanian Coordinate System 1994 (LKS–94)
1	20°28,896`E 56°1,060`N	X-6214874,86; Y-280673,02
2	20°30,137`E 55°58,610`N	X-6210266,97; Y-281731,59
3	20°34,683`E 55°55,962`N	X-6205120,56; Y-286214,29
Section between point 3 and 4	20°34,683`E 55°55,962`N, then, based on the 29,500 m arch between 21°02,476`E 55°52,987`N and 20°34,340`E 55°51,466`N	X-6205120,56; Y-286214,29, po then, based on the 29,500 m arch between X-6198268,02; Y-314907,19 and X-6196802,40; Y-285443,88
4	20°34,340`E 55°51,466`N	X-6196802,40; Y-285443,88
5	20°32,392`E 55°51,392`N	X-6196766,38; Y-283405,67
6	20°29,505`E 55°51,824`N	X-6197719,01; Y-280435,73
7	20°28,524`E 55°54,253`N	X-6202274,37; Y-279642,58
8	20°20,403`E 55°56,059`N	X-6206062,21; Y-271362,10
9	20°18,902`E 55°56,793`N	X-6207506,01; Y-269872,71

2.1. Geographical and Administrative Situation on the Territory of the Proposed Economic Activity

The PEA territory is situated in the Lithuania's Exclusive Economic Zone in the Baltic Sea, at depth of 25 to 45 m isobaths.

The PEA territory is distant from the shoreline and adjacent municipalities of Klaipėda City, Klaipeda District, and Palanga. The shortest distance from the proposed territory to the town of Palanga is approx. 29.5 km.

The shortest distance from the proposed territory to the Latvian EEZ is about 2.8 km, to the Swedish EEZ – about 77 km, and to the Russian EEZ – about 40 km.

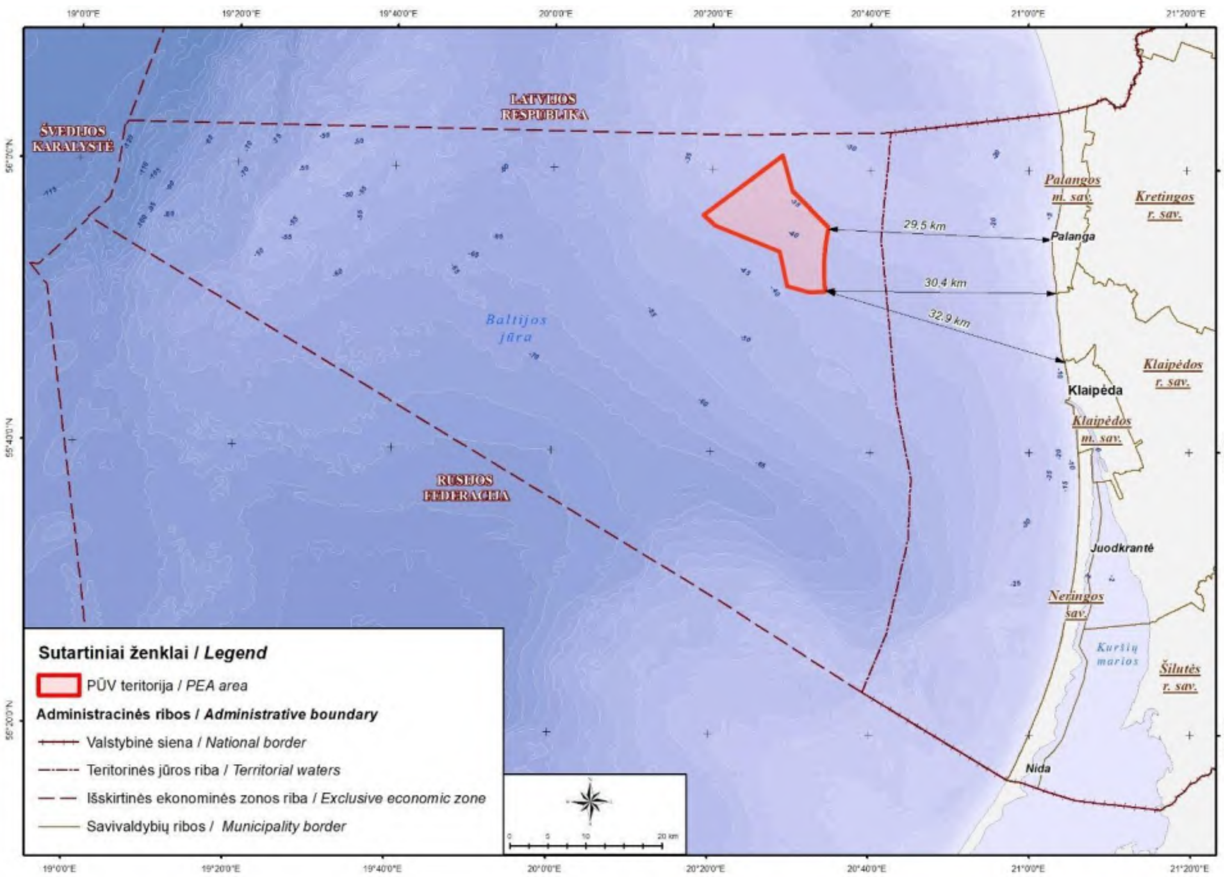


Fig. 2.1.1. Geographical and administrative situation on the PEA territory.

2.2. Current Use of the Territory

Lithuania‘s Exclusive Economic Zone and marine territory are used for shipping, commercial fishing; there are various engineering communication routes laid out, other economic activities carried out or planned (sand excavation, soil dumping, development of renewable energy, military operations, etc.). The Lithuanian seaside is popular as a recreational area and has a great potential for nautical tourism. Protected areas and European sites "Natura 2000" under expansion occupy a significant part of marine waters, i.e., the Curonian Spit National Park, the Seaside Regional Park, and the Baltic Sea Talasological Reserve.

The PEA territory is outside the established international shipping routes. A distance from the PEA territory to the coastal areas used for recreational diving is approx. 18 km, and to the nearest beaches (of Palanga) is approx. 29.5 km. The existing offshore soil dumping sites are more than 17.6 km away from the PEA territory.

The territory borders yet is outside the marked state-protected territories or the territories of habitat and bird protection of the European ecological network "Natura 2000".

The main activities that the PEA territory is currently used for are fishing, but due to the cod fishing restrictions, intensity of the fishing in the area is decreasing.

Part of the PEA territory is within the potential danger zone at sea, i.e., former minefields. Part of the PEA territory is within the territories where design and construction of the WTs (high-rise structures) may be subject to restrictions in relation to national security.

More details on the current use of the proposed marine area and the neighbouring areas are available in Section 4 of the EIA Report discussing the impact of the PEA on individual components of the environment.

2.3. References to Territorial Planning Documents, Strategic Plans and Programmes

Comprehensive Plan of the Territory of the Republic of Lithuania[4]

The solutions of the CPTRL (Clause 310) provide for the following importance: "To develop the installation of offshore wind farm and the electricity transmission network to connect the WT farm to the onshore grid."

Section 3 of the CPTRL solutions "Responsible Use of the Sea and the Coastline" provide that for Lithuania to develop the competitive blue economy, the development of marine and sea-related activities is of special importance.

Clause 551 of the CPTRL provides that the development of new offshore activities creates new experience and, thus, provides an advantage in the Baltic Sea Region (BSR) and an opportunity for its realization on an international scale. The installation and operation of the WT, the development of aquaculture, the use of the Earth's interior resources, and the application of innovative inventions in the marine activities form new directions of economy. It is therefore necessary to support a cohesive development of activities and a consistent and stable growth of marine activities, by defining the strategic directions of blue economy, creating legal and administrative preconditions for the formation and installation of on-site facilities (ports, small ports, wharves), resource operating equipment, facilities and territories on the LR coast and marine territories.

Clause 583 of the CPTRL provides that there are three priority territories proposed for the construction and installation of renewable energy facilities, i.e. in the territorial sea beside Palanga between the Baltic Sea Talasological Reserve and the shipping route where the installation of WT is subject to strict restrictions, in the 20–50 m depth zone north to Klaipėda (Klaipėda–Ventspils Plateau) and further westwards in the Bank of Klaipėda where there are no restrictions for the installation of WT. The priority of the first territory is the development of RES which does not violate the restrictions imposed on the territory (waves, loads, sun, etc.). All facilities in the territories specified must correspond with the national security and evironmental requirements. To reduce the visual impact of the WT on the marine landscape, construction of WT is possible outside the borders of the territorial sea (approx. 30 km from the coastline).

The area of interest is within RES priority zone of the valid CPTRL (Fig. 2.3.1)

[4] Approved by the Resolution of the Government of the Republic of Lithuania no. 789 of 29 September 2021 "On Approval of the Comprehensive Plan of the Territory of the Republic of Lithuania."

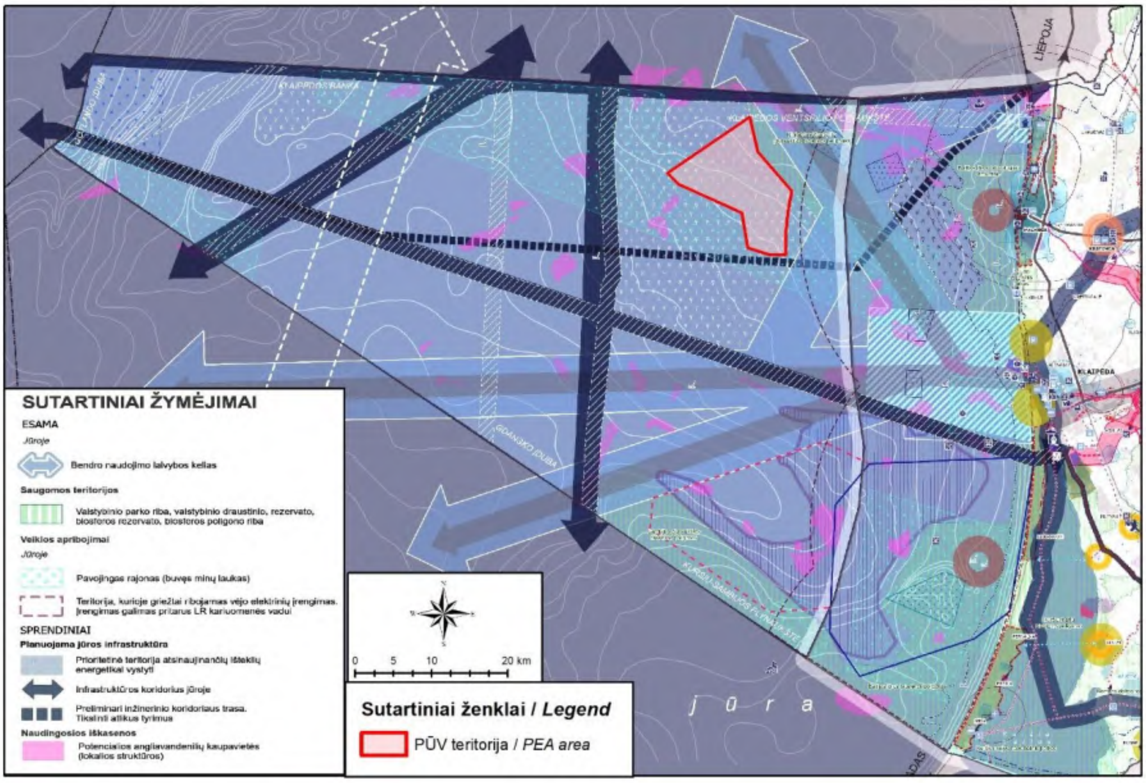


Fig. 2.3.1. Layout of the PEA territory in relation to the scheme in the Comprehensive Plan of the Territory of the Republic of Lithuania "Responsible Use of the Sea and the Coastline".

Engineering Infrastructure Development Plan for Marine Areas of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic Sea, Designed for the Development of Renewable Energy

Pursuant to the Order of the Minister of Energy of the Republic of Lithuania no. 1-253 of 17 August 2020" On Commencing the Preparation of the Engineering Infrastructure Development Plan for Marine Territories of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic Sea, Designed for the Development of Renewable Energy, and on the Setting of the Planning Objectives" and in view of the objectives to create conditions for energy production from wind power in the Baltic Sea and, thus, to increase a share of renewable energy sources in Lithuania's domestic energy production and total final energy consumption, the Engineering Infrastructure Development Plan for Marine Areas of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic sea, Designed for the Development of Renewable Energy (hereinafter referred to as the Development Plan) was prepared and approved by the Order of the Minister of Energy of the Republic of Lithuania no. 1-377 of 18 November 2022.

The territory proposed in the concretised solutions of the Development Plan[5], which is defined in the Comprehensive Plan of the Territory of the Republic of Lithuania as a potential territory for the development of renewable energy, is divided into separate areas where the development of the RES facilities will be carried out is stages. The PEA territory is marked in the Development Plan as the area under development in Phase I (Fig. 2.3.2).

[5] The concretised solutions of the Engineering Infrastructure Development Plan for Marine Areas of Lithuania's Territorial Sea and/or the Exclusive Economic Zone of the Republic of Lithuania in the Baltic sea, Designed for the Development of Renewable Energy. August 2022. Developed by: Ardynas, UAB. 2021-03-VP-KS.AR

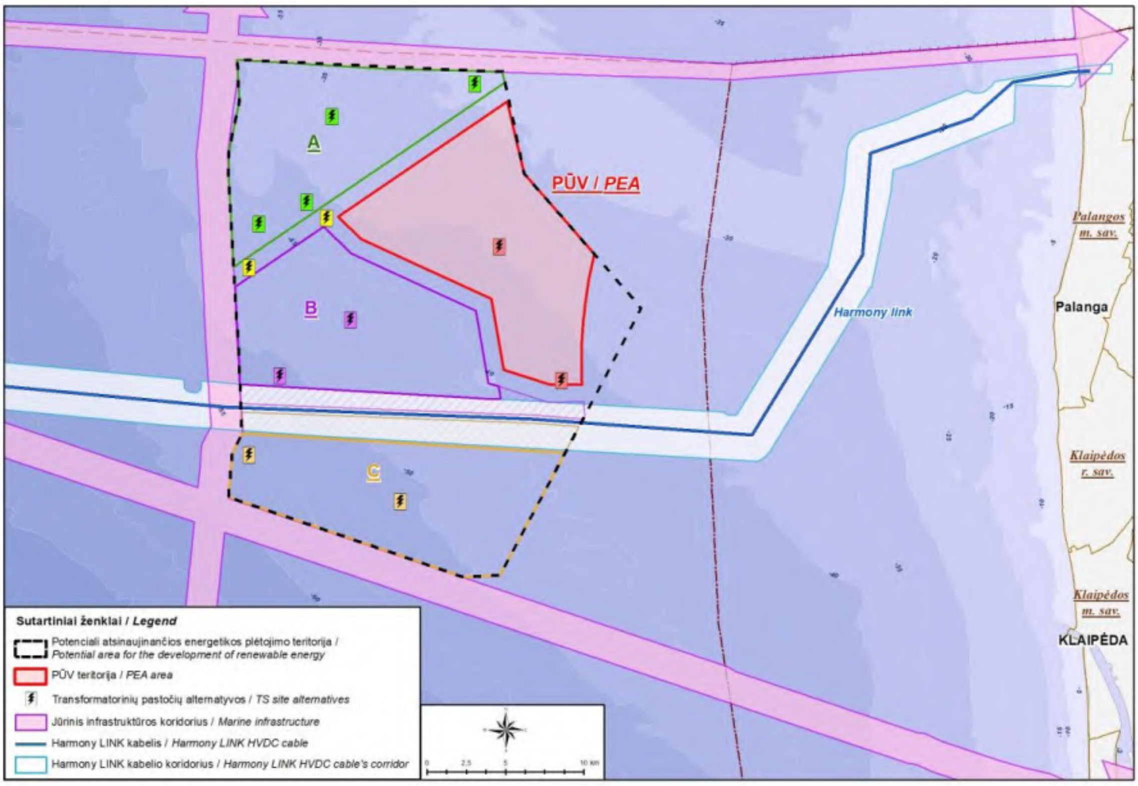


Fig. 2.3.2. Layout of the PEA territory in relation to the solutions of the Development Plan.

References to Strategic Plans and Programmes

- National Strategy for Sustainable Development[6];
- National Environmental Protection Strategy[7];
- National Energy Independence Strategy[8] (hereinafter referred to as NEIS);
- National Strategy for Climate Change Management Policy[9];

The National Strategy for Sustainable Development provides for a more effective use of natural resources. One of principles, the Strategy's implementation is based on, is the principle of substitution. Non-hazardous substances and renewable resources must replace hazardous substances and non-renewable resources. The wider use of renewable energy sources (wind, etc.) in energy and transport sector will make it possible to reduce the use of organic fossil fuel and the resulting air pollution, and to cut the amounts of greenhouse gases.

One of the four priority areas of the environmental protection policy under the National Environmental Protection Strategy is sustainable use of natural resources. According to the Lithuanian environmental

[6] Approved by Resolution of the Government of the Republic of Lithuania no. No. 1160 of 11 September 2003 "On Approval and Implementation of the National Strategy for Sustainable Development."

[7] Approved by Resolution of the Seimas of the Republic of Lithuania no. XII-1626 of 16 April 2015 "On Approval of the National Environmental Protection Strategy."

[8] Approved by Resolution of the Seimas of the Republic of Lithuania no. XI-2133 of 26 June 2018 "On Amendment of the Resolution of the Seimas of the Republic of Lithuania no. XI-2133 of 26 June 2012 'On Approval of the National Energy Independence Strategy'."

[9] Approved by Resolution of the Seimas of the Republic of Lithuania no. XI-2375 of 6 November 2012 "On Approval of the National Strategy for Climate Change Management Policy."

vision under the Strategy, in 2050, Lithuania will have renewable energy resources involved in all the sectors (energy, industry, transport, agriculture, etc.) of national economy.

The National Energy Independence Strategy states that in 2016, RES accounted for about 25.5% of final energy consumption in Lithuania. In pursuit of the strategic RES target, the aim will be to increase the share of renewable energy sources in the total final energy consumption of the country to 30% by 2020, 45% by 2030, and 80% by 2050. RES will become the main source of energy in electricity, heating and cooling, and transport sectors.

The National Strategy for Climate Change Management Policy sets GHG emission reduction targets and implementing measures. The Strategy presents the vision of the climate change management policy until 2050: By 2050, Lithuania will have ensured adaptation of the sectors of the domestic economy to environmental changes caused by climate change and climate change mitigation (reduction of GHG emissions), developed competitive low-carbon economy, implemented eco-innovative technology, achieved energy generation and consumption efficiency and use of renewable energy sources in all sectors of the domestic economy, including energy, industry, transport, agriculture, etc.

2.4. Analogous Activities Planned in the Adjacent Territories

The PEA territory is on of the four activities approved by the Development Plan. It is therefore likely that soon the aim would be to develop other territories designed for the development of RES facilities proposed in the Development Plan as well. Moreover, on 4 April 2022 EPA has adopted a Decision no. (30.2)-A4E-3820 regarding the extension in validity of the environmental impact assessment of the possibilities of the installation and operation of the WT farm in Lithuania's waters of the Baltic Sea in the marine territory adjacent to the WT farm proposed by AVEC, UAB (within the borders of the territory of the WT development as planned within the scope of the Development Plan).

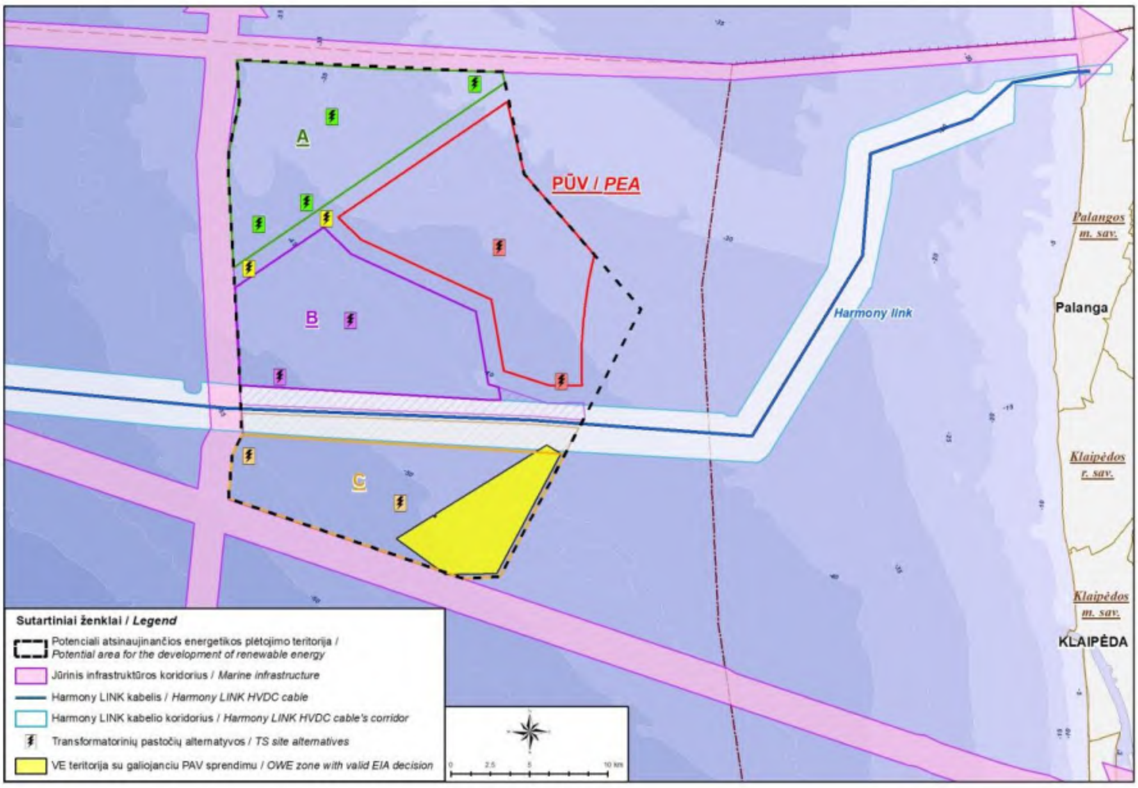


Fig. 2.4.1. Layout of the WT farm territory proposed by JSC AVEC.

3. TECHNICAL INFORMATION FOR ALTERNATIVES TO BE DEVELOPED

The EIA Report includes the consideration of two main alternatives: 'zero' alternative, i.e. without carrying out any activity, and project development alternatives, i.e. the offshore WT farm installed in Lithuania's marine territory.

The PEA territory is provided for in the LRV Resolution No. 697 and territory planning documents (the Development Plan). The alternatives of the location for the offshore WT farm installation are therefore not analysed.

The 'zero' alternative, or, inactivity, shows current circumstances and an environmental situation in the event of non-performance. In this case, changes in the environmental situation of Lithuania's marine territory in the Baltic Sea would have no connection with the development of the PEA.

Project development alternatives, as approved by the the the LRV Resolution No 697. Offshore WT farm of up to 700 MW installed capacity installed and operated in the territory approved by. The developer could install the offshore WT farm of the capacity exceeding 700 MW, without violating the restrictions set in the EIA that influence the environmental impact, provided that this is permitted by the current legislation.

Physical and technical characteristics of offshore WTs

The EIA Report is developed in the early phase of the project implementation when the exact WT models proposed to be installed are not known.

The technical specification for the preparation of the EIA stipulated that for the installation of the WE park in the initial evaluation stage, models of offshore wind power plants with a capacity of 8 MW to 16 MW are currently offered on the market, and it is highly possible, that during the development of this offshore WE park project, WTs with a capacity of up to 20 MW or more will be available. The height of a marine WT of such power can be from 140 m to 300 m (but not limited to), respectively; depending on the power of the model, the number of such power plants in the planned territory can be tentatively from 87 to 43 VE (but not limited). In order to assess the possible maximum impact of the WE park on the environment and not to limit the possibilities of potential developers to choose one or another model in the future, the EIA is not performed for the WT models of a specific manufacturer, but by analyzing the generalized technical-physical parameters of the WT (Table 3.1.1).

After evaluating the trends in the development of the most advanced technologies of marine VE, taking into account the technical solutions of existing WE parks in the Baltic and North Seas and evaluating the aspect of economic efficiency related to the implementation of advanced technologies, models of marine WT with a power of 20 MW or more should be analyzed at the EIA stage for the installation of the planned VE park. The total height of a marine VE of this power can reach up to 350 m.

Table 3.1.1. Potential physical and technical characteristics of WTs examined in the EIA Report

Characteristics	**Maximum values**
Preliminary capacity, MW	20+
Maximum number of WTs installed under the alternative	Up to 90
Maximum height up to the highest blade point	350
Maximum rotor diameter	320

Principles of Laying out the Power Plants

A principle of geometrical layout is used for the schematic placement of offshore WTs in the PEA territory based on the diameter of the WT rotor (D):

- in wind direction 7–10xD;
- in the direction perpendicular to wind direction 4–5xD;

Taking into account solutions under the Development Plan and with a view of using the entire territory most efficiently, peripheral wind turbines are planned to be constructed at the cable protection zone (100 m)[10] from the boundaries of the territory, by planning the entire power plant layout grid, accordingly.

To assess the greatest possible impact of installation of offshore WT farm on various components of the environment and on public health, the EIA Report provides for the mandatory measures to mitigate the impact of the installation, operation and decommissioning of the WT farm. It also examines the maximum number (by the PEA area) of WTs calculated based on the geometrical layout method, i.e. 90 WTs. WT locations and their number with be specified at the technical design phase on the basis of the methodology provided by the developer or one of the turbulent wake models, with regard to the selected (specified) WT model/s and technical parameters thereof. It is envisaged that the PEA developer will be able to choose the most suitable WT model and its capacity, WT layout, as well as the technical parameters of the offshore substations and their number, the technical parameters of the connection cables to the land network and their number.

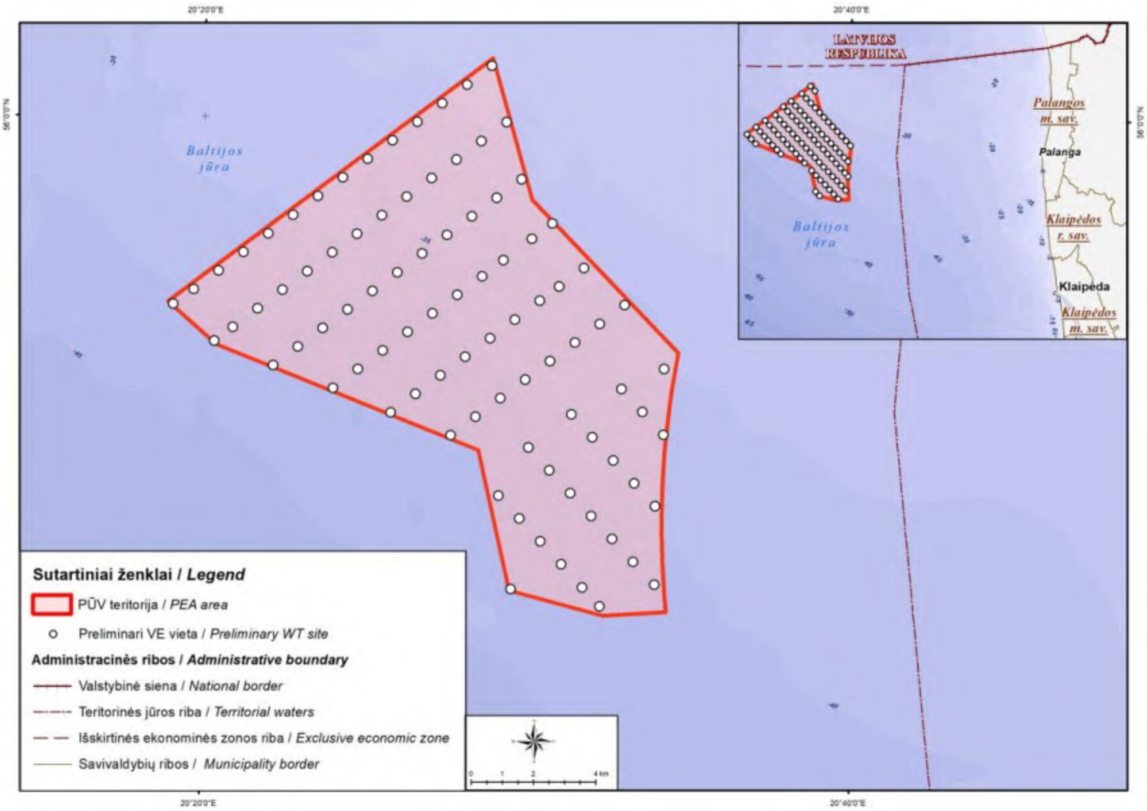


Fig. 3.1.1. Example of wind farm layout in the PEA territory.

[10] https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/TAIS.416425

Installation Solutions for the Offshore Transformer Substation

A transformer substation (the 'TS') is designed to accumulate the power generated by the entire wind farm, to transform it, and to transmit electricity to grids. A TS is usually built in the centre of the generated power or in another location suitable for bringing medium and high voltage cable lines. Step-up transformer substations in a WT farm do not occupy much[11] space in the PEA territory: Dimensions of the TS foundation is similar to the one of the WT.

The choice of substation location is influenced by such factors as:

- Sea depth: construction is more cost efficient in shallower waters;
- Lengths of medium-voltage cables and energy losses in them: most cost-efficient location for the substation is a centre of generating sources;
- Proposed high-voltage connections with onshore and other wind farms;
- Additional wind turbulence caused by a substation as a structure.

Preliminary optional locations for transformer substations of the proposed offshore wind farm are proposed with regard to the solution alternatives of the Development Plan (Fig. 3.1.2).

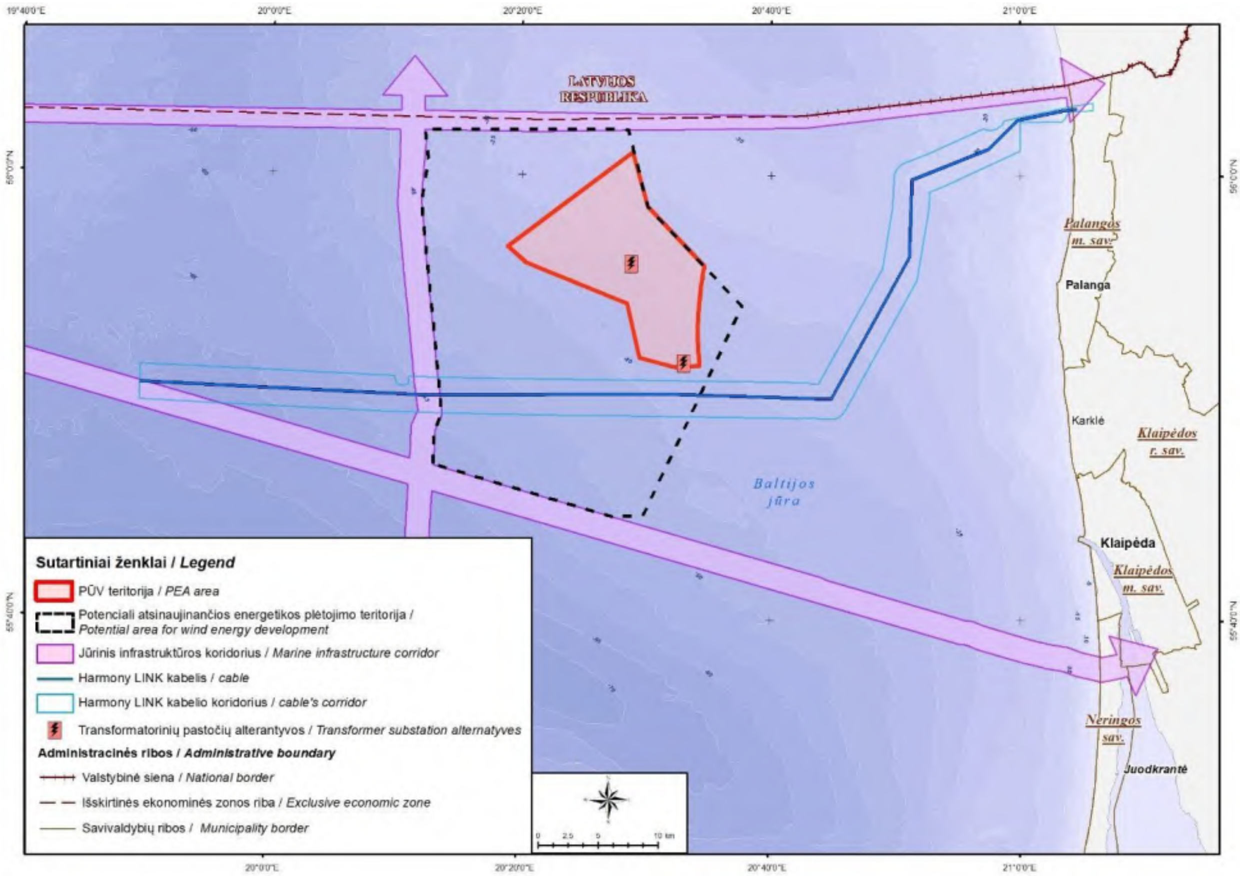


Fig. 3.1.2. Alternative locations of TS of the planned OWE farm according to solutions of the Development Plan.

The technical design will specify the need for and the number of step-up (intermediate) transformer substations and the electrical network connection scheme. During the technical design phase, taking the above criteria into consideration, the proposed location of the TS may change.

[11] https://www.nordseeone.com/engineering-construction/offshore-substation.html

4. EXPECTED IMPACT OF THE PROPOSED ECONOMIC ACTIVITY. MEASURES TO PREVENT, REDUCE AND COMPENSATE FOR SIGNIFICANT ADVERSE EFFECTS ON THE ENVIRONMENT

4.1. Water

4.1.1. Hydrological and Hydrodynamic Conditions

The PEA territory is in the south-east part of the Baltic Sea and the predominant hydrological and hydrodynamic conditions here are typical of the average common conditions of this part of the Baltic Sea.

4.1.1.1. Waves.

There are wind waves prevailing in the Baltic Sea, thus, a wave regime is identical to the wind regime.

Nearshore, data of Klaipėda and Palanga coastline stations are used to assess the wave regime. Based on long-term observations, it is obvious that waves in western direction prevail at the Lithuanian nearshore of the Baltic Sea. Below are the wave diagrams according to the results off five-year observations (2012–2017) (Fig. 4.1.1).

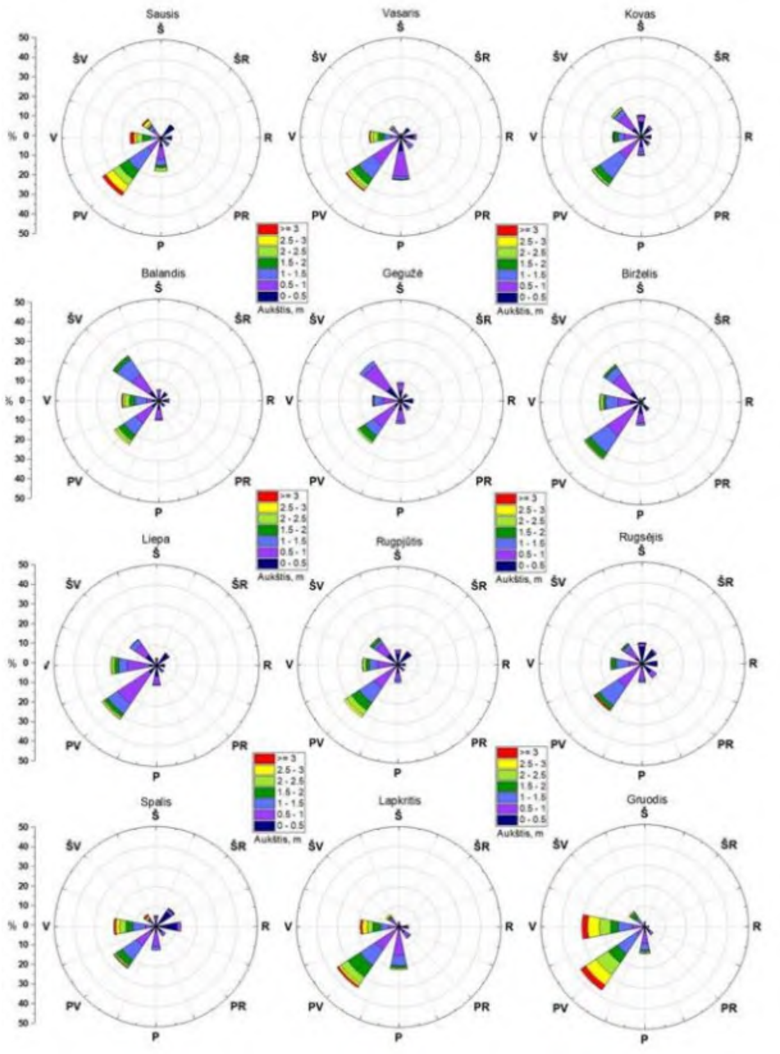


Fig. 4.1.1. Wave regime at the nearshore (as per data for 2012–2017).

An annual average wave height at Lithuanian nearshore is about 0.7 m. 50% of wave heights are up to 0.6 m high waves; 90% - up to 2 m high waves. High (over 5 m high) waves occur on average once in 10 years (Kelpšaitė et al., 2011). The lowest waves are observed May to August; the highest waves (>2.5 m high) are often observed in cold seasons (October to February, especially in December) with the prevailing strong winds in the W-S-W and W directions determining extreme values of wind waves. Eastward waves are relatively low, only up to 0.5 high in most of the cases. Such wave regime is typical at 20–25 isobath at the nearshore. Moreover, mixed waves, i.e. 2-3 m high waves and sway, are quite frequent.

To characterise the **<u>open sea</u>** conditions, 2D digital modelling system MIKE 21 has been used for simulation of wave propagation. The NSW (Near-shore Spectral Wind-Wave Module) has been a model when simulating the parameters of wind-produced wave propagation at the Baltic Sea coast (MIKE, 2002). The baseline data on the offshore wave model were retrieved from the ECMWF (European Centre for Medium-Range Weather Forecasts, www.ecmwf.int) wave model for the period 2016-2018 (inclusive). The simulation results show that in open sea, similar to the coastline, the maximum waves are formed by the prevailing W winds, and the average high of prevailing SW-NE waves in the PEA territory can reach 0.8-0.9 m or more on the average.

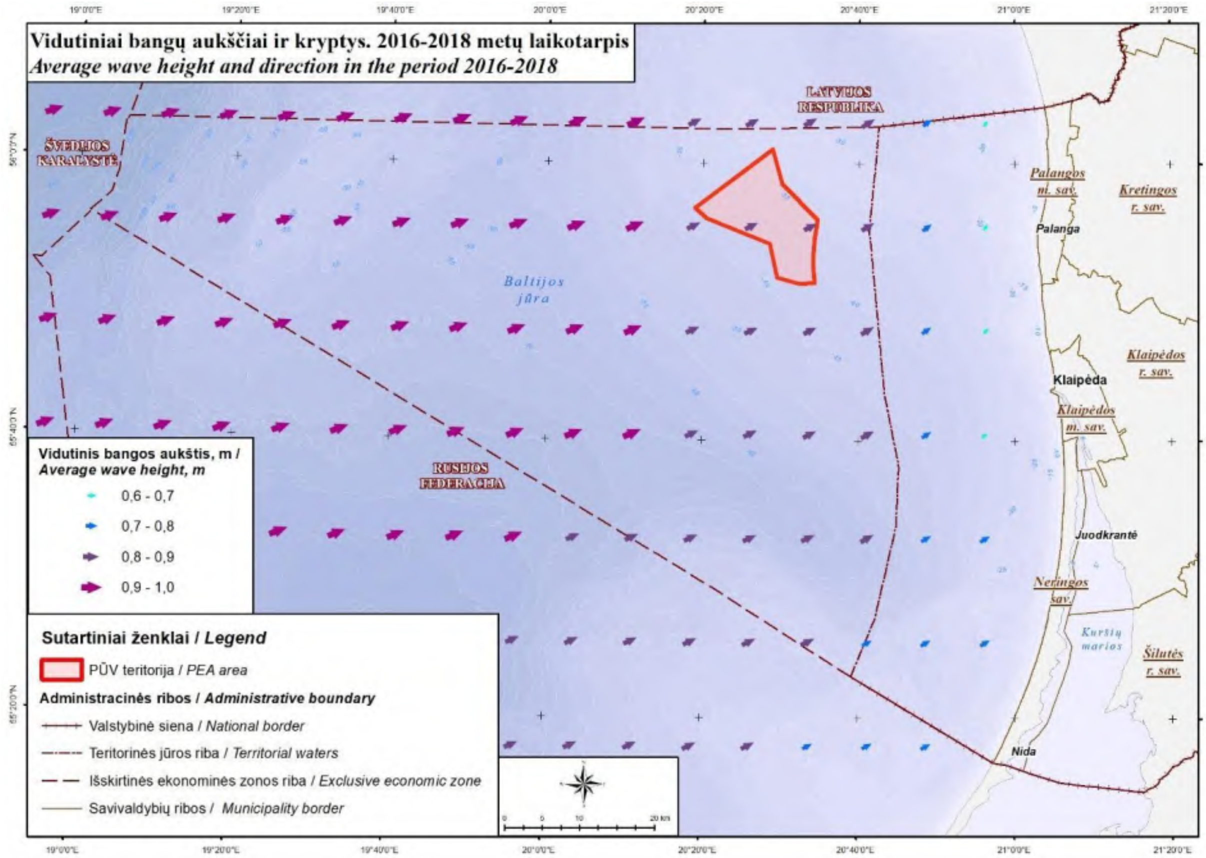


Fig. 4.1.2. Average wave height and direction (as per modelling data for 2016–2018).

According to the latest data, the data for the period of July to December of the meteorological observation systems (EOLOS FLS200, buoys E01 and E06) installed in 2022 revealed that the heighiest waves in the **<u>PEA area</u>** were observed during September-October (6.69 m max). To compare – in summer the highest wave reached 3.77 m in July and 5,5 m in August. Defined, that biggest waves are characteristic to September-December period, and the smallest – July-August (Table 4.1.1). In the summer the waves are generated by the Western, whereas in autumn – SouthWestern and in December – Southern winds (Fig. 4.1.3).

4.1.1 lentelė. Maksimalių bangų režimas antrą 2022 m pusmetį

H(max), m	July-August	Augist-September	September-October	October-November	November-December
Mean	1.01	1.64	1.98	1.74	1.58
Max	3.77	5.29	6.69	5.51	6.65
Min	0.09	0.14	0.17	0.28	0.14
Standard deviation	0.81	1.04	1.07	0.95	1.30

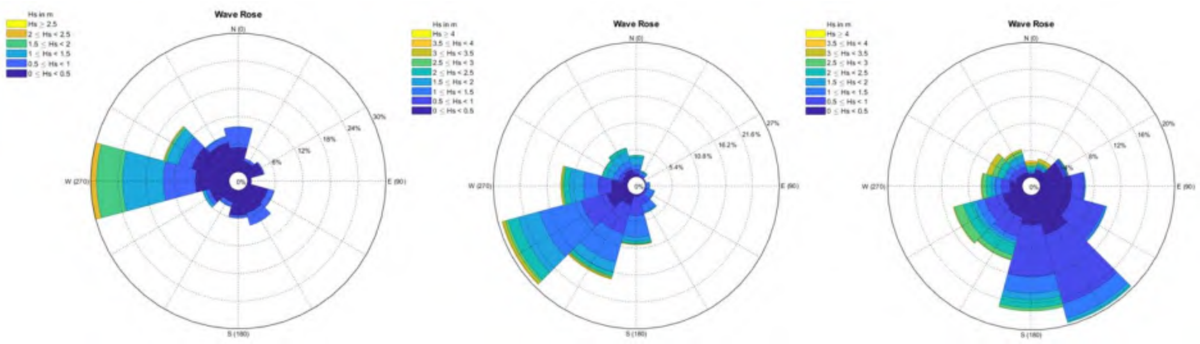


Fig. 4.1.3. Significant wave (Hs) roses for summer (on the left), autumn (in the center) and December (on the right) (after Eolos, 2022 m. E01 buoy data).

4.1.1.2. Currents

Lithuania‘s territorial waters have a basic cyclonic direction of currents in the Baltic Sea (counter-clockwise) (Žaromskis, 1996), which forms prevailing flows of water masses along the coast from south to north. The interaction between atmospheric processes and inert water mass forms a complex structure of surface and deep currents. Varying seasonal activity of atmospheric processes above the Baltic Sea is reflected in the annual change of current rates. The lowest current rates are observed in the spring-summer season, the highest – in autumn-winter. Moreover, the speed of wind-induced currents is decreasing in greater depths.

At the sea surface, in the 0-10 m thick layer, there are weak and medium currents prevailing, with a speed normally not exceeding 0.20 m/s (Žaromskis, Pupienis, 2003). The marine area between the coast and 35 m isobath has northward currents. Currents are directed toward the south far less often, toward the south-west – least often. To the north of Klaipėda, the current direction (relatively constant northward direction of the current) is also determined by the freshwater flowing from Curonian Lagoon. The 35-45 m deep area away from the shore is predominated by south-west, south, and west currents. Even further, i.e., beyond the 45 m isobath, currents are directed toward the east and north-east.

In the intermediate water layer (10-30 m), there are various current regimes formed. The water area of up to 35 m depth, like in the surface layer, mostly has northward currents. Less frequently, currents are directed south- and westward. Beyond the 45 m isobath, there are north and north-east currents prevailing. In the intermediate water layer, current speed is 0.11 to 0.14 m/s.

Weak, 0.07-0.09 m/s rate currents normally prevail in the bottom layer. The water area to 35 m isobath mostly has north-west and south-east currents, in 35 to 45 m isobath – north-west, west, and south-west currents, and beyond 45 m – north currents (Žaromskis, Pupienis, 2003).

Simulation of average current rates (m/s) and directions (degrees) for different seasons (spring, summer, autumn, winter) (SMHI BALTICSEA_REANALYSIS_PHY_003_011 2012-2016) shows that weak surface and bottom currents prevail in the open sea, with the speed averaging 3-5 cm/s in the surface layer and 1-3 cm/s in the bottom one (Fig. 4.1.4–4.1.5.).

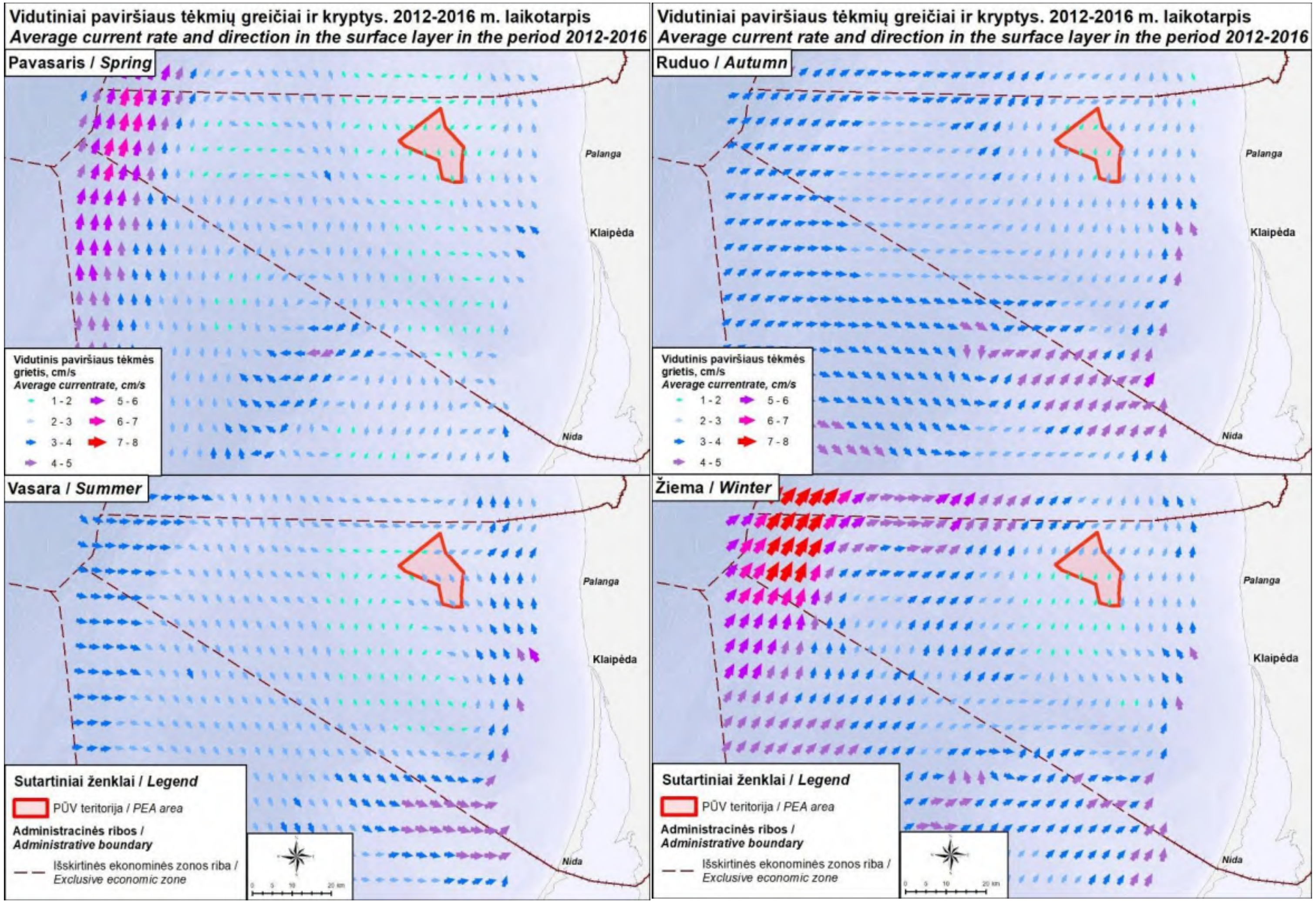


Fig. 4.1.4. Average current rate and direction in the surface layer (as per data of 2012-2016, SMHI, Sweden).

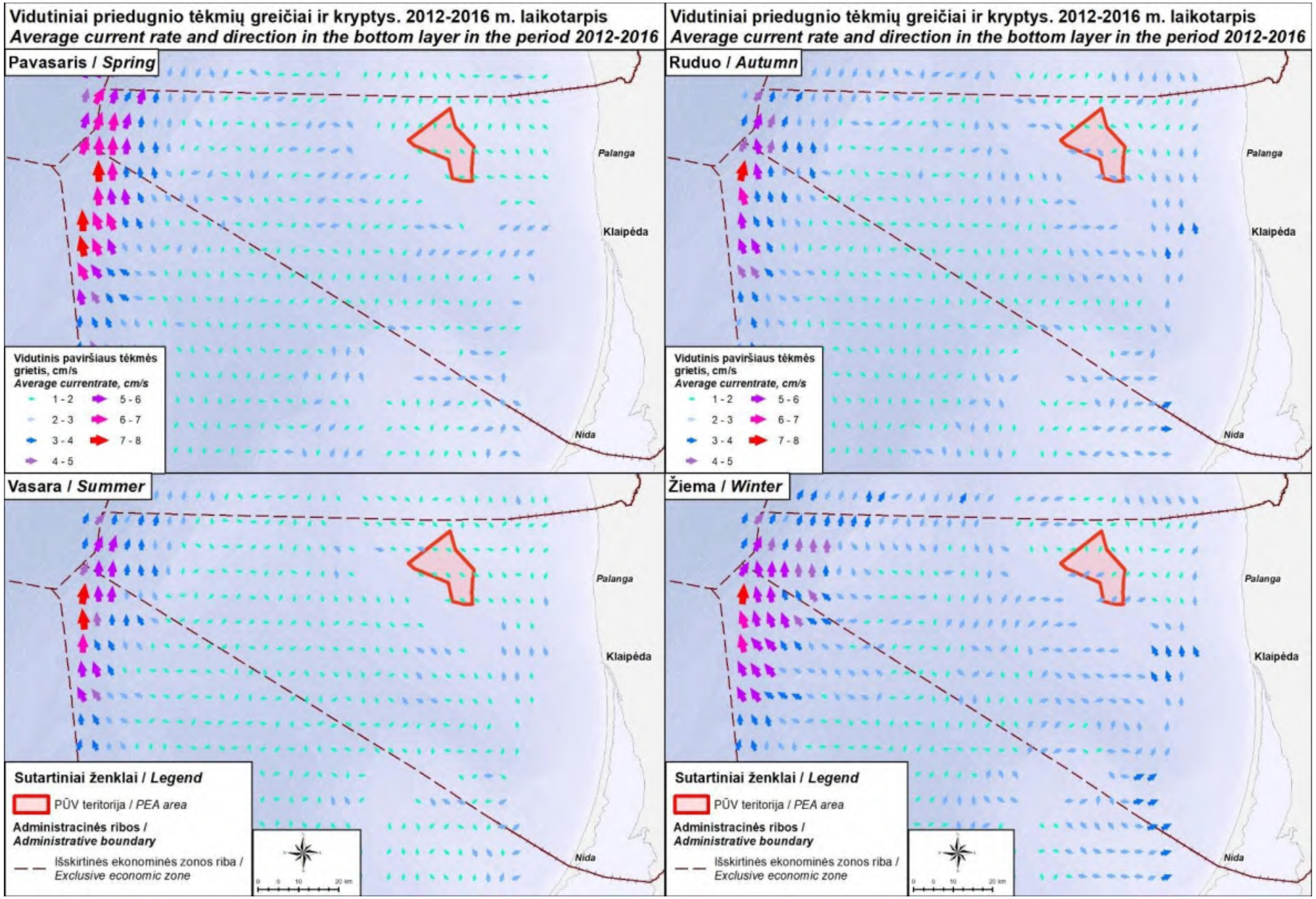


Fig. 4.1.5. Average current rate and direction in the bottom layer (as per data of 2012–2016, SMHI, Sweden).

According to the latest data, the data for the period of July to December of the meteorological observation systems (EOLOS FLS200, buoys E01 and E06) installed in 2022 revealed that the current speeds in the **PEA area** at the surface (4.5 m depth) during summer were the strongest (up to 0.28 m/s). In autumn the speed reached 0.16 m/s only (Table 4.1.2). It is obvious, that the surface currens are similar in the entire area – i.e. current speed in the Northern (buoy E01) and Southern (buoy E06) part of the area reached the similar values.

Table 4.1.2. Surface (at 4.5 m depth) currents in second half of the year 2022.

Currents, m/s	July-August	Augist-September	September-October	October-November	November-December
Mean	0.09	0.08	0.06	0.04	0.04
Max	0.28	0.25	0.18	0.16	0.22
Min	0	0	0	0	0
Standard deviation	0.06	0.04	0.03	0.02	0.03

In contrast, current regime near the sea bottom do varies. The strongest currents have been observed in the Souther part (buoy E06), where the sea bottom starts to slope into the Gdansk deep (Table 4.1.3). Differently to surface regime, the stringest currents were observed in December and reached up to 1.21 m/s. In the summer – in opposite, currents were the weakest and reached up to 0.40 m/s only.

Table 4.1.3. Nearbottom (at 36 m depth) currents in second half of the year 2022.

Currents, m/s	July-August	Augist-September	September-October	October-November	November-December
Mean	0.09	0.11	0.12	0.16	0.19
Max	0.40	0.57	0.69	0.90	1.21
Min	0	0	0	0	0
Standard deviation	0.05	0.07	0.08	0.13	0.16

The direction of the currents does not show any regular pattern and is often varying (Fig. 4.1.6 - 4.1.8)

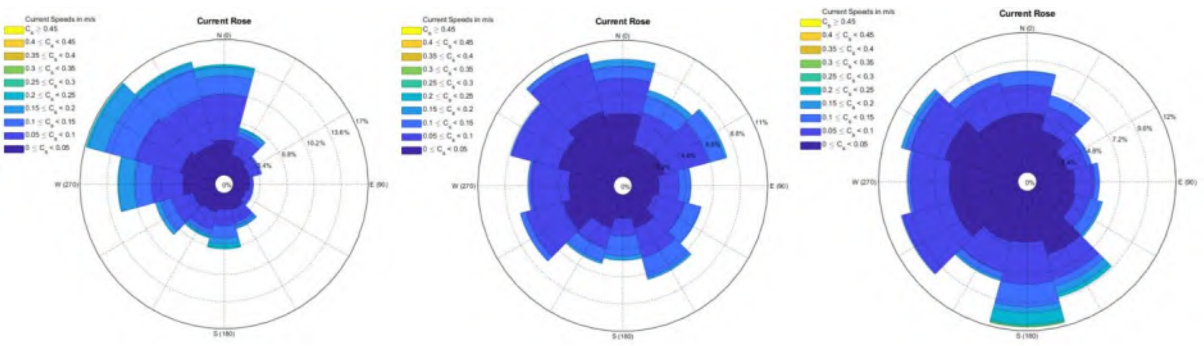


Fig. 4.1.6. Prevailing surface current directions in the summer (on the left), autumn (in the center) and in December (on the right) (according Eolos, 2022 data).

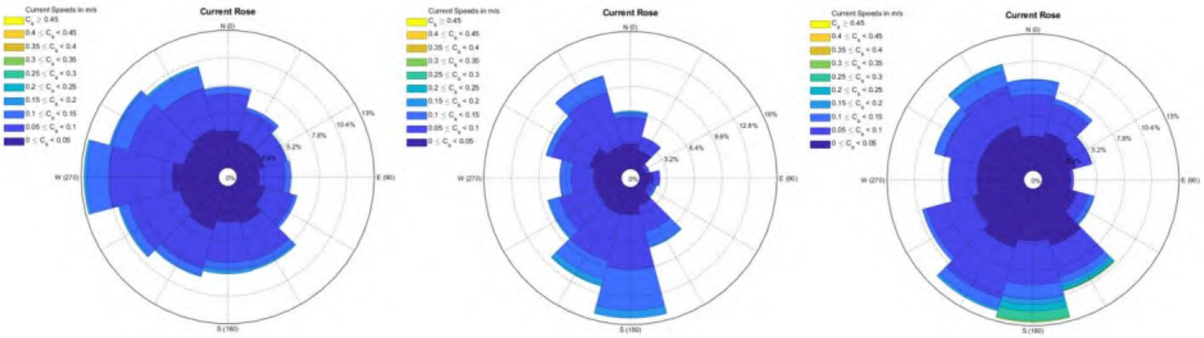


Fig. 4.1.7. Prevailing nearbottom (31.6 m depth) current directions in the Northern part of the area in summer (on the left), autumn (in the center) and in December (on the right) (according Eolos, 2022 data).

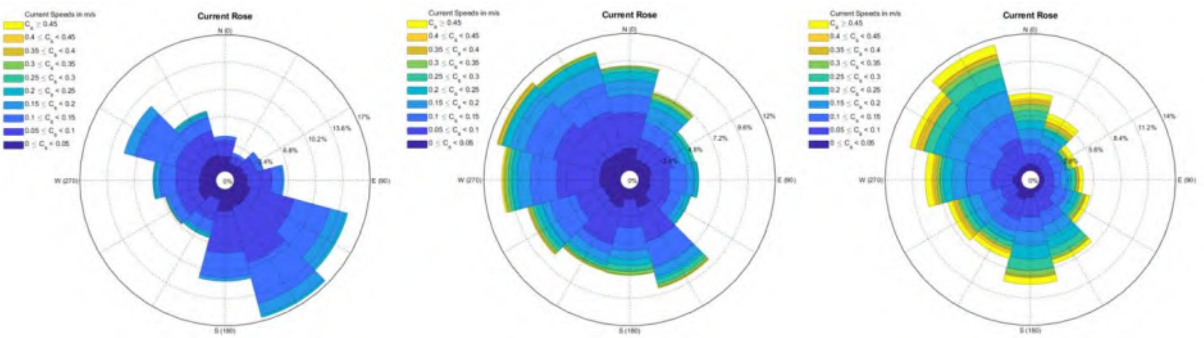


Fig. 4.1.8. Prevailing nearbottom (36 m depth) current directions in the Southern part of the area in summer (on the left), autumn (in the center) and in December (on the right) (according Eolos, 2022 data).

4.1.1.3. Temperature, salinity, and water clarity

Lithuania's marine area in the Baltic Sea is relatively shallow, as a result, thermal regime of the water responds to seasonal fluctuations of climate conditions very quickly (Dailidienė et al., 2011). Minimum water temperatures are reached in February (to -0.5°C), and maximum – in July-August (to 28.2°C).

In any single year, the coastal area, territorial waters of the Baltic Sea, and the open sea have specific horizontal distribution of water temperature and certain vertical stratification of water related to temperature gradients. In all seasons, at the sea surface up to a depth of 10 m, there is a homo-thermal layer of convective and turbulent mixing formed. Seasonal thermocline (a layer of rapid temperature drop) develops in summer at the depth range of 10-40 m; the water temperature gradient in this layer is 0.5 - 1.0 °C/m. The thermocline separates a surface, warm mass of water from the intermediate cold layer. Meanwhile, the difference between water temperature in coastal areas and in deep-water areas may reach 15 or more degrees. In a halocline area and deeper, temperature fluctuations are minor throughout the year.

In autumn, waters of the open sea thermally mixed down to permanent halocline at the depth of 40 m (Vyšniauskas, 2003). At this time, not only intense convective mixing takes place, but stronger winds and higher waves are observed, too. In a halocline area and deeper, temperature fluctuations are minor throughout the year (Dailidienė et al., 2011).

Variations of salinity in the south-eastern Baltic Sea, in Lithuania's marine area, depend on the inflow of fresh waters from rivers, as well as on the variations of salinity in the central Baltic Sea. In Lithuania's water area, average water salinity is about 7 ‰. The western part of the Lithuanian EEZ belongs to the central Baltic Sea which has a two-layer structure of water. In the upper layer (at the depth of 0 m to approx. 60 m), salinity is 6–8 ‰. This layer is isolated from the saltier deeper layer by a permanent halocline. In the central Baltic Sea, a halocline borders at a depth of 64-90 m, its centre is at a depth of 74 m; salinity of this layer rapidly jumps from 7.7 to 10.4 ‰ (Matthäus, 1990). At greater depths, isolated with a halocline, oxygen saturation of the water decreases. In the bottom layer, there is oxygen deficiency observed and a hydrogen sulphide zone formed.

In coastal areas and in the shallow open sea, clear and permanent stratifications do not develop due to salinity; a homogeneous well-mixed water mass prevails up to a depth of 55-60 m (Dailidienė et al., 2011).

Based on the measurement data of the EPA Department of Environmental Research for the period of 2012–2017, the Baltic Sea shows regular variations in horizontal and vertical salinity. Surface layer salinity increases as moving away from Klaipėda strait into the open sea. In transitional water, salinity varies between 2.36 and 7.48 ‰. Meanwhile, variations in the open sea show a marked minimum with salinity ranging between 6.5 and 7.4 ‰. The increase in salinity is also observed in vertical direction, i.e. the maximum salinity value at the seabed layer was registered at 12.85 ‰, while salinity value at the surface was approx. 7 ‰. The maximum salinity variations are observed down to a halocline (60–80 m) with a more homogenous water layer below.

Based on the EPA monitoring data for the period of 2012–2017, water clarity of the coastline waters amounts to 3.8 m (between 1.5 m and 9.5 m) on the average, in the territorial seal the clarity increases up to 6.1 m (maximum clarity values reach up to 12 m), and in the open sea the average clarity value reaches 7 m.

Based on the latest hydrological studies carried out in the PEA territory in May 2021 (Fig. 4.1.9.), it was established that the highest current speeds reaching 0.8–1 m/s are typical for the southern and northern parts of the territory (measurement stations VP1, VP2 ir VP7), where the maximum speed values were registered at the depth of 5–12 m. Quite strong current were also registered at the measurement station VP8, where the speeds reached 0.7–0.8 m/s. The current speeds show a typical high degree of distribution, although the currents in the west and north-west directions are prevailing in the major part of the measurement stations. Fluctuation of other parameters at different measurement stations is very similar. Water temperature reaches 8–9 °C down to the depth of 20 m and further shows a gradual decrease down to 4 °C as the layers get deeper. The temperature fluctuation gradient coincides with dissolved oxygen concentration in the sea water. Vertical variations of hydrological parameters, i.e. current speed and direction, temperature, salinity, in different study sites, are presented in profiles available in Annex 5.

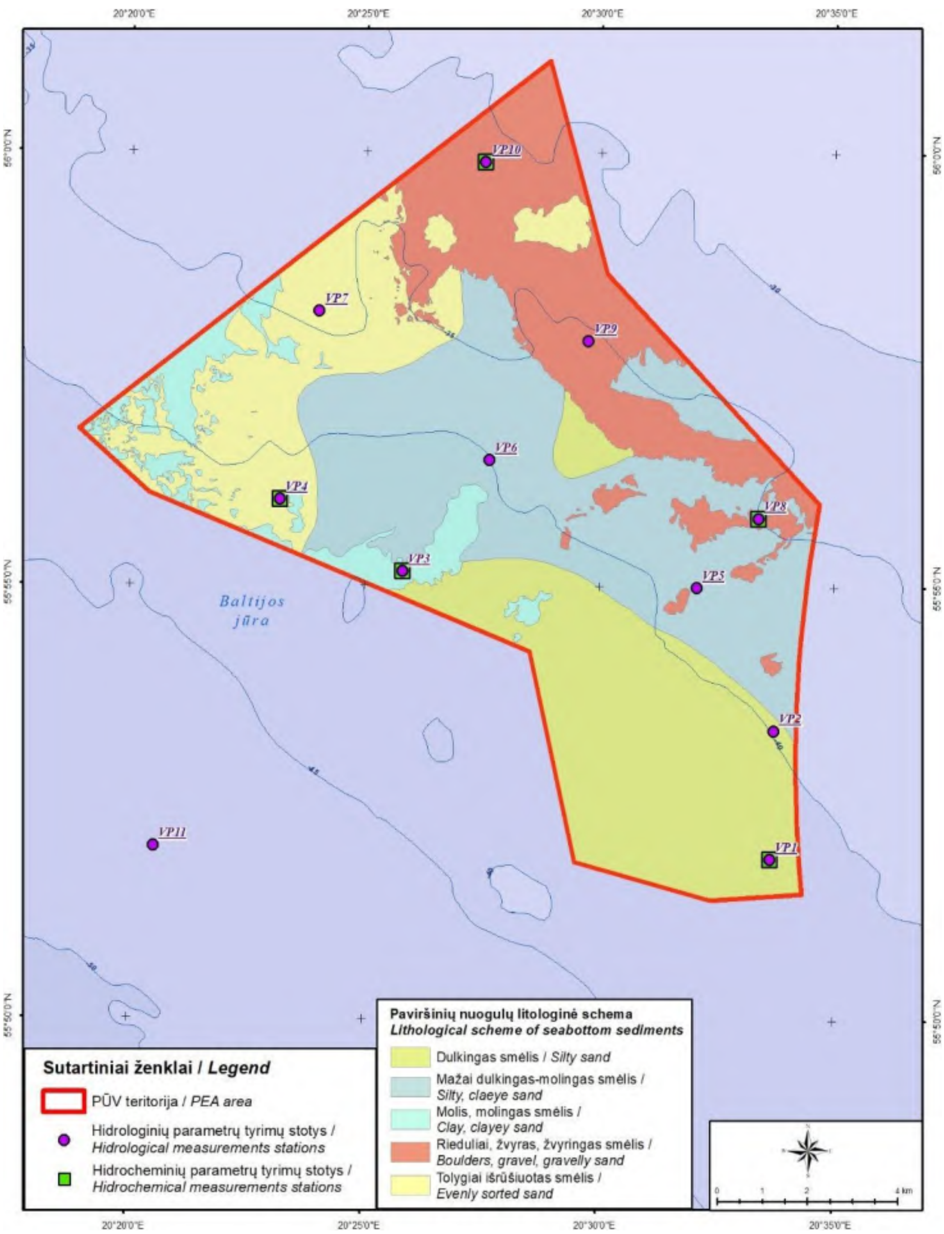


Fig. 4.1.9. Sites of hydrological and hydro-chemical measurements.

4.1.1.4. Ice cover

No permanent ice cover is formed in the Lithuanian area of the Baltic Sea. In normal and severe winters, a shore ice belt, from a few metres to a few kilometres wide, is formed in coastal areas. It usually consists of piled ice rocks, brought to the shore by wind and water currents which stays stable only in calm and cold weather. Ice cover develops up to 1.5 km from the shore. Drifting ice sheets, up to 10 cm thick, cause ice jams at a distance of up to 7 km from the shore. Due to climate change and, thus, milder winters, there are fewer days of ice phenomena in the Baltic Sea observed. In the Lithuanian coastline, an average duration of ice phenomena decreased by approx. 50 percent during the period of 1961-2009 (Dailidienė et al., 2011).

4.1.2. Hydrochemical Status and Water Quality

In Lithuania, the ecological and chemical status of the Baltic Sea is constantly controlled through the state environmental monitoring of the Curonian Lagoon and the Baltic Sea. Chemical status is determined for transitional waters, coastal waters, marine area, and exclusive economic zone by assigning the status with one of the two quality grades: good or below good. Good chemical status of a surface water body means that no concentrations of substances listed in Annex 1 and Annex 2, Parts A and B (List B1) of the Wastewater Management Regulation exceed an annual average value of the Environmental Quality Standards (AA-EQS)) and/or a maximum allowable concentration (MAC-EQS) and/or the biota EQS[12]. Should the concentration of at least one substance is found to be exceeded, the status of a water body is considered below the good status.

Chemical status of Lithuanian waters of the Baltic Sea in regards of concentration limits for polluting substances in the bottom sediments are determined in accordance with the Order of the Minister of Environment of the Republic of Lithuania no. D1-194 of 4 March 2015 "On Approval of the Requirements for Determining the Characteristics of the Good Environmental Status of the Lithuanian Marine Area."[13]

According to the data of environmental monitoring and natural observations carried out in the period of 2014–2019, chemical status of waters and bottom sediments near the PEA territory (according to the data of the monitoring station No. 65) was good without exceeding the limit values established by the Order of the Minister of Environment of the Republic of Lithuania no. D1-194 of 4 March 2015 "On Approval of the Requirements for Determining the Characteristics of the Good Environmental Status of the Lithuanian Marine Area", i.e. corresponded with the good environmental status (Fig. 4.1.10).

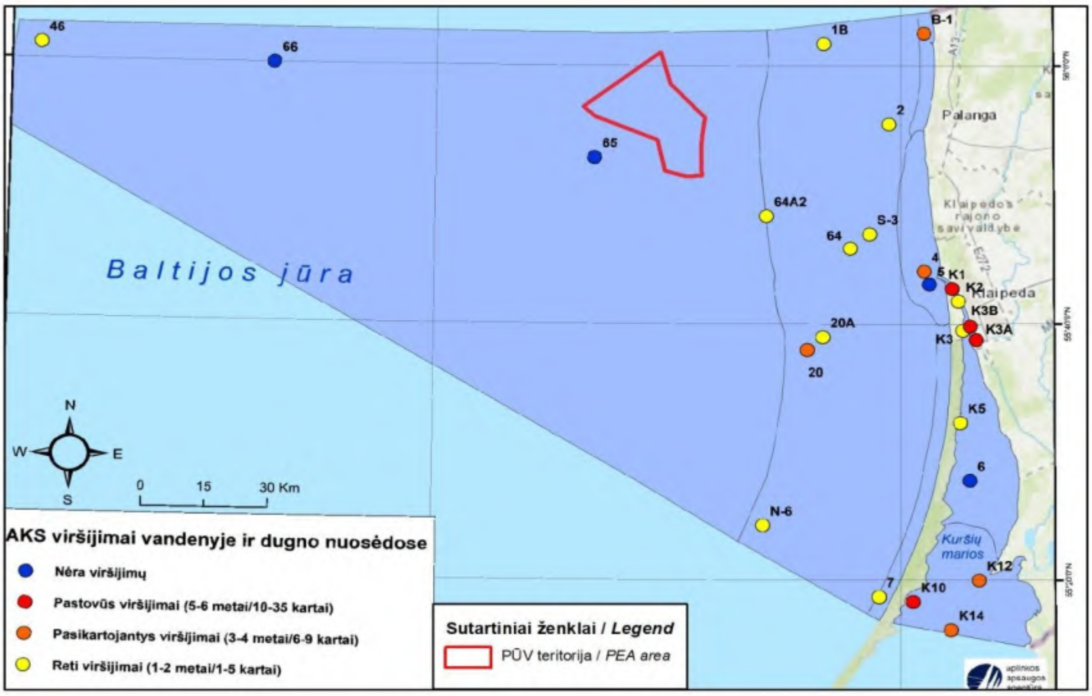


Fig. 4.1.10. Generalised data of chemical status assessment of the environmental monitoring of the Baltic Sea and the Curonian Lagoon for the period 2014-2019.

Based on the latest hydrological studies carried out in the PEA territory in May 2021 (Fig. 4.1.10.) and the analysis of concentration of pollutants in the sea waters, it was established that the actual values of

[12] Order of the Minister of Environment of the Republic of Lithuania no. D1-236 of 17 May 2006 "On Approval of theWastewater Management Regulation."
[13] Order of the Minister of Environment of the Republic of Lithuania no. D1-194 of 4 March 2015 "On Approval of the Requirements for Determining the Characteristics of the Good Environmental Status of the Lithuanian Marine Area."

metals are mostly lower than the quantitation limit (Table 4.1.4), i.e. they do not exceed the allowed limits.

Table 4.1.4. Results of heavy metal analysis in the water (Vandens tyrimai, UAB, research protocol No. 220513GC039)

Sample No.		Metals, µg/l								
		As	**Cd**	**Cr**	**Cu**	**Ni**	**Pb**	**V**	**Zn**	**Hg**
VP1_1	Surface	4.2	<0.3	<1	2,4	<2	<1	<20	<40	<0.1
VP1_2	Seabed	3.1	<0.3	<1	1,4	<2	<1	<20	<40	<0.1
VP3_1	Surface	2.7	<0.3	<1	<1	<2	<1	<20	<40	<0.1
VP3_2	Seabed	2.6	<0.3	<1	1,9	<2	<1	<20	<40	<0.1
VP4_1	Surface	2.1	<0.3	<1	<1	<2	<1	<20	<40	<0.1
VP4_2	Seabed	2.4	<0.3	<1	<1	<2	<1	<20	<40	<0.1
VP8_1	Surface	2.1	<0.3	<1	<1	<2	<1	<20	<40	<0.1
VP8_2	Seabed	2.2	<0.3	<1	<1	<2	<1	<20	<40	<0.1
VP10_1	Surface	2.3	<03	<1	<1	<2	<1	<20	<40	<0.1
VP10_2	Seabed	1.8	<0.3	<1	<1	<2	<1	<20	<40	<0.1
	AA-EQS *	**-**	**0.2**	**-**	**-**	**8.6**	**1.3**	**-**	**-**	**-**
	MAC-EQS**	**-**	**-**	**10**	**10**	**34**	**14**	**-**	**100**	**0.07**

* annual average value of the Environmental Quality Standards (AA-EQS);
** maximum allowable concentration of the Environmental Quality Standards (MAC-EQS).

The analysis of concentration of oil hydrocarbons in the water allows for a partial assessment of anthropogenic activities related to the transportation of oil and oil products, intensive shipping, and illegal discharge of oil waters in the open sea.

Polyaromatic hydrocarbons (PAH) is the most dangerous oil component, which remains in the water for a long time and accumulates in seabed sediments and living organisms. PAH is a range of compounds, starting with naphthalene ending with coronene. The most toxic PAH are anthracene, fluorene, naphthalene, and phenanthrene. PAH compounds with high molecular weight, e.g. benzo[a]pyrene, are cancerogenic.

Analysis of concentrations of oil products (C10–C40) in the waters of the proposed wind farm area showed no traces of significant pollution. Maximum allowable concentration (MAC) of oil hydrocarbons, i.e. 200 µg/l, was exceeded insignificantly (210 µg/l) in the only site of research (VP8, Fig. 4.1.9), in the layer of surface waters. In other sites of research, hydrocarbon concentrations were lower than the quantitation limit (Table 4.1.5). Such random local increase in oil hydrocarbon concentrations is likely to be conditioned by a more intensive shipping in the mentioned area of research.

Analysis of concentrations of individual PAH compounds in the sea waters showed no significant pollution, as well. Concentrations of the priority (fluoranthene, naphthalene) PAH in all sites were lower than the quantitation limit. The same is valid for the concentration distribution of the priority dangerous PAH, i.e. benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, indeno[1,2,3-cd]pyrene, anthracene.

Water samples for the pollution studies were taken in May 2022 using a Hydrobios batometer at five measurement stations (VP1, VP3, VP4, VP8, VP10) from two horizons: surface (at the depth of approx. 0.5 m) and seabed (approx. 0.5 m from the seabed surface). The pollutants (oil products C10-C40, polyaromatic hydrocarbons, heavy metals As, Cd, Cr, Cu, Ni, Pb, V, Zn, Hg) were determined in the certified laboratory of Vandens tyrimai, UAB (as per LST EN ISO/IEC 17025:2018).

Vertical variations of hydro-chemical parameters, i.e. pH, dissolved oxygen, suspended solids, in different study sites, are presented in profiles available in Annex 5.

Table 4.1.5. Results of analysis of oil products (C10–C40) and polyaromatic hydrocarbons in the water (Vandens tyrimai, UAB, research protocol No. 220513GC039)

Sample No.	Oil, µg/l	PAH, µg/l														
		NFT	ACNFT	FLR	FEN	ANT	FRT	PIR	BZA	CHRZ	BZB	BZK	BENZA	DBAH	BENZGHI	IND123
VP1_1	<100	<0.005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP1_2	<100	<0.005	<0.005	<0.005	0.026	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP3_1	<100	<0.005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP3_2	<100	<0.005	<0.005	<0.005	0.041	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP4_1	<100	<0005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP4_2	<100	<0.005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP8_1	**210**	<0.005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP8_2	100	<0005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP10_1	<100	<0.005	<0.005	<0.005	<0.005	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
VP10_2	<100	<0.005	<0.005	<0.005	0.024	<0.002	<0.005	<0.010	<0.005	<0.005	<0.002	<0.002	<0.002	<0.005	<0.005	<0.005
AA-EQS *	**-**	**2**	**-**	**-**	**-**	**0.1**	**0.0063**	**-**	**-**	**-**	**-**	**-**	**0.00017**	**-**	**-**	**-**
MAC-EQS**	**200**	**130**	**-**	**-**	**-**	**0.1**	**0.12**	**-**	**-**	**-**	**0.017**	**0.017**	**0.027**	**-**	**0.00082**	**-**

Abbreviation: NFT – naphthalene; ACNFT – acenaphthene; FLR – fluorene; FEN – phenanthrene; ANT – anthracene; FRT – fluoranthene; PIR – pyrene; BZA – benz[a]anthracene; CHRZ – chrizene; BZB – benzo[b]fluoranthene; BZK - benzo[k]fluoranthene; BENZA - benzo[a]pyrene; DBAH – dibenzo[a,h]anthracene; BENZGHI - benzo[g,h,i]perylene; IND123 - indeno[1,2,3-cd]pyrene.

* annual average value of the Environmental Quality Standards (AA-EQS);
** maximum allowable concentration of the Environmental Quality Standards (MAC-EQS).

4.1.3. Potential Impact on Water

4.1.3.1. Potential consequence on hydrodynamic status due to wind energy farm installation

The impact of WT farm installation on hydrodynamic status will largely depend on the method of the proposed anchoring of the wind turbines to the seabed and the size of the foundations. Mono-pile structures with foundation diameter reaching 10–12 m and turbine towers more than 1000 meters away from each other typically have no significant impact on changes in water current regime. Small distances between the turbine towers can cause a so-called 'cascade effect' and condition the formation of downstream whirls, which would ensure a more intense mixing of water masses. For comparison, the studies carried out in the WT farm installed in Denmark revealed that in 72 WT farm, where diameter of each turbine foundation is up to 5 meter and the turbines are 480 meters away from each, the impact on water current dynamics is insignificant (<10–15 %) (SEAS, 2000).

The 2002 study conducted by the United Kingdom scientists (Cooper et al., 2002) has assessed the potential impacts of offshore WTs on the coastal area processes with an special focus on the scale of changes in waves, current and sediment regime and its further impact on the general silt flow. The assessment was carried out using different scenarios, i.e. 'best', 'worst acceptable' and 'typical' using computer models. The generalised results of the simulation of all the scenarios allowed for a conclusion that the impact of WTs on waves, currents and sediment transportation is insignificant: The wave speed after colliding with the wind turbines reduces by one percent, while the direction alters by approx. 0.5°, and the wave height reduces by approx. 0.5–1.5 %. The results of simulation of WT impact on wave regime carried out in 2009 in the Yangtze estuary and the Hangzhou Bay revealed that fluctuations of wave amplitudes could reach up to 1 mm or 0.3% (Zhang, et al., 2009). The study also allowed stating that impact of offshore WT on changes in currents is subject to the number of piles, distance between the piles and angle between the prevailing current and WT farm location.

The 2010 analysis (simulation) of 0.1 m/s current changes around one pile established that the current speed by the pile sides has increased by approx. 0.1 m/s, whereas the current speed registered at the downwind part reduced down to 0.01–0.025 m/s (Ahrendt, Schmidt, 2010). The study above also included the simulation of current changes around 144 WT mono-pile structures at 0.128 m/s background current. The generalised study results allowed stating that the total current speed in the farm territory reduced by approx. 3 %.

4.1.3.2. Potential consequence on water quality due to changes in turbidity

Installation of WT foundations and submarine cable laying would affect the temporary increase in the number of suspended particles (turbidity) in the water column of the proposed farm territory during construction. For comparison, US experts have assessed the environmental impact of 130 offshore WT arm proposed in the Horseshoe shallows of the Nantucket Strait, Massachusetts (USA) and found that the water turbidity could increase in about 0.1 ha territory around each pile installed during the foundation installation (Cape wind energy project, Draft Environmental Impact Statement, 2008). Installation of offshore WT farm in the Belgium-owned Northern Sea area revealed that the foundation installation caused no significant changes in turbidity and increase in the number of suspended particles in the water column compared to natural conditions in the part of the Northern Sea mentioned (Eynde et al., 2010).

4.1.3.3. Potential consequence on sea water quality and good environmental status

Under normal working conditions, WT farm operation would have no impact on sea water quality. A potential additional water pollution with chemicals is typical related to an accidental collision of tankers and WT, in unfriendly weather conditions, or in case of a vessel breakdown. In such a care, most of the problems would be caused by oil spillage into the marine environment from the tanker wrecked. The PEA territory is outside the shipping routes, roadsteads, anchorage sites. The risk of collision is thus relatively low.

Smaller-scale pollution of marine environment with synthetic compounds is also possible due to spillage of hydraulic liquids and lubricating oil from the systems operating in the WT nacelle (Bonar et al., 2015).

Total amount of oil in each turbine can reach 200 to 1400 litres subject to size of the turbine (https://energyfactor.exxonmobil.eu/). There is not enough scientific data on accidental spillage of chemicals from offshore WTs. It is however supposed that the amounts are very small compared with the operation of offshore oil extraction plant (Kirchgeorg et al., 2018).

Modern WTs design is such that it reduces the possibility of potential spillage of potentially dangerous chemicals to the minimum. Depending of the WT model, corresponding reservoirs are installed under nacelles to collect hydraulic liquids and lubricating oil to prevent the pollution of marine environment in case of unscheduled spillage due to turbine breakdown. The risk of spillage is also reduced by ensuring the watertight integrity of WT systems (Bonar et al., 2015).

During the installation of WT (cable laying, installation of foundation), secondary water pollution with chemicals such as heavy metals and organic compounds is possible due to moving the seabed sediments. According to the data of the state environmental monitoring and natural observation, the sediments accumulating in the territory of the proposed farm show no significant chemical pollution and the secondary water pollution is thus not expected.

Table 4.1.6 Summary table for impact on water

Component	Phase	Impact	Nature	Scale	Duration	Significance	Measures	Notes
Water quality	Design	Increase in turbidity	Direct. Increase in suspended particles in the water column at the site of installation of foundation structures and cable trenches.	Local in the site of WT tower installation	During construction only	Insignificant	Not applied	
		Secondary water pollution with chemicals in seabed sediments	Direct. Secondary pollution at the sites of polluted seabed sediments.	Local in the site of WT tower installation	During construction only	Insignificant	Not applied	According to the data of the state environmental monitoring and natural observation, the sediments accumulating in the territory of the proposed farm show no significant chemical pollution
	Operation and maintenance	No impact on water quality under normal working conditions				Insignificant	Not applied	
	Decommissioning	Increase in turbidity	Direct. Increase in suspended particles in the water column at the site of installation of foundation structures and cable trenches.	Local in the site of WT tower disassembly	During dismantling only, if the WT tower foundation is to be dismantled	Insignificant	Not applied	
		Secondary water pollution with	Direct. Secondary pollution at the sites	Local in the site of WT	During dismantling only, if the WT	Insignificant	Not applied	According to the data of the state environmental monitoring and natural

		chemicals in seabed sediments	of polluted seabed sediments.	tower disassembly	tower foundation is to be dismantled			observation, the sediments accumulating in the territory of the proposed farm show no significant chemical pollution
Hydrodynamic status	Design	Changes in current direction and speed	Direct. Local change in hydrodynamic regime due to objects emerging in the water.	Local in the site of WT tower installation	During construction	Insignificant	Not applied	
	Operation and maintenance	Changes in current direction and speed	Direct. Change in hydrodynamic regime in the wind farm territory due to objects emerging in the water.	Local. In the territory of WT farm	Short-term, more intensive at the start of activity, stabilizing later on	Insignificant	Selection of a proper distance between the wind towers	
	Decommissioning	Changes in current direction and speed	Direct. Local change in hydrodynamic regime due to objects emerging in the water.	Local. In the territory of WT farm	Short-term, more intensive at the start of activity, stabilizing later on	Insignificant	Not applied	

– Insignificant impact (consideration is optional, measures not applied).

4.1.4. Impact Mitigation Measures

In the case under study, the distance between the WTs should reach about and over 1 km, so the impact on hydrodynamic status will the insignificant and the additional measures would thus be counter-productive.

Since the WT farm territory is proposed at the depth of more than 30 m, it is likely that mono-pile or jacket foundations will be used for the installation as their impact on hydrodynamic environment is insignificant considering that those will be installed away from the coastline in a stable geological site, i.e. on a solid moraine bed rather than on mobile sandy one. Moreover, the conducted researched have established that the generation of washouts is typical for mono-pile structures and in sandy coastline area only. The generation intensity is the greatest at the initial stage of wind turbine operation, gradually reducing later on until reaching the maximum depth possible. To avoid washouts, soil reinforcement gravel (or other) flooring are installed near the foundation; however, solid bed subsurface rocks are prevailing in the PEA territory. The intensive washout of the foundation (and the application of impact mitigation measures) is hardly probable or very insignificant.

The increase in turbidity would take place only in sites of foundation installation cable laying; its impact therefore should be qualified as local (seabed layer) and temporary (during installation only), with no significant long-term impact on hydro-chemical water parameters and consequences for the Baltic Sea water quality. The distance from the site of the proposed activities to the nearest recreational areas and beaches of Palanga Municipality is approx. 29.5 km. The significant impact of the installation of operation of the proposed wind far on Palanga coastline will thus be avoided. Application of additional measures is counter-productive.

Although the WT farm territory under consideration is outside the existing roadsteads and anchorage sites, it however borders the existing shipping route. It is therefore necessary to assess the risk of collision with the passing ships (see Section 4.9, Risk Analysis and Assessment).

To select the due technological solutions of the WT farm development and assess the impact on the proposed WT structures on hydrodynamic environment, current measurements are carried out at the approaches to the proposed farm (two meteorological station FLS200, E01 and E06 installed by EOLOS). The monitoring of the current regime is also recommended after construction is completed.

During installation of the WT farm, a local and temporary impact on water quality and additional water pollution with chemicals (heavy metals, oil hydrocarbons, polyaromatic hydrocarbons) is possible due to intensified shipping. To assess whether the pollutant concentration corresponds with the values of the good environmental status, it is reasonable to make the pollutant research as part of the environmental monitoring programme and schedule the research prior to construction (background concentration), during construction (installation of foundation, cable laying) and after construction is completed (3 to 6 months after completion). To reduce or avoid the spillage of heave metals into the water, corrosion control methods with increased eco-friendly parameters should be used during construction and operation of WT farms.

4.2. Ambient air and climate

Weather peculiarities, wave conditions, current regime and changes in water level are essential for selection of electrical structures. By the seaside, the most common winds are western rhumbs, i. e. NW– W–SW. The main meteorological factor determining favourable conditions for wind energy development in the sea is wind intensity. Based on the summarized data, wind speed in the sea (Lithuanian EEZ) intensifies as it moves away from the shore and changes from 7 to 10 m/s.

Despite the fact that PEA are neutral for possible air pollution, construction machinery and vessels working in the territory at the time of WPP installation, service and liquidation become concentrated sources of environmental air pollution.

The use of RER is highly favoured in the context of impact on climate as it has extremely positive impact on reducing negative climate changes. The wind energy is one of the renewable energy forms which reduces the use of fossil fuels, reduces emissions of CO_2 and other substances into the ambient air. The use of wind energy plays a major role in the fight against climate change by reducing greenhouse gas emissions from the energy sector. The PEA implementation is expected to have an indirect positive impact on climate.

4.2.1. Climatic conditions

Hydrometeorological conditions of the Baltic Sea roughly meets the general conditions of the central part of the sea in the Lithuanian economic zone. The aggregated data on characteristic climatic conditions in Klaipėda region is provided in table 4.2.1. The data is based on average multiannual data collected by the Klaipėda Marine Meteorological Station and the observational data collected by the Lithuanian Hydrometeorological Service.

Table 4.2.1. Climatic conditions

Indicator	M o n t h s												Yearly
	01	02	03	04	05	06	07	08	09	10	11	12	
Air T, °C													
average	-2.1	-2.5	0.3	5.4	10.8	14.4	17.1	17.2	13.5	8.8	3.7	0.3	7.3
maximum	8.7	15.4	17.1	27.0	30.4	34.0	34.0	34.0	30.4	22.2	15.4	10.3	34.0
minimum	-32.0	-33.4	-20.8	-12.8	-4.0	-0.7	4.9	2.9	-2.1	-9.1	-14.4	-24.2	-33.4
Precipitation, mm													
average quantity	55	37	40	35	40	57	68	81	83	84	87	68	735
Maximum daily precipitation	27	15	20	28	24	54	74	48	35	42	33	21	74
Fog													
average duration, h.	24	27	41	44	33	20	9	6	10	19	20	31	284
Wind													
Predominant direction	SE	SE	SE	NW	NW	NW	W	W	W	SE	SE	SE	SE
Average speed, m/s	5.7	5.1	4.8	4.3	4.0	4.1	4.4	4.4	5,1	5.6	6.2	6.0	4.8
Maximum speed in gusts, m/s	34	30	28	26	24	25	34	28	30	40	36	38	40
Number of days when W≥14 m/s	12.0	5.0	5.7	2.4	0.6	1.5	2.6	3.9	8.2	10.5	9.0	11.3	73
Average number of storms	3.9	2.1	1.9	2.1	0.8	1.0	1.4	2.4	3.0	3.2	3.6	3.8	29
Predominant direction in stormy winds	SW	SW	SW	NW	W	W	SW	W	W	SW	SW	SW	SW

The percentage distribution of various wind speed gradations over the years is presented in table 4.2.2. The data available for the long term (1999–2007) reveals possible patterns in wind strength. Light winds (2-3 m/s) have a tendency to decrease in the total sample of all winds as it constitutes only about 10% of all fixed winds, while the multiannual statistics showed that light winds constitute about 15% over the multiannual period. However, winds of 6−7 m/s speed are more frequently observed and comprises about 27% (multiannual statistics showed about 21%). Besides, extreme winds (storms) are becoming more frequent. Among them is storm *Erwin* of 2005 which had a maximum wind speed of 28 m/s, while average wind speed was 8–18 m/s during the period of 33 h. At the time of storm *Pero*, which occurred on 14–15 January 2007, wind speed during gusts reached 29 m/s, while at the time of storm *Kirill* (which occurred on 21 January of the same year), it reached 21 m/s.

Table 4.2.2. The recurrence of wind speeds calculated in percentage in Klaipėda during the period from 1999 to 2007 (composed by M. Kovalenkovienė (LEI) based on the data of Hydrometeorological Service)

Wind speed	Months												Yearly
m/s	01	02	03	04	05	06	07	08	09	10	11	12	
Still													1.7
0–1	7.4	10.0	9.7	11.7	11.5	11,5	16.5	13.0	11.2	7.0	5.4	8.5	10.0
2–3	15.9	21.4	23.5	30.3	30.3	32,6	34.0	32.1	31.2	23.7	17.8	15.3	26.2
4–5	21.2	21.0	27.9	28.4	28.6	24,8	24.3	26.4	23.7	21.6	22.5	17.9	24.0
6–7	34.7	27.6	27.5	23.4	25.3	23,9	21.9	22.0	26.8	31.0	37.2	34.4	27.0
8–9	9.9	10.5	6.8	4.5	3.1	4,5	2.5	4.3	5.6	8.5	9.9	12.6	6.5
10–11	5.5	4.3	2.1	1.4	1.0	1,5	0.5	1.5	1.2	4.4	3.4	4.0	2.3
12–13	2.3	2.3	1.6	0.1	0.2	0,8	0.2	0.2	0.2	2.0	2.5	3.0	1.3
14–15	2.2	1.7	0.2	0.2		0,4	0.1	0.2	0.1	0.9	1.0	2.4	0.7
16–17	0.5	0.3	0.4					0.1		0.3	0.4	0.8	0.2
18–20	0.4		0.4								0.2	0.6	0.1
21–23												0.4	0.03
24–25												0.1	0.01

Strong, sufficiently long in duration and constant direction winds have the greatest impact on formation of currents and waves in the coastal zone. According to the Lithuanian classification, strong winds are defined as those with a speed ≥15 m/s, while stormy winds with a speed ≥20 m/s. Stronger winds reaching more than 30 m/s are considered as hurricane winds. Based on long-term observations, winds of more than 14 m/s are observed for about 88 days per year, while winds of more than 20 m/s for 17 days at the coast of Klaipėda. 1990 was a special year, because winds of more than 14 m/s were observed for 115 days, while wind speed of more than 20 m/s for 31 days. In terms of 1999, the maximum wind speed in gusts reaching 20 m/s was observed for 32 days, while the speed of 25 m/s was observed for 7 days. In 2006, winds stronger than 14 m/s were observed for only 34 days and those stronger than 20 m/s for only 2 days, while in 2007, winds stronger than 14 m/s were observed for 61 days and those of ≥20 m/s for 7 days. The duration of strong wind periods (when maximum speed is more than 14 m/s) ranged from 2–3 to 106 hours according to the data of 1999–2007. At the time of storms, not only hurricane-like (>30 m/s) wind speed values are observed but also sufficiently long (24–96 h.) periods of high and moderate speeds (8–18 m/s). Strong winds are characterized by strong seasonality since they are mostly observed in autumn-winter months. According to the prevailing directions, hurricane-like winds differ from moderate. Among strong winds, those of S–W sector stand out clearly: winds of SW direction comprise 37.6 %, winds of W direction comprise 28.3 %, winds of S direction comprise 13.3 % and winds of NW direction comprise 11.2 %.

Based on the results of modelling carried out by the Latvian Institute of Marine Research in 2007, average wind speed in the sea intensifies as it moves away from the shore and changes from 7 to 10 m/s. The biggest differences in wind speed are registered closer to the seashore, while winds become more constant as you move into the middle of the sea. After completion of mathematical modelling in the sea 100 m above the water level, it was found that average wind speed can reach about 9–10 m/s in the PEA area (Fig. 4.2.1.).

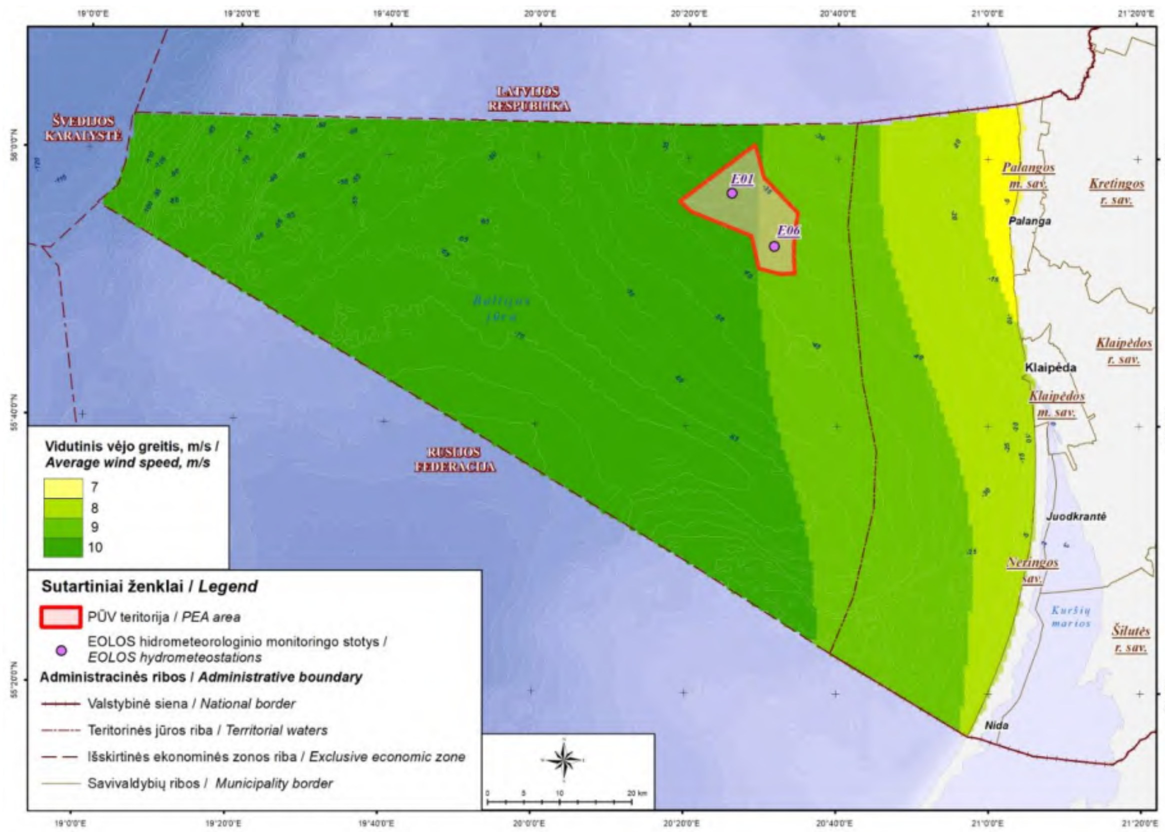


Fig. 4.2.1. Average wind speed in the sea

Similar results were obtained in the Danish RISO laboratory which also conducts modelling of Baltic and part of North Sea wind speeds, and links modelling results with real (installed at wind measuring stations) measured sizes. The research carried out at the RISO laboratory confirmed that average wind speed in the sea around the PEA area (at the height of 100 m) can reach from 8 to 9.5 m/s speed (Peña, 2011).

According to the newest data, based on the data of installed meteorological observation systems in 2022 (EOLOS, 2022(a), (b), (c), (d) and (e), Fig. 4.2.1.) (during a period from July to December), wind strength differs in the PEA area. The wind regime of the northern part is represented by the indications of E01 meteorological station, and the southern ones by E06. Wind speeds are interpolated from the available natural measurements to any height horizon of your choice, but in terms of energy efficiency, the most important horizon is the one that corresponds to the height of the rotor. Based on the measurement data of summer and autumn (E01 station), average wind strength reaches from 7.26 m/s (in July and August) to 10.12 m/s (in September and October) in the northern part of the PAE area at the height of 200 m (max height were data is still reliable). More detailed statistics is provided in table 4.2.3.

Table 4.2.3. The distribution of wind speeds (at the height of 200 m) in the northern part of the area (m/s).

E01 station	**July-August**	**Augist-September**	**September-October**	**October-November**	**November-December**
Mean	7.26	8.26	10.12	9.89	7.93
Max	20.56	19.56	22.34	22.11	22.03
Min	0.38	0.56	0.54	0.60	0.87
Standard deviation	3.60	3.54	4.39	4.30	4.19

Respectively, in the southern part of the area (E06 station), wind strength reaches from 7.12 m/s (in July and August) to 9.93 m/s (in September and October). More detailed statistics is provided in table 4.2.4.

Table 4.2.4. The distribution of wind speeds (at the height of 200 m) in the southern part of the area (m/s).

E06 station	**July-August**	**Augist-September**	**September-October**	**October-November**	**November-December**
Mean	7.12	8.18	9.93	9.88	7.80
Max	19.83	19.16	22.19	21.68	20.80
Min	0.40	0.68	0.47	0.65	1.10
Standard deviation	3.59	3.52	4.33	4.19	3.92

According to the wind rose charts drawn up for summer and autumn periods, winds of W-SW and SE, seldom NE, directions were prevailing during summer, while winds of S, W and SW directions were prevailing during autumn and SE in December in the northern part of the PAE area at the height of 150 m. (Fig. 4.2.2.)

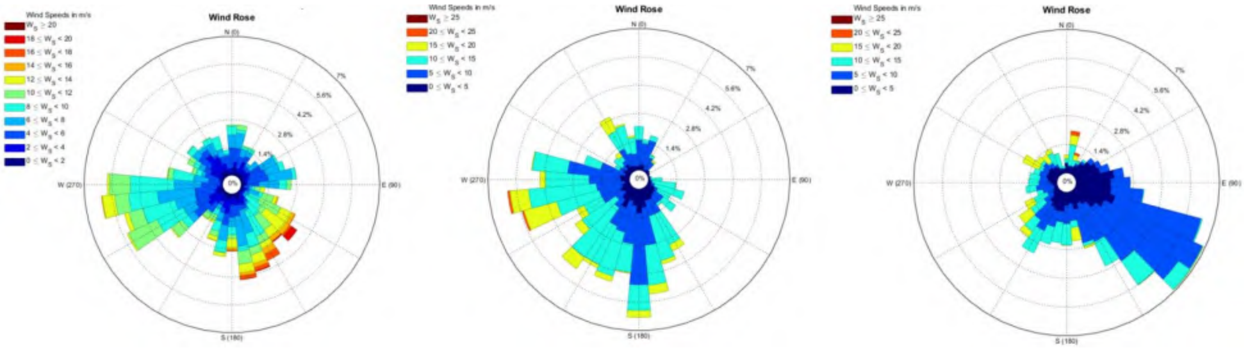


Fig. 4.2.2. The wind roses in summer (on the left), autumn (in the center) and in December (on the right) (based on 2022 Eolos data at E01 observation station).

Respectively, in the southern part pf the PAE, at the height of 150 m, wind rose diagrams reveals that prevaiiling winds in this part of the area in the summer are of N, less often SE and SW directions, while in autumn - S and SW wind were dominating. In December – the main direction of the winds was – SE (Fig. 4.2.3). This obviously shows that metheorological conditions are not the same in different parts of the PAE area.

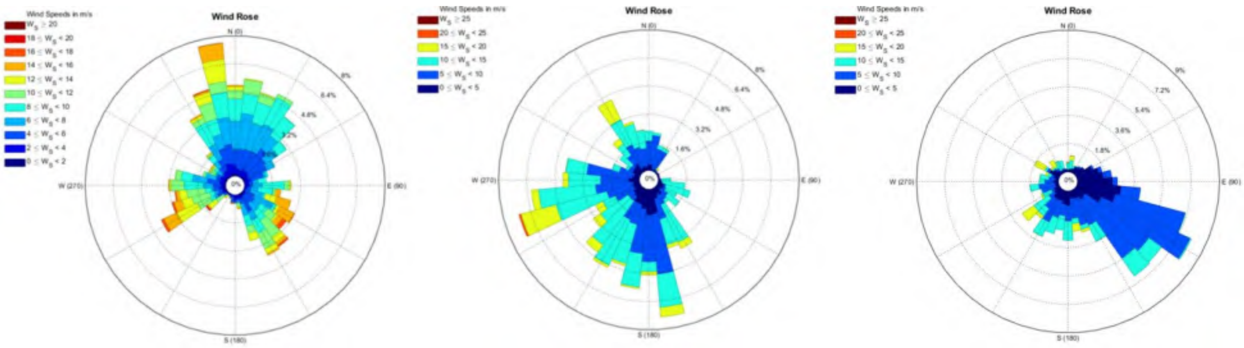


Fig. 4.2.3. The wind roses in summer (on the left), autumn (in the center) and in December (on the right) (based on 2022 Eolos data at E06 observation station).

4.2.2. Ambient air pollution sources and emissions

During electricity production at WPP, stationary sources of ambient air pollution and pollutant emissions are not expected. Air pollution is possible during the construction, maintenance and dismantling of wind parks. The main ambient air pollution sources are vessels and construction equipment in operation at the offshore wind park during construction, exploitation and dismantling stages.

WE park (onshore and offshore) emissions throughout the whole life cycle were evaluated in the study prepared by the international project "Wind energy: the Facts". Life Cycle Assessment method made it possible to compare traditional electricity generation systems of European countries using fossil fuels (coal or natural gas) and emissions from wind energy during the production of 1 kWh of electricity.

Table 4.2.5. Pollutant emissions from wind energy and electricity produced using coal or natural gas throughout the whole life cycle (CIEMAT)

Emission	Offshore WE	Onshore WE	Electricity from coal	Electricity from lignite	Electricity from natural gas (in combination with coal)
CO_2, g	8	8	836	1060	400
Methane, mg	8	8	2554	244	993
NOx, mg	31	31	1309	1041	353
LOJ, mg	6	5	71	8	129
Solid particles, mg	13	18	147	711	12
SO_2, mg	32	31	1548	3808	149

Preliminary quantities of ambient air pollutants resulting from mobile pollution sources

Air pollutant emissions are possible from internal combustion engines of service vessels during the operation of WE parks. During WE park decommissioning, emissions similar to those during WE park construction are possible at the time of WE dismantling.

Possible ambient air pollution from mobile pollution sources will be local and temporary at the time of construction and operation of construction machinery. Pollutant emissions into the atmosphere are possible from internal combustion engines of vessels and other machinery in operation. Emissions: NOx, CO, SO_2, hydrocarbons and solid particles.

Ambient air pollutant emissions from internal combustion engines of vessels depend greatly on a vessel's type, tonnage, type of engine, loading and working mode and on the type of fuel burned.

The quantity of pollutant emissions from internal combustion engines of vessels are limited by the requirements of Annex VI to the MARPOL (Regulation for the prevention of Air Pollution from Ships. Annex VI to International Convention MARPOL 73/78/IMO. London, 1997). Vessel emissions are also subject to the standards set by the U.S. Environmental Protection Agency EPA.

Table 4.2.6. Emission standards for vessel engines (based on Air emission from Marine Vessels. Report of Jodint Standing Committee on Natural Resources. Maine department of Environmental Protection Bureau of Air Quality. 2005)

Standard	Vessel engine type				Emissions (g/kW per hour)				Production year
	Category	Capacity	Power (kW)	Speed, rpm	NOx	NOx and THC**	PM	CO	
MARPOL			>130 kW	N<130	17.0	-	-	-	2005-05-19*
				130<N<2000	45.0 x $N^{-0.20}$				
				N>2000	9.8				
EPA Tier 1	1, 2, 3	>2.5	>37	N<130	17.0	-	-	-	2004–2006
				130<N<2000	45.0 x $N^{-0.20}$				
				N>2000	9.8				
	1	<0.9	Any	-	-	7.5	0.40	5.0	2007

		0.9-1.2	Any			7.2	0.30	5.0	2007
		1.2-2.5	Any			7.2	0.20	5.0	2007
		2.5-5.0	Any			7.2	0.20	5.0	2007
EPA Tier 2	2	5.0-15.0	Any	-	-	7.8	0.27	5.0	2007
		15.0-20.0	<3300			8.7	0.50	5.0	2007
		15.0-20.0	>3300			9.8	0.50	5.0	2007
		20.0-25.0	Any			9.8	0.50	5.0	2007
		25.0-30.0	Any			11.0	0.50	5.0	2007

* MARPOL VI came into effect from 19.05.2005 and is applicable to engines of ships built after 01.01.2000

** Total hydrocarbons

Emissions can have greater impact at the moment vessels start moving, at mooring or standing by quays in ports. Favourable pollution spreading conditions are in the open sea, far from the shore and living or public environments, therefore emissions will be easily spreadable and will not affect living environment on the shore.

4.2.3. Possible impact on climate

When assessing indirect impact on the ambient air, it is necessary to note that wind energy is one of the renewable energy types reducing the use of fossil fuels and emissions of CO_2 and other substances into the ambient air. The use of wind energy plays a major role in the fight against climate change to reduce greenhouse gas emissions from the energy sector.

The UNFCCC Kyoto Protocol[14] set the tasks for the countries of the world to reduce CO_2 emissions and other pollutants. Each EU member state, based on the European Union (EU) directive 2001/77/EC[15], is obliged to establish and harmonize with the EU electricity production norms utilizing RES.

In order to assess the impact of renewable energy on the climate, studies based on life cycle analysis are increasingly being conducted. Such studies allows to compare the impact of different energy production technologies on the climate, which is expressed by the global warming potential coefficient and is evaluated as gCO_2 eq/kWh. 1 MWh of thermal energy produced by burning liquid fuels emits about 0.27 t of CO_2 (data according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories Part 2 "Energy"[16]. Meanwhile, taking into account Anna Garcia-Teruel et al. (2022) [17] and Barbara Mendecka and Lidia Lombardi (2019) [18], depending on the technological parameters of WT, the global warming potential of offshore power plants ranges from 25 gCO_2 eq/kWh to 133 gCO_2 eq/kWh, which is significantly less than that needed to produce energy using fossil fuel.

4.2.4. Measures reducing the impact

Vessels working at WE parks have to comply with the requirements of international organisations (MARPOL). Measures reducing impact on ambient air are not required or foreseen for WE park establishment.

[14] Kyoto protocol to the United Nations framework convention on climate change. http://unfccc.int/resource/docs/convkp/kpeng.html

[15] Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market // Official Journal L283, 27/10/2001. P. 0033-0040.

[16] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_2_Ch2_Stationary_Combustion.pdf

[17] Anna Garcia-Teruel, Giovanni Rinaldi, Philipp R. Thies, Lars Johanning, Henry Jeffrey, 2022. Life cycle assessment of floating offshore wind farms: An evaluation of operation and maintenance, Applied Energy, Volume, ISSN 0306-2619,

[18] Barbara Mendecka, Lidia Lombardi, 2019. Life cycle environmental impacts of wind energy technologies: A review of simplified models and harmonization of the results, Renewable and Sustainable Energy Reviews, Volume 111, ISSN 1364-0321.

Table 4.2.7. Summary table of impact on ambient air and climate

Component	Operational stages	Impact	Nature	Scale	Duration	Significance	Measures
Ambient air	Construction	Pollutant emissions from engines of vessels / construction machinery	Direct impact having no significant impact on ambient air quality	At a ship's / technical machinery's workplace	Only at the time of construction phase	Insignificant	Not applicable
	Operation and maintenance	Pollutant emissions from service vessels	Direct impact having no significant impact on ambient air quality	At a ship's / technical machinery's workplace	Only at the time of maintenance/ repair works	Insignificant	Not applicable
		Electricity production from renewable sources	Indirect, positive impact reducing the use of fossil fuels and emissions of CO_2 and other ETS into the ambient air	Regional / global	Long-term, at the time of WE park's operation	Positive contribution is significant for reduction of climate change	Not applicable
	Termination of operation	Pollutant emissions from engines of vessels and construction machinery	Direct impact having no significant impact on ambient air quality	At a ship's / technical machinery's workplace	Only at the time of work	Insignificant	Not applicable

Significance:

– positive impact; – impact is not significant (it is not necessary to take into account, no measures are applied).

4.3. Underwater Noise

4.3.1 General Characteristics

By its origin, underwater noise is divided into natural and anthropogenic:

- Natural noise: hydro- and meteo-dynamic noise caused by wind and wave impact on the sea surface (wind-dependent noise), also caused by atmospheric precipitations (rain, snow, hail);
- Seismic/geoacoustic noise: generated by tectonic and volcanic activity of the Earth's surface (hardly probable in Lithuania);
- Biologic noise: sounds produced by invertebrates, fish, mammals;
- Anthropogenic noise: generated by human offshore activities, mostly due to shipping, hydrotechnical operations (installation of piles, seabed dredging/excavation), scientific esearch (seismoacoustic studies, sonar and echo sounding device surveys).

Depending on its origin, anthropogenic noise can be impulse or uninterrupted (constant). Both constant and impulse underwater noise may have a great impact on marine environment. Marine mammals and some fish species use acoustic signals for communication and navigation purposes; any additional, that is unnatural, noise may therefore disturb or even injure marine animals.

Wind-induced sound (breaking waves and generating splashes) primarily generates in the frequency band between approx. 100 Hz and 30 kHz. Rain generates noise mostly in the frequency band between 1 kHz and 10 kHz, yet also contributes to higher frequencies. Noise generating due to the migration of different temperature water masses (thermal noise) is caused by mixing of molecules and is the main source of the sound with frequency above 100 kHz.

The range of animal-produced sounds falls between several Hz and up to several hundred kHz, while the duration of animal-produced sounds ranges from very short, few dozens of microseconds, up to tens of seconds.

Deep-sea shipping noise contributes to the ambient noise in the frequency bands between 10 Hz and 1000 Hz. On the other hand, ships in the vicinity, and small ships, generate noise in higher frequency bands, as well. Ship-related noise is caused by rotors, engine operation and hull friction against the water surface.

It is important to consider that ambient noise level may greatly differ with time. Changes in the ambient noise level observed in time and space may reach tens of decibels (i.e. amplitude may show several-fold difference). Such differences are determined by the fact that sounds from certain sources has a direct dependency on weather conditions. Such a change may be short-term (in minutes or hours) or of average duration (e.g. twenty-four hours (day and night) fluctuations) or of a longer duration, i.e. seasonal changes. Biologic noise may be subject to time of the day and season. Noise level may also be subject to location, for example, distance (vicinity) to intensive shipping routes or in case of observing the noise close to an active biological source (Robinson *et al.*, 2014). Moreover, sound propagation conditions are highly dependent on hydrological conditions, which are determined by different temperature and salinity layers. An expressive stratification of the sea-water column due to different temperature and salinity is one of the specific features of the Baltic Sea water. Typically, the Baltic water covers a denser layer of water inflowing from the Northern Sea with a relatively stable halocline around the depth of 40–90 m; meanwhile, vertical and horizontal temperature and salinity gradients are regularly registered in the basin (Piechura, Beszczyńska-Möller, 2004). Furthermore, a seasonal thermocline, which separates the warm surface layer from the intermediate/deep Baltic water layer, i.e. cold or winter layer, is forming in the medium part of the water column in the period from late spring to autumn.

Typically, sound speed during the entire winter season close to the sea surface is the least. On the other hand, a mixed water layer occurring at the depth of 40-60 m show the formation of a wide subsurface acoustic waveguide (underwater sound channel). Meanwhile, during summer, when seasonal thermocline is generating at the depth of 20–40 m, a three-layer structure forms at the sea. Such a structure occurs when warm summer Baltic Sea water in the upper layer is above cold winter Baltic Sea water layer, which, in turn, covers the deep water layer of the Northern Sea. In a cold-water layer of low salinity, the sound speed is minimum and thus a 20–60 m thick deep-sea acoustic waveguide is forming between thermocline and seabed (Klusek, Lisimenka, 2016). Such fluctuation in noise propagation conditions in the Baltic Sea throughout the year and hydrological changes in water mass structure condition large (measured) seasonal changes in the sound pressure levels, which are, moreover, subject to water depth. The observations showed that, in case of a similar wind velocity, noise spectrum level in winter is approx. 10–15 dB higher than in summer, especially in the low frequency band below 1 kHz (IEC, 2006). Furthermore, in low frequencies the sound spectrum of winter and summer seasonal waveguides is up to 10 dB longer and has a weak correlation with the local wind velocity. Inside the winter subsurface waveguide, the wide frequency range shows a negative correlation of noise level and wind velocity.

4.3.2 Study on Underwater Noise Propagation

To determine the specificities of underwater noise propagation in the PEA area, two underwater noise monitoring systems equipped with the omnidirectional hydrophone working at frequency range from 20 Hz up to 60 kHz (SoundTrap ST600STD (Ocean Instruments, New Zealand) were installed. The main aim of the study is to determine the current situation in relation to the underwater noise level in order to obtain the possibility of identifying potential changes in the marine environment caused by anthropogenic activity during the construction phase, operation and liquidation.

Acoustic data are collected according with the international measurement standards [BSH, 2011; Dekeling *et al*., 2014a, b, c; Van der Graaf *et al*., 2012] as well as according to the updated HELCOM guidelines for monitoring continuous noise [HELCOM 2021], deploying the noise recorders up to about 5 m above the seabed. Detailed analysis of the acoustic data was performed in frequencies of 1/3-octave frequency bands with central frequencies from 20 Hz up to 20 kHz what, all in general, is in agreement with the recommendations of HELCOM [HELCOM, 2021] and international standards and recommendations of the Expert Groups (EU TG-Noise, HELCOM EG-Noise) in the field of acoustic data analysis of the underwater noise.

The result of the calculation of the mean values of power spectrum density PSD [dB re 1 $\mu Pa^2/Hz$] in the particular 1/3-octave frequency bands is presented in the form of the "boxplots" (MATLAB®), reflecting the general statistical information of the noise data (Fig. 4.3.1.). In the scheme, the central red line marks the median value in each "box" (rectangle), the bottom and upper limits of which determine, respectively, the first quartile Q1 and third quartile Q3, i.e. the percentiles 25 and 75. According to the definition, the interquartile range (IQR), i.e. the distance between Q1 and Q3, comprises half of all observations. The values of so-called whiskers are determined by default as 1.5 of the interquartile range, i.e. $\Delta Q=1.5*IQR$. If the observed minimum is higher than the value of the bottom whisker Q1-ΔQ and/or the observed maximum is lower than the upper whisker Q3+ΔQ, the length of the whiskers is limited by the appropriate observed extreme values.

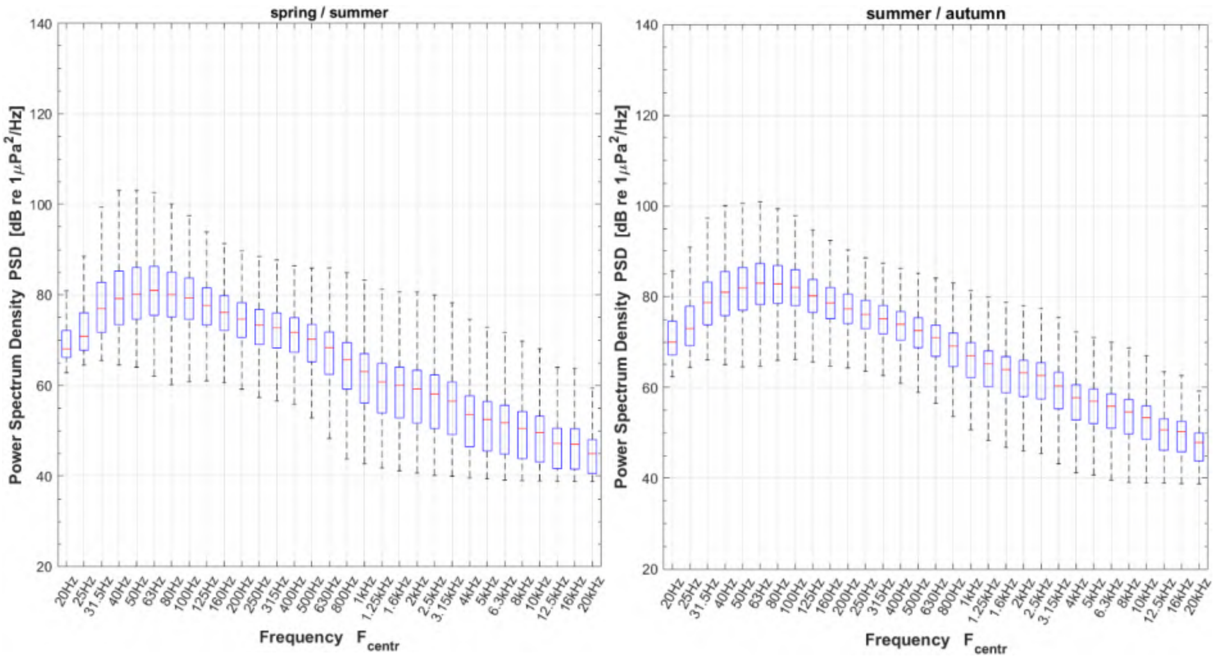


Fig. 4.3.1. Statistical distribution of the averaged power spectral density PSD [dB re 1 μPa^2·Hz^{-1}] values of the underwater noise in 1/3-octave frequency bands. As per measurements data obtained during the period between 2 May 2022 to 11 August 2022 (on the left) and between 12 August 2022 to 14 November 2022 (on the right).

Moreover, the mean values of the power spectrum density PSD in the 1/3-octave frequency bands are calculated for different percentiles (*p* = 0.05; 0.10; 0.25; 0.50; 0.75; 0.90; 0.95). For example, the L05 percentile defines that the noise level is larger than the L05 threshold during 5% of the observation time (so-called 'the loudest sounds'). In turn, the L95 percentile corresponds to 'the quietest sounds'. Respectively, the L50 percentile is the median value (Fig. 4.3.2.).

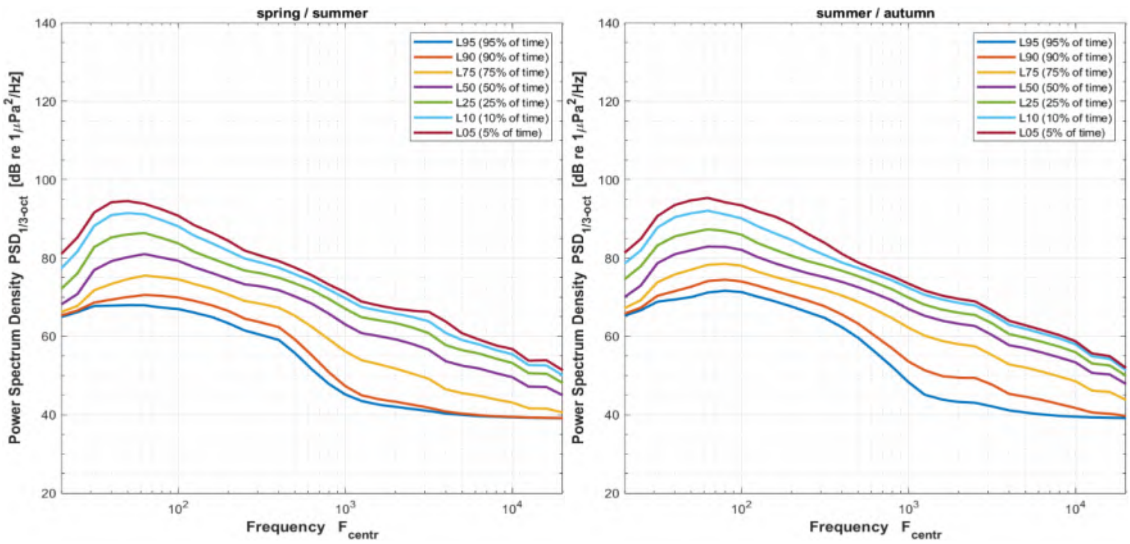


Fig. 4.3.2. Mean values of the power spectrum density of the underwater noise in the 1/3-octave frequency bands PSD [dB re 1 μPa^2·Hz^{-1}]. As per measurements data obtained during the period between 2 May 2022 to 11 August 2022 (on the left) and between 12 August 2022 to 14 November 2022 (on the right).

The underwater noise characteristics presented above correspond with (are typical for) the transient period of time between spring/summer and summer/autumn sound propagation conditions in the Baltic

Sea [Klusek and Lisimenka, 2016; Mustonen *et al*., 2019; ICES Continuous Underwater Noise dataset, 2022].

4.3.3 Potential Impact of Underwater Noise during the WT Installation

Noise of anthropogenic origin has been recognized on a global scale as a pollutant for years, and it is assumed that it is one of the most harmful forms of pollution, ubiquitous in both terrestrial and underwater ecosystems. As measurement and observation techniques advance, there is increasing evidence of the negative effects of anthropogenic noise on marine life. This noise is a major stress factor for marine organisms, causing changes, for example, in the hearing threshold (auditory ability), as well as causing behavioural and physiological changes in them. In legal terms, in 2008, the Marine Strategy Framework Directive (MSFD) was adopted in the EU, which defines the main legal conditions regarding underwater noise. In this document, under the law, underwater noise was recognized as a significant pollutant of the marine environment, negatively affecting the welfare of animals and potentially threatening their life. It also emphasized that the level of noise emissions should be limited, and one of the basic tasks is to protect European seas.

The primary source of underwater noise during the offshore wind farm development is fortification of foundation structures during construction. It is especially true in case of monopile and jacket foundations, which installation requires the use of a falling ram of different modifications generating impulse noise of various intensity. The underwater noise measurements performed (Bellmann *et al.*, 2020) during un-mitigated impulse pile-driving (reference measurements according to the DIN SPEC 45653 standard (2017) in absence of noise mitigation measures), showed that, in 750 m distance to the monopile-driving location, the following underwater noise values were reached:

162 dB <= Sound Exposure Level SEL <= 183 dB and

185 dB <= zero-to-peak Sound Pressure Level SPLp,pk <= 205 dB;

Such impulse noise emissions are especially dangerous for sensitive species of marine fauna, particularly those in vicinity of the noise-generating source. Therefore, reducing the potential impact requires noise-mitigation measures and concepts.

It should be noted that geological seabed conditions in the PEA area, i.e. relatively solid soil, and small distance to the shore create especially favourable underwater sound propagation conditions in the winter season and relatively most unfavourable sound propagation conditions in the summer season. The modelling of noise propagation from one monopile driving showed that the noise level at the 750 m distance (as per BSH, 2011) to the pile-driving location significantly increases the limit values established, i.e. reaching up to 170 dB (Fig. 4.3.3.). It is thus recommended – if no sufficient noise mitigation measures to be applied, to refrain from operations while using pile-driving technologies generating high-level underwater noise or limit them during winter.

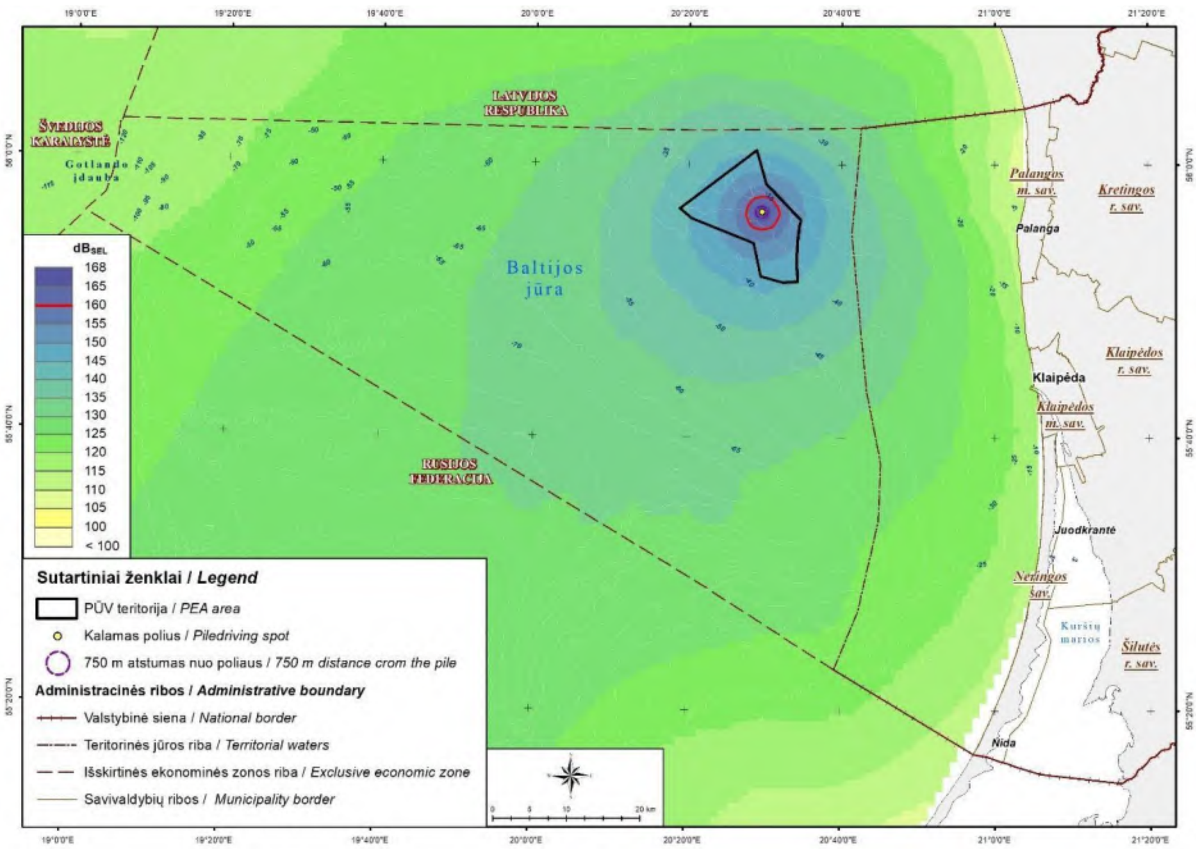


Fig. 4.3.3. Propagation of underwater noise from driving the pile without application of mitigation measures.

4.3.4 Recommended Impact Mitigation Measures

Negative impact from noise could be reduced through the use of direct noise mitigation measures: Reducing the generated noise (modification of the source of the noise itself) and reducing the radiated noise (dampening of the acoustical energy propagating away from the source). In recent years, several underwater noise mitigation systems to reduce the radiated noise from pile driving have been developed. The Big Bubble Curtains (BBC), the isolation casings (IHC-NMS) and the Hydro Sound Dampers (HSD) have been deployed in the North Sea (Koschinski and Lüdemann, 2020). With the BBC, NMS and HSD, underwater noise levels in broadband frequency band could be dampen by at least 10 dB up to about 15-16 dB for each system and reductions of up to about 20 dB could be achieved when combing several systems (Bellmann *et al.*, 2020). The modelling of the underwater noise propagation conducted in the PEA area (SEL 20Hz-5kHz values when the noise source is one metre away from the seabed) from one pile driving, where pile diameter was 8 m, showed that, in case of a single mitigation systems, the noise level from the source over the established distance of 750 m has damped from 170 dB$_{SEL}$ down to 149 dB$_{SEL}$, i.e. did not exceed the maximum level of 160 db$_{SEL}$ (Fig. 4.3.4).

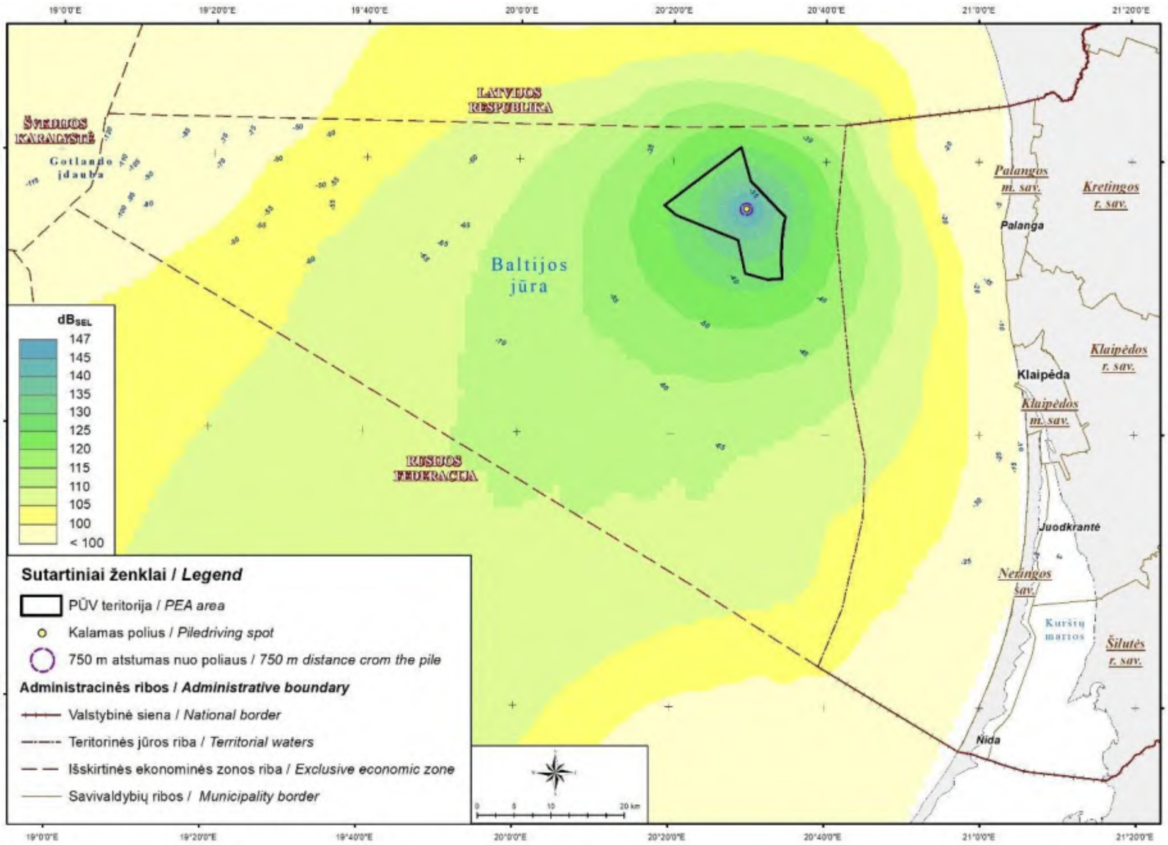


Fig. 4.3.4. Propagation of underwater noise from driving the pile after applied mitigation measures.

Moreover, a key mitigation measure for preventing injury (hearing loss) to marine mammals from pile driving is to deter animals acoustically prior to start of pile driving. This can be done by two methods, often used in conjunction. The first method is deployment of additional acoustic deterrence devices (ADDs), capable of deterring marine mammal from the vicinity of the pile-driving location. The second method is a soft start of pile driving, i.e. while driving the pile, the energy applied by the hammer is ramped up gradually, thus, deterring the animals, but not creating any sudden noise pulses that are especially harmful and potentially damaging to the animals (Tougaard and Mikaelsen, 2020).

At the present time, the developers comply with the dual noise mitigation threshold values established by the German Federal Maritime and Hydrographic Agency (BSH) to be observed during pile-driving works to mitigate impact of underwater noise during the WT installation. The requirement is not to exceed 160 dB_{SEL} (to be met by the Sound Exposure Level) and 190 $dB_{Lp,pk}$ (to be met by the zero-to-peak Sound Pressure Level) of underwater noise at a distance of 750 m from the pile-driving location.

To control the caused negative impact on marine organisms (marine mammals, fish), also to assess and control the efficiency of noise mitigation measures during the construction, i.e. during the installation of WT foundations, the future developer must implement underwater noise monitoring during installation of foundations. The aim of monitoring is to register if the noise generated exceeds the limit values established, i.e. at a distance 750 m from the pile-driving location the noise level should not exceed 160 dB_{SEL} and 190 $dB_{Lp,pk}$). If it is determined that the noise has exceeded the set limits, it is necessary to stop the work and apply other/additional noise reduction measures.

4.4. Earth: Seabed and Deeps

4.4.1. Seabed Characteristics, Relief, Depths

The today's seabed of the Lithuanian marine area in the Baltic Sea was mostly caused by glacial activity during pleistocene glaciation, when ice covered the entire area of the sea. The retreating glacier has left various accumulation (hills, ridges) and exaration (depression, rapids, shoals) relief forms (Trimonis, 2002). The silt from deglaciation waters covered the moraine depression and formed accumulation plains. Later, the seabed was formed by the processes related to water level changes in different eras of Baltic Sea evolution, and by modern sedimentation processes. Due to these processes, there are favourable topographic forms, i.e. plateaus, banks, formed at the bottom of the sea, whereas the sloping plains parting them form the adverse relief forms, i.e. basin slopes. In Lithuanian marine territory, the key geomorphologic structures (Fig. 4.4.1) are the Klaipėda-Ventspils and the Curonian-Sambian Plateaus (Gelumbauskaite, 1986), the Gotland and Gdansk Basins and the connecting slopes. Specific seabed structures to be mentioned additionally are the Bank of Klaipėda and, supposedly, the Nemunas Valley (Gelumbauskaite, 2010). The Klaipėda-Ventspils Plateau in the northern Lithuanian water area starts at the Gulf of Riga, stretches along the shore, and somewhere in the latitude of Liepaja turns south-west, to settle between the Gotland and Gdansk basins. There are also more prominent elevations at this location. One of them is known as the Bank of Klaipėda, located in the north-western part of the Lithuanian Economic Zone. The sea depth in some places of this area reaches 47 m (Gelumbauskaitė et al., 1999). Westwards, this bank descends a steep slope into the Gotland Basin.

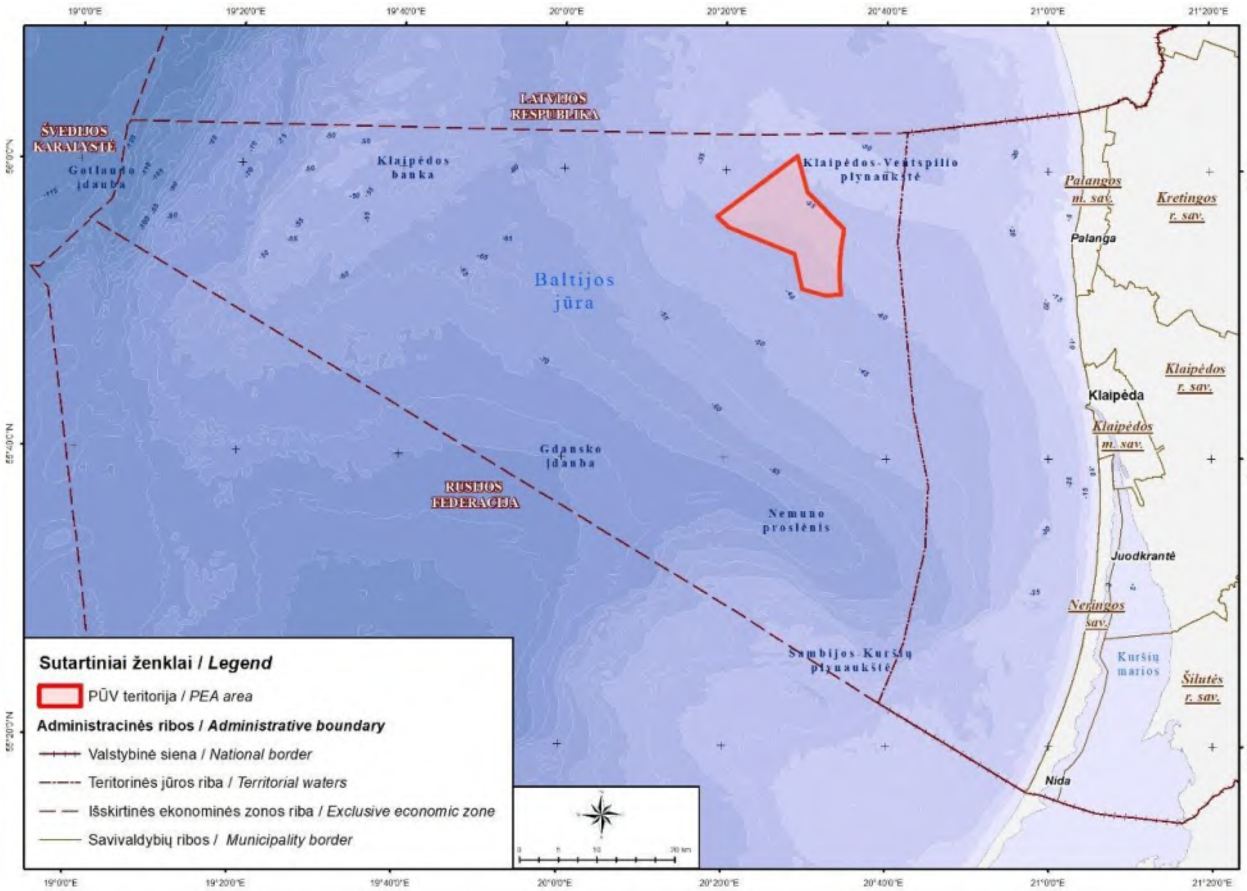


Fig. 4.4.1. Geomorphologic demarcation of the seabed in the Lithuanian marine area.

The Klaipėda-Ventspils Plateau and the south-western slope of the Gdansk Basin, where potential wind energy development area is located, are most significant in terms of the object under study. The deeper northern slope of the Gdansk Basin, the Bank of Klaipėda in the west and the slope of the Gotland Basin as well as the Nemunas Valley are beyond the boundaries of the territory under study.

Based on modern fixed-site foundation technologies, the best conditions for the installation of offshore wind farms are coastal areas with a depth not exceeding 40 m (50 m the most). In Lithuania, the use of the sea at the depth up to 20 m is regulated by the Law on Coastal Strip (LR, 2002); the installation of fixed-site engineering structures in the costal areas is thus not possible. Based on the latest bathymetric measurements (Sea Bottom Surveys, Part II, 2022), the PEA territory is consistently fragmented into a shallower (28-36 m) north-eastern and a deeper (36-46 m) south-eastern areas. The northern part morphologically is the western segment of the Klaipėda-Ventspils Plateau, while the south-western part is a slope of the Gdansk Basin, which evenly deepens southward. The prevailing depths are 38–43 m (amounting to approx. 40 % of all values), the second most prevailing depth area (basically, the entire slope) 34–38 m (about 30 % of the area) is relatively most plane central part of the area, while depths between 31 and 34 m are registered only at the Klaipėda-Ventspils Plateau, accounting for approx. 10 % of all depth values (Fig. 4.4.2.).

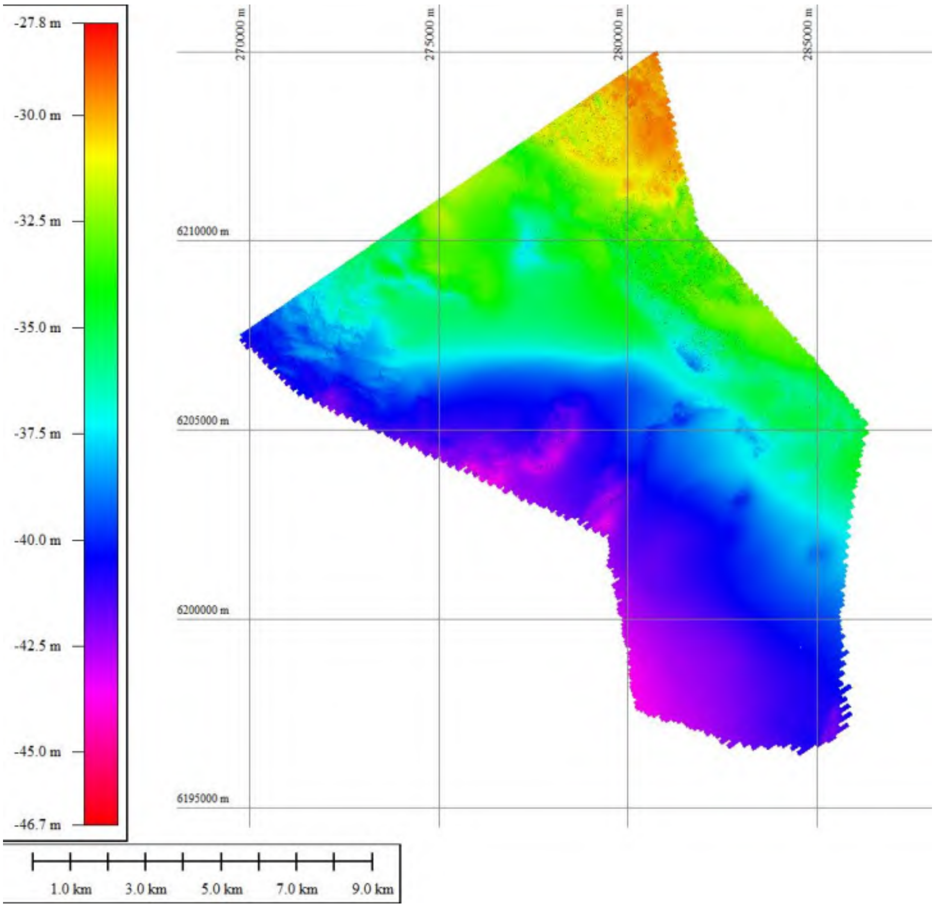


Fig. 4.4.2. Sea depth scheme of the PEA territory. (Source: Sea Bottom Surveys, Part II, 2022)

4.4.2. Sedimentation Conditions

4.4.2.1. Distribution and Composition of Surface Sediments

The seabed of the Lithuanian water area is covered with recent and relict bottom sediments (Gulbinskas, 1995). Relict sediments are sediments deposited during the Ice Age and Baltic Sea evolution stages. They occur in hydrodynamically active areas of the sea where sedimentation no longer takes place today or where bottom destruction occurs. In many such spots, glacial deposits (moraine) are heavily eroded; their surface is covered with boulders, pebble, shingle, or uneven-grained sand.

Recent sediments are found in accumulation areas. The main types of sediment are sand (mostly fine-grained), siltstone, and sludge) (Emelyanov et al. 2002). The areas of fine-grained sand dispersal are found at elevations /plateaus. Bottom in deeper marine areas (basin slopes about 45–65 m deep) is covered by silty sediments. Sludge sediments consisting of fine siltstone and pelitic siltstone cover the bottoms of Gdansk and Gotland basins (at a depth of over 60 m).

Relict deposits and sediments also cover the Klaipėda-Ventspils Plateau, within which the PEA territory is located (Sea Bottom Surveys, Part II, 2022). Relict sediments consist of moraine of varied composition (sand, loam, boulder clay) and the eroded elements (boulders, pebble, shingle). Here, the prevailing glacial (washout moraine) unsorted mixed sand, gravel and boulder sediments occur directly on a moraine bed (moraine sandy loam and clayey loam). The remaining part of the territory shows the prevalent modern marine sand, silty and clayey sand sediments that formed in the relief ranges and on the Klaipėda-Ventspils Plateau slope (Fig. 4.4.3.). Thickness of the surface loose sediments varies from several centimetres in the north-eastern segment with washout moraine sediments, to several metres (3–6 m) in the rest of the PEA area, where sandy, silty, clayey sediments are prevailing. Solid glacial sediments occur below the indicated point.

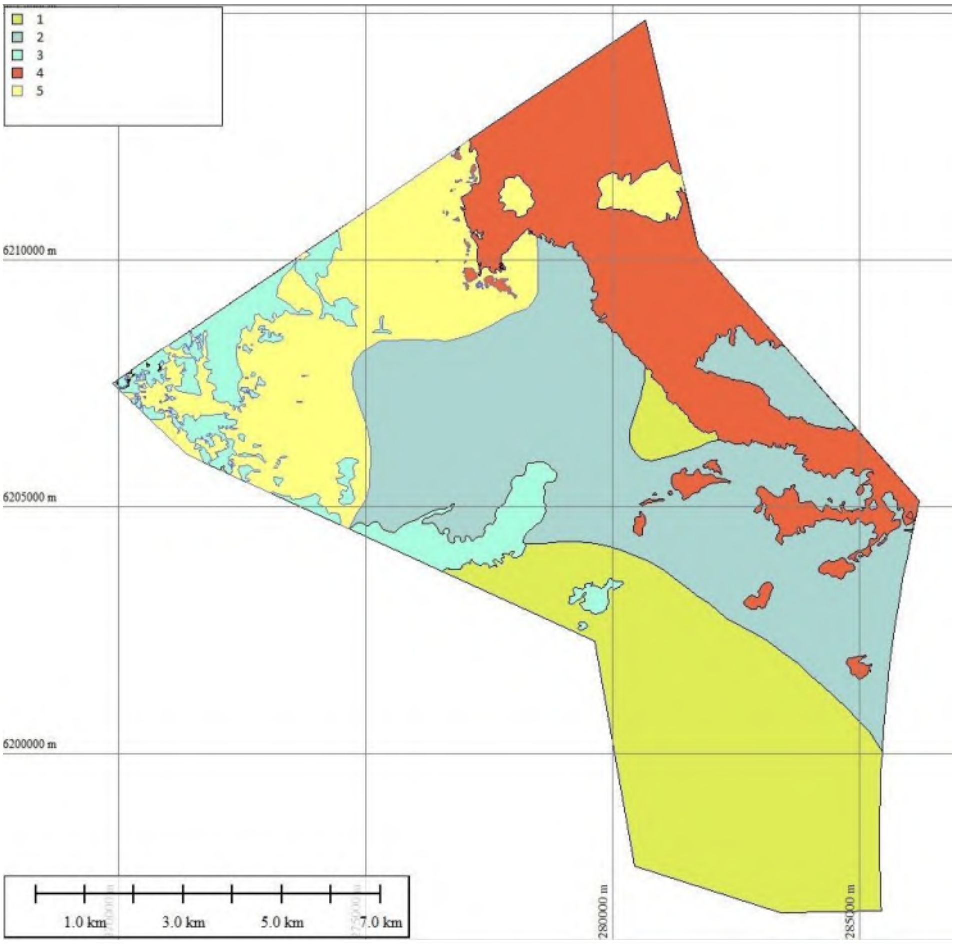


Fig. 4.4.3. Lithological composition of bottom sediments**. Legend: 1-silty sand; 2-silty, clayey sand; 3-clay, clayey sand; 4-boulders, gravel, gravely sand; 5-evenly sorted sand. (Source: Sea Bottom Surveys, Part II, 2022).**

4.4.2.2. Studies on contamination of seabed sediments

Seabed sediment samples were taken at ten measurement stations in the proposed WT farm area (Fig. 4.4.2.1.) for geochemical studies. The samples were taken using Van Veen grab sampler (seabed coverage area 0.1 m^{-2}).

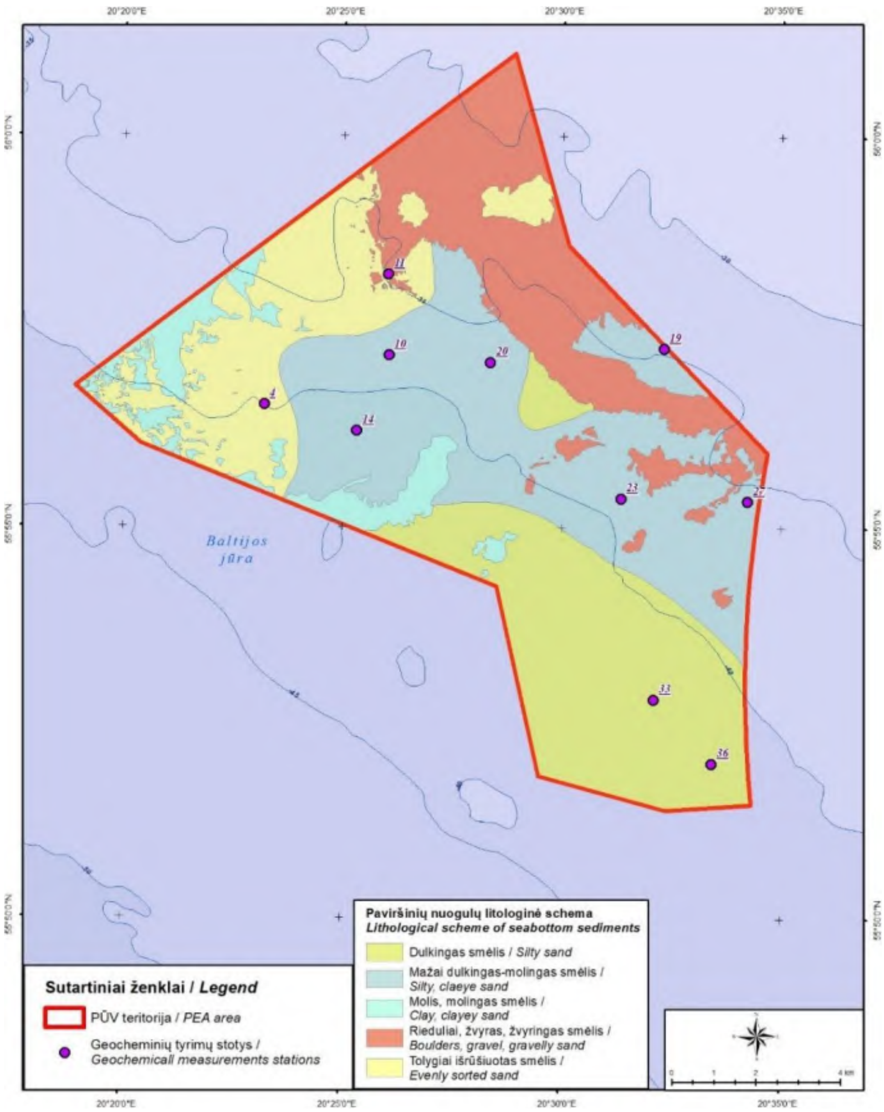


Fig. 4.4.2.1. Sites of seabed sediment contamination studies.

The pollutants (oil products C10-C40, polyaromatic hydrocarbons, heavy metals As, Cd, Cr, Cu, Ni, Pb, Zn, Hg) were determined in the certified laboratory of Vandens tyrimai, UAB (as per LST EN ISO/IEC 17025:2018). Chemical status of Lithuanian waters of the Baltic Sea in regards of concentration limits for polluting substances in the bottom sediments are determined in accordance with the Order of the Minister of Environment of the Republic of Lithuania no. D1-194 of 4 March 2015 "On Approval of the Requirements for Determining the Characteristics of the Good Environmental Status of the Lithuanian Marine Area" and the average annual values for pollutants in seabed sediments of good environmental status qualities.

Based on the analysis of concentration of heavy metals and arsenic carried out in the current seabed sediments in the proposed WT farm territory, no traces of significant pollution were established (Table 4.4.2.1.).

Table 4.4.2.1. Results of heavy metal analysis in the seabed sediments (Vandens tyrimai, UAB, research protocol No. 220513GC040)

Sample No.	Sediments	Concentration of pollutants, mg/kg								Amount of organic substance, %
		As	Cd	Cr	Cu	Ni	Pb	Zn	Hg	
4	Evenly sorted sand	3	<0.15	3	<4	<4	1	<20	<0.05	0.79
10	Silty, clayey sand	3	<0.15	4	<4	<4	1	<20	<0.05	0.85
11	Silty sand	3	<0.15	8	4	4	2	<20	<0.05	1.64
14	Silty, clayey sand	2	<0.15	4	<4	<4	1	<20	<0.05	1.06
19	Silty, clayey sand	2	<0.15	3	<4	<4	1	<20	<0.05	1.14
20	Silty, clayey sand	2	<0.15	3	<4	4	1	<20	<0.05	1.33
23	Silty, clayey sand	1	<0.15	4	<4	<4	1	<20	<0.05	1.36
27	Silty, clayey sand	1	<0.15	3	<4	<4	1	<20	<0.05	1.23
33	Silty sand	2	<0.15	5	4	<4	2	<20	<0.05	0.42
36	Silty sand	2	<0.15	6	<4	<4	2	<20	<0.05	1.11
	GES*	**3**	**0.5**	**30**	**10**	**10**	**20**	**60**	**0.1**	**-**

* GES (Good Environmental Status) values is annual average concentration of pollutants in seabed sediments, mg/kg of dry weight. Result below the established limit is marked as (< …).

Concentrations of the priority dangerous heavy metals, i.e. mercury (Hg) and cadmium (Cd), in the seabed sediments of the area under study are lower than quantitation limit. The same is true for zinc (Zn) concentration. Concentrations of other heavy metals (Cr, Cu, Ni, Pb) and arsenic (As) do no exceed the established limit values, which proves the good environmental status of the sea waters under study. Conditionally higher concentrations of metals are found in sandy clayey sediments containing more of organic matter.

The analysis of concentration of oil hydrocarbons in seabed sediments allows for a partial assessment of anthropogenic activities related to the transportation of oil and oil products, intensive shipping, and illegal discharge of oil waters in the open sea. PAH is a range of compounds, starting with naphthalene ending with coronene. It is the most dangerous oil component, which remains in the water for a long time and accumulates in seabed sediments and living organisms. The most toxic PAH are anthracene, fluorene, naphthalene, and phenanthrene. PAH compounds with high molecular weight, e.g. benzo[a]pyrene, are cancerogenic.

No oil products (C10–C40) were found in seabed sediments of the PEA area. Concentration of oil hydrocarbons in all sites of the studied area were lower than the quantitation limit (Table 4.4.2.2).

Analysis of concentrations of individual PAH compounds in seabed sediments showed no significant pollution, as well. Concentrations of the priority PAH, fluoranthene, in the studied area reached 1.1. to 11 µg/kg. Concentrations of another priority PAH, naphthalene, were lower than the quantitation limit. The sum PAH concentration is between 20 and 700 times lower than the established GES value, the chemical status of the sediments should thus be assessed as good.

Table 4.4.2.2. Results of analysis of oil products (C10–C40) and PAH in seabed sediments (Vandens tyrimai, UAB, research protocol No. 220513GC040)

Sample No.	Oil products, mg/kg	PAH, µg/kg															
		NFT	**ACNFT**	**FLR**	**FEN**	**ANT**	**FRT**	**PIR**	**BZA**	**CHRZ**	**BZB**	**BZK**	**BENZA**	**DBAH**	**BENZGHI**	**IND123**	**SUM**
4	< 100	< 1	< 1	< 1	< 1	< 1	2,5	2	< 1	1,4	1,5	< 1	< 1	< 1	1,7	1,2	10,3
10	< 100	< 1	< 1	< 1	< 1	< 1	1,8	1,9	< 1	1,1	1,3	< 1	< 1	< 1	1,8	1,1	9
11	< 100	< 1	< 1	< 1	< 1	< 1	3,2	3,2	1,1	1,3	2,1	< 1	< 1	< 1	2,7	1,6	15,2
14	< 100	< 1	< 1	< 1	4,2	< 1	11	10	3	3,9	4,5	1,6	< 1	< 1	4,8	3,1	46,1
19	< 100	< 1	< 1	< 1	4,2	< 1	11	10	3	3,9	4,5	1,6	< 1	< 1	1,4	< 1	1,4
20	< 100	< 1	< 1	< 1	< 1	< 1	1,2	1,4	< 1	< 1	< 1	< 1	< 1	< 1	1,7	1,1	5,4
23	< 100	< 1	< 1	< 1	< 1	< 1	1,1	1,2	< 1	< 1	1,2	< 1	< 1	< 1	1,7	1	6,2
27	< 100	< 1	< 1	< 1	< 1	< 1	1,9	2	< 1	< 1	1,1	< 1	< 1	< 1	2,2	1,1	8,3
33	< 100	< 1	< 1	< 1	< 1	< 1	2,1	2,3	< 1	1,1	1,4	< 1	< 1	< 1	2,4	1,3	10,6
36	< 100	< 1	< 1	< 1	< 1	< 1	1,4	1,5	< 1	< 1	1,1	< 1	< 1	< 1	2,4	1,2	7,6
GES*	**100**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1000**

Abbreviation: NFT – naphthalene; ACNFT – acenaphthene; FLR – fluorene; FEN – phenanthrene; ANT – anthracene; FRT – fluoranthene; PIR – pyrene; BZA – benz[a]anthracene; CHRZ – chrizene; BZB – benzo[b]fluoranthene; BZK - benzo[k]fluoranthene; BENZA - benzo[a]pyrene; DBAH – dibenzo[a,h]anthracene; BENZGHI - benzo[g,h,i]perylene; IND123 - indeno[1,2,3-cd]pyrene, SUM – sum of 15 PAH compounds.

* GES (Good Environmental Status) values is annual average concentration of pollutants in seabed sediments, mg/kg of dry weight.

Result below the established limit is marked as (< …).

4.4.3. Geologic Structure and Mineral Resources

4.4.3.1. Structure of the Sediment Column

In the bottom of the Baltic Sea, there are found sediments of various ages, origins, and compositions. The layer of sedimentary rocks in the Lithuanian marine areas is about 2 km thick. Depending on the intensity of sedimentation, the recent formation of sediments does not occur in some areas of the bottom; instead, deposits and rocks from previous geological periods are uncovered.

The upper part of the geological section consists of quaternary sediments. Thickness of the quaternary sediments greatly varies, i.e., from 5-10 m in plateaus to more than 100 m in paleosections. Under the quaternary sediments, there occur formations of the Middle and Upper Devonian periods (sandstone, siltstone, dolomite), Permian (dolomite limestone), Lower Triassic (clay, clayey siltstone, and marl), Middle and Upper Jurassic (argillite), and Lower and Upper Cretaceous epochs (Terigenic clay, siltstone, glauconitic-quartz sand).

The quaternary column of the Lithuanian waters in the Baltic Sea consists of three key lithostratigraphic complexes: Pleistocene glacial deposits (prevailing moraine loams and sandy loams), sediments (clays, sands) formed during various phases of Baltic Sea evolution (Late Glacial and Holocene periods), as well as recent marine sediments (sand, siltstone, mud). Deposits and sediments from the first two lithostratigraphic complexes are also known as relict deposits and sediments (Gulbinskas, 1995). They occur in hydrodynamically active areas of the sea where sedimentation no longer takes place today or, even, where bottom destruction occurs.

In the PEA territory, quaternary sediments are about 20–30 m thick. Beneath them, there are normally deposits of the Triassic, less often (in paleo-incisions) of the Permian period found. (Fig. 4.4.4).

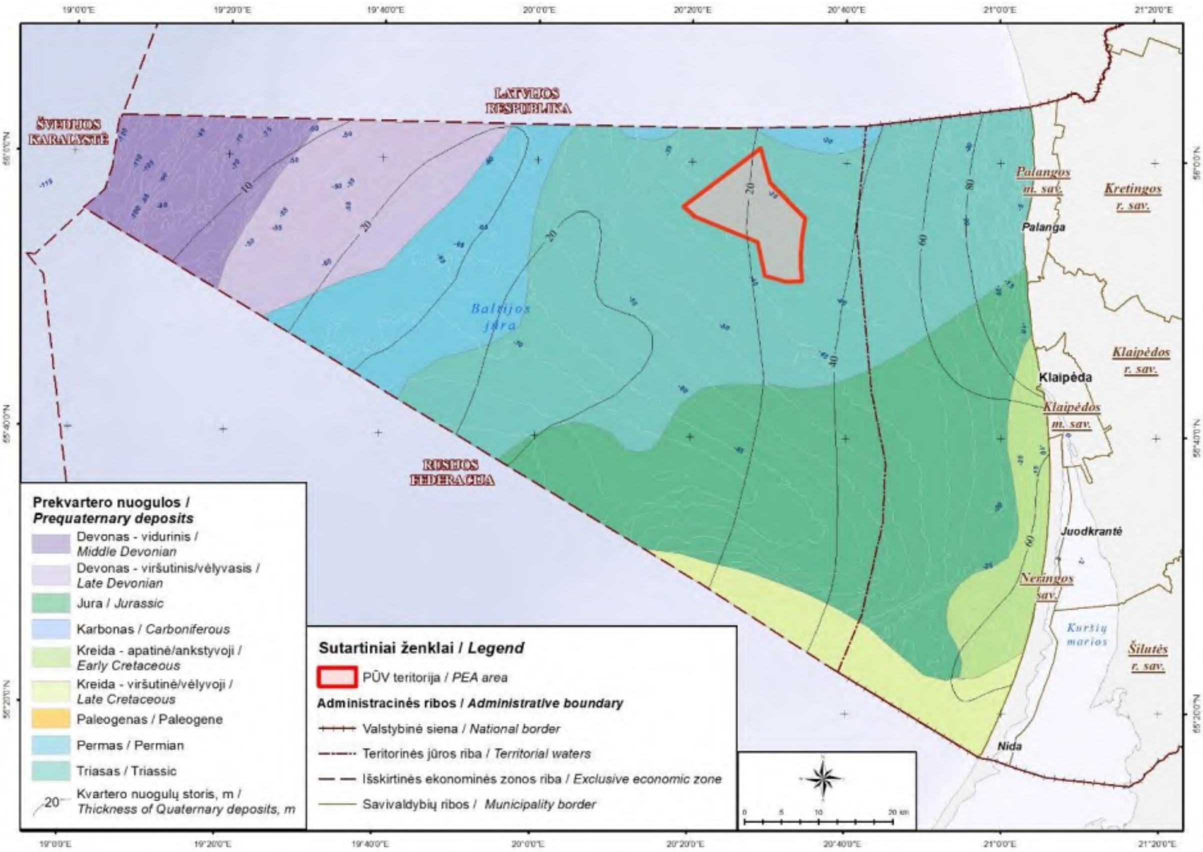


Fig. 4.4.4 Under-quaternary sediment prevalence and thickness of quaternary sediments.

4.4.3.2. Tectonic Activity and Seismicity of the Territory

In terms of tectonics, the Baltic Sea belongs to rather stable Eurasian lithospheric plate. Lithuania's part of the Baltic Sea mostly belongs to the Baltic tectonic depression spreading from northeast to southwest (Puura ir kt. 1991). The main evolution of this depression and up to 4 km tick sediments have formed during the Late Caledonian Orogeny (Grigelis, 2011). The tectonic history of the region is marked with several active stages; however, the main deep-see structure has formed during Hercynian Orogeny (Suveizdis, 1994). During the Late Cretaceous period, the seismic activity resumed, this time in southern Lithuanian and Kaliningrad Regions (Šliaupa, Holth, 2011). The contemporary tectonic processes are largely related to neotectonic processes as a result of restoration of post-Ice Age seabed surface (Puura ir kt. 1991).

The sea itself is very young, formed in the Quaternary age and, thus, continental glaciation and the process of deglaciation were of special importance in its short history. According to geological structure, morphology and history of development, the Baltic Sea depression can be divided into two parts: smaller south-western and larger north-eastern. While the southern (western) part is young and shallow and is ascribed to the West European Platform, the northern (eastern) part covering Lithuania's part of the Baltic Sea belongs to the East European Craton, which underwent very active tectonic processes in the Late Pleistocene. These processes in turn formed the main geomorphological and deep-sea structures (Šliaupa, 2004).

Compared with the neighbouring countries, seismic activity in Lithuania is relatively the lowest. It is conditioned by post-deglaciation glacio-isostatic processes and partially minor seismic events related to earthquakes from remote zones of seismic activity. Major natural earthquakes registered in the Kaliningrad Region, in the coastal areas of the Baltic Sea in September 2004 reached the magnitude of 4.8 and 5.2, respectively (https://www.lgt.lt/index.php/apie-lietuvos-zemes-gelmes/seismologija/biuleteniai).

Vertical glacio-isostatic crust movements can reach up to 2 mm per year. As the glaciers have retreated, the generated horizontal pressure force gradually subsides yet still can provoke activity of older fracture systems, especially in the neighbouring Latvia and Estonia, In Lithuania, these processes are much weaker, the tectonic activity is thus the least, compared with the adjacent territories (Šliaupa ir kt., 2004).

In the territory under study, the fracture system, and the zones of potential secondary seismic activity, coincide with the scheme of potential oil structures because the oil structures form in sites of dislocated (through fractures) deep-sea oil-bearing layers (Fig. 4.4.5.).

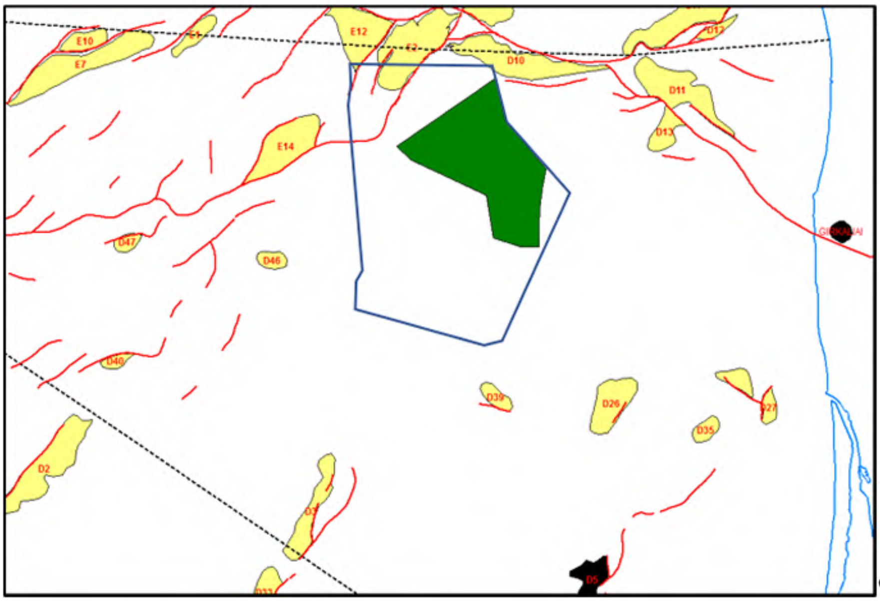


Fig. 4.4.5. Scheme of deep-sea fractures and potential oil structures in Lithuanian EEZ (green: the PEA area). Scheme prepared based on: Report on geophysical measurements in the Baltic Sea Curonian Area

1984-1985. AB Petrobaltic, 1985; Comprehensive seismic measurements in the Baltic Sea region, near the territory of the Republic of Latvia. Riga, 1992; Consolidated maps of the Baltic Sea Curonian Area, scale 1: 100 000. VO Tekhnoexport, Moscow, 1985.

Although only part of seismic event (historical and device-registered) in the Baltic region are likely to be related to the tectonic fractures, it nevertheless can be stated that the territory under study for the proposed WT farm is relatively least affected by the tectonic activity; the least density of deep-sea fractures and relatively small number of strong earthquakes with magnitude over 4). Given that the PEA territory is adjacent to considerably large potential oil structures, additional deep-sea seismic measurements were completed (Sea Bottom Surveys, Part I, 2022), which revealed that the main potential oil structures are outside the area of the measurements (Fig. 4.4.6.).

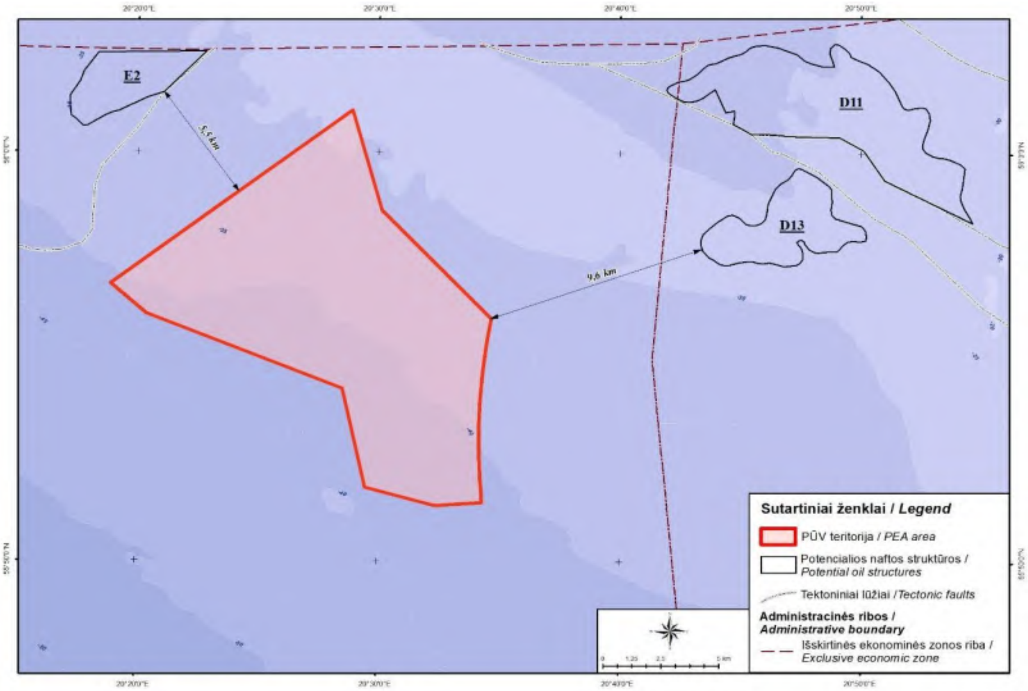


Fig. 4.4.6. Specified sites of potential oil structures (E2, D11 and D13) in respect of the PEA territory (as per data of the Sea Bottom Surveys, Part I, 2022)

4.4.3.3. Mineral Resources

Oil. According to the Lithuanian Geological Survey on potential oil structures in the Lithuanian marine area (Fig. 4.4.7.), the Lithuanian EEZ is supposed to store about 40–80 million tons of oil.

Chapter 8 of the solutions of the Comprehensive Plan of the Territory of the Republic of Lithuania 2030 "Preservation and usage of resources, development of bio-production economy," p. 465, states that regulation for the development of oil resources in the maritime part shall be envisaged in coordination with other activities (wind energy, shipping, etc.), internal, inter-sectoral, and international cooperation shall be promoted and enhanced (Lietuva 2030, 2021).

The PEA territory does not fall within the known potential oil locations (Fig. 4.4.6.). Therefore, no additional measures for the installation of WTs in the PEA area are required in terms of potential oil extraction perspectives.

Sand and Gravel. The sand and gravel resources in the Lithuanian EEZ have not been yet explored or included in the state register of mineral resources as a mineral deposit. Nonetheless, there have been found accumulations of these resources during the geological mapping. The most intense sand dispersal is found in the hydrodynamically active area up to 20 m. The sand in this area, however, maintains the dynamic balance of the coastline, nourishes the beaches, and is prohibited from usage due to the environmental and coastal protection constraints.

Another range of sand dispersal is found on the south-eastern slope of the elevation of Liepaja – the Klaipėda-Ventspils Plateau – the Curonian-Sambian Plateau and its north-western slope (Fig. 4.4.7.). In these areas, the occurrence of sand and coarse-grained sediments is associated with the coastal formations of the transgressive and regressive phases of the Baltic Sea. Such ancient sediments are often covered with recently formed sea sands. The thickness of the sands reach 5 meters and more.

In this marine area, there are two locations defined as potential sources of sand for shore management:

- The south-eastern slope of Klaipėda-Ventspils Plateau, 25-30 m deep, coastal formations of the transgressive and regressive phases of the Baltic Sea. Sand dispersal over relatively large areas on the slopes of the plateau. A sand layer thickness reaches 1 metre and more.
- On the surface of the Curonian-Sambian Plateau, there are found relict formations of the Ice Age or the Baltic Sea evolution stages. Sea depth is 20-30 metres. Sand dispersal range is the largest here; a layer thickness is over 3 metres.
- In Preila-Juodkrantė district, the most promising elevation area is between 20-27 m isobaths. When implementing the Coastal Strip Management Programmes, the sand from the district of Preila - Juodkrantė was used for restoration of beaches of Palanga.

There are no approved sand deposits in the PEA territory.

Amber. The world's largest amber deposits are found on the Sambian Peninsula, the current Kaliningrad region. Here, near the small village of Yantarny, the world's largest amber reserves are extracted in the open-cast mine. Despite the immediate vicinity, there are no large amber deposits in Lithuania. Small deposits of amber are found near Priekulė, next to the King Wilhelm Channel, as well as in the districts of Preila, Juodkrantė, and Nida, though, of minor commercial significance. There are no known amber deposits in the PEA territory.

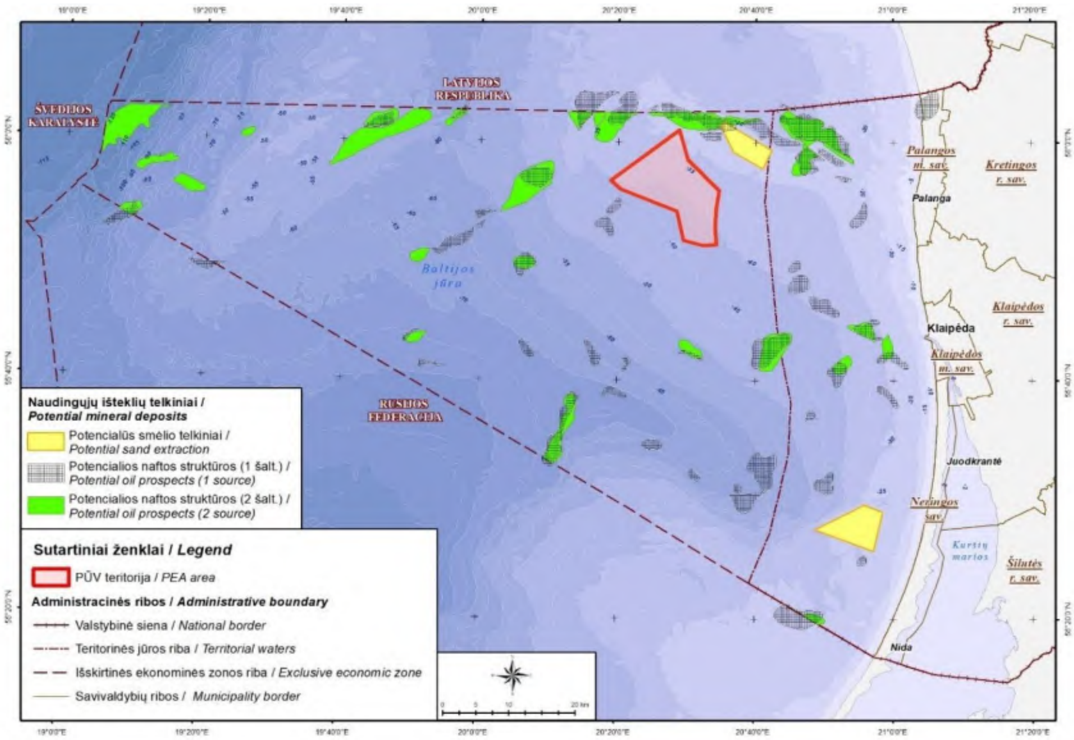


Fig. 4.4.7. Layout of the PEA arear in respect of mineral deposits. Legend: source 1 - Underground Register, Lithuanian Geological Survey, Deposits of underground resources (with borders); source 2 – as per Fig. 4.4.4.

4.4.4. Anthropogenic Objects at the Sea Bottom

Side scanning was carried out complete an acoustic survey of the seabed surface (Sea Bottom Surveys, Part II, 2022) and develop a catalogue of acoustic reflections off seabed objects and a scheme of distribution limits of geologic structures and different types of sediments. 858 objects (Fig. 4.4.8.) were selected, which are recommended to take into account during the next stage, the stage of engineering geological and liquidation of unexploded ordnance (UXO) and cleaning of cable trenches from dangerous objects organised by the developer, before the future developer begins the drilling or installation of foundations.

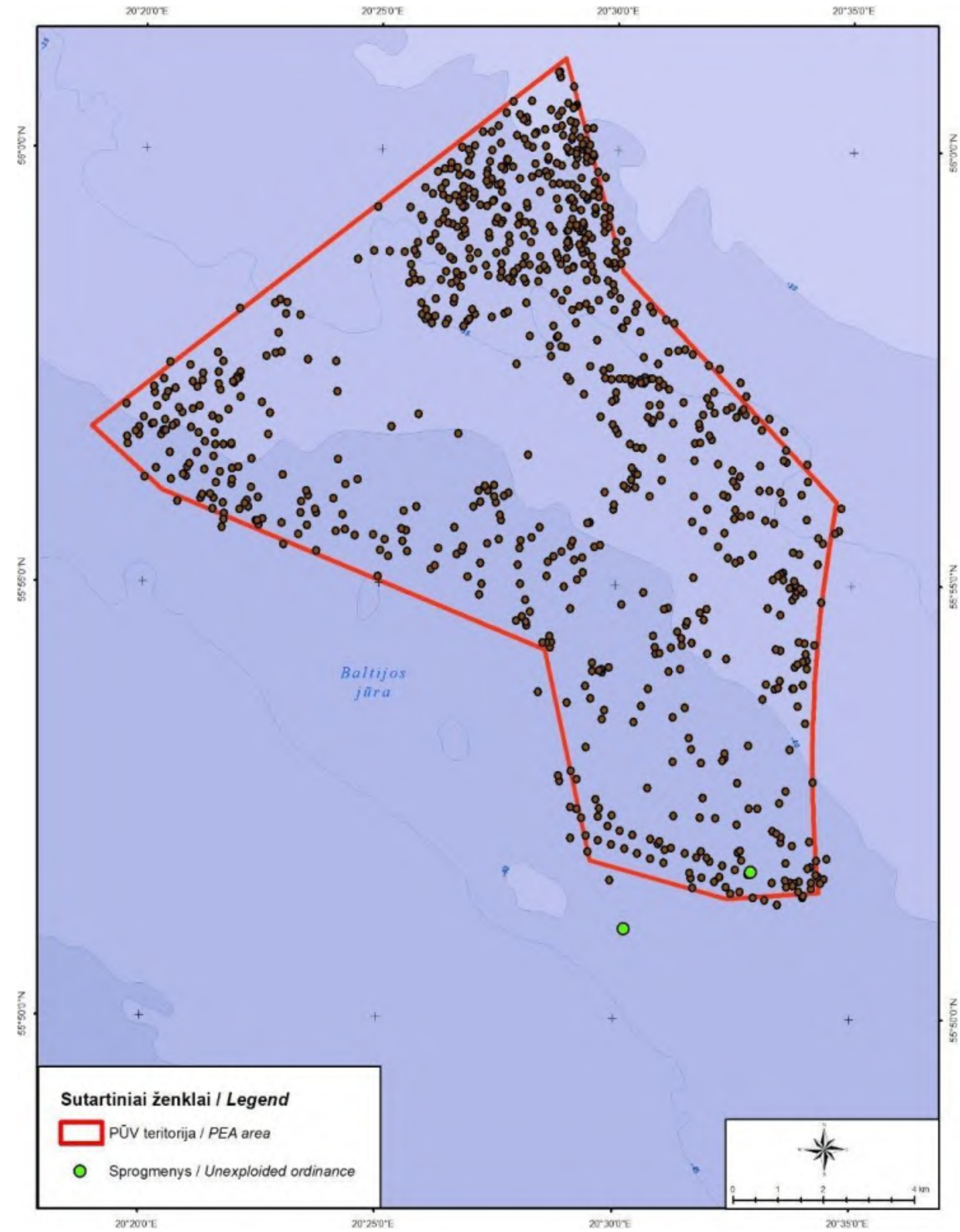
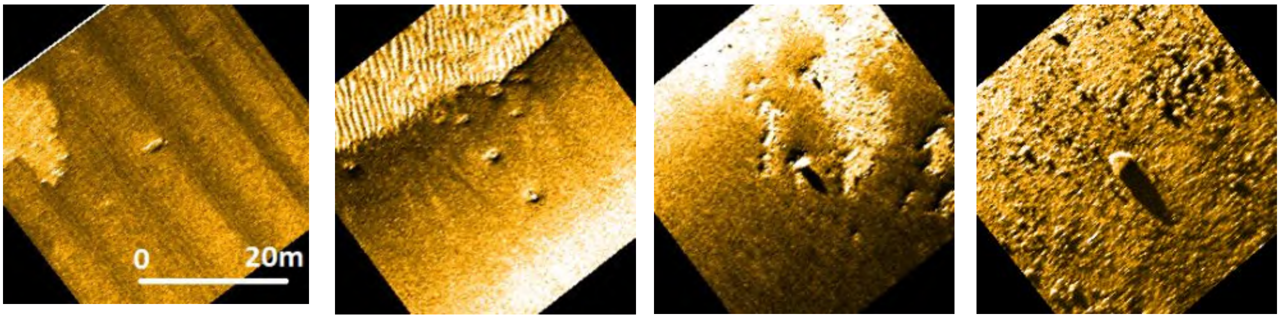


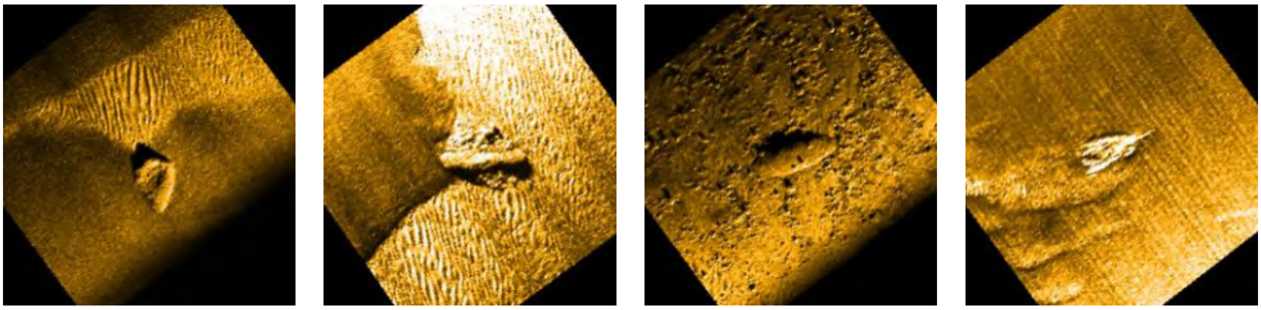
Fig. 4.4.8. Seabed objects. (source: Sea Bottom Surveys, Part II, 2022)

Preliminary classification of objects is solely based on visual assessment. Because both anthropogenic both large natural objects can have an impact for the planning of sites for the installation of foundations and cable trenches, the catalogue of objects provides a complete code collection of the objects with specification of object's centre coordinate and preliminary length and width. The following were detected:

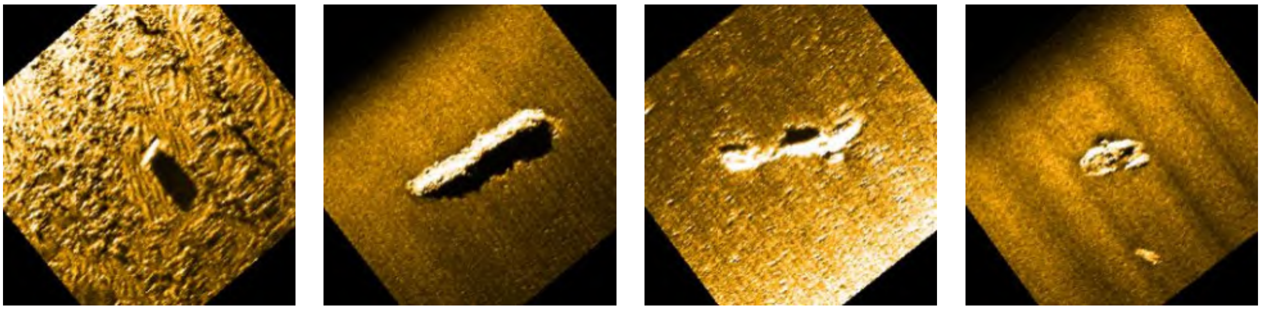
- 496 natural objects (samples below) are mostly individual boulders of a larger, over 2 m, diameter, more expressive relief forms, geologic objects (blocks, moraine protrusions, potholes, and other bodies looking like natural objects);



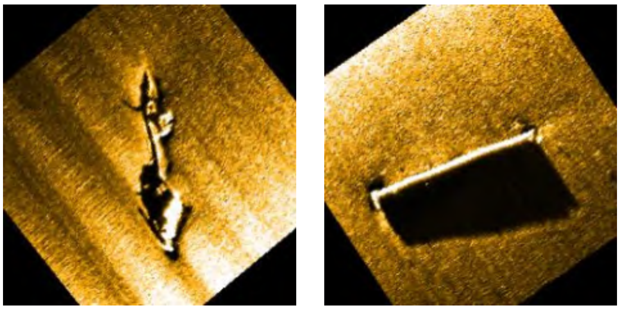
- 276 potentially natural objects that are questionable in terms of their natural and/or anthropogenic nature because of their distinctive acoustic qualities and/or geometry of the object itself, i.e. sharper or regular angles, acoustic shadow which is longer than that of the surrounding natural objects;



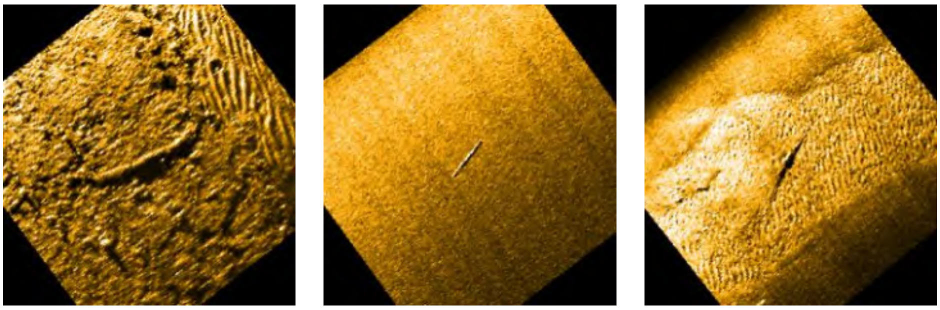
- 58 potentially anthropogenic objects that are less similar to the above-mentioned 'potentially natural';



- 2 especially similar to artificial, anthropogenic objects, which are preliminary classified as anthropogenic;



- And 24 distinctive linear objects, which are generally not natural, yet, may be a product of certain specific natural structures.



Identified anthropogenic objects underwent an additional assessment from the perspective of archeologic/cultural heritage (see part of archeologic studies) and military/unexploded ordnance. Two explosives were identified during additionally military exercises within the limits of southern area under study (the studies were conducted long the historical mining line): one within the PEA borders and another nearby, both destroy in site (Fig. 4.4.8.).

Archeologic studies identified no cultural values. However, the identified explosives show that there is still a probability of UXO remaining in the area. Therefore, it is recommended either to avoid the sites with the identified objects or to conduct additional studies prior to commencing the seabed dredging and foundation installation to make sure that the identified objects cause no hazard for the performance of economic activity. Please note that the marine forces conduct regular mine detection and liquidation, if such are detected, in Lithuanian waters, including the PEA area.

The conducted survey of magnetic anomalies in the area (Sea Bottom Surveys, Part II, 2022) revealed a distinctive linear anomaly in the north-south direction, i.e. a potentially submarine cable, in the western segment of the PEA area (Fig. 4.4.9.). Although it was not possible to detect this object on the seabed surface, it may be partially covered with surface sediments and/or seabed vegetation. The future developer, thus, has to consider how much this object could interfere with the installation of the WT farm and, if required, provide for additional studies and/or obstacle elimination at own expense before commencing the design of the sites for the installation of foundation and cable trenches.

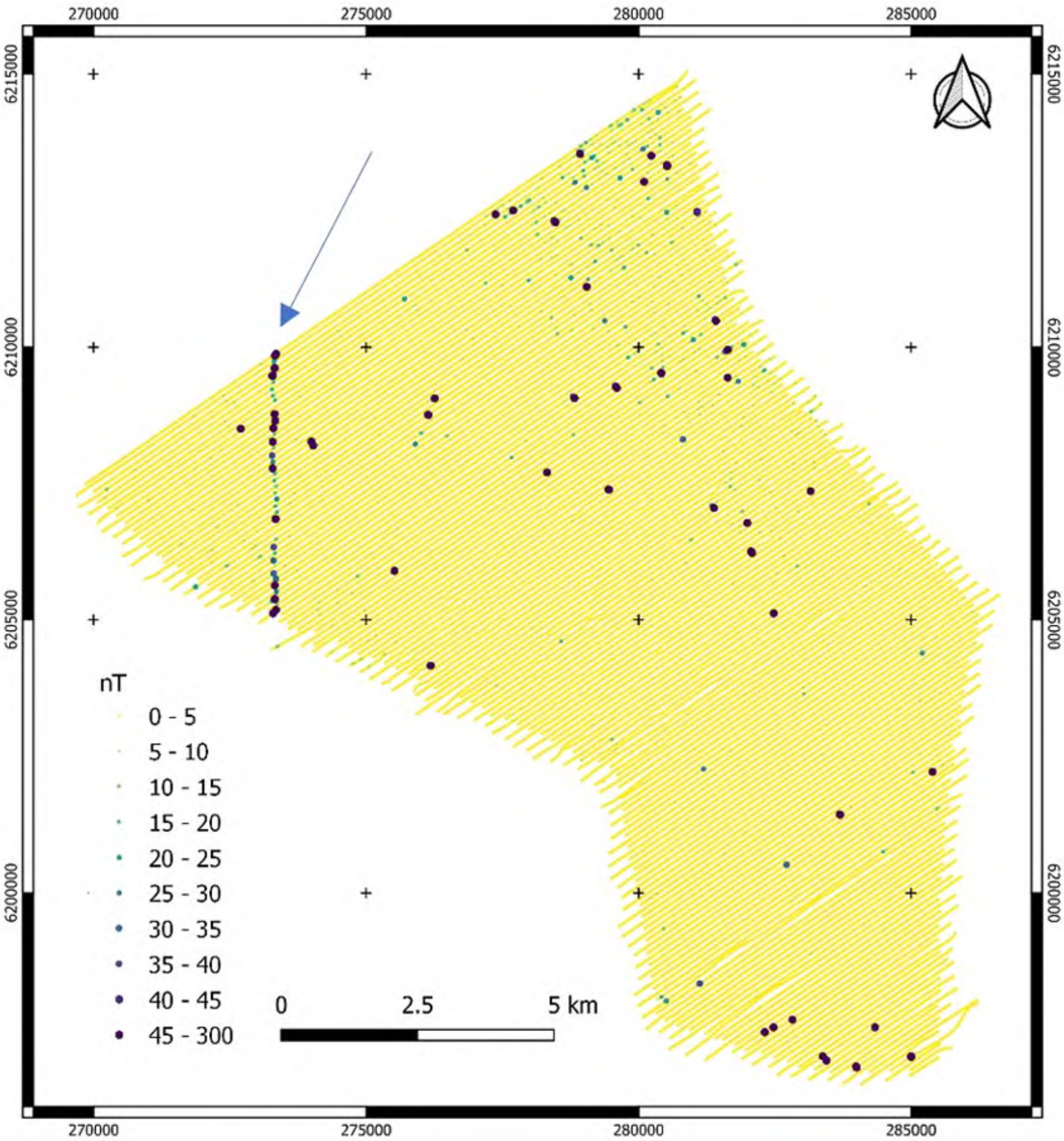


Fig. 4.4.9. Magnetic field gradient (anomaly) and potentially, the site of submarine cable. Source: Sea Bottom Surveys, Part II, 2022.

4.4.5. Potential Impact on Seabed

There are two categories in terms of impact on seabed:

1. Impact on environmental components due to installation of wind turbines during construction;
2. Impact on wind turbines and the related infrastructure due to the existing geologic conditions.

With consideration of seabed structure, type and distribution of surface sediments and the formation of the related valuable seabed habitats, it can be stated that the impact on seabed essentially can only be local and relatively low. Predominantly, the negative impact is related only to the partial disturbance of the seabed and secondary sedimentation in the sites of installation of foundations and cable tranches. Damages to value seabed habitats are also possible provided that there are land disturbance are scheduled in the area during construction design.

In terms of wind turbine infrastructure, it is crucial for the installation of foundations how stable is the geological structure of the seabed, how easily the sediments are excavated in the sites o cable installation and how easily the sites of secondary erosion can occur in the sites of installation of wind turbine infrastructure, which could have a negative impact on stability of the structures and safety of the engineering infrastructure. Moreover, it is important to assess the seabed objects, their potential hazard for the operations safety and/or for the selection of crucial structural solutions.

The 2002 study conducted by the United Kingdom scientists (Cooper, Beiboer, 2002) has assessed the potential impacts of offshore WTs on the coastal area processes with an special focus on the scale of changes in waves, current and sediment regime and its further impact on the general silt flow. The generalised results of the simulation allowed for a conclusion that the impact of WTs on waves, currents and sediment transportation is insignificant: The wave speed after colliding with the wind turbines reduces by less than one percent, while the direction alters by approx. 0.5°, and the wave height reduces by approx. 0.5–1.5 %. Dislocation of WTs further away from the main silt flows also has no significant impact on changes in the direction of sediment transportation. In Lithuanian coastal areas, the main silt flow covers the 1–1.5 km coastal area; therefore, wind turbines installed in the PEA territory, more than 29 km way from the shore, will have no significant impact on coastal dynamics and dynamics of sediment transportation.

A greater impact is possible in the north-eastern part of the territory, where glacial sediments are prevalent (see Fig. 4.4.3.). Gravelly accumulations of sand of various size and boulders in this area are the soil potentially favourable for the valuable habitat of *Mytilus Crustacea*. The seabed fauna studies conducted (see Section 4.5.2.2. Seabed Habitats) revealed that this substrate shows abundant accumulation of the stated mussel, which is important for the nearby established Natura 2000 reef and bird habitats feeding here. When planning the layout of WT foundations and cable routes, it is recommended to avoid the destruction/damage of sensitive bottom areas - move the WTs away from the south-western border of the protected area (at least 2 km), or - in order to maximize the use of the PEA area - before planning the construction of WT, perform additional bottom survey - to clarify the distribution zone of the valuable bottom habitat and to avoid the construction in this zone as a preventive measure.Please note that this area mostly coincides with the areas important for birds in the PEA area and, thus, the measures required for the protection of birds applied (see Section 4.5.2.4. Birds and Bats) would also protect the valuable seabed habitats.

Potential negative impact on the objects of cultural heritage is possible in sites where potentially anthropogenic remains are identified. To remove them or to conduct a seabed disturbance in their vicinity requires additional archeologic studies. No potentially archeologic findings were reliably detected in the area of study. No additional archeologic studies and/or measures for the protection of objects of maritime cultural heritage are required.

Since the PEA territory does not coincide with areas of occurrence of oil, sand or other valuable mineral resources, no negative impact on natural resources is expected, as well.

Formation of washouts in loose soils (sandy sediments) is typical for pile foundations. The risk of formation should be examined during the design of WT structures because it is crucial for the stability of wind turbines and, to a lesser extent, for geologic environment. To avoid washouts, seabed reinforcement with gravel or boulders is installed near the foundation. Due to intensive seabed currents, washouts may occur in cable trenches, as well. Therefore, the monitoring of seabed condition in the sites of both foundations and cable trenches is a standard procedure to be performed by the PEA operator during the post-construction and operation of the wind farm.

For laying high-voltage cables on the seabed, two main technological methods are used: Inside the trench or covering the cable laid directly on the seabed with massive concrete covers or a sand or gravel cover. Subject to geologic conditions and soil characteristics, it is possible to dig the trenches using special marine plough or a high-pressure water jet.

In all cases, the impact on seabed is local and minimum. The trenches are dug up to 2 m deep, subject to the equipment used, and up to 3 m wide at the most. When cable-laying plough is used, the impact is especially short-term since the trench is filled at the same time with the same sediments that were dug while laying the cable. The cable laying technology is used only under specific conditions, when the trench digging is not possible or expensive in terms of technology.

Table 4.4.1. Summary table for impact on land subsurface:

Component	Phase	Impact	Nature	Scale	Duration	Significance	Measures
Seabed	Design	Impact on seabed during installation of foundation	Direct. Upper layer of seabed sediments at the depth of foundation structure installation is affected; Potential damage to valuable seabed communities	Local in the site of WT tower and cable trenches installation	During construction only	Low	Additional studies are required to identify most sensitive seabed sites, where physical seabed destruction is recommended to be avoided
	Operation and maintenance	Potential impact on seabed due to washouts near foundation and in cable trenches	Direct. Upper unstructured layer of seabed sediments at the depth of foundation structure and cable trench installation is affected	Local in the site of WT foundation and cable trenches installation	After construction, during operation	Low	Additional fortification of seabed bear foundation
	Decommissioning	Potential impact on seabed provided foundation is to be dismantled	Direct. Upper layer of seabed sediments is affected	Local in the site of WT tower dismantling	During dismantling only, if the WT tower foundation is to be dismantled	Insignificant	Not applied

(cyan box) – Insignificant impact (consideration is optional, measures not applied)

(yellow box) – Low impact (solutions at the design stage, preventive measures).

4.4.6. Impact Mitigation Measures

Measures reducing the impact on environmental components are as follows:

- To protect the valuable seabed habitats, it is recommended to prevent the development of WTs in the identified sites of accumulation of valuable seabed biotopes, i.e. in the area of occurrence of sediments containing boulders and gravel and sand of various size (north-western part), where the large accumulations of *Mytilus Crustacea* were detected, or avoid WT development in the 2 km buffer zone from SW margin of the adjecent Natura 2000 site. This would allow preventing the direct negative impact on the quality and restoration of the said habitats.
- To avoid an excessive fragmentation of seabed sediments and formation of new lithologic types due to secondary sedimentation in the sites of damages oils, it is recommended to use eco-friendly technologies that allow minimizing the impact on the seabed at the time of cable trench digging and to use the original soil, which was dug from the same trenches, to the maximum to fill back the trenches provided that construction technologies allow for this.
- Since no potential objects of cultural heritage were identified in the PEA area, no special measures are required. However, during the design it is recommended to avoid the identified potentially anthropogenic objects, also to avoid or provide for the seabed cleaning at the sites of concentration of unclear objects. In case WT needs to be installed in the area close to the identified object (within 10 m distance), it is necessary to organize additional investigations allowing identification of the objects cultural value and/or the risk to the WT itself.

Measures reducing the potential impact on wind turbine infrastructure are as follows:

- To reduce the potential risk for foundations and cables due to seabed washout, it is proposed to carefully assess the lithologic conditions of the surface sediments and, if required, it is recommended to apply additional fortification around the foundation piles during construction;
- Prior to commencing the detailed WT and cable trenches design, the future contractor the unexploded ordnance (UXO) studies, which would also allow assessing the site and danger of unidentified historical cable (in the western part of the PEA area, see Fig. 4.4.9.);
- It is recommended not to plan cable trenches in the areas of high-amplitude seabed relief (steep slopes or deep ravines) changes to avoid potential damages to the electricity transmission system, also to provide for the procedures of partial equiplanation in the sites of cable trenches.

4.5. Landscape

4.5.1. Current situation

4.5.1.1. Overall landscape character and values

The area of the proposed economic activity (PEA) is located in the maritime area of the Republic of Lithuania, in the exclusive economic zone (EEZ), in the contiguous sea, on the Baltic Sea shelf, in the south-western part of the underwater coast slope of the seabed elevation known as the Klaipėda-Ventspils Plateau, more than 29 km from the coastline (Fig. 4.5.1).

The proposed wind turbines (WT) will directly affect the area where they will be built, and they will have an indirect or visual effect also on the sea areas eastwards from the PEA area throughout the entire Lithuanian contiguous zone, the territorial sea, the nearshore, the coast, the Curonian Spit and the Curonian Lagoon, and the coastline, in particular the western part of Lithuania in Kretinga District, Klaipėda District and the western parts of the municipalities in Šilutė District (Fig. 4.5.15, 4.5.16).

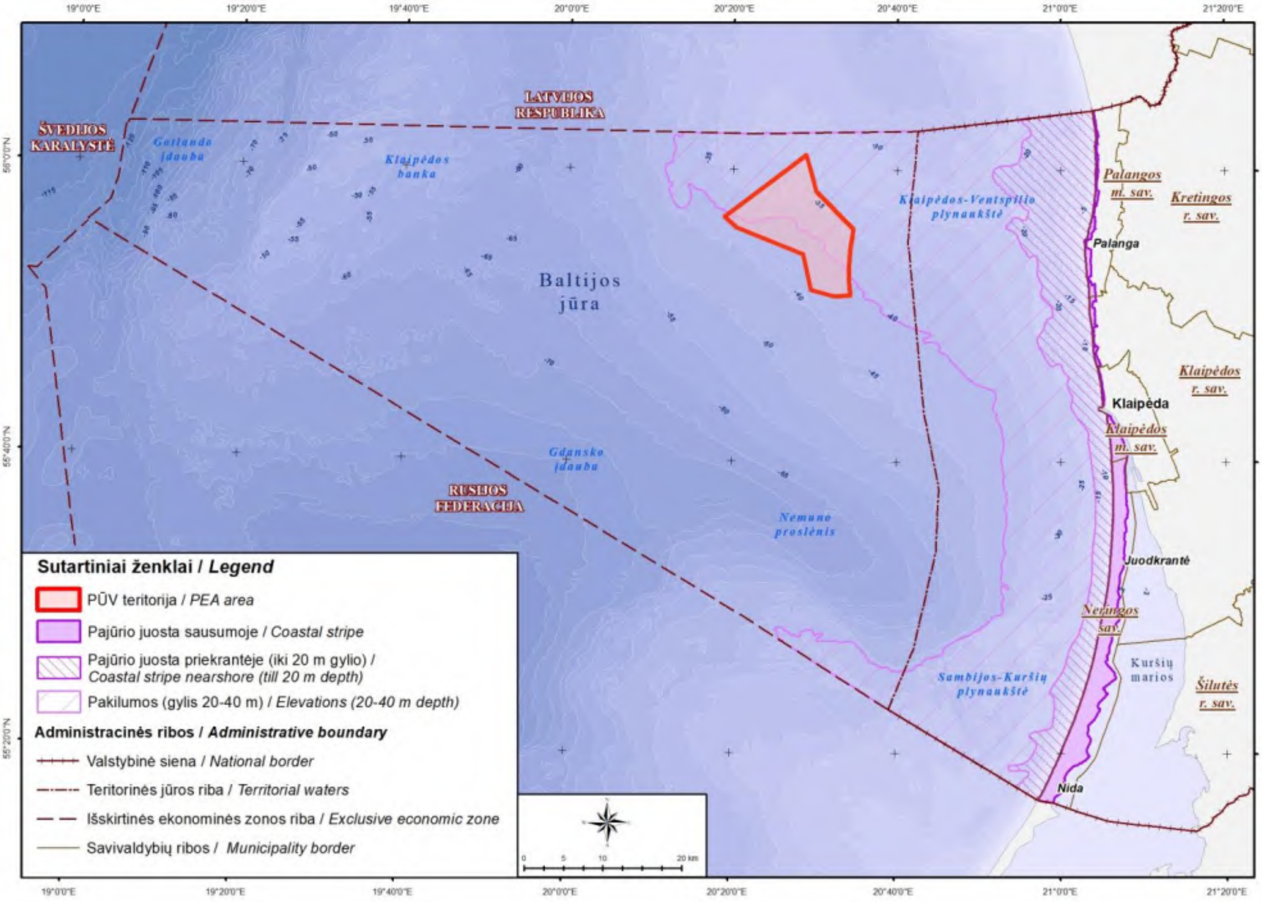


Fig. 4.5.1. Geographical location of the PEA

The PEA buildings are likely to be visible from various parts of the Coastal Lowland and in some places further afield from the Western Samogitian Lowland (Fig. 4.5.1, 4.5.2).

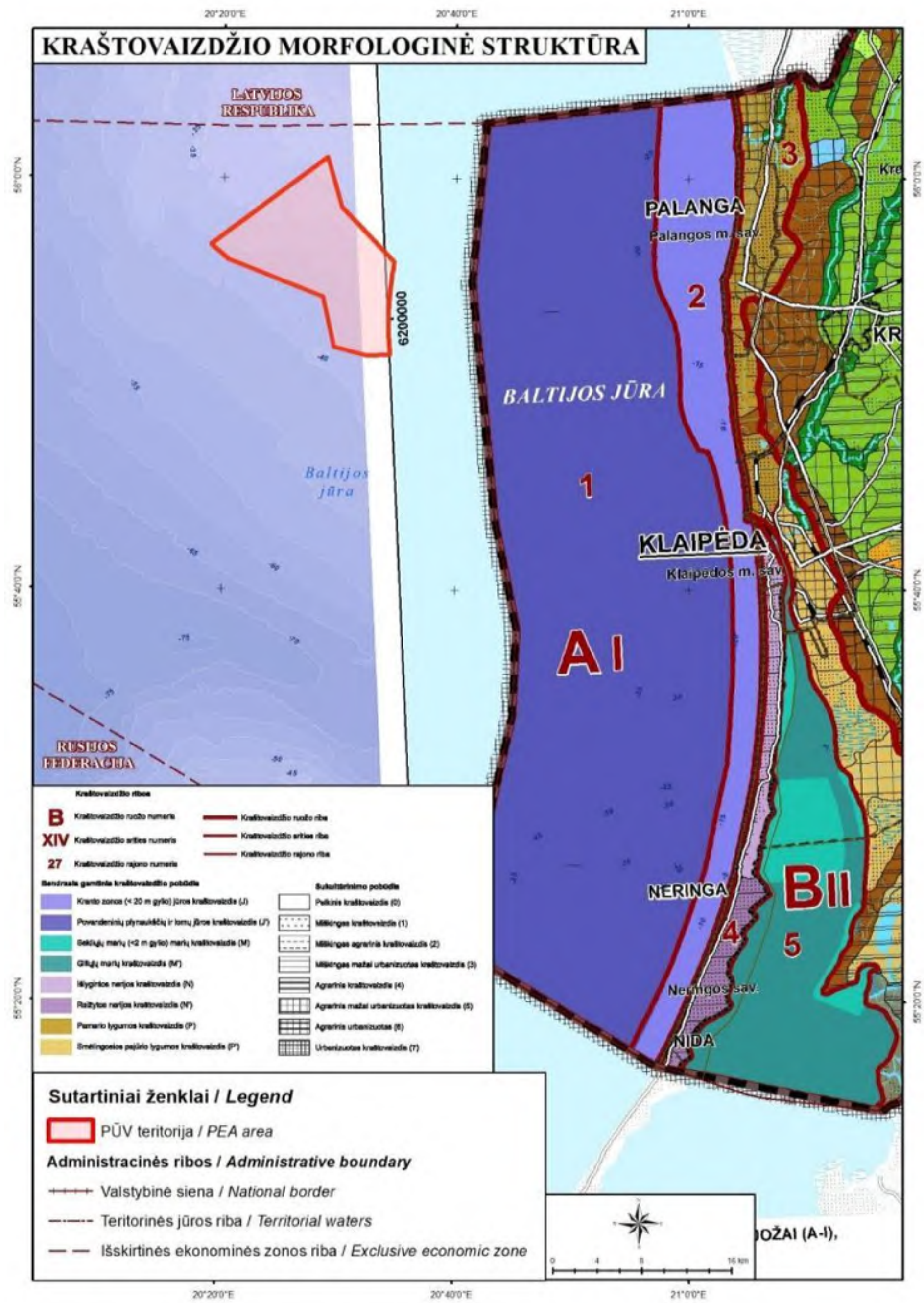


Fig. 4.5.2. Morphological structure of the landscape of the Lithuanian sea and coastal region (an extract from the current status drawing 'Morphological structure of the landscape' of the National Landscape Management Plan (NLMP)[1])

Fundamental values of the landscape. The rarity of the landscape character determines the extent to which it is a landscape resource in Lithuania, and the relative size of the space to be cultivated by the new PEA.

The coastal lowlands are home to very different types of small landscape areas that are rare in Lithuania: the urbanised wooded Baltic Coastal Plain (BII 3, accounting for 0.27% of Lithuania's territory), the thinly populated wooded Curonian Spit that is protected as a national park and a World Heritage Site (BII 4, 0.16% respectively), the Curonian Lagoon (BII 5, 0.64%), and the urbanised agrarian plain of the Nemunas Delta Plain (BII 5, 1.23%) (NLMP[2], see Fig. 4.5.2).

The degree of cultivation determines the level of significance of the semantic cultural contrast between the anthropogenic objects of the region under consideration and the PEA solutions in question. Despite a few local anthropogenic objects (Klaipėda State Seaport piers, Palanga pedestrian bridge or Būtingė oil terminal buoy), the Baltic Sea and the Curonian Lagoon inland waters of the Republic of Lithuania have not been cultivated and the degree of their urbanisation in 2022 was nil.

Other landscape morphologies in western Lithuania have a degree of cultivation/development of 7.23% in the urbanised wooded Baltic Coastal Plain (BII 3), 5.44% in the urbanised agrarian Nemunas Delta Plain (BII 5), and only 1.85% on the thinly populated wooded Curonian Spit (BII 4). Despite the greater forest cover of the Seaside Regional Park area and the restrictions on construction applied there, the Baltic Coastal Plain with the Klaipėda-Palanga agglomeration is one of the most built-up regions in Lithuania, with two out of four districts with >5% built-up area (NLMP).

In terms of the semantic cultural contrast, most of the anthropogenic and engineering elements are situated near Klaipėda. Therefore, the engineering structures planned for the Klaipėda section are likely to be perceived as less contrasting than those in recreational or conservation areas.

4.5.1.2. Aesthetic potential and values of the landscape

According to the National Landscape Management Plan[19] (hereafter 'the NLMP'), Lithuania's Baltic coastline (the beach and the coastal dunes) is assessed as an area of high aesthetic potential (AP) in Lithuania as a whole, with the highest values (very high AP) on the Curonian Spit and the Karklė (Dutchman's Cap) stretch.

The Curonian Lagoon landscape is considered to be an area of above-medium AP. In the Coastal Lowlands, east of the coastal strip, medium to below-medium AP prevails (Fig. 4.5.3). The landscape of enclosed or semi-enclosed spaces of the protective dunes of the continental wooded coastline on the coastal strip (V1-2H1-3) is recognised as more scenic than the Coastal Lowlands and Plains, but not as distinct country-wide, where only one visual space with single vertical or horizontal dominants of larger or smaller size is usually observed (Fig. 4.5.3).

The Curonian Spit (hereinafter 'the CS') has the highest aesthetic landscape potential and is characterised as a landscape of particularly distinct and medium vertical fragmentation, semi-enclosed and enclosed spaces, while the area of the Nagliai Nature Reserve boasts a landscape of particularly distinct and medium vertical fragmentation of open spaces. The entire Curonian Spit is subject to particular protection under the NLMP as an area with the highest aesthetic potential in Lithuania (Fig.s 4.5.3 and 4.5.4). Since 2000, the Curonian Spit National Park has been protected by UNESCO as a World Heritage Site and a global-level protected area. The CS panorama and outline from the Curonian Lagoon is one of the attributes of the outstanding universal value of this UNESCO site.

According to the Curonian Spit National Park Landscape Structure Scheme (P. Kavaliauskas, State Service for Protected Areas, State Enterprise Land Fund, 2018), the main visual orientation axis of the CS is the grand dune ridge, which forms the major spatial divide between the spatial basins of the Baltic coast and the nearshore of the Curonian Lagoon. In addition, a small spatial divide (the protective dune ridge) is also distinguished, separating the nearshore. In both spatial basins, separate and distinct, homogeneously perceived spaces (videotopes) are to be distinguished, the boundaries of which correlate with the boundaries of the defined landscape surroundings. The steep slopes of the dunes and the tops of the distinct great dunes, which concentrate the main directions of observation, are also of particular visual importance on the CS.

The Curonian Spit is characterised by the abundance of landscape spatial units of exceptional complex value (1/2 of all localities and almost 3/4 of the vicinities). This is due to the uniqueness, naturalness, conservational and recreational value of its landscape. It is this that shapes the identity and image of the CS landscape (P. Kavaliauskas, 2018).

[19] National Landscape Management Plan, approved by Order No. D1-703 of the Minister of Environment of the Republic of Lithuania of 2 October 2015..

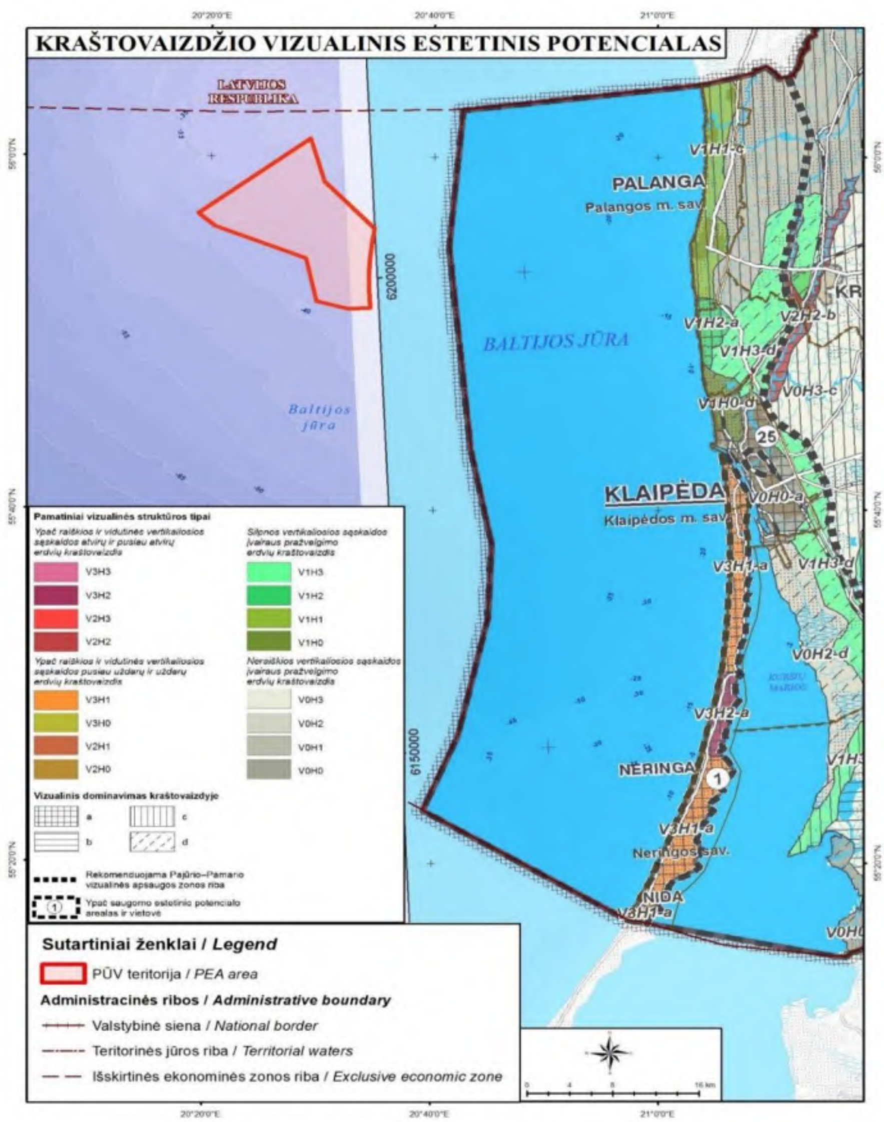


Fig. 4.5.3. Aesthetic potential of the landscape of the Lithuanian sea and coastal region (an excerpt from the drawing 'Visual aesthetic potential of the landscape' in the Solutions Part of the National Landscape Management Plan)

The main visual spaces (videotopes) for which it is important to analyse the visual impact of the PEA (the potential east-west visibility) in the region under consideration are:

1) the Curonian Lagoon visual space (the view from the eastern shore of the lagoon, the lagoon water area to the Curonian Spit);
2) the Baltic Sea main visual space (a) the view from the Curonian Spit and the highest points of the mainland coast to the west, and the subspace (b) the view from beaches on the mainland and the Spit;
3) the eastern visual space of the mainland coast up to the coastal strip.

In terms of aesthetic resources, the Curonian Lagoon visual space is the most vulnerable (sensitive) (1); in terms of recreational resources, the main visual space of the Baltic Sea on the mainland and spit coast is the most vulnerable (2). Based on this, these zones are assessed in greater detail.

The PEA area does not fall within the highly protected areas of aesthetic potential defined in the NLMP (Fig. 4.5.4).). However, it can potentially be observed from the Curonian Spit, which is located between the NLMP-designated areas and sites of highly protected visual aesthetic potential of Lithuania, highly and moderately distinct landscape complexes of very high and high aesthetic potential (AI, AII, AIII landscape visual structure types) (hereinafter 'highly protected landscape or HPL areas'), Klaipėda Old Town (an HPL area) and the Akmena-Danė valley.

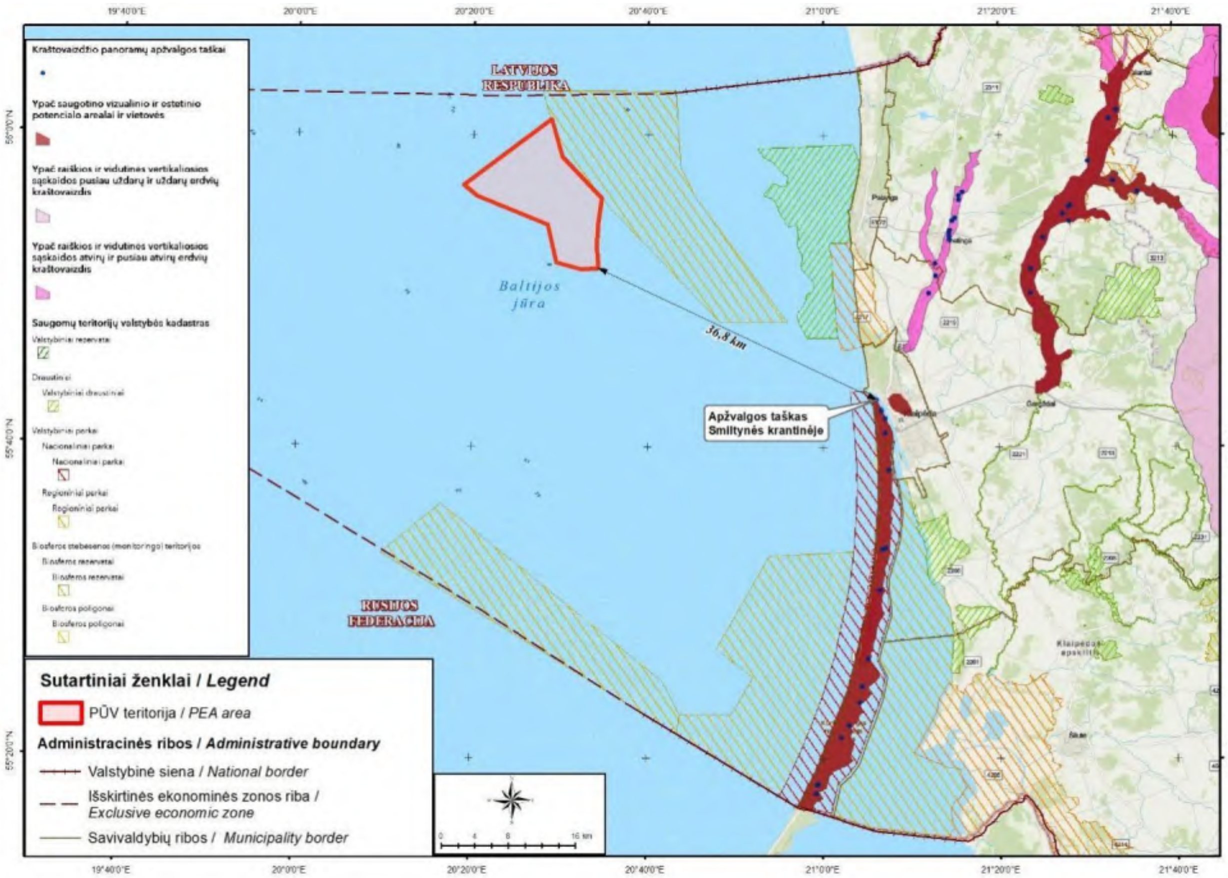


Fig. 4.5.4. PEA area in relation to the most valuable areas and panoramas of the Lithuanian landscape (an excerpt from the map of the most valuable panoramas of the Lithuanian landscape, State Service for Protected Areas.[20]

The map of the most valuable panoramic viewpoints of the Lithuanian landscape (hereafter 'the VLKPAT') (Fig. 4.5.4).) shows the HPL area in Klaipėda Old Town, the landscape of open and semi-open spaces of particularly distinct and medium vertical fragmentation in the Akmena Valley (9 viewpoints) and the further visually significant area in the Minija Valley, but their aesthetic values are not associated with marine panoramas (the direction of monitoring is not specified).

Visual monitoring of the landscape is carried out within the framework of the Lithuanian State Environmental Monitoring Programme 2018-2023 (Register of Legal Acts, 2018, No. 15880). In 2021, the Directorate of the Curonian Spit National Park (CSNP) conducted landscape monitoring in accordance with the plan approved by Order No. D1-711 of the Lithuanian Minister of Environment of 29 November 2019 under which visual monitoring of the landscape is carried out not at all 17 points identified on the VLKPAT. Until now, visual monitoring and aesthetic potential assessments in the national parks have been related to the attributes of their outstanding universal value. They do not include marine panoramas, nor do they consider views to the west (e.g. the CSNP assesses the level of visibility of the Curonian Spit peninsula, the dune ridge, the settlements, the architectural landmarks, etc.).

[20] Most valuable areas and panoramas of the Lithuanian landscape, VSTT. https://vst-t.maps.arcgis.com/apps/webappviewer/index.html?id=80388c28c00845d9a9792bb01cd936df&fbclid=IwAR1zQPTJtJYwQ_Udg-dxVrfexT7IzesZ45I34wFHxoBH3t0CvTJSU5q9rsM.

4.5.1.3. Visibility conditions

Visibility is the distance (in metres) at which an object or light can be clearly perceived. According to the Meteorological Service for International Air Navigation: (a) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognised when observed against a bright background; (b) the greatest distance at which lights in the vicinity of 1 000 candelas can be seen and identified against an unlit background.

The theoretical visibility at sea is close to the mathematical visibility that depends on the Earth curvature.

The distance to the horizon on the plain is approximately $\sqrt{13h}$ kilometres, where h is the height of the eyes above the Earth's surface. If the observation height is close to the height of a person (h is about 1.7 m), the mathematical horizon (the boundary between the sky and the sea) is 4,700 m away, but due to the specific weather conditions in the sea the visible horizon is always below the mathematical horizon, i.e. it is visible further away, but only the absence of visible objects prevents it from being assessed. However, if the observation height were 100 metres, we would ideally see the horizon 36 000 m out to the sea. Visibility also depends on meteorological conditions. The perception of observational contrast is influenced by the illumination and the direction of light, humidity, fog, cloud cover, precipitation, temperature and, in particular, the difference between the observer's location and the location of the object being observed, as well as atmospheric pollution. By comparison, due to the Earth curvature, at a distance of 30 km, under ideal conditions, the lower part of a 350 m tall wind turbine will be completely invisible for less than 9% (~33 m) of its height.

The visibility of the upper part of the WT depends on the cloud cover. The average number of cloudy days per year is estimated to be around 150-160 (least cloudy in May-August and most cloudy in November-January when more than 80% of the sky is covered by clouds). The number of days when the Sun shines from sunrise to sunset is low: around 10% in spring and summer (up to 15% in the coastal areas due to the lower cloud amount), and only 1-2% in autumn and winter (Climate Atlas of Lithuania, 2013).

The maximally good visibility in Lithuania is specified as 20 km (this is the instrumental limit of measurement), but in reality it can be much greater. In addition, it is noteworthy that, due to meteorological patterns, visibility is statistically at its best at the seaside during the tourist season.

According to the Klaipėda Meteorological Measurement Station (2012-2019), low visibility conditions are recorded on <25% of days per year, mostly in October-April (always in November-March). On average, 47% (34-59%) of low visibility days occur in December-February, 19% (13-33%) of low visibility days occur in April-September. <25% of the days per year have visibility below 900-18000 m. <5% of the days per year have visibility below 1800-3900 m; <1% of the days per year have visibility below 500-800 m. The minimum visibility of 100-200 m was recorded episodically for a few hours over several days, only in 2013 during the warm season.

Table 4.5.1. Visibility distance at sea in Lithuania. Klaipėda Meteorological Measurement Station data 2012-2019

Year	Number of days oflow visibility (MN < 1500 m)		Minimum visibility conditions (100-200 m)		Rate of visibility distance vs number of days per year		
	months 04 to 09	months 12 to 02	Seasonality, mth	Min MN - distance and repetition	< 1 %	< 5 %	< 25 %
2012	14	34	11-03	100, 1 d.	≤ 500	≤ 1800	≤ 9000
2013	33	42	11-03	200, 4 d., 3 in warm season	≤ 700	≤ 2600	≤ 11000
2014	24	42	11-04	200 m, a few days, in the interval of a few hours	≤ 500	≤ 2400	≤ 10000
2015	14	51	12-04	100 m, a few episodes	≤ 600	≤ 2800	≤ 14000
2016	17	51	12-04	100, 2 d.	≤ 700	≤ 3900	≤ 15000
2017	19	59	12-04	200, 2 d.	≤ 500	≤ 2900	≤ 14000
2018	17	48	10-03	100, 1 d.	≤ 500	≤ 2800	≤ 14000
2019	13	50	11-03	100, 1 d.	≤ 800	≤ 3750	≤ 18000

*The prevailing sea visibility in Lithuania is 20 000 m (instrumental limit of measurement)

The Lithuanian Baltic Sea area currently has no permanent vertical structures, and the surface roughness is only due to objects that change their nature and position in space, such as waves and ships, which can be up to 70 metres high.

In Lithuania, the visibility of the sea from land is very limited, which makes a seascape tour an exceptional experience. The sea horizon in Lithuania is only visible from the coastline itself, the beaches, the protective dune ridge on the mainland and Curonian Spit coast, the CS Great Dune Ridge and the Dutchman's Cap escarpment in Karklė, as well as from other specially constructed observation sites. The largest visual barrier on the mainland coast is the coastal forests (40.21% forest cover on the Baltic coastal plain), although the protective dune ridge rises slightly above the surrounding plains and shoreline (10-12 m NN at Palanga and 2-4 m NN at Būtingė).

In the Curonian Lagoon and on its eastern shore, south of Klaipėda, the horizon view is obstructed to the west by the open or wooded areas of the Curonian Spit Grand Dune Ridge. The highest points of the Curonian Spit Dune Ridge (Parnidis, Nagliai) are more distant from the western shores of the Curonian Lagoon than the lower ones (Hagenas, Smiltynė) which are closer to Klaipėda. The boundaries of the lowest parts of the Curonian Spit ridge (the Grand Dune Ridge) vary from 15 m in Smiltynė to 22-28 m on Hagenas Hill. Rising the highest above sea level are the points of the CS Grand Dune Ridge, among them Vecekrugas Dune 67 m NN, Vingkopė Dune in the Nagliai Nature Reserve, Parnidis Dune 51 m NN and Gliders' (Grand) Dune 50 m NN.

Lithuania's seacoast, and especially its lagoon coast, is dominated by flat terrain. The prevailing altitudes of the coastal lowlands are as low as 10 m, and some parts of the Nemunas Delta are lie sea level. Open field spaces provide views of up to several kilometres, with minimal visibility to the west in wooded areas.

Due to this landscape character, large objects in the Coastal Plain can be seen from long distances.

The largest spatial objects on the seaside are forests 20-30 m in height, high-voltage pylons about 30 m high, the Klaipėda Radio and TV Tower 202 m, the high-rise building Pilsotas 112 m, the buildings BIG 73-82 m, K and D 72 m, and the office and apartment building Klaipėdos Burė 66 m.

4.5.1.4. Nature frame of the Lithuanian Baltic Sea, its nearshore and coast

The nature frame (hereinafter 'NF') is an integral network of natural ecological compensation territories, connecting various natural and environmentally important territories, such as reserves, sanctuaries, state parks, restoration and genetic plots, ecological protection zones and other ecologically important water, forest, agricultural and other areas (Art. 12 of the Law on Environmental Protection of the Republic of Lithuania, Art. 21 and 22 of the Law on Protected Areas, and the Regulations on the Nature Frame approved by Order No. D1-624 of the Minister of Environment of the Republic of Lithuania of 16 July 2010). It includes European and national ecological networks, as well as highly protected areas.

According to the ecological functions performed by geosystems, the terrestrial NF consist of (1) geoecological divides (supporting), (2) internal stabilisation areas of geosystems, and (3) axes (eco-compensatory) and migration corridors (connecting). Pursuant to the Law on Protected Areas, the structural parts of the nature frame are classified as parts of European, national, regional and local significance.

The areas of the nature frame and their ecological functions on land will not be affected by the PEA.

In the CPTRL part 'Maritime Areas' (CPTRL Maritime Areas)[3], the drawing and the text on the ecological balance of the maritime area and the preservation of cultural heritage emphasise that the NF is shaped both in the sea and on land.

According to the CPTRL Maritime Areas, the maritime nature frame that is shaped with account of the aquatic landscapes characteristics, the distribution of the most valuable biodiversity areas and the sedimentation and hydrodynamic conditions is based on 3 geomorphologically different zones which are characterised by the specific nature of natural processes and the distribution and sensitivity of natural values and which occupy 38% of Lithuania's total water area:

- The littoral zone of the Curonian Spit and the mainland coast: the underwater slope and the shallow part of the sea (down to 20 m deep) are an important zone of interaction between the sea and land, with active hydrodynamic processes and the presence of main natural values. It covers about 34 000 ha (5.3% of Lithuania's total water area);
- Elevations: the Klaipėda-Ventspils Elevation, together with the Klaipėda seabed elevation in the northern part bordering Latvia, and the Curonian-Sambian Elevation in the south where the sea depth is relatively smaller in the more remote parts of the sea water area. The natural conditions here are favourable for the formation of valuable benthic habitats. They cover about 50 500 ha (23.6% of Lithuania's total water area);
- Depressions and their slopes: the Gdansk depression situated amid elevations, together with the Nemunas small valley that merges with this depression, and the slope of the Gotland depression at the border of the Lithuanian EEZ with Sweden are the deepest parts of the Lithuanian sea water area where conditions are favourable for the feeding and growth of certain fish species. They cover about 20 000 ha (9.1% of Lithuania's total water area).

4.5.1.5. Existing recreational attractions

The high recreational-tourist potential of the Lithuanian seaside stems from the fact that the majority of the Lithuanian population is concentrated at a great distance from the sea, and visits to the seaside and observation of the sea are rather episodic in the course of a year or even lifetime, as opposed to forests, rivers and even lakes. The recreational areas of the nearshore, their beaches (Fig. 4.5.5), higher elevations of the terrain and existing observation sites are highly valued as providing a multifaceted experience of a rare landscape and seascape, enhanced by the impression of unexpectedness and unexpected opening-up for the visitor, experienced as the pulling back of the 'natural curtain' of forests, reed beds and dunes from the monotony of the plains. This turns the observation of the active element - the sea - into a unique ritual that is available not every day and not to everyone. Lithuania's Baltic Sea coast is oriented westwards due to its geographical position, which means that in good weather we can observe sunsets from our coast when the Sun's disc dips below the sea horizon.

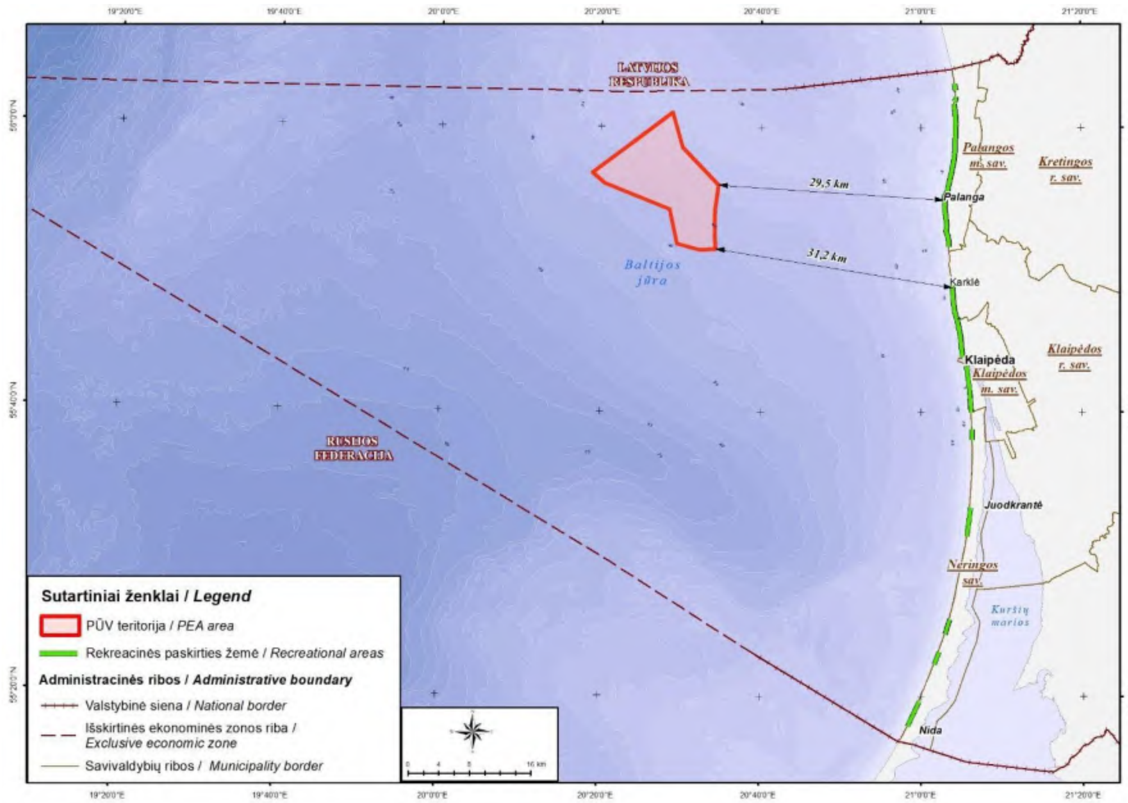
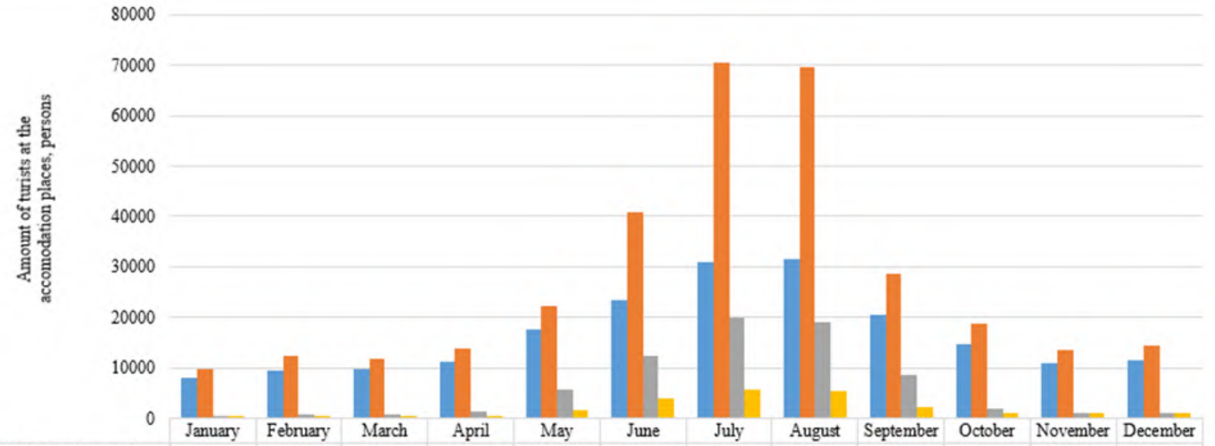


Fig. 4.5.5. PEA area in relation to the recreational areas (beaches) along the Lithuanian Baltic Sea coast

In assessing the potential impact of the PEA on the landscape, it is important to define the time periods during which the position of the Sun's disc at sunset at the horizon will be beyond the proposed offshore WT. The identification of such periods and their comparison with the period attracting most tourists to the Lithuanian Baltic Sea coast allow determining the most sensitive periods for the PEA impact on the local landscape.

Taking into account the seasonal dynamics of the number of tourists at accommodation establishments in municipalities bordering the Baltic Sea over the last six years (2016-2021), as provided by Statistics Lithuania (Fig. 4.5.6), it has been found that the peak period for the tourist flow, and thus the period that is most sensitive to the PEA potential impact on the local landscape, is the calendar summer period (June-August). It should be noted that the months of July and August in Palanga are distinctly different, when the number of tourists is significantly higher compared to other months.



	January	February	March	April	May	June	July	August	September	October	November	December
Klaipėda city munic.	8116	9439	9739	11090	17751	23526	31018	31493	20529	14679	11021	11563
Palanga city munic.	9898	12283	11712	13788	22381	40939	70352	69569	28697	18734	13597	14552
Neringa municipality	505	661	642	1500	5807	12520	19839	18952	8540	1980	933	959
Klaipėda region munic.	346	440	391	598	1679	4082	5621	5546	2134	1215	938	935

Fig. 4.5.6. Average number of tourists at accommodation establishments (2016-2021) (Source: Statistics Lithuania, https://osp.stat.gov.lt)

4.5.1.6. Legal requirements for the protection of landscape in the sea, on the nearshore and the coast

Requirements of international laws

Convention Concerning the Protection of the World Cultural and Natural Heritage (1972, Paris). The requirements apply to the conservation of the cultural landscape of the Curonian Spit and the attributes of outstanding universal value of the area, including the outlines of the Curonian Spit and the panoramic views from the Curonian Lagoon.

Council of Europe Landscape Convention (Florence, 2000), which applies to both terrestrial and maritime areas. It requires that the redevelopment of the landscape be carried out in a manner that minimises the impact on the landscape, taking into account the provisions of legislation and spatial planning documents adopted after extensive consultations with the parties concerned and the public.

Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) and the Marine Strategy developed on its basis in order to protect and preserve the marine environment, prevent its deterioration or, where practicable, restore marine ecosystems, and to ensure that the use of the marine environment is at a level that is sustainable: the structure, functions and processes of the constituent marine ecosystems, together with the associated physiographic, geographic, geological and climatic factors, allow those ecosystems to function fully and to maintain their resilience to human-induced environmental change, marine species and habitats are protected, human-induced decline of biodiversity is prevented and diverse biological components function in balance; (b) hydro-morphological, physical and chemical properties of the ecosystems, including those properties which result from human activities in the area concerned, support the ecosystems as described above.

In the field of biodiversity, the main laws are the European Union (EU) Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC) and the Directive on the conservation of wild birds (79/409/EEC).

Provisions of national strategic legal acts and solutions of spatial planning documents

In terms of ecology, it is necessary to take into account the objectives of the Strategy for the Protection of the Baltic Sea Environment approved by Lithuanian Government Resolution No. 1264 of 25 August 2010: to protect and conserve the marine environment, to prevent deterioration of the marine environment and, where possible, to restore the marine ecosystems in areas where the marine environment has been adversely affected; and to avoid impacts on, or significant risks to, marine biodiversity, marine ecosystems, human health, or the legitimate use of the marine environment.

The most important national spatial planning documents applicable to the region in question are the Comprehensive Plan of the Territory of the Republic of Lithuania approved by the Seimas of the Republic of Lithuania in 2021, its general and other parts relating to the development of territorial elements, the protection of natural landscape and ecosystems, and the seashore, and the relevant CPTRL drawings on 'Responsible use of the sea and the coast', 'Landscape formation and ecological balance' (hereinafter 'the CPTRL', 'ANJP' and 'KFEP'), as well as the solutions of the National Landscape Management Plan (approved by the Minister of Environment of the Republic of Lithuania in 2015), which have been integrated into the present document.

CPTRL solutions relating to the maritime part of the country

549. Priority is given to achieving a good status of the marine environment and resources through an ecosystem-based approach and the precautionary principle.

550. Priority is given to the sustainable development of new activities (renewable energy, aquaculture, mineral extraction, fish processing, etc.) and the sustainable development of existing activities (recreation, tourism, fishing, shipping (sea and inland waterways, freight and people), development of transport infrastructure, etc.).

553. New resort areas and tourism service centres are proposed, existing resorts are to be strengthened, the use of therapeutic resources is to be expanded; all types of tourism and their infrastructure are to be developed, and public and private infrastructure for cultural and business tourism and green (ecological) tourism is to be developed.

555. All activities in the marine area are possible in a mutually compatible manner, while maintaining the requirements of protected areas and the good status of the marine environment, taking hydrodynamic processes into account.

556. Activities disturbing the seabed surface shall not be allowed in areas of natural values, places of wrecked ships and other underwater cultural heritage sites, or in areas of the planned territory where historical or archaeological objects have been discovered but have not been investigated in accordance with the procedure established by legislation, until the findings have been investigated.

557. The most valuable areas of the natural protected cultural landscape are the relics of the ancient Baltic Sea shores near Juodkrantė at a depth of 27-30 m and the underwater canyons near Palanga at a depth of about 15 m (see the drawing 'Responsible use of the sea and the coast').

558. In the maritime area, engineering systems are planned within the proposed infrastructure corridors, and structures and facilities are to be installed in a manner sustainable for the marine resources and the seabed structure. The interests of the development of existing and new activities and of the environment shall be coordinated throughout the water area under the procedure established by the Republic of Lithuania and international legal acts and agreements.

573. The protection of marine cultural and natural heritage sites and public accessibility, the development of recreational services and attractions and the creation of new businesses and services in the coastal zone shall be ensured. The comprehensive development of Lithuania's coastal beach infrastructure and its adaptation to tourism shall be promoted.

591, 592. Balancing the ecosystems in the terrestrial and maritime areas. A nature frame is to be formed in the sea. To preserve the spatial integrity of protected natural areas, the development of maritime protected areas shall be concentrated on the existing elevations in the maritime territory of Lithuania.

CPTRL solutions relating to the terrestrial part of the country

Protection of the aesthetic values of the landscape

350. At the national level, the aesthetic potential of the landscape (scenic beauty) is shaped by the expressiveness of its visual structure, its landmarks, the variety of landscape elements, the panoramic view and the value attributed to the landscape by society. With account of the characteristics of the visual structure of the landscape, areas of highly protected visual aesthetic potential of the country and areas (HPL) where visual protection requirements apply are identified:

350.2. To preserve the identity of the coastal landscape. To establish a coastal/lagoon landscape visual protection zone covering the Curonian Spit, the Curonian Lagoon and a coastal strip up to 10 km wide on the mainland, including the Nemunas Delta and the Klaipėda Ridge.

350.3. When assessing the impact on the landscape, to aim at preserving the most visually distinctive landscape structures (see CPTRL Annex 5 'National Landscape Management Plan', p. 61, AI, AII, BI landscape types) and the existing landscape character of these areas and natural processes, to ensure the protection from visual pollution.

351. In the assessment of potential visual pollution, to follow the aspects, such as: changes in land use patterns, impact on landscape value attributes (including the attributes to which the public assigns value), natural and cultural values and elements, their visibility, panoramas, the value and use of recreational resources, and the impact on biodiversity.

Protection of ecological and immanent values of the landscape

354. To conserve areas with a landscape structure of ecological importance and sensitivity.

355. While preserving and nurturing the landscape and biological diversity, to protect the natural, aesthetic and historical values of the landscape and the relationship of spaces.

356. To analyse the characteristics of the landscape, the processes that affect it and the value assigned to it by the population, and to provide for long-term measures for protecting and managing the valuable and/or scenic landscape of natural and cultural character.

364. To ensure the ecological stability of the territory of Lithuania and its separate parts and the protection of biodiversity and to neutralise anthropogenic impacts of various nature and intensity, to create a complete, viable, resilient and functional ecological compensation system - a nature frame with a distinguished ecological network ensuring the integrity of ecologically most valuable areas of the nature frame – Natura 2000 network.
371. The total area covered by structures of the nature frame in the country's territory must not decrease. The geo-ecological potential of these structures needs to be enhanced.

Protection of biodiversity

373. To halt the loss of biodiversity and the degradation of ecosystems and the quality of services they provide, and to restore them where possible.

373. To ensure the sustainable economic use of relatively natural ecosystems, avoiding adverse impacts on biodiversity and providing scientifically sound conditions for the spatially uniform formation and protection of particularly valuable natural areas.

Protected areas

376. Protected areas. A priority objective for the State is to maintain a favourable conservation status of natural habitats and species and other natural values in existing and newly established protected areas.

377. Priority is given to implementing the requirements of the European Union (EU) Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC) and the Directive on the conservation of wild birds (79/409/EEC), and to expanding Natura 2000 network in Lithuania.

The development of Natura 2000 network in Lithuania aims at ensuring the adequate protection of all 54 natural habitat types and 55 species found in Lithuania, and to establishing the required number of protected areas.

381. To ensure the requirements for the protection of the cultural and natural heritage of UNESCO World Heritage Sites in Lithuania, including the Curonian Spit, and to preserve and maintain their outstanding universal value.

National Landscape Management Plan solutions

The solutions of the NLMP approved by the Minister of Environment of the Republic of Lithuania in 2015, integrated into the CPTRL (2021), are relevant through the landscape management zones and their management regulation guidelines specified in this plan.

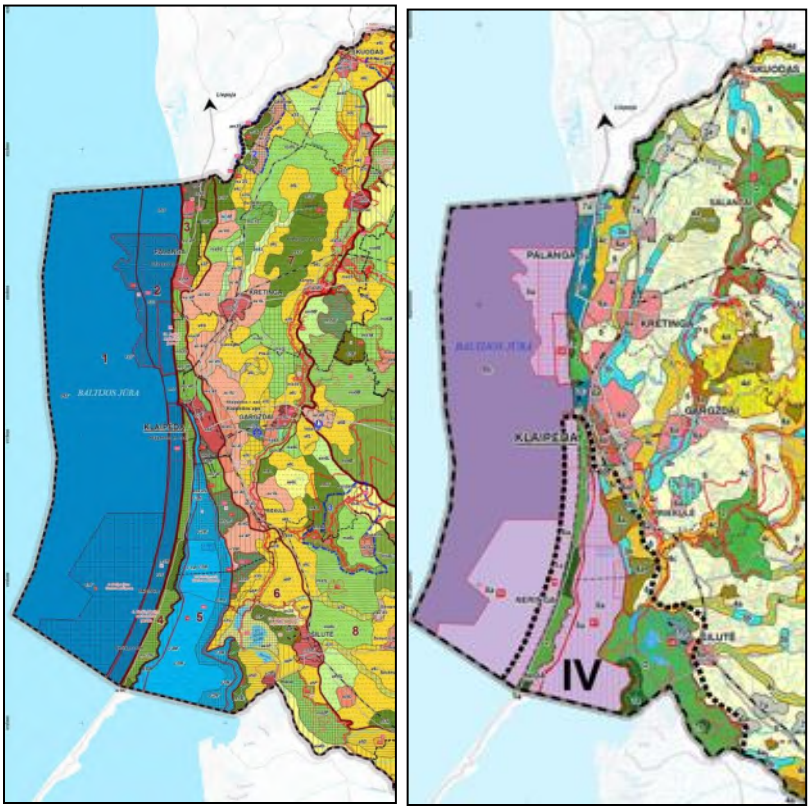


Fig. 4.5.7. Excerpt from the drawings 'Landscape Management Zones' and 'Landscape Management Regulation Guidelines' in the Solutions Part of the National Landscape Management Plan

The PEA area is located outside the boundaries of NLMP analysis, but its character is similar to that of the shallow part of the Baltic Sea area, representing a natural landscape of large bodies of water recommended for intensive use. According to the NLMP drawing 'Landscape Management Regulation Guidelines', a strategy for the intensive use of the sea is to be applied in the PEA area.

In the Curonian Spit National Park, including its marine part, and the whole of the Curonian Lagoon, the NLMP identifies problem landscape area IV where the PEA will not impact the direct use of the areas on land, except for the possible conflict with recreation for which the aesthetic potential of the sites is important.

According to the NLMP (Fig. 4.5.7), the visual impact of the PEA on recreational areas on the Curonian Spit, the mainland and the shore of the Curonian Lagoon shall be avoided (with a particular emphasis on the visual protection of the Palanga-Šventoji area, the Japanese Garden in Mažučiai, the Akmena-Tenžė area and Minija area to the north of Priekulė, as well as of the small harbours of the coastal area).

Specific legislative provisions in the field of the landscape

The legal basis for landscape protection in the region in question is formed by Law on the Seaside Strip, the Law on Protected Areas and its regulations that establish protected areas (define the objectives of their establishment and conservation) and regulate activities in them (regulations, protection regulations and plans on boundaries, zone boundaries and management). The PEA must not prevent the implementation of the objectives of preservation and good status of specific sites and their values as set out in the laws.

In accordance with the Regulations on Environmental Impact Assessment of the Proposed Economic Activity approved by Order No. D1-885 of the Minister of Environment of the Republic of Lithuania of 31 October 2017, when assessing the impact on the visual aesthetic potential of the landscape by special structures higher than 30 metres (hereinafter 'high structures'), except for the wind turbines, for which the significance criteria for the impact on the landscape are laid down in Article 49(18) of the Law on Energy from Renewable Sources of the Republic of Lithuania, the expected significant impact of high structures is to be determined by considering whether:

- 101.1. high structures fall within areas and localities of highly protected visual aesthetic potential of the country and within particularly and moderately distinctive landscape complexes of very high and high aesthetic potential (AI, AII, AIII, AIV, BI, BII, BIII and BIV landscape visual structure types) as defined in the NLMP (hereafter 'highly protected or HP landscape areas');
- 101.2. high structures are not within HP landscape areas, but they will be visible in the horizontal field of observation of the country's most valuable landscape panoramas at a vertical subtended angle greater than 2.80º from viewpoints in HP landscape areas.

Pursuant to the criteria for assessing the significance of the WT impact on the landscape as set out in Article 49(18) of Law on Energy from the Renewable Sources:

'The impact of the proposed economic activity on the landscape shall be considered insignificant if no WT higher than 30 metres are built in the most valuable landscape areas or at a distance closer to them, which is calculated by equating one metre of the WT height (measured in terms of the height of the WT tower) to the 10-metre distance to the nearest viewpoint of the landscape panorama in the most valuable landscape areas.'

The most valuable landscape areas are the areas of highly protected landscape and the particularly distinctive landscape complexes defined in the CPTRL. The list of the most valuable panoramic viewpoints, which are identified in the most valuable landscape areas, is approved by the Minister of Environment and is presented on the map of the Most Valuable Panoramic Viewpoints in Lithuania (Fig. 4.5.4).

4.5.2. Potential impact on the landscape

From a landscape perspective, the impact of offshore WTs is assessed at a regional scale, i.e. covering the PEA area itself and the areas that may be affected in terms of the landscape or the character of which contributes to the visual perception of offshore WTs. This is the marine complex from the PEA area eastwards through the entire Lithuanian contiguous zone, territorial sea, nearshore, coast, the Curonian Spit and the Curonian Lagoon, and the coastline - the western part of Lithuania, in the western parts of the municipalities of Kretinga District, Klaipėda District and Šilutė District.

4.5.2.1. Principles and methodologies for landscape impact assessment

The potential PEA impact on the landscape is examined from the following aspects:

- landscape diversity;
- geo-ecological stability;
- visual.

With a view to determining the intensity of the impact, the size of the area likely to be adversely affected, the importance of the affected landscape and the magnitude of the change are assessed in terms of landscape diversity, the size of the new development, its size in relation to existing landscapes, and whether it will encroach on and affect the unique protected areas and the landscape values protected there are considered.

In terms of the geo-ecological stability of the landscape, the position of the proposed wind park in relation to the nature frame and the changes that will take place in this structure are examined.

In terms of the visual aspect of the landscape, the aesthetic potential of the areas where the PEA is to be located, the extent to which the wind park and its structures will be visible ('high' and 'wide') and the coverage of the areas, and how this will change the perception of the seascape in tourism and recreational areas where landscape monitoring is a major focus are analysed.

The extent (scale) of the PEA impact on the landscape is determined using:
- the requirements of legislation, and solutions of spatial planning and strategic documents;
- the comparative (analogy) method, for example, resorting to an existing analogy for visual assessment - the existing wind park in Šilutė District viewed from the Curonian Spit;
- reference sources;
- conclusions of expert assessments.

Methodology of visual impact assessment

The visual impact on the landscape due to the PEA is considered as one of the most important impacts. The assessment has been carried out according to the WT impact zones identified by J. Abromas (2021), the Methodology for determining Kamičaitytė-Virbašienė, G. objects (2021) prepared by J. Kamičaitytė-Virbašienė and G. Godienė for the Ministry of Environment of the Republic of Lithuania, the international experience with account of the height of the proposed WT installations, the park's position in relation to the coast, the nature of the most important observation sites affected and other contexts.

The level of visual impact on the landscape is determined by the following factors:
- spatial significance that depends on the WT technical parameters and distances, the vertical and horizontal subtended angle and the visibility conditions;
- dominance, i.e. the exposure and relationship to other visible objects;
- semantic contrast, i.e. the relationship to objects, spatial formations and compositions that are significant/valuable to the observer, their value scientifically established, recognised by legislation and defined in spatial planning and strategic documents.

The report assesses the maximum potential visual impact of the PEA on the landscape, by analysing:
- the points from which the panoramas opening up are the most sensitive to visual impact;
- the weather conditions that maximise visibility;
- the tourist season when the number of observers is the highest;
- the time of the day (sunset) when the forming shadow makes the WT the brightest, resulting in the greatest colour contrast between the environment and the object.

Under all other circumstances, the visual impact of the wind park is considered to be lower.

The factors considered in assessing the level of visual impact on the landscape include:
- Vertical subtended angle (VSA): assessment factor 1.00;
- Horizontal subtended angle (HSA): assessment factor 0.75;
- Duration of the intervention in the socio-emotional phenomenon (sunset effect): assessment factor 0.5;
- regulatory compliance: assessment factor 0.25.

The final assessment of the impact of the visual pollution object (VPO) (F_{VPO}) in relation to each of the main affected observation sites is carried out by adding up the determined notional points of the potential impact on the landscape.

$F_{VPO} = \sum \alpha * \beta$, where

α is the notional unit of the potential impact on the landscape factor;
β is the observation site importance factor in the potential landscape impact assessment.

The significance of the final VPO impact on the landscape is determined according to:
- **No impact**, where the aggregate VPO assessment score is < 10% of the sample size threshold, i.e. from 0 to -1.39;

- **Insignificant impact**, where the aggregate VPO assessment score is < 30% of the sample size threshold, i.e. from -1.40 to -4.19;
- **Significant impact**, where the aggregate VPO assessment score is 30% or more of the sample size threshold, i.e. from -4.20 to -14.

The visual impact of the PEA is assessed in the main visual spaces of the Lithuanian seaside:

1. The Curonian Lagoon. Assessing the visual impact from the eastern shore of the lagoon and the lagoon water area towards the Curonian Spit (CS). Particular attention is paid to the Curonian Spit, a videotope of great aesthetic resources (UNESCO heritage), i.e. to determine whether the WTs will be visible above the outline of the CS dune ridge from the Curonian Lagoon observation sites;

2. The Baltic Sea panorama from the highest points of the Curonian Spit and the mainland coast and the beaches to the west, i.e. determining the extent to which the WTs will be visible in the open marine space where there are no other permanent objects rising above sea level.

3. The eastern mainland coastal area up to the coastal forests, determining the potential WT impact on the established coastal landscape.

The PEA visual impact is assessed in greater detail at 17 observation sites on Lithuania's Baltic Sea coastal strip and the Curonian Spit (Fig. 4.5.8). The sites have been chosen in accordance with the proposals made to the Palanga City Municipality (letter No. S22-034 of 09.03.2022); including the visual monitoring viewpoints of the CSNP landscape located at the highly protected landscape sites and marked on the map of the most valuable panoramic viewpoints of the Lithuanian landscape. The present report assesses the specific vertical and horizontal subtended angles of the wind park installations and examines the sunset effect (Fig. 4.5.8). The Annex provides visualisations of the proposed wind park at these observation sites at different times of the day and season. In view of their different importance and the potential for the observation of the landscape of large water areas, the observation sites considered in the EIA report have been divided into three groups (Table 4.5.2).

Table 4.5.2. Groups of observation sites used in the visual impact assessment of the wind part by their importance and landscape conservation status

Group number	Importance or conservation status of the observation sites	Importance factor of the observation site	Observation sites analysed in the EIA report
1	Included in the list of the most valuable panoramic viewpoints of the Lithuanian landscape or located in the HPL area.	1.0	Juodkrantė Beach (No. 14), Observation site Nagliai Nature Reserve (No. 15), Observation site on Vecekrugas Dune (No. 16), Nida Beach (No. 17).
2	Agreed with Palanga Municipality Administration as to be considered during the preparation of the EIA report.	0.75	Alka Hill (No. 2), Observation platform at Fisherman's Daughters (No. 3), Beach for the disabled (No. 4), Beach (exit from Jūratės St.) (No. 5), Viewing platform of Palanga Bridge (No. 6), Palanga Bridge (No. 7), Beach (exit from Dariaus ir Girėno St.) (No. 8), Birutė Hill (No. 9).
3	Other observation sites under consideration during the preparation of the EIA report	0.25	Pape Beach (Latvia) (No. 1), Dutchman's Cap (No. 10), Giruliai Beach (No. 11), Klaipėda Harbour northern breakwater (No. 12), Smiltynė Beach (No. 13).

*It should be noted that at the moment (the end of 2022) the panorama of the Baltic Sea is heavily obscured by vegetation at the viewpoints of Mount Alka and Mount Birutė. If the view to the sea can be more or less fully opened after landscape formation cuts are made on the Alka mountain, then on the Birutė mountain it would not be possible to open panoramas of such a width that the entire projection of the VE park could be fully seen in them without harming the nature. The visual impact (VSA and HSA) on the landscape from the Alka mountain viewpoint is evaluated without taking into account the presence of greenery. There is no assessment of the Birutė mountain observatory VSA and HSA.

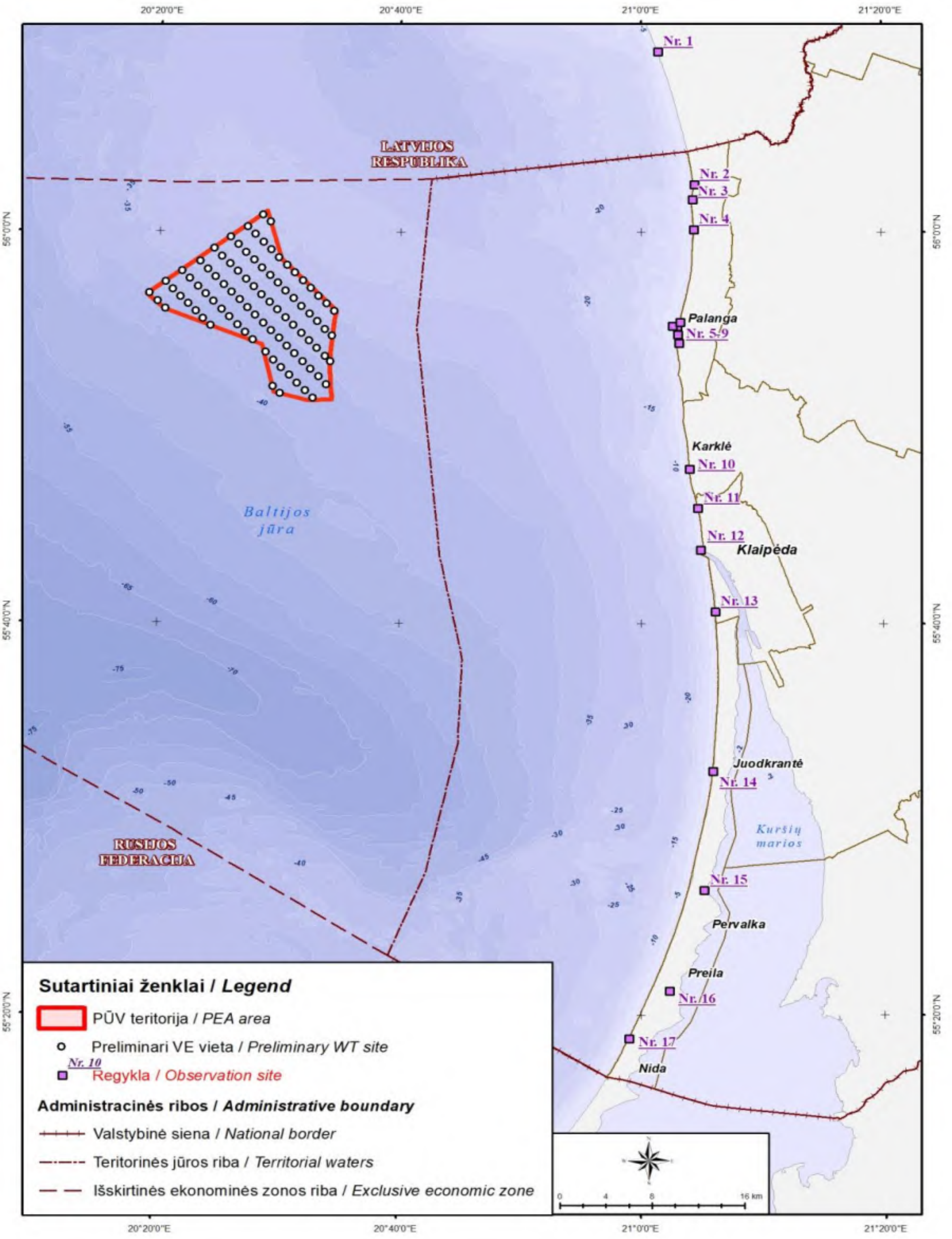


Fig. 4.5.8. Scheme of the observation sites

Quantitative criteria for assessing the visual impact on the landscape: vertical and horizontal subtended angles

The quantitative visual impact of an object is determined by calculating the vertical and horizontal subtended angles of the proposed facility in degrees. The vertical subtended angle (hereinafter 'the VSA') is calculated between two observation rays, the upper of which reaches the top point of the WT (the overall height of the WT) and the lower of which is directed towards the visible lower part of the WT tower. The horizontal subtended angle is calculated between two horizontal objects furthest apart (as seen from the point of the observation site being assessed).

The Zone of Visual Influence (hereinafter 'the ZVI') module of WindPro 3.3 software was used to assess the visibility of the proposed wind park for analysing:

●Position coordinates (X, Y, Z) of the WT installations and wind park's edge facilities;

●WT tower height and rotor diameter;

● Digital spatial terrain model of Lithuania (10 m resolution). Data source: National Land Service under the Ministry of Agriculture, 2017;

●Forest areas as visibility obstructions [Data source: forest areas and their height from the Forest Cadastre Database (revision date 13.09.2017), State Forest Survey Service under the Ministry of Environment] (the height ranges from 1 metre to 34 metres);

●Calculation step: 25 metres;

●Estimation of the degree of Earth curvature;

●Height of the point of the calculated VSA and HSA, based on the photographic height of the photo-fixation sites, with the absolute height of + 1.8 m above sea level. The ZVI subtended angles for the observation towers were calculated by estimating the height of these observation towers plus the photographic height (1.8 m).

The horizontal subtended angle of an object that significantly alters the landscape is not defined by legislation. It depends on the context; therefore, to assess the impact on the 180 degree westward panorama of the sea in Lithuania we have used the Methodology for determining visual pollution for natural landscape complexes and objects (J. Kamičaitytė-Virbašienė, G. Godienė (2021), on the basis of which the determination of visual significance levels was developed (Table 4.5.3).

Table 4.5.3. Assessment of the WT visual impact based on the horizontal subtended angle: according to the methodology of J. Kamičaitytė-Virbašienė, G. Godienė (2021)* and the option adapted to the offshore wind park used in the report**.

Level of visual impact	**Horizontal subtended angle of the object's width***	**Horizontal subtended angle of the object's width****	**Landscape impact assessment (notional units)****
Discernible	5`–1	5`–1	–1
Visible, but insignificant	1 –2.5	1 –2.5	–1
Visually significant	**2.5 –30**	**2.5 –14.99**	**–2**
		15 –30	**–3**
Clearly dominant	30 –120	>30	–4

The assessment of the object in terms of the values of the vertical subtended angle was carried out according to an adapted landscape impact assessment matrix[5] (Table 4.5.4).

Table 4.5.4. Assessment of the WT visual impact based on the vertical subtended angle (adapted from the analogue method and reference sources)

Vertical subtended angle, degrees	**Nature of impact**	**Extent of impact**	**Impact (notional units)**
0	INVISIBLE	no impact	**0**
0.1–0.2	DISCERNIBLE, captured in good weather at day and night, partially visible	very low	**–1**
0.21–0.49	NOTICEABLE. The body is visible day and night, the blades are seen at good visibility. **Visual obstruction. Important where panoramas show valuable objects at a great distance.**	low	**–2**
0.5–1	VISIBLE, but sub-dominant element of low significance. **Low visual pollution. Important where the landscape is continuously monitored and where valuable objects are visible in panoramas at a long distance.**	medium	**–3**
1–2.79	VISIBLE, visually clear, with both the body and blades visible. They crossing the horizon and can no longer be ignored. Psychological disturbing impact. **Visual pollution that reduces the aesthetic potential and hinders the perception of valuable panoramas.**	above medium	**–4**
2.8–5	CLEARLY VISIBLE, visible movement of the blades, stands out in the overall view. Psychological, disturbing impact. **Significant impact. Visual pollution that reduces the aesthetic potential of the site, competes with significant dominant elements of the landscape and interferes with the perception of panoramas important to the local population is not permissible.**	high	
5.01–10	DISTINCTLY VICIBLE, DOMINANT. Form panoramas, cross the horizon line. Strong psychological impact. **Significant impact. Visual pollution that reduces the high aesthetic potential of the site and hinders the perception of valuable panoramas is not permissible.**	very high	**–5**
10–90	**OBSTRUCT significant landmarks and form the main view**	fundamentally changing	

Analogy limit. *The existing wind park in Lankupiai, Šilutė district, 0,47 VSA from the Curonian Lagoon coast of Juodkrantė, and 0.21 VSA from the Curonian Lagoon shore in Nida.*

Significant impact *according to the description of the EIA procedure for PEA, approved by Order No. D1-885 of the Lithuanian Minister of Environment of 31.10.2017, in assessing the significance of the landscape impact special structures higher than 30 metres, other than wind turbines, at 2.8 VSA.*

Significant impact *under the Lithuanian Law on Energy from Renewable Sources: 10 m for each metre of plant height or* 5.7 *VSA.*

Sunset trajectory during the tourist season

With a view to assessing the effect of the PEA on the ritual of watching the sunset at sea, a favourite ritual of most Lithuanian seaside visitors, an assessment of the projection of the horizontal subtended angle of the wind park from the subject observation sites to the position (trajectory) of the Sun disc at sunset (during the tourist season, Fig. 4.5.9) was carried out. In addition, the number of days on which the planned outline of the wind park coincides with the position of the Sun's disc as it descends into the sea at sunset has been estimated for all subject observation sites (Table 4.5.4).

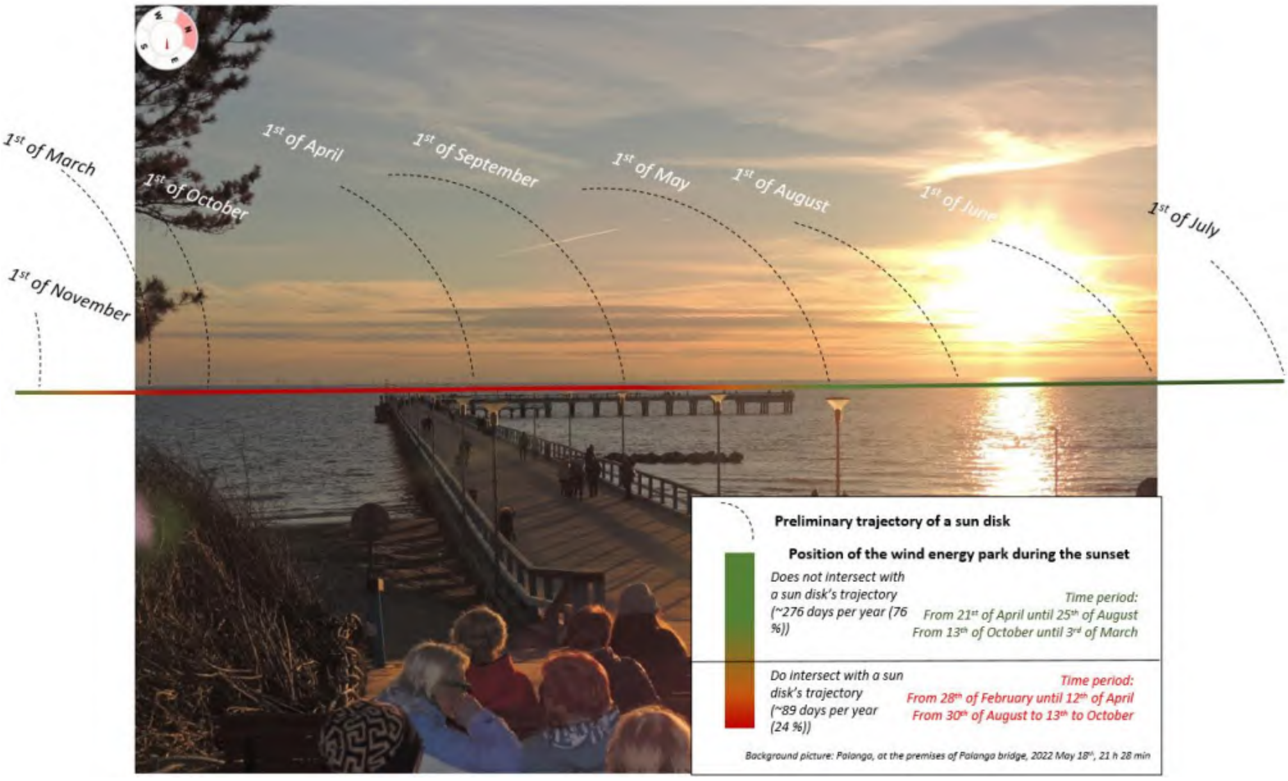


Fig. 4.5.9. Trajectories of the Sun's disc over the year at the Palanga Bridge observation platform

The position of the proposed WTs in relation to sunset (the most important period for tourism) is an important socio-emotional criterion for determining the PEA impact (Table 4.5.5).

Table 4.5.5. Maximum number of days when the wind park coincides with (projects onto) the sunset trajectory of the peak tourist season

Duration of overlap	Impact (notional units)
No overlapping	**0**
Episodic and off-season	**–1**
During tourist season, but less than 10 days	**–2**
During tourist season, 11-20 days	**–3**
During tourist season, more than 20 days*	**–4**

*20-day period reflects the duration of the population's annual leave

4.5.2.2. Assessment of visual impact on the landscape

Sunset disturbance during the tourist season

The number of days per year when the sunset trajectory coincides with the offshore wind part varies between the subject observation sites (Fig.s 4.5.10 and 4.5.11, Table 4.5.6).

At the Neringa Municipality observation sites (Nagliai Nature Reserve, Vecekrugas Dune and Nida Beach), the proposed wind turbines will not be visible all year round. Only on Juodkrantė Beach, under ideal visibility conditions, the proposed WTs are likely to be visible at sunset for approximately 40 days per year, from 3 June to 12 July.

At the Klaipėda City observation sites (Giruliai Beach, Klaipėda Port northern breakwater and Smiltynė Beach), the WTs will be visible under ideal visibility conditions in spring and summer. In spring, as the Sun's trajectory moves towards its highest point above the horizon (solstice), the proposed wind turbines would fall within the sunset trajectory as viewed from Giruliai Beach from 27 July to 31 August, from Smiltynė Beach between 1 May and 6 June, and from Klaipėda northern breakwater from 19 April to 24 May. In summer, as the Sun's trajectory moves towards the autumnal equinox after the solstice, the wind park would be in the sunset trajectory as seen from Smiltynė from 5 July to 11 August, from Klaipėda northern breakwater between 18 July and 22 August, and from Giruliai Beach from 27 July to 31 August. This means that the Klaipėda City observation sites would be affected (at sunset) for a maximum of about 36-44 days per year.

In Klaipėda district, at the Dutchman's Cap escarpment, the wind park will be in the sunset trajectory for 73 days a year: 36 days in spring (4 April to 9 May), 30 days in summer (2-31 August) and 7 days in autumn (1-7 September).

The Palanga City Municipality observation sites are the closest to the PEA, so the visibility of WTs at sunset is crucial. The number of days per year when the sunset would be directly behind the proposed wind park is the same for the beach at Dariaus ir Girėno St., Palanga Bridge and its observation platform, and the beach at Jūratės St. At these observation sites, the wind park would be in the sunset trajectory mostly in spring (43 days per season) and autumn (43 days per season). It is at these observation sites most visited by tourists and most often associated with the seascape near Palanga that the proposed wind turbines will enter the sunset trajectory on the last days of August (30-31 August). At the observation site on Birutė Hill, the proposed wind turbines will also be in the sunset trajectory on the last days of August (26 to 31 August). At the remaining observation sites in the Palanga Municipality area, the proposed wind turbines would only be in the sunset trajectory in autumn, winter and spring.

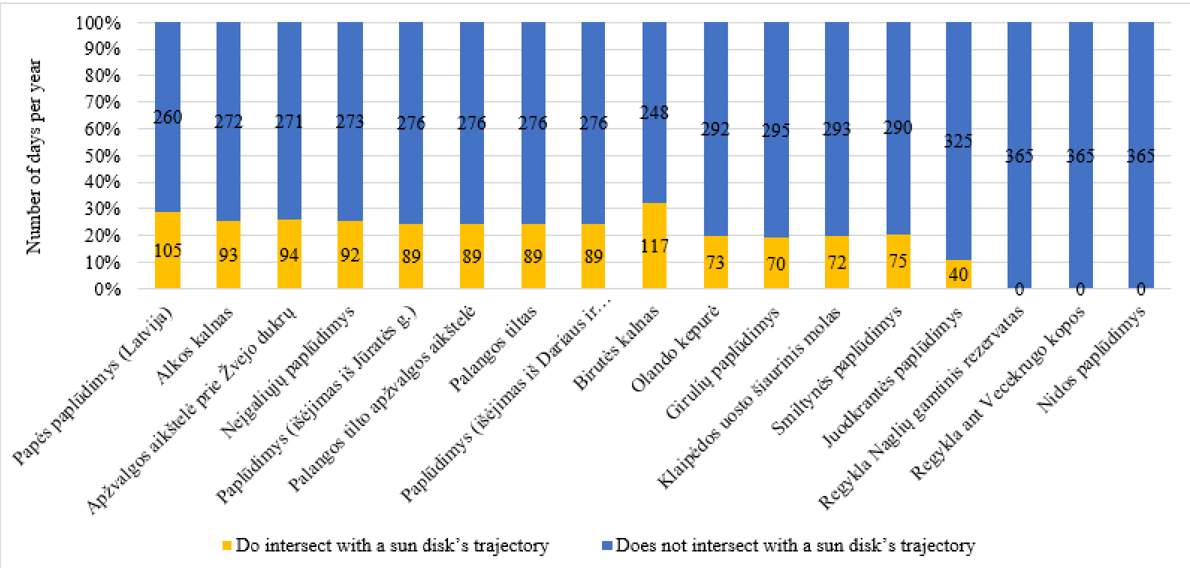
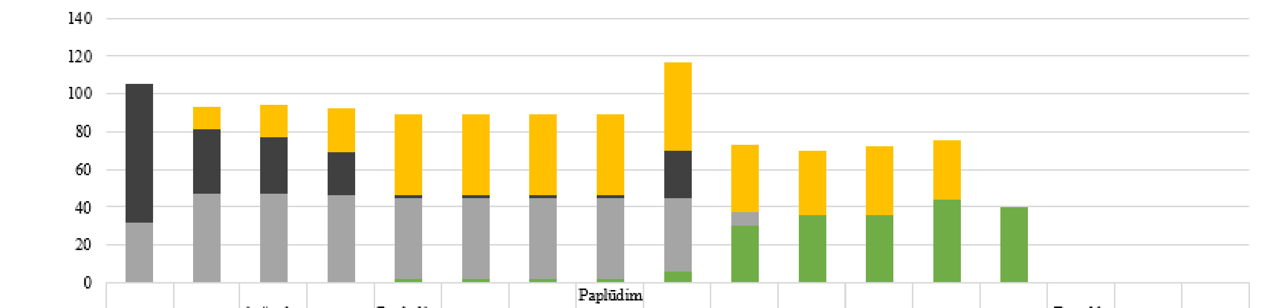


Fig. 4.5.10. Overlapping of the proposed WTs with the sunset trajectory (number of days)



	Papės paplūdimys (Latvija)	Alkos kalnas	Apžvalgos aikštelė prie Žvejo dukrų	Neįgaliųjų paplūdimys	Paplūdimys (išėjimas iš Jūratės g.)	Palangos tilto apžvalgos aikštelė	Palangos tiltas	Paplūdimys (išėjimas iš Dariaus ir Girėno g.)	Birutės kalnas	Olando kepurė	Girulių paplūdimys	Klaipėdos uosto šiaurinis molas	Smiltynės paplūdimys	Juodkrantės paplūdimys	Regykla Naglių gamtinis rezervatas	Regykla ant Vecekrugo kopos	Nidos paplūdimys
Spring	0	12	17	23	43	43	43	43	47	36	34	36	31	0	0	0	0
Winter	73	34	30	23	1	1	1	1	25	0	0	0	0	0	0	0	0
Autumn	32	47	47	46	43	43	43	43	39	7	0	0	0	0	0	0	0
Summer	0	0	0	0	2	2	2	2	6	30	36	36	44	40	0	0	0

Fig. 4.5.11. Overlapping of the proposed WTs with the sunset trajectory in different seasons (number of days)

Table 4.5.6. Assessment of the overlapping of the proposed WTs with the sunset trajectory at the observation sites

Observation site		WTs visible before summer solstice	WTs visible after summer solstice	Total days per year	Visual impact* after applying the importance factor of the observation site
No. 1	Pape Beach (Latvia)	30.10-15.02	Invisible	105	-0.5
No. 2	Alka Hill	30.09-15.11	26.01-12.03	93	-0.5
No. 3	Observation platform at Fisherman's Daughters	26.09-11.11	30.01-17.03	94	-0.5
No. 4	Beach for the disabled	20.09-04.11	06.02-23.03	92	-0.5
No. 5	Beach (exit from Jūratės St.)	30.08-13.10	28.02-12.04	89	-1
No. 6	Palanga Bridge observation platform	30.08-13.10	28.02-12.04	89	-1
No. 7	Palanga Bridge	30.08-13.10	28.02-12.04	89	-1
No. 8	Beach (exit from Dariaus ir Girėno St.)	30.08-13.10	28.02-12.04	89	-1
No. 9	Birutė Hill	26.08-09.09	04.02-16.04	117	-1
No. 10	Dutchman's Cap	02.08-07.09	04.04-09.05	73	-1.5
No. 11	Giruliai Beach	27.07-31.08	12.04-15.05	70	-1.5
No. 12	Klaipėda Port northern breakwater	18.07-22.08	19.04-24.05	72	-1.5
No. 13	Smiltynė Beach	05.07-11.08	01.05-06.06	75	-1.5
No. 14	Juodkrantė Beach	03.06-12.07	Invisible	40	-1.5
No. 15	Nagliai Nature Reserve observation site	Invisible	Invisible	0	0
No. 16	Observation site on Vecekrugas Dune	Invisible	Invisible	0	0
No. 17	Nida Beach	Invisible	Invisible	0	0

**Note: According to the assessment criteria given in Table 4.5.5*

During the tourist season and for more than 20 days, sunset will overlap with the wind park area as seen from Giruliai Beach and Klaipėda Port northern breakwater, Smiltynė Beach and Juodkrantė. For less than 10 days (the last day of summer), sunset will overlap with the wind park area as seen from Palanga: from Jūratės St., the exit to Birutė Hill and from the Dutchman's Cap observation platform. In total, the wind park will be visible in the sunset trajectory from 75 days per year from Smiltynė (up to 105 days), Pape (Latvia) to 117 days from Birutė Hill.

Visibility assessment of the proposed wind turbines

Visibility of WTs was assessed in terms of the possible vertical and horizontal subtended angles. Assemssment was done against maximum technical parameters – WT total height up to 350 m.

The results are presented in Fig.s 4.5.12 and described in the following sections.

Potential visual impact of the proposed wind turbines on the Curonian Spit

The Curonian Spit is a UNESCO World Heritage Site, a protected cultural landscape of sand dunes, one of the attributes of which is the characteristic outlines of the spit and the panoramic views of the Curonian Lagoon, which are of outstanding universal value (world value). This outline is viewed from the visual space of the Curonian Lagoon, i.e. from the entire Curonian Lagoon water area and the eastern shore of the lagoon. Spatial analysis of the visibility of the PEA solutions (Fig.s 4.5.12) shows that under none of the alternatives considered would the planned offshore WTs be visible above the Curonian Spit outline as viewed from the Curonian Spit and the greater part of the eastern shore of the Curonian Lagoon.

The PEA area (the nearest boundary) will be located between 35 km (Kopgalis) and 70 km (at the Ventė Cape headland) away from the Curonian Lagoon and the Curonian Spit and will not be visible from the Curonian Lagoon in the direction of the Curonian Spit, with the exception of the port entry channel in Klaipėda City. The 350 m high WT will be visible in good visibility conditions in Smiltynė, from the eastern shore of the Curonian Lagoon in Klaipėda City (taking into account their location, the WTs will be projected on the background of Klaipėda rather than Neringa skyline). The vertical subtended angle can amount to 0.4–0.6 , which means medium visual impact.

The Curonian Spit's grand dune ridge forms the major spatial divide between the spatial basins of the Baltic Sea and the Curonian Spit, and is home to the highest observation points in the subject area. Due to the higher altitude of these observation sites, the installations of the wind park will be visible from the Nagliai Nature Reserve that has no forest cover (observation site No. 15), potentially affecting the wooded areas of the Hill of Witches in Juodkrantė, Eumas Hills and the especially open and treeless Bear Hill.

The western shore of the Curonian Spit is also very important in terms of recreation, especially for Lithuania to preserve recreational resources in a transboundary UNESCO World Heritage Site that should be free of signs of visual pollution.

Potential visual impact of the proposed wind farms on the Baltic Sea panorama according to the vertical and horizontal subtended angles

Vertical subtended angle. The modelling of the WT visibility (in relation to the vertical subtended angle) shows that WT of 350 m does not exceed the criteria for significance of the impact (i.e. impact - insignificant) on the landscape as set out in Article 49(18) of the Law on Energy from Renewable Sources of the Republic of Lithuania (no significant impact is foreseen pursuant to the laws).

Nevertheless, WTs can be visible in good visibility conditions in the warm and tourist seasons. According to the methodology for assessing the visual impact on the landscape presented in Table 4.5.4, at the closest point to the proposed WT (approximately 29 km to the Palanga Bridge) the potential visual impact in terms of the vertical subtended angle (VSA) is considered to be medium (VSA of 0.49 to 1.0; see Table 4.5.7).

It should be noted that the assessment of the visual impact (both vertical and horizontal subtended angles) at the Alka Hill and Birutė Hill observation sites did not take into account the plantations that strongly blocked the panorama of the Baltic Sea at the end of 2022. Even after the felling for the purpose of landscaping, these observation sites would not be able to provide panoramic views of a width sufficient to show the full projection of the wind park without damage to nature.

Table 4.5.7. Visibility of the proposed WTs (vertical subtended angle) from the main observation sites*****.

No.	**Observation site**	**Minimum distance to WT, km**	**Vertical subtended angle**	**Visual impact** after applying the importance factor of the observation site**
1	Pape Beach (Latvia)	37,0	0,45	-2
Palanga municipality				
2	Alka Hill	33,2	0,54	-3
3	Observation platform at Fisherman's Daughters	32,6	0,56	-3
4	Beach for the disabled	31,9	0,57	-3
5	Beach (exit from Jūratės St.)	29,8	0,62	-3
6	Palanga Bridge observation platform	29,5	0,62	-3
7	Palanga Bridge	29,2	0,61	-3
8	Beach (exit from Dariaus ir Girėno St.)	29,6	0,62	-3
Klaipėda district municipality				
10	Dutchman's Cap	31,7	0,57	-3
Klaipėda city municipality				
11	Giruliai Beach	33,4	0,53	-3
12	Klaipėda Port northern breakwater	35,1	0,48	-3
13	Smiltynė Beach	38,9	0,44	-3
Neringa municipality				
14	Juodkrantė Beach	48,4	0,28	-2
15	Nagliai Nature Reserve observation site	56,7	0,30	-2
16	Observation site on Vecekrugas Dune	63,3	0,25	-2
17	Nida Beach	65,9	0,14	-1

not taking into account existing woody plantations

**according to the assessment criteria given in Table 4.5.2*

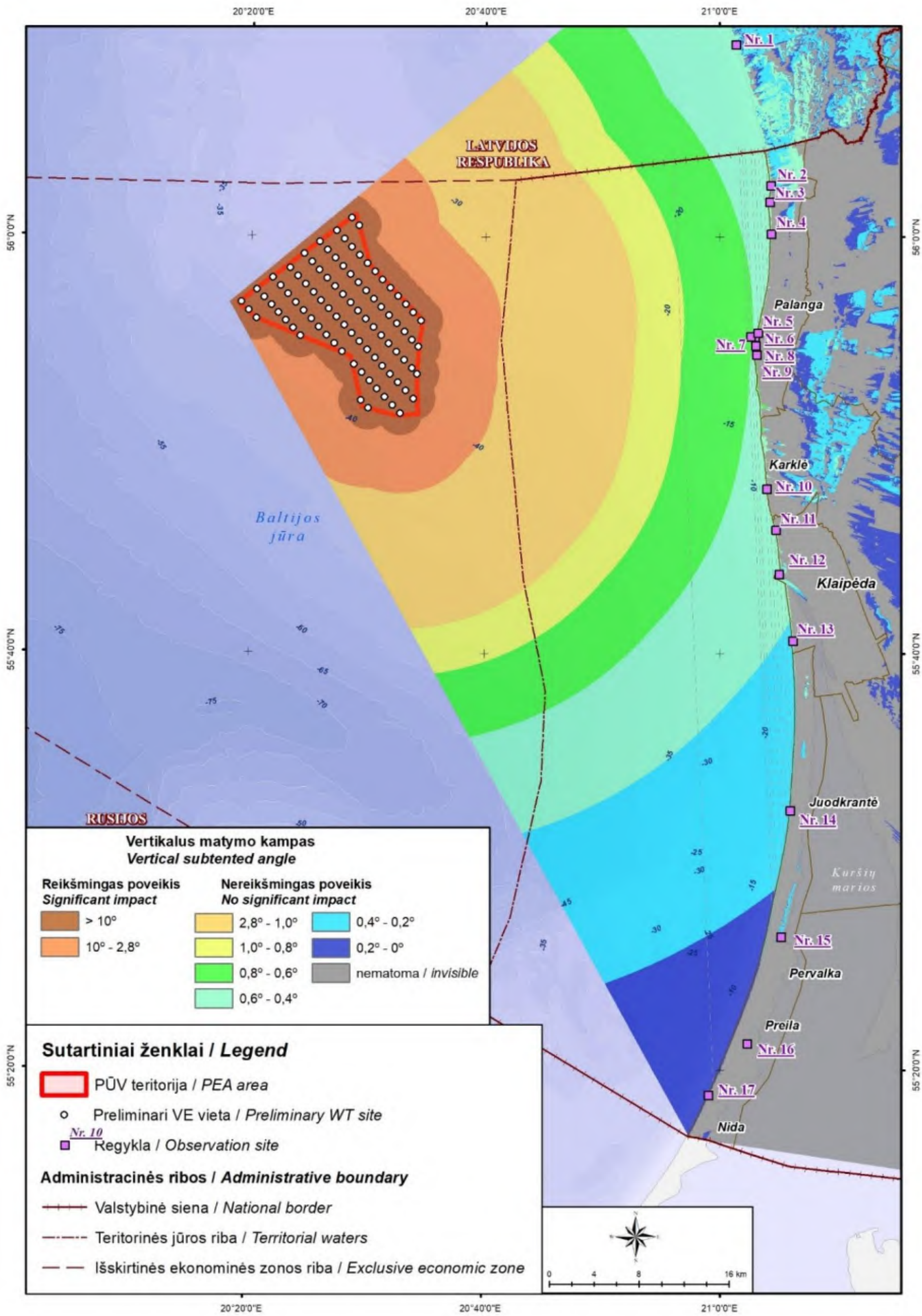


Fig. 4.5.12. Visual impact of 350 m high offshore WTs from the vertical subtended angle

Horizontal subtended angle. For assessing the potential impact of the proposed WTs on the integrity of the Lithuanian Baltic Sea water area, the horizontal subtended angle (hereinafter 'HSA') of the wind park was analysed (Fig.s 4.5.13), i.e. the horizontal fragmentation of the landscape and changes of the visual structure were assessed. Currently, the landscape of the Lithuanian Baltic Sea water area is fully open, and its existing vertical technogenic landmarks or ships are variable objects in terms of both position and visibility. The PEA will create an assemblage of permanent vertical technogenic objects of interest. In terms of the landscape character, the existing area of large open waters will become an openwork assemblage of particularly high engineering structures, which, due to their tower-like form and height, will be an important part of the technogenic, spatial and semantic landscape structure of the Lithuanian water area.

Although this criterion for assessing such significance is not regulated by legislation, the HSA criterion was analysed to determine the proportion of the open Baltic Sea horizon that will be occupied by the built-up area of the wind park (Table 4.5.8). Due to its size, shape and position, the wins park will be sufficiently visible along the entire Lithuanian coastline, except for the remote sections where the wind turbines will not be visible at all or their visible part will occupy less than 10 degrees of the field of view. These sections of lower visual impact will only occur in the southern part of the Curonian Spit.

Table 4.5.8. Visibility analysis of the proposed WTs from the horizontal subtended angle

No.	Observation site	Estimated horizontal subtended angle	Visual impact** after applying the importance factor of the observation site
1	Pape Beach (Latvia)	23.87	-2.25
2	Alka Hill*	27.68	-2.25
3	Observation platform at Fisherman's Daughters	28.11	-2.25
4	Beach for the disabled	28.53	-2.25
5	Beach (exit from Jūratės St.)	29.05	-2.25
6	Palanga Bridge observation platform	29.19	-2.25
7	Palanga Bridge	29.49	-2.25
8	Beach (exit from Dariaus ir Girėno St.)	28.90	-2.25
10	Dutchman's Cap	22.12	-2.25
11	Giruliai Beach	20.12	-2.25
12	Klaipėda Port northern breakwater	18.21	-2.25
13	Smiltynė Beach	15.45	-2.25
14	Juodkrantė Beach	11.10	-1.5
15	Nagliai Nature Reserve observation site	10.29	-1.5
16	Observation site on Vecekrugas Dune	4.84	-1.5
17	Nida Beach	10.26	-1.5

*not taking into account *existing plantations and trees. **according to the assessment criteria given in Table 4.5.2.*

Considering all the observation sites selected for analysis, it is evident that the offshore wind park will become a visually significant element of the seascape from the HSA (see Table 4.5.1, HSA from 2.5º–30º), at all the observation sites (except for Vecekrugas Dune and Nida Beach), the proposed wind park will be more or less visible in good weather conditions.

The overall semantic contrast between the wind park and the contextual landscape will be minimal in Klaipėda City that currently has other vertical landmarks of interest (existing buildings, port facilities, chimneys of boiler houses and radio towers). The semantic contrast will be the greatest in the resorts, on the beaches of Palanga and Šventoji during the tourist season, at the Palanga Bridge and the remnants of the Šventoji harbour pier, where a large number of visitors observe the sea horizon, especially at sunset.

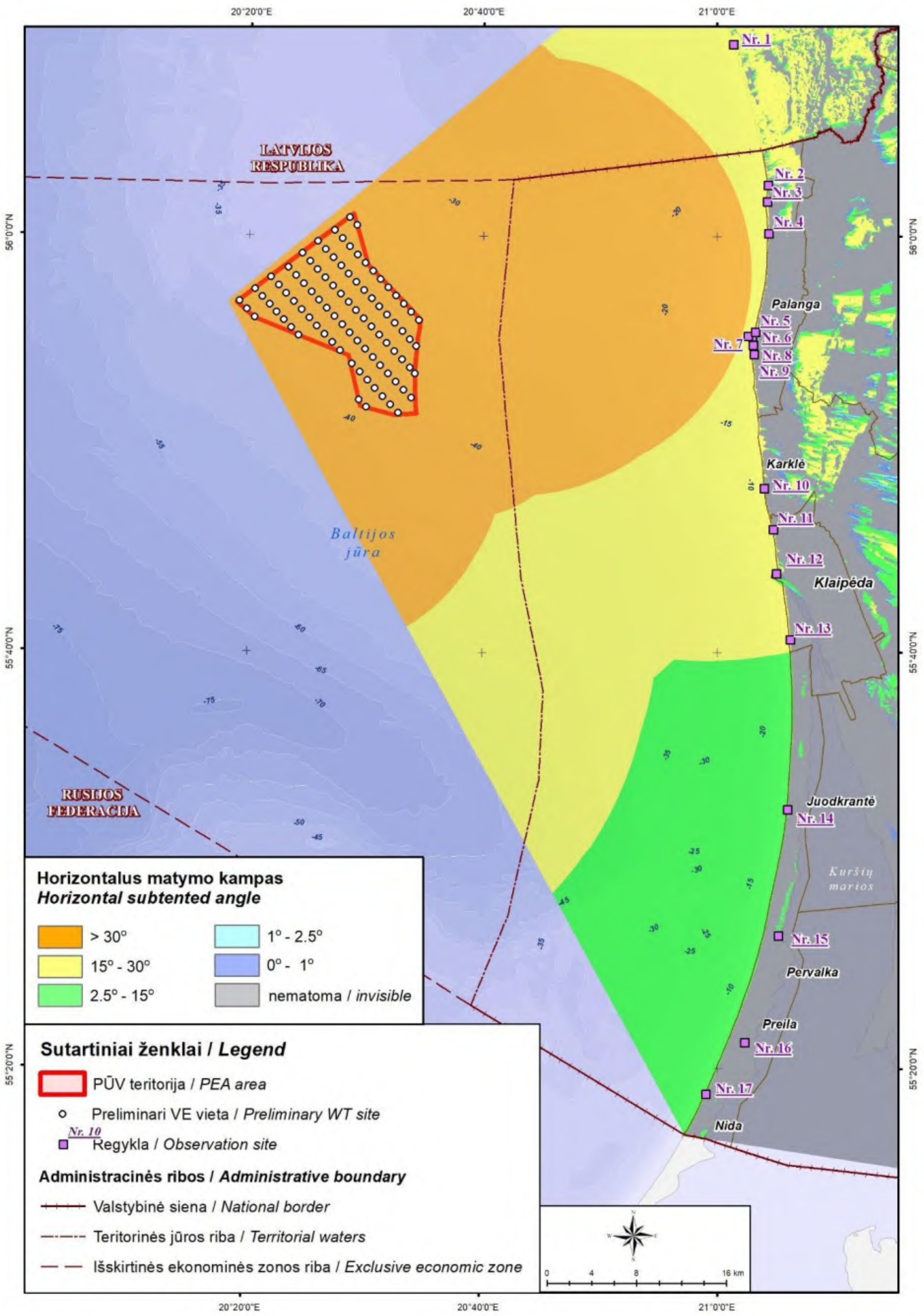


Fig. 4.5.13. Visual impact of 350 m high offshore WTs from the horizontal subtended angle

4.5.2.3. Potential impact on the intrinsic values and the spatial structure of the local landscape

According to the European Landscape Convention, landscape encompasses the whole of space, both terrestrial and aquatic, and landscape character is the immanent value of a region's identity. Landscape is in a constant state of dynamic change, but the changing characteristics of the landscape as a result of human activity cannot lead to damage to, or the disappearance of the essential relative proportion of individual landscape types. In other words, the future generations must be able to experience and use all the landscape types that are identified today.

The wind park that is to occupy a water area of maximum 137.5 km^2, this is a small part of the Lithuanian sea area, but the particularly high installations of the wind park will change fundamentally the level of cultivation of the area. This will lead to the emergence of a new type of urbanised marine energy landscape, similar to that of a medium-sized city. In terms of the size of its territory, a new landscape district will not be formed, but the new formation will rank the same as a landscape district, i.e. it will be slightly smaller than a large city (e.g. the area of Kaunas City (158 km^2)).

The implemented PEA will create a new technogenic area of an open Baltic Sea in the vicinity of the Lithuanian landscape in the plateau part of the shallow Baltic Sea (A), located in the region of the aquatic landscape of the underwater plateau area of the Southeastern Baltic Sea (AI) and of the Curonian-Western Samogitian Baltic nearshore underwater plateaus and depressions.

4.5.2.4. Potential impact on the local nature frame

The assessment of the potential impact of the PEA on the territories of Lithuania's marine nature frame is based on Order No. D1-96 of the Minister of Environment of the Republic of Lithuania of 14 February 2007 which defines the possible density of development for land parcels classified as land for other uses.

Part of the PEA area (about 8 900 ha) falls within the geomorphological zone of elevations of the Klaipėda-Ventspils Plateau and would cover approximately 5.8% of the elevation zone in Lithuania's Baltic Sea water area. It is important to note that the exact potential seabed area demand determined by the PEA solutions depends on the foundation design that will be chosen depending on the prevailing seabed geology and the technical parameters of the power plant model, and can range from 28 m^2 to 113 m^2.

Considering that the density of the proposed WT development will not exceed 30 per cent of the area of the geomorphological zone of the Lithuanian Baltic Sea elevations, it can be maintained that the potential impact of the REA on the nature frame areas will be insignificant.

4.5.2.5. Potential cumulative impact on the landscape

The proposed installation of the wind park will increase the cumulative environmental impact of other offshore economic activities, but by aligning the activities with their location according to the solutions of the spatial planning documents, this impact should be controlled and will not have any substantial significant adverse consequences.

In developing offshore wind parks and assessing their impact on the landscape, it should be noted that another area to the south of the water area analysed in the Report, as shown in Fig. 4.5.14, has been designated for a similar activity (AVEC, WT installation height of 197 m), the impact of which on the Curonian Spit protected as a UNESCO World Heritage Site has not been elaborated.

In addition, the Republic of Latvia is planning to build a renewable energy wind farm at its northern border with Lithuania.

Both projects could more than double the horizontal subtended angle of the wind turbines, which will have a particularly significant impact on Palanga Resort where the projection of the wind park at sunset will be significantly enlarged. Implementing only the REA considered in the Report, but not the AVEC project, would result in the greater protection of the Curonian Spit.

No cumulative impact on the nature frame areas is foreseen. Taking into account the area covered by both this wind park and the AVEC project, a new larger offshore Baltic Sea technogenic area will be created in the aquatic landscape region of the Curonian-Western Samogitian Baltic nearshore underwater plateaus and depressions.

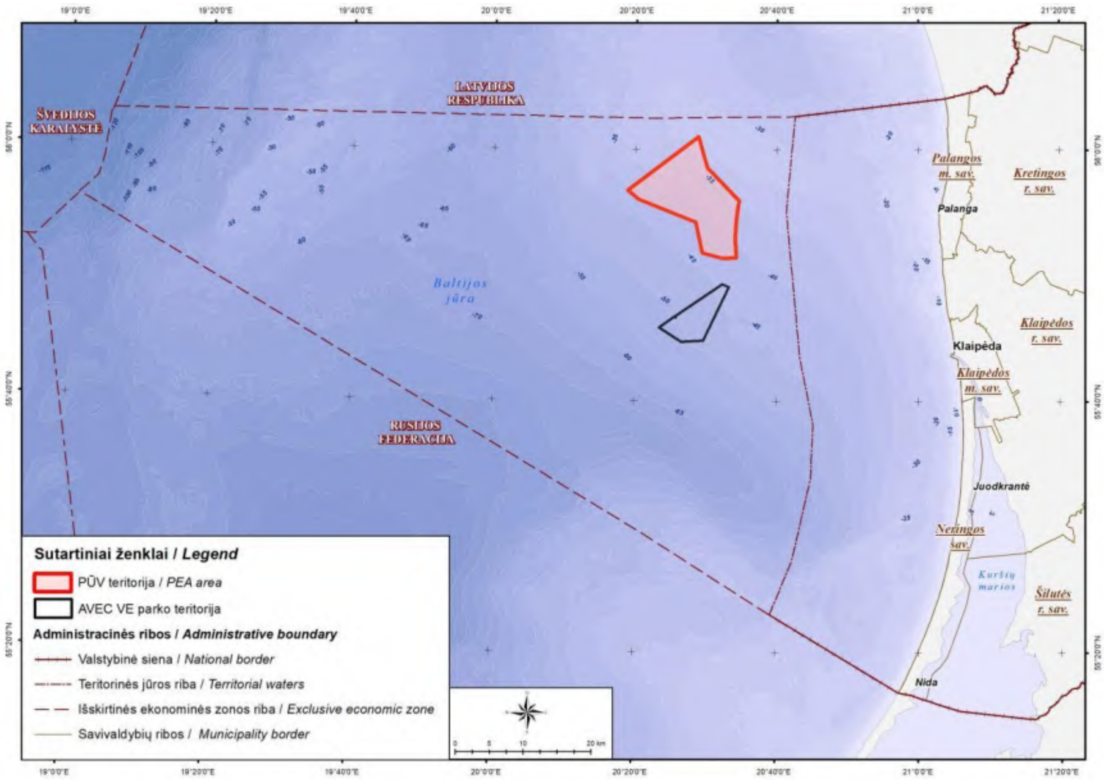


Fig. 4.5.14. Cumulative impact of the proposed wind parks in the aquatic landscape region of the Curonian-Western Samogitian Baltic nearshore underwater plateaus and depressions

4.5.2.6 Overall assessment of the potential impact on the local landscape

In the cases of almost all the observation sites considered the PEA would not exceed the threshold of significant impact on the landscape with respect to the laws, therefore the impact of the wind turbines on the landscape can be classified as insignificant.

Taking into account that the WE park can be visually seen from the shore in good visibility conditions, the final significance scores of the potential impact on the landscape of the planned WE park in the sea are determined (Table 4.5.9), showing that the visual impact are possible.

Table 4.5.9. Summary table of the potential impact on the local landscape.

Observation sites		**Potential impact on the local landscape (notional units) after applying minimising measures**				
		according Lithuanian laws	according analogy and international methodology (vertical subtended angle)	by the scope of observation (horizontal subtended angle)	according to the duration of the intervention in the exclusive ritual (sunset)	**Total significance**
Pape Beach (Latvia)	No. 1	0	-2	-2,25	-0,5	-1,19
Alka Hill	No. 2	0	-3	-2,25	-0,5	-4,31
Observation platform at Fisherman's Daughters	No. 3	0	-3	-2,25	-0,5	-4,31
Beach for the disabled	No. 4	0	-3	-2,25	-0,5	-4,31

Observation sites		**Potential impact on the local landscape (notional units) after applying minimising measures**				
		according Lithuanian laws	according analogy and international methodology (vertical subtended angle)	by the scope of observation (horizontal subtended angle)	according to the duration of the intervention in the exclusive ritual (sunset)	**Total significance**
Beach (exit from Jūratės St.)	No. 5	0	-3	-2,25	-1	-4,69
Palanga Bridge observation platform	No. 6	0	-3	-2,25	-1	-4,69
Palanga Bridge	No. 7	0	-3	-2,25	-1	-4,69
Beach (exit from Dariaus ir Girėno St.)	No. 8	0	-3	-2,25	-1	-4,69
Dutchman's Cap	No. 10	0	-3	-2,25	-1,5	-1,69
Giruliai Beach	No. 11	0	-3	-2,25	-1,5	-1,69
Klaipėda Port northern breakwater	No. 12	0	-3	-2,25	-1,5	-1,69
Smiltynė Beach	No. 13	0	-3	-2,25	-1,5	-1,69
Juodkrantė Beach	No. 14	0	-2	-1,5	-1,5	-5,00
Nagliai Nature Reserve observation site	No. 15	0	-2	-1,5	0	-3,50
Observation site on Vecekrugas Dune	No. 16	0	-2	-1,5	0	-3,50
Nida Beach	No. 17	0	-1	-1,5	0	-2,50

*subtended angles without account of the existing plantations and trees

Notional unit values chosen to assess the cumulative significance of the potential impact on the landscape:

No impact	When cumulative VPO assessment does not exceed 10 pct. of the sample size threshold, i.e. from 0 to -1.39
Insignificant adverse impact	When cumulative VPO assessment does not exceed 30 pct. of the sample size threshold, i.e. from -1.40 to -4.19
Significant adverse impact	When cumulative VPO assessment does not exceed 30 pct. of the sample size threshold, i.e. from -4.20 to -14

According to the overall assessment of visual impact, Palanga Central Beach observation site and Juodkrantė Beach observation site located in the Lithuanian landscape reserve with a special protection regimen are assigned to the category of significant visual impact.

To determine the maximum WT height for the visual impact of on the above-mentioned observation sites becoming insignificant, it was determined that the visual impact category shift from significant to insignificant when the total height of WT is under 280 m. For this purpose, a visibility analysis was conducted for a WT with a total height under 280 m. Moreover, the assessment of changes in visual impact once the WT height was reduced down to the maximum of 280 m also included the assessment of the impact of increasing the distance between the WT installation sites and the border of "Natura 2000" site on WT visibility. Results of the vertical and horizontal subtended angle calculation, where total height of WT is up to 280 m and WT installation site is up to 2 km away from the border of the protected area, are provided for in Table 4.5.10.

Table 4.5.10 Visibility of the proposed WTs (vertical subtended angle) from the main observation sites after the application of the measures

No.	**Observation site**	**Minimum distance to WT, km**	**Vertical subtended angle**		**Horizontal subtended angle**	
			WT up to 280 m	***WT up to 280 m and area reduction***	***WT up to 280 m***	***WT up to 280 m and area reduction***
1	Pape Beach (Latvia)	37.0	0.34	0.31	23,76	23,59
	Palanga Municipality					
2	Alka Hill	33.2	0.42*	0.39*	27,56*	26,05*
3	Observation platform at Fisherman's Daughters	32.6	0.44	0.42	27,98	26,32
4	Beach for the disabled	31.9	0.44	0.43	28,40	26,43
5	Beach (exit from Jūratės St.)	29.8	0.49	0.48	28,91	26,48
6	Palanga Bridge observation platform	29.5	0.49	0.48	29,05	26,59
7	Palanga Bridge	29.2	0.47	0.48	29,35	26,86
8	Beach (exit from Dariaus ir Girėno St.)	29.6	0.49	0.48	28,76	26,30
	Klaipėda District Municipality					
10	Dutchman's Cap	31.7	0.45	0.45	22,00	19,83
	Klaipėda City Municipality					
11	Giruliai Beach	33.4	0.41	0.41	20,01	17,99
12	Klaipėda Port northern breakwater	35.1	0.37	0.37	18,10	16,25
13	Smiltynė Beach	38.9	0.33	0.33	15,35	13,71
	Neringa Municipality					
14	Juodkrantė Beach	48.4	0.2	0.2	11,03	9,50
15	Nagliai Nature Reserve observation site	56.7	0.23	0.23	10,22	8,89
16	Observation site on Vecekrugas Dune	63.3	0.19	0.19	10,13	9,12
17	Nida Beach	65.9	0.08	0.08	7,95	6,13

**not taking into account existing woody plantations.*

The conducted assessment revealed that increasing the distance between WT installation sites and "Natura 2000" site has no impact on the visual impact values, while reducing the total height of WT down to 280 m affects only Palanga Central Beach observation site and Juodkrantė Beach observation site, the visual impact on which would also be insignificant in case of installing a WT up to 280 high.

To summarize the visual impact analysis, it can be stated that pursuant to the provisions stipulated in Article 49 (18) of the Law of the Republic of Lithuania on Energy from Renewable Sources, the impact of installation of a 350 m high WT at the distance of 29.5 km away from the coast and the important observation sites located therein on the landscape is considered to be insignificant. The conducted visual impact analysis revealed that informal partial limit of visual impact significance (from significant to insignificant) in terms of PEA is 280 m high WT, i.e. visual impact of a WT farm of the state height would be insignificant based on the calculated VSA and HSF values.

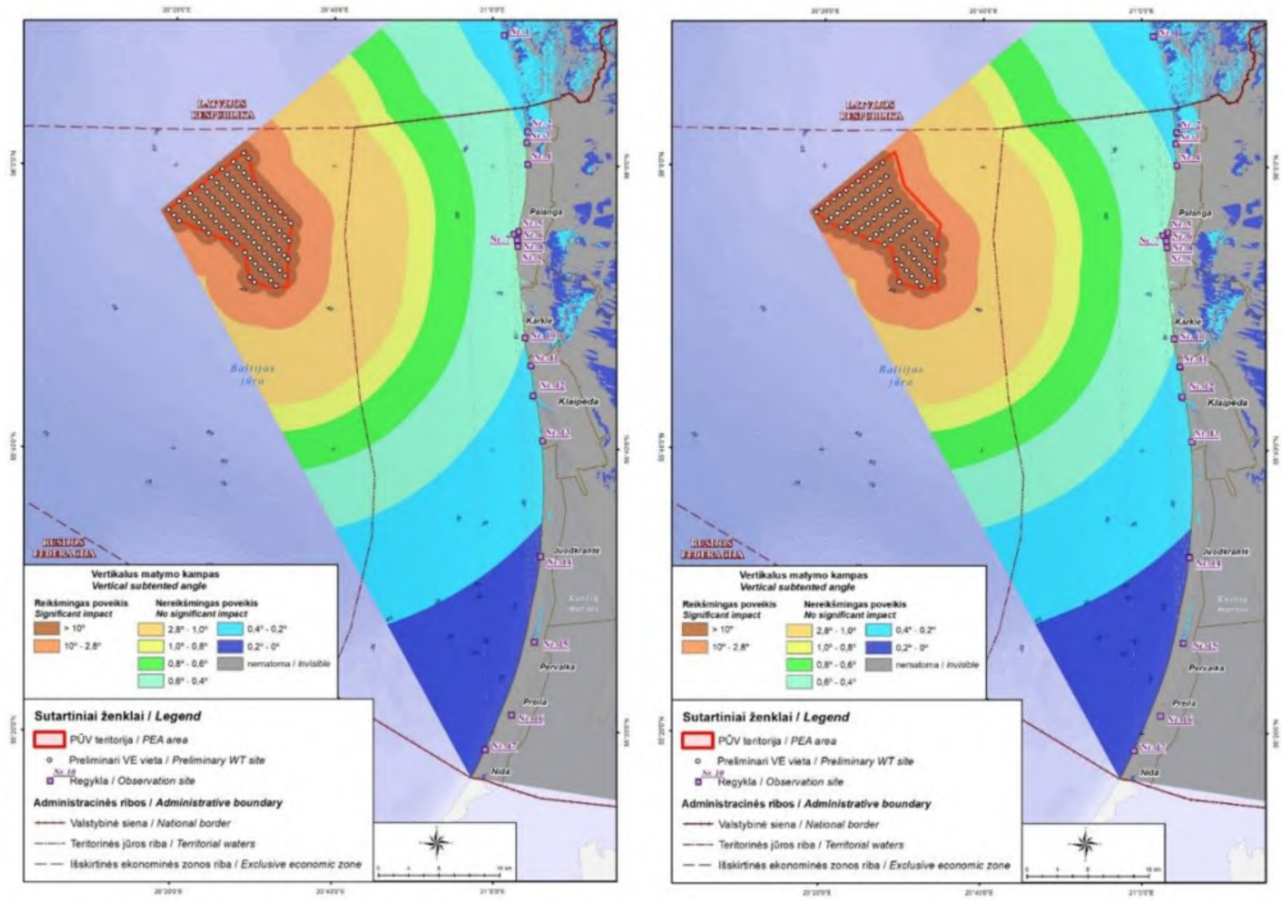


Fig. 4.5.15. Visual impact of 280 m total height marine WT by vertical subtended angle without (left) and with (right) area retraction.

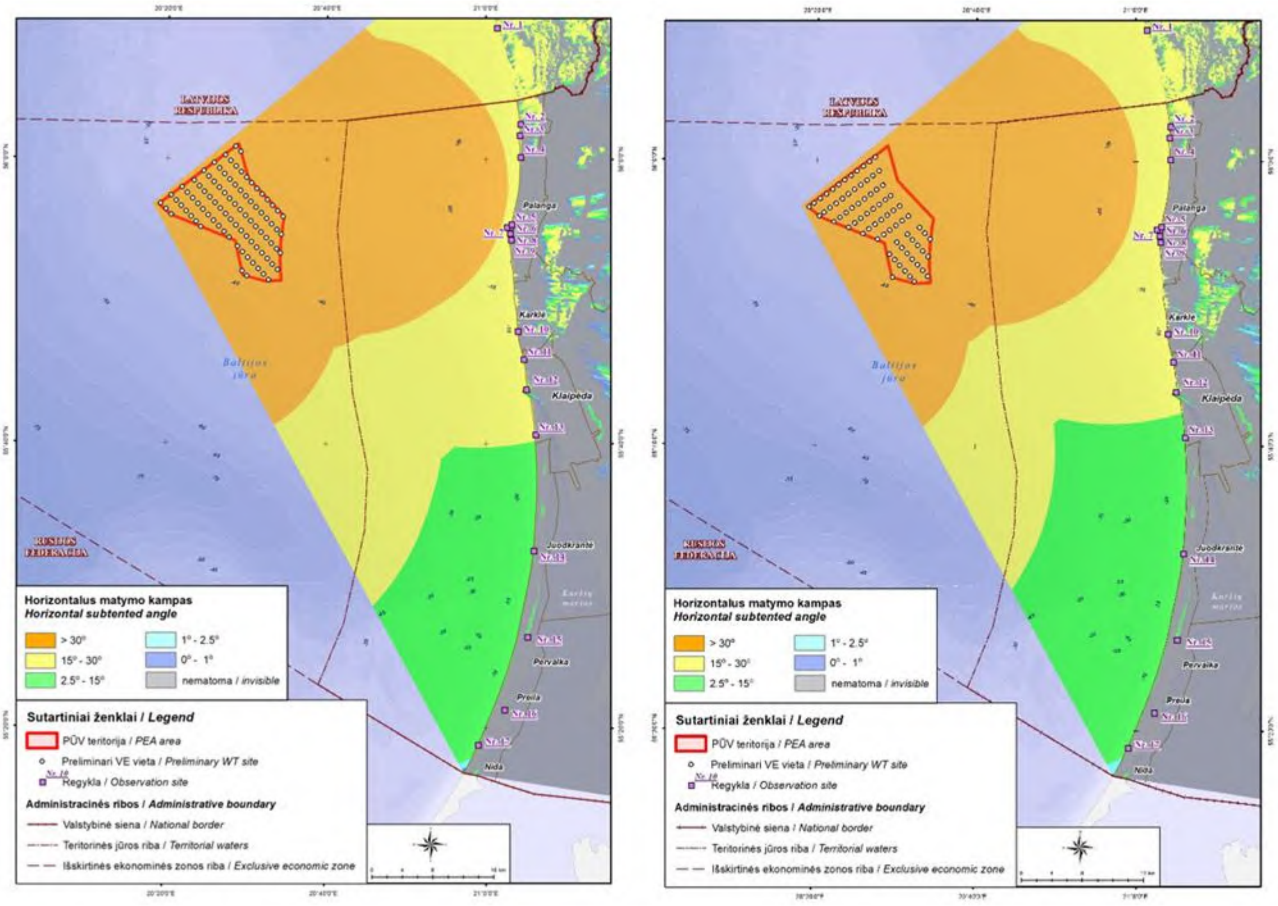


Fig. 4.5.16. Visual impact of 280 m total height marine WT by horizontal subtended angle without (left) and with (right) area retraction

Table 4.5.11 Summary table of potential impact on the local landscape after applying minimising measures

Observation sites		Potential impact on the local landscape (notional units) after applying minimising measures									
		according Lithuanian laws		according analogy and international methodology (vertical subtended angle)		by the scope of observation (horizontal subtended angle)		according to the duration of the intervention in the exclusive ritual (sunset)		**Cumulative significance**	
		WT up to 280 m	WT up to 280 m and area reduction	WT up to 280 m	WT up to 280 m and area reduction	WT up to 280 m	WT up to 280 m and area reduction	WT up to 280 m	WT up to 280 m and area reduction	WT up to 280 m	WT up to 280 m and area reduction
Pape Beach (Latvia)	No. 1	0	0	-2	-2	-2,25	-2,25	-0,5	-0,5	-1,19	-1,19
Alka Hill	No. 2	0	0	-2*	-2*	-2,25*	-2,25*	-0,5*	-0,5*	-3,56*	-3,56*
Observation platform at Fisherman's Daughters	No. 3	0	0	-2	-2	-2,25	-2,25	-0,5	-0,5	-3,56	-3,56
Beach for the disabled	No. 4	0	0	-2	-2	-2,25	-2,25	-0,5	-0,5	-3,56	-3,56
Beach (exit from Jūratės St.)	No. 5	0	0	-2	-2	-2,25	-2,25	-1	-1	-3,94	-3,94
Palanga Bridge observation platform	No. 6	0	0	-2	-2	-2,25	-2,25	-1	-1	-3,94	-3,94
Palanga Bridge	No. 7	0	0	-2	-2	-2,25	-2,25	-1	-1	-3,94	-3,94
Beach (exit from Dariaus ir Girėno St.)	No. 8	0	0	-2	-2	-2,25	-2,25	-1	-1	-3,94	-3,94
Dutchman's Cap	No. 10	0	0	-2	-2	-2,25	-2,25	-1,5	-1,5	-1,44	-1,44
Giruliai Beach	No. 11	0	0	-2	-2	-2,25	-2,25	-1,5	-1,5	-1,44	-1,44
Klaipėda Port northern breakwater	No. 12	0	0	-2	-2	-2,25	-2,25	-1,5	-1,5	-1,44	-1,44
Smiltynė Beach	No. 13	0	0	-2	-2	-2,25	-1,5	-1,5	-1,5	-1,44	-1,25
Juodkrantė Beach	No. 14	0	0	-1	-1	-1,5	-1,5	-1,5	-1,5	-4,00	-4,00
Nagliai Nature Reserve observation site	No. 15	0	0	-2	-2	-1,5	-1,5	0	0	-3,50	-3,50
Observation site on Vecekrugas Dune	No. 16	0	0	-1	-1	-1,5	-1,5	0	0	-2,50	-2,50
Nida Beach	No. 17	0	0	0	0	-1,5	-1,5	0	0	-1,50	-1,50

*subtended angles without account of the existing plantations and trees

Notional unit values chosen to assess the cumulative significance of the potential impact on the landscape:

No impact	Where the score of cumulative VPO assessment does not exceed 10 pct. of the sample size threshold, i.e. from 0 to -1.39
Insignificant adverse impact	Where the score of cumulative VPO assessment does not exceed 30 pct. of the sample size threshold, i.e. from -1.40 to -4.19

4.5.3. Measures for minimising and compensating the impact on the landscape

Pursuant to the provisions stipulated in Article 49 (18) of the Law of the Republic of Lithuania on Energy from Renewable Sources, the impact of installation of a 350 m high WT at the distance of 29.5 km away from the coast and the important observation sites located therein on the landscape is considered to be insignificant. With consideration of the above, **the measures for minimising the visual impact are not mandatory**

With consideration of the nature of the proposed economic activity, i.e. operation of a WT farm in the open seascape where the existing vertical and technogenic dominants are only occasional (ships), the measures for minimising and compensating the impact on the local landscape are complex.

The following is proposed to minimise the potential impact on the landscape:

- Paint the WTs in light colours creating a minimal colour contrast, avoiding white colour contributing to a greater contrast;
- Use paint with special ingredients that would allow avoiding glance and gleam of the structures.
- Assess the possibility of positioning the WT farm perpendicular to the coast (in parallel to the Palanga Bridge axis) and/or position individual WTs in lines (arches).
- With consideration of the established fact that lower WTs (up to 280 m high) would have a lower visual impact, it is proposed for the developer to assess the technical possibilities of choosing lower (up to 280 m) WT models, if such choice would ensure that the WT farm could general an optimum amount of electricity, which is necessary to ensure the objectives of the Lithuanian Energy Independence Strategy.

4.6. Biodiversity

4.6.1. Protected Areas and NATURA 2000 Sites

4.6.1.1. Current Situation

In the Lithuanian waters of the Baltic Sea, there are protected areas and sites of the European ecological network "Natura 2000" demarcated. The PEA territory borders the biosphere reserve of the Klaipėda-Ventspils Plateau and important habitat and bird protection areas (Fig. 4.6.1). Information on the closest protected areas is provided in Table 4.6.1

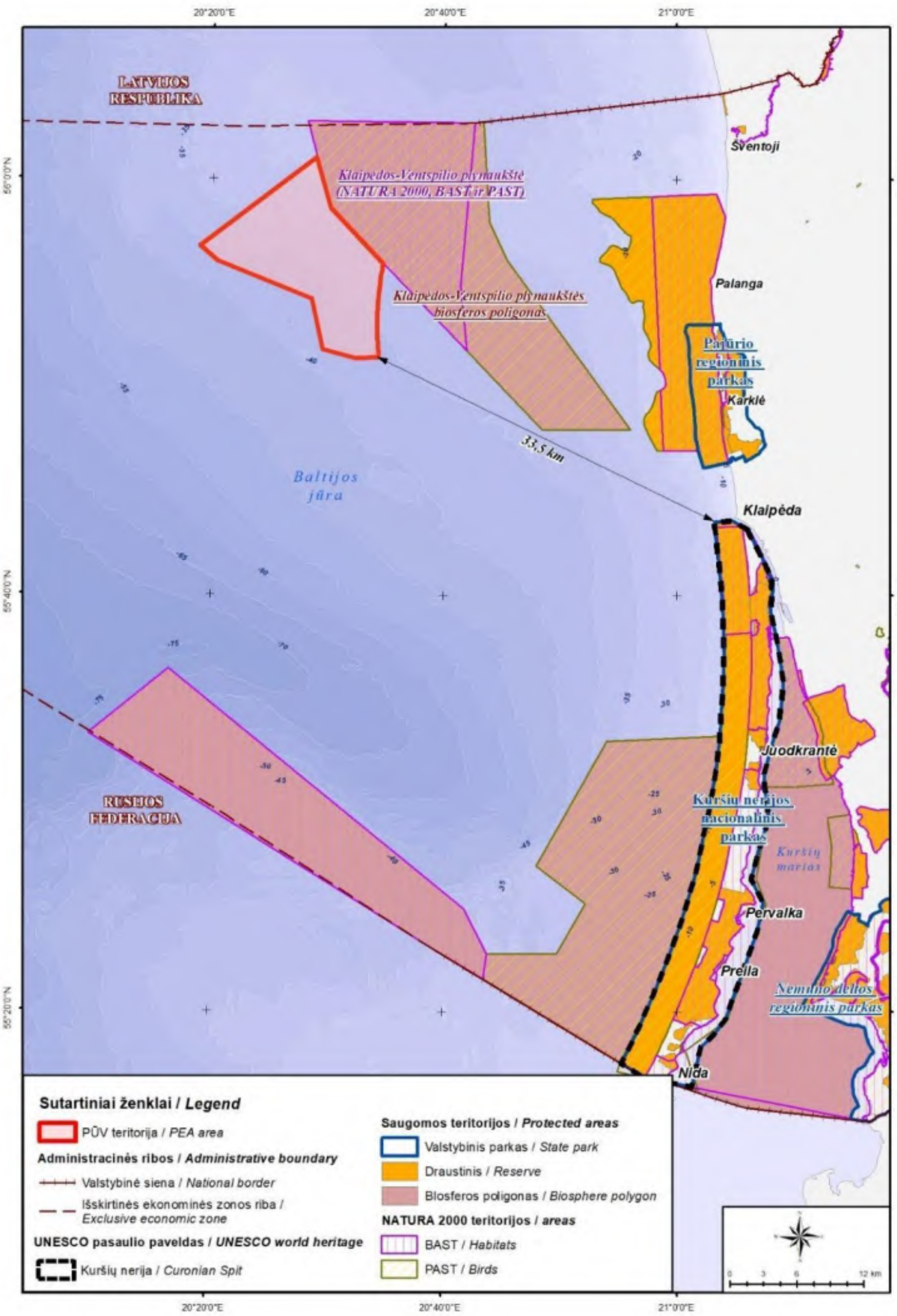


Fig. 4.6.1. Protected areas and NATURA 2000 sites closest to the PEA territory

Table 4.6.1. information on the protected areas and NATURA 2000 sites bordering the PEA territory, purposes of establishment thereof, protected natural habitats and species of EU importance (according to the State Cadastre of Protected Areas of the Republic of Lithuania).

Protected area	Area, ha	Purpose of establishment, protected valuables	Distance from the boundary of the proposed territory
Biosphere reserve of the Klaipėda-Ventspils Plateau	31949.309903	To protect a valuable part of ecosystem of the Baltic Sea in the Klaipeda-Ventspils Plateau, in particular, with a view to conserve: Areas of the natural marine habitat of EU importance, i.e., 1,170 reefs, to ensure a favourable conservation status thereof; a place of regular gatherings of wintering water birds of EU importance: velvet scooter (*Melanitta fusca*), to ensure a favourable conservation status thereof; wintering and migrating populations of razorbill (*Alca torda*), long-tailed duck (*Clangula hyemalis*), to ensure a favourable conservation status thereof; to conduct observation (monitoring) of the natural habitat and the protected species referred to in paragraph 3.1 of the Regulation, studies in relation to the protected valuables; to collect information on status thereof; to analyse the impact of human activities on the marine ecosystem; to ensure the sustainable use of natural resources; to promote ideas and ways of biodiversity conservation.	borders
NATURA 2000 IBPA Klaipėda-Ventspils Plateau	31949.309903	To protect gatherings of the wintering velvet scooter (*Melanitta fusca*)	borders
NATURA 2000 IHPA Klaipėda-Ventspils Plateau	17948.498809	1,170 reefs	borders

Biosphere Reserve of the Klaipėda-Ventspils Plateau

Pursuant to the Regulations for the Biosphere Reserve of the Klaipėda-Ventspils Plateau, as approved by the Order No. D1-333 of the Minister of Environment of the Republic of Lithuania of 23 April 2015, economic or other activities performed in the Biosphere Reserve cannot worsen the favourable protection status of the valuables provided for in the objectives of the Regulations. In the entire Biosphere Reserve, it is prohibited to:

- Perform economic or other activities if that would change water content chemically, long-term hydrodynamic processes (except when these processes have been caused by passing vessels), conditions of underwater habitats, or otherwise would significantly worsen the protection status of natural habitation of wintering seabirds;

- Handle and disrupt sea bottom, perform dumping activities or otherwise change the habitations if that would significantly worsen protection status of the valuables protected;
- Hunt seabirds;
- Perform construction activities below and above water level if that would significantly worsen the protection status of the valuables protected;

In the marine territory of the Republic of Lithuania falling within the Biosphere Reserve, it is prohibited to:

- Fish with bottom trawls;
- Fish with surface nets with a mesh size of 50 mm and more - from 1 November to 30 April;
- Fish with bottom-set nets of mesh size of 50 mm and more at a depth of more than 20 meters from the water surface to the upper boundary of the net. This restriction applies from 1 November until 30 April;

In the Exclusive Economic Zone of the Republic of Lithuania falling within the Biosphere Reserve, the restrictions on fishing or other economic activity established by the European Commission must be observed for the purposes of the protected valuables.

Biosphere Reserve of the Klaipėda-Ventspils Plateau as the area of importance for the protection of Natura 2000 birds (EU code LTPALB002).

Established by the Order No. D1-530 of the Minister of Environment of the Republic of Lithuania of 8 July 2015. Its borders coincide with the borders of the Biosphere Reserve of the Klaipėda-Ventspils Plateau. The purpose of attributing the protected site to the Natura 2000 network is to protect gatherings of the wintering velvet scooter (*Melanitta fusca*).

General activity regulations in the territory are defined pursuant to Annex 2 of the Resolution No. 276 of the Government of the Republic of Lithuania of 15 March 2004 "On Approval of General Regulations of Areas of Importance for the Conservation of Habitats or Birds":

In gatherings of the velvet scooter (*Melanitta fusca*) (Clause 14 Section III):

- Fishing with trap nets with a mesh size of 50 mm and more is prohibited in the Baltic Sea from May to April (this prohibition is not applicable when the nets of the specified mesh size are set in the Baltic Sea at a depth of at least 15 meters from the water surface to the upper boundary of the net, or in all cases when the specified nets are used for ice fishing);

- Handling sea bottom, performing dumping activities (except for beach replenishment with sand) or otherwise change the habitations is prohibited if that would worsen status thereof;

Biosphere Reserve of the Klaipėda-Ventspils Plateau as the area of importance for the protection of Natura 2000 habitats (EU code LTPAL0002). Established by the Order No. D1-418 of the Minister of Environment of the Republic of Lithuania of 3 June 2016.

General activity regulations in the territory are defined pursuant to Annex 1 of the Resolution No. 276 of the Government of the Republic of Lithuania of 15 March 2004 "On Approval of General Regulations of Areas of Importance for the Conservation of Habitats or Birds":

Changing the seabed relief, performing other activities is prohibited in 1,170 reef habitats if that would violate the hydrological mode and change water content chemically, change, pollute or otherwise worsen the conditions of the habitats;

4.6.1.2. Potential impact on the protected areas and the protected valuables therein and mitigation measures

The area considered for the WT construction does not fall within Natura 2000 and the protected areas, however, it borders with the Biosphere Reserve of the Klaipėda-Ventspils Plateau and important habitat and bird protection areas on the east side. Indirect impact on the valuables of the protected areas is thus potential (Table 4.6.2).

Table 4.6.2. Information on protected areas, protected valuables therein and potential impact

<table>
<tr><th>Protected site</th><th>Protected valuable that are potentially subject to impact by the installation of WT farm</th><th>Potential impact</th><th>Mitigation measures</th></tr>
<tr><td>Biosphere Reserve of the Klaipėda-Ventspils Plateau</td><td>1,170 reefs
Gatherings of wintering water birds - velvet scooter (Melanitta fusca) and to ensure a favourable conservation status thereof;
Wintering and migrating populations of razorbill (Alca torda), long-tailed duck (Clangula hyemalis)</td><td rowspan="2">Potential impact on the protected species of birds due to disturbance and eviction from habitat with proper feeding grounds.
It is estimated that the impact of eviction from habitat and scaring away is potential for sea ducks feeding on benthic organisms - velvet scooter and long-tailed duck.
The scaring away effect during bird wintering is potential due to the increase in the shipping intensity during construction or regular transportation of the servicing personnel by vessels or helicopters at the stage of WT operation.</td><td>Protection of benthic habitats important for bird feeding and mitigation of scaring away of wintering water birds by avoiding installation of WTs within 1–2 km zone from the protected and Natura 2000 IBPA area Klaipėda-Ventspils Plateau,</td></tr>
<tr><td>Klaipėda-Ventspils Plateau</td><td>Protection of gatherings of the wintering velvet scooter (Melanitta fusca)</td><td>During construction, if operations are to be performed during the bird wintering (December to March) to mitigate the impact for the birds wintering in the protected areas, the routes of vessels installing the WT farm should be provided for to avoid the Natura 2000 IBPA areas.</td></tr>
<tr><td>NATURA 2000 IHPA Klaipėda-Ventspils Plateau</td><td>1,170 reefs</td><td>No direct impact on the reefs identified in the protected area is provided. However, the studies identified that the valuable reef habitats also suitable for feeding of the protected species of birds spread to the PEA area, as well.
A significant physical decay of the seabed due to irreversible changes of seabed substrate or morphology and a destructive impact on the seabed biotopes are probable during the wind farm installation, operation and dismantling phases in the identified sites of circalithoral boulders and biogenic reefs.</td><td>A part of the PEA territory, where the significant adverse impact is probable, borders with Natura 2000 IHPA biogenic reef (1,170) area. The most valuable is the Mytilus trossulus-Crustacea community, which forms on a solid ground (boulders, rock bedding) that is common at the north-eastern border of the proposed area.
To mitigate the impact of installation of offshore WTs on the protected benthic habitat and to ensure that the spread and participation of valuable seabed molluscs in the general food chain remains uninterrupted, it is recommended not to build WT foundations and avoid laying the cable in places of valuable reefs. It is recommended not to plan WT foundations and cable routes in the area of high distribution of Macoma trossulus abundance zone (Fig. 4.6.2.10).</td></tr>
</table>

4.6.2. Seabed habitats

4.6.2.1. Survey methods used

Macrozoobenthos (sin. macrofauna) are benthic invertebrates that live in the bottom habitat of the aquatic environment, bigger than 0.5-1 mm (< 0.5 mm meiobenthos; > 50 mm megabenthos), most of which are highly fertile and have a planktonic stage of development that allows the organisms to spread widely.

Surveys on the taxonomic composition, density and biomass of macroinvertebrates were conducted in accordance with LST EN ISO 16665:2014 Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna and LST EN ISO 19493:2007 Water quality - Guidance on marine biological surveys of hard- substratum communities and HELCOM recommendations (HELCOM, 1988; HELCOM, 2014). The main principles and recommendations - of the Guidelines for the environmental impact studies on marine biodiversity for offshore wind farm projects in the Baltic Sea Region have been taken into account.

Fifty-four sampling sites were selected on the basis of data from multibeam echosounder and side-scan sonar. Three background survey sites (stations 37, 38, 48) approximately 1 nautical mile from the boundaries of the PEA area have also been selected out of 54 taken (Fig. 4.6.2.1). The results of these surveys are planned to be used in the future to assess the condition during the operation of the WF park. For the assessment of the species composition, density and biomass of benthic invertebrates in the PEA area, two testing methods have been combined: quantitative - sediment sampling of the bottom with a suction dredger and qualitative - dredge.

A total of 106 bottom sediment samples were taken from depths of 30.1 to 43.1 m from 9 to 11 March 2022 (1-3 repetitions per site), using a suction dredger at 48 sites, a dredge at 6 sites, and in 2 places with a suction dredger and dredge (Table 4.6.2.1).

Table 4.6.2.1. Seabed samples

Seabottom sediments type	Sampling sites	Sample number Van Veen	Sample number Draga
Siltyy sand	14	28	-
Low silty,-clayey sand	14	30	-
Clay, clayey sand	3	3	3
Boulders, gravel, gravelly sand	9	11	3
Evenly sorted sand	14	26	2
Total:	**54**	**98**	**8**

At sea, quantitative samples were taken with Van Veen grab (bottom coverage area 0.1 m-2) by taking 2-3 samples from each site. In hard-bottom areas where Van Veen grab could not be used, a dredge was used, by taking 1 semi-quantitative sample while the ship was sailing slowly at a speed of 5 minutes per nautical mile. If the sample failed to be taken, the test was repeated by extending the dredging time up to 10 minutes. A sieve of 500 µm mesh (approved by the manufacturer) was used to rinse the samples. Invertebrates with the bottom residues were transferred into plastic containers and fixed with a 4 % formaldehyde solution neutralised with sodium tetraborate. A stereo microscope was used in the laboratory to calculate and characterise the density of each invertebrate species or taxon (magnification 7-230 times).

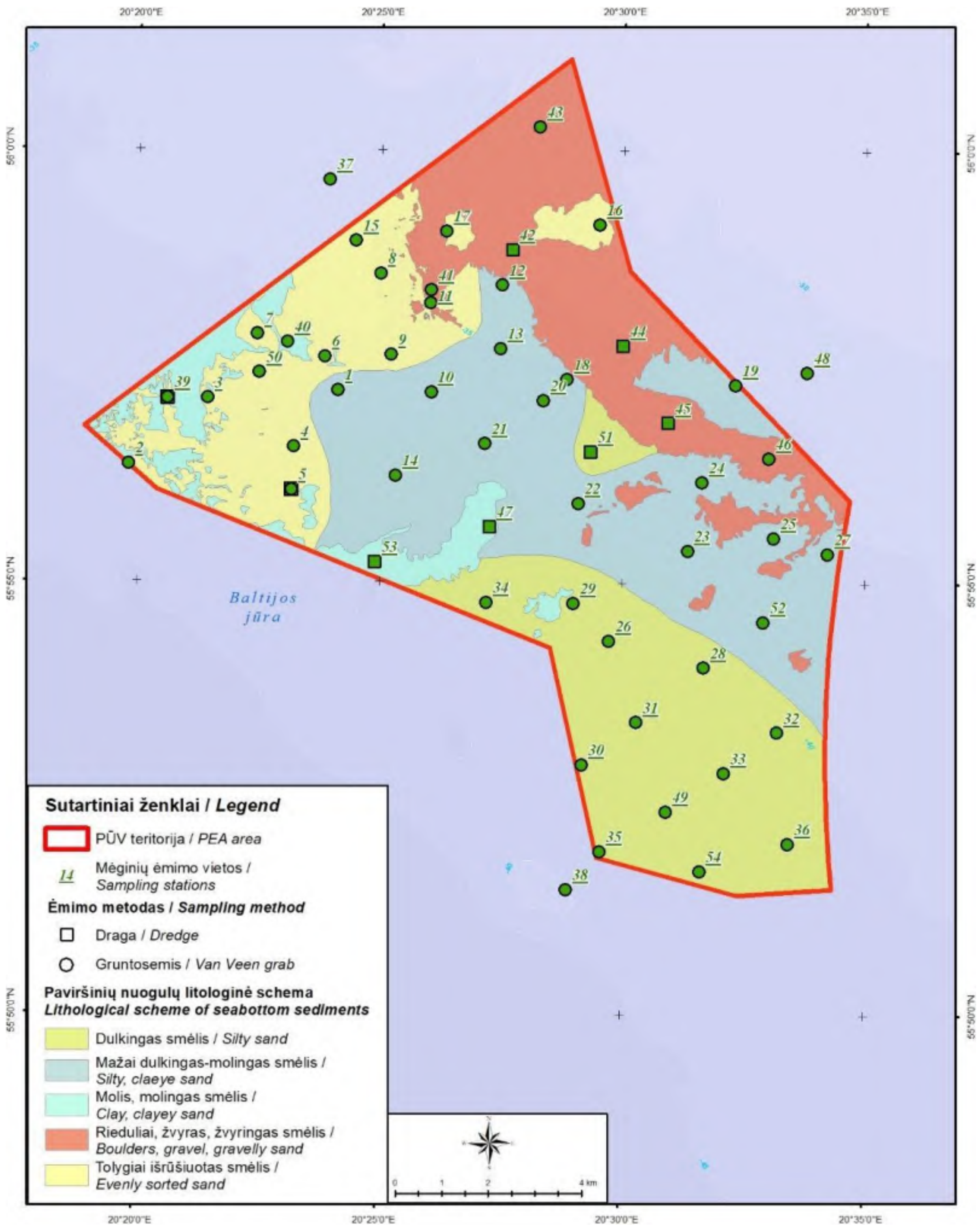


Fig. 4.6.2.1. Sites of benthos sampling.

The calibrated laboratory analytical scales of precision class I (accuracy 0.0001 g) were used for the formalin wet weight of invertebrates. The lengths of Macoma balthica and Mytilus trossulus shells were measured with the digital caliper (L, mm) with an accuracy of 0.01 mm.

The animals were described to the lowest possible taxon level. The taxonomic nomenclature corresponds to the European Register of Marine Species (ERMS, http://www.marbef.org/data/erms.php) and the World Register of Marine Species (WoRMS, http://www.marinespecies.org).

The density and biomass of individuals of each counted and weighed species/taxon of each quantitative (Van Veen) sample were converted into an area unit m^2. The organisms of each sample taken by the dredge were counted, the dominant species were distinguished, and the taxonomic composition was determined. As the ship was sailing at the same speed at all dredging sites and at the same time interval, the density and biomass of the dominant species of different sites were relatively scored (from 1 to 10).

4.6.2.2. The present situation

According to the results of inventories conducted under "Renewal of the Lithuanian Baltic Sea Environmental Management Strengthening Documents (condition assessment)" in 2020, based on the recommendations of Evans et al. (2016) and Condé et al. (2018), the seabed habitats in Lithuania are classified as 13 broad habitat types corresponding to EUNIS classification level 2. These habitat types largely have equivalents at the HELCOM HUB level 3 (HELCOM, 2013) in the classification (Fig. 4.6.2.2).

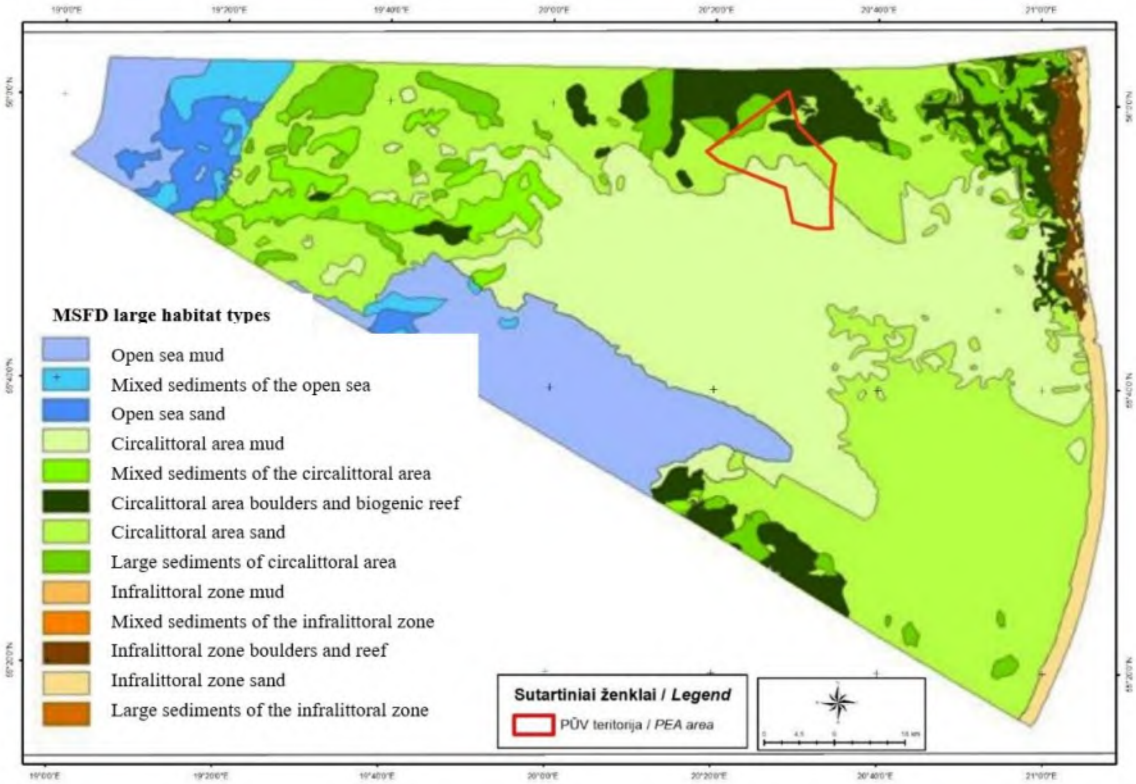


Fig. 4.6.2.2. Distribution of the main habitat types of the MSFD in Lithuanian marine waters (according to "Renewal of the Lithuanian Baltic Sea Environmental Management Strengthening Documents (condition assessment)", 2020)

Four large habitats in the aphotic zone in the PEA area are under assessment. The names and codes of these large habitat types in EUNIS and HELCOM HUB level 3 classifications are given in Table 4.6.2.2.

Table 4.6.2.2. Spatial characteristics of predominant large benthic habitat types and correspondence with EUNIS and HELCOM HUB level 3 classifications

Predominant benthic habitat types	EUNIS habitat codes (2016)	HELCOM HUB level 3 habitat code	Area (km^2)	Percentage share of the PEA area (%)
Circalittoral silty sand (mud)	MC6	AB.H	52.4	38.4
Circalittoral sand	MC5	AB.J	60.5	44.4
Circalittoral coarse sediment + Circalittoral mixed sediment	MC3	AB.I, AB.M	8.7	6.4
Circalittoral boulders and biogenic reef + Circalittoral mixed sediment	MC1, MC2	AB.A, AB.M	14.8	10.8

In the PEA area, the most valuable habitat is the circalittoral rocks (boulders site) and the biogenic reef. It is a biologically important bottom habitat according to the "Renewal of the Lithuanian Baltic Sea

Environmental Management Strengthening Documents (condition assessment), 2020" and the habitat types of Annex I to the Habitats Directive.

From a geomorphological point of view, reefs are morainic ridges with epifauna bivalve molluscs *Mytilus trossulus* and barnacle crustaceans *Amphibalanus improvisus*, the findspot of which has been dtermined not only in the Lithuanian territorial sea at Palanga but also in the PEA area under assessment.

The interim report of the project "Surveys of Natura 2000 the marine reef (1170) habitats in the Baltic Sea and macrophytes in the Baltic Sea and the Curonian Lagoon in 2020" presents a detailed monitoring plan for reef habitats located off the coast of the Baltic Sea, within the boundaries of the biosphere polygons of Sambia and Klaipeda-Ventspils plateau in the territorial sea and in the exclusive economic zone, specifying the exact monitoring sites as well as other relevant information related to the implementation of monitoring and the provision of data. During the preparation of the monitoring plan, the recommendations of HELCOM (2014) and other relevant scientific information for the monitoring of hard-bottom habitats were taken into account.

The adequacy of the reef habitat monitoring plan is justified in order to assess the status against the indicators of the Marine Strategy Framework Directive (MSFD) 2008/56/EC, the Habitat Directive 92/43/EEC, the Water Framework Directive 2000/60/EC, the Helsinki Commission (HELCOM) indicators related to the assessment of marine habitats and impact on them as well as the criteria set out in the State Environmental Monitoring Programme for 2018-2023.

The part of the PEA area falls within the reef monitoring area (Fig. 4.6.2.3; 4.6.2.7).

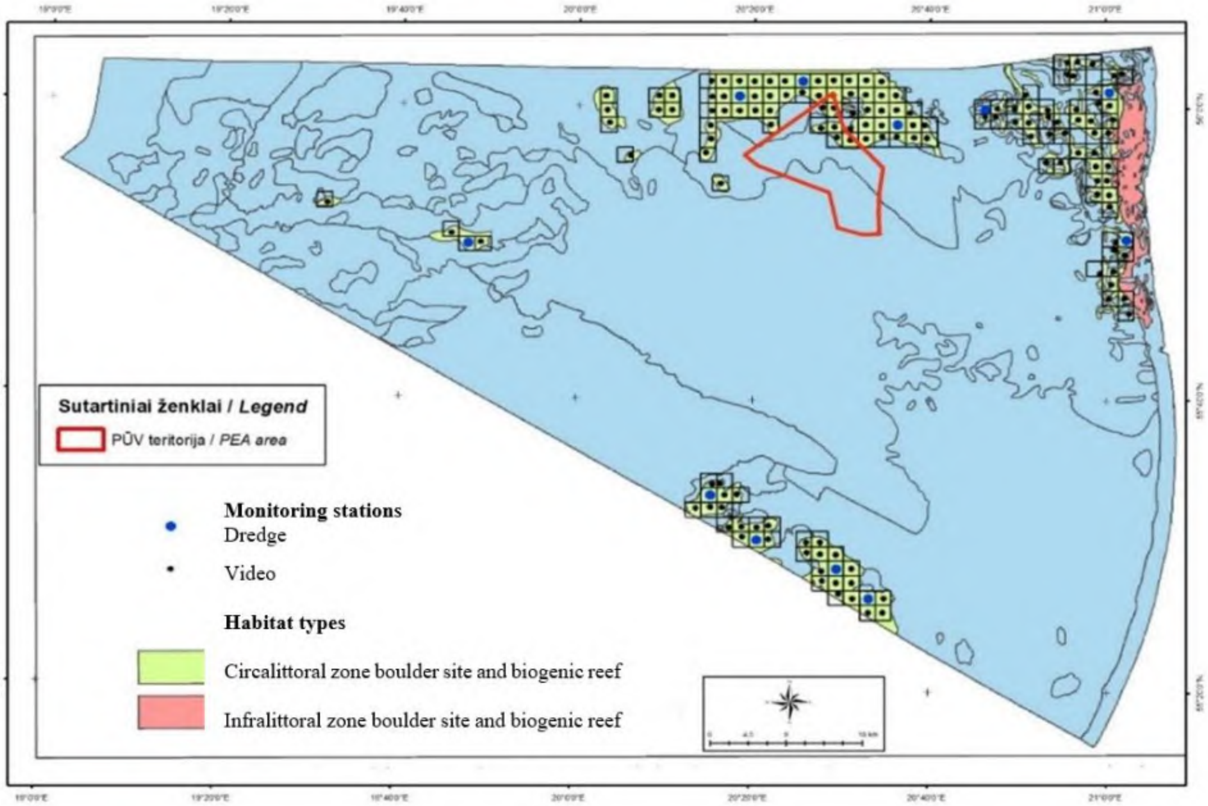


Fig. 4.6.2.3. Lithuanian Baltic Sea reef monitoring plan.

During the surveys conducted in 2022, 36 invertebrate species/taxa were found in the PEA area, with the incidence frequency of 14 species exceeding 40% (Table 4.6.2.3). Colonial invertebrates Gonothyraea loveni and moss animals Einhornia crustulenta were found throughout the survey area. The distribution of other species in the survey area depended on the structure of the bottom substratum, either the hard bottom or the soft bottom.

Table 4.6.2.3. Determined bottom invertebrates

Phylum	Taxon	Taxon / Species	Frequency of occurrence ± SE, % (Van Veen and Drage)	Mean density ± SD, ind. m^{-2}	Mean biomass ± SD, g m^{-2}
Cnidaria	Hydrozoa	*Laomedea sp.*	1.9 ± 1.8	-	-
		Gonothyraea loveni [3]	77.8 ± 5.7	-	-
		Cordylophora caspia [3]	1.9 ± 1.8	-	-
Cephalorhyncha	Priapulida	*Halicryptus spinulosus*	68.5 ± 6.3	95 ± 78	0.85 ± 1.18
Nematoda	Nematoda	*Nematoda gen. sp.* [1]	3.7 ± 2.6	-	-
Nemertea	Nemertea	*Cyanophthalma obscura*	1.9 ± 1.8	-	-
		Nemertea gen. sp.	1.9 ± 1.8	-	-
Platyhelminthes	Tricladida	*Tricladida* gen. sp.	3.7 ± 2.6	-	-
Annelida	Polychaeta	*Bylgides sarsi* [4]	11.1 ± 4.3	-	-
		Hediste diversicolor	46.3 ± 6.8	34 ± 40	1.87 ± 9.30
		Fabricia stellaris	1.9 ± 1.8	-	-
		Marenzelleria spp.	94.4 ± 3.1	218 ± 149	0.96 ± 1.79
		Pygospio elegans	94.4 ± 3.1	377 ± 261	0.16 ± 0.15
	Oligochaeta	*Oligochaeta* gen. spp.	94.4 ± 3.1	587 ± 484	0.38 ± 0.49
	Hirudinea	*Piscicola geometra*	1.9 ± 1.8	-	-
Arthropoda	Crustacea	*Ostracoda* gen. spp.[1]	53.7 ± 6.8	161 ± 171	0.009 ± 0.01
	Mysida	*Mysis relicta* [2]	1.9 ± 1.8	-	-
	Mysida	*Neomysis integer* [2]	11.1 ± 4.3	-	-
	Isopoda	*Jaera (Jaera) albifrons*	9.3 ± 3.9	-	-
	Isopoda	*Saduria entomon*	63.0 ± 6.6	24 ± 50	5.22 ± 6.52
	Cirripedia	*Amphibalanus improvisus*	9.3 ± 3.9	-	-
	Amphipoda	*Corophium volutator*	14.8 ± 4.8	-	-
	Amphipoda	*Gammarus* sp. juvenile	14.8 ± 4.8	-	-
	Amphipoda	*Gammarus oceanicus*	1.9 ± 1.8	-	-
	Amphipoda	*Gammarus salinus*	5.6 ± 3.1	-	-
	Amphipoda	*Gammarus zaddachi*	1.9 ± 1.8	-	-
	Amphipoda	*Monoporeia affinis*	59.3 ± 6.7	143 ± 151	1.53 ± 1.52
	Amphipoda	*Pontoporeia femorata*	3.7 ± 2.6	-	-
	Cumacea	*Diastylis rathkei*	75.9 ± 5.8	38 ± 58	0.18 ± 0.26
	Decapoda	*Crangon crangon*	11.1 ± 4.3	-	-
	Chelicerata	*Halacaridae* gen. sp.	1.9 ± 1.8	-	-
Mollusca	Bivalvia	*Macoma balthica*	98.1 ± 1.8	393 ± 318	37.36 ± 31.61
		Mya arenaria	77.8 ± 5.7	42 ± 48	1.80 ± 3.13
		Mytilus trossulus	63.0 ± 6.6	797 ± 2631	78.24 ± 291.02
	Gastropoda	*Peringia ulvae*	35.2 ± 6.5	119 ± 159	0.32 ± 0.44
Bryozoa	Bryozoa	*Einhornia crustulenta* [3]	100.0 ± 0.0	-	-

1 - nectobethic species; 2 -meiobenthos species (< 1 mm); 3 - colony, fouling; 4 - semi pelagic.

The main zoobenthos communities have been distinguished. Community names reflect the names of bivalve molluscs predominant in biomass (> 40 %) and the names of the most abundant (> 40 %) taxa. The soft sandy soil is dominated by infauna bivalve molluscs *Macoma balthica*, nektobentos and semi-pelagic species, while on solid stoned, gravelly substratum communities are formed by epifaunas *Mytilus trossulus*, *Amphibalanus improvisus* sedentary species and mobile crustaceans. The number of species/taxa, total mean density and biomass at survey sites are presented in Fig. 4.6.2.4 and 4.6.2.5.

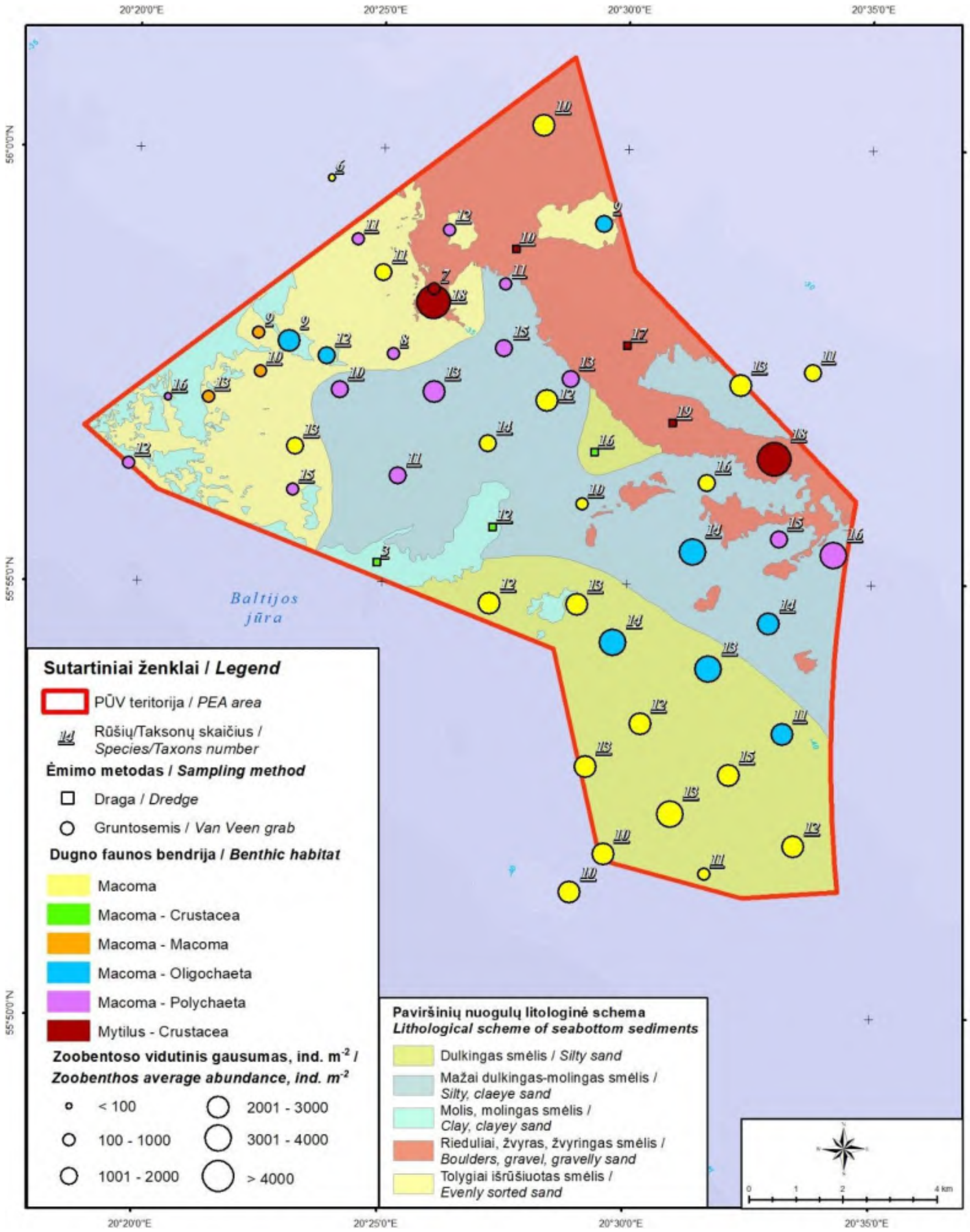


Fig. 4.6.2.4. The number and density of species/taxa of benthos communities.

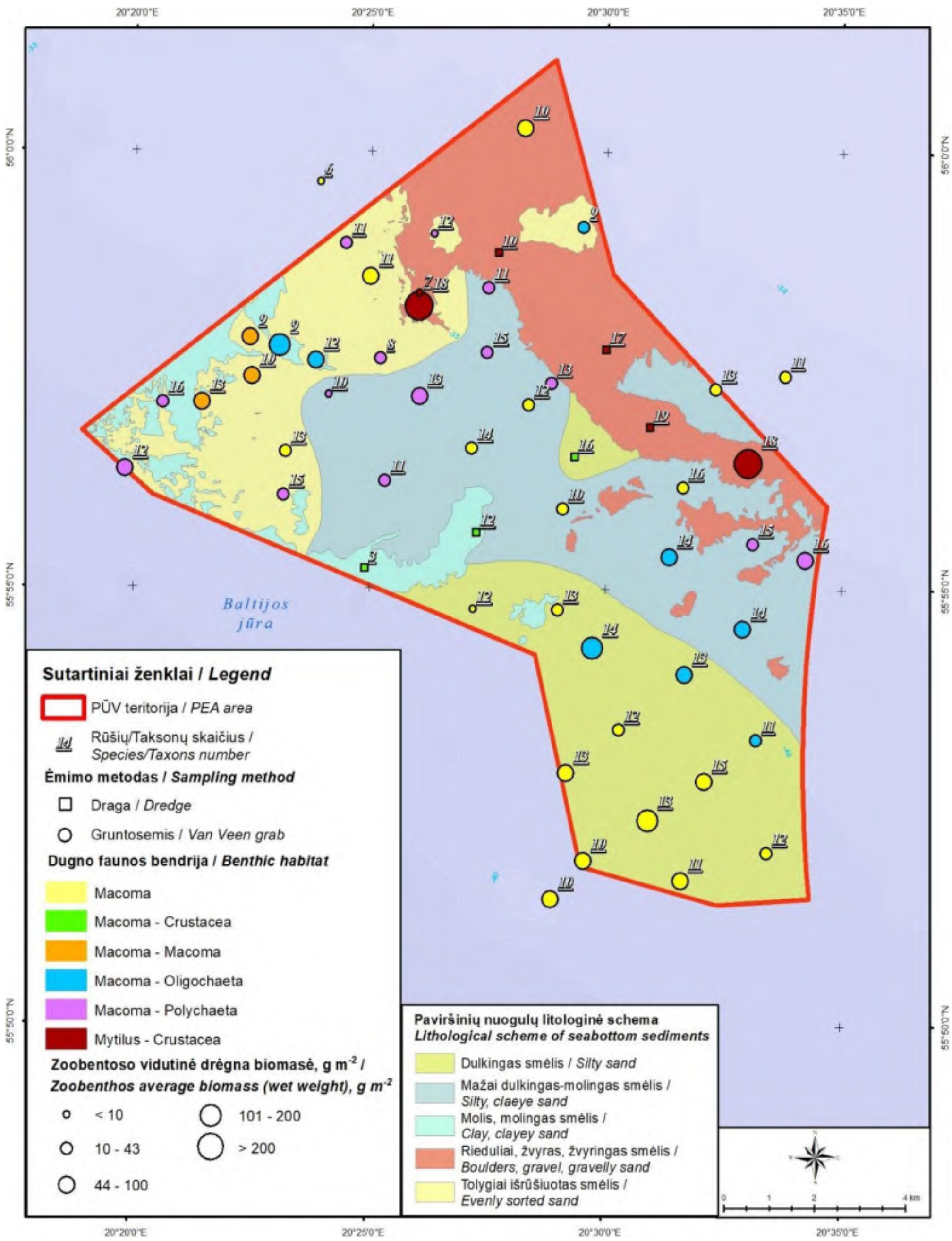


Fig. 4.6.2.5. The number and biomass of species/taxa of benthos communities

In the Lithuanian Baltic Sea, the distribution of the two main species of bivalve molluscs forming bottom communities is primarily determined by the different localisation of soft bottom and hard bottom substratum, as a hard substratum is needed for the *Mytilus trossulus* epifauna filter feeder to attach. For the burrowing, semi-mobile *Macoma balthica* bivalve molluscs, the substratum of a small fraction is the most suitable. Although these biocenosis-forming bivalve mollusc species live in different biotopes, and the spatial and trophic aspects of their ecological niches are separated, both species have a long life span of 7-14 years. Due to high fertility and planktonic development stage, *M. balthica* and *M. trossulus* spread widely. In the area under assessment, *M. trossulus*, which dominates in the biomass and density of the hard substratum, is covered with the bivalve crustaceans *Amphibalanus improvisus*, the moss animal *Einhornia crustulenta* and the hydrozoans *Gonothyraea loveni*, *Cordylophora caspia*, *Laomedea sp.*, thus forming a strong bottom fauna filter feeding community. A variety of mobile invertebrate species (*Turbellaria*, *Hirudinea*, *Crustacea*, *Halacaridae*) live among non-mobile intensively filtering organisms.

The density of *M. balthica* and *M. trossulus* (ind. m-2), the number and distribution of species/taxa in the PEA area and reference locations are shown in Fig. 4.6.2.6 and 4.6.2.7.

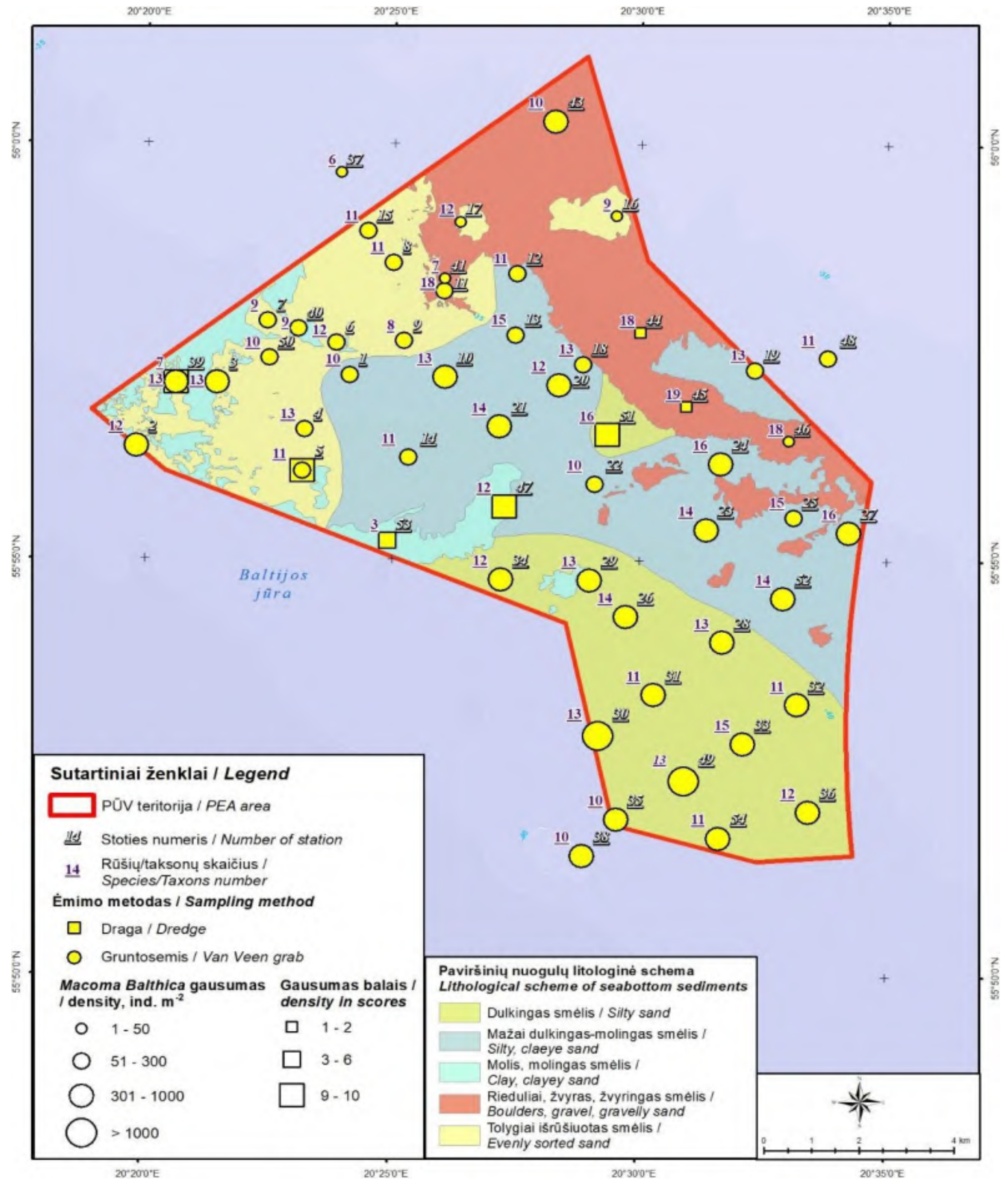


Fig. 4.6.2.6. Density of *Macoma balthica* (ind. m-2), number and distribution of species/taxa.

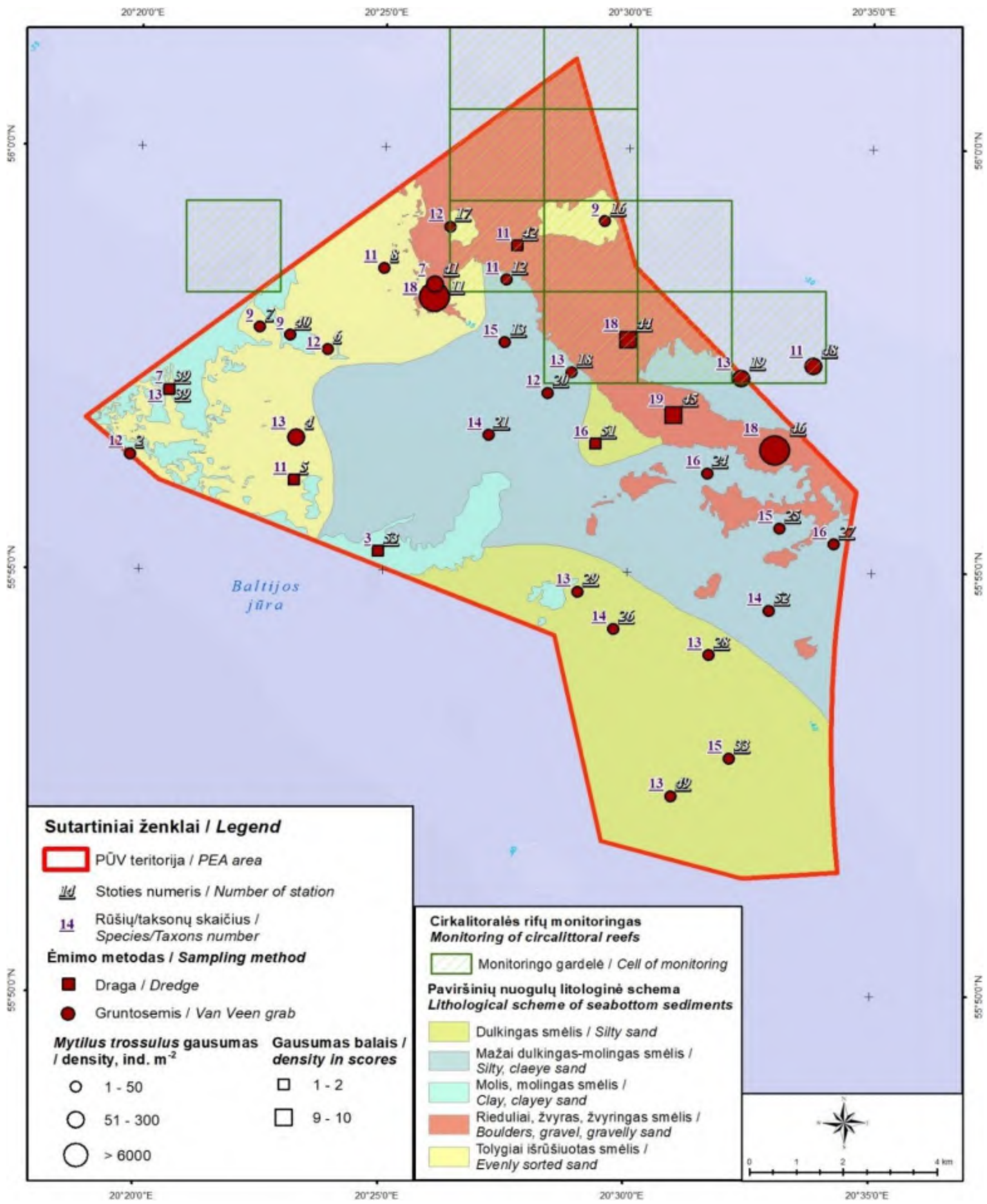


Fig. 4.6.2.7. Density of *Mytilus trossulus* (ind. m-2), number and distribution of species/taxa.

Another species of bivalve molluscs, *Mya arenaria* (Fig. 4.6.2.8), is widespread in the small fraction substratum of the PEA area, but only small individuals have been found.

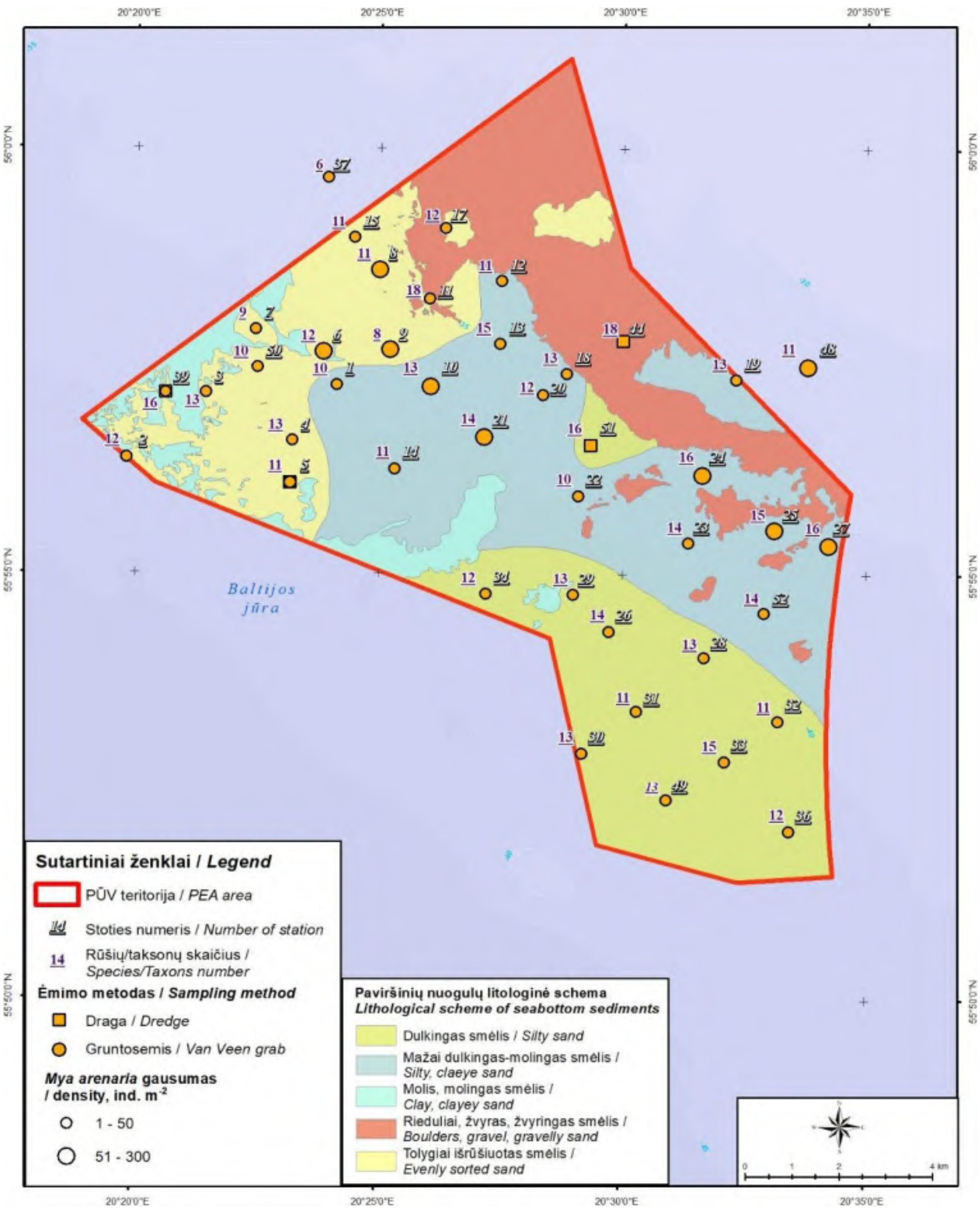


Fig. 4.6.2.8. Density of *Mya arenaria* (ind. m-2), the number and distribution of species/taxa.

Zoobenthos organisms are an important source of food for benthic-feeding birds and fish.

4.6.2.3. Assessment of the condition of circalittoral soft bottom habitats

For each habitat type, a single assessment conducted in accordance with criteria D6C4 and D6C5 of Directive 2008/56/EC (Annex I) is to be used for both benthic habitats under Descriptor 1 and seabed integrity under Descriptor 6 (Seabed integrity is at a level that ensures the preservation of ecosystem structures and functions, and in particular there are no adverse impacts on benthic ecosystems).

State of soft-bottom macrofauna community, according to the Benthic Quality Index (BQI). (HOLAS II 6E-2017, 4-1; HELCOM, 2018). APPROVED by Order No D1-210 of the Minister of the Environment of the Republic of Lithuania of 12 April 2007 (version of Order No D1-645 of the Minister for the Environment of 4 November 2021).

The status of bottom habitats prevailing in the soft bottom of the Baltic Sea in Lithuania is assessed according to the Benthic Quality Index (BQI). The macroinvertebrate quality index (MQI[21]) determines the assessment of the ecological status of marine water bodies on the basis of the taxonomic composition, density and sensitivity of taxonomic groups of macroinvertebrates. Surveys on the taxonomic composition, density and biomass of macroinvertebrates are conducted in accordance with LST EN ISO 16665:2014 Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna. MQI applies to sand seabed samples in the infralittoral and circalittoral areas dominated by *Macoma balthica, Pygospio elegans* or *Marenzelleria spp.*

The MQI is calculated according to the following formula:

$$MKI = \left(\sum_{i=1}^{n} \left(\frac{A_i}{A_{tot}} \times ES_{50\ 0,05i} \right) \right) \times log\ log\ (ES_{50} + 1) \times \left(1 - \frac{5}{5 + A_{tot}} \right),$$

where:

n - the number of species; A_i - a density of species i; A_{tot} - total density; $ES_{50\ 0,05i}$ - the value of the sensitivity index for species i/taxon;

The ES_{50} - the Hurlbert Index.

The Hurlbert Index (hereinafter - ES_{50}) is the expected number of species/taxa at the 50 ind. m-2 bottom macroinvertebrates density. The index is calculated according to the following formula:

$$ES_{50} = \sum_{i=1}^{n} \frac{(A_{tot} - A_i)!\,(A_{tot} - 50)!}{(A_{tot} - A_i - 50)!\,A_{tot}!},$$

where: n - the number of species in the sample; A_{tot} - total density in the sample; A_i - a density of species i in the sample.

Good Environmental Status (GES) threshold value 2.9 per circalittoral area. The survey sites are divided into three groups based on the size of the most detectable substratum grains. In the biotope of sand evenly sorted out in circalittoral area (substratum particle mode 0.2 mm), the BQI was below the GES value in several stations, but the mean value of the BQI corresponded to the GES value (3,0 ± 0.3). In circalittoral area, evenly sorted out low-dusty-clayey sand (substratum particle mode 0.125 mm) and dusty sand (substratum particle mode of 0.063 mm), good environmental status was observed in 2022. The results of the F test showed no significant difference between the BQI in areas where the most detectable substratum particles are 0.2 and 0.125 mm ($F_{12.5} = 1.45$, $p > 0.05$), but that the BQI (Groups I and II) differ significantly from the sites (Group III) where small substratum fractions of 0.063 mm predominate ($F_{18.18} = 11.10$, p & 0.05). In the areas of sedimentation, there are abundant small species of zoobenthos.

[21]Methodology for determining the condition of surface water bodies. Approved by the Ministry of the Interior of the Republic of Lithuania in 2007. April 12 by order no. D1-210 (revision of Order No. D1-645 of the Minister of the Environment of the Republic of Lithuania of November 4, 2021)..

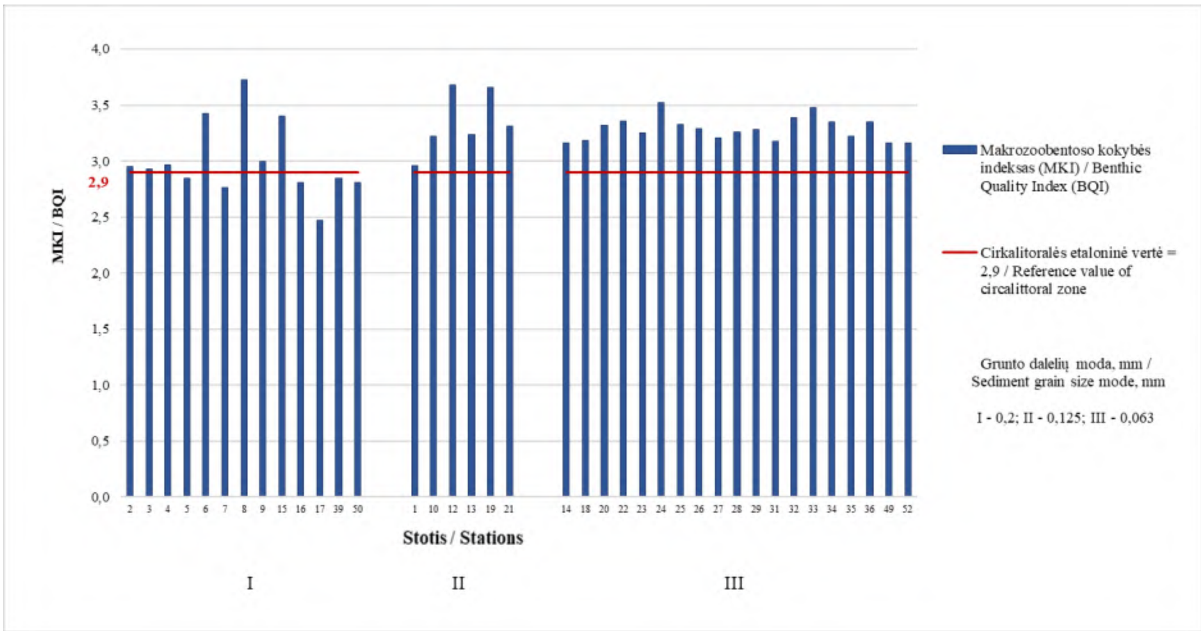


Fig. 4.6.2.9. MQI index values in the sites of circalittoral area sand.

4.6.2.4. Possible significant effects on benthos

The most vulnerable is the *Mytilus trossulus* community made up of large long-lived individuals and rarer species (distribution can be seen in Fig. 4.6.2.7), so a significant physical loss of the seabed due to irreversible changes in the seabed substratum or morphology is very likely, as well as the destructive effect on bottom biotopes during the construction, operation and dismantling phases of the WF park in the areas of circalittoral area boulder sites and biogenic reefs.

During construction, the impact on bottom biotopes due to possible hydrological regimes, electromagnetic fields and other negative factors caused by laying the WF park and cable connections is unavoidable.

Effects during installation/operation are a physical disturbance of the seabed (temporary or disappearing), the formation of suspended material and secondary bottom sedimentation, increased turbidity may adversely affect planktonic invertebrate larvae and cause increased mortality. A possible consequence is a short-term malfunction of nutrition system.

During operation, *Mytilus trossulus-Crustacea* community formation on underwater parts of the WF structures (artificial reef formation) is very likely. The map in Fig. 4.6.2.7 shows the distribution of small plankton-deposited *Mytilus trossulus* organisms outside the hard substratum (boulders, gravel, gravelly sand). This demonstrates the ability of the *M. trossulus* molluscs to spread widely and form a community on the underwater parts of the WF structures. Macrophyte growths are formed on the piles in the photic zone. It is very likely that these new habitats would accomodate colonial epifauna species.

In the upper layers of water, the salinity is lower than at the bottom and the temperature is higher, therefore the transfer (navigation, anchors, birds) of local and non-indigenous crustaceans living in the mouth of the Curonian Lagoon (at the bottom, in the macrophyte growths of berths, water buoys and navigational buoys) and at the Palanga bridge (in the macrophyte growths of boulders and piles) and settling on the underwater parts of the WF is likely.

Table 4.6.2.4. Classification of benthic habitat according to EUNIS marine habitat classification 2019 including crosswalks review and impact of the WF park on macrofauna communities during installation and operation

Characteristic of seabottom sediments	Area, km^2	Habitat type MSFD	EUNIS Code(2022)	HELCOM HUB level 3 habitat code	HELCOM HUB level 6 habitat code	Zoobenthos community	Effects of the WF installation	Community recovery potential after installation
Dusty sand Low dusty-clayey sand Evenly sorted out sand	34.0 43.9 23.2	Circalittoral area sand	A5.273	AB.J Baltic aphotic zone, sand	AB.J3L1 Baltic aphotic zone, sand, dominated by *Macoma balthica*	Infaunae *Macoma balthica* with other species of infauna (Priapulida, Oligochaeta, Polychaeta), benthic and nectobenthic crustaceans	Violation of the integrity of the bottom; an increase in turbidity can destroy part of the planktonic larvae	A favourable, highly probable possibility of community recovery, as species are widespread; high biomass and density; most species have high fertility and planktonic development stage
Clay, clayey sand	8.8	Circalittoral area boulder site and biogenic reef		AB.B Baltic aphotic zone, clay		Mixed community in biomass; is dominated by *Macoma balthica;* density is significantly lower than in the sand community	Violation of the integrity of the bottom; temporary increase in turbidity; minimal adverse effects on the community because of the poor community	Natural regeneration (recolonisation) of dominant species in the affected area is highly likely
Boulders, gravel, gravelly sand	26.4	Circalittoral area boulder site and biogenic reef Circalittoral area coarse-grained bottom sediments	A5.6 A.14	AB.A Baltic aphotic zone, boulders and stones AB.I Baltic aphotic zone coarse-grained bottom sediments	AB.A1E1 Baltic aphotic zone, boulders and stones with *Mytilidae* molluscs AB.I1E1 Baltic aphotic zone coarse-grained bottom sediment with *Mytilidae* molluscs	Epifaunae, sedentary/semi-sedentary organisms, *Mytilus trossulus* with *Amphibalanus improvisus*, mobile *Gammaridae* crustaceans	Destruction of the bottom during the construction; non-recoverable destruction of the structure of morainic ridges	The natural regeneration of dominant species in the affected area is highly likely due to the high fertility of the dominant species and the planktonic larvae development stage. Adjacent intact areas may become donors for recolonisation of low-breed species

4.6.2.5. Prevention, mitigation and compensatory measures of effects on bottom biotopes

According to the performed assessment, the most valuable part of the territory of the PEA, which is expected to have a significant negative impact, borders the territory of the "Natura 2000" BAST biogenic reef (1170). The most valuable is the *Mytilus trossulus-Crustacea* community, which is formed on a hard base (boulders, stony bottom), which is common in the northeastern edge of the planned area.

In order to reduce the impact of installation of marine WT on the protected bottom habitat and to ensure that the distribution of valuable molluscs and participation in the common food chain remains uninterrupted, when planning the installation of WE parks, it is recommended not to plan WT foundations and cable routes on *Mytilus trossulus* abundance zone (4.6.2.10 Fig.).

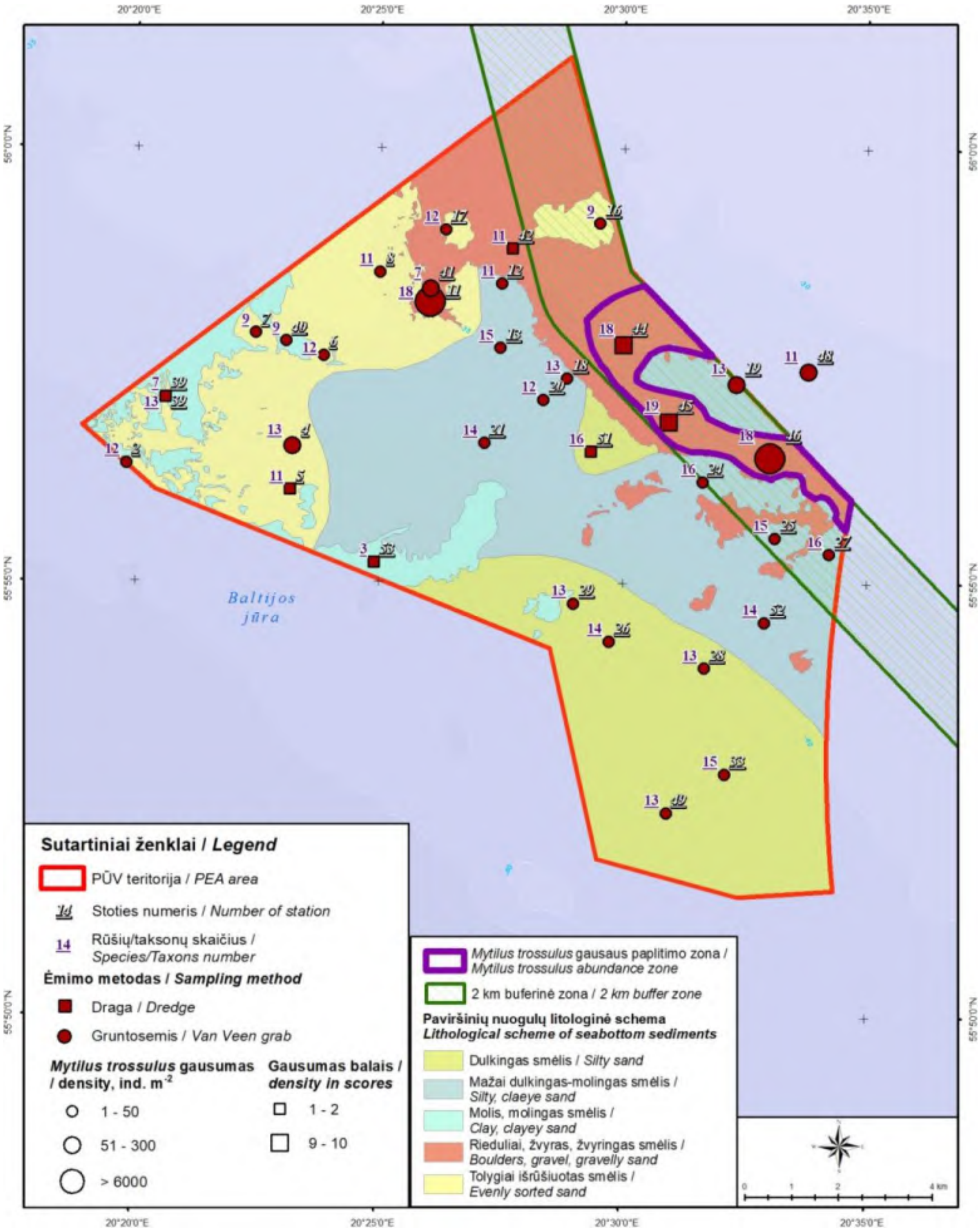


Fig. 4.6.2.10. *Mytilus trossulus* zone of high density and recommended buffer zone.

Table 4.6.2.5. Possible effects on bottom biotopes and benthic organisms

Stages	Impact	Nature	Scale	Duration	Significance	Measures
Construction	Increased turbidity	Adverse direct effects on the vital functions of some benthic organisms	Local (in the WF park area)	Short-term (during works)	Insignificant The density of benthic organisms will not change significantly	Not applicable
	Physical destruction of bottom habitats	Adverse direct impact on the habitat at the site of the installation of the foundation, at the site of laying the cable	Local. In the area of the foundation of the WF towers. Local at the cable laying site.	Long-term (will last until the end of the operation of the WF park) Short-term	Little significant effect, as it will potentially destroy a small part of the biotopes of benthic reefs	Do not build-up the WF foundations, avoid laying the cable in places of valuable *Mytilus trossulus* abundace zone
Operation and maintenance	Physical destruction of seabed habitats	Adverse direct effects (small-scale destruction of existing habitats)	Local (in small separate areas around individual WFs)	Short-term (one-off damage to the bottom habitats will quickly recover)	Insignificant, as only a small part of the biotopes of the dominant benthic species will be destroyed	Not applicable
	The emergence of secondary habitats	Positive direct effects (additional substratum will increase habitat area, community diversity, biomass)	Local (in the WF park area)	Long-term (will last until the end of the operation of the WF park)	Slight positive. New habitats will be formed in the additional vertical substratum in the photic zone. At the aphotic level, the usual animal community will be restored.	Not applicable

Stages	Impact	Nature	Scale	Duration	Significance	Measures
		Adverse direct effects (vertical substratum may become a habitat for non-native species)			Insignificant, as natural reefs are found in similar depths relatively near the territory of the WF park	Not applicable
End of operation/dismantling	Increase in turbidity	Adverse direct effects on the vital functions of benthic organisms	Local (in the WF park area)	Short-term (possible only during dismantling works)	Insignificant, as the density of benthic organisms will be affected insignificantly	Not applicable
	The recovery of the original seabed habitat	Positive direct (conditions for recovery of initial habitats are returned)	Local (in the areas of the bases of individual towers)	Long-term (length of the period does not depend on the activity under consideration)	Insignificant The density and biomass of benthic organisms may gradually decrease as a result of the loss of an additional substratum	Not applicable
	The destruction of secondary habitats	Adverse indirect	Local (in the WF park area)	Long-term (additional substrates will be removed)	Insignificant because it will not affect the status of natural bottom habitats and the density of benthic organisms	Not applicable

- positive effects;

- the effects are insignificant (no need to take into account, no measures are applied)

- low-significance effects: decisions during the design; preventive measures.

4.6.3. Fish

4.6.3.1. Predominant ichthyocenoses

65 cyclostomes and fish species were registered in the Lithuanian waters of the Baltic Sea, including 21 freshwater, 33 marine and 11 migrating species. About 19 cyclostomes and fish species are protected under the Habitats Directive, the Berne or CITES Conventions (International Trade in Endangered Species of Wild Fauna and Flora), 5 are included in the Lithuanian Red Book, and 18 are considered very rare. Of the total number of species registered in Lithuanian waters of the Baltic Sea, some species are found very often, whereas some species (swordfish, anchovy, agonidae) have only been registered once or several times.

Baltic herring (*Clupea harengus membranes*), Baltic cod (*Gadus morhua callarias*) and European flounder (*Platichthys flesus*) are one of the most abundant fish in Lithuania's economic zone and are therefore heavily fished. The spawning of the Baltic herrings is observed in the rocky bed with underwater vegetation on the northern coast of Lithuania, as well as at the breakwaters at the gates of the port of Klaipeda at a depth of 2-5 m.

There are a lot of anadromous fishes and freshwater fish both in the area of the Klaipeda State Seaport and northward to Sventoji and southward to Alksnynes and Juodkrante. Anadromous fishes include European smelts, vimba breams, salmons, sea trout, whitefish, twaite shads, eels and river lampreys. Most species of anadromous fishes keep near the coast, usually up to a depth of 20 m, however, salmons migrate over very long distances. Salmons spawning in Lithuanian rivers can be found both in the northern part of the sea near the coasts of Finland and near the southern coasts of Germany. The migration of sea trout lasts a little shorter. In recent years, the number of twait shads and vimba breams has increased significantly with reduced pollution in rivers and the Curonian Lagoon.

In most cases, freshwater fish, such as bream, zander, white bream, ide, roach, common bleak, cod, perch, ruff and three-spined sticklebacks, are caught only at the nearshore.

In summer, the sea is dominated by marine and anadromous fish species, but the off-coast area (especially near Klaipeda) is also rich in freshwater fish coming from the Curonian Lagoon. In autumn, September-October, there are many anadromous fish species off the coast of the Baltic Sea swimming to spawn into rivers, such as vimba bream, salmon, sea trout, whitefish, and smelt. In November, when the water temperature drops, the number of Baltic herrings increases, there are many flounders and cods appear off the coast.

According to the Baltic International Bottom Trawl Survey (BITS) data, a total of 12 fish species were caught by standardised bottom trawling in the PEA area from 25 February 2019 to 18 November 2022 (Fig. 4.6.3.1): Baltic cod (*Gadus morhua callarias*), European sprat (*Sprattus sprattus*), shorthorn sculpin (*Myoxocephalus scorpius*), European flounder (*Platichthys flesus*), European plaice (*Pleuronectes platessa*), Baltic herring (*Clupea harengus membras*), viviparous eelpout (*Zoarces viviparus*), three-spined stickleback (*Gasterosteus aculeatus*), European smelt (*Osmerus eperlanus*) and turbot (*Scophthalmus maximus*), great sand eel (*Hyperoplus lanceolatus*) and twait shad (*Alosa fallax*). On average, eight fish species were caught during different trawling.

Table 4.6.3.1. Fish abundance (N) and biomass (B) in 2019-2022 (according to: BITS trawling, catches recalculated per one hour of trawling)

Species	2019				2022			
	Q1		Q4		Q1		Q4	
	N	B	N	B	N	B	N	B
Baltic herring	3079	120	3234	128	672	24	6	<<1
Baltic cod	384	76	1085	288	114	8	1036	149
Great sand eel			2	<<1				
Shorthorn sculpin	182	38	50	11	48	9	4	2

Species	2019				2022			
	Q1		Q4		Q1		Q4	
	N	B	N	B	N	B	N	B
European smelt			8	<<1	4	0	6	<1
European flounder	482	135	2567	480		12	544	104
European plaice	4	<1			128			
Viviparous eelpout					2	<1		
Three-spined stickleback					2	<<1		
Turbot	10	3	8	2	2	<1		
European sprat	2	<<1	2	<<1	56	<1	104	1
Twait shad							38	4

Three main commercial fish species (Table 4.6.3.2.) predominate the PEA area (Table 4.6.3.2): Baltic herring, Baltic cod, European flounder; also, a shorthorn sculpin seasonally distinguished by biomass can be attributed to the group (Fig. 4.6.3.1).

Table 4.6.3.2. Species composition and structure of the fish community during the 2019-2022 survey period

Dominance of fish species in the community	2019 Q1		2019 Q4		2022 Q1		2022 Q4	
	N	B	N	B	N	B	N	B
Real dominants	Baltic herring	European flounder	Baltic herring	European flounder	Baltic herring	Baltic herring	Baltic cod	Baltic cod
		Baltic herring	European flounder	Baltic cod		European flounder	European flounder	European flounder
		Baltic cod				Shorthorn sculpin		
Dominant	European flounder	Shorthorn sculpin		Baltic herring	Baltic cod	Baltic cod	European sprat	
	Baltic cod				European flounder			
Sub-dominant	Baltic cod				European sprat			
					Shorthorn sculpin			
Found							Twait shad	
Non-abundant				Shorthorn sculpin				Twait shad
Passing	European plaice	European plaice	Great sand eel	Great sand eel	Viviparous eelpout	European sprat	Baltic herring	Baltic herring
	Turbot	Turbot	Shorthorn sculpin	European smelt	Three-spined stickleback	Viviparous eelpout	Shorthorn sculpin	Shorthorn sculpin
	European sprat	European sprat	European smelt	Turbot	European smelt	Three-spined stickleback	European smelt	European smelt
			Turbot	European sprat	Turbot	European smelt		European sprat
			European sprat			Turbot		

Shannon's (H') and Pielou's (J) indices were used for the assessment of the species structure of the fish species community and for the continuity of species distribution. The values of these indices were close but relatively low during the survey period: 2019 Q1 H'=0.854 J=0.439, 2019 Q4 H'= 1.07 J=0.514, 2022 Q1 H'=1.15 J=0.523 and 2022 Q4 H'=0.977 J=0.502. The values of both indices for the winter (usually the value of H' varies between 1.5 and 3 in different organism communities) indicate the uneven distribution of fish in the community, where the structure of the community is particularly dominated by one or more species. In this case, the Baltic herring dominates in the PEA area during the winter-spring season, and in the autumn season - both the Baltic herring and the European flounder.

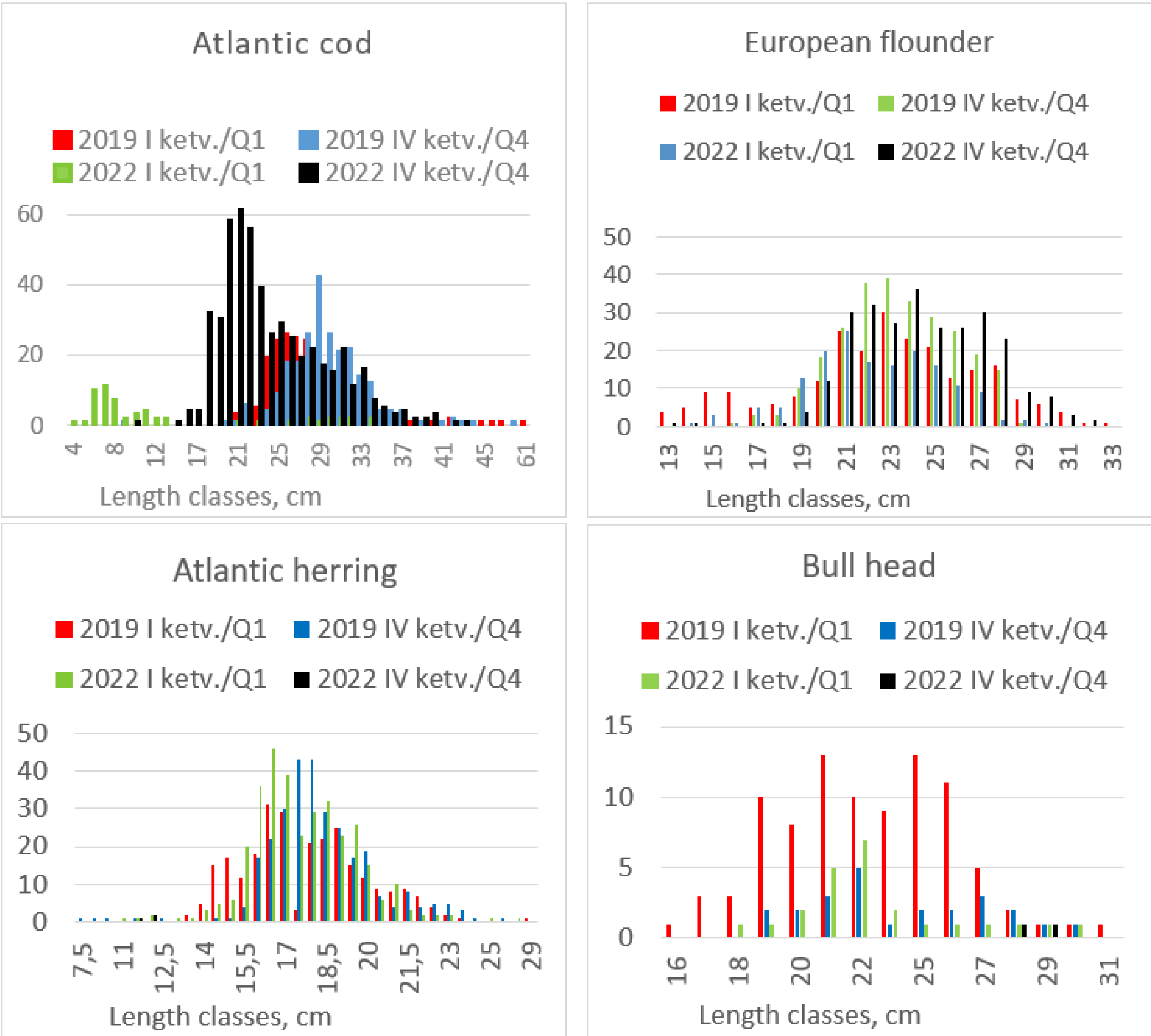


Fig. 4.6.3.1. Dimensional structure of species dominated in the fish community in 2019-2022

The distribution of Baltic herring length and shorthorn sculpin length groups in the analysed periods has not changed or varied within insignificant limits, however, the dimensional structure of Baltic cod and Baltic flounder has changed significantly. These changes are undoubtedly linked to the state of the resources of the eastern Baltic cods and the drop in fishing intensity in the PEA area. Among the cod caught in the PEA area in 2022 small and young fish also predominated (average length 23.2 cm in 2022), which may indicate the successful functioning of resource protection measures. The opposite trend is observed among the Baltic flounder where the average flounder size increased from 23.1 cm in 2019 to 24.3 cm in 2022 Q4. 2022 Q4

4.6.3.2. Composition and structure of fish communities

The composition and structure of the fish communities were also assessed in an adjacent area far-off within a radius of 12 nautical miles from the PEA area. According to the BITS data for 2019-2021, 9 fish species were caught in adjacent areas: Baltic cod (*Gadus morhua callarias*), European sprat (*Sprattus sprattus*), shorthorn sculpin (*Myoxocephalus scorpius*), Baltic flounder (*Platichthys flesus*), Baltic herring (*Clupea* *harengus membras*), three-spined stickleback (*Gasterosteus aculeatus*), European smelt (*Osmerus eperlanus*) and turbot (*Scophthalmus maximus*), sand goby (Pomatoschistus minutus) and twait shad (*Alosa fallax*). The species diversity in adjacent areas was 25 % lower than that of the PEA area, and on average 6 fish species were caught during different trawling. The species structure of the fish community and the continuity of species distribution were close to the PEA area, while the average Shannon's (H') and Pielou's (J) indices for the survey period were H'=0.995 and J=0.548 respectively. The only differences found between the adjacent and the PEA area are the additional dominance of European smelt and the presence of sand goby in the adjacent fish community.

Among the species of fish caught in the PEA area, only the twait shad is a species to be protected. It is a species of EU interest listed in Annexes II and V of the EU Habitats Directive 92/43 EEC, and the twait shad was included in the Lithuanian Red Book by 2005. This species of anadromous fish lives in European coastal waters from the Iberian Peninsula to the Norwegian coast. It comes for spawning to the rivers of the southern and eastern outskirts of the Baltic Sea basin: Elbe, Oder, Vistula, Nemunas, Dauguva, and Neva. The Curonian Lagoon is the main place for their spawning in Lithuanian waters, and juveniles migrate from the Curonian Lagoon to the sea in their first year of life and spread within the eastern outskirt of the Baltic Sea.

Data from fish surveys show that in coastal fisheries twait shads are often found in shoals together with Baltic herrings and Atlantic sprats. Since during the BITS, twait shads were caught both in the PEA area and the adjacent area, surveys of pelagic fish were additionally reviewed in 2019-2021 for the detection and abundance of juveniles of this species in the pelagic zone. Species composition and biological data about the fish species in the PEA area of the Baltic sea were collected by the Baltic International Acoustic Survey (BIAS) and Baltic Acoustic Spring Survey (BASS). During these surveys, 6 species were caught using standardised pelagic trawls: Baltic herring (*Clupea harengus membranes*), Atlantic sprat (*Sprattus sprattus*), three-spined stickleback (*Gasterosteus aculeatus*), great sand eel (*Hyperoplus lanceolatus*) and Baltic flounder (*Platichthys flesus*). Catches were dominated by both abundance and biomass of Atlantic sprat, with its abundance and biomass in trawling catches ranging from 14,304 to 227,667 ind./h and 60-1,951 kg/h respectively (Table 4.6.3.3). The twait shad has not been recorded in catches of these pelagic surveys and the fish caught during BITS trawling are not abundant and are therefore classified as occasional (in the adjoining area) or detectable species (in the PEA area) according to the dominance in the fish community. Twait shads were detected in the PEA area for the first time in the period of the last 3 years in November 2022. Most (79 %) are fish that have reached maturity, and actively feed with fish fry, their juveniles and crustaceans. Following the active fishing and the disturbance of the integrity of the seabed, it is likely that this area will become a feeding area for twait shad in the PEA area.

Table 4.6.3.3. Fish abundance (N) and biomass (B, kg/h) (according to BIAS and BASS trawling in 2019-2021, catches recalculated per one hour of trawling)

Species	2019				2020				2021	
	Q3		Q4		Q2		Q4		Q4	
	N	B	N	B	N	B	N	B	N	B
Baltic herring	1467	49			10768	247			4	<1
European sprat	227667	1951	14304	60	100502	553	160801	1400	20690	160
Three-spined stickleback	4	0								
European smelt					2	<<1				
Great sand eel	2	<<1			2	<<1				
European flounder	2	1							10	2

4.6.3.3. Potential effects on fish species

Lithuania manages the smallest part of the seawater area (around 3.5 %) of all Baltic States and has an off-coast of less than 100 km. European sprat caviare and larvae, especially northward of Palanga can be found here. About 20 % of this year's European sprat biomass in the Eastern Baltic is found in the Lithuanian

EEZ (the rest is common in the Russian and Latvian EEZ). Individual fish nutrition areas in the Baltic Sea off-coast or Economic Zone are not distinguished, as fish-suitable substrates are found throughout the Lithuanian EEZ. The species composition of ichthyocenoses varies depending on the season. This mainly affects fish spawning, nutrition and winter migrations. The fish community was dominated by the benthophage fish - Baltic flounder and Baltic cod in the PEA area. Over the last 3 years, there was a very high fishing intensity in the PEA area, where the majority of catches were made up of Baltic flounder. This area is important as the feeding area for the Baltic flounder. Here, the flounders feed on various crustaceans and small fish, and for spawning migrate to shallower waters closer to the coast (ICES, 2010). According to the latest year's survey data, the number of Baltic cod of smaller length groups in the PEO area is increasing. It seems that if the bottom trawling in the PEA area is reduced (restricted), its importance as a feeding area for this species would increase.

Following the analysis of available literature and experience of similar surveys in other countries (DONGEnergy et al., 2006; Bergström et al., 2012, Galparsoro et al. (2022), 5 species of direct effects of the WF on fish may be distinguished:

- Noise effects during construction:

Despite the fact that the adverse effects of anthropogenic noise on marine organisms, in particular mammals, fish and invertebrates (Shannon et al., 2016) , as well as zooplankton (McCauley et al., 2017), have been recognised in recent years, however, there are still no noise level limit values corresponding to good environmental status. Results of previous surveys have shown that high-intensity anthropogenic underwater noise, especially in the low-frequency range, has a negative effect on the development of marine organisms, including underdevelopment/deformation of the body, higher mortality of roe and/or juveniles, declining growth rate (Aguilar de Soto et al., 2013; Nedelec et al., 2014, 2015). Also, anatomical changes are caused such as hearing loss, severe internal trauma, and disorientation (Hastings, et al., 1996; McCauley et al., 2003; André et al., 2011; Solé et al., 2017); physiological changes, including an increase in stress hormones, metabolism, oxygen intake (Wysocki, et al., 2006; Anderson et al., 2011; Nichols et al., 2015; Spiga et al., 2016); behavioural changes, e.g. increased aggressiveness, reduced defensive behaviour and feeding habits, distraction (Kastelein, et al., 2008; Fewtrell and McCauley, 2012 La Manna et al., 2016; Nedelec et al., 2017).

The effects of noise on fish depend on the nature of the work carried out. The greatest impact during the entire life cycle of the WF is the driving of piles to the seabed during the installation of the foundation. During this process, fish may experience barotrauma or damage to cells with sensory vibrissae arranged in the lateral line and neuromasts, resulting in a violation of one of the most important sensory organs of fish (De Backer et al., 2014b; Halvorsen et al., 2012). However, the impact on different species of fish can vary greatly. For example, in the case of Californian anchovy (*Engraulis mordax*) and European Dover sole (*Solea solea*), after 4 minutes of exposure to artificially emitted pole driving noise, no increased mortality or pathology occurred in fish (Abbott et al. 2005; Bolle et al., 2012). On the other hand, the stress in the European bass (*Dicentrarchus labrax*) was detected at a distance of 2 km away from the source of the noise (Mooney et al., 2020). The effect is likely to be directly related to the size of the swim bladder and its reduction in some groups of fish (e.g.: in the flatfish). The Baltic herring (*Clupea harengus*) and Atlantic sprat (*Sprattus sprattus*) found in the PEA area are among the fish the most sensitive to noise (Andersson, 2011) with sound response in the low-frequency range from a few dozen Hz to 3-4 kHz (with the highest observed sensitivity of about 100 Hz). In turn, the hearing of cod (*Gadus morhua*) is within a limited frequency range above about 500 Hz. In a typical case, during any construction and/or installation works, fish react to noise. Boyle and New (2018) found that fish can react to pile-driving noise up to 15.4 km away and leave the area. However, many species of fish do not react to pile driving noise or the exposure distance is significantly lower. It is predicted that the pile driving works may have the most significant impact on Baltic cod of the largest length groups and pelagic fish species found. After completion of the installation work, the fish will return to the nutrition area, so only short-term insignificant effects are expected.

- Effects of silt and suspended particles during construction.

Water turbidity and increased sediment concentration in the water column can be caused by digging and drilling works. As a result, fish larvae or juveniles may first be affected. Fish at these stages of development are the most vulnerable. Turbidity can not only complicate the nutrition of fish in the area but can also affect fish spawning grounds. However, sediments suspended in the water persist for a relatively short period of time, and their spread depends on the type of sediment, the directions of currents and the strength of the sediment. Given the limited duration and the local significance of these negative effects as well as the fact that the fish spawning grounds in the EEZ concentrate in the coastal zone where the installation of WF parks is not planned, it can be stated that these negative effects will not be significant. Some surveys show (BioConsult, 2004) that during cable installation, water turbidity can attract potential predators (Baltic cods and flounders) that take advantage of the conditions created by hunting other fish.

- Influence of foundation structures on habitats.

Part of the nutrition area of benthophages such as Baltic flounder, Baltic cod or shorthorn sculpin will be destroyed when installing the foundations of the WF. However, given the relatively small areas of individual WF foundation areas and the large distance between individual WFs, it can be argued that the negative local effects on the nutrient base of benthophage fish will be insignificant.

An increase in organisms living on the hard seabed is predicted in the PEA areas as a result of the emergence of a suitable substrate for new habitats. This can have a positive impact on the fish community through the creation of new habitats and an increase in the number of potential nutritional objects. Andersson et al. (2009), Stenberg et al. (2015), Methratta and Dardick (2019) identified positive long-term effects of WF on the species composition and abundance of fish communities. Also, new underwater objects can attract fish, actively using hiding places. WF installation can serve as an artificial reef for fish. The species composition and abundance of fish in the PEA area are likely to increase during the operation of the WF.

- Noise generated by turbines and WF servicing vessels.

The exposure to noise from mechanisms during operation depends on the species of fish and the distance to the source of the noise. The stress caused by this noise on fish has not yet been fully studied, but its effects cannot be discarded as low-frequency noise is also audible for most fish species. The noise generated by the WF park can be compared to the noise emitted by a large cargo ship (Tougaard et al., 2009). However, surveys carried out on Atlantic salmon and Atlantic cod at 8 m/s wind speeds show that these species hear the WF noise at a distance of 0.4 km and 13 km respectively (Westerberg, 2005), and the avoidance response in fish occurs within a radius of 4 m around the WF at wind speeds of 13 m/s and above (Wahlberg and Westerberg, 2005).

- Exposure to the electromagnetic field.

Alternating current in the electric cables laid on the seabed generates electromagnetic fields. This field is believed to disturb fish migration due to disturbed detection of the earth's magnetic lines (Gill et al., 2012) or for the fish using changes in the electromagnetic field to detect nutrition objects (Gill, 2005). On the other hand, experimental studies on eel migrations off the Swedish coast (Westerberg & Lagenfelt, 2008) have not demonstrated the effects of electric current flowing via electric cables on the behaviour or swimming of these fish. Bochert & Zettle (2004) conducted studies on juvenile flounder and found that the development of fish at this stage was not affected by the electromagnetic fields. Most studies have shown that, in normal cases, the effect of electromagnetic field on fish is minimal or its negative influence has not been demonstrated (Ohman et all., 2007; Gill & Bartlett, 2010; Normandeau et all., 2011). However, with an increasing number of offshore WF parks in the Baltic Sea, it should be taken into account the potential cumulative effects of all power lines on fish.

Based on the results of the monitoring of existing WFs in the Baltic Sea, it can be stated that the emergence of WFs will not have a significant impact on the local fish community or will be slightly positive. During construction and structure removal works, at the end of the operation of the power plants.

To sum up, the greatest impact on individual fish species can only occur during the installation of WF parks and during the removal works of structures. This impact on the fish community will be short-term and insignificant. However, some species with a large swim air bladder, such as Baltic cod, may withdraw from the area. However, once the installation or removal work has been completed, the fish will return to the nutrition area, so only a short-term impact is expected. The avoidance reaction is observed only at a distance of a few metres from WF and only at high wind speeds, which may result in a positive impact on fish populations due to newly emerging artificial reef habitats during the operation period.

From anadromous fish species, only twait shad and European smelt are present in the PEA area. The available survey data do not indicate that the PEA area would be on the migratory routes of twait shads, and fish were not detected in the area during migration. Smelt migration to the Curonian Lagoon is known to take place between November and March and the main smelt mobs migrate from the northern side at depths of 6-40 m. It may be assumed that migratory fish routes may change at the time of the installation of the parks or the accumulation of fish in certain places due to adverse conditions (water turbidity or noise) created during construction. However, during the surveys, European smelt in the PEA area was classified as incidental fish species in the community and no large shoals swimming to spawn were recorded.

4.6.3.4. Preventive, mitigation and compensatory measures of effects on fish

Based on the analysis of scientific trawling conducted, the PEA area, as well as the surrounding areas, are the nutrition areas for Baltic flounders and eastern Baltic cods. In order to avoid impact on fish stocks, impact mitigation measures in the area should be concentrated in the area during construction and dismantling periods. The measures proposed during these periods are analogous to those applied to marine mammals used to reduce the intensity of noise emitted by impulse noise sources, as well as audible deterrence measures applied.

During operation, a positive impact on fish due to secondary habitats forming on the foundations of the WF is expected. During the operation of the park and the monitoring of fish and seabed communities, having ascertained that the formed secondary habitats have had a significant positive impact, the application of compensatory measures during the dismantling stage is proposed: such measures would include the installation of artificial habitats of an analogous area, using boulders of 0.1 m - 1 m near the WFs being dismantled. Habitats should be installed at a distance of at least 50 m from the WFs being dismantled and within two years after the WFs dismantling date at the latest. The shape of the habitat is not fixed but the form thereof must be selected considering the possible intensity of fishing with the bottom trawls and the direction.

Table 4.6.3.4. Summary table of effects on fish

Stages	**Ongoing works**	**Impact**	**Nature**	**Scale**	**Duration**	**Significance**	**Impact mitigation measures**
Construction	Installation of underwater parts: WF foundations and electric cables	Increased turbidity	Adverse direct effects on fish nutrition and fish breathing	Local (in the WF park area)	Short-term (possible only during installation works)	Insignificant	Not applicable
		Physical destruction of seabed habitats	Adverse indirect impact, part of the seabed habitats used by benthophage fish for food search will be destroyed at the foundation site	Local (in the areas of the foundation of individual towers)	Short-term (habitats quickly recover due to a small damaged area)	Insignificant	Not applicable
		Noise and vibration	Adverse direct impact, fish will be scared away from the WF construction site or a change in the migration routes of anadromous fish	Local for most of the species; around the installation site of the WF, and for other species found in the pelagic zone or with a large and well-expressed swim bladder at a distance of up to 15 km	Short-term (possible only during installation works)	Average	Use of repellent or suppression devices of propagating impulse noise during the execution of pile driving works
Operation and maintenance	Traffic and anchoring of maintenance vessels	Disturbance	Adverse direct effects, as the movement of vessels can scare off the fish	Local (only at vessel sailing points)	Short-term (only during maintenance)	Insignificant	Not applicable
	Presence of underwater structures	Noise and vibration	Adverse direct effects as fish feel underwater-propagating waves	Local (in small separate areas around individual WFs)	Long-term (will last until the end of the operation of the WF park)	Insignificant, as it will not change the abundance and distribution of fish within the WF park	Not applicable
		Electromagnetic fields	Adverse direct effects on sensitive fish (migratory fish and fish in early stages of development)	Local (around electric cables)	Long-term (will last until the end of the operation of the WF park)	Insignificant, as it will not change the behaviour and migratory nature of	Not applicable

Stages	Ongoing works	Impact	Nature	Scale	Duration	Significance	Impact mitigation measures
						fish within the WF park	
		The emergence of secondary habitats	Positive indirect effects due to the increase in potential food objects, the emergence of hiding places and new spawning habitats	Local (in the WF park area)	Long-term (will last until the end of the operation of the WF park)	Will marginally increase the abundance of the population of individual fish species and fish stocks	Not applicable
Decommissioning	Structure removal works	Increased turbidity	Adverse direct effects on fish nutrition and fish breathing	Local (in the WF park area)	Short-term (possible only during works)	Insignificant, as it will not change the abundance and distribution of fish within the WF park	Not applicable
		Noise and vibration	Adverse direct effect, as the fish will be scared off from the WF dismantling site	Local (at the site of the WF dismantling)	Short-term (possible only during works)	Insignificant	Not applicable
		The recovery of the original seabed habitat	Positive indirect effects as the conditions for the recovery of the original habitats suitable for the search of food for benthophage fish will be returned	Local (foundations of individual towers)	Long-term (length of the period does not depend on the activity under consideration)	Insignificant because it will not affect the status of natural seabed habitats	Not applicable
		Destruction of secondary habitats formed	Adverse indirect effects due to reduced feeding areas	Local (separate towers)	Long-term (additional substrates will be removed)	Insignificant – non-natural habitats are destroyed	Restoration of a similar habitat area in an adjacent area using boulders of different diameters (0.1 m - 1 m) after the formation of valuable fish communities

- positive effects;

- the effects are insignificant: no need to take into account, no measures are applied;

- moderate effects: addressed by impact mitigation measures.

4.6.4. Birds and bats

The Lithuanian Baltic Sea region is poorly researched for seabirds[22]. Except for the coastal part of Lithuanian territorial waters, which has most surveys. More than 20 species of seabirds are regularly found in this area.

The Lithuanian part of the Baltic Sea is most important for wintering seabirds. Abundant numbers of Velvet Scoters (*Melanitta fusca*), Long-tailed Ducks (*Clangula hyemalis*), Razorbills (*Alca torda*), Common Guillemots (*Uria aalgea*), Red-throated Divers (*Gavia stelatta*), Great Crested Grebes (*Podiceps cristatus*) and other species can be found not only in the coastal parts, but also in the open sea of the Lithuanian part of the Baltic Sea waters. Birds, which feed on benthos (diving sea ducks), are found in depths from 5 to 35 m. Therefore, their abundance in suitable habitats (coastal shallow waters) is high. Pelagic birds, such as Divers and Razorbills, can dive to depths of up to 50–60 m, therefore suitable feeding habitats are located further from the shore. Even though they are regularly feeding in depths of 20–30 m.

The Baltic Sea is important for migrating birds flying to wintering or breeding grounds. Migration of wildfowl, cranes, divers, passerines and other birds is intense above Lithuanian territorial waters. Depending on species, some fly close to water, others fly high, up to few hundred meters above it.

During summer, only a small number of birds remain in Lithuanian territorial waters: local breeders such as Great Cormorants (*Phalacrocorax carbo*) and Common Terns (*Sterna hirundo*) are using coastal waters intensively, also few species of gulls: the Herring (*Larus argentatus*), the Common (*Larus canus*), the Black-headed (*Chroicocephalus ridibundus*) and the Great Black-backed (*Larus marinus*). Few Razorbills and Common Guillemots can be found in the open sea.

Until now, in Lithuania, there was no data on bat migration over the sea. During autumn, an intensive migration is found over the coast and in the western mainland of Lithuania, up to ~70 km inland from the sea. It is known that Lithuanian ringed Nathusius's Pipistrelles (*Pipistrellus nathusii*) were found wintering in the United Kingdom (further on – UK). Bats had to fly over the North Sea in order to reach UK (Bat Conservation Trust). Some bats are known to migrate to UK from the Netherlands and Belgium. Therefore, there is a high probability that bats can migrate to the wintering grounds above coastal part of the Lithuanian Baltic Sea, under suitable natural conditions. In Europe, the Nathusius's Pipistrelle migrates on a very wide front, covering coastal areas and flying over the sea from continental Europe to UK (Fig. 4.6.4.1).

Fig. 4.6.4.1 Distribution and migration of Nathusius's Pipistrelle in Europe. Source: Riccardo Pravettoni, UNEP/GRID-Arendal (https://www.grida.no/resources/7643).

[22] The term 'seabird' includes all the birds using sea environment at different stages of their lives – the real seabirds, grebes, divers, sea ducks and some waders.

https://www.bats.org.uk/our-work/national-bat-monitoring-programme/surveys/national-nathusius-pipistrelle-survey

4.6.4.1. Bird observations

Monthly surveys of resting seabirds were carried out in all seasons of the year in the PEA territory. During the warm season, when days are long enough, the observations were made from the ship, and during the cold season, they were made from the airplane.

4.6.4.1.1. Ship-based surveys of resting birds: monthly in spring–autumn seasons (from May to October)

Methods. The surveys from the ship were conducted on months from May to October while sailing on the selected transect design. The surveys were performed closely on the basis of the methodology used in the European Seabird-at-Sea programme (GARTHE & HÜPPOP 1996, 2000) and the BSH guidelines of StUK4 (BSH 2013).

The surveys were held from the ship and resting birds were observed while sailing on the selected transect design. The transect design (Fig. 4.6.4.2) includes 6 transects with transect lengths of 25.9 km. In total, transect length of 155 km is reached. The transects run parallel to each other and are separated by 4 km. The area covered by the transect design is 533 km².

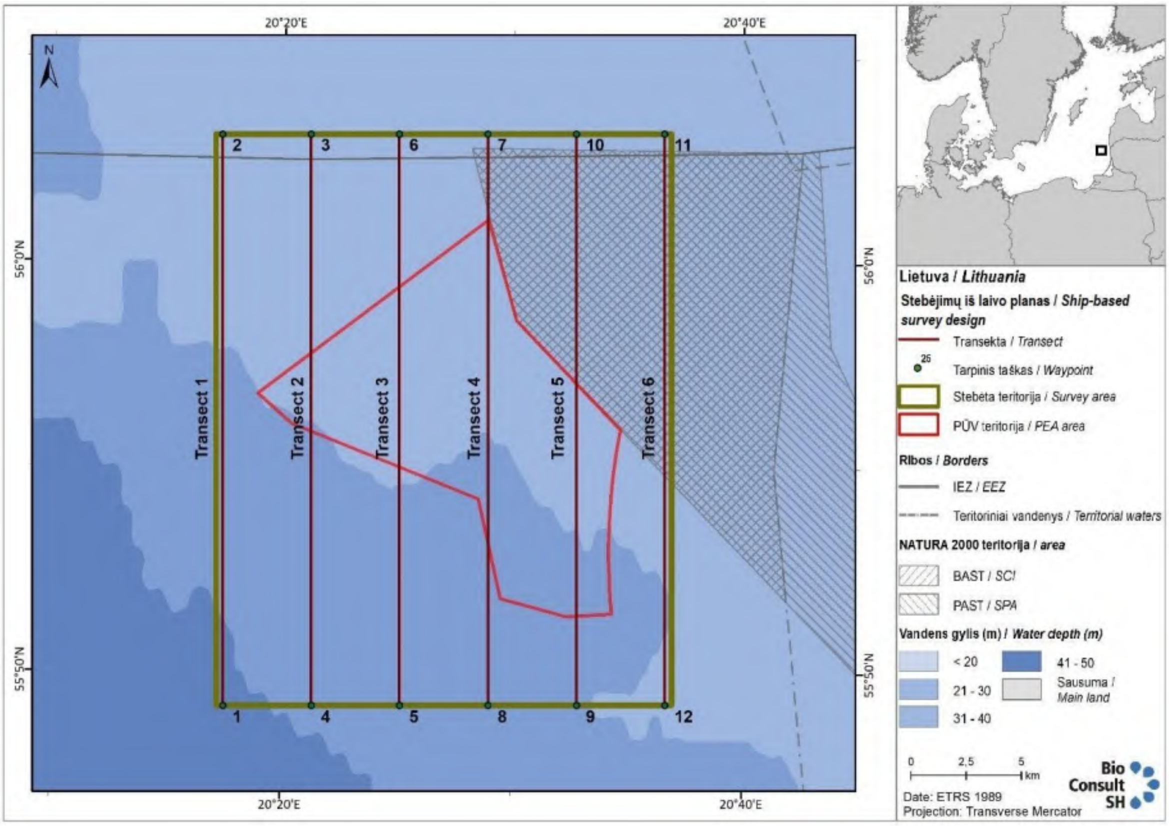


Fig. 4.6.4.2 Transect design for ship-based resting bird monitoring.

In addition to the species affiliation, further information, such as age, sex, moulting condition, behaviour, association with other species or ships, flight altitude and flight direction of the birds observed, were determined where possible.

Ship-based survey results. In the seven ship-based transect surveys conducted between September 2021 and September 2022 (November to April not covered due to too short daylight hours), a total of 5,206 birds belonging to 26 species were observed. In total, 5,162 resting birds were observed, 4,276 of which (Table 4.6.4.1) occurred within the transect area and are used for further analysis (only birds observed up to 300 m from the ship were included in the transect).

Densities (ind./km²) were calculated for all relevant resting bird species and species groups (Table 4.6.4.2). The number of detected individuals of each species/taxon in each survey is divided by the area covered by the transect in order to calculate densities.

Table 4.6.4.1 Bird counts and percentages of all resting bird species during the ship-based transect surveys in the survey area between September 2021 and September 2022.

Species	Latin name	Ship-based surveys	
		N° ind.	%
Red-throated Diver	*Gavia stellata*	12	0.3
Black-throated Diver	*Gavia arctica*	27	0.6
Unidentified diver	*Gavia sp.*	15	0.4
Great Cormorant	*Phalacrocorax carbo*	5	0.1
King Eider	*Somateria spectabilis*	-	-
Long-tailed Duck	*Clangula hyemalis*	28	0.7
Common Scoter	*Melanitta nigra*	3	0.1
Velvet Scoter	*Melanitta fusca*	-	-
Common/Velvet Scoter	*Melanitta nigra/M. fusca*	-	-
Little Gull	*Hydrocoloeus minutus*	3,307	77.3
Black-headed Gull	*Chroicocephalus ridibundus*	4	0.1
Unidentified small gull		-	-
Common Gull	*Larus canus*	221	5.2
Lesser Black-backed Gull	*Larus fuscus*	36	0.8
Herring Gull	*Larus argentatus*	350	8.2
Common/Herring Gull	*Larus canus/L. argentatus*	-	-
Great Black-backed Gull	*Larus marinus*	1	0
Unidentified large gull	*Larus (magnus) sp.*	-	-
Unidentified gull	*Larus sp.*	-	-
Common Tern	*Sterna hirundo*	0	0
Arctic Tern	*Sterna paradisae*	9	0.2
Unidentified tern	*Sterna sp.*	1	0
Common Guillemot	*Uria aalge*	191	4.5
Razorbill	*Alca torda*	65	1.5
Common Guillemot/ Razorbill	*Uria aalge/Alca torda*	-	-
Unidentified auk	*Alcidae*	1	0
Total		**4,276**	**100**

Table 4.6.4.2 Monthly mean densities (ind./km²) of selected species/species groups recorded in the survey area during the ship-based transect surveys between September 2021 and September 2022.

Survey Method	**Ship-based survey**							
Species/Species-group	**2021/09**	**2021/10**	**2022/05**	**2022/06**	**2022/07**	**2022/08**	**2022/09**	**Max. (ind./km²)**
Red-throated Diver	0.03	0.03	**0.15**	0	0	0	0.01	**0.15**
Black-throated Diver	0.05	0.09	**0.23**	0	0	0	0.08	**0.23**
Long-tailed Duck	0.02	0	**0.34**	0	0	0	0	**0.34**
Common Scoter	0	0	**0.04**	0	0	0	0	**0.04**
Velvet Scoter	0	0	0	0	0	0	0	**0**
Little Gull	0.11	1.11	0.07	0.09	**36.1**	16.4	1.51	**36.1**
Black-headed Gull	0	0	0	0	**0.06**	0	0	**0.06**
Common Gull	0.05	0.42	0.02	0.01	**2.11**	0.90	0.10	**2.11**
Lesser Black-backed Gull	0	0	0.26	0	0	0.01	**0.29**	**0.29**
Great Black-backed Gull	0	0	0	0	0	**0.02**	0	**0,02**
Herring Gull	0.42	0.43	0.13	0.05	1.60	**1.85**	1.05	**1.85**
Common/Arctic Tern	0	0.02	0	0	0	0.04	**0.07**	**0.07**
Common Guillemot	0.03	0.95	0.33	0	0.09	1.13	**1.67**	**1.67**
Razorbill	0.12	**1.28**	0.13	0	0	0	0	**1.28**
Divers	0.08	0.12	**0.57**	0	0	0	0.09	**0.57**
Ducks	0.02	0	**0.38**	0	0	0	0	**0.38**
Gulls	0.47	0.85	0.41	0.06	**3.71**	2.78	1.44	**3.71**
Auks	0.16	**2.23**	0.46	0	0.09	1.13	1.67	**2.23**
No. of surveys	**1**	**1**	**1**	**1**	**1**	**1**	**1**	

During the surveys, strong dominance of the little gull was observed, which contributed with 86.7% to the total number of birds. Most abundant are summer months (Fig. 4.6.4.2). Little gulls were observed in the area after their breeding season, during migration, with the highest number recorded in July and August. Other gulls, such as the Herring Gull and the Common Gull, made up less than 9% respectively and Common Guillemots and Razorbills made up less than 5% each (Fig. 4.6.4.3). There were few bird species observed in the PEA territory during summer. During breeding season, the territory is mainly used by local birds. There were no ship-based surveys in winter months due to too short daylight hours, therefore there were few records of sea ducks which were gathering here for winter. Other species represented less than 1% (Lesser Black-backed Gull, Long-tailed Duck and Black-throated Diver). Overall, gulls made up 91.6% of the total number of birds observed, whereas auks, divers and sea ducks represented only 6.0%, 1.3% and 0.7% of the whole, respectively.

More information about species densities, abundance and distribution in Annex 3.

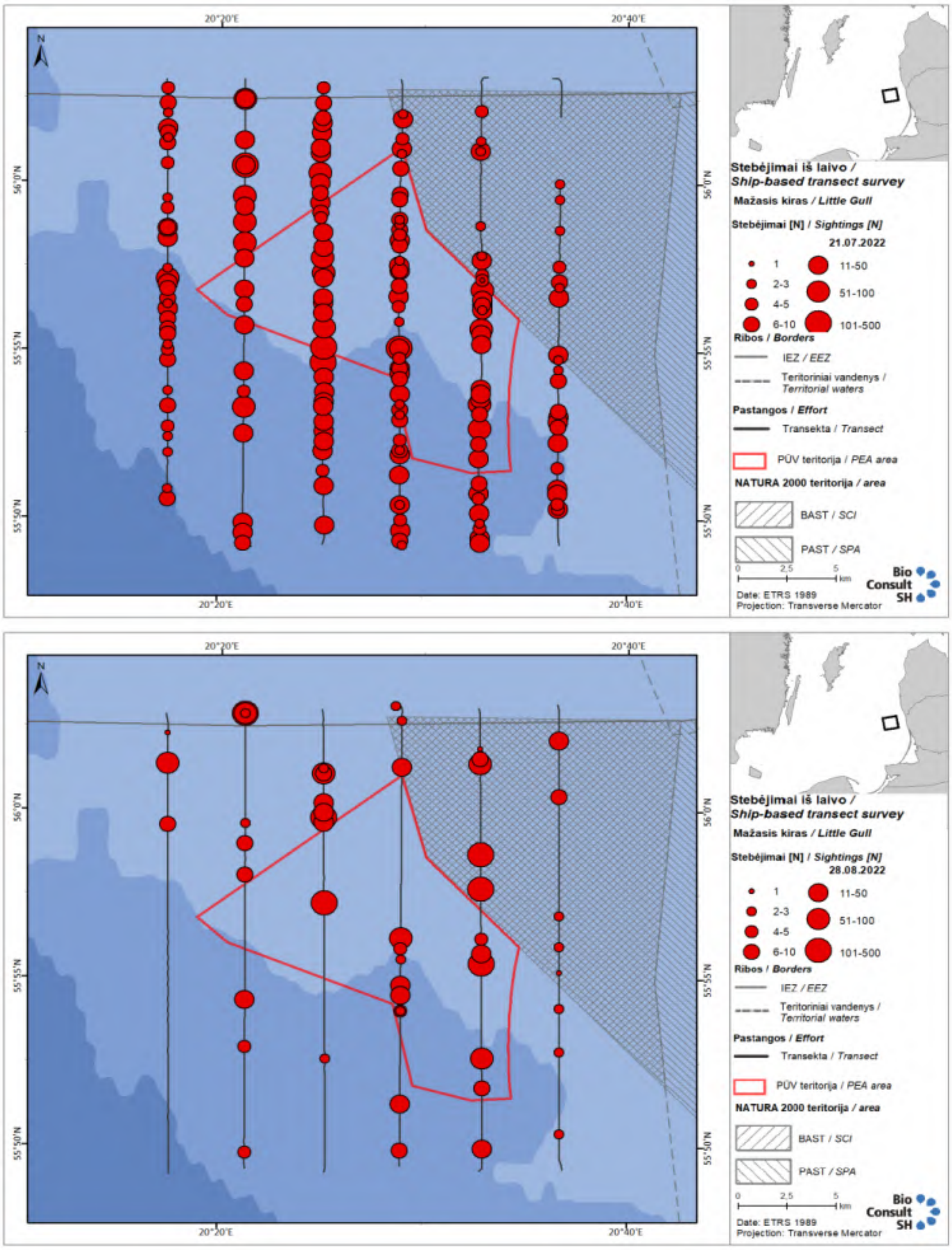


Fig. 4.6.4.2 Abundance and distribution of Little Gulls (ship-based surveys of July and August 2022).

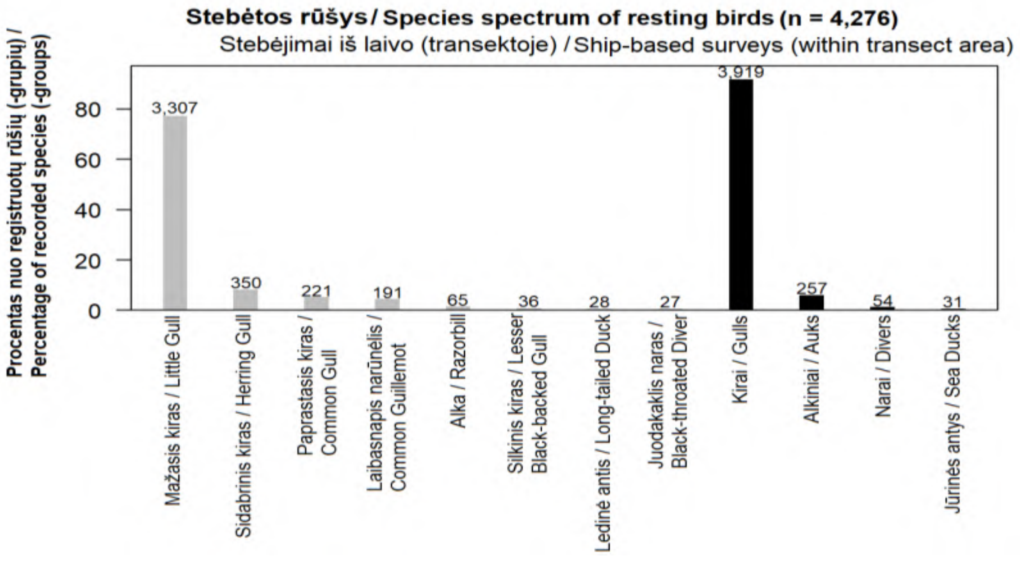


Fig. 4.6.4.3 Percentage of the most common species or species groups representing at least 0.5% of the total number of resting birds recorded during ship-based transect surveys the area between September 2021 and September 2022. Species are depicted in grey, species groups in black.

4.6.4.1.2 Aerial surveys of resting birds: monthly in autumn–spring seasons (from November to April)

Methods. The recording of resting birds was performed using the digital video technology developed by company HiDef.

A twin-engined, high-wing propeller-driven aircraft (Partenavia P 68) was used for the acquisition of digital videos. This aircraft is equipped with four high-resolution video camera systems which take approximately seven images per second and can achieve a resolution of two cm at the sea surface. To facilitate the detection of objects, the video sequences taken from each camera were split into two halves so that each half of the picture fitted the width of a large monitor. Since the camera system is not directed vertically downwards (depending on the sun position, it can be slightly inclined or even set against the flight direction), interferences arising from solar reflections (glare) can be effectively reduced. The external cameras (indicated by A and D, Fig. 4.6.4.4) cover a strip of 143 m width while the internal ones cover a width of 129 m each, resulting in 544 m effectively covered. However, there is a distance of about 20 m between each strip to avoid double counting of individuals detected by the cameras. Thus, the total recorded strip of 544 m is distributed over a width of 604 m. Such modern monitoring system was used for the first time not only in Lithuania, but also in all Baltic countries.

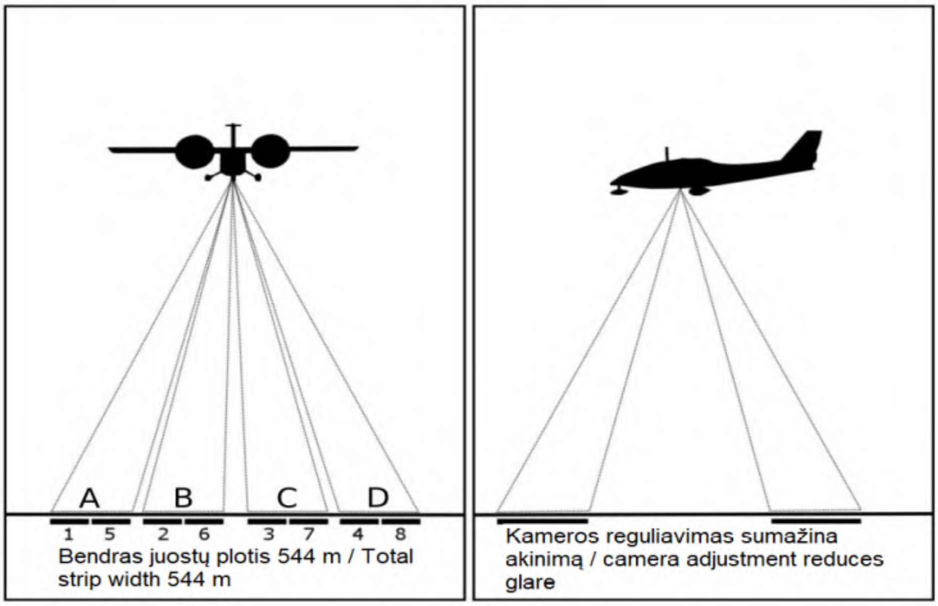


Fig. 4.6.4.4 The HiDef Camera-System. (left: frontal view; right: side view).

The transect design (Fig. 4.6.4.5) includes 13 transects with transect lengths of 39 km and 4 shorter transects in between, to cover the planned wind farm area, with a transect lengths of 19.07 km. In total, a transect length of 583.28 km is reached. The long transects run parallel to each other and are separated by 4 km, the shorter transects are located in between at a distance of 2 km. The area covered by the transect design is 2,340 km².

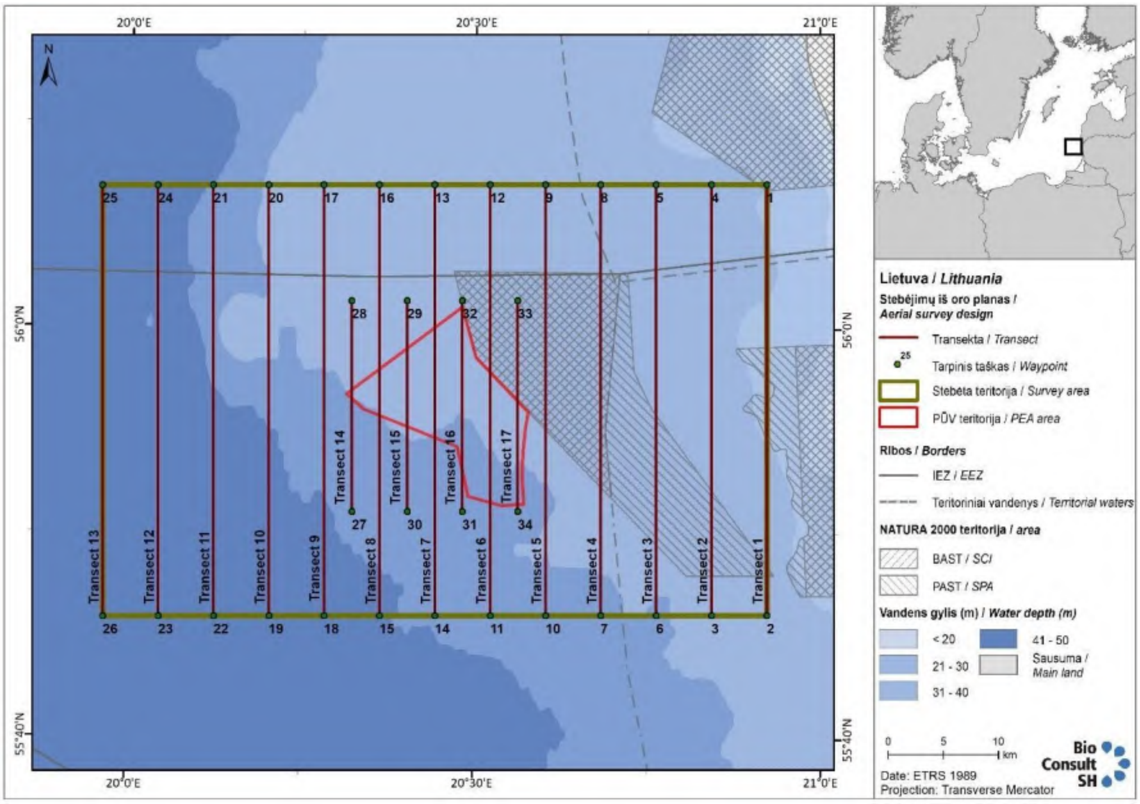


Fig. 4.6.4.5 Aerial survey transect design for the survey area.

In the data processing phase, the birds were identified from the footage collected by the aircraft. Often birds can be identified on the images to species level. Because of strong similarities between some species (e.g., common guillemot and razorbill, common and Arctic tern, and red-throated and black-throated diver), it is not always possible to identify the individuals to species level. However, it is usually possible to identify individuals as belonging to a species group formed by two (or few) closely related species. In addition to the identification, other information such as position, age, behaviour (swimming or flying) and flight direction were determined whenever possible.

Aerial survey results. A total of six surveys were conducted between November 2021 and April 2022. During this period, 15,711 birds belonging to 29 species were recorded, of which 14,039 were resting birds (Table 4.6.4.3). There were 433 resting birds which could not be identified to species level (only 3.1% of the total). Nonetheless, resting birds could be classified into 20 species.

Densities (ind./km²) were calculated for all relevant resting bird species and species groups (Table 4.6.4.4). The number of detected individuals of each species/taxon in each survey is divided by the area covered by the transects in order to calculate densities.

Table 4.6.4.3 Bird counts and percentages of all resting bird species during the aerial surveys in the survey area between November 2021 and April 2022.

Species	Latin name	Aerial surveys	
		N° ind.	%
Red-throated Diver	*Gavia stellata*	576	4.1
Black-throated Diver	*Gavia arctica*	33	0.2
Unidentified diver	*Gavia sp.*	58	0.4
Great Crested Grebe	*Podiceps cristatus*	5	0
Slavonian Grebe	*Podiceps auritus*	1	0
Red-necked/Great Crested Grebe	*Podiceps grisegena/Podiceps cristatus*	4	0
Slavonian / Black-necked Grebe	*Podiceps auritus/Podiceps cristatus*	1	0
Great Cormorant	*Phalacrocorax carbo*	12	0.1
King Eider	*Somateria spectabilis*	1	0
Long-tailed Duck	*Clangula hyemalis*	2,859	20.4
Common Scoter	*Melanitta nigra*	26	0.2
Velvet Scoter	*Melanitta fusca*	7,763	55.3
Common/Velvet Scoter	*Melanitta nigra/M. fusca*	103	0.7
Little Gull	*Hydrocoloeus minutus*	625	4.4
Black-headed Gull	*Chroicocephalus ridibundus*	11	0.1
Unidentified small gull		13	0.1
Common Gull	*Larus canus*	108	0.8
Lesser Black-backed Gull	*Larus fuscus*	4	0
Herring Gull	*Larus argentatus*	288	2.0
Common/Herring Gull	*Larus canus/L. argentatus*	2	0
Great Black-backed Gull	*Larus marinus*	5	0
Unidentified large gull	*Larus (magnus) sp.*	7	0.05
Black-legged Kittiwake	*Rissa tridactyla*	3	0

Species	Latin name	Aerial surveys	
		N° ind.	%
Unidentified gull	*Larus sp.*	10	0.1
Sandwich Tern	*Thalasseus sandvicensis*	1	0
Common Tern	*Sterna hirundo*	-	
Arctic Tern	*Sterna paradisae*	-	
Unidentified tern	*Sterna sp.*	-	
Unidentified tern/gull		2	0
Common Guillemot	*Uria aalge*	762	5.4
Razorbill	*Alca torda*	521	3.7
Common Guillemot/ Razorbill	*Uria aalge/Alca torda*	228	1.6
Black Guillemot	*Cepphus grylle*	2	0
Unidentified auk	*Alcidae*	5	0
Total		**14,039**	**100**

Table 4.6.4.4 Monthly mean densities (ind./km²) of selected species/species groups recorded in the survey area during the aerial transect surveys between November 2021 and April 2022.

Survey Method	**Aerial Survey**					
Species/Species-group	**2021/11**	**2021/12**	**2022/02**	**2022/03**	**2022/04**	**Max.**
Red-throated Diver	0.02	0.05	0.42	**0.57**	0.41	**0.57**
Black-throated Diver	0	0	0.02	0.01	**0.06**	**0.06**
Long-tailed Duck	0.35	1.27	**2.76**	1.83	0.43	**2.76**
Common Scoter	0	0.01	0	0.01	**0.07**	**0.07**
Velvet Scoter	0.91	**9.21**	7.25	0.89	0.05	**9.21**
Little Gull	**0.86**	0.61	0.16	0.07	0.17	**0.86**
Black-headed Gull	0	<0.01	0	0	**0.03**	**0,03**
Common Gull	**0.11**	0.09	0.03	0.05	0.05	**0.11**
Lesser Black-backed Gull	0	0	0	0	**0.01**	**0,01**
Great Black-backed Gull	0	0.01	0	0	**0.01**	**0,01**
Herring Gull	**0.22**	0.19	0.11	0.19	0.13	**0,22**
Common/Arctic Tern	0	0	0	0	0	**0**
Common Guillemot	0.47	0.60	0.20	0.27	**0.73**	**0.73**
Razorbill	0.47	0.18	0.21	**0.54**	0.07	**0.54**
Divers	0.04	0.06	0.46	**0.64**	0.53	**0.64**
Ducks	**0.10**	0	0.01	0	0.02	**0.10**
Gulls	**0.34**	0.29	0.14	0.24	0.20	**0.34**
Auks	**1.05**	0.84	0.57	0.95	0.97	**1.05**
No. of surveys	1	1	2	1	1	

Sea ducks dominated the resting bird community making up 76.6% of the total. Auks and gulls followed representing 10.1% and 7.7% respectively. Divers (mainly Red-throated Divers) contributed 4.7% to the sum of birds observed in the survey period (Fig. 4.6.4.6). In terms of species, two species made up over 75% of the total. Velvet Scoters were the most recorded species with 55.3% of the total number of birds while Long-tailed Ducks contributed 20.4%. All other species, including Little Gulls, Common Guillemots and Razorbills, contributed each less than 6% of the total.

More information about species densities, abundance and distribution in Annex 3.

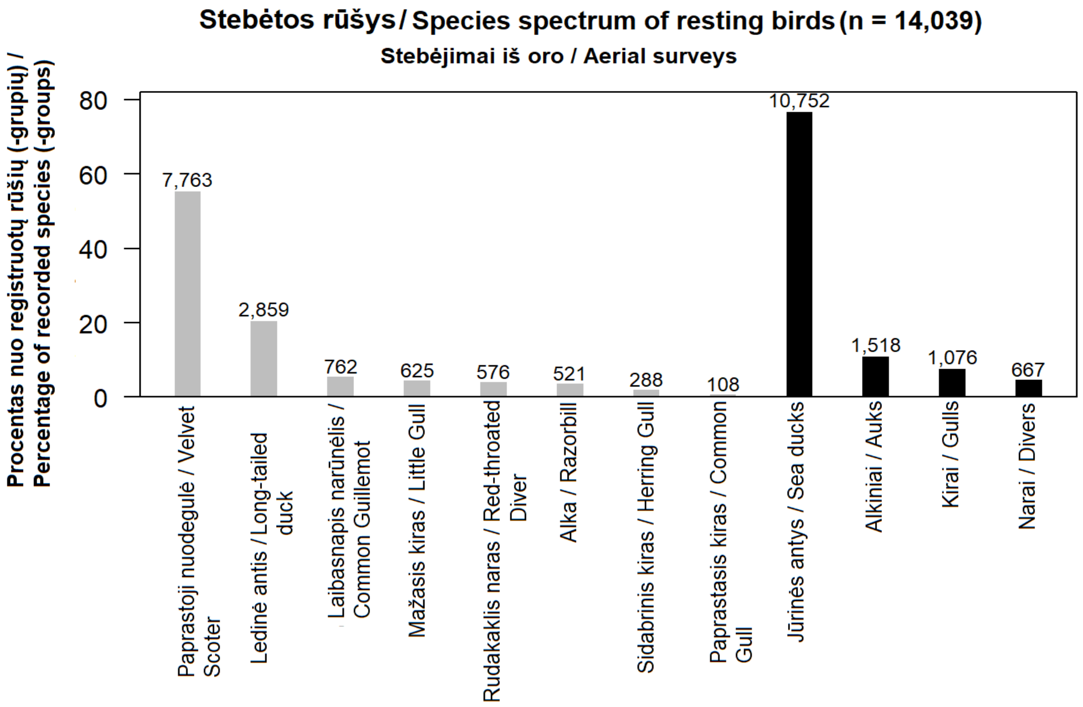


Fig. 4.6.4.6 Percentage of the most common species or species groups representing at least 0.5% of the total number of resting birds recorded during the aerial surveys in the survey area between November 2021 and April 2022. Species are depicted in grey, species groups in black.

4.6.4.1.3. Bird migration surveys by visual and radar methods during the spring and autumn migration seasons.

<u>Methods.</u> The research methodology, developed by a company BioConsult SH, consists of three parts: observations from the ship during daylight hours, 24 hours a day working vertical radar signal registration and night surveys listening to the sounds of migrating birds. We will briefly review each part.

Observations from the ship during daylight hours. The surveys begin before sunrise and continue till after sunset as long as visibility is good. The observation area is divided into 4 zones – A1 (from the port front of the ship); A2 (from the port end of the ship); B1 (from the starboard front of the ship); B2 (from the starboard end of the ship). Two 15-minute observation sessions are performed per hour with at least 5 min. break between them. In addition to identification and abundance, other information, such as sex, age, flight direction and altitude, observation area zone, distance from the ship, were determined whenever possible.

Recording of radar signals. The vertical radar method was used. The radar was rotated so, that it would be perpendicular to the direction of main migration flow. The radar captures all signals of birds flying within 1,500 meters from it. Every few minutes, special software took screenshots of the radar screen and all the signals on it. The running of the radar was constantly monitored and if the direction of the ship would change, the radar was turned perpendicular to the direction of bird migration. Meteorological parameters were also collected in order to make corrections in case of precipitation, fog or other phenomena that could affect the radar.

Night surveys listening to the sounds of migrating birds. The observations were made after sunset with stationary audio recording equipment or by listening twice every hour for 15 min. and doing 15 min. breaks.

<u>Bird migration survey results</u>.

There were 18 surveys done from November 2011 to May 2022 in autumn and spring seasons. 9,185 migrating or resting birds were observed. Bird species divided into species groups (Fig. 4.6.4.7).

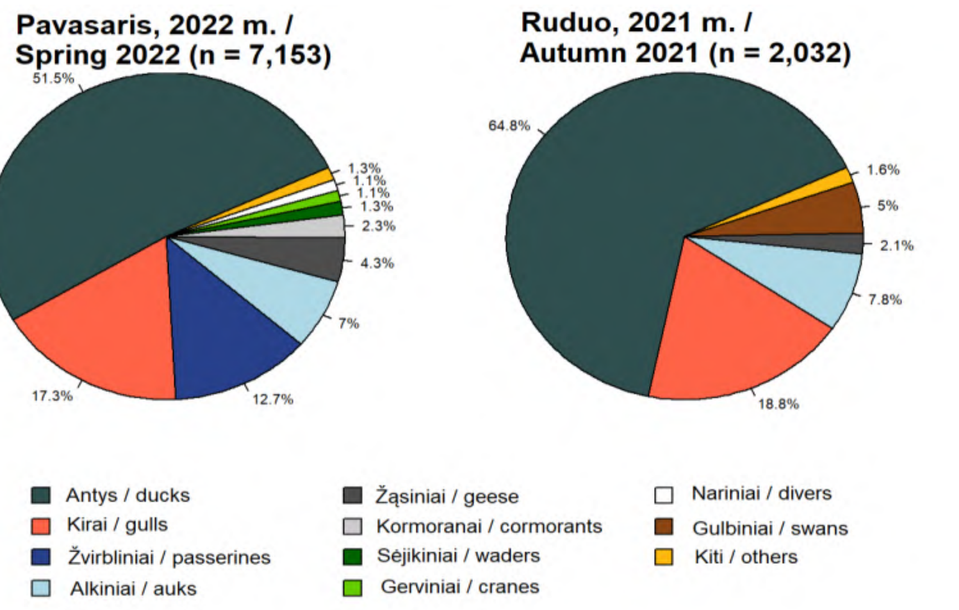


Fig. 4.6.4.7 Bird species groups abundance and their percentage distribution in seasons of autumn 2021 and spring 2022.

During the observations from the ship in daylight hours, all altitudes of flying birds were estimated. Cranes, geese and swans were flying the highest and most of ducks and auks were flying in the lowest altitudes. Detailed altitude diagrams are presented in Fig.s 4.6.4.8 and 4.6.4.9.

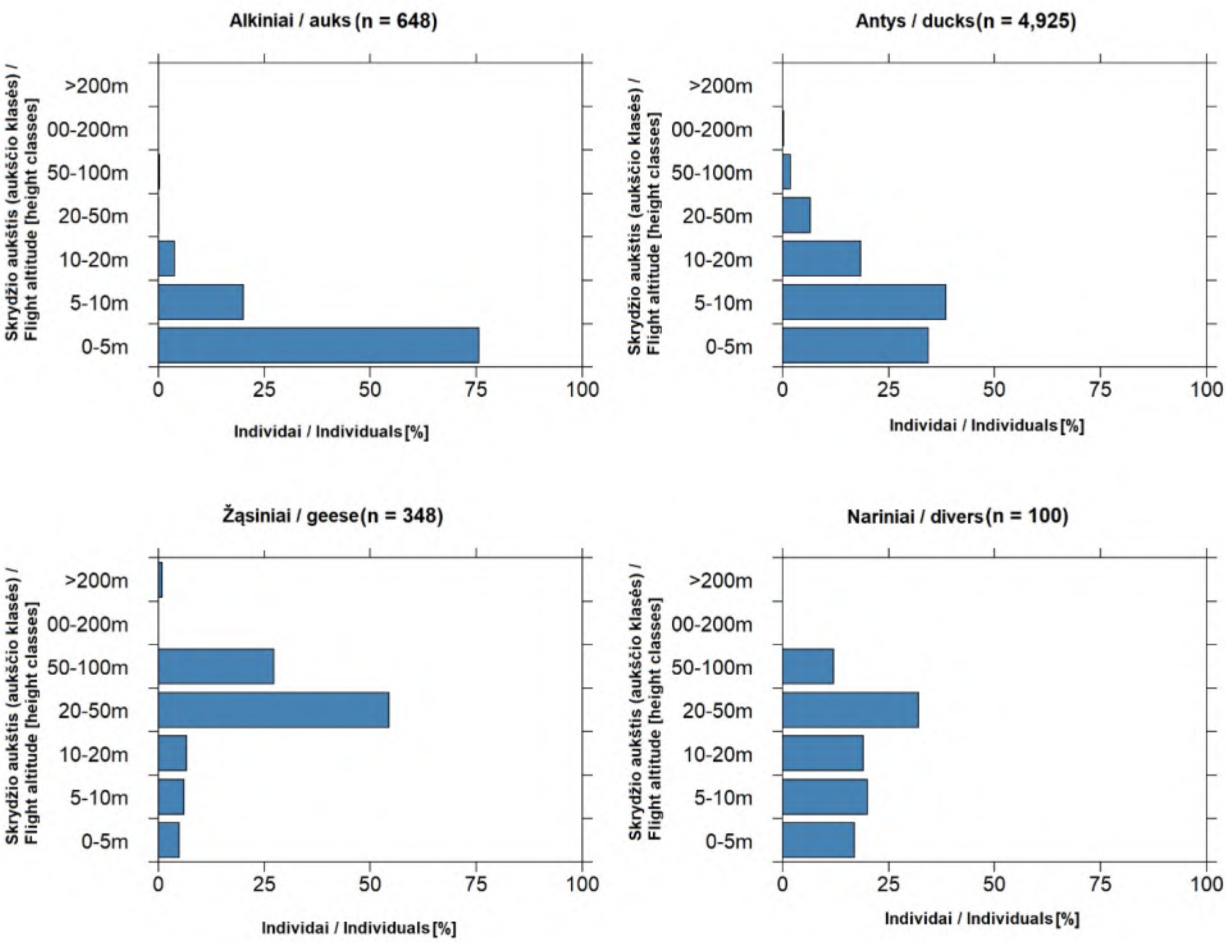


Fig. 4.6.4.8 Flight altitudes of auks, ducks, geese and divers observed in daylight hours.

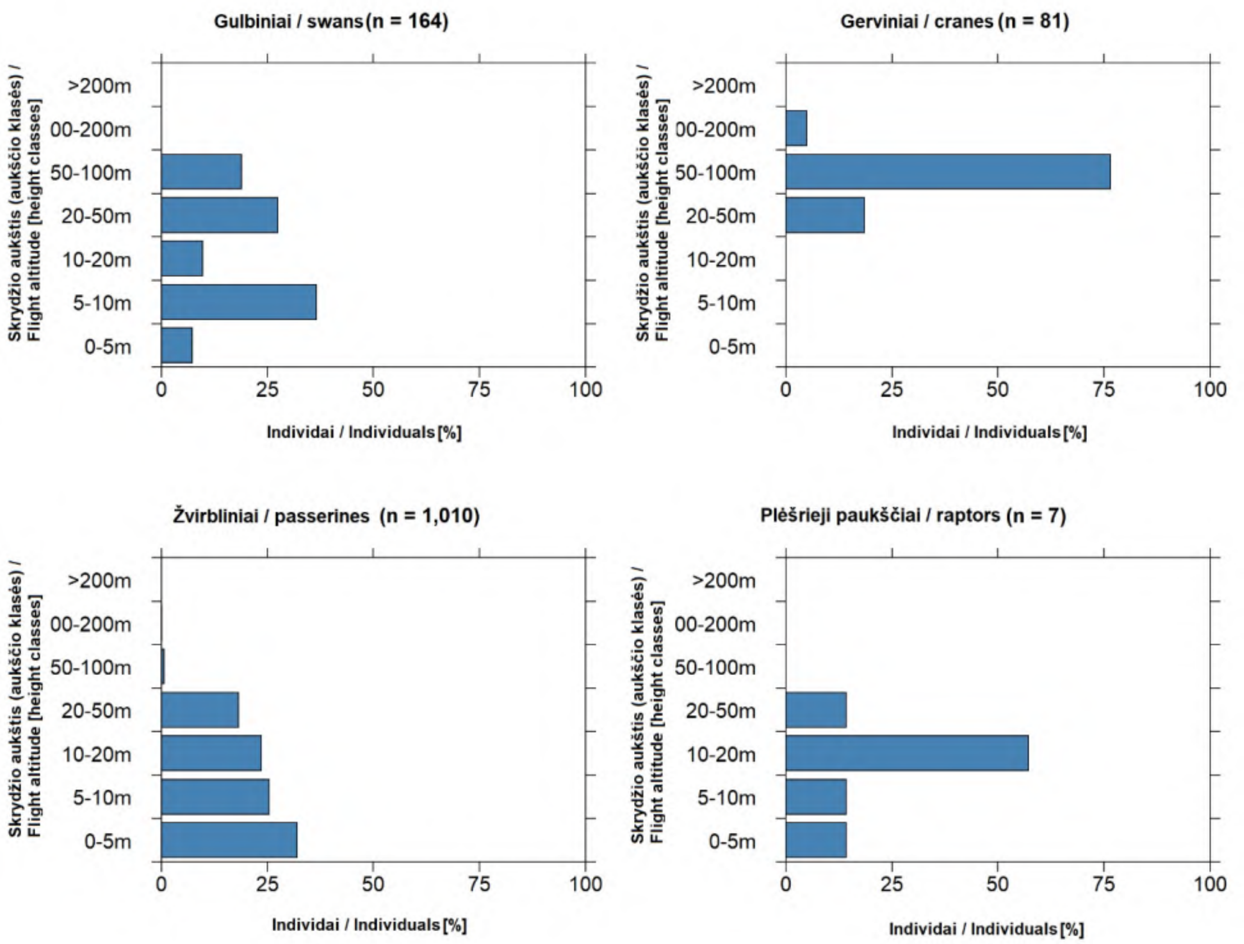


Fig. 4.6.4.9 Flight altitudes of swans, cranes, passerines and raptors observed in daylight hours.

In order to evaluate reliability of signal distances recorded by the radar, a model of expected values was created, when combined with the values of observed birds, it was established that the radar records the signals correctly (Fig. 4.6.4.10).

In total, 2,287 bird flight signals were recorded by the radar in autumn 2021 and spring 2022 seasons (Fig. 4.6.4.11). This is a very low number of migratory birds recorded in the area. The main directions of autumn migration are south, southwest, southeast. This corresponds to the direction of the eastern coast of the Baltic Sea. Therefore, majority of birds use land flyway and fly by the shore or some at a close range over the sea. During EuroBirdwatch, annual bird counts are held by the Lithuanian Ornithological Society and the University of Klaipėda on the shore of the Baltic Sea (1-2 km inland from the sea near Klaipėda). During the peak of migration in October, 170,000 to 250,000 birds are recorded within half a day (from 7 a.m. to 12 p.m.), mostly passerines (www.birdlife.lt). Based on the radar surveys held by other countries in other parts of the Baltic and North Seas, it can be assumed that the migration is not too intense in Lithuanian part of the Baltic Sea (pers. comm. Jorg Welcker, Andres.Kalamees).

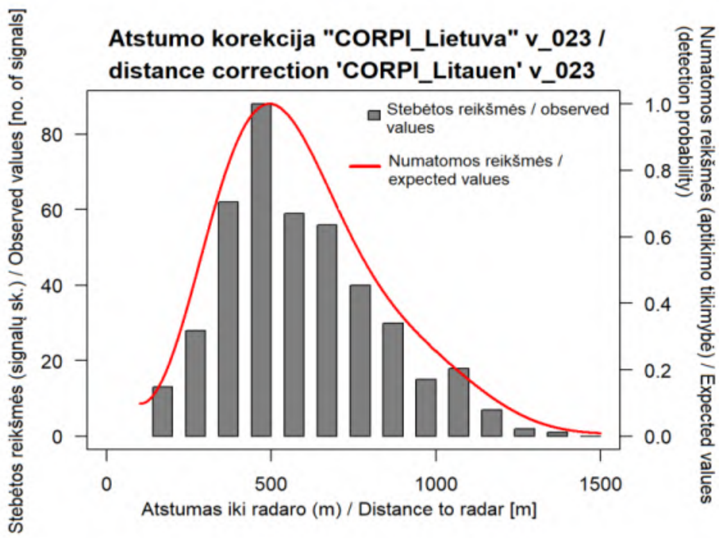


Fig. 4.6.4.10 Model of expected and observed values.

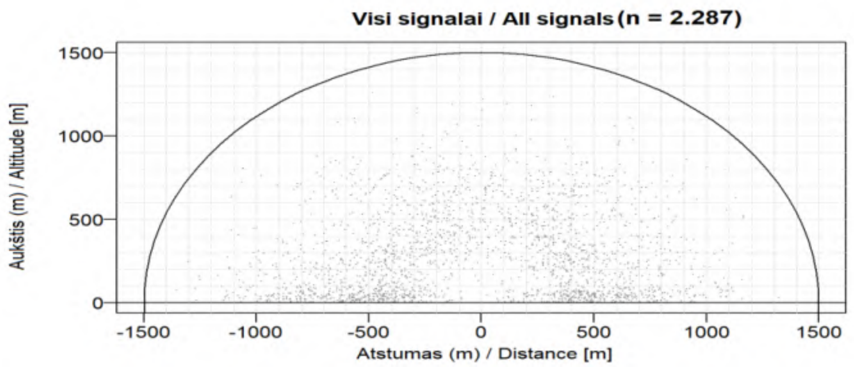


Fig. 4.6.4.11 All bird flight signals recorded by the radar.

After evaluating the intensity of all signals, it was found that most signals were recorded up to 1,000 m away from the radar, and the most intense birds were flying over the water surface at a distance of 300-700 m from the ship (Fig. 4.6.4.12). The signals of migratory birds were mostly recorded between 20 and 800 m above the sea level.

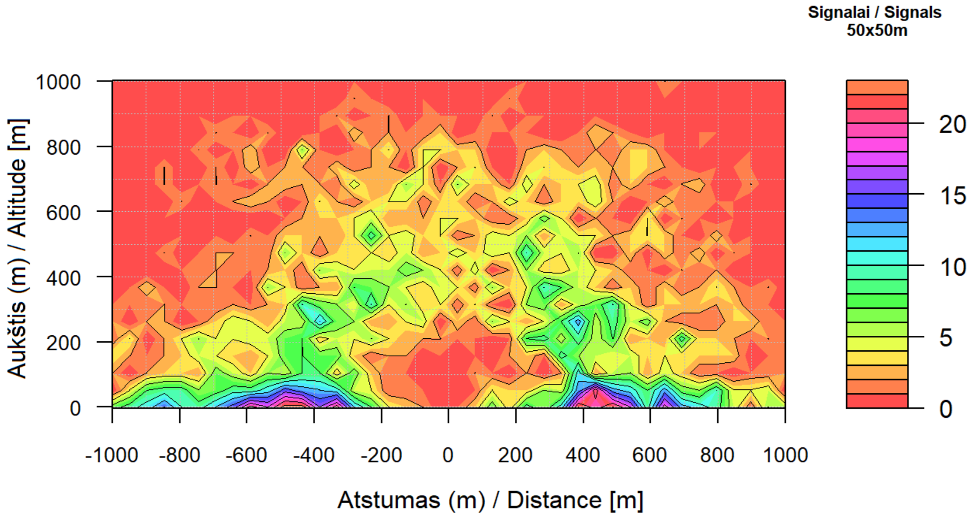
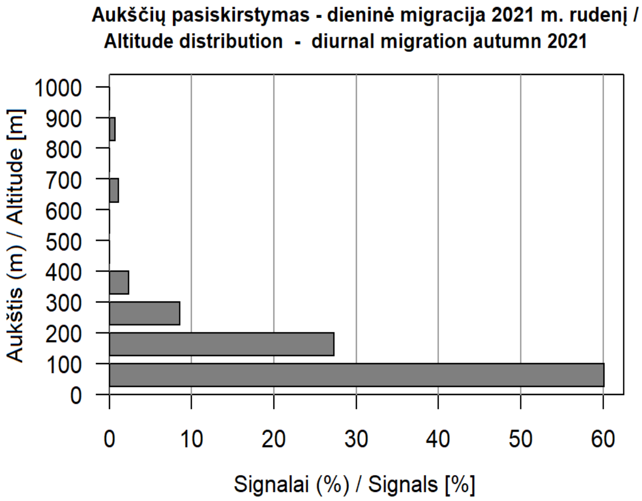


Fig. 4.6.4.12 Signal distance intensity.

Compared to the altitudes of autumn 2021 and spring 2022 radar recorded signals during the day and night migration, it was found that birds fly at lower altitudes above the water surface during a day, and most of them fly at higher altitudes during a night. Birds associated with the ship and frequently flying by, such as gulls circling the ship during daylight hours or passerines at night attracted by the lights of the ship, were not included in the evaluation of the radar signals. Below, in Fig.s 4.6.4.13 and 4.6.4.14, the distribution of all altitudes of all radar-recorded migrating bird signals in autumn 2021 and spring 2022 seasons is presented.

Furthermore, MTR (migration traffic rates) were evaluated for individual seasons of autumn 2021 and spring 2022 (Fig. 4.6.4.15). During autumn, diurnal migration was more intense, while in spring season – more intense was nocturnal migration. Passerines, such as thrushes and skylarks, are mostly migrating at night. The peak of migration was reached few hours after sunset when migrants from the shore would reach the point of observation in the PEA territory.



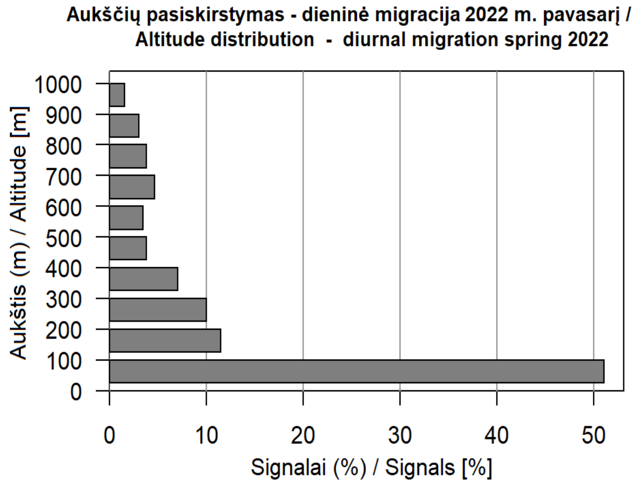


Fig. 4.6.4.13 Diurnal bird migration altitude distribution in autumn 2021 and spring 2022 seasons.

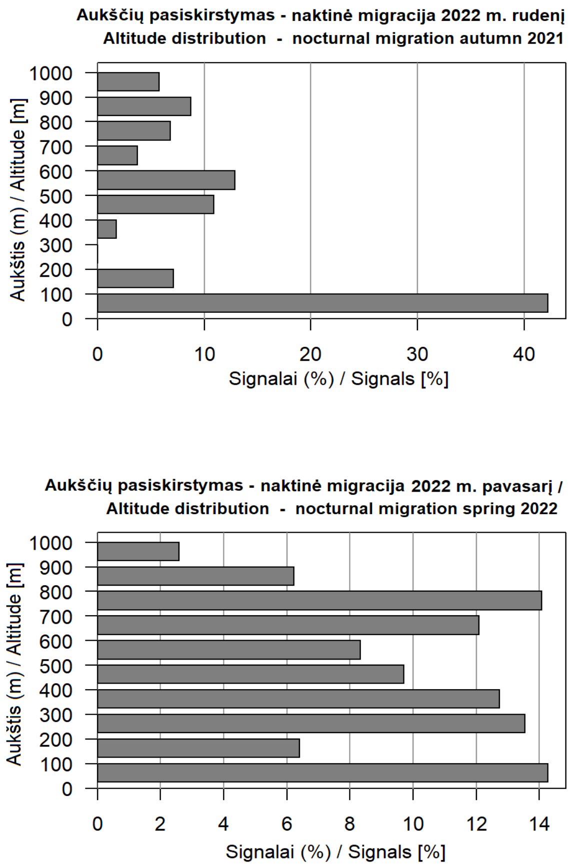


Fig. 4.6.4.14 Nocturnal bird migration altitude distribution in autumn 2021 and spring 2022 seasons.

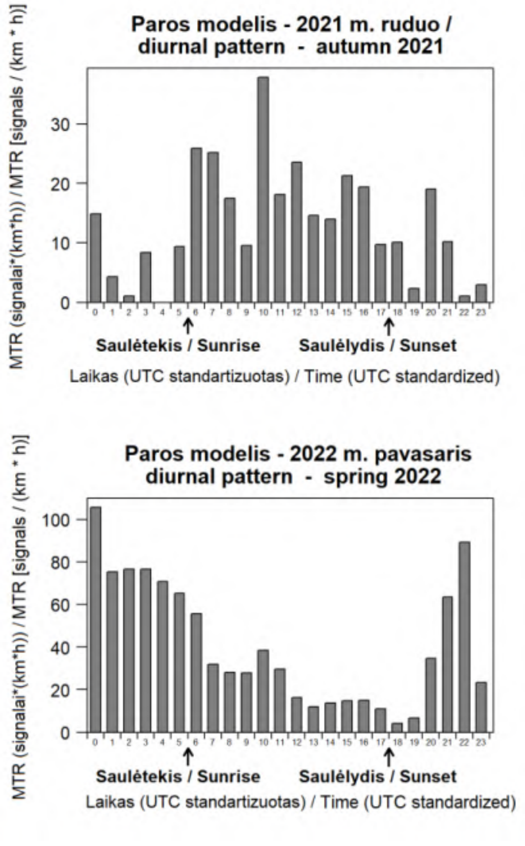


Fig. 4.6.4.15 Migration traffic rates in autumn 2021 and spring 2022 seasons.

4.6.4.1.4 Bird watching using telemetry transmitters

The distribution and behavior of birds above and below water was studied in the seabird bycatch projects carried out by the Lithuanian Ornithological Society (LOD), Royal Society for the Protection of Birds (RSPB) and Klaipėda University (KU) with partners. The research carried out in 2021-2022 was financed by the Lithuanian Environmental Protection Agency, and the research carried out from 2021 to 2024 is financed by the German Environmental Protection Agency and is intended to reduce the bycatch of birds and study the behavior of birds.

Methodology. Seabirds for research were caught and tagged at the Curonian Spit and at Karkle-Giruliai coastal zones at depths of up to 30 meters. In the winter periods of 2021-2023, birds were marked with GPS/GSM transmitters by attaching them to their back feathers. During this period, 32 velvet scoters, 10 long-tailed ducks and 13 red-throated divers were tagged. Most of the birds tagged with transmitters stayed in coastal areas and only a small number used the open sea. Places adjacent to the planned WE parks were used by 2 (out of 10 marked) long-tailed ducks and 6 velvet scoters (out of 32 marked).

Results of bird monitoring using telemetry transmitters. According to the preliminary results of the research, long-tailed ducks used very different territories, both inshore and in the open sea. Two male long-taled ducks used the protected territory of "Natura 2000" Klaipėda-Ventspils Plateau for several days. Two individuals stayed almost exclusively in the protected area, where they searched for food and dived to a depth of 30-35 m. One GPS point was fixed in the planned territory of the WE park (Figure 4.6.4.16).

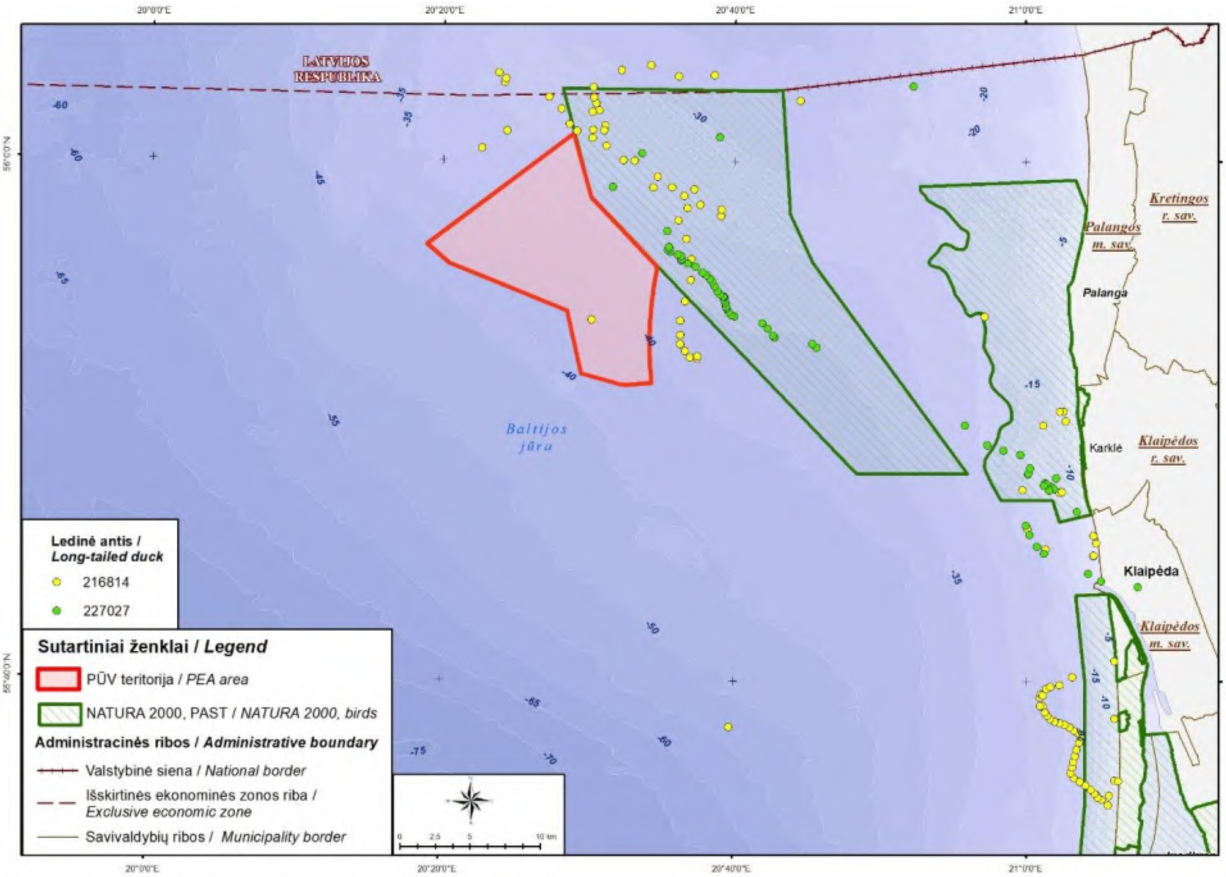


Fig. 4.6.4.16. Area used by two long-tailed ducks during winter (LOD, KU and RSBP unpublished data).

Marked velvet scoters mostly used the territories where they were caught and marked – at the nearshore of the Curonian Spit, but sometimes they also used other territories far from the coast. From the telemetry data, it was possible to determine that the velvet scoters, which are marked at the nearshore, feed intensively at depths from 5 to 30 meters, but some individuals sometimes also fed at depths of 35-50 meters. In the open sea, velvet scoter mostly used the Natura 2000 Klaipėda-Ventspils plateau area and the unprotected sea area about 30-50 km east of Klaipėda. GPS points of only two individuals were recorded in the area of the planned WE park, but not for long. According to the collected data, they were only there for 1-2 days. To the south of the planned WE territory, 3 individuals were registered: the velvet scoters stayed longer and used the territory for about a week. To the east of the planned WE park, in the protected area, the velvet scoters were observed mainly in the northern and eastern edge of the protected area. Also, at the border of the planned WE park, individuals fed for two to three days (Figure 4.6.4.17).

Out of all the marked velvet scoters (32 individuals), only 6 moved away from the coast and used distant territories. Based on this, it can be concluded that the birds are attached to their wintering places, which they change depending on environmental factors. Therefore, the velvet scoters that winter on the adjacent Klaipėda-Ventspils plateau probably spend most of their time in this protected area.

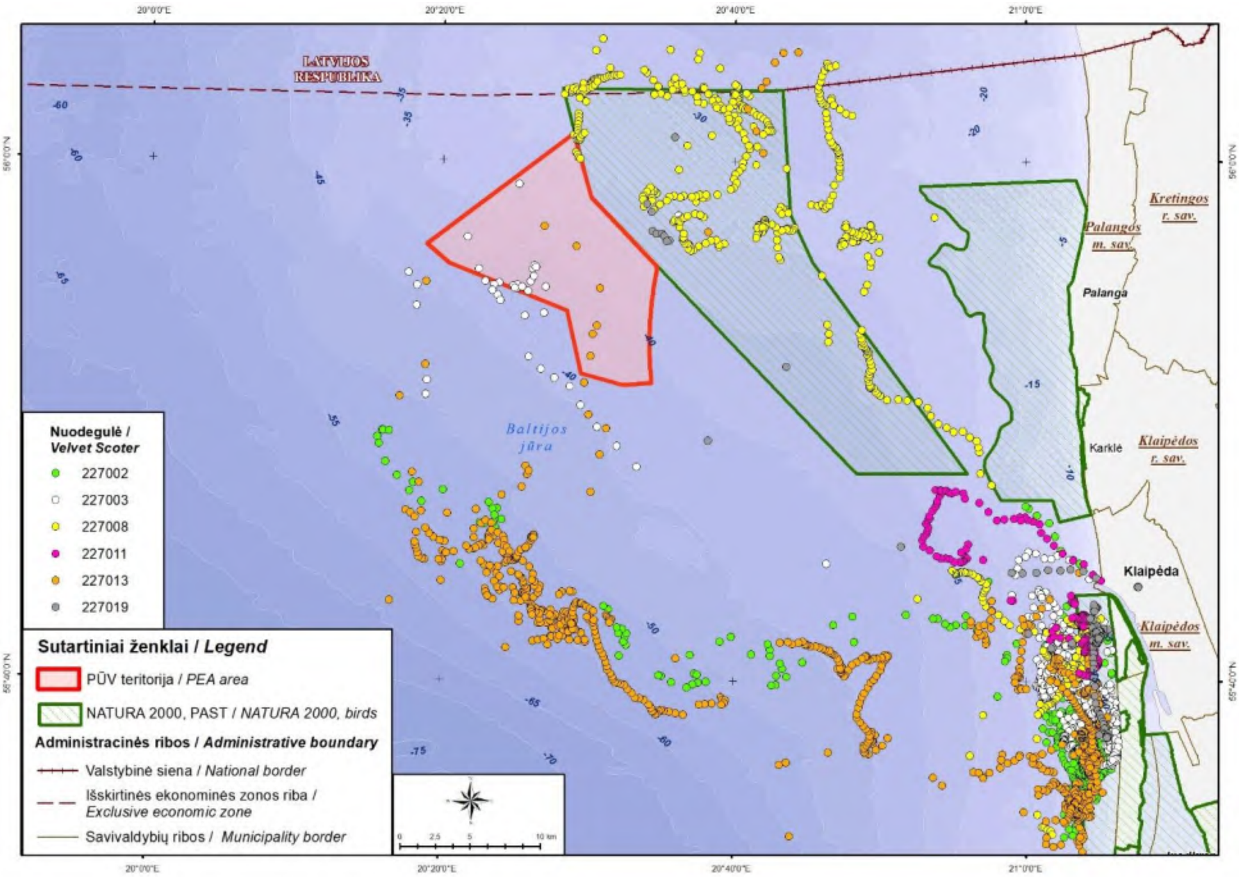


Fig. 4.6.4.17. Area used by two velvet scoters during winter (LOD, KU and RSBP unpublished data).

After summarizing the results of the telemetry data of long-tailed ducks and velvet scoters, it was found that the birds visit and occasionally use the territory of the planned WE park, but the protected "Natura 2000" territory and the territory about 20-30 km south of the planned WE park are significantly more intensively used.

Velvet scoters are very sedentary birds and only change their wintering grounds due to certain factors. Long-tailed ducks are mobile and often move, change their wintering places. Therefore, the planned WE park may have a negative significant effect of displacement from the wintering grounds on velvet scoters and long-tailed ducks

4.6.4.1.5 PEA territory analysis by bird groups or species

A total of 25,779 birds were recorded during all counts. The largest number of birds was recorded in the aerial surveys – 11,775, while observing from the stationary point on the boat, while the radar was recording signals – 9,728, and during the ship-based transect surveys – 4,276 birds. Sea ducks and auks were the most observed bird species.

Sea ducks. Velvet Scoters were the most abundant birds in the area with 10,280 recorded individuals. Long-tailed Ducks were also abundant – 4,534 individuals. The majority of both species were recorded via the aerial surveys – 7,763 Velvet Scoters and 2,859 Long-tailed Ducks. High numbers of sea ducks in winter months represent the wintering period of the species when birds gather in the Baltic Sea. Almost all Common Scoters were observed from the stationary surveys from the boat. The abundance of sea ducks is presented in Fig. 4.6.4.18.

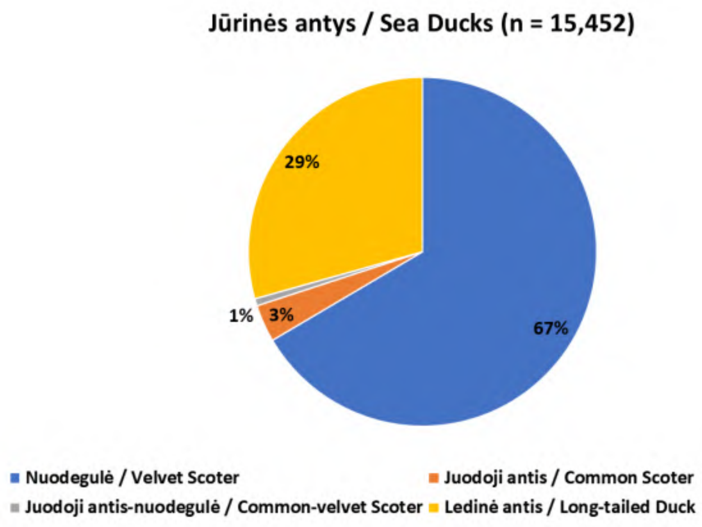


Fig. 4.6.4.18 Abundance distribution of sea ducks.

The highest density and abundance of Velvet Scoters and Long-tailed Ducks were observed from the aerial surveys in winter months (Fig.s 4.6.4.19 and 4.6.4.20). The biggest distribution is observed in the eastern part of the territory in the Special Protection Area (further on – SPA) "Klaipėdos–Ventspilio plynaukštė" where waters are shallower and it is easier to find food for birds (Fig. 4.6.4.21 and 4.6.4.22).

Velvet Scoters are wintering almost exclusively in the Baltic Sea (Durinkc et al. 1994). Various depths are used for feeding depending on food source. In waters of the coastal part of Lithuania, Velvet Scoters are mostly observed in waters with depths up to 20 m (Morkūnas et al. 2022), however, it is known that they can feed in waters up to 30-40 m deep (Mendel et al. 2008). In the Baltic Sea, Velvet Scoters mostly feed on bivalve molluscs and crustaceans both from sandy and solid bottoms of the sea. Big mortality rate of Velvet Scoters is observed in Lithuania due to bycatch in fishing nets – from 500 to 1000 birds per year (Morkūnas et al. 2022). Not much is known on impact of wind farms (further on – WF) on Velvet Scoters, but it is likely that weak WF avoidance may be recorded, similar to Common Scoters; both species avoid intensive shipping lanes (Dierschke et al. 2016). Overall, Velvet Scoters were mainly recorded not only in SPA, but also in the PEA territories. The highest densities (very high) were from 20 to 100 ind./km^2. Most of Velvet Scoters were observed in months from December to February. The highest density in the PEA territory was on the border with SPA territory where 3 squares had densities from 20 to 100 ind./km^2, and two squares with densities higher than 100 ind./km^2.

The Long-tailed Duck is the second species of observed birds by abundance. Around 90 % of wintering population is in Europe, winters in the Baltic Sea (Durinkc et al. 1994). During winter, Long-tailed Ducks can be found in waters with depths of 10-35 m (Skov et al. 2011, Morkūnas et al. 2022). Long-tailed Ducks mostly feed on molluscs found in solid bottoms of the sea, such as mussels, but also crustaceans, however, birds feeding close to the shore also catch fish (Fornit et al. 2022, Skabeikis et al. 2019). Big mortality rate of Long-tailed Ducks is observed in Lithuania due to bycatch in fishing nets – up to 1,000 birds per year (Morkūnas et al. 2022). It is known, that Long-tailed Ducks avoid WF and intensive shipping lanes (Durinkc et al. 1994, Fliessbach et al. 2019).

Long-tailed Ducks were mainly observed mostly in the SPA territory and only in a small part of the PEA territory close by. Birds observed only in wintering period, from the aerial surveys 2,859 individuals were counted, while from the ship – only 28 birds. The highest density of 2.76 ind./km^2 was recorded in February, and the lowest of 0.35 ind./km^2 in November 2021. Long-tailed Ducks were mainly distributed by the northeastern border of the PEA territory. In some squares, the density was high – up to 20–100 ind./km^2. Overall, the distribution of Long-tailed Ducks depends on the sea bottom habitats and shallower waters outside the border of the PEA territory.

It is likely that the planned WF may disturb and scare sea ducks wintering in the "Natura 2000" area. As a result, decrease in densities and distribution may be observed in the protected area, as the ducks would move away from the planned WF. The distance that Long-tailed Ducks and Velvet Scoters avoid from WF structures is not specifically determined from literature sources, but according to similar species, decrease of up to 50% or more individuals has been observed at a distance of 1 km from the WF. At a distance of 5 km from the WF, decrease is smaller. The planned WF almost borders "Natura 2000" territory, so it is likely that it would cause displacement of birds from feeding territory, also would have scaring effects to the species that are protected there. In this case, in order to reduce the potential negative impact of the WF and to preserve the important wintering grounds and feeding territories of protected birds, it is recommended to move the WF away from the "Natura 2000" territory at least 2 km in order to reduce the negative impact of the PEA.

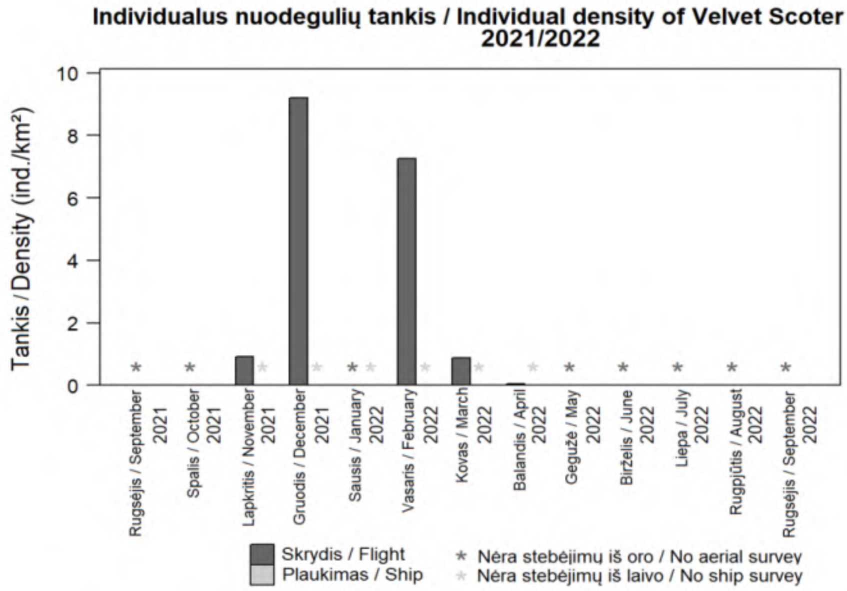


Fig. 4.6.4.19 Monthly densities of Velvet Scoters in the survey

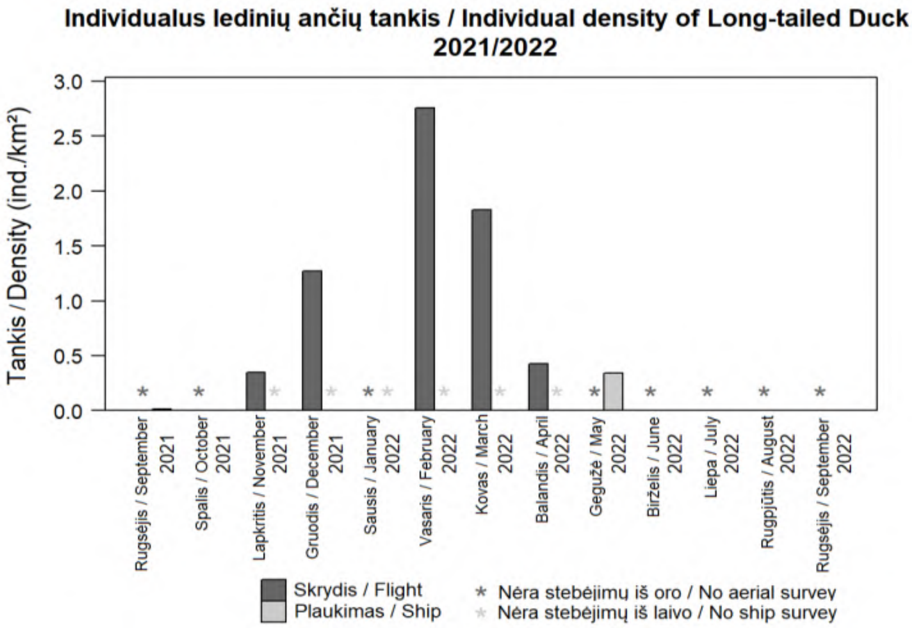


Fig. 4.6.4.20 Monthly densities of Long-tailed Ducks in the survey area.

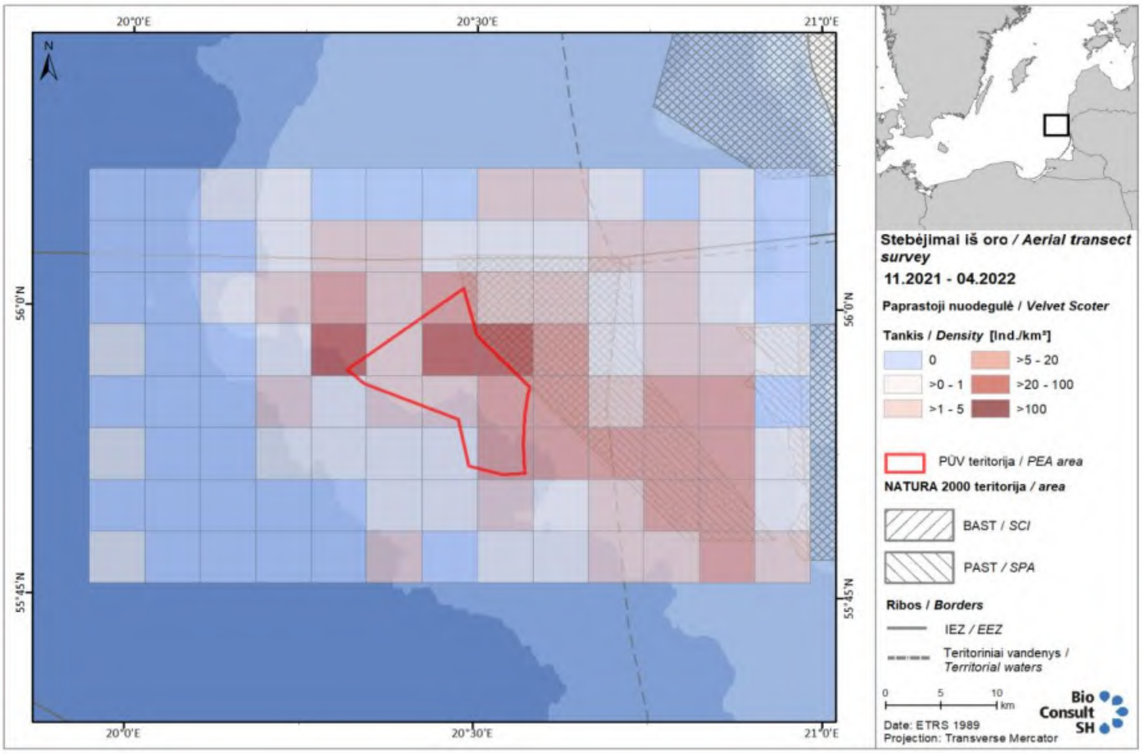


Fig. 4.6.4.21 Distribution of Velvet Scoters in winter.

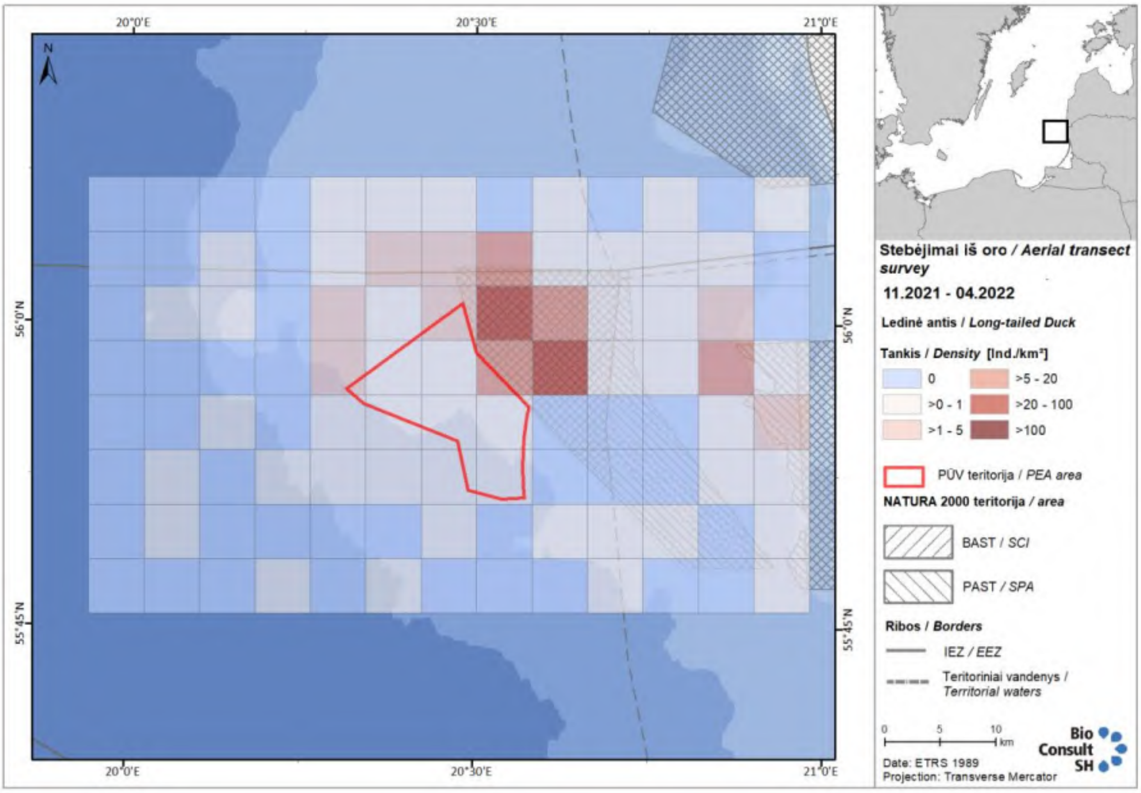


Fig. 4.6.4.22 Distribution of Long-tailed Ducks in winter.

Auks. There were 1,145 Razorbills and 1,032 Common Guillemots recorded in the area. Most of Razorbills were observed from the stationary surveys from the boat, while most of Common Guillemots were recorder from the aerial surveys. 559 and 762 birds, respectively. While analyzing the aerial survey data, 2 Black Guillemots were identified. Due to similarities in appearance and behavior of the species, 244 individuals from the aerial survey material could not be identified to the exact species, so they were assigned to the unidentified auk bird group. The abundance of auks is presented in Fig. 4.6.4.23.

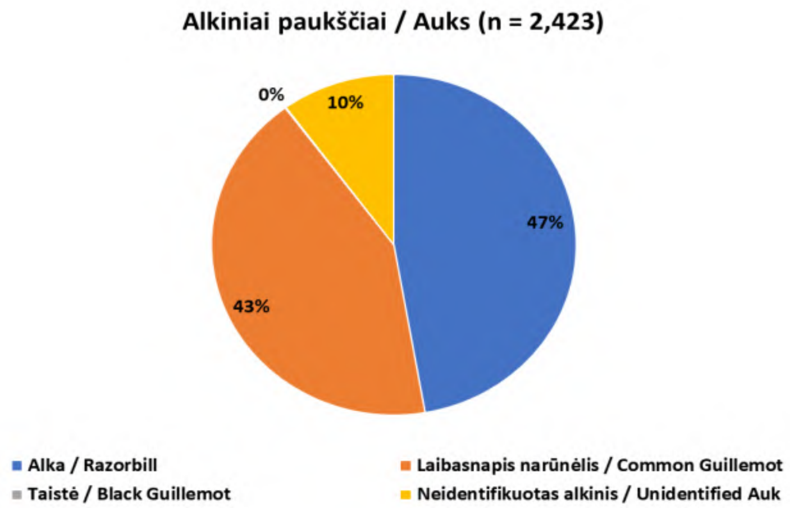


Fig. 4.6.4.23 Abundance distribution of auks.

The Common Guillemot is a species of birds that hunts pelagic fish, these birds breed in the Baltic Sea on the islands of Sweden and Finland. It is estimated that the population of the Baltic Sea is about 50,000 birds. Most of them winter in the southern parts of the Baltic Sea, in waters of Denmark and Sweden (Mendel et al. 2008). It is known that Common Guillemots avoid WF, but avoidance widely varies from very weak to strong (Dierschke et al. 2016, Peshko et al. 2022). During the aerial surveys, 762 Common Guillemots were counted. During early autumn – summer and spring (6 months) 191 Common Guillemots were counted. The highest density and abundance of Common Guillemots were observed in autumn and spring months (Fig. 4.6.4.25). The highest distribution was observed in the western part of the study area where deeper waters prevail (Fig. 4.6.4.27). However, the highest density was recorded in September and reached 1.671 ind./km^2. Conditionally higher density was also recorded in the PEA territory, but only in certain months.

The Razorbill is a northern bird species, birds of subspecies *Alca torda torda* are found in the Baltic Sea and breed in Sweden, Finland and Estonia (Mendel et al. 2008). The birds feed on pelagic small fish, which they hunt in the deep waters. During the aerial surveys from the plane, 521 individuals were counted, while during the ship-based surveys during early autumn-summer and spring, 65 razorbills were counted, and during the stationary surveys from the boat, there were 559 birds observed in later autumn and early spring. The highest density and abundance of razorbills were observed in the autumn and spring months (Fig. 4.6.4.24). During the winter period, the highest density reached 0.54 ind./km^2, and during the observations from the ship in October, it reached 1.28 ind./km^2. The largest distribution is observed in the western part of the PEA territory where deeper waters prevail (Fig. 4.6.4.26).

Both Common Guillemots and Razorbills did not intensively use the territory during the winter. The birds were observed regularly in the autumn and winter, but not as densely as sea ducks. The Razorbill densities were recorded from 0.01 to 2 ind./km^2 and there were no records of the birds in some squares at all. Common Guillemots were observed a little more often than Razorbills in the territory, however, the densities were also low from 0.01 to 5 ind./km^2. There were no differences between bird concentrations in the protected areas and the PEA territory. The density of birds increased with increasing depth and distance from the shore, so it can be concluded that PEA most likely will not affect auks.

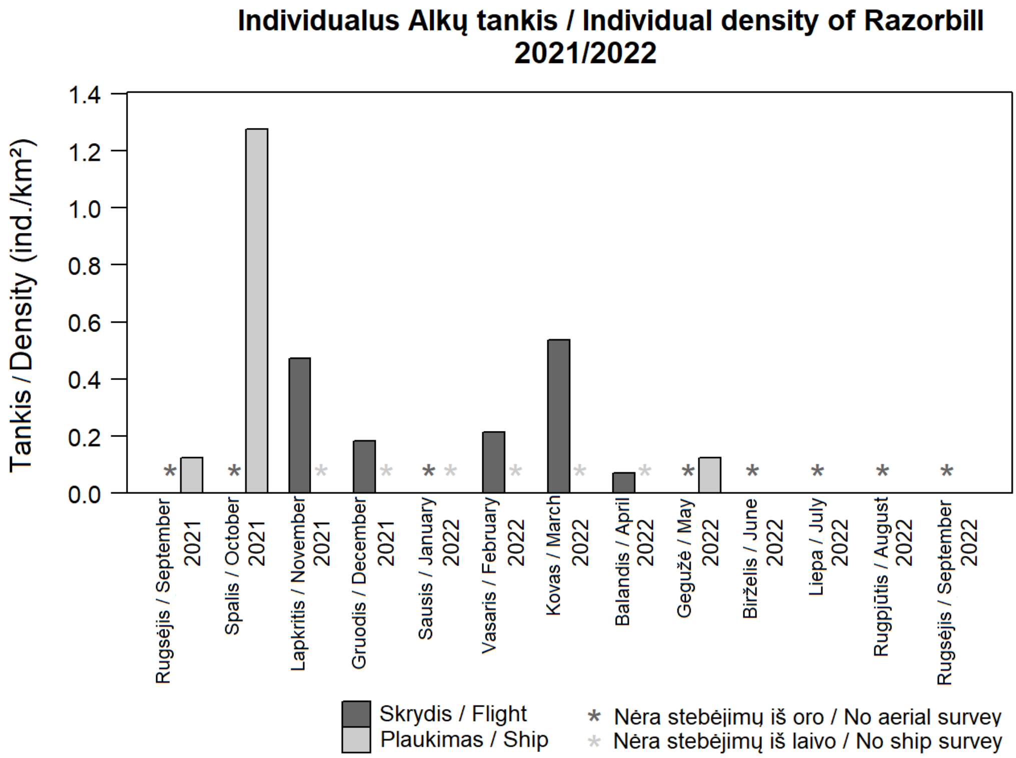


Fig. 4.6.4.24 Monthly densities of Razorbills.

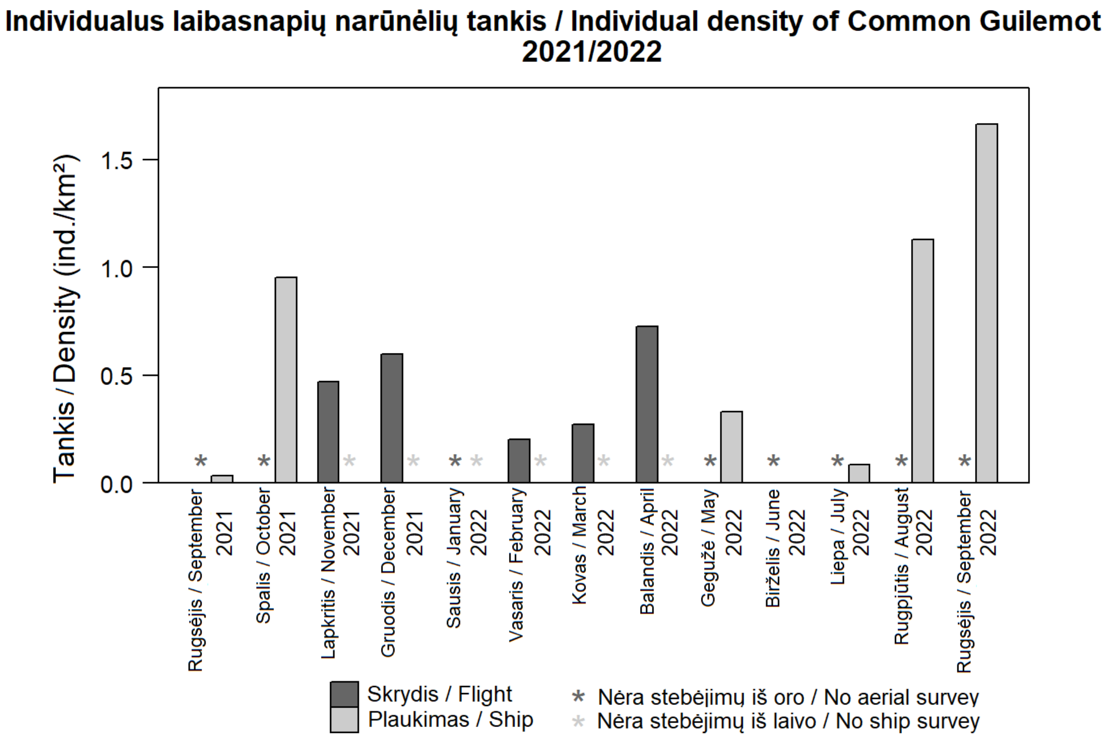


Fig. 4.6.4.25 Monthly densities of Common Guillemots.

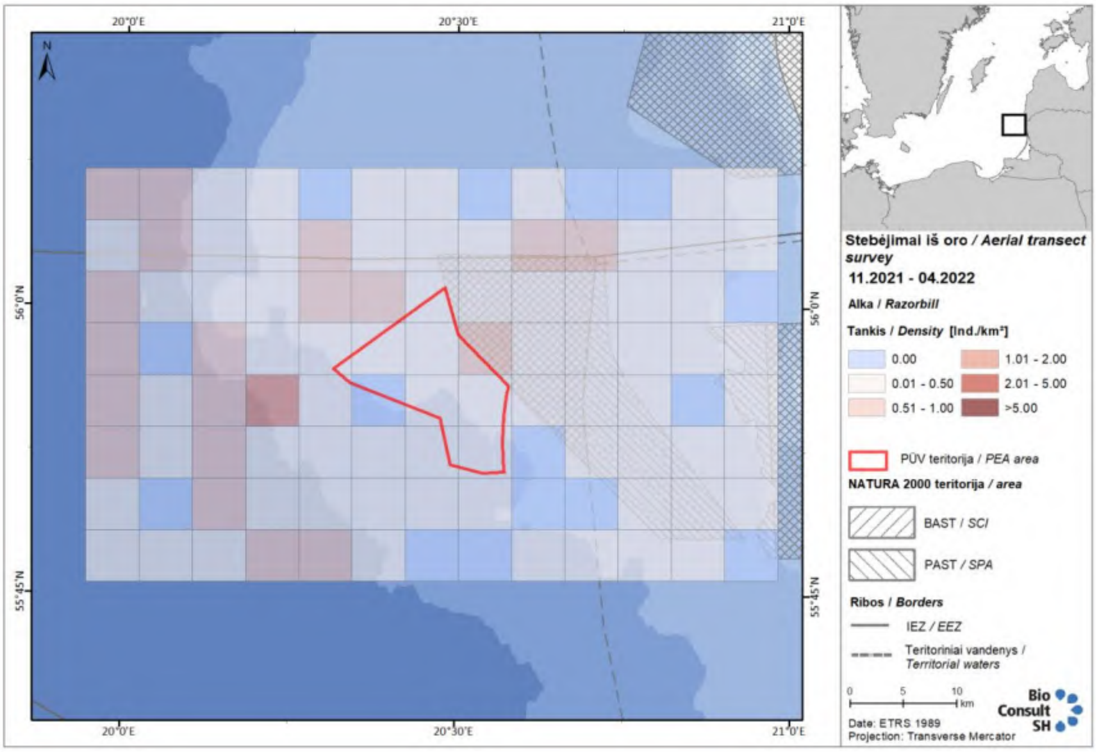


Fig. 4.6.4.26 Distribution of Razorbills.

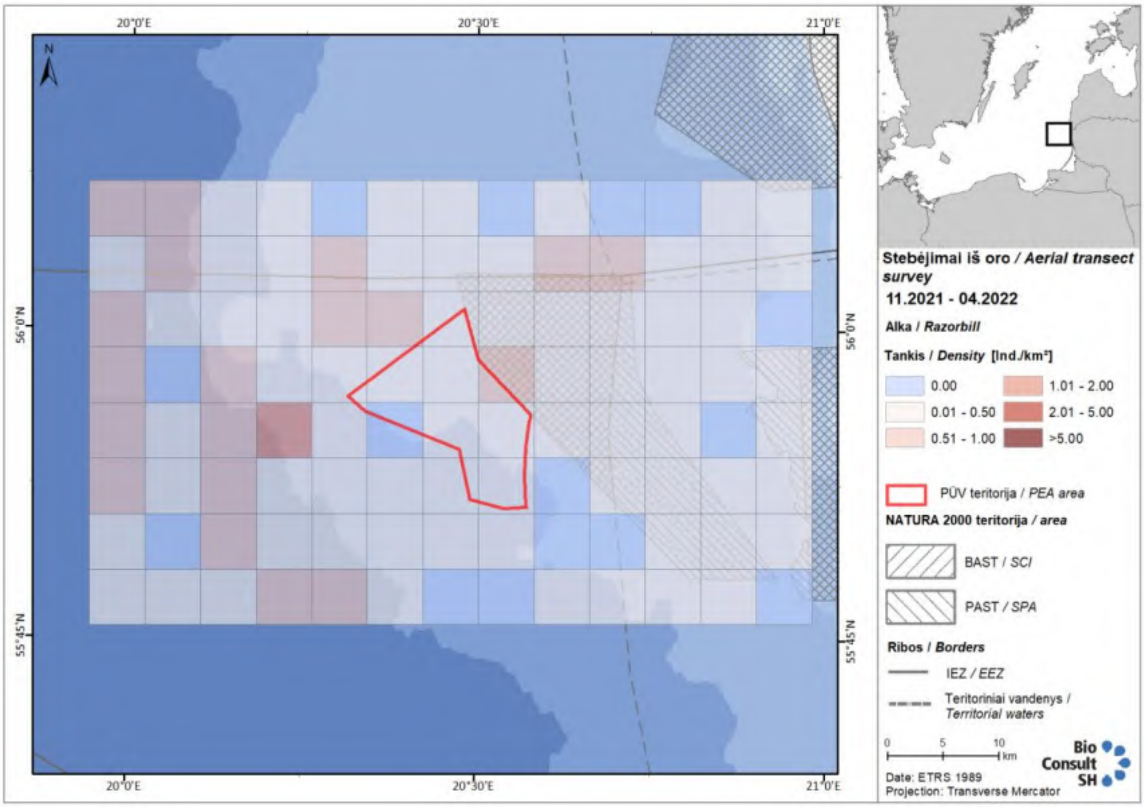


Fig. 4.5.2.4.27 Distribution of Common Guillemots.

Divers. Two species of divers are regularly found in Lithuanian part of the Baltic Sea which are the Black-throated Diver and Red-throated Diver. Both species feed on small fish. The Red-throated Diver is more widely observed and regularly encountered during wintering period. During the wintering bird surveys (in January) from the shore, Red-throated Divers are much more common and make up about 90% of all observed divers (www.birdlife.lt). The Black-throated Diver is more present while on migration with few staying for wintering. Red-throated Divers are one of the most vulnerable species to anthropogenic disturbance. This species is sensitive to the effects of marine WF, intensive shipping lanes, and a large proportion of birds are killed in fishing nets. A strong area avoidance effect is recorded within 5 km of the WF (Hainanen et al. 2020). The most divers observed were Red-throated Divers with 619 individuals, and 82 birds of Black-throated Divers were also recorded. Most of Red-throated and Black-throated Divers have been recorded during the aerial surveys. 576 and 33 birds respectively. Due to similarities in appearance and behavior of the species, 100 individuals could not be identified to the exact species in all the conducted surveys, so they were assigned to the unidentified diver group. Fig. 4.6.4.28 shows abundance distribution of divers.

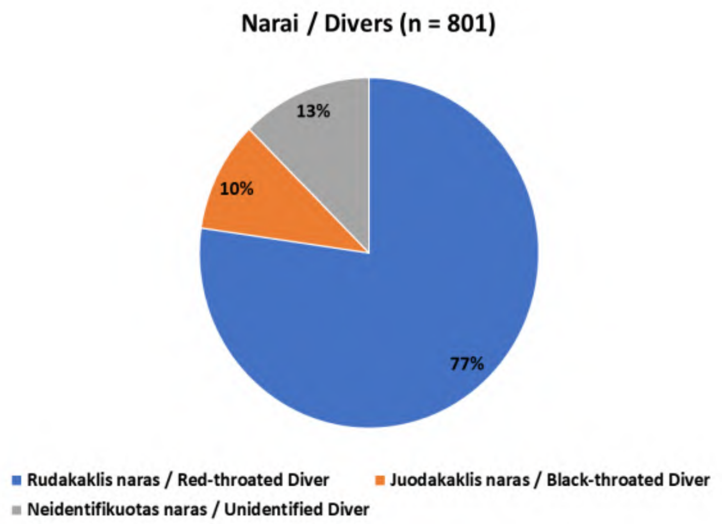


Fig. 4.6.4.28 Abundance distribution of divers.

The highest density and abundance of Red-throated Divers were observed in the winter and spring months (Fig. 4.6.4.29). The highest average monthly density was 0.57 ind./km^2 in March. Data from the surveys show that Red-throated Divers were observed in almost entire territory at low densities up to 0.5 ind./km^2 in the winter period. During the spring, the densities increased up to 2-5 ind./km^2, but only in the zone closer to the coast outside the PEA territory. Overall, the highest distribution of Red-throated Divers was observed in the western and northern parts of the PEA territory where deeper waters prevail (Fig. 4.6.4.31). Red-throated Divers were not a very abundant species in the PEA territory, their density ranges from 0.01 to 0.50 ind./km^2. In "Natura 2000" territory, divers were also not abundant.

Black-throated Divers were observed more often in the spring months (Fig. 4.6.4.30). The largest distribution of Black-throated Divers was observed in the western part of the study area where deeper waters prevail (Fig. 4.6.4.32). Black-throated Divers were very rarely found in the PEA territory, therefore the planned WF should not cause negative impact on divers.

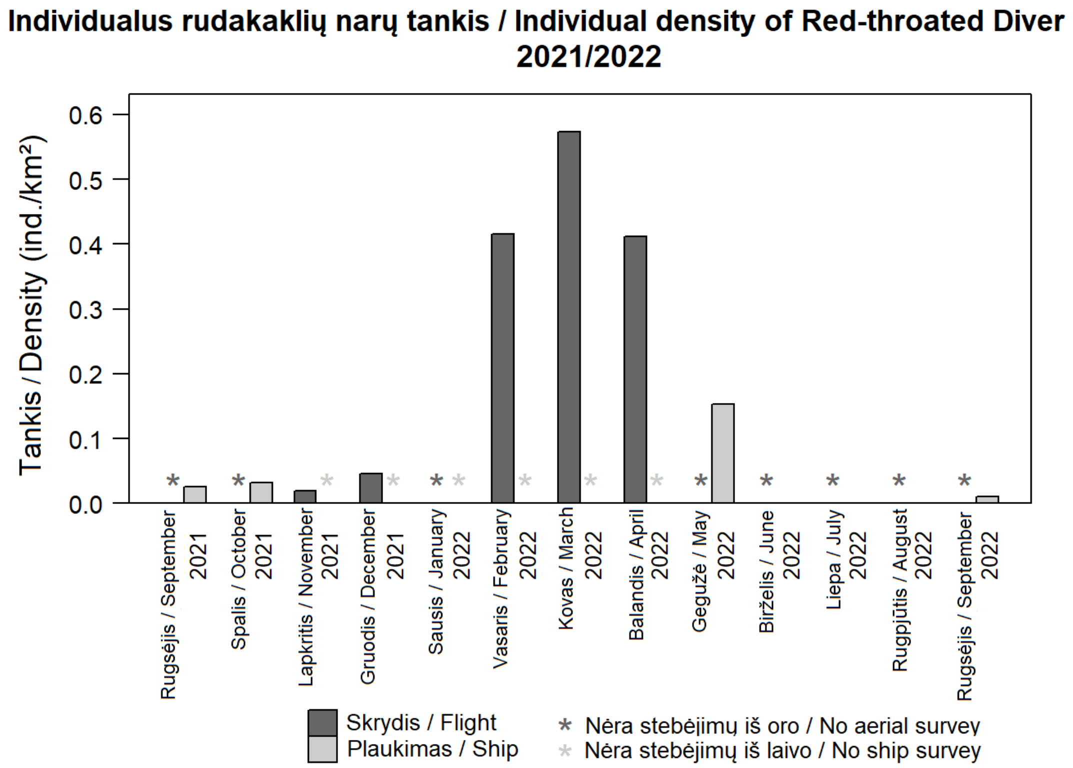


Fig. 4.6.4.29 Monthly densities of Red-throated Divers.

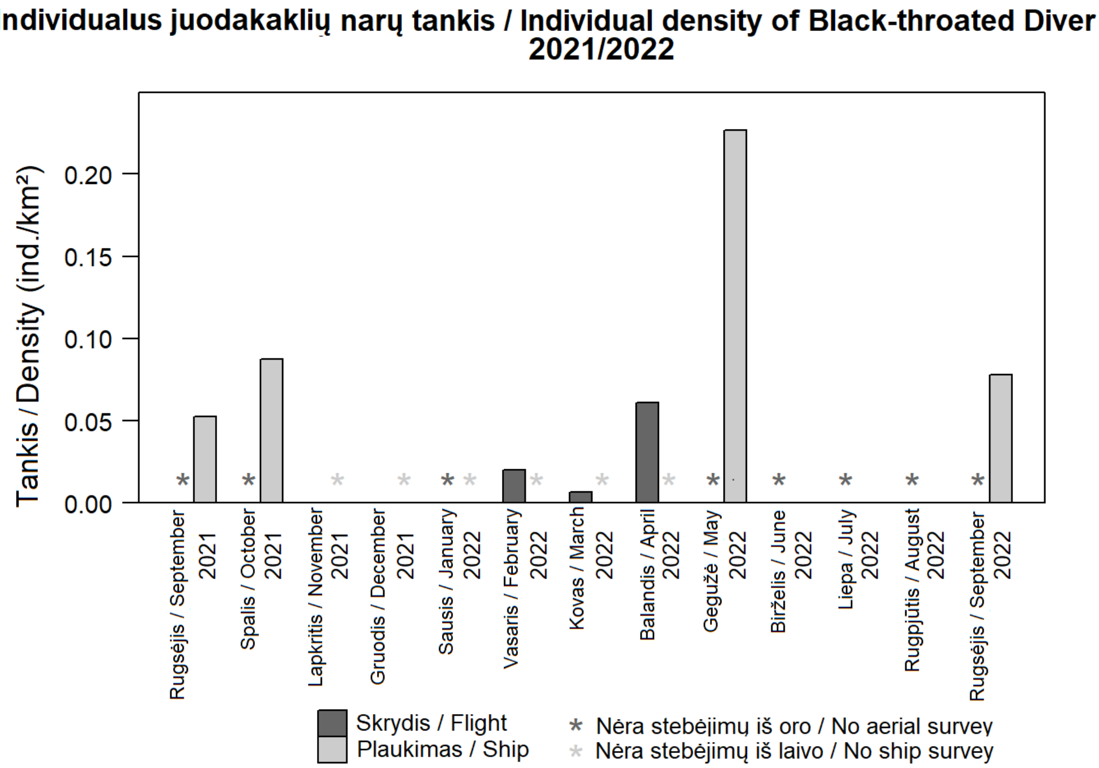


Fig. 4.5.2.4.30 Monthly densities of Black-throated Divers.

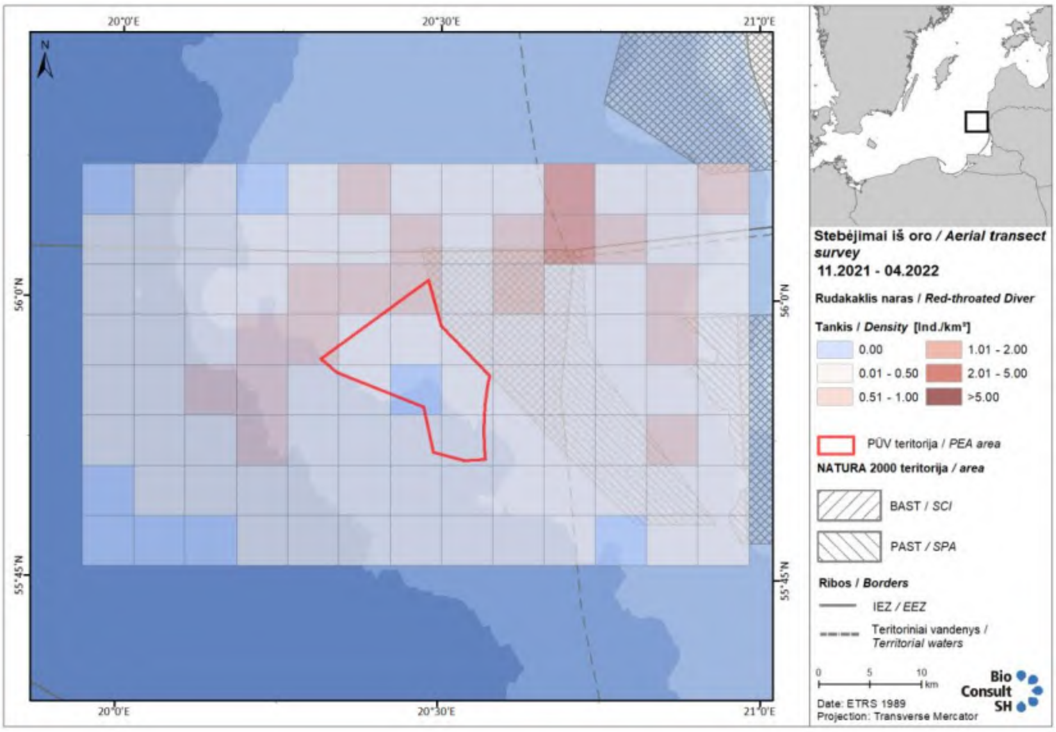


Fig. 4.6.4.31 Distribution of Red-throated Divers.

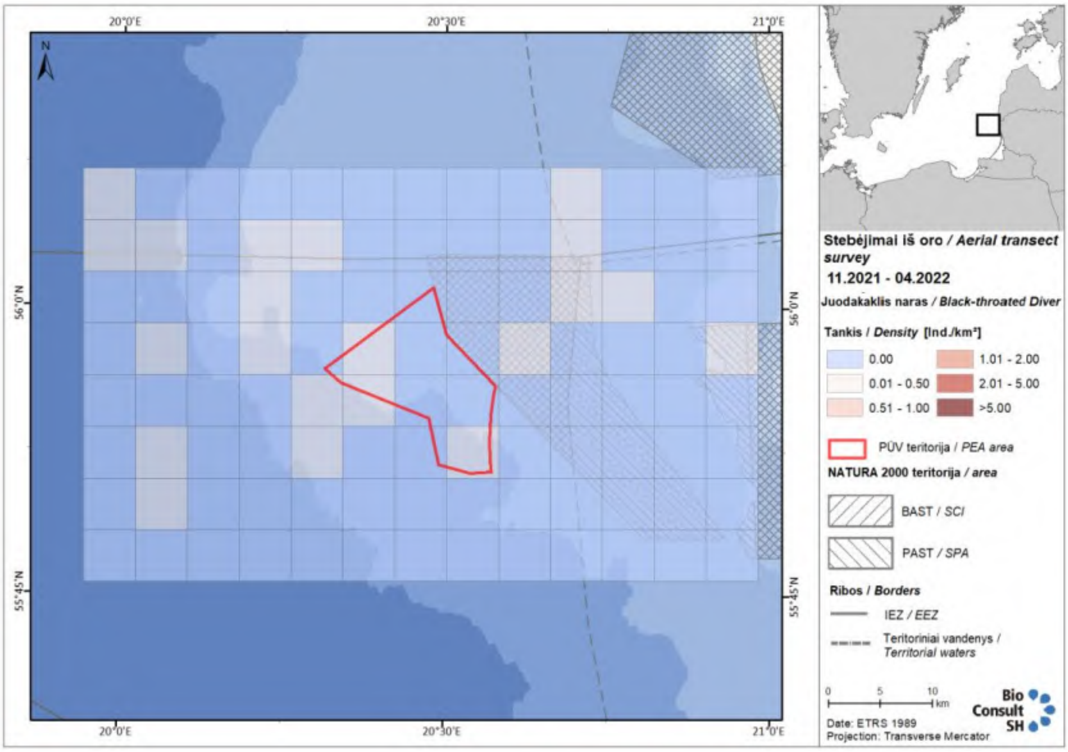


Fig. 4.6.4.32 Distribution of Black-throated Divers.

Passerines. Almost all passerines were observed during the stationary surveys from the ship, with very rare exceptions, when individual birds were observed during the transect ship-based surveys. The largest group recorded was finches - 412 individuals, of which 295 were Eurasian Siskins (*Spinus spinus*), 93 were Common Chaffinches (*Fringilla coelebs*). Tits took the second place in terms of abundance - 161 birds, of which 115 Great Tits (*Parus major*), 41 Eurasian Blue Tits (*Cyanistes caeruleus*). Larks go the third place - 134 birds, of which 131 were Eurasian Skylarks (*Alauda arvensis*) and 3 Woodlarks (*Lullula arborea*). Fig. 4.5.2.4.33 shows abundance distribution of passerines.

The most intense passerine migration was observed in the spring months. The number of passerines observed is very low compared to migration on the mainland where such number of passerines can fly by in less than a minute.

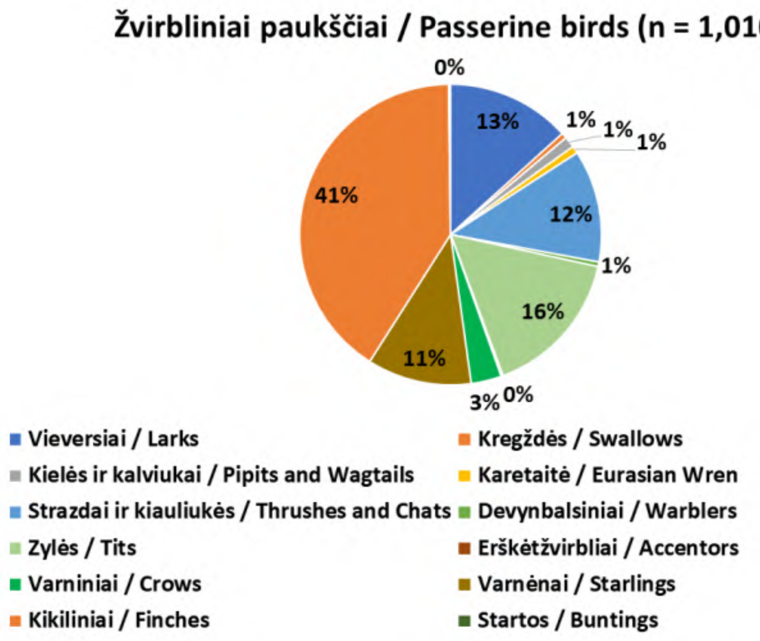


Fig. 4.6.4.33 Abundance distribution of passerines.

The Little Gull. To the east of the researched area, close to the shore of the mainland, "Natura 2000" SPA area "Baltic Sea Coast" is located, which amongst other birds (wintering grounds of the Steller's eider, the Common Goldeneye and the Common Merganser), was established to protect migratory gathering grounds of the Little Gull.

The Little Gull was the most abundant bird species on the ship-based surveys in July and August (Fig. 4.6.4.34). A total of 3,307 birds were recorded in the area covered by transects. During the aerial surveys, only 625 of Little Gulls were observed. The birds were found in almost entire observed area, without any structure and in large numbers. The highest density of 36.1 ind./km² was recorded in July, and the lowest density of 1.51 ind./km² in September 2022. The biggest density was only 1.11 ind./km² in 2021. According to the spatial distribution of the species, Little Gulls more often chose places in the open sea, i.e. to the west of the PEA territory (Fig. 4.6.4.35). Little Gulls were usually observed flying and feeding at heights up to 5 m.

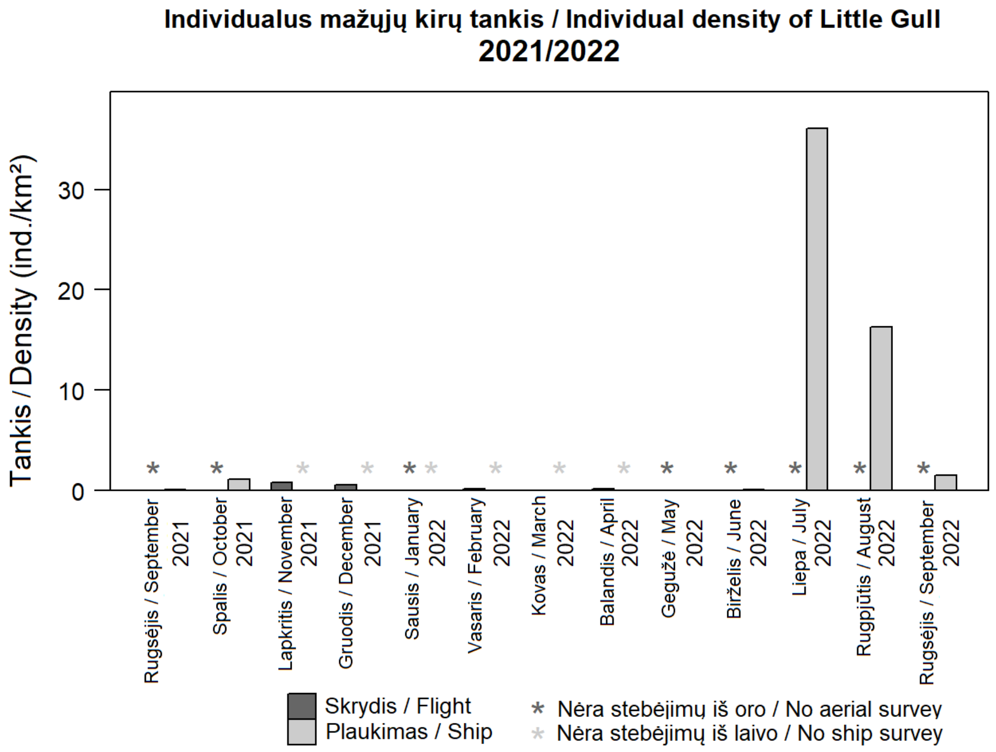


Fig. 4.6.4.34 Monthly densities of Little Gulls.

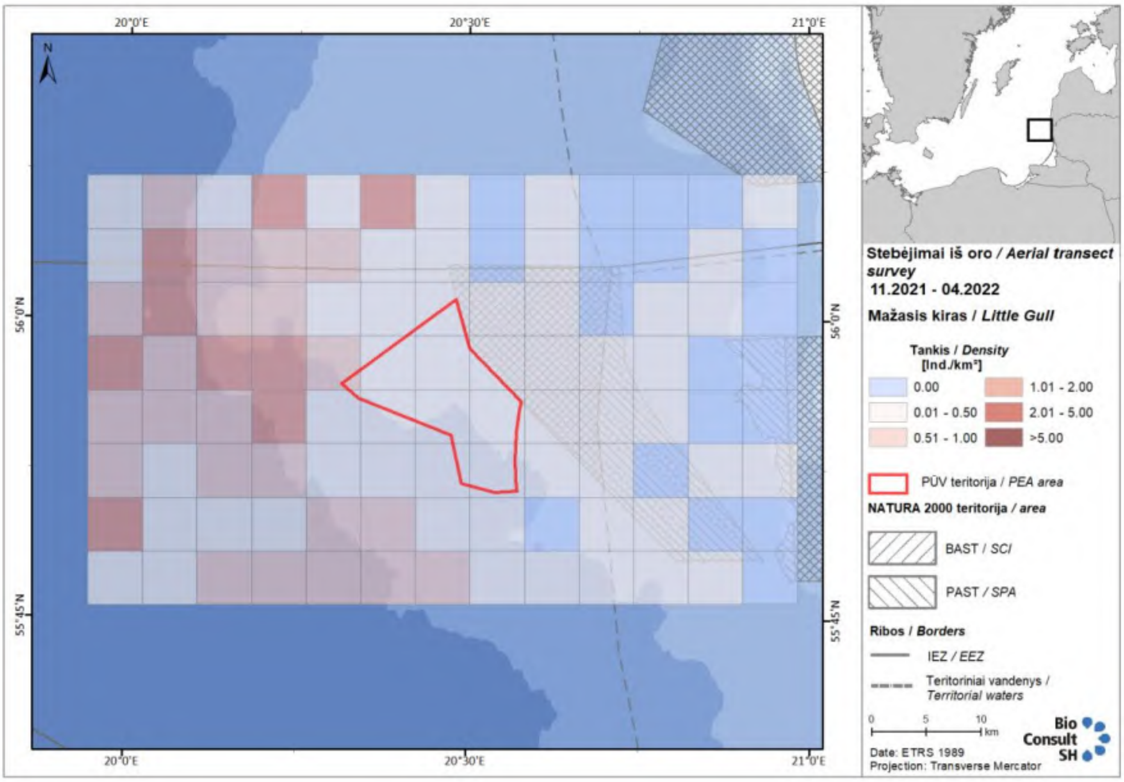


Fig. 4.6.4.35 Distribution of Little Gulls.

4.6.4.2. Bat surveys

Bat migration and overflight intensity registration using an ultrasound detector

Methods. The migrating bat surveys were carried out from the Palanga pier (PALANGA) about 0.3 km from the shore and also from a ship SL TENGIZ about 5-7 km away from the shore at Būtinge (BŪTINGĖ) in autumn (Fig. 4.6.4.36). In the spring, in May, the bat surveys were carried out from the ship that was doing radar surveys of bird migration in the middle of the PEA territory. Ultrasound detector was installed on a ship SL TENGIZ in order to estimate the intensity of bat migration while moving away from the shore, since the ship is on standby and serves the Būtingė oil terminal, it constantly sails at distances of 5-7 km from the shore. Stationary bat detectors SM4BAT FS with U2 microphones were installed on the ship and on the pier of Palanga. The microphone's coverage range was about 50 m, depending on the bat species. The detector was installed on the Palanga pier on July 28, 2022 and on a ship SL TENGIZ on August 18, 2022. All data collected from the Palanga point was used for the analysis, while from the Būtingė point, only those days of collected data were used when the ship would sail or be on standby in open waters (days in port were excluded). The analysis was performed with Kaleidoscope Pro software, and most of the recordings were listened to by researchers for species verification with accuracy of the software's performance.

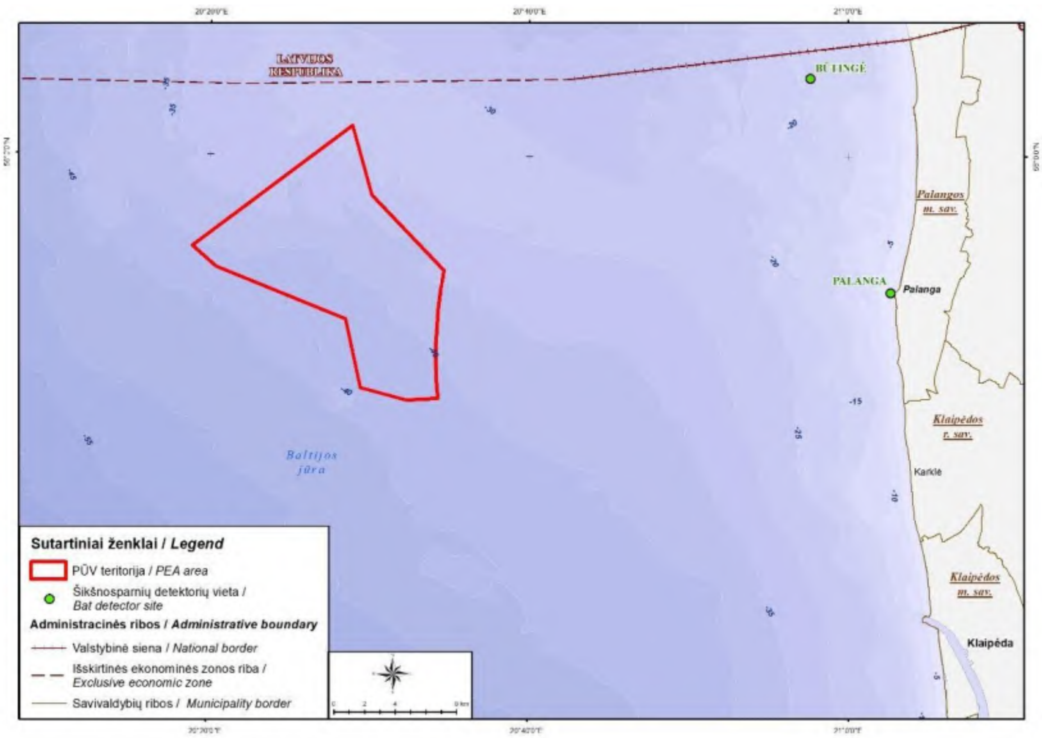


Fig. 4.6.4.36 Location points for bat migration surveys.

Results.

In the spring, there were no ultrasound recordings of bats recorded from the ship that was doing radar surveys of bird migration in the middle of the PEA territory.

During the survey period, 11,838 ultrasound recordings were recorded at the Palanga point, and 515 ultrasound recordings were recorded at the Būtingė point. Ultrasound recordings of 8 bat species were recorded at the Būtingė point and signals of 12 bat species were recorded at Palanga.

There were 22 times more bat recordings made at Palanga compared to Būtingė. In August, the most bat recordings were made at Palanga – 10,581 registrations, while in September, the intensity decreased 10 times and reached only 1,053 registrations. During half of August, there were 427 ultrasound recordings registered in Būtingė, while in September – only 72. Therefore, the trends are similar to those in Palanga. The further the registration point was from the shore, the fewer bats were recorded.

Table 4.6.4.5 Number of registered bat ultrasounds

Location and species	July	August	September	October	Total
BUTINGE	*	**427**	**72**	**16**	**515**
Parti-coloured bat		21	2	1	24
Pond bat		2	4	1	7
Lesser noctule		203	16	4	223
Nathusius's pipistrelle		54	31	5	90
Common noctule		62	10	4	76
Northern bat		10			10
Common pipistrelle		1			1
Serotine bat		61	7	1	69
NoID		13	2		15
PALANGA	**180**	**10,581**	**1,053**	**24**	**11,838**
Parti-coloured bat		323	90		413
Western barbastelle	3	2			5
Pond bat		52	5		57
Lesser noctule	21	2,418	292	7	2,738
Nathusius's pipistrelle	10	996	254	14	1,274
Brown long-eared bat		5			5
Common noctule		541	60		601
Northern bat	107	5,691	303		6,101
Soprano pipistrelle	10	135	13		158
Common pipistrelle	3	35		3	41
Daubenton's bat	23	229	13		265
Serotine bat	3	111	11		125
NoID		43	12		55
Iš viso/ Total	**180**	**11,008**	**1,125**	**40**	**12,353**

The species composition varied between different registration sites. In Palanga, during the migration, the Northern bat dominated, which accounted for more than 52% of all registrations, the Lesser noctule (23%), the Nathusius's pipistrelle (11%) and the Common noctule (5%). In Būtingė, the most abundantt was the Lesser noctule with 43%, the Nathusius's pipistrelle (18%), the Common noctule (15%) and the Serotine bat (13%) (Figs 4.6.4.36 and 4.6.4.37).

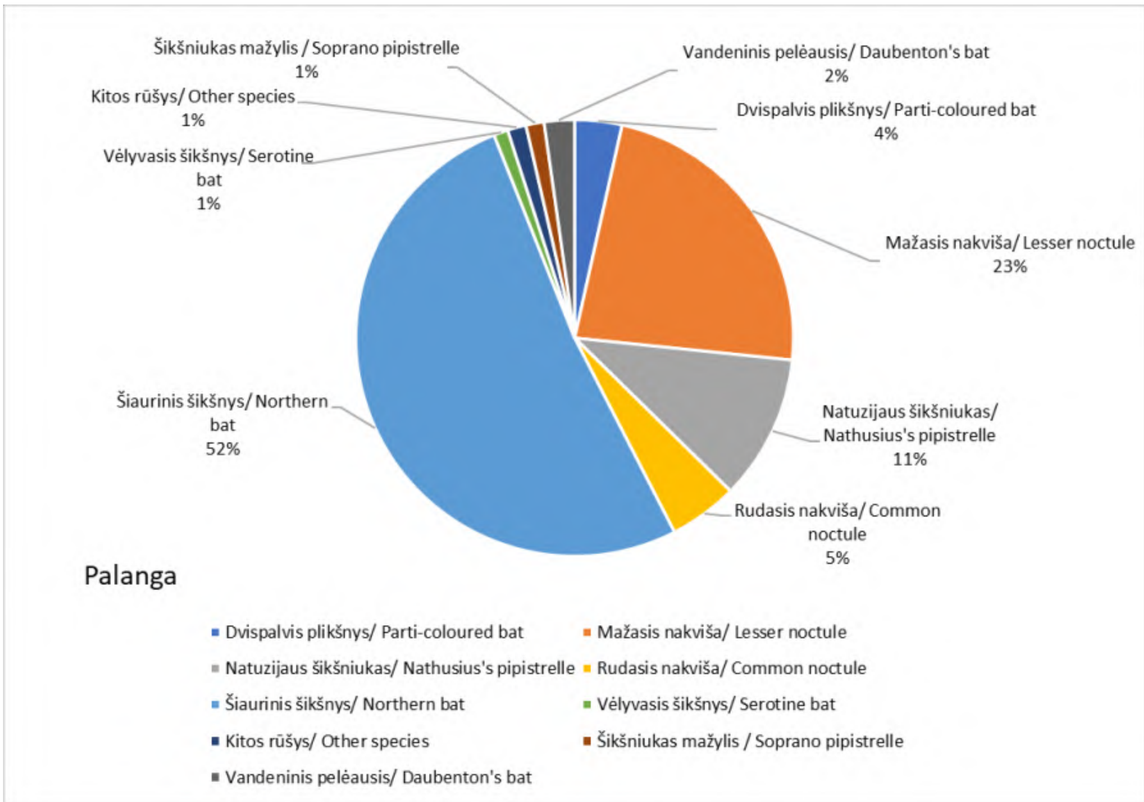


Fig. 4.6.4.37 Species composition at Palanga.

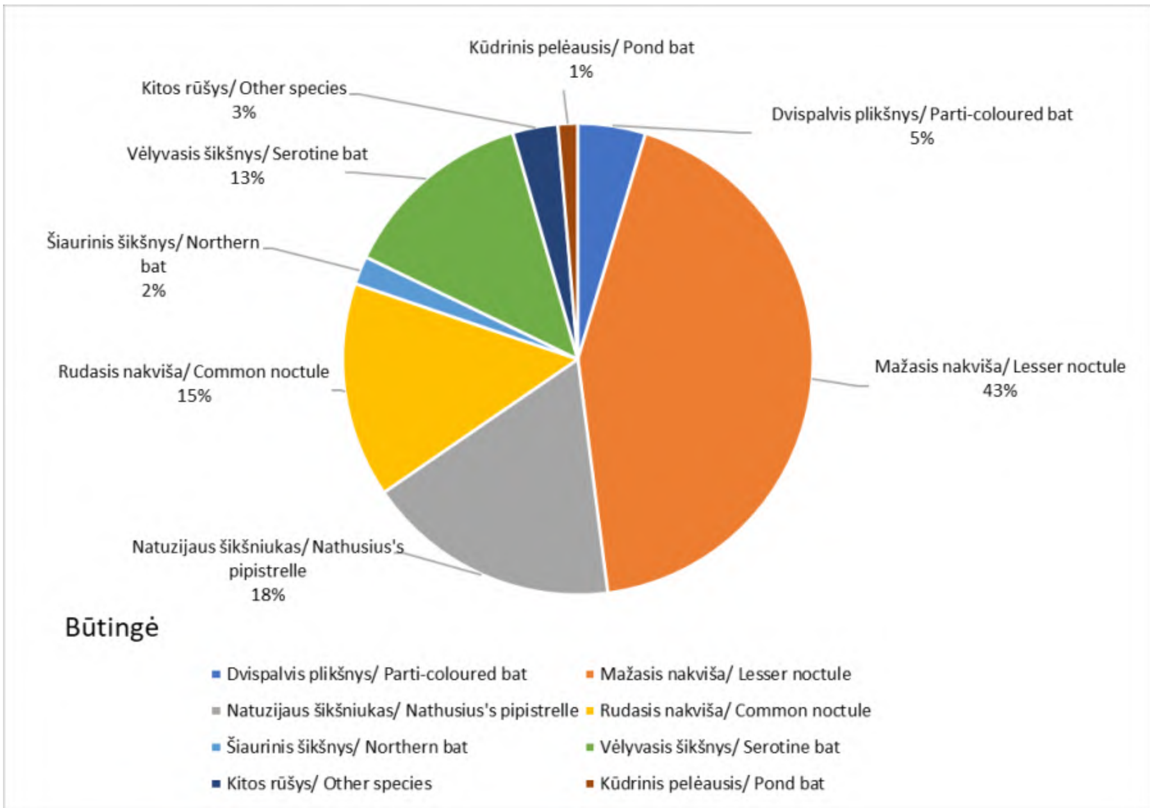


Fig. 4.6.4.38 Species composition at Būtingė.

The peak of bat migration in Palanga was from August 10 to August 29. From 300 up to 1,093 ultrasound registrations were recorded overnight. This indicates intensive migration along the coast and in the close environment over the sea. Meanwhile, at Būtinge, 5-7 km from the shore, the migration decreases significantly and during the peak, maximum number of 138 ultrasound registrations was recorded per night, while during other days, only 23-75 registrations were recorded per night. This corresponds to the recorded intensity of bat migration in the eastern part of Lithuania. The migration of bats is weakly expressed in Būtingė, but the peak of migration, about 2 weeks from the beginning to the middle of August, corresponds to the Palanga period (Fig.s 4.6.4.39 and 4.6.4.40).

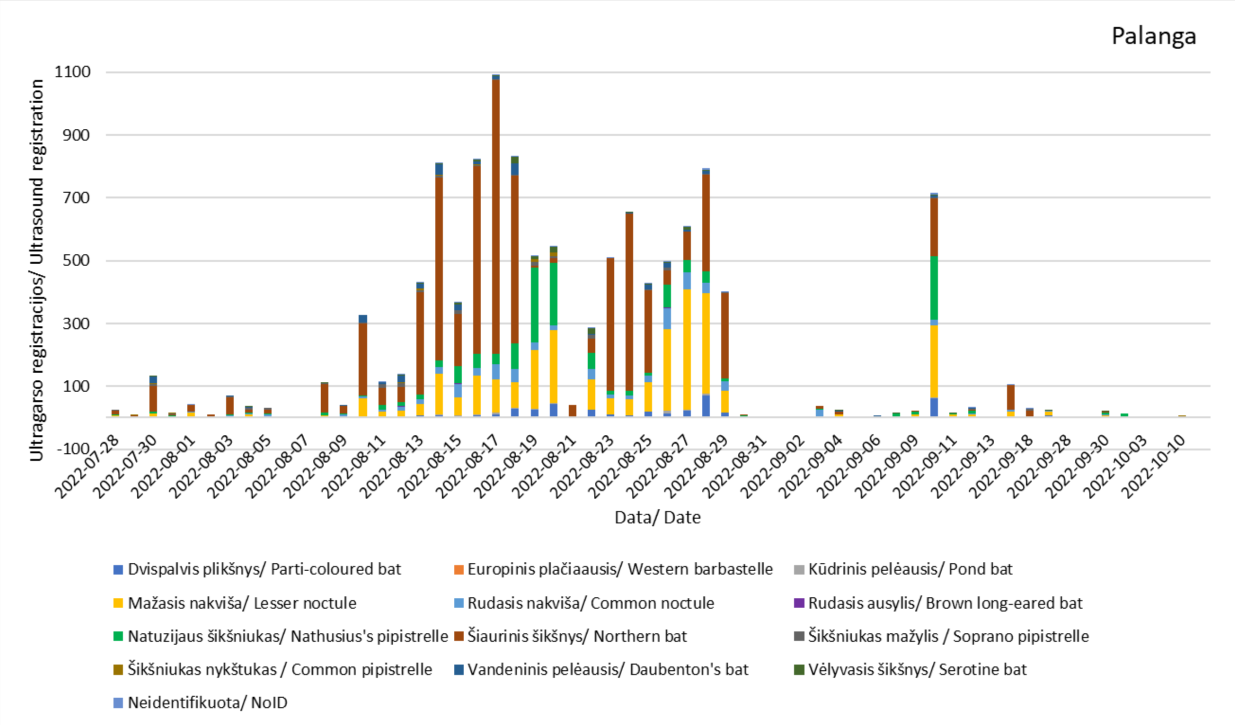


Fig. 4.6.4.39 Phonology of bat migration in Palanga.

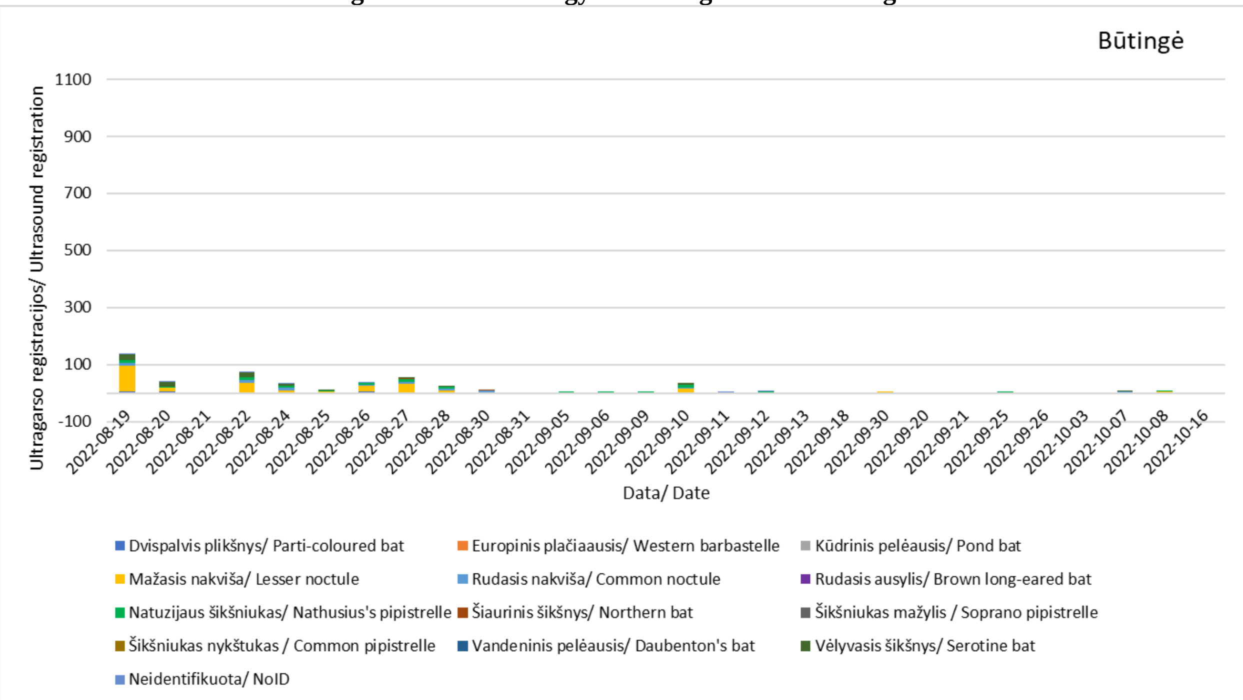


Fig. 4.6.4.40 Phonology of bat migration in Būtingė.

By selecting only the days that coincide between two registration points, the intensity of migration between two different locations was evaluated. If we consider that 100% of bats fly over Palanga, then at Būtinge, this number decreases to an average of 9.6% of the number of bats that flew over Palanga (Fig. 4.6.4.41 and Table 4.6.4.6).

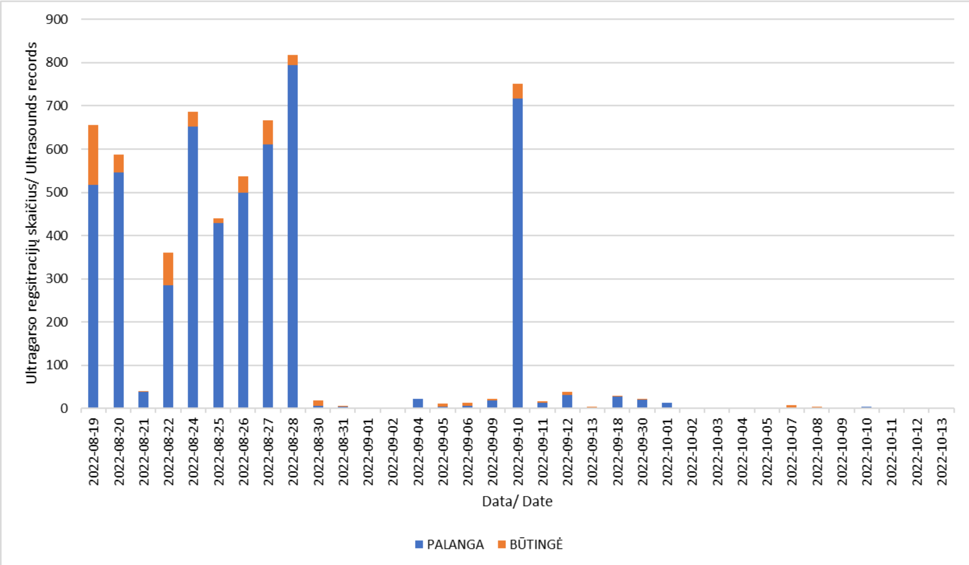


Fig. 4.6.4.41 Bat migration at two recording points when data were recorded on the same nights at different locations.

Table 4.6.4.6 Intensity of bat migration moving away from the coastline (assuming that the Palanga registration site is 100% of the number of ultrasound registrations)

Date	Location		% at Būtingė vs Palanga
	PALANGA	BŪTINGĖ	
2022-08-19	518	138	26,6
2022-08-20	547	40	7,3
2022-08-21	39	1	2,6
2022-08-22	286	75	26,2
2022-08-24	653	33	5,1
2022-08-25	430	10	2,3
2022-08-26	499	38	7,6
2022-08-27	611	56	9,2
2022-08-28	795	23	2,9
2022-08-30	7	11	157,1
2022-08-31	5	2	40,0
2022-09-01	1	0	0,0
2022-09-02	3	0	0,0
2022-09-04	23	0	0,0
2022-09-05	4	7	175,0
2022-09-06	7	7	100,0
2022-09-09	19	4	21,1
2022-09-10	717	34	4,7
2022-09-11	14	3	21,4

Date	Location		% at Būtingė vs Palanga
	PALANGA	BŪTINGĖ	
2022-09-12	32	6	18,8
2022-09-13	2	1	50,0
2022-09-18	28	1	3,6
2022-09-30	20	3	15,0
2022-10-01	14	0	0,0
2022-10-02	0	0	0,0
2022-10-03	1	1	100,0
2022-10-04	0	0	0,0
2022-10-05	0	0	0,0
2022-10-07	0	8	100,0
2022-10-08	0	5	100,0
2022-10-09	0	0	0,0
2022-10-10	5	0	0,0
2022-10-11	0	0	0,0
2022-10-12	0	0	0,0
2022-10-13	1	0	0,0
Total	**5281**	**507**	**9,6**

A very intense migration of bats takes place on the coast close to the shoreline, but when moving away from the shore to the open sea at a distance of about 5-7 km, it decreases very strongly (more than 10 times) and reaches only 9.6% of that registered above the sea near the shore. Therefore, the probability that there will be an intensive migration of bats over the PEA territory is very doubtful and the planned WF will not have an impact on bats.

4.6.4.3. Potential impact on birds and bats

It has been established that wind power plants cause different effects on birds: permanent wintering (and feeding) grounds might be disturbed, migration routes might be affected. As a result, the birds would have to find new feeding grounds, not necessarily of the same quality from which they were displaced, or experience additional energy costs on the migration path necessary to fly around the obstacles that have appeared.

- Direct collision: birds flying in the area of the windmill are at risk of being hit by the blades and killed;
- Displacement: individual bird species strongly avoid sites where WF are built, resulting in loss of habitat or feeding sites;
- Barrier effect: installed WF prevent birds from flying their migration route, therefore they need to fly around the installed WF by flying up or make new routes around it, which requires additional energy costs;
- Scaring: effects occur during the development of WF due to increased shipping, traffic flows, construction works servicing WF, due to these effects, birds are temporarily scared away from their feeding grounds.

Impacts on adjacent protected areas and "Natura 2000" SPA protected bird species.

The borders of the planned marine WF area are planned right next to the "Natura 2000" SPA area, which was established to protect Velvet Scoters, Long-tailed Ducks and Razorbills. These species are sensitive to WF activities due to disturbance and might be forced to avoid the part of the SPA closest to the WF. Effects of displacement and scaring are expected. Therefore, there is high probability that the density of protected bird species in the SPA area may decrease, i.e. birds that use the PEA territory or adjacent SPA areas for feeding will be forced to leave and look for other feeding grounds. Displacement and scaring effects are predicted for sea ducks which feed on benthos, such as Velvet Scoters and Long-tailed Ducks.

The scaring effect for wintering birds is possible due to increase in intensity of ship movement during construction works or regular movement of service personnel by ships or helicopters during operation stage of the WF.

Possible effects on birds and bats.

No significant effects are expected on other wintering, breeding or migrating bird species. Migration through the planned WE park is not intensive both in autumn and spring, and various groups of birds fly through the park. Due to the geographical location, the main migration flow is concentrated along the coast on the mainland, and only a small part of birds are using the open sea to migrate to breeding grounds in the north or wintering areas in the south. The marine WF should not affect migrating cranes, geese, ducks, passerines. It is likely that offshore structures will attract weakened passerines, some of which may be killed by the rotating blades.

During winter, besides sea ducks, the territory is moderately intensively used by Common Guillemots, Razorbills, and various types of gulls. Birds of this group react differently to operating WF, some of them show strong avoidance, others tend to ignore existing WF and continue to feed near WF.

Red-throated and Black-throated Divers are among the most sensitive species that respond strongly to WF by avoiding areas where WF operate: displacement from habitat is recorded more than 5 km from WF. In the analyzed case, the location of the PEA territory is not important for these species and does not stand out from the surrounding other areas, so even if this area would be lost from the feeding grounds by divers, the birds could find enough suitable and ecologically similar habitats in other parts of the Baltic Sea. No significant impact is expected in this aspect.

No impact on bats is expected, as the intensity of bat migration decreases significantly when moving away from the shore. The conducted surveys showed that very intensive migration takes place up to 300 m from the shore at Palanga, above the Palanga pier, but just 5-7 km out to the open sea in Būtingė, less than 10% of the intensity of bat migration was recorded compared to Palanga. In Būtingė (at a distance of 5-7 km from the shore), the intensity of migration was very low and did not even reach the intensity of migration recorded in eastern parts of Lithuania. Based on the data, it is likely that bat migration does not take place in the PEA territory, 20-30 km from the coast, and it can only be reached by single individuals flying aimlessly.

Possible impact of the marine WF on bird migrations through Lithuanian waters of the Baltic Sea.

The planned WF park might have a minimal impact on bird species that migrate over the sea, which will require birds to change their migration routes or fly around the WF, also there is a possibility of death due to direct contact with the WF blades.

From the conducted surveys, it was established that daytime migration in autumn is most intense at altitudes up to 300 m. Most birds fly up to 100 m (60% of migrants), about 25% of birds fly between 100 and 200 m, and about 9% of migratory birds fly between 200 and 300 m.

During diurnal spring migrations, unlike autumn, most birds fly at altitudes up to 400 m: more than 50% of all birds fly at altitudes up to 100 m, about 11% of birds fly from 100 to 200 m, 10% fly from 200 to 300 m and 8% of birds from 300 to 400 m.

During nocturnal migration in autumn, birds fly in higher altitudes. Most of them fly in two zones - up to 200 m and from 300 to 1000 m. Most fly at heights up to 200 m - about 50% of birds, the rest are distributed between 300-1000 m.

Nocturnal migration in spring is more or less even and birds fly over in a very wide range of altitudes. About 20% of birds fly at heights up to 200 m, and 26% of birds fly between 200 and 400 m, respectively 8-14% of birds fly at other heights.

Overall, comparing spring and autumn migrations, the majority of migrants fly at altitudes up to 400 m, therefore, the higher the height of planned WF, the higher probability of birds encountering with WF, as larger flow of them passes through the area of windmill.

Possible total impact of different activities carried out and/or planned in the analyzed area and in the adjacencies (such as fishing, shipping) on biodiversity.

Seabirds are negatively affected by several anthropogenic activities: fishing, plastic pollution, shipping, as well as the effects of invasive species.

Fishing is an anthropogenic activity that has a strong negative impact on seabirds: every year, from 1,000 to 3,000 seabirds are killed on the coasts of Lithuania during coastal fishing (Morkūnas et al. 2022). Most of birds die in winter months when they get caught in fishing gillnets.

Recent studies of dead birds obtained from fishing nets have shown that Long-tailed Ducks and Red-throated Divers had variety of debris in their stomach. Long-tailed Ducks were the most affected species, of which 5% of individuals had plastic and metal debris in their stomach (Morkūnas et al. 2021).

Intensive shipping and constant presence of ships in the area disturbs seabirds, birds avoid feeding near shipping lanes. Passing ships scare feeding sea ducks, divers and auks. During the construction of the WF and its subsequent maintenance, there will be lots of ships in the area and it will increase the disturbance of birds around the planned WF.

Due to the impact of invasive species on seabed habitats, ecosystems are being changed, and coastal mollusc (mussel) communities are being eaten by the Round goby (*Neogobius melanostomus*), therefore Long-tailed Ducks are losing optimal coastal wintering sites. Long-tailed Ducks try to adapt and change their food sources, they start catching fish (Skabeikis et al. 2019, Forni et al. 2022).

These effects mentioned above are not new and birds partially adapt to them by changing their wintering grounds, diet or behavior, but that requires additional energy resources. Therefore, the planned marine WF may have a cumulative effect with other activities already carried out in the marine area. This effect may be greater for sea ducks which feed on benthos, such as Velvet Scoters and Long-tailed Ducks. No cumulative effects are expected for other species.

Impact on birds due to potential hydrological regime, electromagnetic fields, underwater noise and other negative effects caused by WF and cable connections.

No impacts on birds and bats are foreseen due to changes in the hydrological regime or electromagnetic fields. In the PEA territory, the installation of the foundations and the construction of the cables linking the WF may result in the destruction of a small part of the benthic habitats used by birds for feeding. Noise from underwater pile driving may have an impact on diving birds and it is therefore recommended that the piles would not be driven from December to March, thus avoiding negative impacts on wintering birds. If pile driving is required during bird wintering season, underwater noise mitigation measures should be applied (see section 4.3)

Potential cumulative transboundary impacts.

On the Latvian side, a marine park is planned for the Latvian side of the WF, so the cumulative impact could be similar to that identified for this park. At present, there is insufficient data to assess the wintering sites of seabirds on the Latvian side, so it is difficult to assess the impacts on wintering birds.

In terms of migration, the planned WP on the Lithuanian side and the planned WP on the Latvian side are not expected to have significant cumulative impacts on migratory birds. Benthic-feeding species, which are habitat dependent, are likely to be the most affected, and therefore impacts may be significant for Velvet Scoters if similar numbers of Velvet Scoters are wintering on the Latvian side as in Lithuania.

4.6.4.4. Impact reduction and compensatory measures during the construction and operation of the park

During the wintering season, the largest number of velvet scoters is recorded from mid-November to mid-March. The highest density of velvet scoters is registered in December-February, when it reaches from 7.25 to 9.21 ind./km^2. Long-tailed ducks are most abundant from the beginning of December to the end of March. The most numerous long-tailed ducks are observed in February, when their density reaches 2.76 ind/km^2. Razorbils are most frequently registered in March. Therefore, the sensitive period for seabirds is from November till the end of March, i.e. 5 months.

After carrying out an assessment based on individual bird species, the strongest effect was found to be the effect of displacement from the territory. This effect is most likely to occur in wintering seabirds. The impact can be recorded up to 2 km away from installed operating WTs.

The studies of the bottom habitats carried out during the EIA (see section 4.6.2.) made it possible to identify the most valuable areas of the bottom, which are important for the feeding of birds in the territory of the PEA - this is a stretch at the northeastern border of the PEA territory, which in some places reaches up to ~ 2 km.

Taking into account the fact that the WE park borders the Natura 2000 SPA and in order to reduce the possible negative impact on the Natura 2000 area (due to displacement effects) and the bird species protected in it, two mitigation scenarios were evaluated:

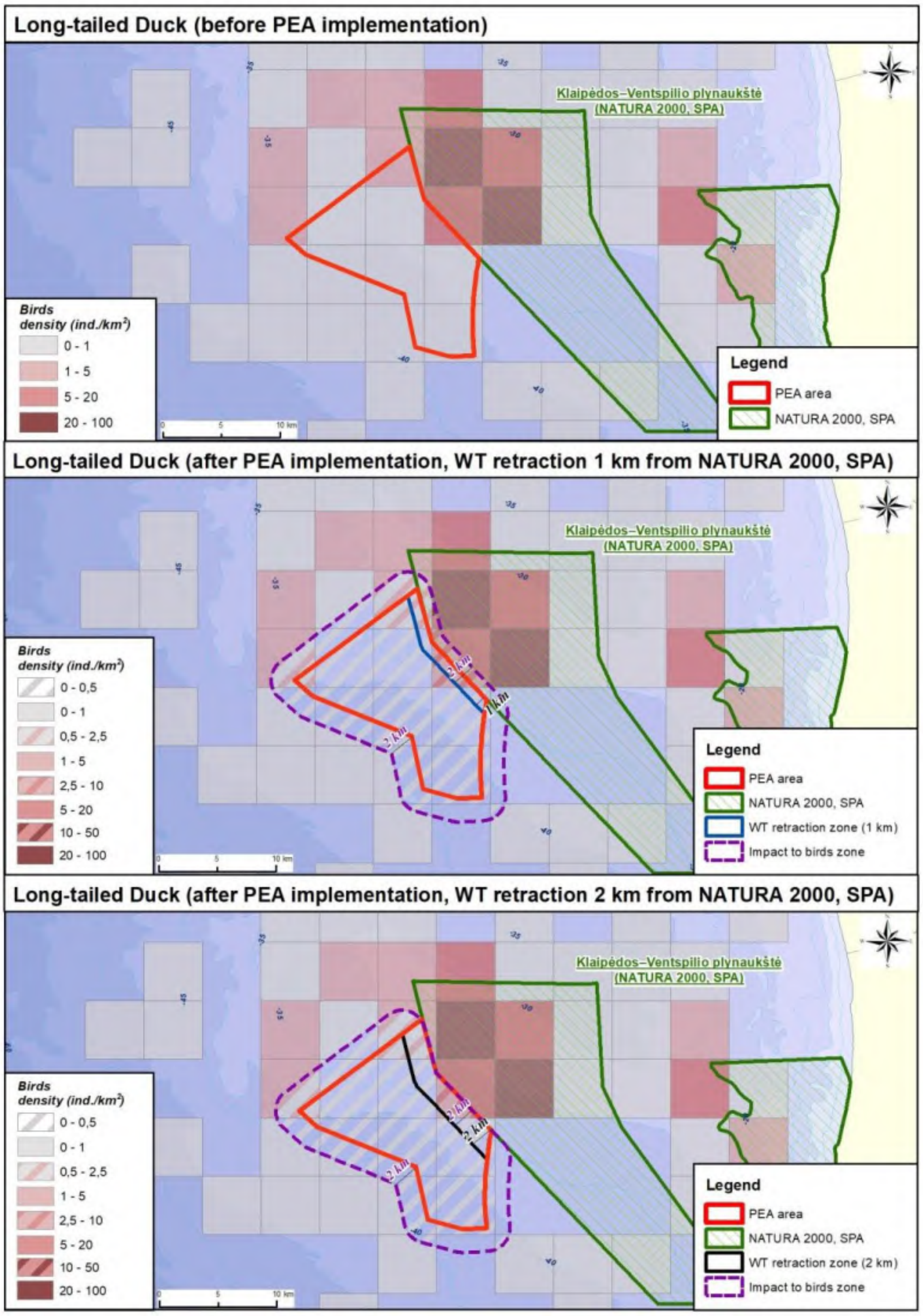
1st, when VTs are built no closer than 1 km from the northwestern boundary of the Natura 2000 area;

2nd, when VTs are built no closer than 2 km from the northwestern boundary of the Natura 2000 area.

Long-tailed duck is the focus species of the protected area, which has been most recorded in the northwestern part of the Natura 2000 site. Only a small number of sea ducks are registered in the territory of the planned VE park, i.e. the maximum flow ranged from 2-20 to 20-100 individuals per 1 km^2.

Scenario 1. If the WT installation sites are moved 1 km away from the boundary of the protected area, the impact (scaring/displacement) on bird species protected in the "Natura 2000" area can be recorded up to 1 km within the boundaries of the "Natura 2000" SPA area (Fig. 4.6.4.42). Birds will avoid using the area close to the planned WTs; it is predicted that their density will decrease by about 50% within a distance of 1 km from the WT in the protected area. There is a possibility that about 800-1500 long-tailed ducks will be displaced due to the operation of the WE park (based on the bird density data recorded during the surveys conducted in the area).

2nd scenario. WT installation sites are set aside at a distance of 2 km from the border of the protected area. In this case, the impact of displacement on long-tailed ducks is predicted to be minimal and there will be no impact on the Natura 2000 SPA, i.e. birds should not avoid feeding within the protected area.



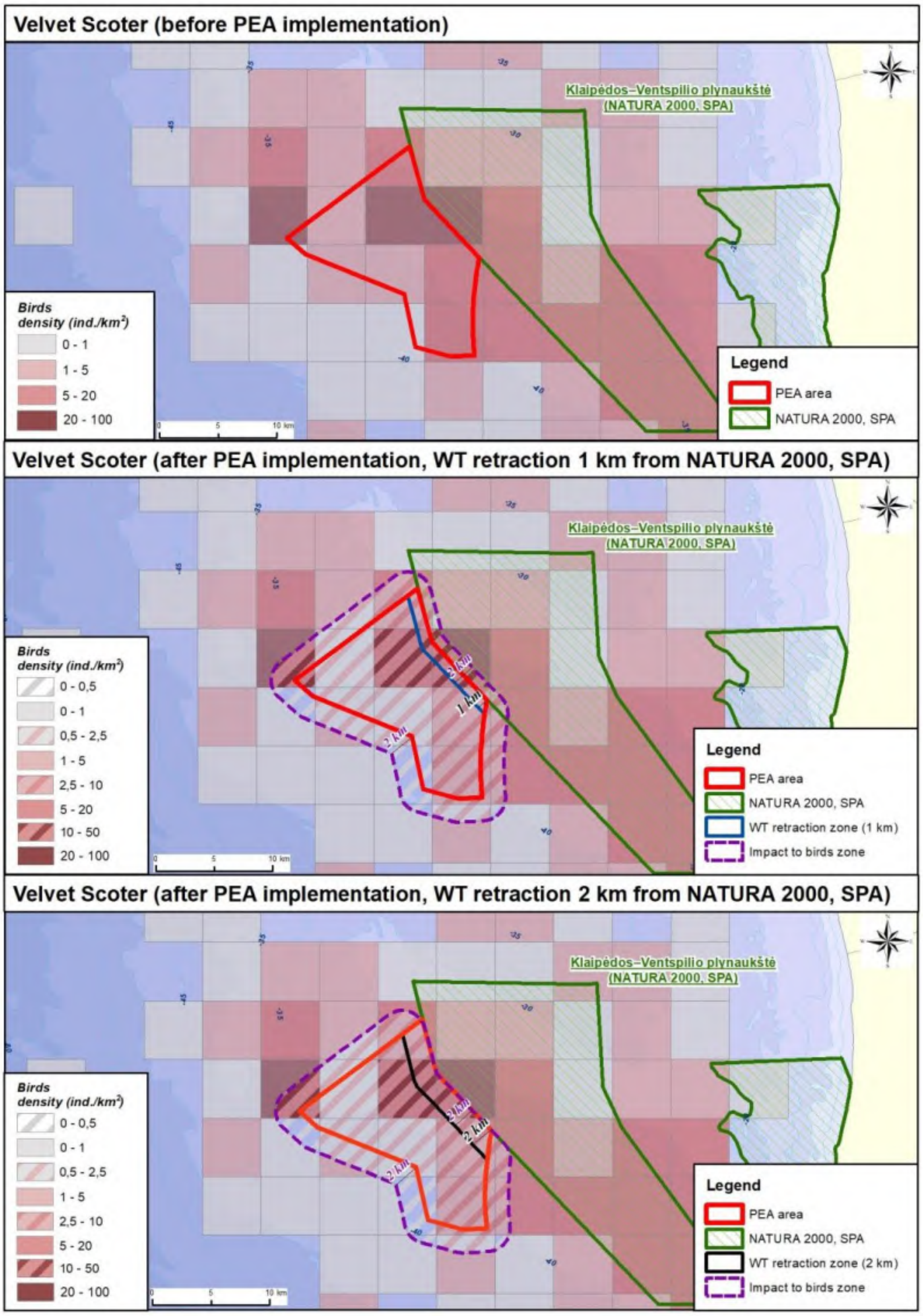
4.6.4.42 pav. Long-tailed duck density before and after mitigation measures applied.

Velvet scoter is the focus species of the protected area. Velvet scoters were abundantly recorded both in the part of the PEA area and in the southern and western edge of the protected area, where the density of birds reached from 20 to 100 individuals per 1 km^2.

Scenario 1. If the WT installation sites are moved 1 km away from the border of the protected area, the effect on Natura 2000 SPA is recorded up to 1 km deep into protected territory (Figure 4.6.4.43). Birds will avoid using the area close to the planned WTs, it is predicted that their density will decrease by about 50%

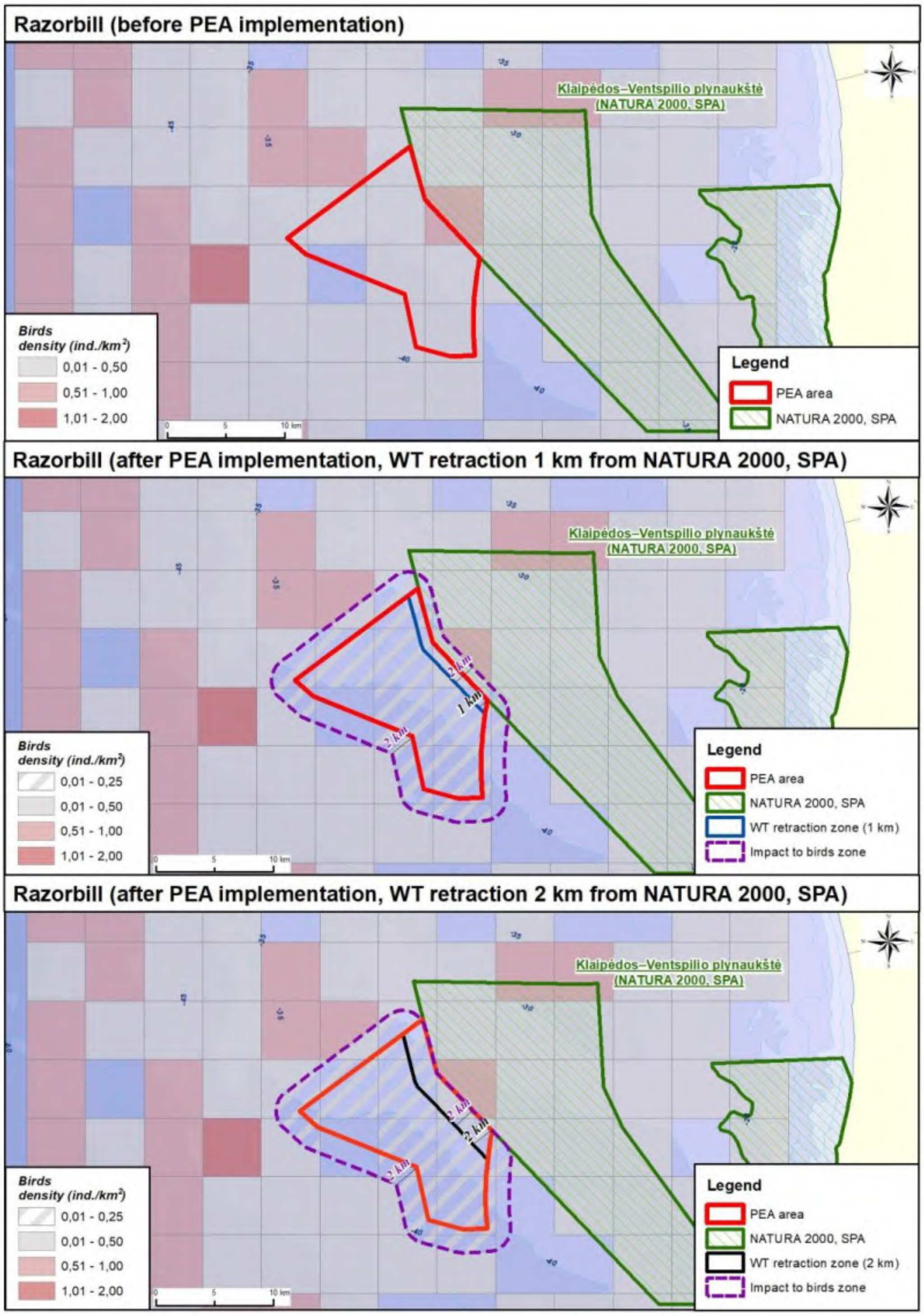
within 1 km of the planned WTs in the protected area. There is a possibility that about 500-1500 birds will be displaced as a result of the operation of the WE park (based on the bird density data recorded during the surveys conducted in the area).

2nd scenario. WT installation sites are set aside at a distance of 2 km from the border of the protected area. In this case, the impact of displacement on the sediments is predicted to be minimal and there will be no impact on Natura 2000 SPA, i.e. birds should not avoid feeding within the protected area.



4.6.4.43 pav. Velvet scoter density before and after mitigation measures applied.

Razorbill is a focus species of the protected area. Razorbills were not abundantly observed both in the territory of the planned WE park and in the protected "Natura 2000" territory beyond its boundary. The maximum density was only up to 1 ind. km^2. Therefore, if the WT is withdrawn at least 1 km from the border of the protected area, the impact on this species will be insignificant (Figure 4.6.4.44).



4.6.4.44 pav. Razorbill density before and after mitigation measures applied.

Retracting WT sites (restriction does not apply to bottom infrastructure and transformer substation) from the protected area will reduce the impact on long-tailed ducks, velvet scoetrs and razorbills due to possible displacement and scaring: further plants will not scare the birds and they will be able to use most of the protected area with minimum densities losses during the winter.

It is predicted that the retraction of WT installation sites at a distance of 2 km from the border of the protected area is an effective measure that allows minimizing the impact of displacement from wintering grounds on all protected bird species: in this case, the planned WE park would not have a significant negative impact on the "Natura 2000" territory.

It is predicted that moving the WT installation sites to a distance of 1 km from the border of the protected area is sufficient for the protection of razorbills, but will only partially reduce the impact on velvet scoters and long-tailed ducks.

In order to reduce the impact on wintering birds, it is recommended that WT installation works - the installation of foundation piles - be carried out outside the wintering period of seabirds, i.e. from April to October. If it is technologically not possible to drive piles in the warm season, noise mitigation measures should be used (see underwater noise - section 4.3): used air bubble curtains around pile driving locations help absorb the sound emitted during pile driving.

During the construction phase, if the works will be carried out during the wintering of birds (December-March), in order to reduce the impact on birds wintering in the protected areas, the routes of the vessels installing the WE park should be chosen avoiding Natura 2000 SPA territories.

If aviation regulations do not conflict with WT lighting, green light lamps should be used. This reduces the attraction of potential migratory birds to the territory of the WE park and reduces the risk of their death due to WT operation.

Compensatory measures

The Marine WF could have significant negative impacts on sea ducks and other bird species. Adverse impacts on seabirds are also possible due to the cumulative effects of the planned WF and other offshore activities. In order to reduce the cumulative impacts on seabirds, offsetting the negative impacts of other activities is encouraged, such as mitigation in fisheries by reducing seabird bycatches. Seabird bycatch reduction is achieved through the selection of safer fishing gear, financial contributions to the implementation of safer fishing measures for seabirds, funding for safer fishing, and temporary cessation of fishing.

Another compensatory measure is introduction of conservation measures in protected areas and funding of scientific research in seabird wintering and breeding grounds.

Preventive measures

It is recommended to carry out monitoring of birds and bats during the construction and 3 years after the construction. Thereafter, monitoring shall be repeated every 5 years for a period of 2 years. If a negative impact more significant than provided for during EIA is detected, to assume additional measures to minimize the impact, such as temporary shut-down of part of WTs for the most intensive period of bird migration in autumn or spring and/or wintering (the number and site of WTs to be shut down will be verified based on monitoring results). The impact (scaring away of the protected area) is to be considered significant when the abundance of birds protected in the "Natura 2000" IBPA area, i.e. the number and/or density of protected bird species individuals in the monitored area, reduces by more than 20% from the natural long-term (10 year) population fluctuation.

Table 4.6.4.7 Summary table of effects on birds (no effects on bats have been identified, therefore bats are not considered)

Stages	Impact	Nature	Scale	Duration	Significance	Impact mitigation measures
Construction	Work noise	Negative direct effects - scaring of birds	Local (within the WF and surrounding areas)	Short-term (only available during installation works)	Potential minor effects - temporary fluctuations in bird abundance	The noisiest work (pile driving) in the area should not be carried out between December and March, and underwater sound attenuation equipment should be used when driving piles.
	Physical destruction of benthic habitats	Negligible effects due to possible reduced abundance of food	Local (within the WF)	Short-term (only available during installation works)	Negligible impact - only a small area destroyed compared to potential feeding areas	Not applicable
	Increased vessel movements and noise	Negative direct effects - scaring of birds	Local (within the WF and surrounding protected area)	Short-term (only available during installation works)	Negligible effects - temporary fluctuations in bird abundance	Not applicable
Maintenance	Movements and noise from surveillance vessels	Negative direct effects - scaring of birds	Local (within the WF and surrounding areas)	Short-term (only available during vessel presence)	Negligible impact - instantaneous reductions in animal abundance may be limited to shipping lanes and their vicinity	Choosing shipping lanes while avoiding the Natura 2000 sites
	Displacement from habitat	Negative direct impact - reduction in abundance due to avoidance of wind farms, resulting in loss of part of the feeding habitat	Local (within and adjacent to the WF, including protected areas)	Long-term (lasting until the end of the lifetime of WF)	Potentially significant impacts - sea ducks will avoid the WF and feeding grounds will be lost.	Move the nearest WT away from the "Natura 2000" IBPA Klaipėda-Ventspils plateau border at a distance of 1 km (applying of part of the WT shutdown during bird wintering) or 2 km (without applying WT activity restrictions)
	Direct collision	Negative direct impacts - bird collision with wind farms	Local (within the WF)	Long-term (lasting until the end of the lifetime of WF)	Possible minor impact - low mortality of birds will not affect the state of the populations	At night, where aviation safety requirements allow, we recommend the use of green light sources.

Stages	Impact	Nature	Scale	Duration	Significance	Impact mitigation measures
Disassembly	Scaring	Negative direct temporary effects on bird dispersal due to the movement of service personnel by boat or helicopter within the WF area	Local (within the WF and surrounding areas)	Short-term	Potential minor effect - scaring sea ducks away from feeding grounds during their wintering period.	Servicing the WF by sailing outside the Natura 2000 area during winter
	Barrier effect	Negative direct impact on bird migration due to the additional energy costs of flying around obstacles	Local (within the WF)	Long-term (lasting until the end of the lifetime of WF)	Potentially low significant effects - low impact on bird migration	There are no measures
	Occurrence of secondary habitats	Positive indirect effects due to the potential increased abundance of food	Local (within the WF)	Long-term (lasting until the end of the lifetime of WF)	Positive impact	Not applicable
	Work noise	Negative direct effect - deterrence	Local (within the WF and surrounding areas)	Short-term (only available during installation works)	Potential minor effects - temporary fluctuations in bird abundance	The noisiest work (pile driving) in the area should not take place between December and March. Alternatively, use sound attenuation equipment when piling
	Destruction of secondary habitats	Negative indirect effects due to possible reduction in the number of food and feeding sites	Local (separate towers)	Long-term	Negligible impact, no impact on the extent of natural habitats	Not applicable
	Increased vessel movements and noise	Negative direct effect - deterrence of birds	Local (within the WF and surrounding areas)	Short-term (only available during installation works)	Negligible impact - bird abundance will recover after completion of works	Choosing shipping lanes while avoiding the Natura 2000 sites

- positive impact;
- impact is insignificant: not to be taken into account, no measures are applicable;
- impact is not significant: decisions during design, preventive measures;
- medium impact: addressed by mitigation measures.

4.6.5. Marine mammals

4.6.5.1. The current situation

Seals

Three species of seals inhabit and breed in the Baltic Sea: grey seal (*Halichoerus grypus macrorhynchus*), ringed seal (*Phoca hispida botnica*) and Atlantic harbour seal (*Phoca vitulina vitilina*). Only one species is included in the list of Lithuanian fauna - a grey seal. This animal species is also included in the Red Book of Lithuania. The other two species are not mentioned in the Lithuanian list of animals, although cases of their presence in Lithuanian territorial waters have been fixed.

These mammals rest and breed on remote rocky islands far-off from human activities, sandy beaches, ice, and buoys (Thompson & Härkönen, 2008). In the last century, in the Baltic Sea, seals used to come to the shores of Lithuania constantly, but only a few individuals per year were observed. Since 2000, grey seals have become a more common phenomenon in Lithuania, however, they are not permanent inhabitants of Lithuanian waters (Natkevičiūtė, Kulikov, & Grušas, 2013). Although smooth, sandy, island- and stone-free as well as densely populated Lithuanian coast is not suitable for seals (Survilienė 2020). In the territorial sea of Lithuania, seals are found on a regular basis; they are usually registered during the cold season and arrive together with migrating fish; however, the exact number of animals is not known.

Porpoises

The Baltic waters are home to two different populations of harbour porpoises. One reproduces in the waters of Belt, Sound, Kattegat, and Skagerrak. Another population is found near the coasts of Germany, Poland and eastern Sweden, in the central part. Animals are characterised by seasonal migration — in winter they retreat farther south. Most often dive at a depth of 20-60 m, but also can dive to a depth of 200 m. They feed most often at night, and feeding places depend on prey migrations (Natkevičiūtė, Kulikov, Grušas, 2013). Lithuanian marine waters do not fall among the areas important for the nutrition of porpoises (Carlén, 2018).

The abundance of porpoises in the Baltic Sea was researched in 2011-2012 during the international LIFE SAMBAH project when conducting static acoustic observations of the Baltic porpoises. Nine of the 300 detectors capable of recognising and recording the sounds emitted by the porpoises were placed in Lithuanian waters. Two detectors recorded the presence of these animals in Lithuanian waters. Still, the probability of detecting them remains low compared to the main places of their habitation in the southwestern part of the Baltic Sea. Only in February and only in part of LIEZ, the simulated probability of detection was 20 % (Carlén, 2018). Until then, only a few cases of observation of porpoises were recorded in Lithuania: 2 individuals were found drowned in fishermen's nets in different years (Natkevičiūtė, Kulikov, Grušas, 2013; Bacevičius, 2014). According to the LIFE SAMBAH project, Lithuanian marine waters do not fall among the areas important for the nutrition of porpoises, and the probability of detecting porpoises in different seasons of the year varies. According to Carlen et al., in 2018, the highest average probability of detecting porpoises in the PEA area during the winter season was up to 11 %, and the lowest in the summer season was up to 5 %. The abundance of porpoises and the probability of detection in Lithuanian waters is low compared to other areas in the Baltic Sea, however, the simulated probabilities of detecting porpoises in the PEA area in different seasons of the year are presented in Figures 4.6.5.1 - 4.6.5.4

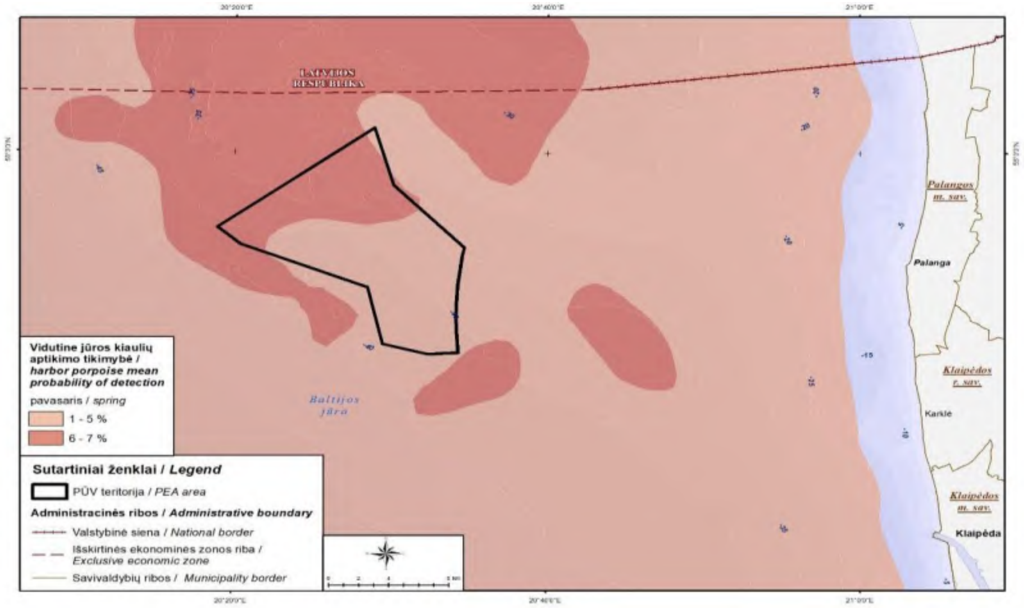


Fig. 4.6.5.1 The average probability of detection of porpoises in the spring season (according to Carlen et. al. 2018)

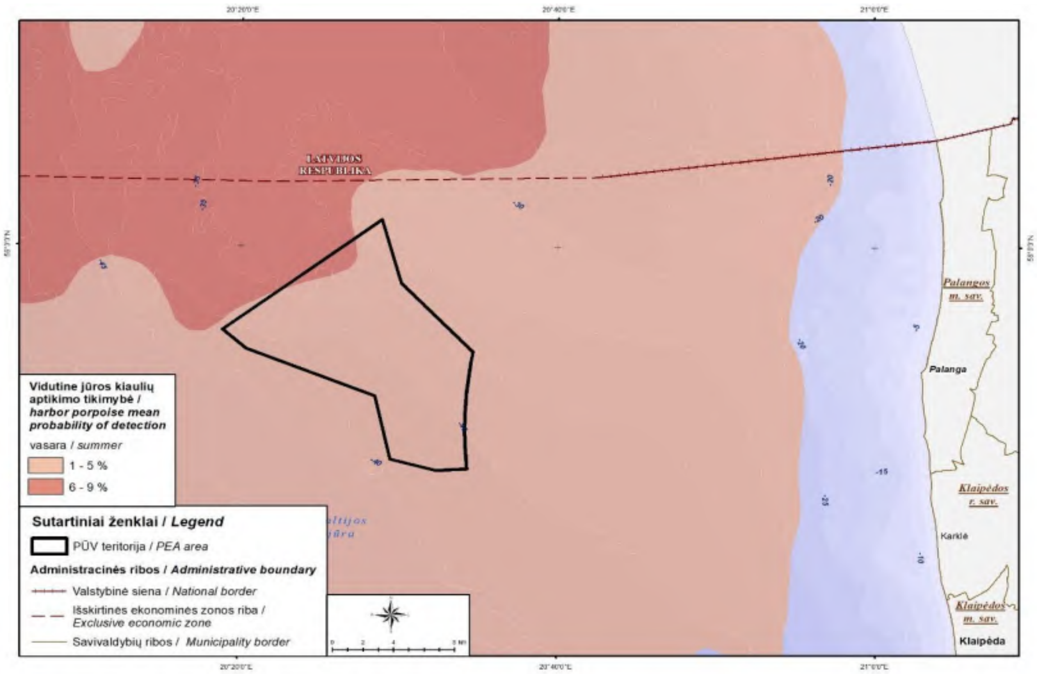


Fig. 4.6.5.2 The average probability of detection of porpoises in the summer season (according to Carlen et. al. 2018)

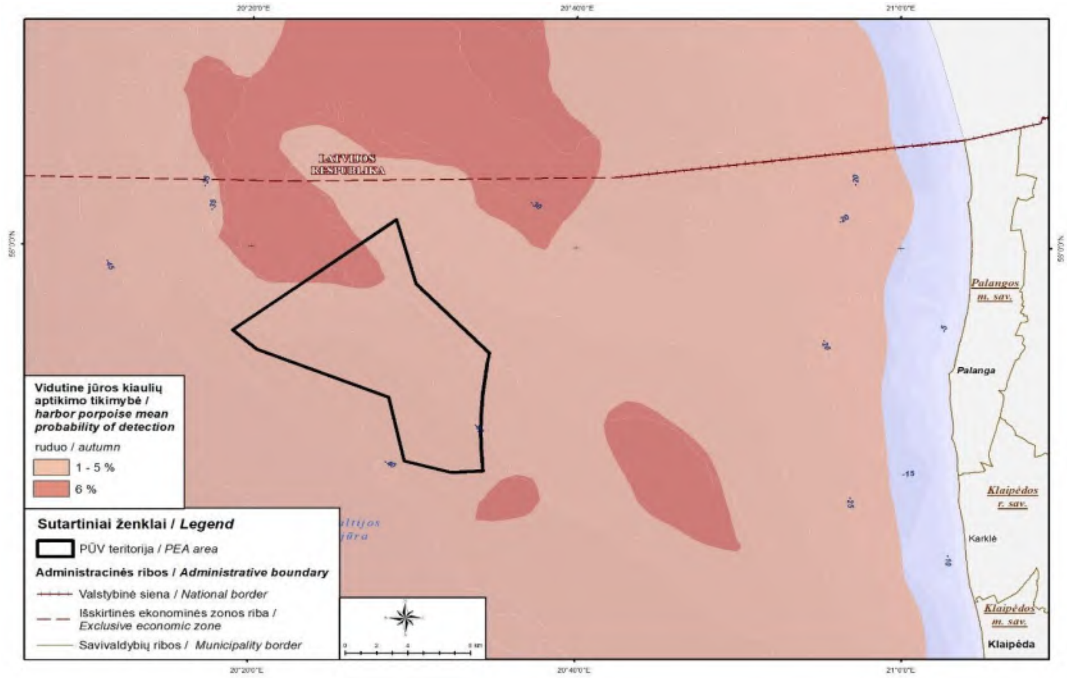


Fig. 4.6.5.3 The average probability of detection of porpoises in the autumn season (according to Carlen et. al. 2018)

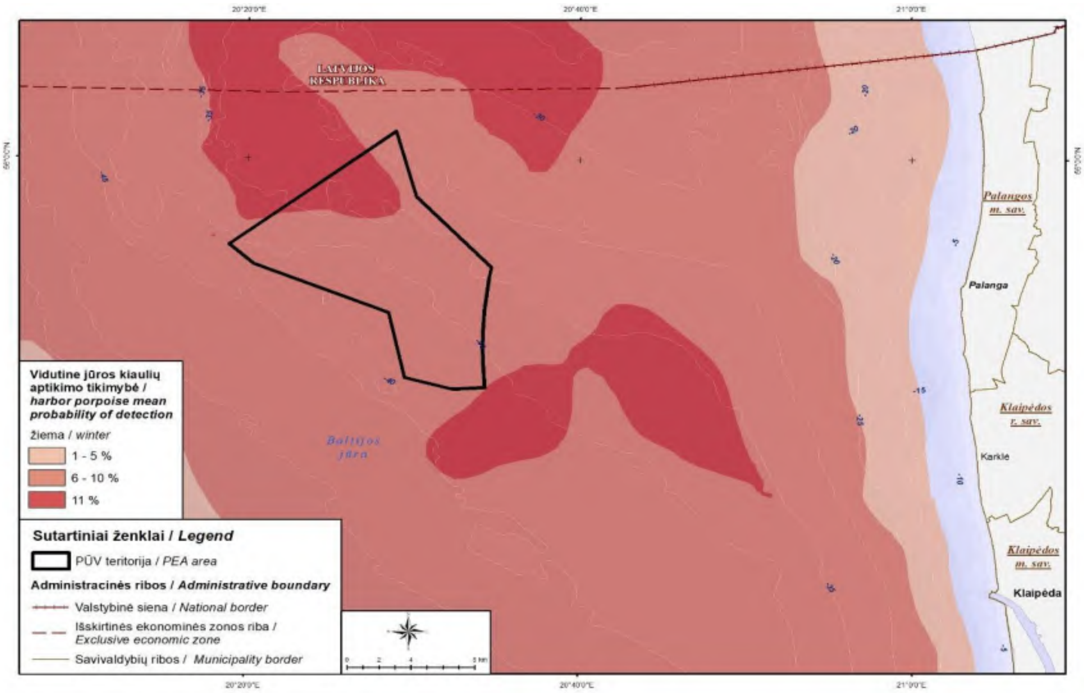


Fig. 4.6.5.4 The average probability of detection of porpoises in the winter season (according to Carlen et. al. 2018)

4.6.5.2. Field observations of mammals

During the warm season, mammals were observed in the area of the PEA together with bird censuses from the vessel and during the cold period from the plane. Also, the data for the months of May 2022 until November 2022 were collected from mammal-emitted sound monitoring stations installed at sea.

Censuses of marine mammals from the vessel: spring-autumn seasons

Methodology. Censuses of mammals and birds from the vessel was conducted together from May to October inclusive, sailing by selected transects (see section 4.6.4.). From November 2021 to April 2022, the censuses by means of the vessel was not performed due to too short daylight hours for such censuses (this period is compensated by the census from the plane). The censuses were carried out in accordance with the program ESAS - European Seabird-at-Sea (GARTHE & HÜPPOP 1996, 2000) and the methodology of BSH guidelines of StUK4 (BSH 2013).

The censuses were conducted while sailing by the intended transect plan and monitoring the mammals from the vessel. The transect plan (Fig. 4.6.4.2) consists of 625.9 km long transects with an overall length of 155 km. The transects are 4 km far-off from each other and cover an area of 533 km².

The results of the censuses from the vessel. Seven censuses were conducted from September 2021 to September 2022. A total of 7 seals were recorded by observations. The density (ind./km²) (Fig. 4.6.5.5) for the seals observed was calculated in different seasons. Only the only grey seal in spring was observed in the PEA area, and all other seals were observed in other seasons in adjacent areas.

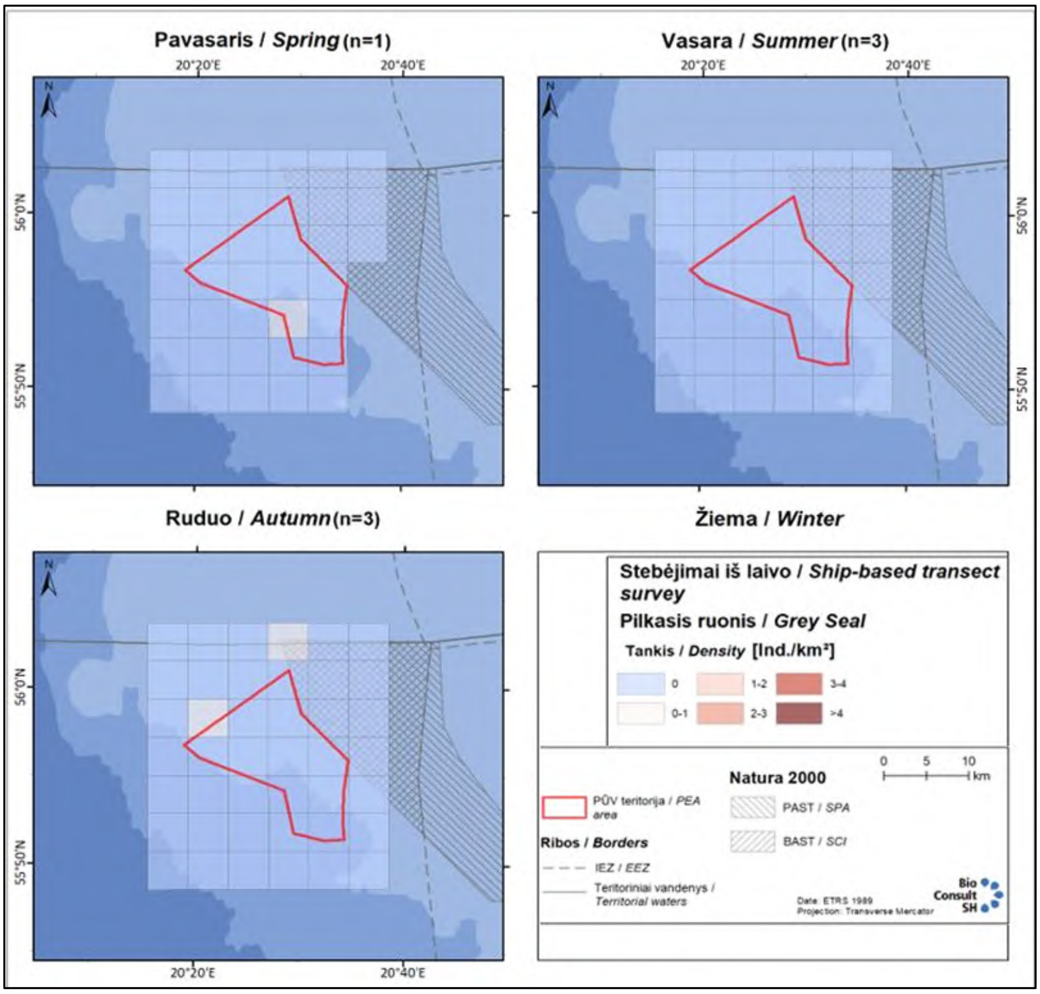


Fig. 4.6.5.5. Distribution and density of grey seals (observations of the winter period are presented in Fig. 4.6.5.6).

The censuses of marine mammals from the plane

Methodology. Marine mammals sailing or resting on the water's surface were captured using digital video recording technology developed by HiDef company (see section 4.6.4.).

The transect plan (Fig. 4.6.4.5) consists of 1,339 km long transects and 4 shorter 19.07 km long transects, which intervene among the long ones to cover the park area of the planned WF. The length of all transects is 583.28 km. Long transects are 4 km far-off from each other and short ones are 2 km from the long ones. The transects' plan covers the area of 2,340 km².

Between November 2021 and April 2022, six censuses by plane were performed and two aerial censuses were conducted in February because bad weather conditions prevented the performance of the census in January.

The results of the censuses from the plane

17 seals were recorded during the censuses, 13 of which could have been identified before the species, while the rest ones only up to the higher systematic group - the suborder (Table 4.6.5.1). No porpoises were recorded during aerial monitoring.

According to observation data, a seal density chart in the winter period (Fig. 4.6.5.6) was drawn up.

Table 4.6.5.1. Seal density from November 2021 to April 2022

Species	Latin name of the species	Aerial surveys	
		Number of individuals	%
Grey seal	*Halichoerus grypus*	13	76.5
Seal	*Pinnipedia*	4	23.5

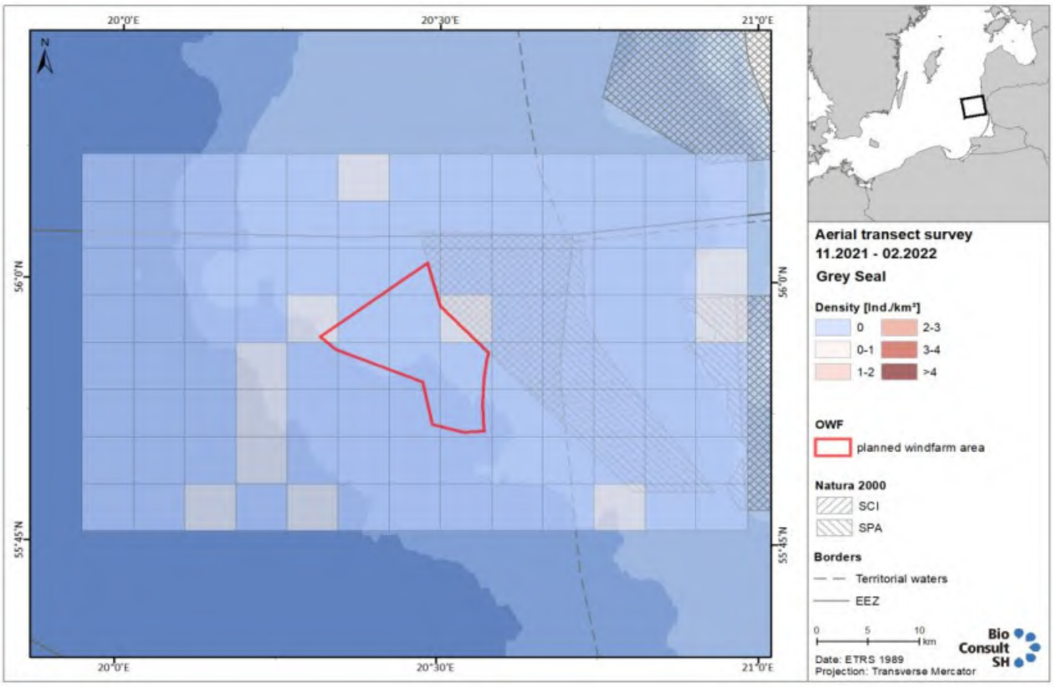


Fig. 4.6.5.6. Distribution of grey seals in the winter period.

Seals were monitored by means of 4 aerial surveys; no seals were observed in the remaining 2 surveys. The average number of seals observed in different surveys varied significantly from 0.08 seals per transect to 0.54 seals per transect.

Grey seals were not observed at the time of the aerial surveys in the PEA area. Several individuals were identified in adjacent areas. It is likely that the same observed seals could have visited the PEA area, but were not recorded at the time of the surveys.

Acoustic monitoring of harbour porpoise sounds

Methodology. In the PEA area, the monitoring of harbour porpoises using acoustic devices was conducted between 1 May 2022 and 13 November 2022. F-POD acoustic receivers were used for monitoring (Chelonia Ltd.) 8 F-POD receivers were evenly arranged throughout the PEA area, which captured high-frequency signals of harbour porpoises within a 400 m radius. 5 m receivers were raised from the bed on anchoring systems designed for this purpose. The detection of the signals of the harbour porpoises was conducted by automated algorithms installed in the equipment.

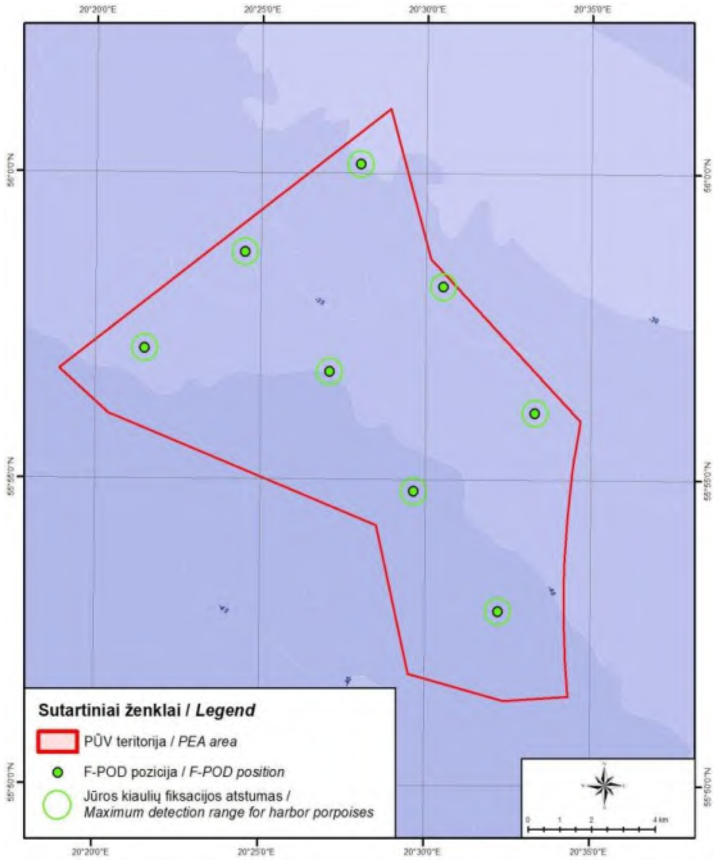


Fig. 4.6.5.7. The arrangement of F-POD acoustic receivers.

Results of acoustic monitoring of harbour porpoises. Despite the published navigational information during the research, 2 receivers were lost during the summer-autumn seasons. The total duration of monitoring the signals of the harbour porpoises was 1,383 days. Even after the arrangement of acoustic receivers in a dense network, no signals of harbour porpoises were recorded during the survey period, so it is very likely that the harbour porpoises did not visit the PEA area during the survey period.

4.6.5.3. Potential significant effects on marine mammals

Most marine organisms use sound as a sensory tool to explore the surrounding marine environment and ensure basic life functions. Mammals, some fish and invertebrates use sound (acoustic signal) for orientation in space and navigation underwater, for food search or seeking to avoid predators; for mating and reproduction, informing about the dangers and fostering the cubs.

The noise of anthropogenic origin has been recognised globally for many years as pollution and is believed to be one of the most harmful forms of pollution widespread both in terrestrial and underwater ecosystems. With the development of measurement and monitoring technologies, there is growing evidence of the adverse effects of anthropogenic noise on marine life. This noise is the main stress factor in marine organisms causing changes such as hearing threshold (hearing ability), as well as behavioural and physiological changes.

From a legal point of view, the Marine Strategy Framework Directive (MSFD) was adopted in the EU in 2008, which defines the legal framework for underwater noise. In this document, according to the law, underwater noise was recognised as significant pollution of the marine environment that adversely affects the welfare of animals and potentially endangers their lives. It is also stressed that noise emission levels must be limited and one of the main tasks is to protect European seas, including the pursuit of the so-called 'good environmental status'.

Impact pile driving is one of the most common methods of installing WF foundations at sea. The impact creates stress waves propagating via the pile that interconnect with the surrounding medium, and acoustic energy flows into water and generates vibration waves in sediment that can emit acoustic energy from the seabed back to water (Denes et al., 2016). The majority of acoustic energy is propagated in the low-frequency range below 500 Hz (Bellmann et al., 2020). The famous underwater noise that occurs during pile driving can have various harmful effects on both marine mammals and fish. The greatest focus was on two types of effects: behavioural disorders (behavioural reactions) and hearing system damage - temporary threshold shift (TTS), sometimes also referred to as temporary hearing loss, and permanent threshold shift (PTS) caused by higher noise levels resulting in damage to sensory cells in the inner ear (Skjellerup et al., 2015).

Porpoises demonstrate very good sound abilities in the high-frequency range (ultrasound frequencies) from around 20 kHz to around 140 kHz. The results of research conducted so far show that even noise generated during the preparatory stage of the installation of the WF may affect the nutrition of harbour porpoises (Sarnocińska et al., 2020). Therefore, the installation of WF parks or the removal of structures undoubtedly affects the behaviour of these animals. The distance determined during different research at which harbour porpoises avoid piling points varies from 15 km (Carstensen et al., 2006; Tougaard et al. 2006) up to 26 km (van Beest et al., 2018) and short-term effects are already observed at a distance of 10 km (Tougaard et al., 2012). In exceptional cases, the harbour porpoises were monitored in WF parks at the time of their installation (et al., 2011). However, pulsed pile driving noise has been found to cause damage to the hearing aid of harbour porpoises at a distance of less than 2 km between the pulse source and the harbour porpose (Brandt et al., 2009). Any hearing damage can impair the echolocation of the harbour porpoises and their ability to find food and become the cause of the individual's death. However, no increased mortality of harbour porpoises at the time of the installation of WF parks (Leopold and Camphuysen, 2008) is known so far.

Information on the impact of the installation of WF on seals is not as complete as in the case of harbour porpoises, although seals, unlike harbour porpoises, are known to have a better hearing perception in the low frequency range. During the installation of the Nysted WF park, an increase in the number of seals in the area adjacent to the WF installation sites was observed between spring and summer 2002 (Tougaard et al., 2006). Seals are likely to have taken advantage of a situation where the fish that have lost orientation and distracted in the area turns into a light prey for seals. Seals are known to ignore pain caused by severe noise due to the possibility of light prey, when it can cause temporary hearing loss or a permanent shift in the hearing threshold. Still, even a partially lost hearing does not end with the death of an individual.

The noise impact on marine mammals (grey seals and harbour porpoises) propagated during the operation of the WF parks is insignificant and, if the behaviour is affected, it manifests at a maximum distance of several hundred metres from WF, although it may not reach 100 m for harbour porpoises (Tougaard et al., 2009). Even when marine mammals are swimming near the WF, there is no risk of damage to hearing organs (Tougaard et al., 2008). In contrast, the increase in the frequency of detection of harbour porpoise signals in WF parks is observed up to several times after installation work compared to adjacent areas. There are several possible explanations for this phenomenon: nutritional objects, i.e. fish increase and/or restrictions on commercial fishing in the area (Scheidat et al., 2011, Teilmann and Carstensen, 2012).

No other effects on marine mammals due to possible hydrological changes, electromagnetic fields or other factors related to the effects of the WF park are foreseen.

The effects of the WF park can be summed up with commercial fishing activities. It is likely that during construction in adjacent areas, intensive fishing with trawls or gill-nets is likely to be carried out in anticipation of higher catches due to fish scampering away from the area during installation of power plants, especially during pole driving. Intensive net fishing is one of the factors attracting seals to the area, and intensive trawling, as well as navigation in adjacent areas, can affect the feeding efficiency of harbour porpoises.

Cumulative effects on marine mammals are only possible if several parks are installed and dismantled in adjacent water areas at the same time. In this way, mammals may not be able to access part of their nutritional areas, as well as changes in fish migration localities and their accumulation places. In such cases, the succession of installation of different parks should be determined, both at the national and cross-border levels, which would allow for a reduction in the cumulative impact.

4.6.5.4. Prevention, mitigation and compensatory measures of effects on marine mammals

One of the main means of reducing the impact is the technical means that dampen the pulse noise emitted during pile driving. One of the most effective ones is bubble curtains, which are installed around the pile driving site. This measure can reduce the distance of extreme impact on harbour porpoises by up to 90 % (Nehls et al., 2016). In the PEA area, with the use of these means, installing the bubble curtain at a 50 m radius around the pile driving site as well as ensuring the air supply of at least 1 m 3/m/min is recommended.

Another measure is pile "sleeves" made of various materials or a steel pipe, which is pulled on the pile and the pile does not come into contact with water during pile driving, and the impulse noise loses most of its energy when moving to another medium. Also, one of the possible options is the Noise Mitigation System (NMS) under constant development which also suppresses low-frequency noise.

The use of only common navigation routes and designated navigation corridors for navigation to and from the PEA area during the construction and maintenance of the WF park is recommended. This would allow for the concentration of noise in a given area and to reduce possible disturbances in the feeding of marine mammals.

These measures should be applied on a permanent basis, but it is particularly important in winter when natural conditions cause the greatest underwater noise dispersion. In addition, WF pile driving is also recommended not to be performed during the winter season, with the highest probability of finding harbour porpoises migrating after fish in the LIEZ.

One of the measures to reduce noise emissions during WF operation is to select turbines that emit lower noise. It is recommended to replace the gearbox with direct-drive turbines that have a more than 4-fold difference in the effect on marine mammal behaviour according to Stöber and Thomsen (2021).

Table 4.6.5.2. Summary table of effects on marine mammals

Stages	Impact	Nature	Scale	Duration	Significance	Impact mitigation measures
Construction	Noise of works	Adverse direct effects - deterrence and possible hearing damage in animals	Local (in WF park area and surrounding areas)	Short-term (possible only during installation works)	Moderate effects due to possible hearing damage and temporary retreat of animals	Use of suppression devices of propagating impulse noise during the execution of pile driving works
	Physical destruction of seabed habitats	Insignificant effects due to possible reduced abundance of nutritional objects	Local (in the WF park area)	Short-term (possible only during installation works)	Insignificant effects - only a small area is destroyed compared to potential nutrition areas	Not applicable
	Increased traffic and noise of vessels	Negative direct effects - deterrence of marine mammals	Local (in WF park area and surrounding areas)	Short-term (possible only during installation works)	Insignificant effects - visit of harbour porpoises to the area whose feeding could be influenced by increased shipping has not been actually confirmed	Not applicable
Operation and maintenance	Traffic and noise from maintenance vessels	Adverse direct effects - deterrence of marine mammals	Local (in WF park area and surrounding areas)	Short-term (possible only during the presence of vessels)	Insignificant effects - an instantaneous abundance of animals can only be reduced on and near navigation routes	Not applicable
	Noise generated by structures	Adverse direct effects - changes in behaviour and loss of abundance in marine mammals	Local (in the WF park area)	Long-term (will last until the end of the operation of the WF park)	Insignificant effects - mammals may avoid the WF park, but this will not affect their abundance in Lithuanian marine waters	Not applicable

Stages	Impact	Nature	Scale	Duration	Significance	Impact mitigation measures
	The emergence of secondary habitats	Positive indirect effects due to the potentially increased abundance of nutritional objects	Local (in the WF area)	Long-term (will last until the end of the operation of the WF park)	Positive effects	Not applicable
Dismantling	Noise of works	Adverse direct effects - deterrence and possible hearing damage in animals	Local (in WF park area and surrounding areas)	Short-term (possible only during works)	Moderate effects due to possible hearing damage and temporary retreat of animals	In case of detection of harbour porpoises during the monitoring of the operation, impulse noise suppression measures shall be applied during hammering, blasting, etc. works
	The destruction of secondary habitats	Adverse indirect effects due to possible reduced abundance of feeding objects/areas	Local (separate towers)	Long-term	Insignificant effects - only a small area is destroyed compared to surrounding feeding areas	Not applicable
	Increased traffic and noise of vessels	Adverse direct effects - deterrence of marine mammals	Local (in WF park area and surrounding areas)	Short-term (possible only during installation works)	Due to the extremely low probability of meeting harbour porpoises in the area under analysis, the potential effects resulting from the retreat of harbour porpoises from the area are negligible. The magnitude of the effects may change upon confirmation of the visit of the harbour porpoises during the monitoring of construction or operational stages.	Insignificant

- positive effects;

- the effects are insignificant: no need to take into account, no measures are applied;

- moderate effects: addressed by impact mitigation measures.

4.7. Cultural Heritage

4.7.1. Legal Grounds

The key document of international law related to the utilisation and planning of territorial sea is the United Nations Convention on the Law of the Sea (UNCLOS). This is the focal document that all other international and national regulations for the utilisation of territorial sea are based on. In terms of the protection of underwater cultural heritage, the following articles of the Convention are considered to have an importance:

Article 149, "Archaeological and historical objects", stating that "all objects of an archaeological and historical nature found in the area shall be preserved or disposed of for the benefit of mankind as a whole, particular regard being paid to the preferential rights of the State or country of origin, or the State of cultural origin, or the State of historical and archaeological origin."

Article 150, "Policies relating to activities in the area", stating that "activities in the area shall, as specifically provided for in this part, be carried out in such a manner as to foster healthy development of the world economy and balanced growth of international trade, and to promote international cooperation for the overall development of all countries, especially developing States, and with a view to ensuring: (a) the development of the resources of the area; (b) orderly, safe and rational management of the resources of the area, including the efficient conduct of activities in the area and, in accordance with sound principles of conservation, the avoidance of unnecessary waste; /.../ (i) the development of the common heritage for the benefit of mankind as a whole."

Article 303, "Archaeological and historical objects found at sea", stating that "(1.) States have the duty to protect objects of an archaeological and historical nature found at sea and shall cooperate for this purpose and (2.) In order to control traffic in such objects, the coastal State may, in applying Article 33, presume that their removal from the sea-bed in the zone referred to in that Article without its approval would result in an infringement within its territory or territorial sea of the laws and regulations referred to in that Article."

Moreover, the Convention divides the territorial sea into territorial waters, contiguous zone and exclusive economic zone (EEZ) and defines that underwater cultural heritage in the first two zones shall be subject to the national law, i.e. Article 303 with a reference to Article 33 and Article 2 of UNCLOS stating that "1. The sovereignty of a coastal State extends, beyond its land territory and internal waters and, in the case of an archipelagic State, its archipelagic waters, to an adjacent belt of sea, described as the territorial sea." Meanwhile, exclusive economic zone shall be subject only to the UNCLOS provision first cited above, as well as the right of salvage or other maritime law de facto rules allowing for almost unrestricted disposal of underwater cultural heritage for those who found it.

Protection of the underwater heritage is regulated by the UNESCO Convention on the Protection of the Underwater Cultural Heritage. "Lithuania - Convention on the Protection of the Underwater Cultural Heritage" was ratified on 12 June 2006. It defines underwater cultural heritage as underwater heritage of historical and cultural significance, containing clear examples of history of the humankind.

According to Article 2 of the Convention, its objectives is to ensure and strengthen the protection of underwater cultural heritage (Clause 1), oblige the undersigned States Parties to preserve underwater cultural heritage (Clause 3) and to cooperate in the protection of underwater cultural heritage (Clause 2), also to, individually or jointly as appropriate, take all appropriate measures in conformity with this Convention and with international law that are necessary to protect underwater cultural heritage, using for this purpose the best practicable means at their disposal and in accordance with their capabilities (Clause 4).

Clauses 5 to 11 of Article 2 of the Convention provide for the principles of the protection of underwater cultural heritage. The preservation in situ of underwater cultural heritage shall be considered as the first option before allowing or engaging in any activities directed at this heritage (Clause 5). Recovered underwater cultural heritage shall be deposited, conserved and managed in a manner that ensures its long-term preservation. (Clause 6). Underwater cultural heritage shall not be commercially exploited. (Clause

7). Nothing in this Convention shall be interpreted as modifying the rules of international law and State practice pertaining to sovereign immunities, nor any State's rights with respect to its State vessels and aircraft. (Clause 8). States Parties shall ensure that proper respect is given to all human remains located in maritime waters (Clause 9). Responsible non-intrusive access to observe or document in situ underwater cultural heritage shall be encouraged to create public awareness, appreciation, and protection of the heritage except where such access is incompatible with its protection and management (Clause 10). No act or activity undertaken on the basis of this Convention shall constitute grounds for claiming, contending or disputing any claim to national sovereignty or jurisdiction (Clause 11).

The Convention is appended with so-called rules that regulate activities directed at underwater cultural heritage, which are an integral part of the Convention. It is understood that these principles are a certain international standard of conduct involving underwater cultural heritage; violation of these principles would mean sanctions to be imposed on the faulty person/entity by the State Party based on Article 17 of the Convention already mentioned. The Rules provide a detailed wording of certain provisions of the Convention and define the procedures of the implementation thereof. Thus, Rule 1 once again emphasises that the protection of underwater cultural heritage through in situ preservation shall be considered as the first option and that activities directed at underwater cultural heritage shall be authorized in a manner consistent with the protection of that heritage, and subject to that requirement may be authorized for the purpose of making a significant contribution to protection or knowledge or enhancement of underwater cultural heritage.

Other general principles indicate that activities directed at underwater cultural heritage shall not adversely affect the underwater cultural heritage more than is necessary for the objectives of the project. Activities directed at underwater cultural heritage must use non-destructive techniques and survey methods in preference to recovery of objects. If excavation or recovery is necessary for the purpose of scientific studies or for the ultimate protection of the underwater cultural heritage, the methods and techniques used must be as non-destructive as possible and contribute to the preservation of the remains. Besides, the above activities shall avoid the unnecessary disturbance of human remains or venerated sites.

Any activities in question shall be strictly regulated to ensure proper recording of cultural, historical and archaeological information. Public access to in situ underwater cultural heritage shall be promoted, except where such access is incompatible with protection and management. Moreover, international cooperation in the conduct of activities directed at underwater cultural heritage shall be encouraged in order to further the effective exchange or use of archaeologists and other relevant professionals.

Protection of underwater cultural heritage at the national level is regulated by the Law on Protection of Immovable Cultural Heritage (1994, No I-733), Article 3 of which stipulates that „(...)the archaeological objects, sites and the items of immovable or movable property recognised as significant which are totally or partially under water, where the only or one of the main sources of scientific data thereon is underwater research and findings." Moreover, Article 17 of the said Law regulates that „at an object safeguarded for scientific knowledge, within the territory thereof, at a site, it shall be prohibited, without the consent of an institution in charge of the protection of cultural heritage, to use metal, electronic or other detectors for the purpose of searching for archaeological and other findings or objects, to move, research, lift underwater objects, separate parts thereof or archaeological findings in inland waters, inland waters of the maritime area, the territorial sea, the contiguous zone and the exclusive economic zone within the meaning of the international treaties of the Republic of Lithuania."

4.7.2. Underwater Cultural Heritage

The best group of findings in the Baltic Sea consists of shipwrecks of different types. However, especially valuable findings related to the oldest period of humans leaving in this territory should be mentioned, as well. The geologic history of the Baltic Sea allows for a presumption that its seabed can contain the remaining archeologic monuments of the Early Holocene Age. Last decade was marked by perfectly preserved Mesolithic period findings detected in Denmark, Germany and Sweden, which gives hope that similar findings would be detected in other parts of the Baltic Sea, as well. In previous century, archaeologist, in cooperation with geologists studying changes in the Holocene sea level of the Baltic Sea, already attempted to detect the Stone Age locations of detection in the Lithuania's seawaters. The relics of subfossil forests that remained at the seabed are used as one the main indicators for the determination of the territories with a great possibility to detect the relicts of the Stone Age human activities. Results of previous works are, inter alia, submitted in the papers by V. Žulkus and A. Girininkas. The seabed of the adjacent territory under study was documented to remodel the remaining underwater cultural seascape in the eastern part of the Baltic Sea, in Lithuania's waters, which, inter alia, consists of remains of tree trunks, peat sediments and traces of humans who lived there that are currently under the water surface. The authors of the research submit the following results obtained: "Based on the latest data of the sediment layers, palynologic and dendrochronologic analysis, the identified flora species and radiocarbon dating of wood and peat samples, we were able to define the dynamics of the Baltic Sea water level in the Yoldia Sea in the stages of the Early Litorina Period. The depth of 39-43 m showed the traces of the Yoldia Sea eroded coasts that were also observed at the depth of 44 and 47 m during transgression of the *Ancylus* Lake. The transgression of the *Ancylus* Lake was marked by an overflow of lagoons and small lakes with a peat layer and the surrounding forests. The water level could have been up 10–9 m below the current sea level. The Litorina transgression is evidenced by the tree trunk detected at the depth of 14.5 m dated 7,900-7,660 inches BP". The article indicates that the remains of the Early Holocene Age inhabitants concentrate in the coastline zone, "which is evidenced by the piles driven into the seabed (one of them dated 9,510-9,460 inches BP) detected at the depth of 11 m, also T-shaped collars (dated 9,510–9,460 inches BP) and T-shaped horn hatches of the Early Neolithic Age washed ashore from the coastline Stone Age settlements."

According to the Cultural Heritage Register of Lithuania, there are nine valuables registered in the maritime territory of Lithuania. The PEA area contains no registered cultural valuables. The distance to the closest registered marine cultural valuable, i.e., the vessel 38471 "L-14" sunken in the Baltic Sea, is approx. 24 km (Fig. 4.7.1.).

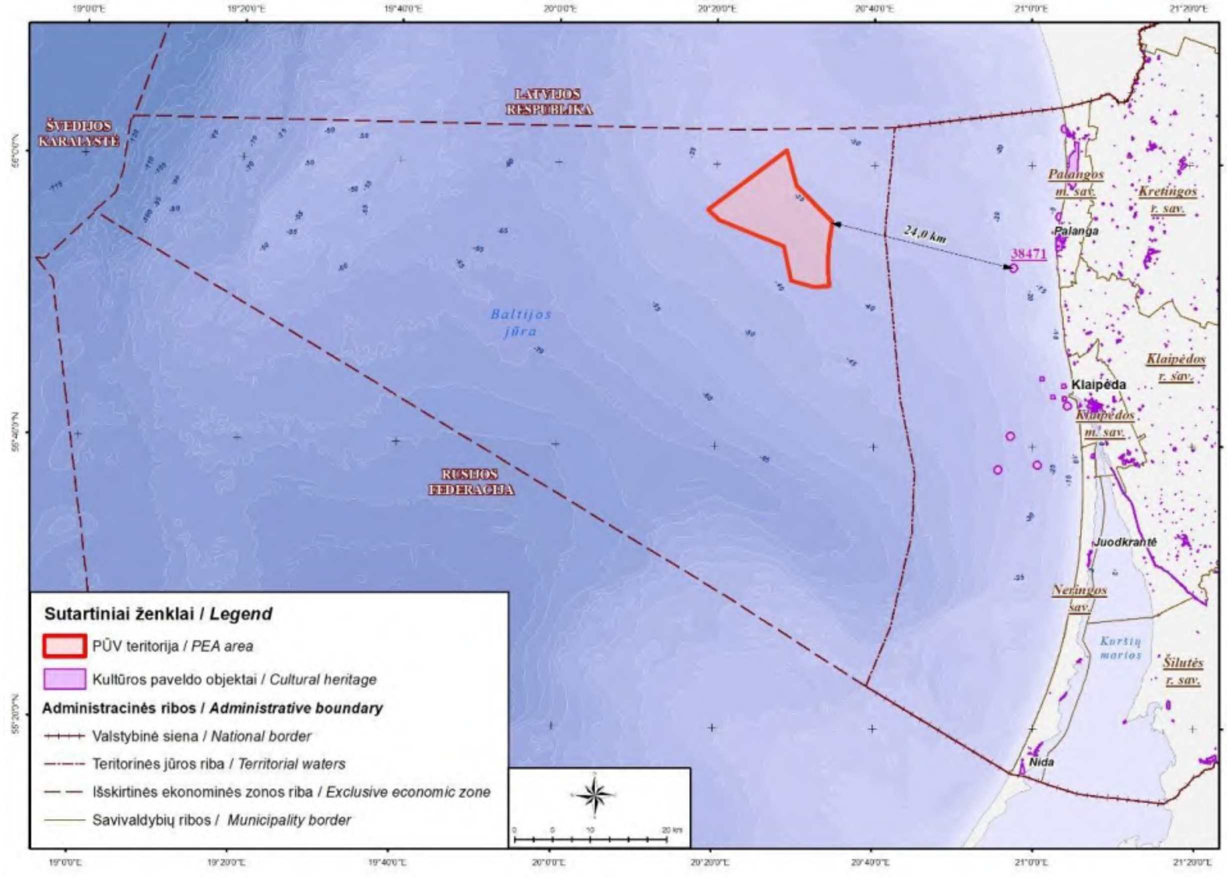


Fig. 4.7.1. Objects of marine cultural heritage registered.

According to the charts of the Lithuanian Transport Safety Administration, there are several dozen sunken objects marked in the Lithuanian EEZ that are not included in the Cultural Heritage Register. Most of the sunken objects are industrial ships; though, remains of wooden vessels of great scientific value were discovered, too. There were also several valuable habitats of cultural underwater seascape with natural relics and tree remains found. One discovery site is marked nearby the PEA territory but does not fall within it (Fig. 4.7.2.).

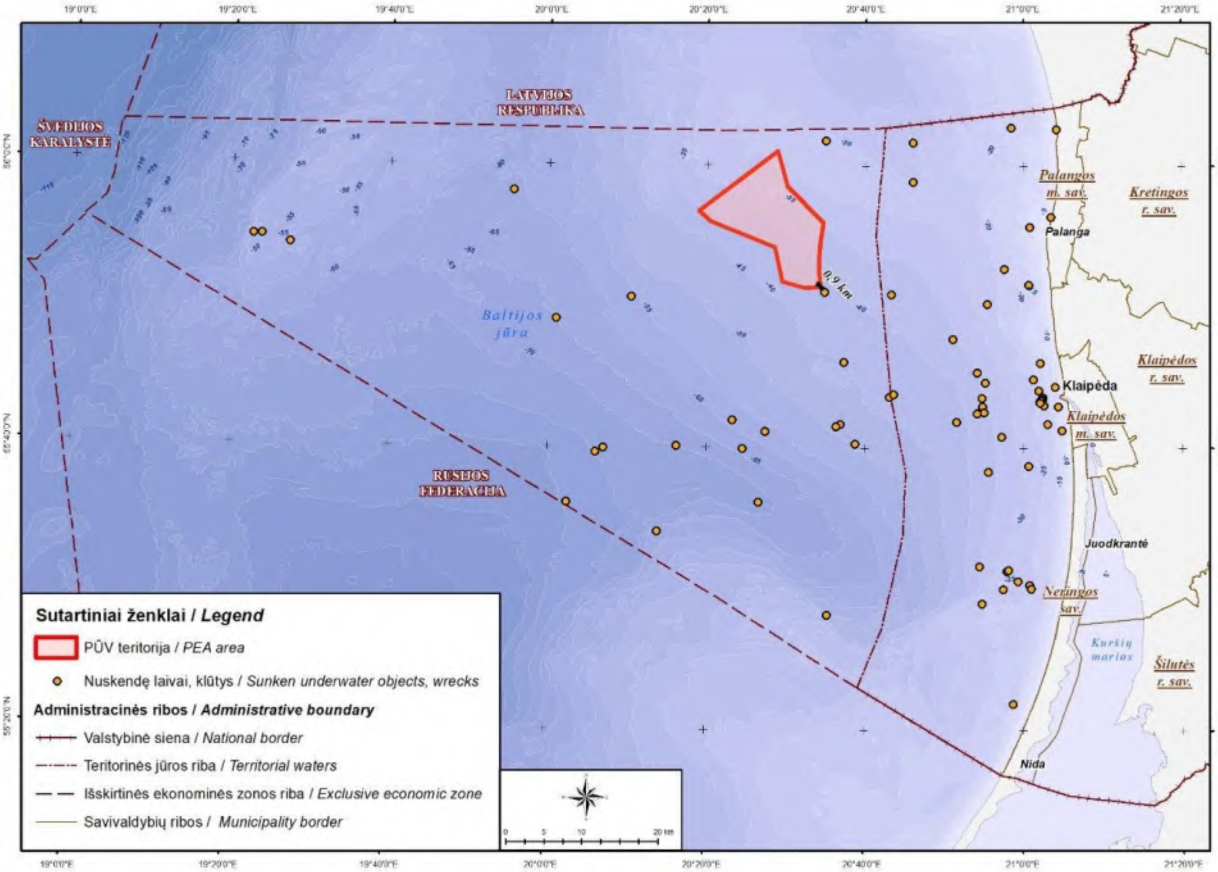
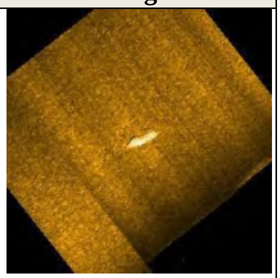


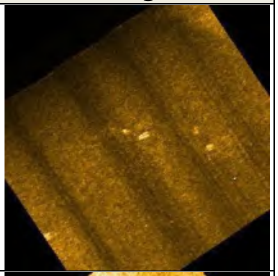
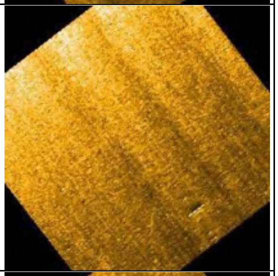
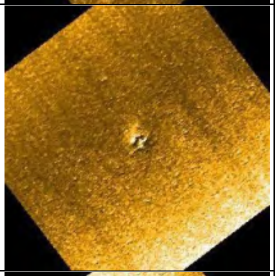
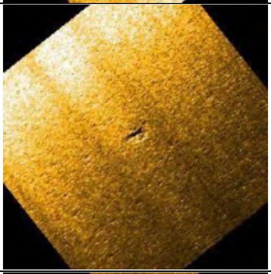
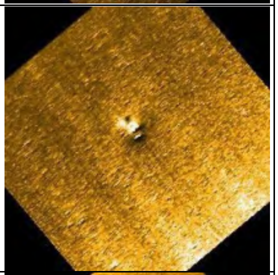
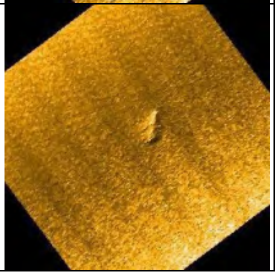
Fig. 4.6.2. Identified locations of sunken underwater objects.

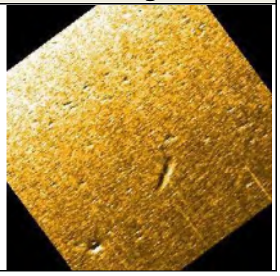
4.7.3. Archeologic Studies in the PEA area

The study analysed acoustic data, i.e. 183 operator-selected images. Eight objects were selected that are potential tree remains (loose tree remains occurring here and there and bottom part of the trunk, i.e. stump) (Table 4.5.1).

Table 4.7.1. Historical tree remains

ID	LAT	LON	L, m	W, m	Comment	Image
#0004	285080.4	6196719.3	5.5	1.5	Oblong stump trunk	

ID	LAT	LON	L, m	W, m	Comment	Image
#0007	285442.4	6197142.4	1.9	0.6	Potential relicts of two stumps/trunk or tree bark	
#0014	285392.3	6197193.0	3.9	0.3	Single stump part / tree bark	
#0032	284717.5	6197101.1	1.5	1.3	Tree remains	
#0034	283992.7	6196766.0	2.5	1.5	Board or stump	
#0052	283157.0	6197142.9	3.4	2.6	Stump remains	
#0124	281768.5	6199210.9	6.3	1	Trunk part	

ID	LAT	LON	L, m	W, m	Comment	Image
#0150	285239.3	6202173.9	7.3	1.7	Potential stump part	

A separate group of eight objects are the obstacles that are potential remains of sunken Stone Age forests. It should be noted that in case of such small objects, their nature cannot be unquestionably identified with a sonar. The identified objects have no significant archeologic value but might be important for the paleogeographic reconstruction of the area to verify the borders of former stages of the Baltic Sea and former coastline.

No artefacts of prehistoric settlements were found in the PEA area. The sonar images show only single objects that could be remains of tree trunks. Remains of tree trunks are not monuments. It should be kept in mind, however, that they are classified as an indicator of a seabed zone with the remaining paleolandscape. For this reason, it would be reasonable to preserve the findings for future studies, i.e. to leave them undisturbed at the location of detection, thus, saving the possibility of detecting their potential historic and scientific value in the future.

Beside potential remains of tree trunk, 58 potential anthropogenic, 2 especially similar to anthropogenic and 24 typical linear objects, which are likely to be unnatural, although could also be a result of specific natural structures, were identified in the PEA area (Fig. 4.6.3.). Archeologic analysis showed that only a part of potential anthropogenic objects was identified as unnatural (Fig. 4.6.2.). Despite that small objects related to human activities were identified at the seabed, no historic findings were detected in the area under study. Sonar images allowed creating a list of obstacles with certain features allowing for a conclusion that these are remains of a wooden sailing-boat structure (# 0001, 0014, 0095). Object # 0013, which is questionable, is described as a wooden shipwreck or clay and/or sludge scalping with loose stones. Final identification is possible by inspecting it with a remote control device or diver's assistance. At the stage of designing the scheme of WT and connecting infrastructure, it is recommended, if possible, to consider, i.e. to leave undisturbed at the location of detection, the potential archeologic monuments (or remains thereof), to avoid their potential destruction and preserve them for future studies.

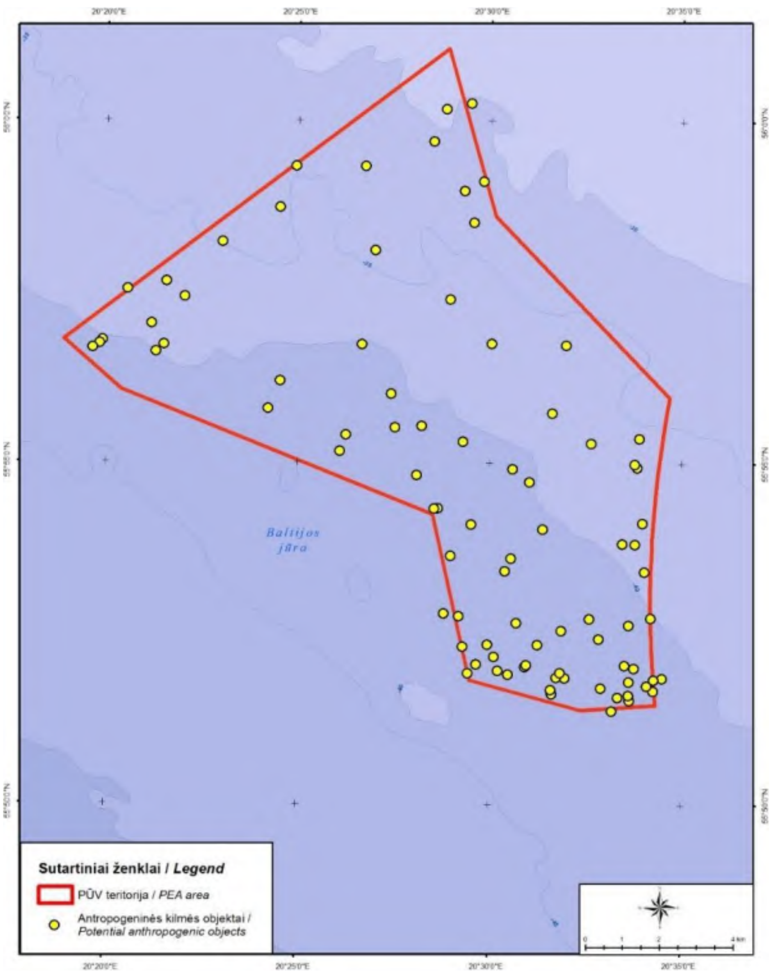
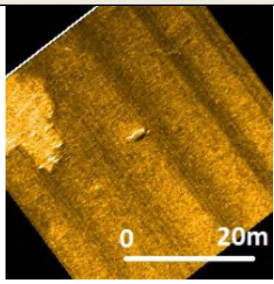
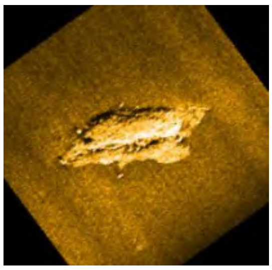
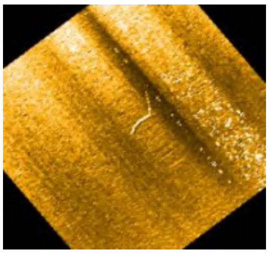
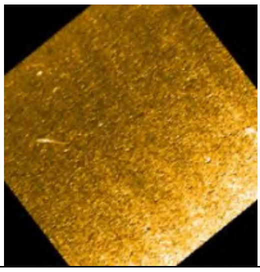
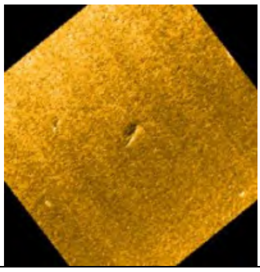
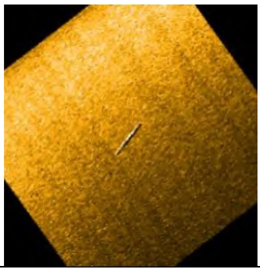
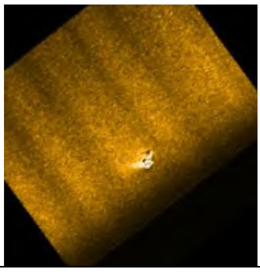
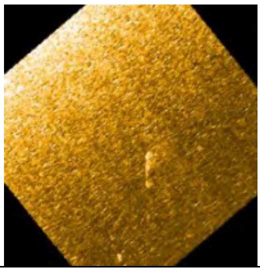
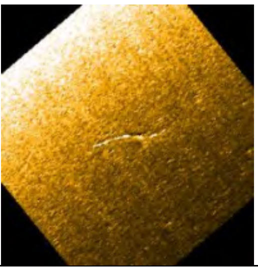
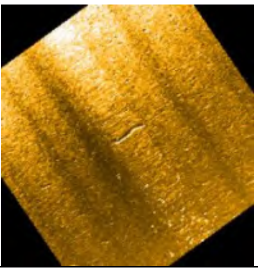


Fig. 4.7.3. Scheme of potential anthropogenic object (as per Sea Bottom Surveys, Part II, 2022).

Table 4.7.2. Remains of potential anthropogenic objects

ID	LAT	LON	L, m	W, m	Comment	Image
#0001	285564.7	6197085.8	3	0.8	Potential remains of a wooden boat	
#0013	285021.9	6197058.3	234	8.1	Wooden boat remains or natural moraine soil scalping	

ID	LAT	LON	L, m	W, m	Comment	Image
#0015	285654.2	6197518.5	7.4	0.7	Rope or chain	
#0045	284650.3	6197925.2	4.5	1.2	Potential rope remains	
#0080	284173.2	6198662.0	1.4	1.4	Rope or fishnet remains	
#0095	281988.0	6198058.4	6.4	0.8	Potential remains of wooden mast	
#0116	280631.8	6198148.1	3.7	1.5	Rope or fishnet remains	
#0158	280213.1	6199475.0	6.1	1.3	Rope	

ID	LAT	LON	L, m	W, m	Comment	Image
#0167	281525.1	6200638.2	10.4	1.1	Rope or wrapped fishnet	
#0182	282601.2	6201723.9	6.6	1.5	Rope or branch remains	

4.7.4. Potential Impact on Cultural Heritage

There are no archeologic/historic/cultural heritage registered in the Cultural Heritage Register in the PEA area under study. However, potential remains of sunken anthropogenic objects and old tree trunk relicts probably representing historical coastline, which are of potential importance for the exploration of seascape, were identified.

4.7.5. Measures for the Protection of Cultural Heritage

Protection of underwater cultural heritage is important in planning activities in the seawaters. Prior to designing the WT foundations and cable routes, it is recommended to, in the proposed area of WT construction, conduct additional archeologic studies of identified objects using underwater robots and/or divers; or to 'isolate' the marked objects and plan for no seabed excavation in the site of the marked objects, including 10 m diameter safety zone. After the studies detect or deny the archeologic value of the identified objects and verify the nature of dangerous obstacles, the entire territory may be used for the WT development. Typically, the future developer conducts the above studies as a part of survey of unexploded ordnance (UXO). Thus, those require no additional time or financial costs.

4.8. Public health

Article 18 of the Public Health Care Act No. IX-886 of the Republic of Lithuania of 16 May 2002 states that improvements made to the environment should be beneficial to human health, negative impact on health from human actions should be reduced, damage made to the environment by human actions should be eliminated, and if one wants to start or expand an economic activity presenting risk to human health, an evaluation on impact to public health is carried out.

The purpose of impact on public health evaluation is to determine, describe and assess possible PEA impact on public health, propose to eliminate or reduce harmful effects by means of appropriate measures.

Based on methodological material "Development of methodological guidelines for the evaluation of wind energy impact on public health. The final report" (SWECO, 2013) prepared by the National Public Health Center under the Ministry of Health, general principles on protection from wind energy risk factors in living environment are appropriate arrangement of wind energy objects (maximum distance from living area).

4.8.1. Evaluation of present condition

Article 49(9) of the Renewable Energy Sources Act No. XI-1375 of the Republic of Lithuania of 12 May 2011 states that WE with installed power greater than 30 kW must be installed in a way that the shortest distance from WE central axis of the mast to garden houses; buildings assigned for residential, hotel, culture purposes; buildings assigned for educational purposes such as general education, vocational and higher education, kindergartens, nurseries; buildings assigned for other educational purposes such as non-formal education; buildings assigned for recreation, medical treatment, sport and religious purposes; special purpose buildings related to accommodation (barrack buildings, imprisonment institutions); specified purpose premises in buildings of other purpose; recreational areas would be no less than the height of WE mast in meters multiplied by 4, except for cases provided in paragraph 11 of the article.

The PEA area under consideration is in the Baltic Sea, exclusive economic zone and territorial part of the sea of the Republic of Lithuania (figure 2.1.1.). Economic activity is not planned in the mainland.

Living and public areas located the closest to the Baltic Sea are in Klaipėda city, Klaipėda district and Palanga city municipalities. The minimum distance of ~29.5 km is up to Palanga city municipality. Distances from the PEA area to living and public purpose areas on the shore are displayed in table 4.8.1. and fig. 4.8.1.

Table 4.8.1. Distances from the PEA area to living and public purpose areas

Area	Distance from PEA
Living	
Palanga, Palanga city municipality	29.5 km
Karklė village, Klaipėda district municipality	31.2 km
Klaipėda, Klaipėda city municipality	33.7 km
Public purpose objects	
No. 1 – Guest house "Melt in Palanga", UAB "Aktyvistas" (J. Basanavičiaus str. 43, Palanga)	29.7 km
No. 2 – Seaside Regional Park Visitor Center (Placio str. 54, Karklė)	31.9 km
No. 3 – Klaipėda sanatorium nursery-kindergarten "Giliukas" (Turistų str. 18A, Klaipėda)	33.7 km

Based on Order No. D1-601 of the Minister of Environment of the Republic of Lithuania of 28 July 2011 approved by the management plan of the mainland coastal strip, the identified areas for recreational purposes are illustrated in figure 4.8.1. The PEA area concerned is located outside the boundaries of recreational areas, ~29.5 km from the coast.

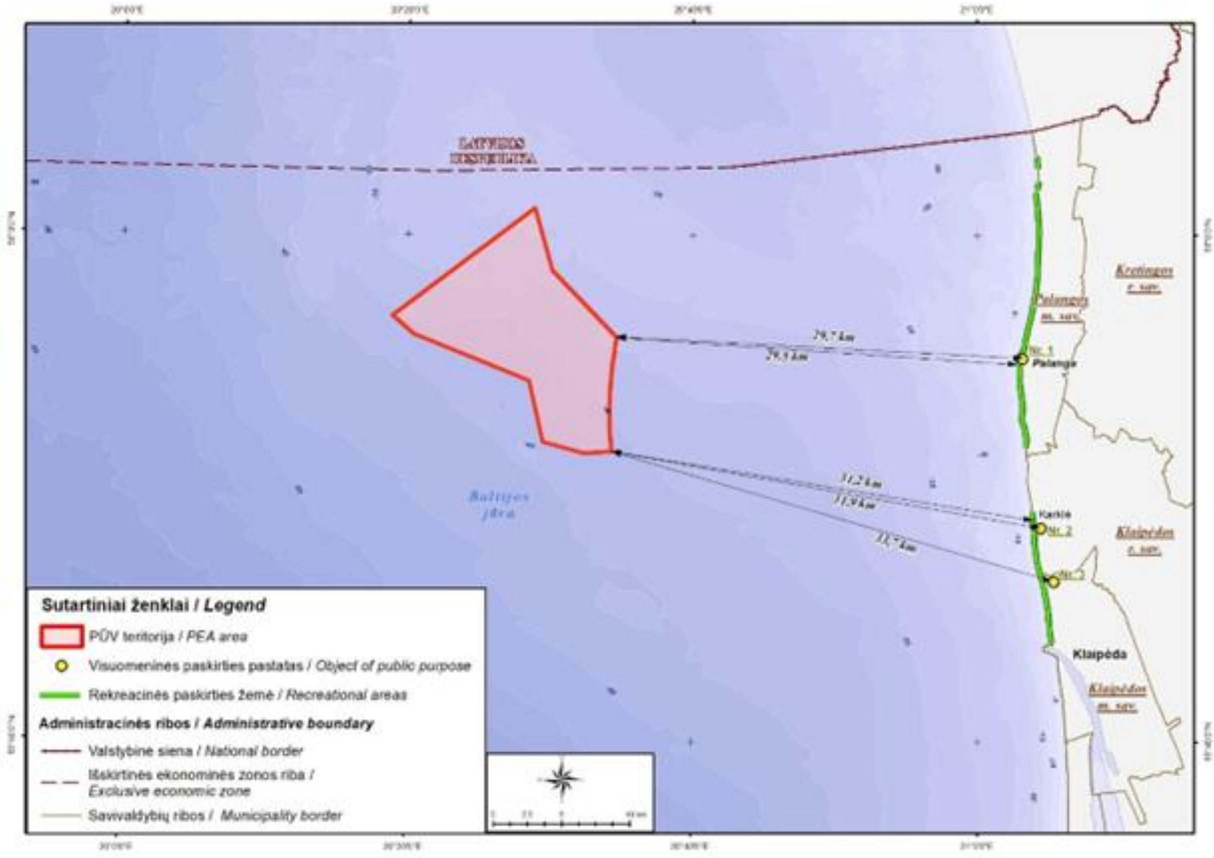


Fig. 4.8.1. Distances to the nearest living, public and recreational purpose areas on the shore.

It should be noted that the PEA area in consideration is in the offshore part of the sea which is located at a great distance from onshore living areas, public purpose objects and recreational purpose lands. Analysis on public health condition is not carried out due to the reason that PEA will not affect the demographics of area's population and morbidity.

Connection of the offshore wind energy park to the onshore electricity transmission network for connections and areas necessary for relevant infrastructure will be determined and identified in other spatial planning documents.

4.8.2. Expected significant impact

After examination of information on planned offshore WE park activity, based on its nature and extent, assessment of technological processes, literature data, it is possible to claim that physical factors related to PEA affecting health are:

- noise;
- shadowing;
- infrasound;
- electromagnetic field.

Only short-term, local and insignificant pollutant emissions into the ambient air are possible from internal combustion engines of vehicles and mechanisms used for construction works and they will be carried out in accordance with all requirements applicable to such work, therefore adverse effect on environment is not expected.

<u>Noise (above the water)</u>

Noise generated by WE can be classified into two main sources: mechanical and aerodynamic (Katinas et al., 2014). At the time of WE park installation, mechanical noise is caused by pile driving machines and vessel mechanisms related to implementation; during operation, main noise sources are moving parts of a rotor, gearbox, nacelle rotation mechanisms. Aerodynamic noise is caused by changes in air flow occurring as it passes over blades.

Noise impact on health is described by two mechanisms (SWECO, 2013):

- causing some autonomic reactions such as increase in blood pressure, breathing intensification, increase in heartbeat, impaired peripheral circulation, possible awakening from sleep.
- causing reactions characteristic to stress due to emotional reaction of people who experience long-term noise irritation.

WE noise impact is relatively little researched and usually interpreted in the same way as noise impact of other sources. It was found that noise audibility and annoying exposure to it increases once WE objects are visible i. e., visual stimuli strengthen adverse noise effect. The review and analysis of literature sources show that WE generated noise intensity level depends on the aerodynamic flow phenomena and mechanical acoustic noise generation processes of structural elements. Studies show that when identifying acoustic noise of area, it is necessary to consider levels of noise generated by WE and environmental background, the intensity of which is greatly influenced by wind speed. With increase in wind speed, noise level intensifies, however, when wind speed reaches about 12 m/s and the distance to WE tower is greater than 100 m, the noise level generated by WE equals environmental background noise level (Katinas et al., 2014).

<u>Shadowing</u>

In certain geographical and time of day conditions, sun rays fall behind the rotor and cast a shadow. Rotating blades cause a sudden change between light and darkness in shadow casting area, the frequency of which depends on rotation speed of blades influenced by wind speed, size and type of rotor. This phenomenon is typical for northern latitudes and depends on the sun's position in the horizon, wind speed and direction, distance from a power plant to a building, etc. Shadows are formed in northerly direction from WE.

The impact of shadowing caused by WE can be felt by surrounding residents who live at distance up to 2–2.5 km from WE towers. The planned offshore WE park will be at distance of more than 29.5 km from the coastline and the closest buildings, therefore shadowing cannot cause adverse effect to public health.

<u>Infrasound</u>

Infrasound is a sound which is inaudible to human ears and has frequency lower than 16 Hz. Low frequency sound ranges from 16 to 200 Hz. Lower infrasound frequency limit is undefined (~0,001 Hz). Human ears are sensitive to sound of frequency ranging from 20 Hz to 20000 Hz. Ear sensitivity to low frequencies decreases, so infrasound can only be caught as very strong (at 20 Hz frequency, it should be above 70 dB).

Infrasound sources encountered in nature are atmospheric turbulence, wind, thunders, volcanic eruptions, earthquakes, while in industry, they occur as vibrations from vehicles, buildings, WE, low frequency vibrations generated by the machynery; jet engines, explosions, cannon shots, grandiose concerts. Infrasound is absorbed and scattered weakly in air, water, earth's crust, etc., therefore it travels very far. It was found that elephants and whales communicate with each other by infrasound at the distance of several kilometres. Infrasound can only be produced by extremely large animals, therefore these are probably the only animals communicating by infrasound.

The rotating rotor produces infrasound due to unsteady aerodynamic loads of blades (Mažuolis, 2013). The higher rotor rotation speed, the stronger infrasound comes from blade tips. Many of earlier WE rotors are oriented downwind behind a tower, therefore low frequency sound was often recorded. Modern WE turbines are almost always oriented upwind, with blades against a tower.

The planned WE comes with a upwind rotor instalation scheme, therefore wind first flows through the rotor then through the generator, so undisturbed air flow reaches the rotor and thus avoids infrasound formation (SWECO, 2013).

In the course of WE operation, infrasound can be produced due to the same reasons as noise of higher frequency, and can be of mechanical and aerodynamic origin. When evaluating infrasound produced by WE, difficulties arise in the process of distinguishing it from existing infrasound level caused by wind itself.

In Germany and other European countries, there has not been a single case of WE project suspension due to improper infrasound and low frequency sound requirements (SWECO, 2013). There have also been no cases that operating WE exceeded the specified requirements concerning infrasound limits. In European countries, infrasound and low frequency sound produced by WE are not open to debates as it is established by competent experts that modern WE produces only insignificant intensity infrasound.

Electromagnetic field

Electromagnetic field, also known as electromagnetic radiation, is a physical field created by moving electric charges consisting of interconnected and time-changing electric and magnetic fields. Altering electric field creates a magnetic field which also varies in time and creates an electric field. Electric and magnetic fields cannot exist without one another. Such variation in both fields creates electromagnetic fields (hereinafter referred to as EMF).

The sources of EMFcan be both natural and created by human activities. The sources of natural EMF and waves found in nature are electric and magnetic fields of the earth's atmosphere, electromagnetic waves created by atmospheric discharges, electromagnetic radiation coming from the sun and other celestial bodies.

It is very difficult to demonstrate non-specific electromagnetic radiation impact on human health with reasonable certainty because scientific research practically cannot be done by isolation of effects from other potential factors. It is more specifically about effect of strong fields, while consequences of low intensity but long-term effect are viewed rather critically. Electric fields are usually created in environment of high-voltage electricity transmission lines. Electric field located under the three-phase electricity transmission line is the strongest in the middle between two supports, because there is the smallest distance from the ground due to curvature. The strength of magnetic field depends on line load in line surroundings.

EMF intensity is reversely proportional to the square of distance from the source, i. e. electromagnetic radiation spreads and weakens when moving away from the source. When moving away from the source of EMF, both electric and magnetic fields decrease in proportion to the distance what means that several dozens of metres from high-voltage electricity transmission lines electromagnetic field decreases to insignificant values (evaluation and management model of electromagnetic fields generated by electricity transmission lines, NPHSL, 2013).

Under operation of WE, industrial frequency (>0–300 Hz) electromagnetic fields are formed only in the vicinity of high-voltage electrical transformer and transmission installations and in the vicinity of electric generator that, in the case of the analysis, would be high, above the ground, at height from 300 m to 350 m.

Conclusion. Following the review of literature sources and methodological recommendations, the analysis of legislation and other documents, PEA physical pollution (noise, shadowing, infrasound, electromagnetic radiation) that can affect public health is not predicted because there are no residents and other people, especially the most sensitive groups of the population (e. g. children, elderly people and sick people who have the most sensitive reaction to increased pollution) living in the affected area, in the vicinity of the offshore park's installation and operation solutions. PEA demarcated area in the Baltic Sea is at a great distance (29.5–33.7 km) from the shoreline and the environment of buildings of living and public purposes on the shore.

4.8.3. Measures aimed at prevention, reduction and compensation of significant adverse environmental effects

Physical pollution of PEA is unpredicted, so measures necessary to avoid, reduce and compensate environmental impact are not required.

Assessment of impact on public health

Table 4.8.2. Summary table of impact on public health

Component	Stage	Impact	Nature	Scale	Duration	Significance	Measures	Remarks
Public health	Construction	Noise	Direct	Local, at the workplace	Short-term (only during pile driving)	Living environment quality will not be affected	Not applicable	In case of all technological alternatives, PEA demarcated area in the Baltic Sea is at a great distance (29.5–33.7 km) from the shoreline and the environment of buildings of living and public purposes on the shore.
	Operation and maintenance	Noise	Direct	Local, next to WE	Long-term, during operation	Living environment quality will not be affected	Not applicable	
		Shadowing	Direct	Local, next to WE	Long-term, during operation	Living environment quality will not be affected		
		Infrasound	Direct	Local, next to WE	Long-term, during operation	Living environment quality will not be affected		
		Electromagnetic field	Direct	Local, next to WE	Long-term, during operation	Living environment quality will not be affected		
		Energy production	Indirect	National / global	Long-term, during operation	Positive	Not applicable	Indirect impact is positive, because wind is a clean type of energy.
	Termination of operation	Noise	Direct	Local, at the workplace	Short-term (only at the time of work)	Living environment quality will not be affected	Not applicable	

– the impact is positive.

4.9. Material valuables

4.9.1. Current Seause

The feasibilities of developing offshore wind energy are directly related to other activities currently carried out in the marine area, i.e., shipping, navigation routes; fishing; mining sites for excavated soil, potential locations for sand excavation to nourish beaches; offshore engineering installations (power and communication lines, pipelines, etc.) and their safety zones; restricted-use areas (military exercise grounds, sunken ships, dangerous objects, cultural heritage values); marine areas for conservation purposes; other potential activities (prospect sites of useful resources). In order to rationally use marine areas and sea resources, it is important to coordinate basic and projected activities with interests of sea users. It should be noted that the installation of the offshore wind farms will significantly contribute to the implementation of objectives of the Lithuanian Energy Independence Strategy.

4.9.1.1. Fishing

Based on the classification by the International Council for the Exploration of the Sea, Lithuania's marine territory falls within statistical quarters 41H10, 40H10, 40G9, and 39H10 of subdivision 26 of ICES fishing area where fish is caught with trawls and trap nets. The PEA area falls within statistical quarters 41H10 and 40H10 which accommodate trawling areas (Fig. 4.9.1.).

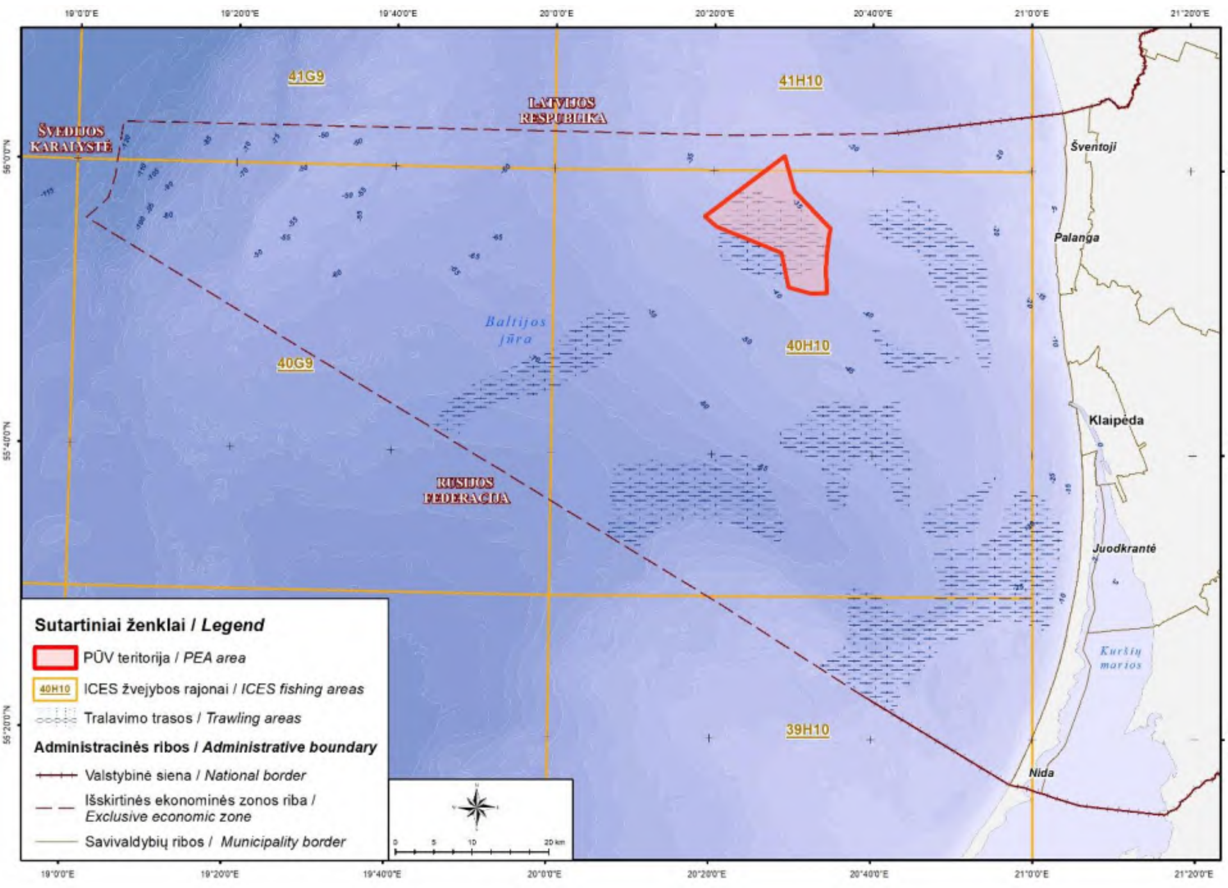


Fig. 4.9.1. Fishing areas.

The distribution and density of trawling in the PEA area has been assessed based on the data of the Automatic Identification System (AIS) of vessels collected for the period of 2012–2021. The data contains information about the geographical coordinates (latitude, longitude), travel speed (knots), travel direction (degrees), and data transmission time of each fishing vessel registered in Lithuania or abroad. Since April, 2014, in the EU, the use of this system is mandatory for fishing vessels over 15 meters.

During the voyage, this information is transmitted from the ships through the system installed on the shore in Klaipėda and Liepaja at intervals of a few seconds or minutes depending on the ship's travel speed. ICES and HELCOM use a grid of 0.05 degrees (about 15 km^2) to analyze the data collected by the vessel monitoring system (VMS) at 1–2-hour intervals. AIS data collected at 5-minute interval using a grid of 0.005 degrees (about 0.15 km^2) has been used to determine trawling events of fishing vessels and their location in the PEA area. The assessment of the structure and sizes of the catch has been carried out using the data of the Integrated Fisheries Information Management System (FIMS) of the Fisheries Service on the VMS fishing location and by analyzing the ship voyage reports. The catch of vessels registered abroad has been evaluated by extrapolating the data of catch of vessels registered in Lithuania and fishing effort.

The density of trawling in the PEA area was evaluated in the period of 2012–2021. As the installation of mandatory vessel monitoring system has just commenced, the trawling data for 2012 only partially represents fishing density and distribution. The data for 2013–2018 (see Fig. 4.9.2–4.9.10) demonstrates active fishing in the PEA area using bottom otter trawls (OTB) as well as low-density fishing using midwater otter trawls (OTM) and set gillnets (GNS). More than 3 numbers of time cell swept or 100% relative trawling area for each grid element (i.e., the entire grid area is trawled more than once per year) has been recorded in 28.1% to 51.5% of the PEA area.

However, after the European Commission banned commercial fisheries for cod in the Baltic Sea (ICES sub-rectangles 24-26) from July 23, 2019, the density of fishing in the PEA area has changed drastically and only 2.4 trawling hours were registered during the calendar year. Fishing potential in the Baltic Sea in 2020 – the European Council has set a by-catch quota for Eastern Atlantic cod, while fishing for other species of fish – 2000 t (for vessels registered in Lithuania – 113 t). Once the by-catch quota is covered, all fishing, where cod by-catch is known, is suspended. In 2020, fishing companies were also granted support from the European Maritime and Fisheries Fund for the temporary cessation of fishing activities in accordance with the Order No. 3D-723 of the Minister of Agriculture of December 20, 2019. Although trawling has been registered again in the PEA area during this period, both fishing density and fishing effort have significantly decreased compared to the period before fishing restrictions. In 2021, the by-catch quota for Eastern Atlantic cod was further reduced to 595 t by the agreement of the European Council (for vessels registered in Lithuania – 36 t), therefore, fishing with bottom trawls in the PEA area has stopped, and, in 2021, only pelagic species – Baltic herring and Atlantic sprat – prevailed in the catch caught in the area.

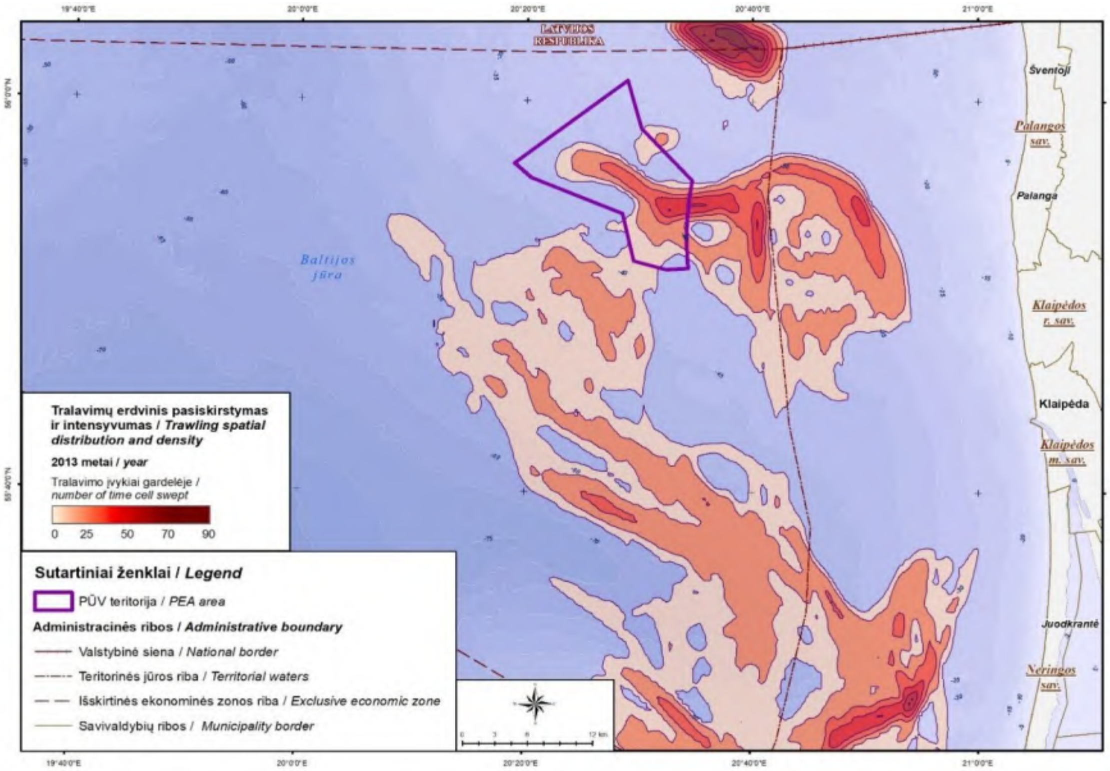


Fig. 4.9.2. Trawling density in 2013.

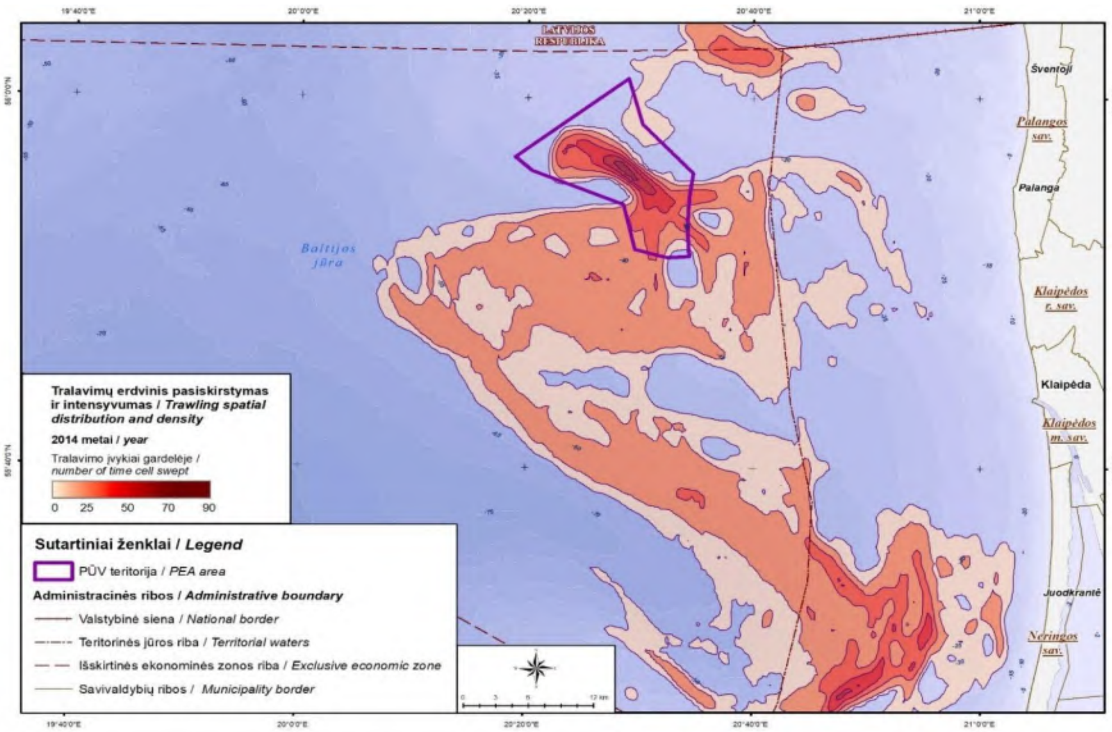


Fig. 4.9.3. Trawling density in 2014.

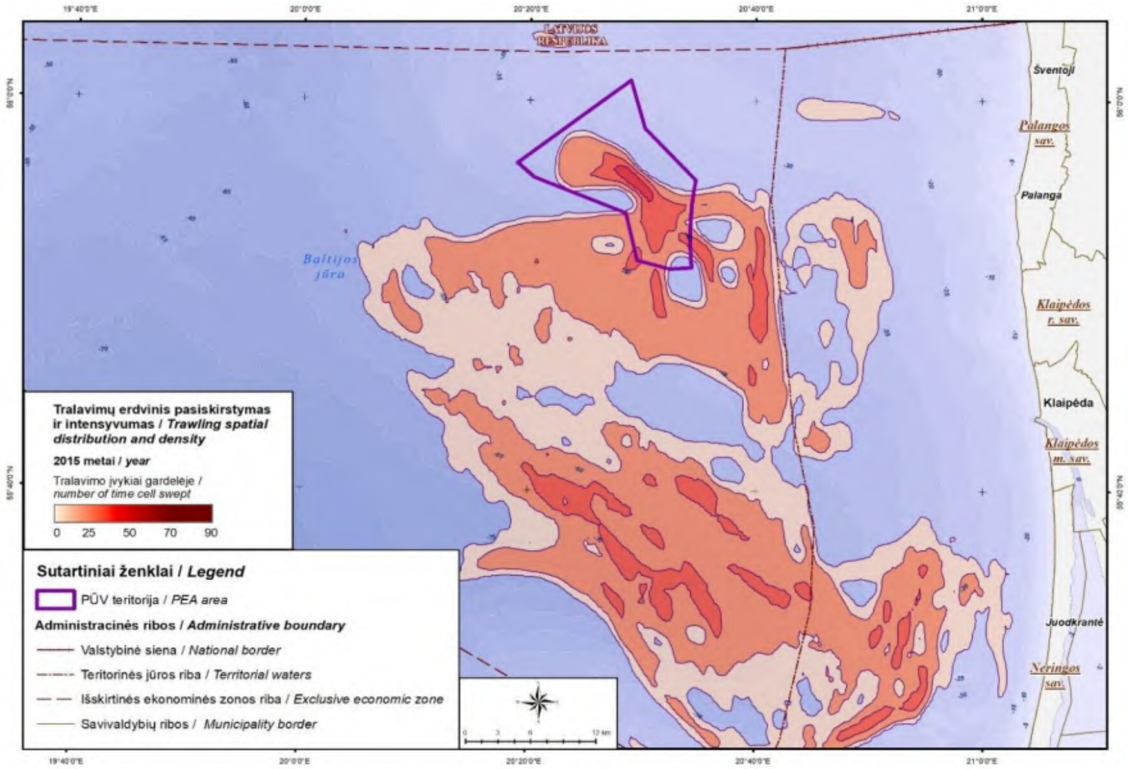


Fig. 4.9.4. Trawling density in 2015.

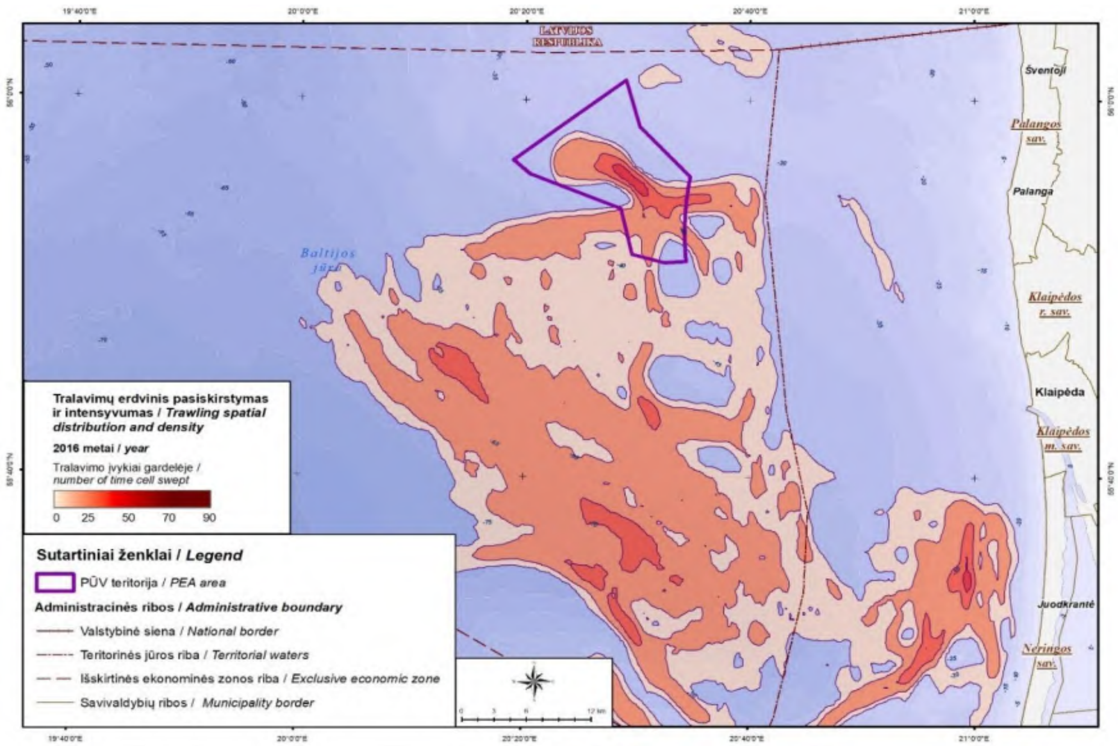


Fig. 4.9.5. Trawling density in 2016.

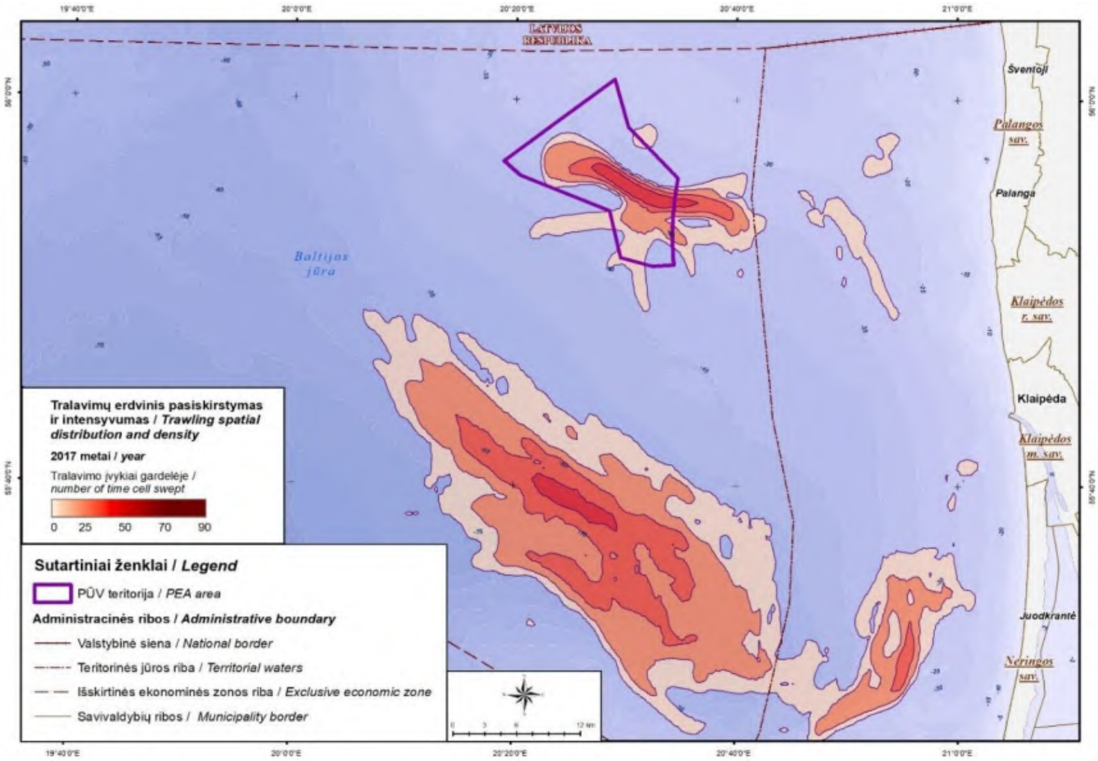


Fig. 4.9.6. Trawling density in 2017.

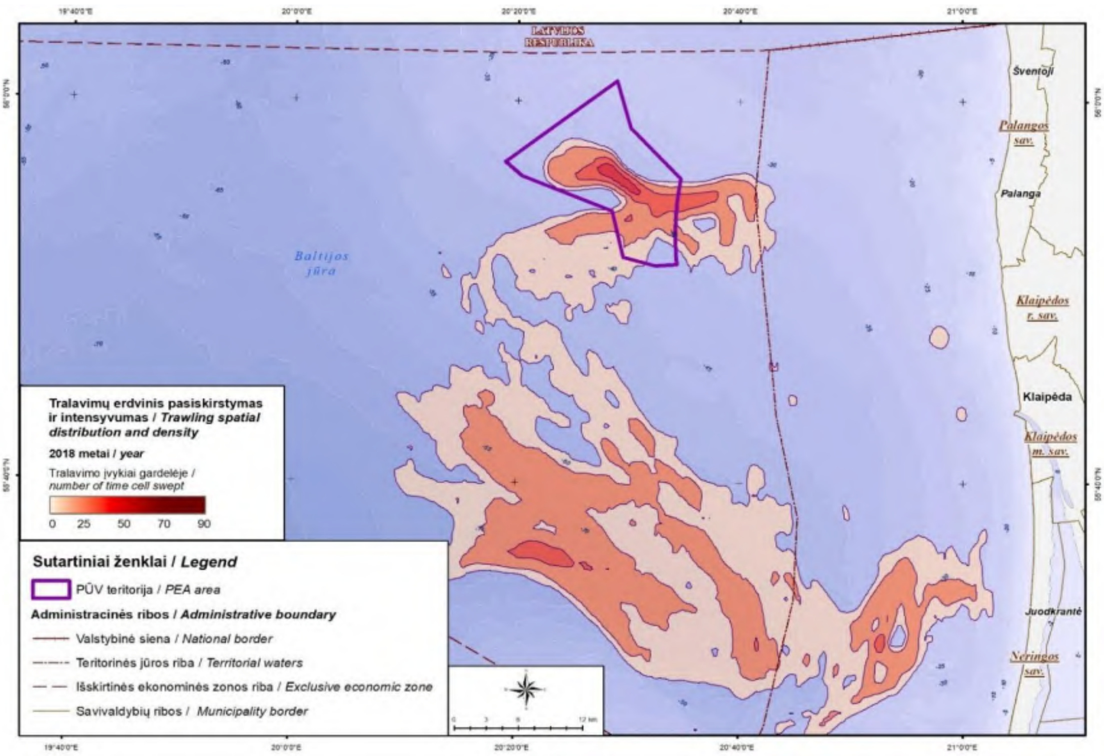


Fig. 4.9.7. Trawling density in 2018.

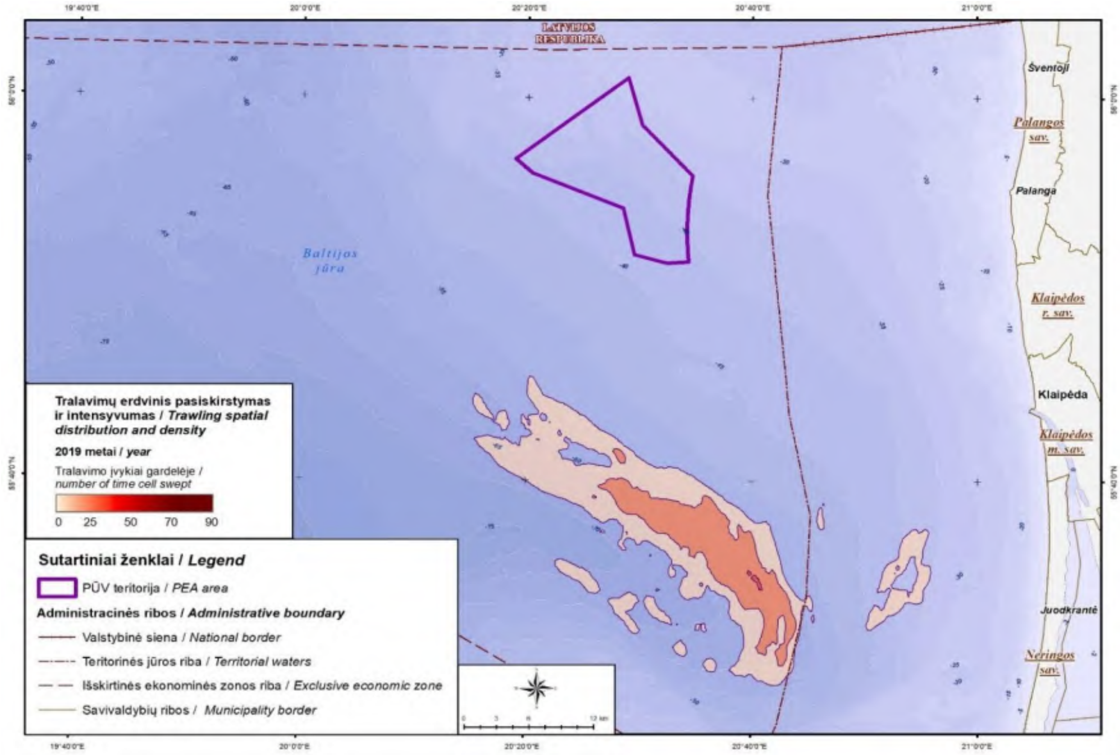


Fig. 4.9.8. Trawling density in 2019.

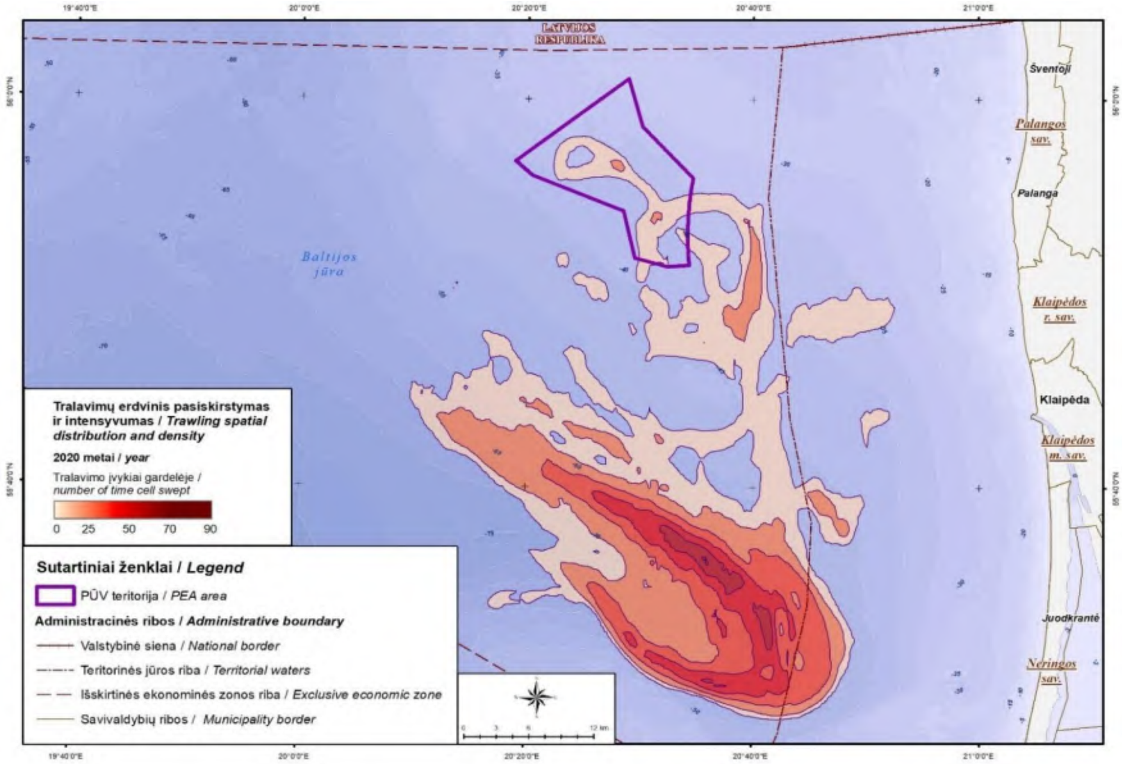


Fig. 4.9.9. Trawling density in 2020.

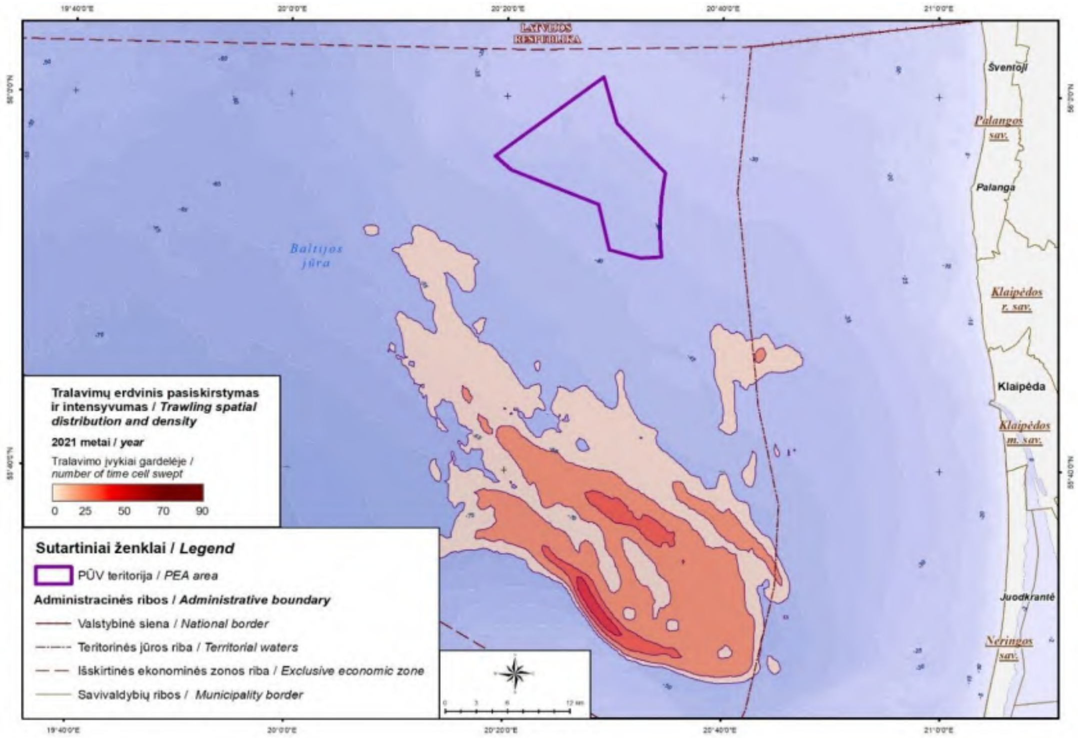


Fig. 4.9.10. Trawling density in 2021.

In the period of 2015–2018, 9 vessels registered in Lithuania and 14 fishing trawlers registered in neighboring foreign countries (Latvia and Russia) fished with trawls in the PEA area. In 2015–2017, in terms of fishing effort, foreign vessels prevailed in the PEA area with a share of 52-87% of the total fishing effort. From 2018, the trawling intensity has redistributed in the PEA area, and the registered share of trawlers registered in Lithuania accounted for 63–100% of the total fishing effort in the area.

Table 4.9.1. Trawling by trawlers of different countries (annual trawling hours)

Vessel registration state	2015	2016	2017	2018	2019	2020	2021
Lithuania	13.5%	21.7%	**48.4%**	**62.7%**	**100%**	**83.9%**	**100%**
Latvia	**60%**	**53%**	**48.4%**	37.3%	-	16.1%	-
Russia	26.5%	25.3%	3.2%	-	-	-	-

Based on the extrapolated catch statistics data for 2015–2021, the main commercial fish species in the catch in the PEA area was the Baltic flounder. The average catch of the Baltic cod in the PEA area in 2015–2018 was about 60 t and accounted for 56-83% of the total fish catch in the area. The Baltic flounder is the only one of the commercial fish species, the catch of which made up a slightly more considerable portion of the total allowable catch (TAC) agreed by the European Commission and in 2015–2018 accounted for 0.8–1.8%. After the restrictions on the Eastern Baltic cod fishing and its by-catch introduced by the European Commission in 2019, the exclusive economic zone (EEZ) of the Republic of Lithuania has lost its importance in the PEA area as one of the most intensive bottom trawling areas. Although 15.7 t of the Baltic flounder were caught in the area in 2019–2020, they were no longer registered in the total catch of 2021.

Table 4.9.2. Trawling performance and catches in the PEA area.

Year	Intensively used part of the PEA area	Trawling hours in the area	Extrapolated catch per the PEA area
2015	50.7%	510	Baltic cod – 4,840 kg Baltic flounder – 59,220 kg Baltic herring – 12,860 kg
2016	41.2%	400	Baltic cod – 12,050 kg European flounder – 60,590 kg
2017	33.8%	392	Baltic cod – 3,250 kg Baltic flounder – 60,130 kg
2018	38.2%	322	Baltic cod – 4,760 kg Baltic flounder – 60,460 kg Atlantic herring – 9,860 kg Atlantic sprat – 33,730 kg
2019	0	3.6	Baltic flounder - 300 kg
2020	1.5%	133	Atlantic cod – 1,960 kg European flounder – 15,400 kg Atlantic herring – 230 kg
2021	0	2,5	Atlantic herring – 640 kg Atlantic sprat – 7 kg

The other two dominant species in the total catch in the PEA area are the Baltic cod and the Baltic herring. The Baltic cod, together with the Baltic flounder, were caught with bottom trawls, and their catch in 2015–2018 amounted to 3.2–12 t. Midwater otter trawl (OTM) fishing in the area was registered in 2015, 2018, and 2020–2021. Pelagic fish species – the Baltic herring and the Atlantic sprat – are caught in the Baltic Sea with these fishing gears. The best catch of the Baltic herring in the PEA area was registered in 2015 (12.9 t), of the Atlantic sprats – in 2018 (33.7 t), but it was insignificant (<0.1%) in terms of the total allowable catch.

4.9.1.2. Shipping

2 main 4-nautical-mile-wide navigation routes have been established in Lithuania, which were approved in HELCOM Copenhagen Declaration and officially mapped out in 2001. Two main shipping lanes that are most intensively used in the Lithuanian marine territory include the navigation line to/from the port of Klaipėda and to/from the Būtingė Oil Terminal. About 7,000 ships arrive at the port of Klaipėda every year (6,453 in 2020). The Būtingė Oil Terminal only service tankers. Their number, compared to the number of tankers arriving at the port of Klaipėda, is small and amounts to about 90–100 vessels every year.

The PEA area is outside the established international shipping routes, roadsteads, or anchorage sites; neither is it bordering them. A cartographic comparison of the PEA area with the defined water areas of Klaipeda State Seaport, Šventoji Port, and Būtingė Terminal, anchorage sites, and shipping corridors is presented in Fig. 4.9.11. below.

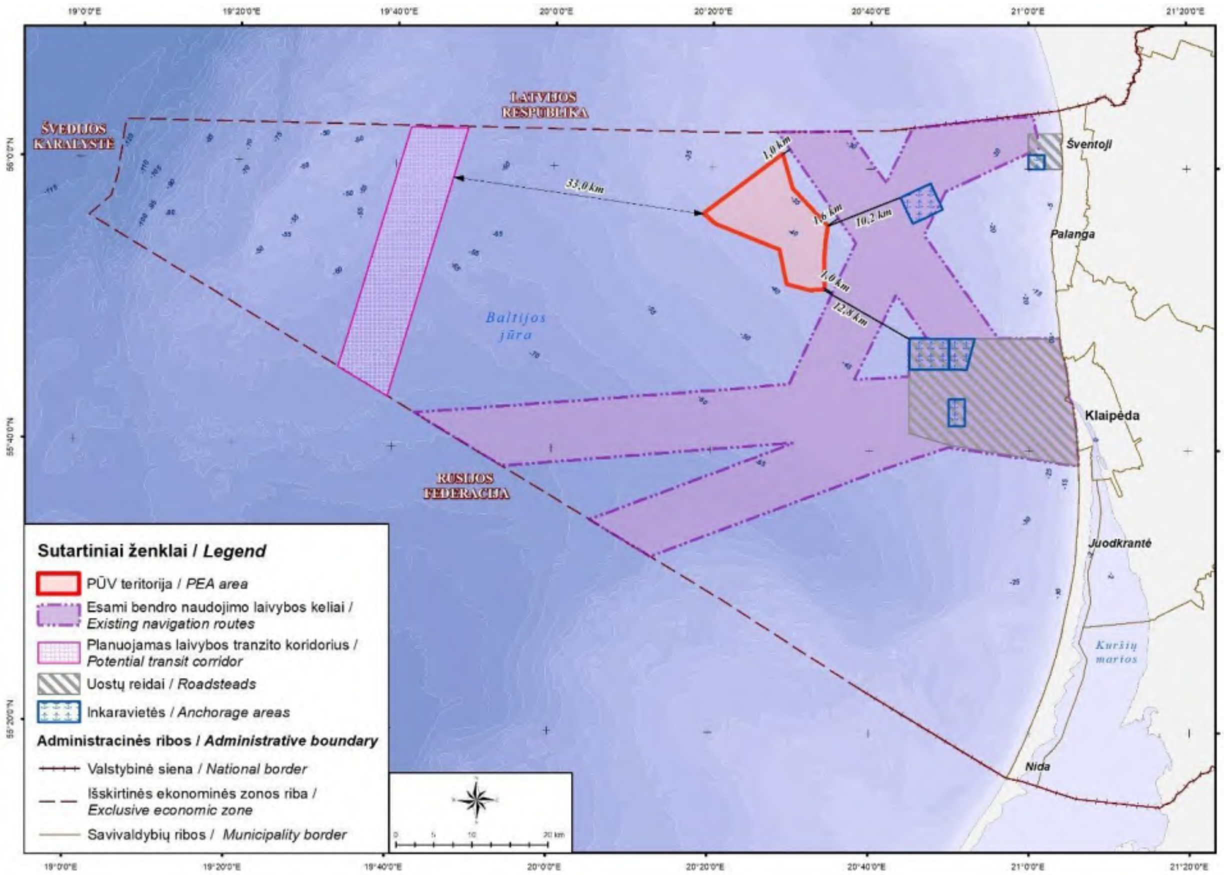


Fig. 4.9.11. Navigation routes, roadsteads, and anchorage areas.

4.9.1.3. Soil Dumping at Sea

There are a few offshore dumping sites where the soil, excavated in the Klaipėda port waters, is dumped. A deep-water dumping site, with an area of 4 square nautical miles (i.e., approx. 13.87 km^2), is 11 nautical miles (i.e., approx. 20.37 km) away S-W from the port gate at a depth of 43-48 m. The dumping site was put into operation in 1987. All the types of soil dumped in this area, i.e., sand, silt, moraine, are excavated during dredging.

Another site for dumping of sandy soils (fine sand and silty sand) is ~6 nautical miles (i.e., approx. 11.11 km) away N-W from the port gate at a depth of 25-30 m.

A coastline nourishment with sand was started in 2001. For this purpose, a section of the coastline with coordinates 55°47'00'' to 55°45'20'' was chosen. The sand was poured at a depth of approx. 5 m. In total, about 400 thousand m³ of sand was poured out in this section of the coastline.

The existing offshore soil dumping sites are more than 20 km away from the PEA area (Fig. 4.9.12).

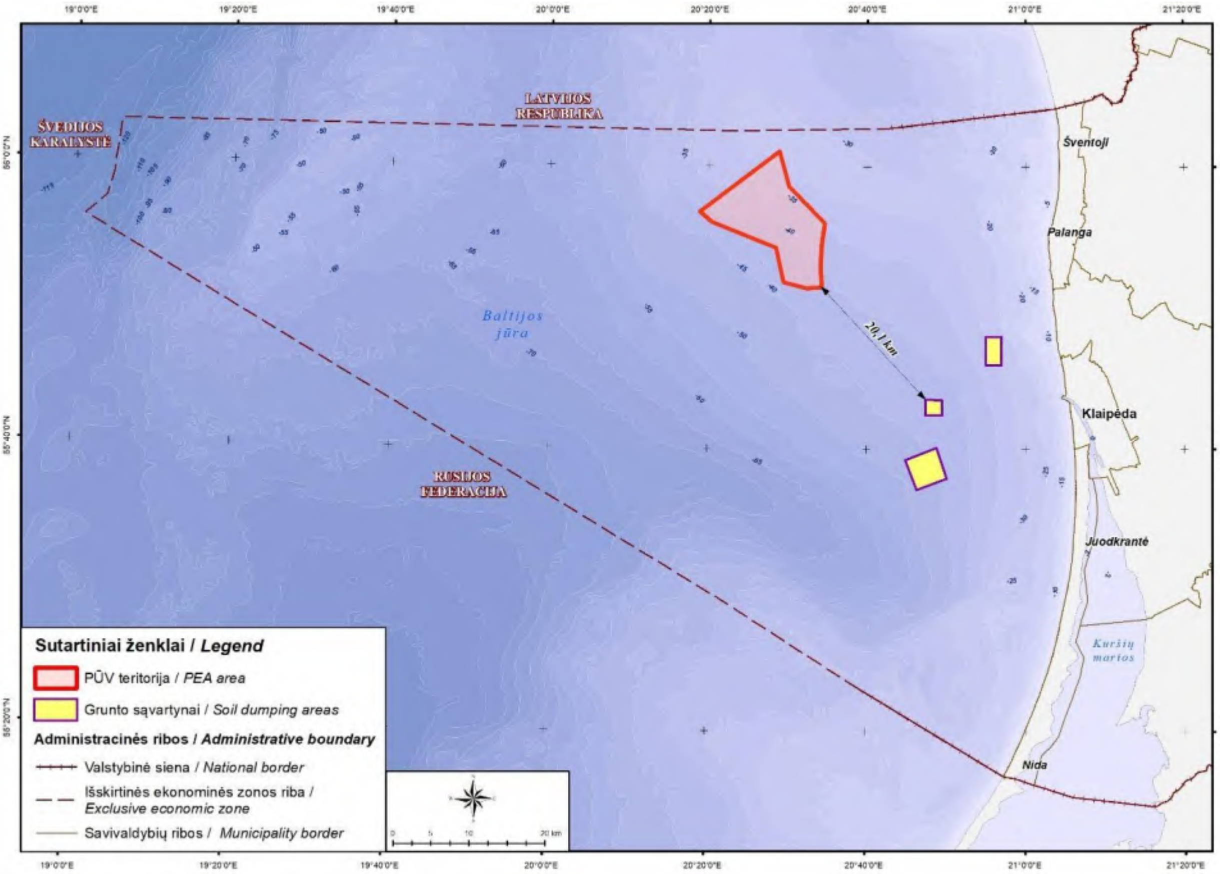


Fig. 4.9.12. Existing offshore soil dumping sites.

4.9.1.4. Recreational Resources

Swimming zones at the beaches of Šventoji settlement and Palanga town were legalized by Order No. A1-559 of Director of Palanga Municipality Administration of July 22, 2010 on Establishment of Swimming Zones at the Palanga Beaches.

Klaipėda beaches by the Baltic Sea were legalized by Order No. AD1-592 of Director of Klaipėda City Municipality Administration of March 21, 2012 on Legalization of Klaipėda City Beaches. The most-visited beaches in Klaipėda district are the ones next to Karklė.

A distance from the PEA area to the nearest recreational areas and beaches of Palanga Municipality is approx. 29.5 km (Fig. 4.9.13).

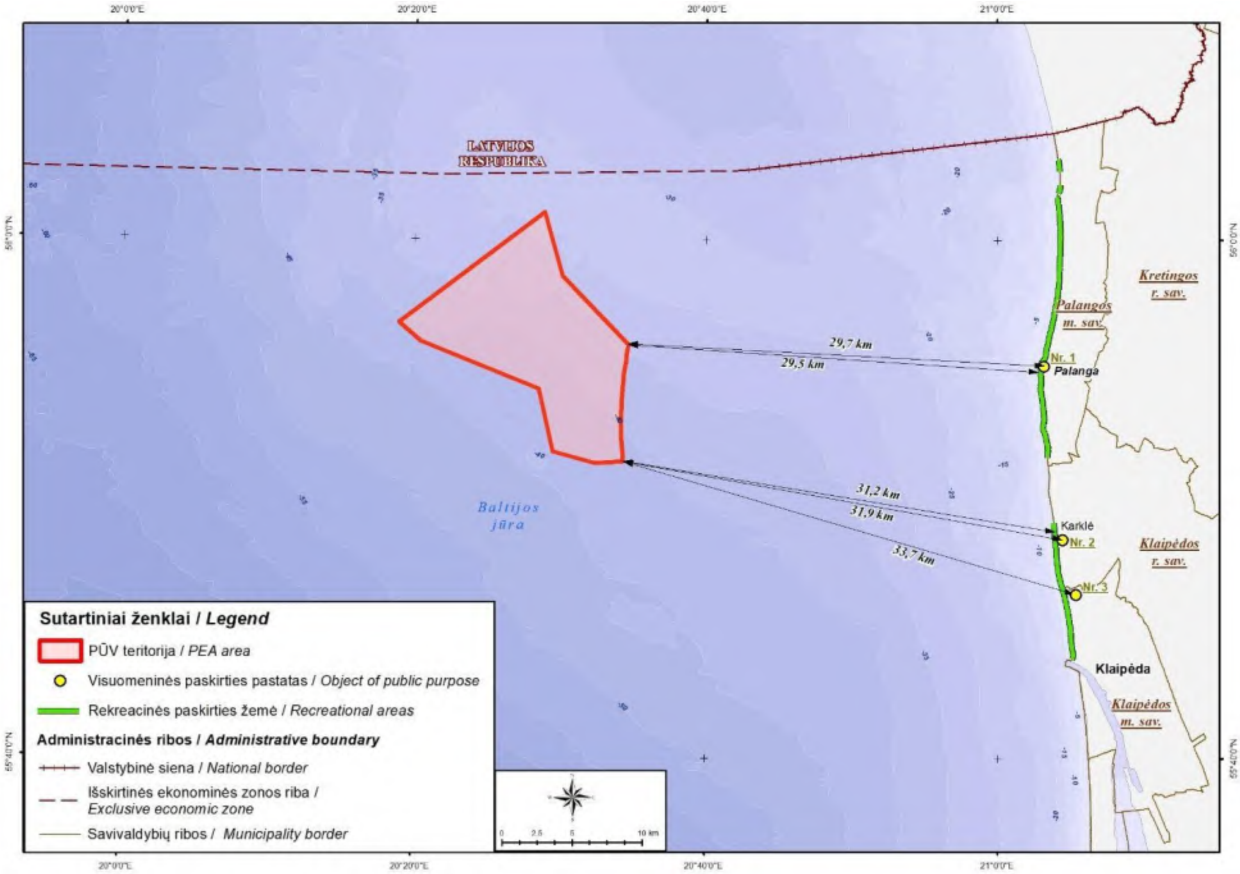


Fig. 4.9.13. Residential and recreational areas in coastal municipalities.

There are nautical tourism services beginning to emerge at the Lithuanian seaside. Nautical tourism is defined as an individual paid service of travel by sea for tourists which needs special infrastructure, i.e., adapted embankments, roads, pedestrian (bicycle) tracks, a specially designed area for tourists, buildings, parts thereof, facilities, and other objects of similar purpose, intended to meet the needs of inbound, outbound, and local tourism in nautical tourism facilities situated in Lithuania's territorial waters and their surrounding areas. Based on this definition, the following most frequent nautical tourism services are identified in the Lithuanian seaside: cruise shipping, inland tourist shipping, recreational fishing, and sea diving services.

There are several diving clubs in Klaipeda region which offer recreational diving services in the Baltic Sea. The best diving destinations in the Baltic Sea are wreck dives and tours to expressive elevations at the bottom of the sea (moraine ridges). According to the diving club OCTOPUS, diving usually takes place in coastal waters. The most popular diving spots are more than 20 km away from the PEA area (Fig. 4.9.14).

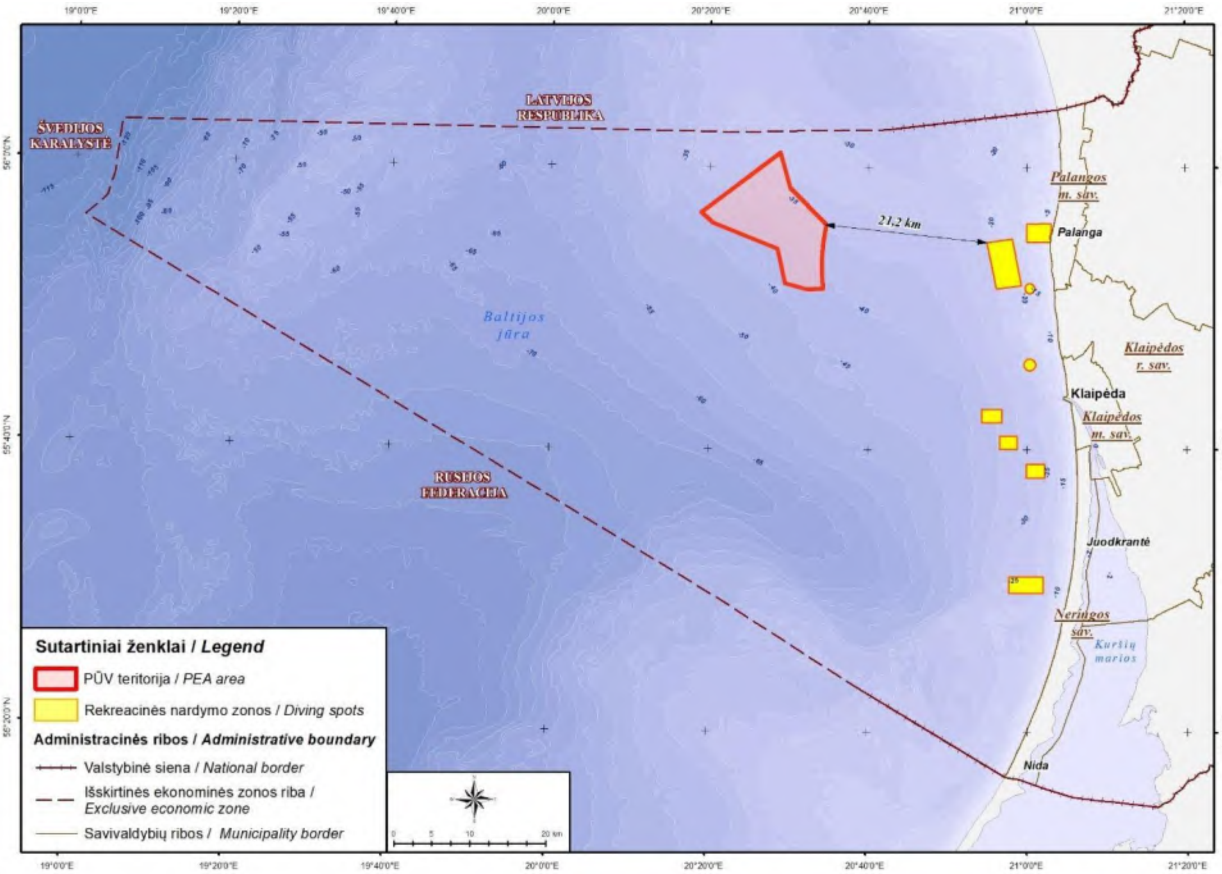


Fig. 4.9.14. The most popular diving spots.

4.9.1.5. Engineering Infrastructure

In Lithuania's marine territory of the Baltic Sea, there have been two types of engineering infrastructure identified: a pipeline complex, including the single point mooring (SPM) buoy at the Būtingė Terminal, and submarine cables.

The 7.3 km long pipeline at the Būtingė Oil Terminal, which connects an underground onshore pipeline with a tanker mooring buoy, is used for oil product handling operations at Orlen Lietuva, AB. Coordinates of location and safety area of the Būtingė Terminal's oil pipeline and buoy (SPM) are provided in the Būtingė Oil Terminal Shipping Rules[23]. The terminal has a water area allocated thereto, within a radius of 1,000 meters around the SPM buoy, and a safety area of 300 meters on each side of the oil pipeline.

The Exclusive Economic Zone is intersected by the following four submarine cable lines: 2 telecommunications cable routes, with the starting point in Šventoji, Lithuania, owned by TeliaSonera, AB (according to: International Cable Protection Committee); that is:

- The 218 km long BCS East-West interlink route (ready for service since 1997) connecting Šventoji with Katthammarsvik, Sweden;
- The 97.8 k long BCS East (ready for service since 1995) connecting Šventoji with Liepaja, Latvia;

An origin of the other 4 cable routes crossing the Lithuanian EEZ South to North and Southwest to Northeast, marked on navigation maps, is unknown.

[23] The Shipping Rules have been approved by the Order No. 3-248 of the Minister of Transport and Communications of the Republic of Lithuania of September 18, 2000 on Approval of the Būtingė Oil Terminal Shipping Rules.

In the central part of the water area, from Klaipėda, via the Curonian Spit, and further towards the Swedish EEZ, there has been a NORDBALT link constructed, that is, a 450 km long, 700 MW high-voltage DC submarine and underground cable.

On December 21, 2018, CEOs of Lithuanian and Polish transmission system operators Litgrid, AB and PSE signed an agreement on commencement of the project of construction of new Polish-Lithuanian submarine HVDC cable – HARMONY Link. The Government of the Republic of Lithuania, by Resolution No. 720[24] of September 01, 2021, approved the engineering infrastructure development plan for the special state importance energy system synchronization project "Construction of Harmony Link Connection and 330 kV Darbėnai Switchyard." It presents a route for the proposed offshore connection HARMONY Link.

The PEA area does not fall within the areas of the existing and proposed engineering infrastructure (Fig. 4.9.15).

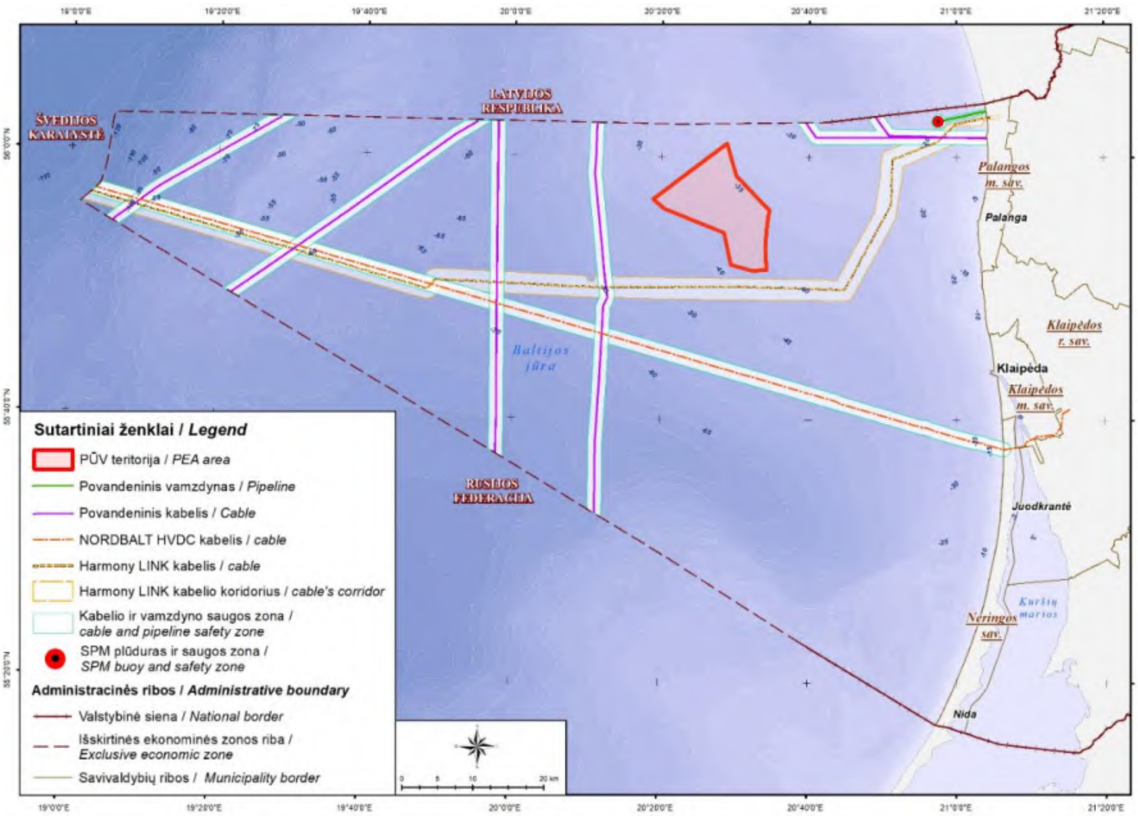


Fig. 4.9.15. Existing and proposed engineering facilities in the marine territory.

4.9.1.6. Restricted-Use Areas and Danger Zones at Sea

Part of the PEA area is within the danger zone at sea, i.e., former minefields (Fig. 4.9.16.).

In Lithuania's territorial sea and the Exclusive Economic Zone, there are several restricted-use, military exercise grounds, a water area with wrecks of World War II munitions, and former minefields of quite a large area. It is possible to carry out economic activities in the said territories, however, a prerequisite is to conduct seabed surveys in search of hazardous objects and, if necessary, to carry out decontamination of hazardous objects before the implementation of technical design solutions.

[24] Resolution of the Government of the Republic of Lithuania No. 720 of September 01, 2021 on Approval of the Engineering Infrastructure Development Plan for the Special State Importance Energy System Synchronization Project "Construction of Harmony Link Connection and 330 kV Darbėnai Switchyard." https://www.e-tar.lt/portal/lt/legalAct/876d697011ff11ec9f09e7df20500045.

Information about a chemical weapon dumped in Lithuanian water area. The official nautical charts, which are updated annually by the Maritime Department of the Lithuanian Transport Safety Administration (formerly the Safe Navigation Administration of Lithuania), mark the area in the westernmost part of the Lithuanian EEZ, the Gotland Deep. In this area, it is recommended not to anchor ships and not to fish with bottom trawlers. Munitions containing mustard gas, tear gas, asphyxiation ingredients, and other chemical warfare agents are believed to have been buried in this area (HELCOM, 1995).

According to the data provided by the Ministry of Environment of the Republic of Lithuania, monitoring stations have been established in the area of the sunken chemical weapon and monitoring of the state of the environment is being carried out. Conducted studies:

- In 2002–2004, the Environmental Protection Agency (EPA) carried out deep-sea exploration and identified 39 objects. Higher concentrations of arsenic were found at the area with wrecks of World War II munitions.
- In 2011–2014, the CHEMSEA Project was carried out with the participation of the EPA. Bottom sediment and benthic material samples were taken. It was established that macrozoobenthos species decreased significantly compared to the results of previous studies (from 10 in 1981–1993 to 3 in 2013), components of chemical weapons were found in bottom sediments.
- In 2013–2015, the MODUM Project was carried out, the purpose of which was to create a monitoring network at the areas with wrecks of World War II munitions.
- In 2015–2019, the DAIMON project was carried out, during which the condition of areas with wrecks of World War II munitions was determined, the potential release of chemical weapon components into the environment was modeled, sediment and water pollution as well as effects of contamination on the biota were analyzed, risk was assessed. Benthic material samples were taken. No living microorganisms were found at the area with wrecks of World War II munitions. *Limecola balthica*, a saltwater clam, which is widely distributed throughout the Baltic Sea, was found only in one of the five sampling sites. Arsenic concentrations were analyzed.
- In 2020, a new DAIMON 2 Project has started, the results of which are not yet available.

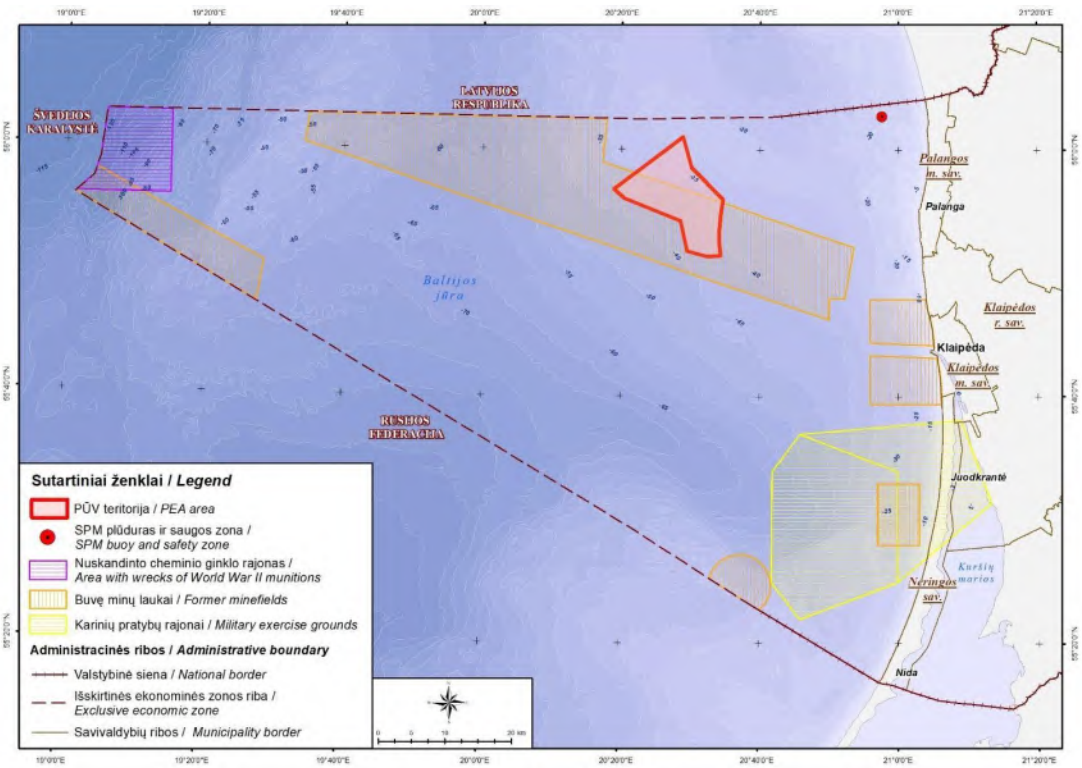


Fig. 4.9.16. Restricted-use areas and danger zones.

4.9.1.7. Important National Security Areas

Based on the Methodology for mapping of territories of the Republic of Lithuania where design and construction of wind power plants may be subject to restrictions in relation to national security, a map of the territories of the Republic of Lithuania, where wind power plant (high-rise buildings) design and construction works may be subject to restrictions[25], has been developed and approved. The PEA area is a part of the areas where construction sites for wind power plants are subject to coordination provided that a manufacturer of energy from renewable resources signs a contract with the Lithuanian Armed Forces on part of the investment and other costs (Fig. 4.9.17.).

Pursuant to Article 49(19) the Law of the Republic of Lithuania on Energy from Renewable Sources, "Locations for the construction of wind power plants in the areas that are be subject to special land use conditions in relation to national security in accordance with the Law of the Republic of Lithuania on Special Land Use Conditions shall be agreed in advance, in the course of territorial planning, and when the territorial planning document is not prepared, - until the issuance of the document authorizing the construction, within the terms set in Article 10(4) of the Law on Public Administration, with the Commander of the Lithuanian Armed Forces and other institutions according to a procedure prescribed by law and other legislation. A location for the construction of a wind power plant is not approved if disturbances to be caused by the planned wind power plant cannot be avoided through the use of additional measures. Should it be determined that disturbances to be caused by the planned wind power plant can be avoided through the use of additional measures, the location shall be approved on condition that the person planning to construct or install the power plant will submit to the institution specified in the conclusion on the agreement to the issue of the building permit, no later than prior to the issue of the building permit, an approved construction project, will enter into agreement with the said institution on a payment of compensation for part of the investments and other costs incurred in securing the national security functions, and will provide a security of discharge of the said obligation. The size of the compensation shall be determined by multiplying the power plant capacity (kW) stated in the authorization to develop electricity generating capacities by EUR 18/1 kW. The procedure for the payment of the compensation shall be established by the Government. The compensations shall be used according to a procedure prescribed by law as other funds of institutions financed from the state budget that have not been received as state budget appropriations."

[25] Approved by Order No. V-217 of the Commander of the Lithuanian Armed Forces of February 15, 2016 on Approval of Methodology for Mapping Territories of the Republic of Lithuania Where Wind Power Plant (High-Rise Buildings) Design and Construction Works May Be Subject to Restrictions.

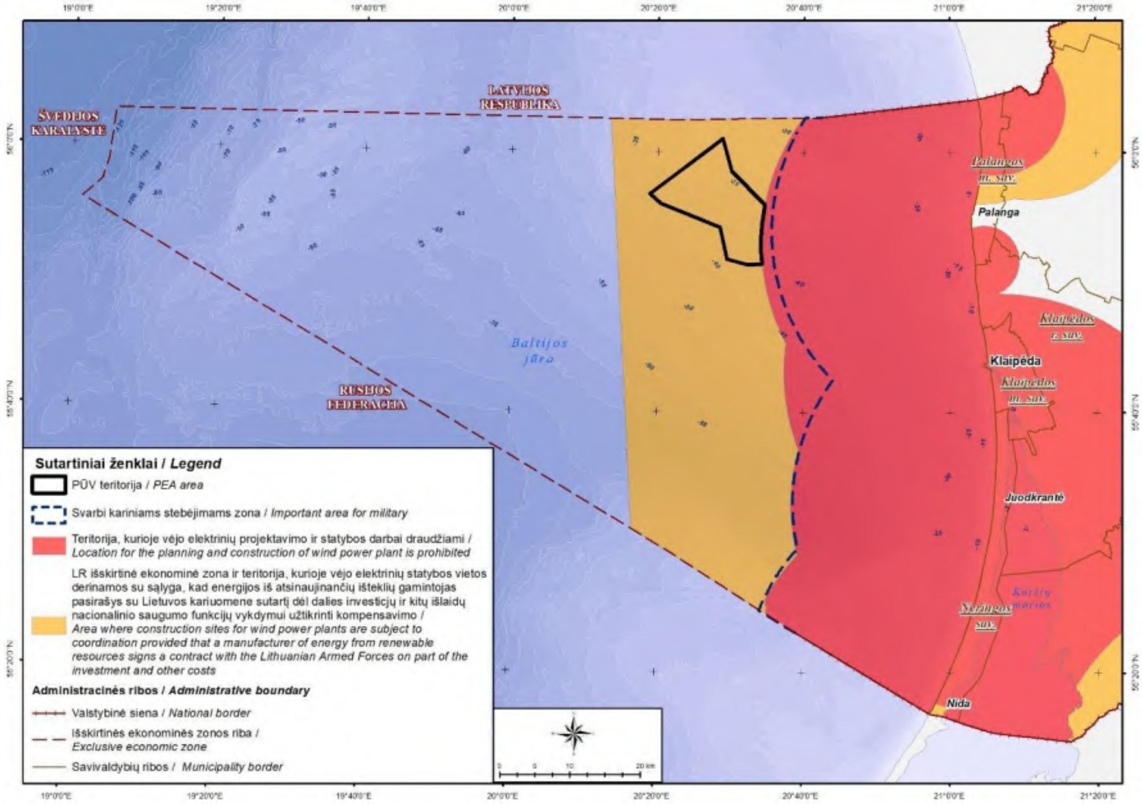


Fig. 4.9.17. National security requirements (basis: the Map of the territories of the Republic of Lithuania, where wind power plant (high-rise buildings)).

In November 2022, the order of the Commander of the Lithuanian Armed Forces "Regarding the approval of maps of areas where construction restrictions are applied, taking into account national security requirements, and military radar protection zones" has not yet been approved (02/02/2023). The analyzed territory of the marine WE park does not fall within the protection zone of military radars provided on the maps (Figure 4.9.17.1), but part of the territory falls within the planned territories where, taking into account the requirements of national security, construction restrictions are applied (Figure 4.9.17.2).

According to Article 135, Part 1 of the Law on Special Land Use Conditions, it is prohibited to build, reconstruct or install wind turbines in territories where, taking into account the requirements of national security, construction restrictions are applied, without the approval (harmonization) of the project by the Commander of the Lithuanian Armed Forces and other institutions ensuring national security in accordance with the procedure established by the Government power plants. In this way, the approval (coordination) of the Commander of the Lithuanian Armed Forces and other institutions ensuring national security will have to be obtained for the installation of WE in the part of the area of the marine WE park that falls within the territories where construction restrictions are applied taking into account national security requirements. The conditions for coordination of wind power plant construction sites with the Commander of the Lithuanian Armed Forces and other institutions ensuring national security are set out in the Renewable Energy Law.

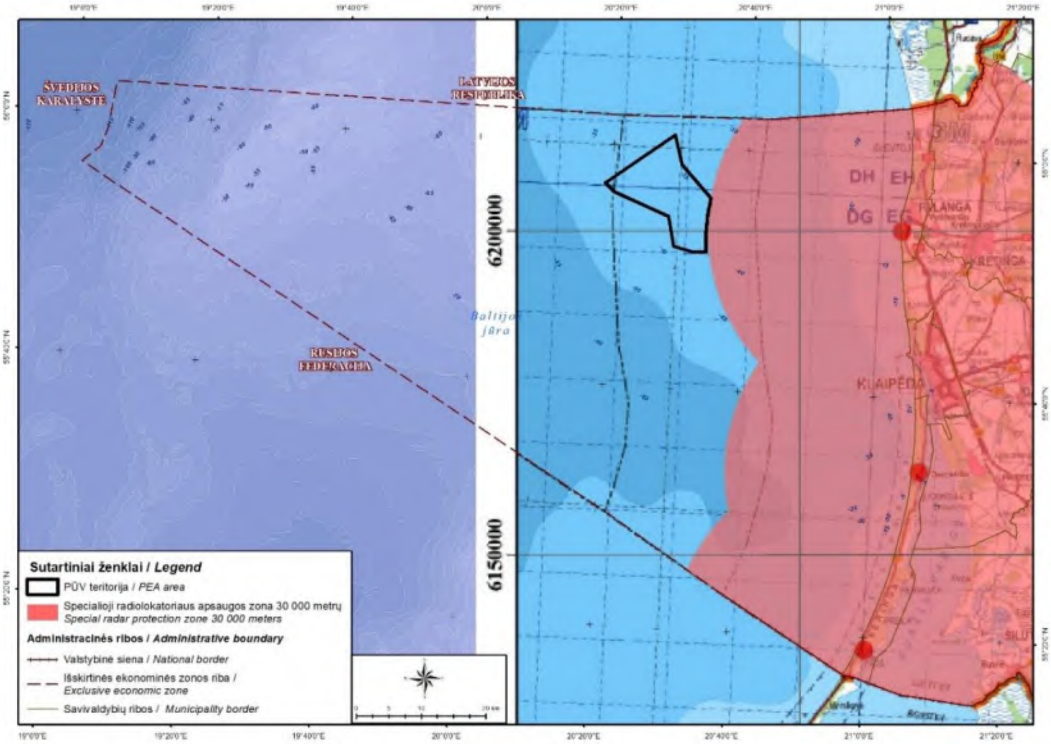


Fig. 4.9.17.1. Possition of the planned marine WE park in relation to the expected radar protection zones (basis: Map of radar protection zones (unconfirmed)).

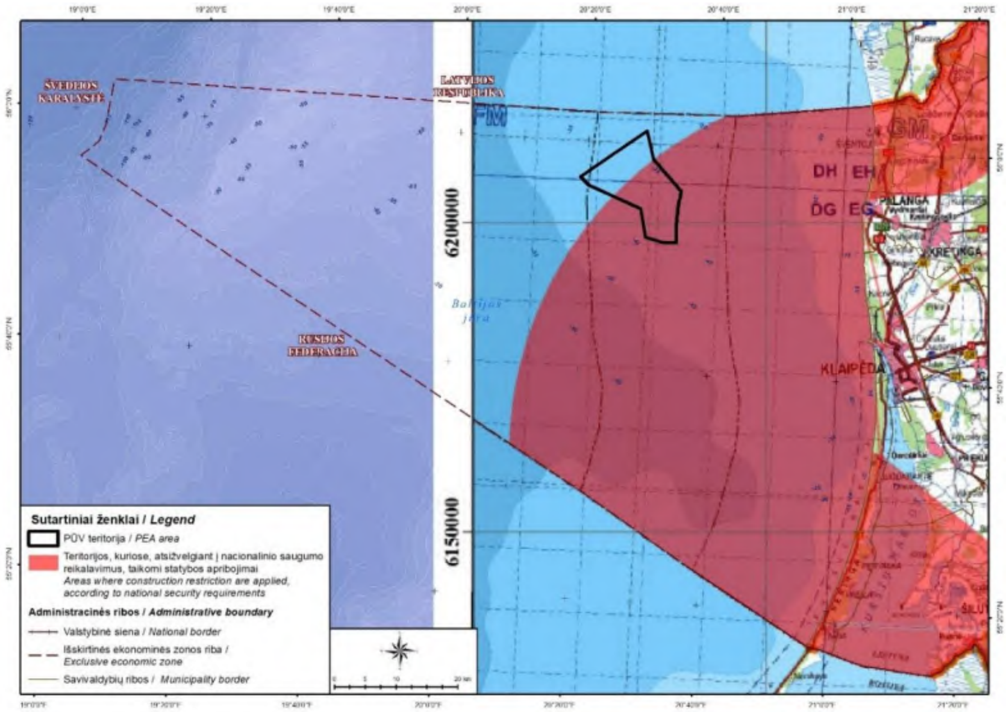


Fig. 4.9.17.2. Position of the planned WE park in relation to the planned areas where construction restrictions are applied taking into account national security requirements (basis: map of areas where construction restrictions are applied taking into account national security requirements (not approved)).

4.9.2. Potential Significant Impact During the Wind Farm Installation, Operation, and Dismantling Phases

4.9.2.1. Impact on the Energy Sector

The key objective of the Lithuanian National Energy Independence Strategy in the area of renewable energy sources (RES) is to further increase a share of RES in Lithuania's domestic energy production and total final energy consumption, thus reducing dependence on imported fossil fuels, and increasing capacities of local electricity generation. Implementation of this strategic objective will aim at gradual increase of RES share, compared to the national total final energy consumption: by 2030 – 45%, by 2050 – 80%. Energy from renewable energy sources will become the main energy in all sectors, including electricity, heating and cooling energy and transport.

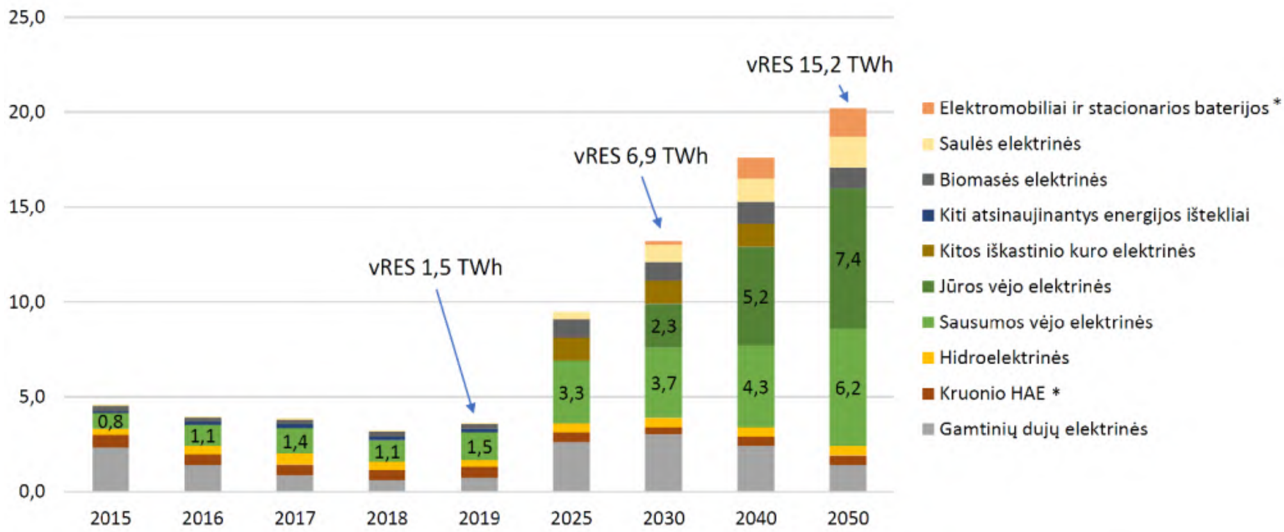


Fig. 4.9.18. Annual production of electric energy in Lithuania (*Source: Litgrid, DNV GL, 2020*). *In the illustration: vRES (variable Renewable Energy Sources), or RES – onshore and offshore WT, solar power plants*. * Electric vehicles, batteries, and Kruonis Pumped Storage Plant (PSP) as also assessed in the demand forecasts. The chart above presents production as supply of energy into the network.

The primary objective is to ensure the origination of the planned number of RES generators, which is related to the energy policy, including the subsidy schemes and market regulatory legislation. Until 2030, major attention will be paid to the first Lithuanian wind turbine farm in the Baltic Sea, which should be connected to the Lithuanian electricity transmission network by 2030 (Litgrid, DNV GL, 2020).

The growing generation from RES increases instability in supply in prices, periods of extremely high and low prices, which, thus, requires the application of flexibility measures. Synchronizing the network with European network by 2025 will provide the opportunity to participate in the RES balancing market. Around 2030, there might be a demand for balancing additional RES capacities, which could be satisfied by stationary batteries and Vehicle-to-Grid (V2G) storages. At the same time, Power-to-Gas (P2G) technology for the production of various gases using excess electric energy would be developed.

High flexibility scenario:

- All flexibility measures are used (stationary batteries and V2G storages, load flexibility, P2G);
- Periods of extremely low prices are reduced, better prices for RES energy producers;
- Most favorable case for consumers and producers due to price level and stability;
- Lower demand for the subsidies sector (a third as many in 2050).

To produce 18 TWh in 2050 using RES alone, the development of these capacities will be especially intensive starting from 2030. This period will give rise to a great demand in flexibility measures. With year 2040 approaching and especially before 2050, P2G resources will be required to maintain affordable prices for wind energy and to reduce subsidies. At the same time, there will be a need to stimulate the hydrogen demand in different sectors:

- Export to other countries, mixing with natural gas and using gas pipeline;
- Methane and ammonia production;
- Vehicle fuel;
- Chemical industry;
- Heating.

The prepared Lithuanian energy system development scenarios present the following forecast for 2050 (Fig. 4.9.19):

- P2G capacity in 2050 - 1.3 GW;
- if P2G is activated at 20 €/MWh, 1.7 TWh electric power would be consumed;
- green hydrogen produced is used in different sectors, mixed with natural gas, exported to foreign markets.

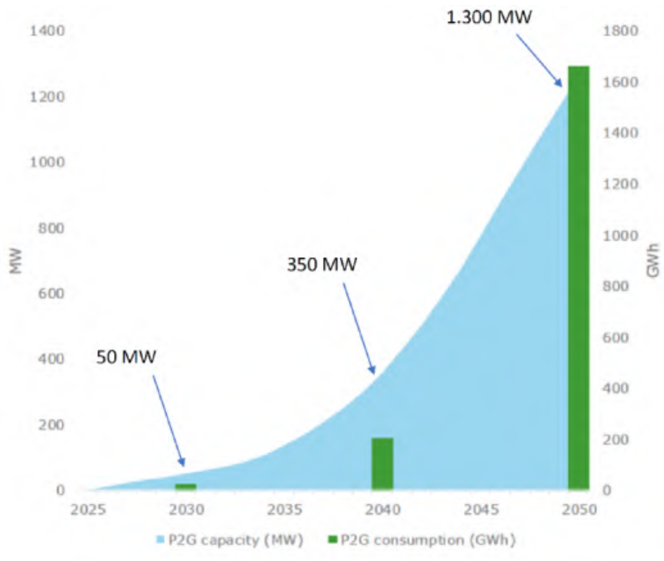


Fig. 4.9.18. Lithuanian energy development scenario until 2050.

The European Union Hydrogen Strategy published on July 08, 2020 states that hydrogen produced from renewable energy sources will play a crucial role in achieving an economy of climate-neutral Europe by 2050. The EU Hydrogen Strategy also provides for the integration of hydrogen in decarbonization of industry, transport, energy production and building sectors across Europe. The development of hydrogen technologies in Lithuania will start pursuant to the objectives of the National Energy Independence Strategy related to mitigation of effects on climate change and environmental pollution, competitiveness, energy security and participation of domestic businesses in pursuit of energy progress.

The study "Scenario Building for the Evolution of Lithuanian Power Sector for 2020-2050" (RAIDA 2050)[26] assumes that the main source of electricity generation in 2050 will be offshore wind farms, which will account for about 40% of the RES generation structure. The three scenarios provide for that a total

[26] https://www.litgrid.eu/uploads/files/dir564/dir28/dir1/15_0.php

installed capacity of offshore wind farms will range from 1.6 to 2.0 GW in 2050. Thus, the objectives of the NEIS will be achieved by means of flexibility measures embedded.

4.9.2.2. Effects on Economy: Creation of Jobs, Contribution to GDP

The International Renewable Energy Agency (IRENA) manages the employment database developed on the basis of primary data sources (ministries and statistics agency of the countries) and secondary data sources (regional and global research). According to the data of IRENA base, in 2019 approximately 500 employees worked in the wind energy sector in Lithuania.

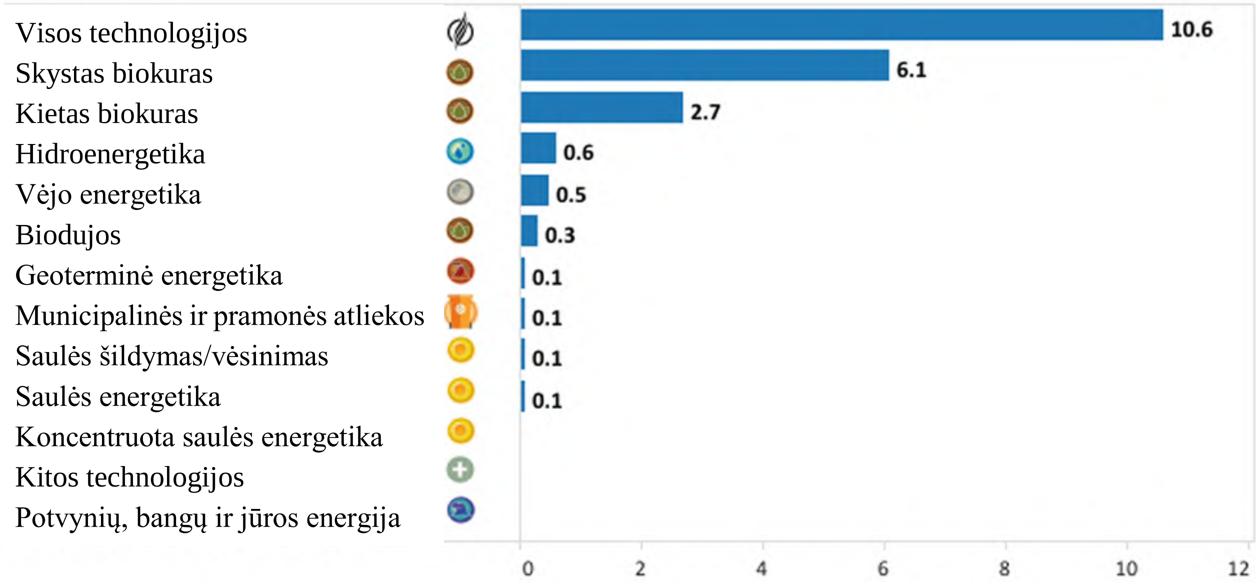


Fig. 4.9.19. Number of jobs (thousand) created by different types of renewable energy (IRENA).

The impact of the offshore WT farm on GDP can be divided into three types: direct, indirect, induced. Direct impacts include the wind energy industry, indirect impacts on other industries involved in the fleet development value chain. The largest indirect impacts are on the electrical equipment, machinery, metal, construction industries, as well as on the engineering services, rubber and plastic products, and real estate sectors. Induced effects include the development of the investment park and the positive effects of new jobs on the consumption of goods and services. In the long run, investment in research and innovation in wind energy also has the potential to create added value (McKinsey & Company, 2016).

The development of wind turbine farm of up to 700 MW installed capacity in the Baltic Sea could generate up to 1.5 billion euros of added value and create up to 8 thousand jobs (half of those are indirect) on the European scale (WindEurope, 2020). Lithuania's share of added value and new jobs will depend on what share of the value chain will be developed locally, i.e., the demand for workforce, raw materials, infrastructure, and equipment in different parts of the value chain, the capacities of existing industries and workforce capacities, also regional and global market trends.

4.9.2.3. Effects on Industry and Services

The value chain of the offshore wind turbine farm can be divided into several main components: project development, production of plants, production of foundations, construction and connection to the electricity network, management and maintenance. The demand for direct workforce in different parts of the value chain has an uneven distribution. Production of turbine components account for more than half of full-time working days, management and maintenance account for about quarter, construction and connection account for up to one fifth. Other development phases account for a little less.

Table 4.9.3. Distribution of workforce demand by shares of the value chain in developing 500 MW offshore wind turbine farm; total of 2.1 million full-time working days. (Source: IRENA, 2018).

	Project development	**Production and procurement**	**Transport**	**Construction and connection**	**Management and maintenance**	**Decommissioning**
Total workforce %	1%	59%	0.1%	11%	24%	5%
Key professions	Ship crews (33%), specialists in law, energy regulations, real estate and taxes (20%), engineers (16%)	Factory workers (54%)	Truck drivers (51%), ship crews (26%)	Ship crews (76%)	Ship crews (17%), technicians (17%), engineers (15%)	Technicians (25%), ship crews (23%), truck drivers (23%), engineers (15%)

Although the production of wind turbine components accounts for the major share of workforce and value added, there is low possibility of developing local production in Lithuania. The key determining factors are the need in tremendous investment in production development, which payback require large-scale wind energy development of extreme intensity in the region, and a limited use of available production capacities and infrastructure, considering that there is no production of onshore wind turbine components developed in Lithuania and no extraction of oil and natural gas at sea taking place. On the other hand, ship construction capacities in Klaipėda port could be adapted and used for the development of local transport, construction and connection, as well as management and maintenance capacities, and, possible, for the production of certain power plant components.

Conditions for local development of other parts of the value chain are more favorable, especially for construction and connection, as well as management and maintenance phases, which combined account for a third of workforce demand and added value. These phases require ship crews, engineers and technicians the most. Ensuring the greatest possible benefit for local socio-economic environment requires investment to education and employee training to have workforce supply in line with the demand created by offshore wind energy development (QBIS, 2020). The state aid and potential changes in legislation are also significant for stimulating competitiveness among local businesses.

4.9.2.4. Effects on Seaport and Port Infrastructure

Ports have a great significance for the development of offshore wind turbines. They play a key role in the supply chain, logistics and maintenance infrastructure (e.g., component storage site) 27. Ports are the place where wind turbines management and maintenance, assembly and transportation of wind aggregates and other equipment are taking place. Moreover, ports will play and exclusive role in the production and allotment of green hydrogen.

Ports, however, cannot provide these services with marked investments in improvement and development of port infrastructure alone. It is essential to expand the territories, reinforce the quays, improve deep-sea wharfs and complete other construction works. This is required for a large fleet operation and maintenance, production of turbine foundation and future disassembly of the WT farms. Ports are also obligated to diversify operations to contribute to the reduction of industrial, energy and transport emissions.

[27] *A 2030 Vision for European Offshore Wind Ports. WindEurope, 2021.*

Based on WindEurope (WindEurope, 2021) data, European ports would have to invest € 6.5 billion in the period from 2021 to 2030 to support the development of offshore wind energy industry. The above investment is expected to pay off within 5 years already, helping the electricity consumers and the general public to greatly cut down the expenses.

Ports will be the most important ones in the development of production and allotment of green hydrogen, especially in associating with the offshore wind power. Ports provide a great number of services and advantages that make them the most important partners:

- Ports are located near offshore wind turbine farms and sites of connection to the network on the shore;
- Ports are integrated into industrial ecosystems that may speed up the development of green hydrogen use;
- Ports can function as allotment centers reducing the emission of other branches of industry by using hydrogen as fuel or processing it into other energy carriers;
- Ports can use hydrogen to reduce the emission bother in own operation and in other local services (such as industrial heating, waste and sewage treatment, fuel supply to land and sea transport).

Cooperation along the entire supply chain, starting with production of components ending with generation of green power, has a vital important in ensuring smart and sustainable activities and creating climate-neutral economy in efficient way, while providing new opportunities for the coast communities.

In 2020, 116 offshore wind turbine farms, with total capacity of 25 GW, supply 3 % of electric power consumed in Europe. According to the National Energy and Climate Actions Plans prepared in 2020, the EU Member States have undertaken to install additional wind turbine farms and reach the total offshore wind power capacity of 111 GW by 2030 and exceed 400 GW by 2050. With these objectives in mind, the speed of installing offshore wind turbines in Europe should increase from the current 3 GW per year to 11 GW per year in 2026 and stay at least the same from then onwards. Great number of countries, including Lithuania, still have no offshore wind economy, they will, therefore, face great challenges in creating and improving this new sector with investment in infrastructure, logistics solutions and political support.

Ports are especially important for the development of this sector as they serve as a link between offshore wind turbines and the mainland. Ports will function as offshore wind energy management and maintenance centers and play a significant role in the entire supply chain because all the necessary equipment is to be transported through the ports. With an expansion of the offshore wind energy, cooperation of ports with value chain participants and with each other gains an increasing importance. Offshore Wind Ports Platform (OWPP) unites the ports and other representatives of the business in sharing the best experience and communicating with all the parties concerned.

Ports should plan logistics and infrastructure for offshore wind energy with consideration of the number of wind turbines planned to be installed and type of foundation, rather than the capacity planned to be installed. In the majority of cases, the countries provide developers with certain freedom of development (the Rochdale Envelope method is used to grant authorization, which determines general farm parameters and provides for the opportunity of changes where needed). This allows providing for different possibilities of turbine number and allocation in auction bids, rather than a fixed-type solution. This is a great practice because the develop can choice the best turbines in commercial aspect by assessing the financial investment solution, increasing power production with less power plants, thus reducing the power price.

The installation of offshore wind farms will require the transportation of various ship crews, technical maintenance of turbines, installation of turbines, laying of cables. The ships of the latter two types are the largest and most expensive. Owners of the ships and ports are to search for optimal solutions in the process.

Table 4.9.4. Trends in the development of ships and ports participating in the installation of offshore wind farms.

Trend	Example	Advantages
Transportation and assembly of large components	*Siemens Gamesa Renewable Energy* ro-ro *Rotra Vente* ship is used for the transportation of rotor blades and generators from the Ports of Hull and Cuxhaven.	The ports will expand component transportation using roro ships, thus reducing the supply period and logistics expenses, comparing with standard transportation methods. Partial assembly of the turbines in the port reduces logistic expenses and, therefore, will be further applied.
Environmentally friendly management and maintenance	*CWind* signed contract with *Ørsted* for the use of hybrid crew transportation ship in *Borssele 1* and *2* farms in Vlissingen. The Port of Oostende will test hydrogen supply equipment for *ISHY* project crew transportation ship.	The companies plan to use hybrid and electric ships for crew transportation and WT servicing, thus reducing the effect of their operations on the environment. The implementation of these plans depends on readiness of the ports to organize power supply to the ships.
Design innovations	*Van Oord* test the tower-foundation connection without screws and mortar.	Design innovations increase the efficiency on installation. New design of connections and foundations accelerate the installation process.

In the offshore wind farms currently operating, about 300 turbines (~700 MW of total capacity) are older than 15 years. The plan is to disassemble them over the next 10 years, removing a part of them entirely and restoring a part of the farms to connect to the network again. Disassembling the turbines will create opportunities for the majority of supply chain participants, including ships and ports. Offshore wind energy industry should duly organize the disassembly and transportation processes and provide for sufficient capacities of loading, storing, and processing in ports and nearby, thus avoiding additional transportation costs.

Allocation of port territories and waters for different operations becomes an increasing problem because marine industry has to compete with freight logistic services generating higher returns in the short term. To overcome infrastructure challenges and prepare for the wind energy industry development, it is very important to ensure long-term stability of port operators' income in using the national power industry policy measures. Regional cooperation and support of European authorities are also important for the ports' development, recognizing the benefits of these investments for the society due to reduced electricity prices.

The Port of Klaipėda is already contributing to the development of wind energy industry in Lithuania and other countries. Stevedoring companies are managing all land components for wind turbines, which are delivered in ships and usually exported by motor transport. For instance, in 2021 Klaipėda Container Terminal (KCT) is managing components for wind turbines for the largest in the Baltic region WT farm under construction in Telšiai District. The next-generation General Electric (GE) wind turbines called Cypress will be the highest and most high-powered in Lithuania, with tower (including rotor blades) 220 meters high and rotor 158 m in diameter. The current project is the most large-scale up to date, with come components weighting 80 – 90 t and blade segments over 65 m long.

Fig. 4.9.19. UHL Future vessel with a cargo of 6900 t wind turbine components undergoes unloading at KCT.

Western Shipyard has been completing orders for offshore wind energy industry for many years, including construction of specialized vessels and production of various components (Fig. 4.9.20.).

Fig. 4.9.20. Windlift I, wind turbine assembly vessel, and transformer platform.

State Enterprise Klaipėda State Seaport Authority conducted a survey among port operators, who could be interested in diversifying a part of their operations in the future for wind turbine production and/or warehousing with consideration of their operation and development plans. The survey results have showed that 4 port spaces could be used for loading wind turbine parts and in the logistics chain of service ships.

The Western Shipyard Group (Fig. 4.9.21, marked as No. 1) is interested and ready to offer comprehensive services: starting with the production of wind turbine components ending with warehousing and logistics as well as construction, modernization, maintenance and repair of special vessels required for the project's implementation. Vakarų krova, UAB is interested in providing wind turbine logistics and production services in the future. The available and to be purchased cargo handling equipment as well as the available areas of reserve sites and new deep-sea quays would allow the company cooperating in this project effectively.

Klaipeda Stevedoring Company (KLASCO) (2) is interested in considering the possibility to diversify its operation in the future on the Smeltė peninsula, allocating a part of it for wind turbine loading and storing.

Kamineros krovinių terminalas, UAB (3) is interested in considering the possibility to diversify its operation in the future, allocating a part of it for wind turbine loading and storing.

The examined and newly formed about 20 ha area on the Smeltė peninsula (4).

Fig. 4.9.21. Potential locations for servicing the offshore wind farms in the Port of Klaipėda.

In the long run, additional territories in the southern part of the port are expected to be developed for servicing the offshore wind farms. Project proposals for the development of southern part of the Port of Klaipėda are in progress by the order of the Klaipėda State Seaport Authority.

4.9.2.5. Potential Effects on Aviation

Procedure for the assessment of effects on aviation is provided for in the Description of the procedure for coordination of construction and reconstruction of buildings and installation of equipment that may hinder aviation approved by the Resolution No. 625 of the Government of the Republic of Lithuania of May 29, 2012 on approval of the description on the procedure for coordination of construction and reconstruction of buildings and installation of equipment that may hinder aviation. The description determines the coordination procedure when construction, reconstruction or installation is planned in the entire territory of the Republic of Lithuania, whereas the height of building and structures upon completion of construction, reconstruction or installation above the ground is 100 meters or higher.

Wind turbines with height upon completion of construction or reconstruction above the ground making 100 meters or higher are subject to additional design and construction restriction as provided for in Article 135(1, 2) of the Law on Special Land Use Conditions and in Article 49(8) of the Law on Energy from Renewable Sources of the Republic of Lithuania.

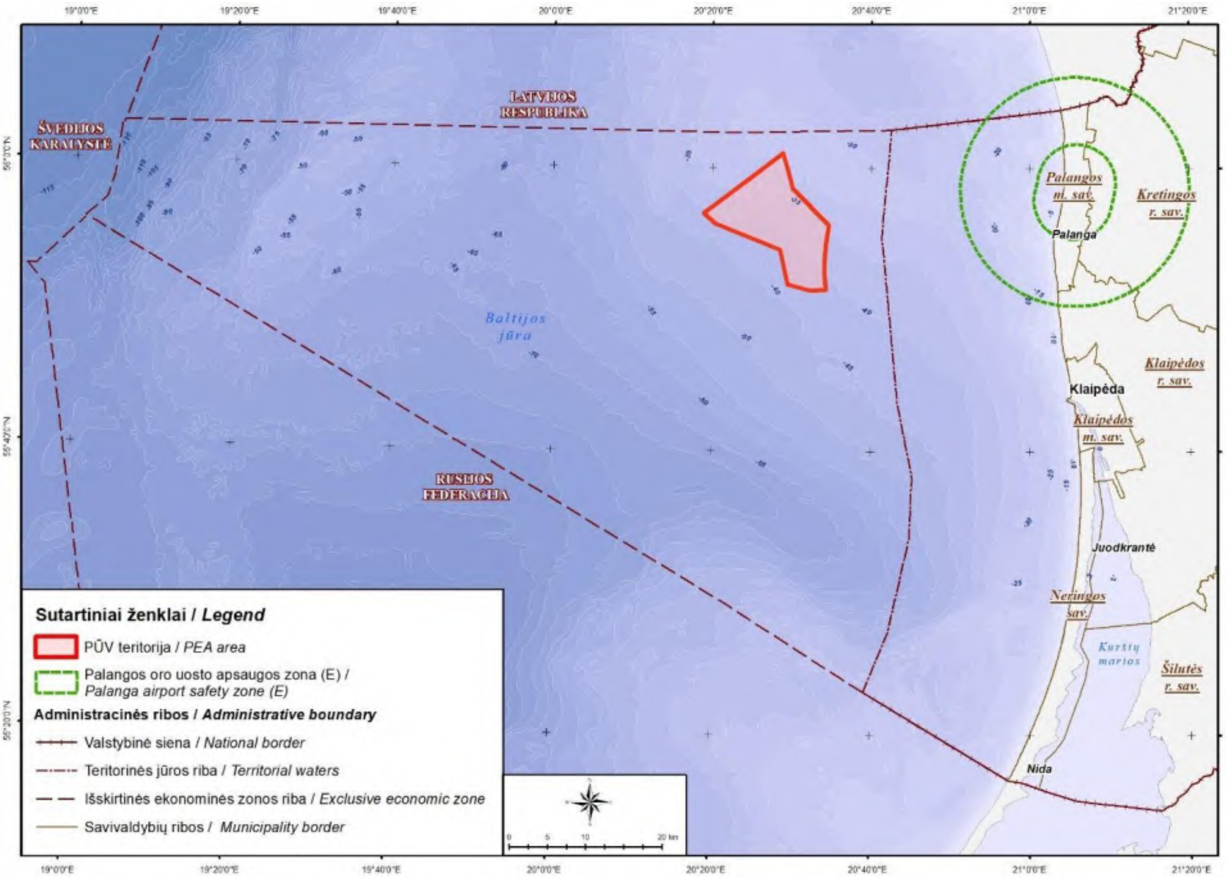


Fig. 4.9.22. Territory of Palanga International Airport and boundaries of the safety zone.

The PEA area is approx. 16 km away from the boundaries of the safety zone of Palanga International Airport, therefore, it will not create any obstacles for the aviation security of Palanga International Airport. The offshore wind farms must be properly marked with conventional aircraft warning lights.

4.9.2.6. Potential Effects on Fish Farming and Fishing

The key commercial fishing areas in the Lithuanian waters are the seacoast, the area near the Russian border, and the area near the Swedish zone. According to the allotment of the International Council for the Exploration of the Sea, the Lithuanian marine territory falls into 40H10, 40G9 and 39H10 statistic squares of the 26th fishing ground, where fishing takes place using trawls and trap nets. Lithuanian Exclusive Economic Zone (EEZ) fits only a small number of areas that are suitable for trawling using bottom trawls (29% of total 7000 km^2) (Statkus, 2006). Sites of soft ground (aleurite, sand or smile) with no hindering objects are selected for trawling. Bottom trawls are used for fishing cod and flatfish. Meanwhile, seabed structure has no impact on the fishing with pelagic trawls, fishing with such fishing gear is thus possible almost in any area of the Lithuanian EEZ.

The boundary of coastal fishing area is determined at 20 m isobath and is divided into 29 fishing bars. The use of trawls, double drag nets and other trawling fishing gear in the coastal waters is prohibited. Nets, longlines and Baltic herring trap are used for fishing. The PEA area is outside the boundaries of coastal fishing area and will have no effect on coastal fishing area.

Harvest of the main commercial fish (Baltic sprat, Baltic herring, cod, salmon) are regulated with quotas. In the economic zone and territorial waters alone, the Lithuanian fishers catch over 10–15, sometimes over 20 thousand tons of fish, mostly Baltic herring and sprat, cod, salmon, smelt.

Recreational fishing also gain popularity in Lithuania, perspectives for the development of marine aquaculture are assessed. However, today marine aquaculture is not developed in Lithuania.

Certain economic impact of PEA implementation on the fishing business is expected due to the emerging fishing restrictions in the areas of wind farms – after the installation of wind turbines, trawling will not be possible due to the risk of damaging the electric transmission cables laid on the bottom.

It should be noted that the analyzed area occupies fishing areas on the high seas that are not allocated to individual companies. Therefore, due to restrictions during the construction and operation of the wind farm, fishing will be possible in adjacent areas and fishers will not suffer losses. However, offshore fishing companies can also claim compensation for lost fishing grounds, especially for trawling areas, which are not exceptionally large.

Pursuant to Article 7(1) of the Law on Fisheries of the Republic of Lithuania (adopted on June 27 2000, No. VIII-1756, valid consolidated version of January 01, 2020 to October 31, 2021) "Users of fish stocks shall have the following rights: (...) to receive compensation for losses where fishing opportunities are lost (also for a fixed period) due to the economic activities of the authorities, state or municipal enterprises or agencies, including the economic activities carried out on their behalf (...)." Paragraph 2 of the same article states that "The procedure and rates for calculating the losses incurred in marine waters shall be established by the Ministry of Agriculture." Should fishers file a claim for compensation for losses related to the loss of fishing grounds, the procedure for compensation for losses shall be established by the Ministry of Agriculture.

The establishment of offshore wind farms may also have positive consequences for fish stocks. According to the data of the study conducted by the Swedish Environmental Protection Agency "Effects of wind power on marine life" (Bergström *et al.* 2012), the foundation for wind turbine towers can function as artificial reefs and attract many fish species. At the beginning of the operation of the wind farm, fish are attracted from adjacent areas to the foundation of the wind farm, but eventually there is a possibility of increase of fish productivity in the wind farm itself if the park is large enough and fishing capacity is low. The locations of wind farms usually create favorable conditions for the formation of fish nutrient base and spawning and increase biodiversity (Leonhard *et al.* 2011). This circumstance and the restriction of fishing in park areas can contribute to the conservation and enhancement of fish stocks.

A balanced approach to the conservation and enhancement of fish stocks and the resulting constraints and compensation can reduce the adverse effects for the fishing industry and the potential for conflicts between the fishing industry and wind energy.

4.9.3. Effect Mitigation Measures

4.9.3.1. Support for Local Communities

The provision of support to local communities is provided for in the legal acts of the Republic of Lithuania. The requirements related to support for local communities are provided in Chapter V of the Description of requirements for persons seeking to acquire and having acquired the right to develop and operate renewable energy sources driven power plants in the maritime territory, and reimbursement of the costs of conducting research and other actions in the maritime territory[28] prepared in 2022:

- It is provided in Clause 23 that the tenderer to whom the contract is awarded must support local communities located in municipalities, whose coastal strip area is parallel to the part of the marine territory, where RES driven power plants are installed. When determining the municipalities, whose coastal strip area should be considered parallel to the part of the marine territory, where renewable energy sources driven

[28] Resolution No. 1049 of the Government of the Republic of Lithuania of October 19, 2022 on the approval of the description of requirements for persons seeking to acquire and having acquired the right to develop and operate renewable energy sources driven power plants in the maritime territory, and reimbursement of the costs of conducting research and other actions in the maritime territory.
https://www.e-tar.lt/portal/lt/legalAct/778c3f80511011edbc04912defe897d1

power plants are installed, the lines are drawn from the north and south corners of the territory, where these power plants are installed, perpendicular to the shoreline (Fig. 4.9.23).
- It is provided in Clause 24 that the tenderer to whom the contract is awarded, in accordance with the procedure established by the Government, pursuant to Article 13[1](4) of the Law on Energy from Renewable Resources, shall pay a fee of EUR 1.00/1 MWh until January 31 of the current year to the administrator of the fee for electricity production from renewables appointed by the Ministry of Energy of the Government (hereinafter referred to as the fee administrator). The fee is paid in the event that the hourly price formed on the electricity exchange of the next day in the Lithuanian zone is higher than EUR 1.00 per 1 MWh. The fee is paid from the day the permit to produce electricity is issued to the tenderer to whom the contract is awarded until the expiration of this permit. The fee to be paid in the current year is calculated taking into account the amount of electricity generated and supplied to the electricity grid by the tenderer to whom the contract is awarded in the previous calendar year.
- Based on Clause 25, the fee administrator shall pay the funds collected in accordance with the procedure and under the terms established by the Government to the municipalities determined by him in Clause 23. The specific amount of the fee paid to the municipalities is proportional to the length of the coastal strip area of the specific municipality in the interval of the coastal strip area determined in Clause 23. Municipal councils decide on the use of funds to meet the social, economic, and environmental protection needs of local communities and residents.

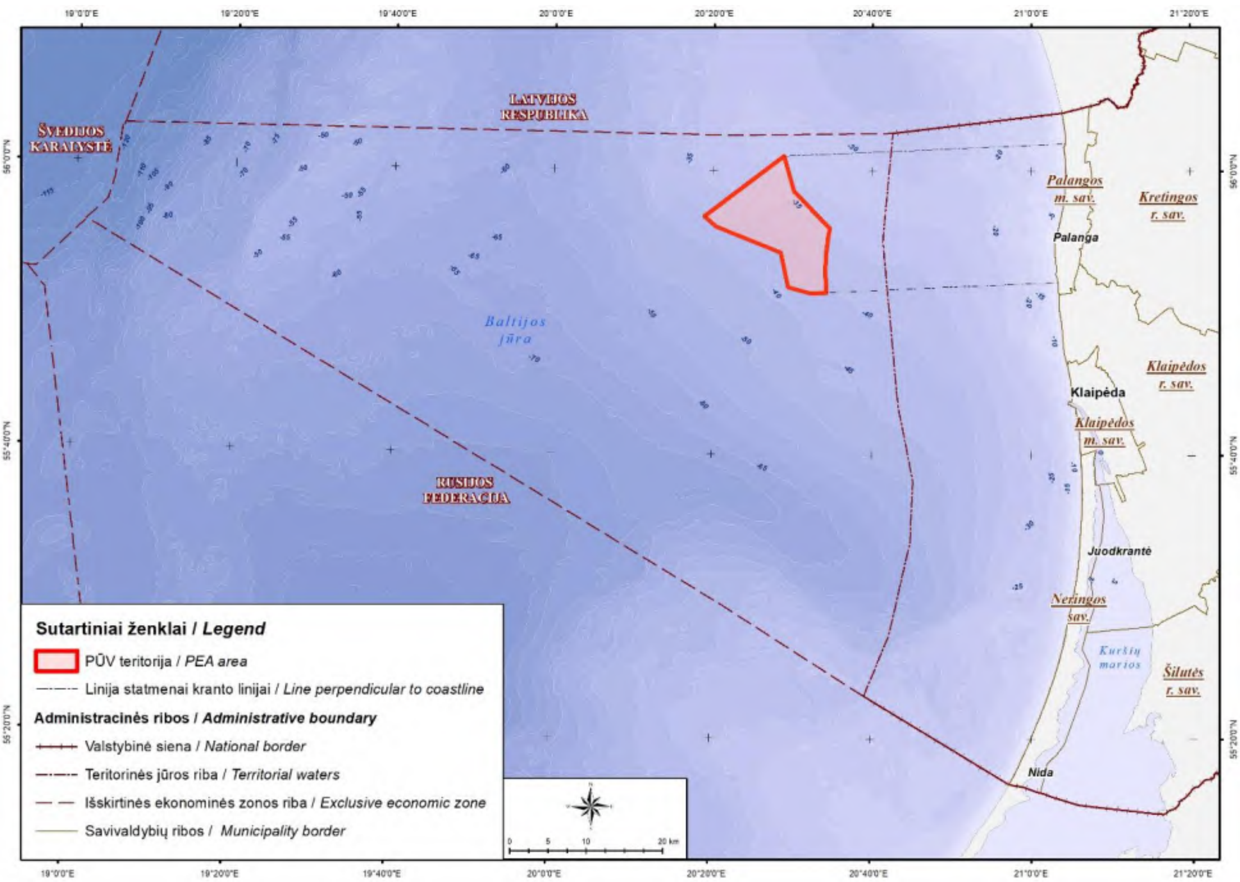


Fig. 4.9.23. Projection of the PEA area to the coastline municipality borders.

4.9.3.2. Reducing the Impact on the Fishing Sector

- Although currently, due to the Eastern Baltic cod fishing ban, the planned installation of the wind farm does not have a significant impact on the fishing sector, but this ban is temporary and its validity period is not defined. In the near future, commercial fishing will depend on the rate of recovery of biological resources, and trawling areas now recorded as "disused" may once again become important to fishermen. Taking into account that the territory of the PEA was intensively trawled in the past (due to its exceptional value - suitable bottom and relatively good catches) there is a possibility that the fishing sector may suffer a negative impact, which is difficult to predict today.

- Any EU-registered vessel that has been granted fishing opportunities (quotas) can fish in the territory of the EEZ, so direct compensations are pointless. In addition, the provided fishing opportunities are not linked to a specific fishing area and can be used mostly in two or more sub-squares of the Baltic Sea determined by the International Council for the Exploration of the Sea (ICES), with an area of 2,280 km^3 - 64 330 km^3.
- However, taking into account the general uncertainty of fisheries development and the former historical importance of the territory, it is recommended to initiate a dialogue with the Ministry of Agriculture regarding the possible contribution of offshore wind energy to the reorganization of the fishing sector, the creation of regulations and principles for the possible adaptation of the territory to small-scale fisheries (determining the principles of commercial fishing, vessel sizes and power, the application of new or traditional fishing methods in a partially occupied area) and/or marine aquaculture, and other relevant fisheries for the solution of issues, thus indirectly compensating the potential damage to the fishing sector, as well as ensuring the competitiveness of the state and the preservation of traditional sea activities.
- Taking into account the historical importance of the PEA territory for fishing, and considering that the operation of the wind power plant is temporary, it is important that after the operation of the WE park is completed, during the dismantling of the power plants, the foundation structures at the bottom do not become artificial traps for fishing tools, i.e. foundations should be dismantled to the level of the former bottom relief, thus avoiding the possible impact of caught and lost fishing gear, which becomes a secondary source of pollution in the sea, and negatively affects marine resources (becoming a passive catching tool).

4.10. Risk analysis and assessment

The main risk assessment methodology used is "Recommendations R 41-02 for risk assessment of potential accidents of planned economic activities" approved by Order No 367 of the Minister for the Environment of 16 July 2002 (hereinafter - Recommendations R41-02). Literary sources generally provide risk assessment methodologies and overviews for offshore WF parks already in operation. The information given in the articles is based either on statistics widely available on accidents and incidents in offshore WF parks (Chou et al., 2021) or on an overview of the methodologies applied (Mou et al., 2021). Recognised and applied methodologies are used on a case-by-case basis, descriptions of which are presented either in the EIA/Risk Assessment Reports of individual objects or as separate methodological guidelines (Methodology for Assessing Risks to Ship Traffic from Offshore Wind Farms, 2008). This risk assessment analysis herein uses both statistical and descriptive risk assessment material given in the literature sources and the methodologies used, complementing the methodology presented in Recommendation R 41-02.

4.10.1. Methodology for risk analysis and assessment

The risk analysis and assessment thereof shall be conducted in accordance with Recommendation R 41-02.

Recommendations R41-02 provide that the risk analysis for the planned economic activity must examine risk factors and vulnerable objects and assess the likelihood and consequences of accidents related to these factors on man, nature and material values (property). The risk analysis must identify existing and potential hazards and demonstrate:

1. Risk objects where an accident may occur;
2. Risk sources in risk objects;
3. The nature of accidents;
4. Potential vulnerable objects;
5. The consequences of an accident;
6. The estimated probability of an accident;
7. Factors that increase risk.

When conducting a risk analysis, the following is important to be clarified and is recommended to be indicated:

1. Sources of information (methodologies, literature, computer programs, etc.);
2. Maps and other information material about the environment of the PEA, infrastructure objects, residential areas and public-purpose objects;
3. Strategic planning in the PEA area environment;
4. Protected and cultural values located nearby;
5. Possible emergencies and their likelihood;
6. Undertakings and organisations located and operating in the territory under consideration;
7. Hazardous substances used in the planned economic activities;
8. Traffic intensity;
9. Available safety and rescue plans;
10. Data on accidents and statistics thereof;
11. Information on the number of people (residents and employees).

In all cases, risk analyses shall examine the following hazards and risks:

1. Potential risks to people and the social environment;
2. Emerging and increasing hazards and risks to the natural environment;
3. Risks to the property;
4. Risks to the prestige of the company.

The risk analysis conducted as a part of the PEA focuses on the possibility of creating emergency situations and the hazards and risks arising therefrom.

The recommended risk assessment structure provides that risks can be assessed depending on the materiality of the risk and the potential impact on the objects falling within the risk area. The recommended structure of the PEA risk analysis (steps 1 to 14) foresees that steps 1 to 3, 1 to 5 or 1 to 14 (Table 4.10.1) are carried out depending on the significance of the impact on humans, nature, property and the presence of the object experiencing the same impact in the impact zone.

Table 4.10.1. Structure of risk analysis

Risks															
Detection			a	**Determination**		b	**Classification**					**Assessment**			
1	2	3	*	4	5	**	6	7	8	9	10	11	12	13	14
Finish here if hazardous factors are scarce															
Finish here if there are no relevant vulnerable objects															

The steps correspond to the column given in Table 4.10.7.1 of Chapter 4.10.7, where potential hazards (risk detection), nature of accidents and vulnerable objects (risk identification), consequences for vulnerable objects, their significance, duration, (risk classification), likelihood and importance thereof (risk assessment) are recorded.

4.10.2. Typical offshore wind farm risk objects and hazardous factors

During the construction and operation of the WF, possible emergency situations and the risks they pose to people and the social environment are related to rotating blades, assessing the possibility of their partial or complete flinging away, the collapse of the tower, and the effect of electric voltage on the service personnel. The risks of collision occur to aircraft, and ships moving near power stations or their parks at sea.

The hazards to the natural environment from emergency situations relate to slight oil leaks from the rotors, fuel leaks from ships, in cases of collisions, and oil leaks from transformer substations.

The operation of cables connecting the power park to coast installations poses a risk of electrical voltage leakage into the environment. Since the potential for such leaks is very limited due to the used cables' reliability, they are not examined separately.

High risks from the operation and construction of offshore WF parks are posed due to navigational risks, such as the possibility of collisions between ships and power stations, as well as possible collisions with aircraft, especially when there are airports in the vicinity, the presence of dislocated air forces, and the commercial recreational routes (sports planes, air balloons) pass nearby the route.

Before analysing the risk objects and hazard factors of offshore WF parks, we briefly review the available statistics on accidents and emergency situations that occurred during the construction and operation of offshore WFs and their parks.

The work "Risk analysis and management of offshore wind farms during construction and operation" by Taiwanese scientists (Chou et al., 2021) analyses the descriptions of emergency situations of 161 offshore WF parks that happened from 1980 to 2019 and were found in public sources. After classifying emergency situations according to their own criteria, situations that occurred during specific works and stages were distinguished (Table 4.10.2).

Table 4.10.2. Accidents caused by primary hazardous events

Primary dangerous events	**Quantity**	**Description**
Events caused by breaches of industrial (work) safety requirements	56	Personnel injuries, traumas and deaths caused by human error or unforeseen circumstances

Equipment and device failures	55	Damage or failure of WF equipment or devices
Lifting accidents	10	Accidents that have occurred during lifting work
Transport accidents	12	Accidents involving work vessels
Dangerous events resulting from environmental effects	8	Pollution resulting from biological, ecological or other environmental effects; accidents due to storms, hurricanes, typhoons.
Other events	20 (eliminated)	Accidents that have caused only minor consequences and did not provoke a public reaction.
Total:	**141**	

20 events that caused only minor and insignificant consequences and did not trigger the public reaction were eliminated from the further survey; 141 events were left to be examined.

During the operation and maintenance of the WF, 109 events occurred: during the construction stage 30 events; 2 events in the further development stage. Thus, the most dangerous stage is the operation stage, including the maintenance of the object under operation.

Table 4.10.2. shows that the most common accidents are related to occupational safety breaches and equipment and device failures. The operation and maintenance of offshore WF parks involve offshore operations and therefore result in serious consequences. 12 accidents were fatal and people were injured in 44 accidents out of the 56 accidents caused due industrial safety violations.

Equipment and device failures are most common in gondolas (25 cases). There were 8 cases each related to blade accidents and power transmission cables, 7 cases occurred in offshore substations, and three in WF towers.

As a result of environmental impact, only 6 % of all events (8 events) have been recorded. With global warming, storms, hurricanes and typhoons are increasing not only in the latitude of formation and spread of tropical cyclones but also in northern areas, therefore the importance of this category of dangerous events is rising and they must also be considered in respect of the WF park on the Lithuanian coastline. In global practice, dangerous events have been recorded due to the liquefaction of the ground forming the basis. In Lithuania, the sediments of glacial, preglacial and postglacial lakes (limnoglacial sediments) had dusty sands and sandy loams characterised with thixotropic properties, intervening into morainic clay loams, developed. These grounds are sensitive to dynamic loads, therefore, if the spread of dusty sand or clay loam is observed during geological surveys, their liquefaction due to dynamic loads is very likely.

The International Electrotechnical Commission (IEC) and the global certification company DNV GL are responsible for developing international design standards and design rules for WF turbines. However, with the increasing number of global wind turbine accidents, the integrity of the safety aspects of these design standards and approval rules has been called into question. The IEC and DNV GL have assessed that tropical cyclones and seismic conditions may impact the performance of the WF and have set up working groups to develop solutions and also have reviewed existing standards and guidelines.

The PMBOK® guide (A Guide to the Project Management Body of Knowledge) (PMI, 2013) describes that the risk as an undefined event has a positive or negative impact on the project. The objective of risk management is to increase the likelihood and impact of positive events and to reduce the likelihood and impact of adverse events. Risk management phases include planning of risk management, risk identification, qualitative/quantitative risk analysis, risk response planning and risk monitoring and control.

The EIA stage assesses the risks of accidents of planned economic activities and the environmental impact of such accidents as well as response to the planning of environmental risks. Attention is therefore paid to the leakage of hazardous substances (transformers and rotor oils) into the water area and to the stoppage of such leakage and emergency liquidation as the planning of emergency response.

In order to avoid and mitigate the high potential risks of offshore power parks, the root causes of the failure of offshore WF are analysed and the maintenance priorities are defined on the basis of their risk assessment.

This is subject to specific risk and reliability analysis methods, which will be analysed in more detail during the preparation of technical design and applied during operation.

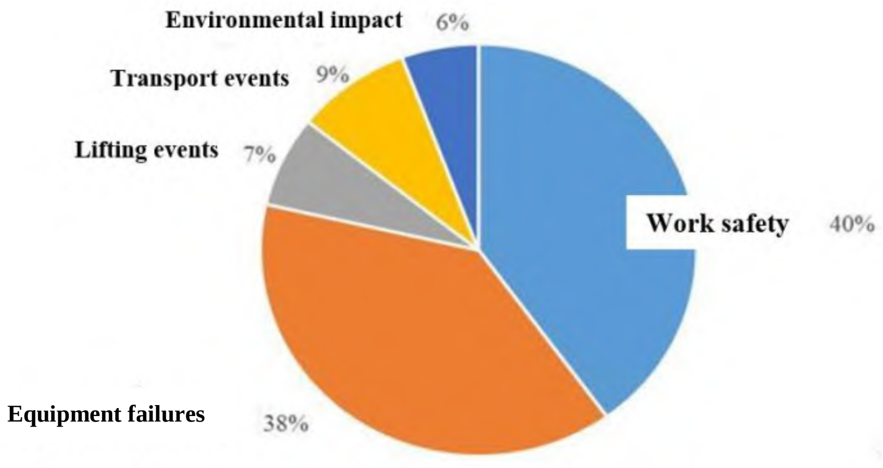


Fig. 4.10.1. Accidents caused by primary hazardous events

Vulnerable objects in the offshore WF parks are as follows:

- Economic activities carried out in and nearby the park area;
- Infrastructural objects of ongoing activities and strategic infrastructure ones (cables, pipelines);
- Territories important for state security (marine and air force training grounds, military aircraft flight routes, etc.);
- Existing archaeological finds, including sinking sites of remaining World War II explosives.

Vulnerable objects often present in offshore WF parks are also risk factors (vessels sailing along navigation corridors may also be the cause of WF accidents and their crews can suffer in the event of an accident, and become a vulnerable object). Sunk explosives are a risk factor but also a vulnerable object that can detonate if damaged during the construction of the WF. These and other objects are considered in risk analysis in both aspects.

4.10.3. Adjacencies of the PEA and activities carried out therein

Vulnerable and/or risk objects located in the adjacent areas of the PEA are given in maps and figures in Chapter 4.9 of this report. For the sake of convenience, in this Chapter, the following figures are added repeatedly and for additional clarifications if deemed necessary.

Fig. 4.10.2. presents the drawing of the General Plan of the Republic of Lithuania with an indication of the PEA location, defined water areas of Klaipeda State Seaport, Šventoji Port and Būtingė Terminal, the anchorages of vessels, the existing navigation routes, the planned navigation transit corridor as well as existing and planned infrastructure corridors.

The area of the planned offshore WF park does not fall within the designated international navigation routes, port roadsteads or anchorage areas and does not border with them (Fig. 4.10.3). The minimum distances to defined navigation routes are as follows:

- To the Navigation route to Šventoji in SE-E direction 1 km (non-intense traffic, small ships);
- To the navigation route to Latvia in the NE-E direction 1-1.6 km (average traffic, large vessels, tankers);
- To the navigation route to Sweden about 12 km in S direction (intensive traffic, large vessels, tankers);
- To the anchorage of the tankers of the Būtingė terminal -10.2 km;

- anchorages of LNG gas carriers - 12.8 km.

Hydrometeorological conditions have a significant impact on the safety and potential risks of navigation on foreseen routes.

Strong winds of sufficiently long duration and constant direction have the greatest influence on the process of the formation of currents and waves. Winds with speeds ≥ 15 m/s are called strong, and stormy ones with wind speeds ≥ 20 m/s. Winds above 30 m/s are already considered hurricane-like. The number of days when the wind speed exceeded 15 m/s during one measurement is 73 days on average per year on the Klaipeda seacoast. Although stormy winds have been observed in all months during the multi-annual period, however, the highest probability of them is from October to January.

Table 4.10.3. Maximum wind speeds in the Klaipeda region and their duration in days (Paulauskas, 2011)

Wind speed, m/s.	1	2	3	4	5	6	7	8	9	10	11	12	Per year
≥8	24.3	18.4	20.4	18.3	17.8	18.2	20.9	20.1	21.3	24.6	22.8	24.9	252
>10	21.4	13.9	14.9	11.7	8.5	8.4	12.7	13.7	18.0	19.6	18.4	20.0	181
>15	12.1	5.0	5.7	2.4	0.6	1.5	2.6	3.9	8.2	10.5	9.0	11.3	73
>20	3.9	1.3	1.7	0.2	0.1	0.2	0.2	0.3	2.2	3.2	2.9	3.0	20
>30	0.1										0.1	0.1	0.3

According to the data of multi-annual observations, an average of 35 stormy winds per year are recorded, with a duration of 20-30, an average of 25 hours, and a maximum speed of 21-38 m/s.

Two types of engineering infrastructure facilities are identified in the Baltic Sea water area of the Republic of Lithuania: a pipeline complex with the Būtingė Terminal buoy (SPM) and underwater cables (Fig. 4.10.4).

The coordinates of the dislocation and safety area of the Būtingė terminal oil pipeline and buoy (SPM) are specified in the Būtingė Oil Terminal Shipping Rules[29]. The water area assigned to the Terminal is within a radius of 1000 metres around the SPM buoy, and the security zone is 300 metres to both sides of the oil pipeline. SPM is about 30 km far-off from the PEA site.

Four underwater cable lines cross the Exclusive Economic Zone. 2 telecommunication cable routes with a starting point in Šventoji are owned by TeliaSonera, AB (according to International Cable Protection Committee), which include:

- 218 km long BCS East-West interlink route (used since 1997) linking Šventoji to Katthammarsvik in Sweden;
- 97.8 km long BCS East (ready for use since 1995), linking Šventoji with Liepaja in Latvia);

The origin of another 4 cable routes crossing the Lithuanian EEZ from south to north and from south-west to north-east that are marked on navigation maps is unknown.

The NORDBALT link connecting Klaipeda with Sweden is 450 km long; with 700 MW high-voltage direct current underwater and underground cable.

The Lithuanian-Polish offshore high-voltage direct current (HVDC) cable is planned within the framework of the Harmony Link project.

[29] Approved by Order No 3-248 of the Minister of Transport and Communications of the Republic of Lithuania of 18 September 2000 "On Approval of the Butinge Oil Terminal Shipping Rules".

The cable protection zones do not enter the territory of the PEA parcel. The nearest is the Lithuanian-Polish offshore high-voltage direct current (HVDC) cable, the planned safety zone of which is about 2 km from the boundaries of the PEA area.

According to the classification of the International Council for the Exploration of the Sea, the Lithuanian maritime territory falls within statistical rectangles 40H10, 40G9 and 39H10 of the 26th fishing area, where fish are caught by trawling and set nets. The PEA area falls within fishing rectangles 504 and 534, where the areas used for fishing with trawl are located (Fig. 4.10.5).

There are several dumping areas in the sea where the ground dug in the port of Klaipeda is sunk. Existing soil sinking points at sea are far-off more than 20 km away from the PEA area (Fig. 4.10.6).

The beginnings of maritime tourism services are observed on the sea coast of Lithuania. According to the definition, it is an independent boat trip organization service provided to tourists for a fee, which requires a certain infrastructure. The following maritime tourism services, which are most often provided to tourists on the coast of the Republic of Lithuania, are cruise shipping, inland waterway tourism and recreational fishing, and diving services at sea. Inland water navigation is offered to Palanga holidaymakers during the season; there are no official data on navigation routes, as well as about recreational fishing sites.

There are several divers clubs in the Klaipeda region that provide recreational diving services in the Baltic Sea. The most attractive places for diving in the Baltic Sea are the remains of drowned vessels, excursions to the fields of expressive bottom elevations (moraine ridges). According to the data provided by the divers club "OCTOPUS", divers usually go diving in off coast waters. The nearest diving zone is more than 21.2 m from the PEA area (Fig. 4.10.7). The known areas of sunk ships, which may be attractive diving areas, are attached in Fig. 4.10.8. The nearest finding site is located near the south-eastern corner of the PEA area.

In the territorial waters of Lithuania and in the exclusive economic zone, there are several areas of limited use (training grounds used by the military) and part of the area with sunken weaponry from the 2nd World War and former minefields. Part of the PEA area falls within the former minefield zone (Fig. 4.10.9).

In territorial waters, the Lithuanian Armed Forces carry out de-mining works and explode the explosives found *in situ*, i.e. at the place where they were found. Explosion sites until November 2016 are indicated in the letter submitted by AM (text annex RA-1). No explosion works were performed between 2016 and 2018. The explosion works were carried out between 2019 and 2022; the data are not yet included in the database of the Ministry of National Defence and are not provided.

Explosives, especially in areas with sunken weaponry from World War II and former minefields and immediate areas, are mobile. Underwater currents, along with sandy and rougher outwash, dislodge the sunken explosives and roll them along the bottom over quite long distances. As a result, new mines or other explosives are found in cleaned areas a few years later or after severe storms. Existing and potential conflict zones are therefore distinguished, where the possibility of detecting unexploded explosives remains possible even after cleaning.

According to the map[30] of the territories of the Republic of Lithuania in which the design and construction works of wind power plants (high structures) may be restricted has been drawn up and approved.

The territory of the PEA is not part of the zone where the design and construction works of the WF are prohibited but falls within the territories where the construction sites of the WF are coordinated, on condition that the producer of energy from renewable sources signs an agreement with the Lithuanian Armed Forces on part of the investment and other costs. (Fig. 4.10.10.)

Safety zones of national importance and military objects of importance to ensuring the national security of the state (Fig. 4.10.11.). The security zone of Palanga Airport includes a trapezoidal area to both sides of the runway in the direction of take-off/landing of aircraft. The length of the protection zone is 3,400 m

[30] Approved by Order of the Commander of the Lithuanian Armed Forces No V-217 of 15 February 2016 "On Approval of Methodology for Mapping Territories of the Republic of Lithuania Where Wind Power Plant (High-Rise Buildings) Design and Construction Works May Be Subject to Restrictions."

from the runway, the length of the smaller base of the trapezoid is 300 m, and the length of the larger one is 1,400 m. For the safe operation of air navigation, a zone where the height of the structures is limited is determined. The 30 km zone is also set for the radar of the Air Force. A protection zone of 5 nautical miles (9.26 km) westward of the western boundary of the outer roadstead is set to ensure the safety of the LNG-carrying vessel.

The territories in which the areas attributable to the possible flight of aircraft include the entire exclusive economic zone (EEZ) of Lithuania.

The natural and catastrophic meteorological phenomena which may have an impact on the operation of the Marine WE park approved by Order No D1-870 of the Minister of Environment of the Republic of Lithuania of 11 November 2011 (version of Order No D1-344 of 9 June 2020) are given in Table 4.10.2.3.

Storms, hurricanes and severe swells are the most dangerous phenomena that complicate the navigation of ships passing by and serving the offshore WE park.

Table 4.10.4. Extreme factors that could jeopardise the operation of the planned offshore WF park

Seq. No	Phenomenon	Units	Critical limit	Possible effects
	Natural hydrometeorological phenomena			
1	Very strong wind in the economic zone of the Baltic Sea of Lithuania	maximum wind speed at a height of 24 metres (m/s)	28-32	Damage to the WF blades
2	Verysevere composite glazed frost	glazed frost thickness/diameter on freezing rain stand wires (mm)	≥35	Ice formation of the WF blades
3	Very heavy freezing rain		≥20	Ice formation of the WF blades
4	Very thick fog	Visibility (m); duration (h)	£100; ≥12	Impact on ship navigation near the WF park
5	Very severe storm (complex of dangerous meteorological phenomena: thunderstorm and heavy rain and/or squall, and/or shower of hail)	fact; precipitation (mm), duration (h); maximum wind speed, m/s. hailstone diameter (mm)	available; ≥15; ≤12; ≥15; ≥6	Impact on ship navigation near the WF park
6	Very heavy icing of vessels in the Baltic Sea, Curonian Lagoon, Klaipeda State Seaport water area	ice layer (cm); duration (h)	≥0.7; ≥1	Impact on ship navigation near the WF park
7	Very heavy swell in the Baltic Sea	wave height at sea (m)	≥6	Impact on ship navigation near the WF park
	Catastrophic hydrometeorological phenomena			
8	Hurricane in the economic zone of the Baltic Sea of Lithuania	maximum wind speed at a height of 24 metres (m/s)	≥33	Damage to the WF blades, impact on navigation near the WF park

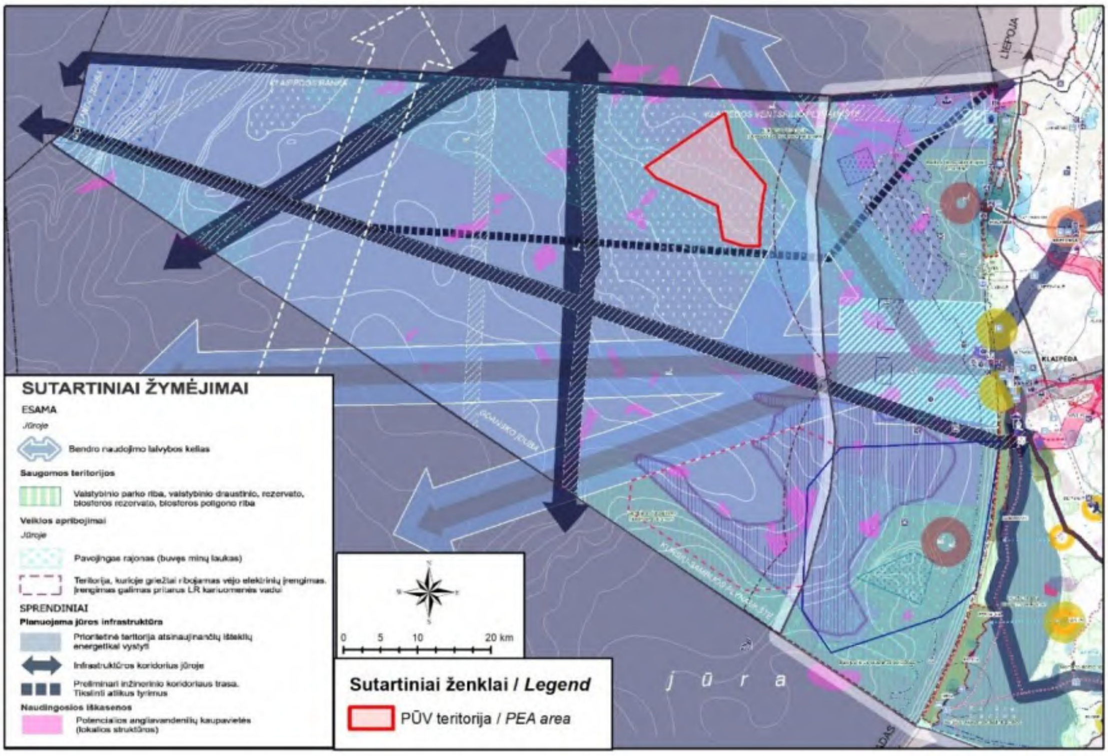


Fig. 4.10.2. The layout of the PEA area in relation to the drawing of the master plan of the territory of the Republic of Lithuania "Responsible use of the sea and coast".

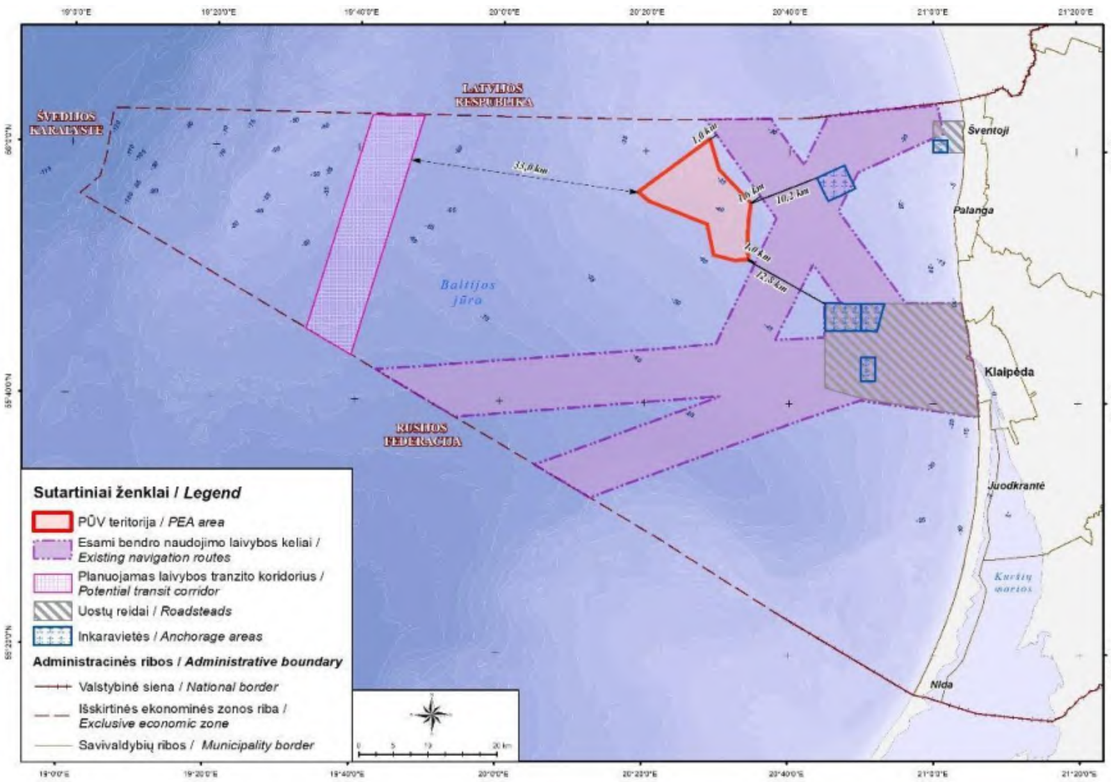
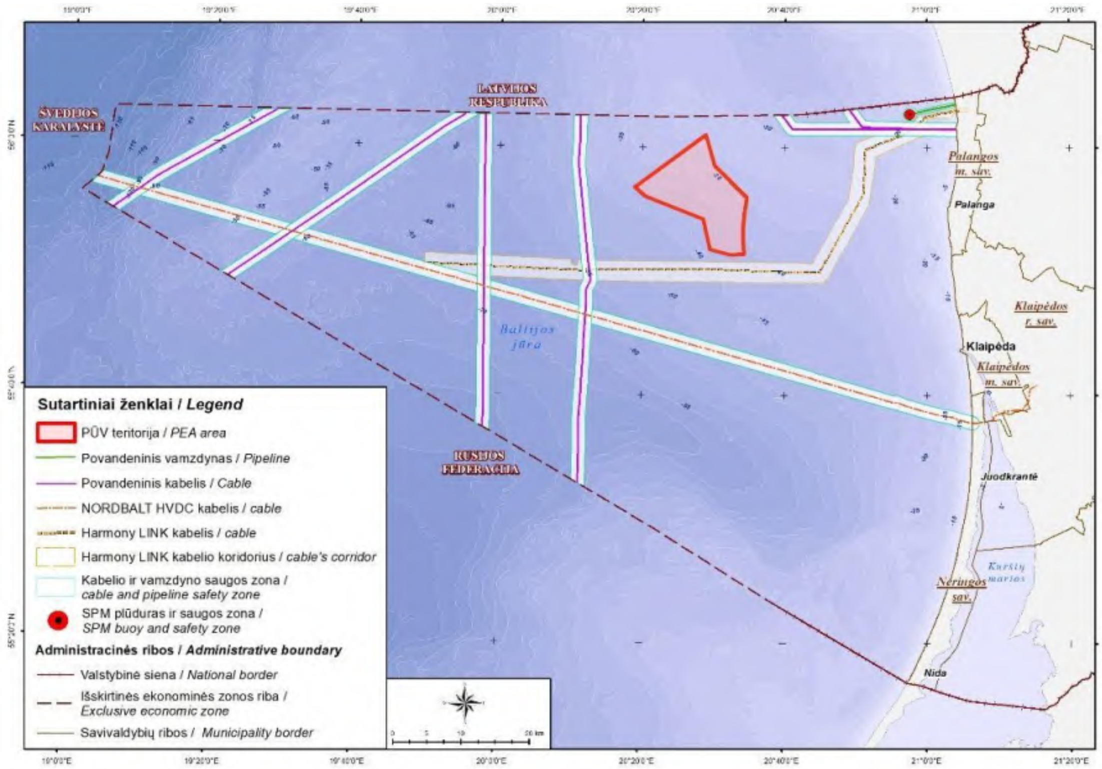


Fig. 4.10.3. Navigation routes.



4.10.4. Maritime infrastructure corridors.

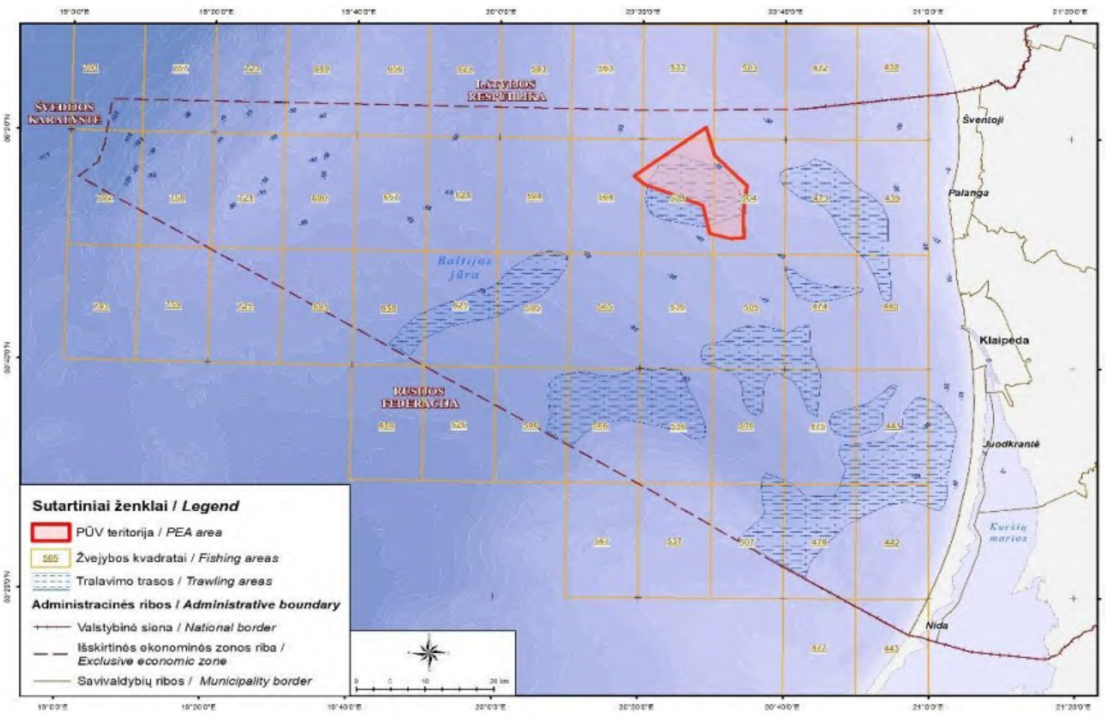


Fig. 4.10.5. Fishing zones.

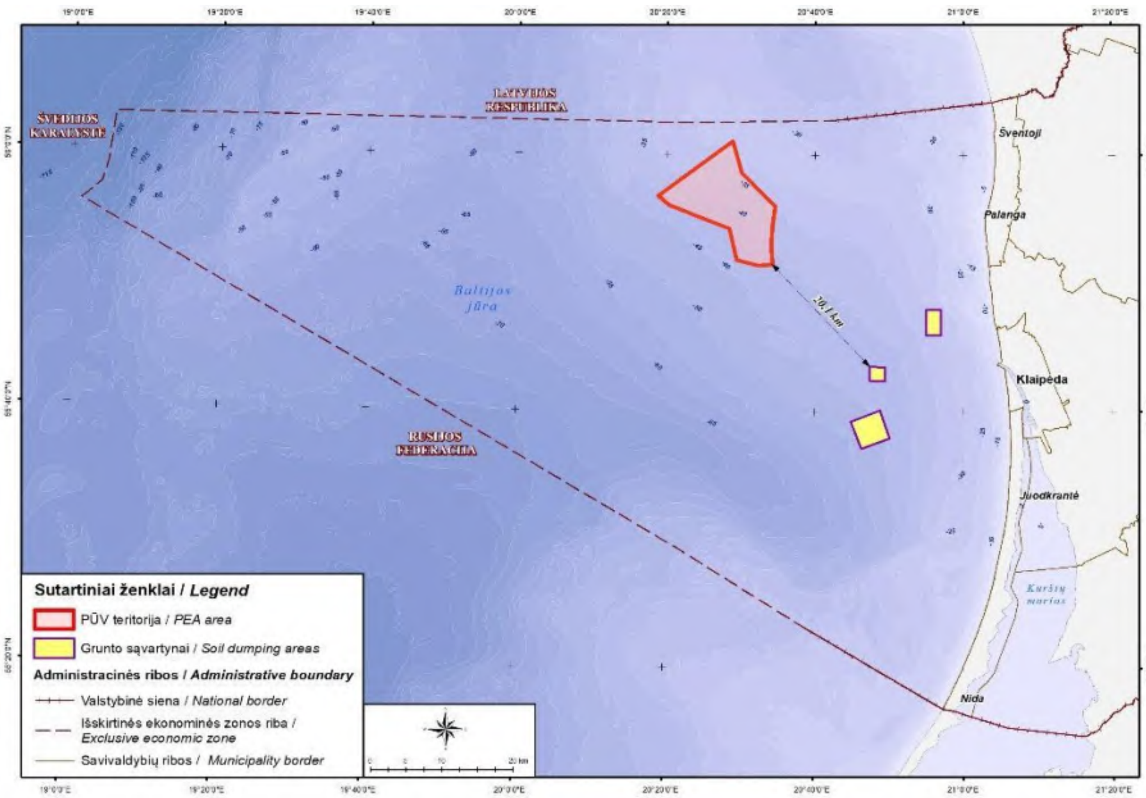


Fig. 4.10.6. Existing sites for soil dumping.

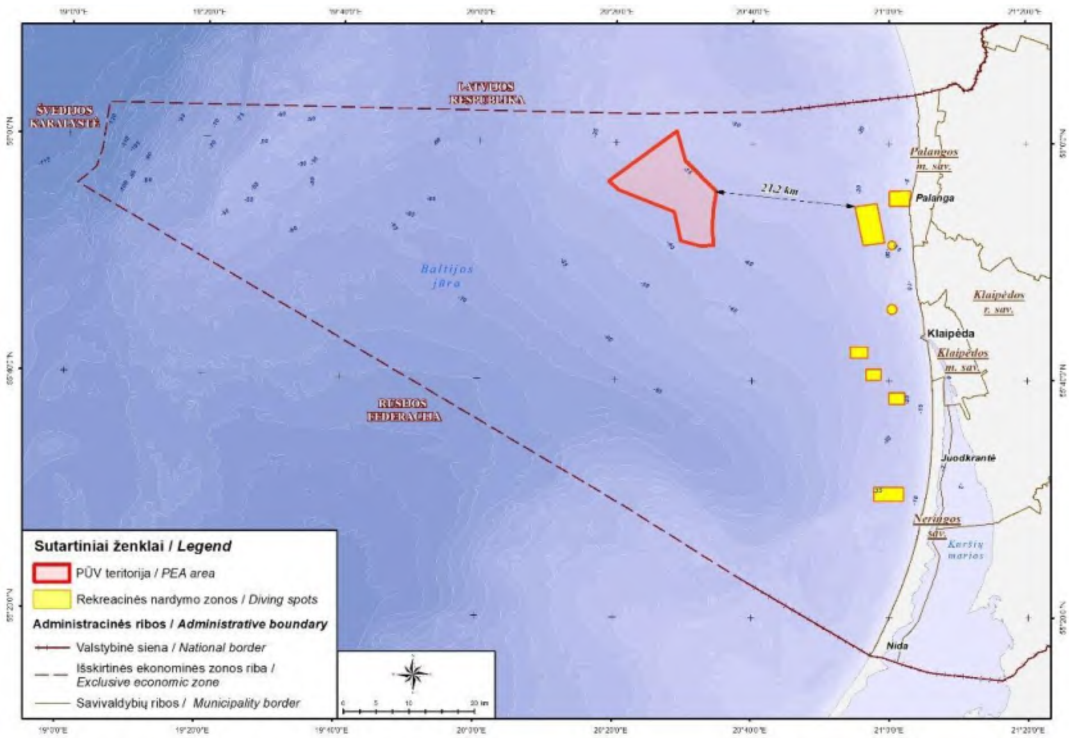


Fig. 4.10.7. The most popular diving areas

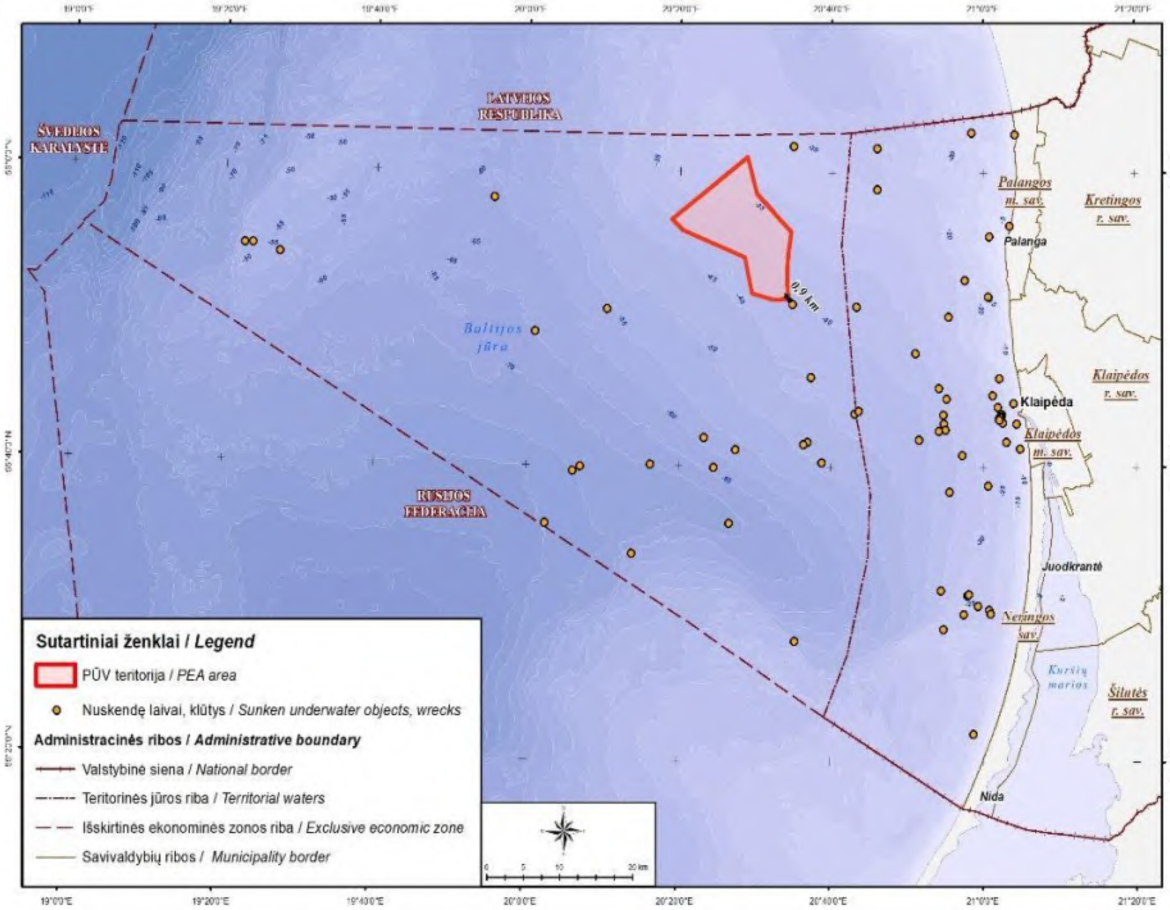


Fig. 4.10.8. Places of wrecks.

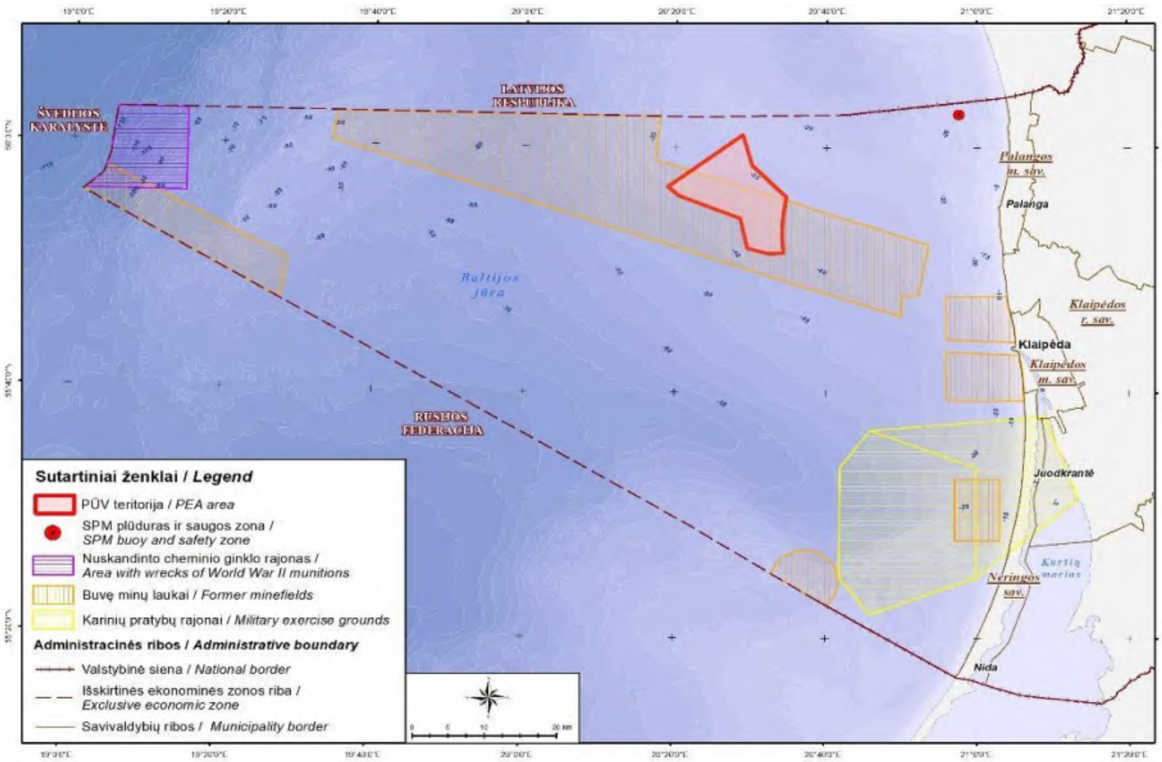


Fig. 4.10.9. Restricted use and hazardous areas (a) and in-situ explosive disposal sites and conflict zones (b).

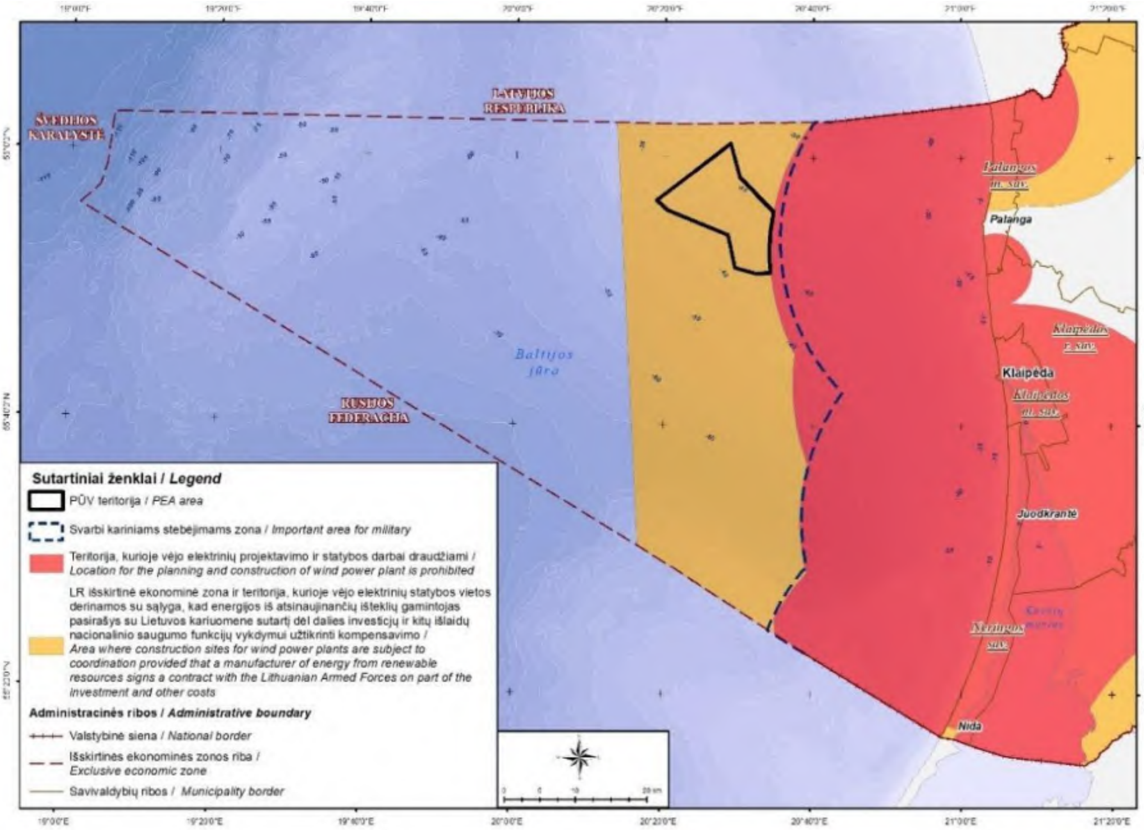


Fig. 4.10.10. Areas subject to national security requirements.

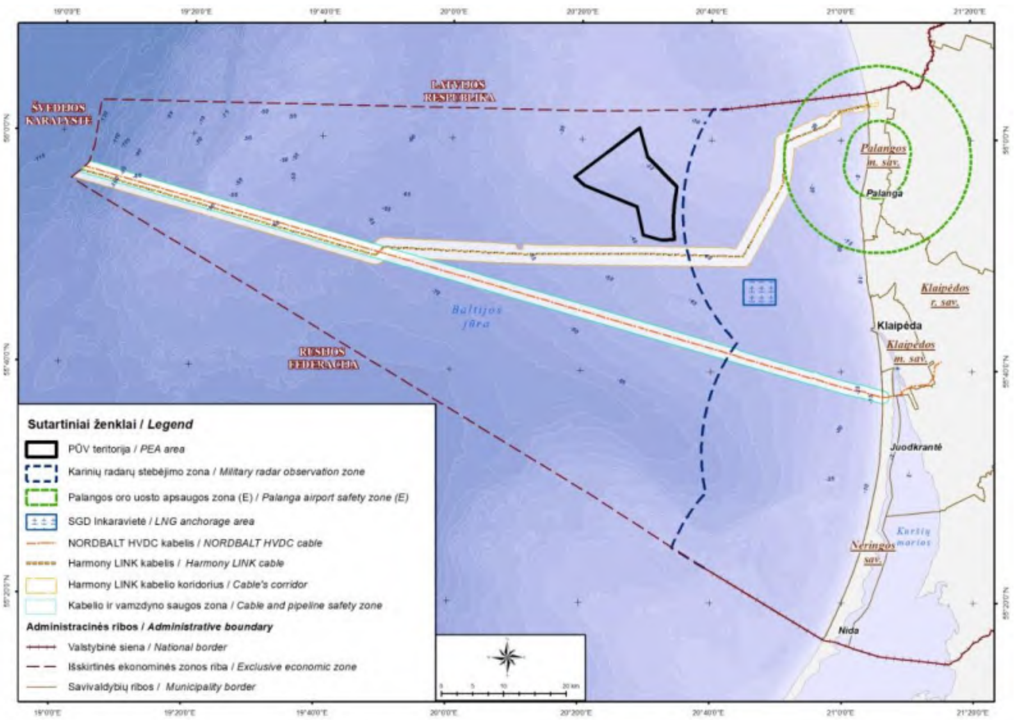


Fig. 4.10.11. Safety zones for objects of importance to national security.

4.10.4. Risk objects and hazardous factors

Table 4.10.5 summarises the risk objects of the PEA and the most characteristic hazardous factors, as well as the potential external effects that may cause emergency situations, by indicating at what time during the service life of the WF park they are important, significant or insignificant.

Table 4.10.5. Hazardous factors of risk objects

Risk objects	Hazardous factors	Stages of works		
		Construction	Operation	Dismantling
Internal factors				
Wind power plant park	Wind power plants; Transformer buildings; Electric cables	Important	Important	Important
Wind power plants	Rotor blades; Power plant towers; Gondola; Rotor oil; Electrical equipment; Fires; Foundation structures	Important	Important	Important
Transformer building	Electrical equipment; Transformer oil	Significant Important	Significant Important	Significant Important
Power transmission cables	Electric voltage	Insignificant	Insignificant	Insignificant
Staff	Staff readiness Human error Intentional activities (sabotage)	Important	Important	Important
Navigation routes (corridors)	Distance from the PEA Traffic intensity Size of vessels	Important	Important	Important
Passing vessels	Dangerousness of cargo Oily bilge waters Fuel Probability of tower damage	Important Significant Significant	Important Significant Significant	Important Significant Significant
Underwater cables	Electric voltage	Insignificant	Insignificant	Insignificant
Būtingė oil pipeline to the coast	Location (remote)	Insignificant	Insignificant	Insignificant
The Būtingė buoy	Location (remote)	Insignificant	Insignificant	Insignificant
Fishing zones	Fishing place Fishing intensity Size of vessels Human error	Important Important Significant Significant	Important Significant Significant Significant	Important Significant Significant Significant
Soild dumping	Dumping place (remote) Vessels	Insignificant	Insignificant	Insignificant
Tourism activities	Boat routes (remote?) Diving places (remote)	Important Insignificant	Insignificant Insignificant	Important Insignificant
Zones of restricted use	Sunk explosives Sunken minefields National defence areas	Important Important Important	Important Important Important	Important Important Important
Accidental detonation of explosive	Impact on the ecosystem Impact on the WF foundation WF tower damage Human injuries and deaths	Significant Important Important Important	Significant Important Important Important	Significant Important Important Important

Aircraft flying past	Fuel for aircraft Probability of damage to blades Probability of tower damage	Significant	Important	Significant
External activities, objects and factors				
Birds	Death of birds Rotor damage	Insignificant	Significant	Insignificant
Extreme hydrometeorological conditions	Icing Hurricane, severe storm	Important Important	Important Important	Important Important

4.10.5. Vulnerable objects and possible consequences

In the planning and construction of power plant complexes in the sea water area, direct impact on the surrounding residents and public objects is avoided, however, vulnerable objects remain (Table 4.10.6.).

Table 4.10.6. Potential consequences for vulnerable objects

Vulnerable objects	Consequences
People:	
During construction:	
- Builders -	Injuries of various degrees, accidental deaths
During operation:	
- service staff	Injuries of various degrees, accidental deaths
- liquidators of accidents and emergency situations	Injuries of various degrees, accidental deaths
- crews of passing vessels	Collision with the WF, a spill of flammable materials, fire, injuries of various degrees, accidental deaths
- passengers of passing passenger ships and ferries	Collision with the WF, a spill of flammable materials, fire, injuries of various degrees, accidental deaths
- pilots of aircraft	Collision with WF rotating blades, a spill of flammable materials, fire, explosion, severe injuries, deaths
During dismantling	
- builders - dismantlers	Injuries of various degrees, accidental deaths
Nature:	
During construction:	
- sea water area	Water pollution - the spillage of hazardous substances and fuels from construction machinery and ships; Environmental pollution - discharge of mounting materials, and construction waste into the water area
- ambient air	Pollution by combustion products during a fire
During operation:	
- sea water area	Water pollution - a spill of hazardous substances from park installations; Water pollution - a slight spillage of hazardous substances and fuel from ships; Water pollution - a spill of fuel from aircraft
- Birds	Death of birds due to a collision with rotating blades; Impact on swimming birds following spills of oils and other hazardous substances
- marine fauna	Impact due to spills of hazardous substances
- ambient air	Pollution by combustion products during a fire

Property:	
- Wind power plants	Failures of various scales, the collapse of towers, blade flinging away
- Passing vessels	Minor mechanical damage to ship hulls
- fishing and recreational boats	Mechanical damage to ship hulls Fuel leaks into the water area Injuries and deaths of sailors Injuries and deaths of holidaymakers
Vulnerable objects	**Consequences**
- infrastructure objects	Damage to underwater cables
- Aircraft flying past	Crash of aircraft Significant mechanical damages to the aircraft body

4.10.6. Classification of consequences, speed and probability of emergency events

Five-point scales for the classification of the consequences for humans, the natural environment and property, the speed of the development of an accident and the probability of risk proposed by Recommendations R41-02 are used in many risk assessment reports worldwide. Often, this scale is supplemented with a sixth point - no effect.

Table 4.10.7. Classification of consequences

Consequencs for human life and health	
Class	**Signs**
Insignificant	Temporary mild deterioration of well-being
Limited	Several injuries, long-term deterioration of well-being
Considerable	Several severe injuries, very marked deterioration of well-being
Extremely considerable	Several (more than 5) deaths, some to dozens seriously injured, up to 500 evacuated
Catastrophic	Dozens of deaths, several hundred severely injured, more than 500 evacuated
Consequences for nature	
Class	**Signs**
Insignificant	No contamination, effect localised
Limited	Mild contamination, effect localised
Considerable	Mild contamination, outspread effect
Extremely considerable	Severe contamination, effect localised
Catastrophic	Quite severe contamination, outspread exposure
Consequences for material values (property)	
Class	**Value of damage, EUR thous.**
Insignificant	less than 100
Limited	100-200
Considerable	200-1000
Extremely considerable	1000-5000
Catastrophic	more than 5000
Speed of development	
Class	**Signs**
Early and clear warning	The consequences localised, no damage
Average warning	Slightly spread, minor damage
No warning	Proceeds secretly until the effect manifests itself completely, the effect is very sudden (for example, an explosion)
Probability	
Class	**Roughly calculated frequency**
Impossible	Less than once every 1000 years

Almost impossible	Once every 100 to 1000 years
Quite likely	Once every 10 to 100 years
Likely	Once every 1 to 10 years
Very likely	More often than once a year

Where there is a lack of statistical material to determine the probability of an event, a frequency scale based on a qualitative description of the frequency may be used (Table 4.10.8). The IMO recommends the frequency scale used in the risk matrix in cases where the statistical material is insufficient for quantitative assessment.

Table 4.10.8. The scale of frequency of events

Probability	
Class	**Roughly calculated frequency**
Very rare event	This is a more theoretical possibility. Such cases are not known in global practice in this field of industry
A rare event	This category includes events that have taken place in the field of this industry, but they are scarce and are only possible in case of coinciding a series of unlikely circumstances.
Possible event	These are emergency situations that occur rarely, but regularly, at least once a year in the world, or that are recorded at least once in at least one analogous object of the country.
Likely event	This is an emergency situation that has occurred at least once in a country or occurs regularly in one of the company's installations.
Frequent event	These are emergency situations and incidents that occur on a regular basis during the operation of the installation.

4.10.7. Register of potential hazards

Hazards arising during construction are related to the accidents of construction mechanisms and ships, personnel errors when mounting WF towers and lifting rotors, as well as connecting electrical equipment:

- machinery and ship accidents accompanied by minor spills of petroleum products into the water area;
- failure of lifting machinery resulting in the collapse or fall of the structures to be mounted;
- the collapse or fall of the machinery to be installed as a result of employees' errors;
- electrical power leakage due to employees' errors in the connection of the power plants and the inspection of their electrical equipment.

The hazards arising during the operation of WF parks related to failures of power plants and infrastructure installations, personnel errors during service, and activities of third parties.

Activities of third parties include possible attacks, sabotages, and thefts from installations. Among the natural factors, the effects of migratory birds, as well as extreme hydrometeorological phenomena, should be noted.

The following emergency events may occur during the operation of the WF:

- falls of service personnel from a great height during inspection or repair work;
- flinging away of an incorrectly attached rotor blade or other parts during the rotation of the rotor;
- flinging away of the entire rotor due to installation errors;
- collapse of the power plant tower due to poorly designed foundation, tower construction defects or blade strikes.

The major incidents caused by external factors are as follows:

- collision of ships with WF during a storm due to fog or failure of positioning or control unit. The power plant tower is demolished, blades are broken, the ship's hull is damaged, fuel spills or transported materials. In exceptional cases, passengers suffer;
- a collision of aircraft with power stations when a small, low-flying aircraft crashes into rotating blades or a tower without noticing the tower. The power plant is demolished or damaged, blades and rotors are broken, the aircraft crashes, pilots and passengers are killed;
- detonation of a migrating sunken explosive or mine in the event of hitting the underwater part of the WF under construction or operation.

The natural and catastrophic meteorological phenomena are approved by Order No D1-870 of the Minister of Environment of the Republic of Lithuania of 11 November 2011 (version of Order No D1-344 of 9 June 2020) and are given in Table 4.9.2.3. Storms, hurricanes and severe swells are the most dangerous phenomena that complicate the navigation of ships passing by and serving the offshore WF park.

The detection, identification, classification and assessment of potential risk objects and hazards, taking into account the risk assessment steps recommended by the AM, are presented in Tables 4.10.9. to 4.10.10.

Table 4.10.9. Detection, identification, classification and evaluation of risk factors

Description of risk factors					Vulnerable objects		Significance (consequences)			An accident			Index in the matrix
Object	**Unit**	**Factor No**	**Factor**	**Nature**	**Identification**	**Consequences**	**People**	**Nature**	**Property**	**Duration (speed, readiness)**	**Probability**	**Importance (degree of risk)**	
1	**2**		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**
Possible accidents and extreme events during construction													
Wind power plant park	Construction of wind power plants	1	Vessels and machinery servicing the construction	Spillage of fuel from the vessel or machinery	marine ecosystems, property,	limited	insignificant	insignificant	limited	fast and unexpected	quite likely	Area of application of the ALARP principle	C2
		2		Collision of service vessels, damage	crews, builders, property, marine ecosystems	limited	limited	limited	limited	fast and unexpected	rare	Acceptable risk	B2
		3		Collision of service vessels with WF under construction, critical damage	property, crews, builders, marine ecosystems	considerable	limited	limited	considerable	fast and unexpected	rare	Area of application of the ALARP principle	B3
		4		Fall of objects being lifted, damage to the vessel, serious injuries	builders, property, marine ecosystems	considerable	considerable	limited	considerable	fast and unexpected	rare	Area of application of the ALARP principle	B3
		5		Collapse of WF towers to be mounted	builders, property, marine ecosystems	extremely considerable	extremely considerable	considerable	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
		6	Passing vessels	Collision of passing vessels with support vessels, critical damage	property, crews of service vessels, marine ecosystems	considerable	considerable	limited	considerable	fast and unexpected	rare	Area of application of the ALARP principle	B3
		7		Collision of service vessels with WF under construction, critical damage	crews of passing vessels, property, marine ecosystems	considerable	considerable	limited	considerable	fast and unexpected	rare	Area of application of the ALARP principle	B3
		8	Minefields and explosives sunk	Damaged explosive during foundation installation or construction	crews, builders, property, marine ecosystems	extremely considerable	extremely considerable	considerable	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
		9	Aircraft flying past	Collision with high-altitude WF structures	aircraft pilots, property, marine ecosystems	extremely considerable	extremely considerable	limited	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
	Construction of transformer buildings	10	Transformer oil filling	Spillage of transformer oil into the water area	marine ecosystems, property,	limited	insignificant	limited	limited	fast and unexpected	rare	Acceptable risk	B2
		11	Connecting the transformer to the network	Effects of electric current	people, the sea fauna	considerable	considerable	limited	limited	fast and unexpected	rare	Area of application of the ALARP principle	B3
	Laying power transmission cables	12	Service vessels	Spillage of fuel from the vessel or machinery	marine ecosystems, property,	limited	insignificant	insignificant	limited	fast and unexpected	quite likely	Area of application of the ALARP principle	C2
		13	Minefields and explosives sunk	Damaged explosive during cable laying	crews, builders, property, marine ecosystems	extremely considerable	extremely considerable	considerable	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
	Staff	14	Fall from high altitude during installation work	Non-compliance with occupational safety rules	builders	considerable	considerable	no effects	no effects	fast and unexpected	rare	Area of application of the ALARP principle	B3

Description of risk factors					Vulnerable objects		Significance (consequences)			An accident			Index in the matrix
Object	**Unit**	**Factor No**	**Factor**	**Nature**	**Identification**	**Consequences**	**People**	**Nature**	**Property**	**Duration (speed, readiness)**	**Probability**	**Importance (degree of risk)**	
1	**2**		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**
Possible accidents and extreme events during operation													
WF operation	WF components	15	WF rotor blades	Flinging away of the rotor blade	people, property	considerable	considerable	insignificant	considerable	fast and unexpected	rare	Area of application of the ALARP principle	B3
		16	WF towers	collapse of the tower	people, property, marine ecosystems	considerable	considerable	limited	considerable	fast and unexpected	rare	Area of application of the ALARP principle	B3
		17	WF gondola	Fire due to overheated oil	people, property, marine ecosystems	considerable	considerable	limited	limited	fast and unexpected	rare	Area of application of the ALARP principle	B3
		18	Rotor oil	Spill of rotor oil	marine ecosystems	limited	no consequences	limited	insignificant	fast and unexpected	rare	Acceptable risk	B2
		19	Electrical equipment	Current leakage	people	considerable	considerable	limited	limited	fast and unexpected	rare	Area of application of the ALARP principle	B3
		20	Fire in electrical equipment	Thermal effects of fire	people, property	limited	limited	insignificant	limited	average warning	rare	Acceptable risk	B2
		21	Structures of tower foundation	Weakening and loss of stability of the tower	people, marine ecosystems	considerable	limited	limited	considerable	early and clear warning	very rare	Acceptable risk	A3
TP operation	Transformer building	22	Fire in electrical equipment	Thermal effects of fire	people, property	limited	limited	insignificant	limited	average warning	rare	Acceptable risk	B2
		23	Transformer oil	Spillage of transformer oil into the water area	marine ecosystems, property,	limited	insignificant	limited	limited	fast and unexpected	rare	Acceptable risk	B2
Operation of power transmission cables	Power transmission cables	24	Cable damage	Current leakage	people, property	considerable	limited	limited	considerable	average warning	very rare	Acceptable risk	A3
Navigation corridors	Passing passenger ships	25	Collision of passing passenger ships with WF, critical damage	Collision with WF, tower damage, passenger injuries	property, ship crews, passengers, marine ecosystems	considerable	considerable	considerable	considerable	average warning	very rare	Acceptable risk	A3
	Passing cargo ships	26	Collision of passing cargo ships with WF, critical damage	Collision with WF, tower damage, cargo sinking	property, ship crews, marine ecosystems	considerable	considerable	considerable	considerable	average warning	very rare	Acceptable risk	A3
	Passing tankers	27	Collision of passing tankers with WF, critical damage, petroleum spill, damage	Collision with WF, tower damage, spillage of high amount of petroleum	property, ship crews, marine ecosystems	catastrophic	considerable	catastrophic	considerable	average warning	very rare	Area of application of the ALARP principle	A5
Passing vessels	Discharge of oily bilge water	28	Passing vessels discharge oily bilge water near the PEA area	Pollution of the water area in the responsibility zone of the WF park	marine ecosystems	limited	no consequences	limited	no consequences	Fast and unexpected for WF parks	likely	Area of application of the ALARP principle	D2
External underwater cables	Damage to underwater cable	Remote object, protection zones for external underwater cables outside the PEA area, there is no possibility of damage during the operation of the PEA WF power plant park, not examined											
Būtingė oil pipeline to the coast	Damage to underwater oil pipeline	Remote object, protection zone outside the PEA area, there is no possibility of damage during the operation of the PEA WF power plant park, not examined											

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Description of risk factors					Vulnerable objects		Significance (consequences)			An accident			Index in the matrix
Object	**Unit**	**Factor No**	**Factor**	**Nature**	**Identification**	**Consequences**	**People**	**Nature**	**Property**	**Duration (speed, readiness)**	**Probability**	**Importance (degree of risk)**	
1	**2**		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**
Fishing zones	Trawling of fishing boats within the area	29	Collision with WF power plant, transformer building	Collision of service vessels with WF under construction, critical damage	property, crews, marine ecosystems	limited	limited	limited	limited	fast and unexpected	rare	Acceptable risk	B2
Dumping areas	Ground immersion	Remote objects, there is no possibility of damage during the operation of the PEA WF power plant park, not examined											
Tourism activities	Routes of recreational boats	There is no information that recreational boats sail in the territory of the future PEA, remote activities, not examined											
	Diving places	There is no information that diving activities are carried out in the territory of the future PEA, remote activities, not examined											
Zones of restricted use	Sunk minefields, unexploded explosives	30	An explosive rolled by currents into the territory of the PEA	threat of self-detonation	property, people	considerable	considerable	limited	considerable	average warning	rare	Area of application of the ALARP principle	B3
	National defence area	31	Damage to WF during military exercises	Various damage to WF blades, tower, TP, transmission cable	property	considerable	No effects on the PEA staff	limited	considerable	early and clear warning	very rare	Acceptable risk	A3
Sunk minefield	Rolled explosive	32	Self-detonation of a rolled explosive in the event of hitting the WF, TP foundation	damage to the foundation of the tower, the lower part of the structures, effects on service personnel and ecosystems	property, service personnel, ecosystems	considerable	considerable	considerable	considerable	average warning	very rare	Acceptable risk	A3
Flying in the coastal area	Military Air Force exercise	33	Aircraft flying past	Collision with high-altitude WF structures	aircraft pilots, property, marine ecosystems	extremely considerable	extremely considerable	limited	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
	Flying of border service helicopters	34	Aircraft flying past	Collision with high-altitude WF structures	aircraft pilots, property, marine ecosystems	extremely considerable	extremely considerable	limited	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
	Uncontrolled flight of motorless aircraft	34	Flight of a glider or balloon	Collision with high-altitude WF structures	aircraft pilots, property, marine ecosystems	extremely considerable	extremely considerable	limited	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
	Unauthorised entry into the PFA area	34	Unknown aircraft lost	Collision with high-altitude WF structures	aircraft pilots, property, marine ecosystems	extremely considerable	extremely considerable	limited	extremely considerable	fast and unexpected	very rare	Area of application of the ALARP principle	A4
Birds	Entry of birds into the PEA area	35	Entry of birds into the rotation zone of the blades	Death of birds, damage to the rotor	property, birds	limited	no effects	limited	limited	fast and unexpected	likely	Area of application of the ALARP principle	D2

Description of risk factors					Vulnerable objects		Significance (consequences)			An accident			Index in the matrix
Object	**Unit**	**Factor No**	**Factor**	**Nature**	**Identification**	**Consequences**	**People**	**Nature**	**Property**	**Duration (speed, readiness)**	**Probability**	**Importance (degree of risk)**	
1	**2**		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**14**
Extreme hydrometeorological phenomena	Natural hydrometeorological phenomena	36	Very strong wind in the economic zone of the Baltic Sea of Lithuania	Damage to the WF blades	property, service personnel	limited	limited	insignificant	limited	average warning	likely	Area of application of the ALARP principle	D2
		37	Very thick fog	Impact on ship navigation near the WF park	property, ship crews, marine ecosystems	considerable	considerable	limited	considerable	average warning	quite likely	Area of application of the ALARP principle	C3
		38	Very severe storm	Impact on ship navigation near the WF park	property, ship crews, marine ecosystems	considerable	considerable	limited	considerable	average warning	quite likely	Area of application of the ALARP principle	C3
		39	Very heavy swell in the Baltic Sea	Impact on ship navigation near the WF park	property, ship crews, marine ecosystems	considerable	considerable	limited	considerable	average warning	quite likely	Area of application of the ALARP principle	C3
	Catastrophic hydrometeorological phenomena	40	Hurricane in the economic zone of the Baltic Sea of Lithuania	Damage to the WF blades, impact on navigation near the WF park	property, ship crews, marine ecosystems	considerable	considerable	limited	considerable	fast and unexpected	quite likely	Area of application of the ALARP principle	C3

Table 4.10.10. Causes of risk factors and safety measures

Factor No	Factor	Nature	Reasons	Safety precautions
1	2	3	4	5
Possible accidents and extreme events during construction				
1, 12	Vessels and machinery servicing the construction	Spillage of fuel from the vessel or machinery	1. Loss of airtightness of the fuel tank of vessels/mechanisms due to corrosion; 2. Damage to the fuel tank of vessels/mechanisms during operation; 3. Leakage of fuel during filling of tanks of vessels or machinery;	1. The vessel's crew and machinery servicing personnel are trained and instructed and ready for fuelling at sea; 2. Technically orderly vessels and mechanisms. If the fuel is delivered to the place of work, this is carried out by special vessels; 3. The minimum amount of PP spill liquidation equipment is stored in the servicing vessels operating at the construction site;
2		Collision of service vessels, damage	1. Mistake of the helmsman, rapprochement with another vessel in the event of a great swell; 2. Technical failure, uncontrollable vessel due to the failure of the steering mechanism or in the event of a halt of the engine; 3. High wind speed, swell, poor visibility;	1. Compliance with navigation safety rules, the operation only under acceptable meteorological conditions; 2. Limitation of the speed of navigation in the area of the WF park, limitation of the wave height at which operation is allowed; 3. Trained and experienced master and crew of the vessel; 4. Briefing on specific works in the WF park;
3		Collision of service vessels with WF under construction, critical damage	1. Mistake of the helmsman, rapprochement with another vessel in the event of a great swell; 2. Technical failure, uncontrollable vessel due to the failure of the steering mechanism or in the event of a halt of the engine; 3. High wind speed, swell, poor visibility;	1. Compliance with navigation safety rules, the operation only under acceptable meteorological conditions; 2. Limitation of the speed of navigation in the area of the WF park, limitation of the wave height at which operation is allowed; 3. Trained and experienced master and crew of the vessel; 4. Briefing on specific works in the WF park;
4		Fall of objects being lifted, damage to the vessel, serious injuries	1. Personnel (crane operator's) error, non-compliance with safe working rules, fatigue due to improper work regime; 2. Rupture of worn crane lifting rope; 3. The load to be lifted exceeds the lifting capacity of the crane;	1. Compliance with safe working rules, weight, lifting speed, meteorological limitations applicable to a specific lifting mechanism, trained and instructed personnel; 2. The rope has been inspected and is technically in good order, without damage; 3. Orderly and maintained equipment, periodic technical inspections and daily inspection before the start of the shift;

			4. During lifting, the power supply of the mechanism is interrupted, and the braking mechanism slips by;	
5	Accidents of the WF structures to be mounted	Collapse of WF towers to be mounted	1. Manufacturing defects, unsuitable materials; 2. Errors in design and engineering geological surveys; 3. Errors of installers, lack of quality control; 4. Non-compliance with restrictions on working under unallowable weather conditions; 5. Hitting of large vessels against the constructions to be installed; 6. Bumping of large aircraft.	1. WF structures are manufactured in stationary companies and purchased only from licensed suppliers; 2. Contracts for design and construction are concluded with reliable and experienced organisations; 3. Prohibitions to perform works under extreme and catastrophic hydrometeorological conditions; 4. Distances from the edge of the nearest 8 km wide shipping corridors are more than 1 km, to the middle thereof about 6 km. 5. Recommended no-fly area for recreational and non-self-propelled aircraft (gliders, balloons).
6	Passing vessels	Collision of passing vessels with support vessels, critical damage	1. Poor visibility, complicated hydrometeorological conditions; 2. Error of the master (skipper) of passing vessel, non-compliance with navigation safety rules;	1. Recommended safety zone of 200-500 m from the boundary of the offshore WF park during construction and operation; 2. Information buoys marking the safety zone near the nearest shipping corridor;
7		Collision of service vessels with WF under construction, critical damage	1. Poor visibility, complicated hydrometeorological conditions; 2. Error of the master (skipper) of passing vessel, non-compliance with navigation safety rules;	1. Recommended safety zone of 200-500 m from the boundary of the offshore WF park during construction and operation; 2. Information buoys marking the safety zone near the nearest shipping corridor;

8, 13	Sunk explosives and minefields	Damaged explosive during foundation installation or construction	1. During the surveys or construction of the foundation, a damaged sunk sanded explosive (mine) detonate; 2. Explosives sunk due to storms and currents migrate and are rolled to the territory of the WF park.	1. To perform surveys of unexploded ammunition (UXO) is recommended before the installation of the WF foundation and the renovation of the towers. 2. In case of the detection of a suspicious object, the contractor shall foresee the identification/liquidation of explosives on site or the safe disposal of the explosives to disposal sites.
9, 30, 33, 34	Aircraft flying past	Collision with high-altitude WF structures	1. Fog, poor visibility, complicated flight conditions, inexperienced aircraft pilot; 2. Aircraft failure, failure of navigation devices, failure of means of communication, loss of orientation;	1. Permits to fly shall only be issued for orderly aircraft piloted by or under the supervision of experienced pilots; 2. At the beginning of the construction, the Air Traffic Control Services, the Lithuanian Armed Forces, Border Guard Service and other interested institutions shall be informed about the covered work area; 3. Commercial and recreational flights shall not be allowed in the offshore WF park area and safety area
10	Transformer oil filling	Spillage of transformer oil into the water area	1. Damage to the tightness of transformers during installation; 2. Spillage during filling.	1. Staff trained, instructed, and experienced; 2. The transformer is new, tested, and without defects; 3. At the site of construction, it is recommended to have a minimum amount of liquidation measures for spills at sea (booms, collection measures or sorbents); 4. Using fast-degrading oil is recommended.
11	Connecting the transformer to the network	Effects of electric current	1. Violation of occupational safety rules; 2. Use of inappropriate materials;	1. Staff trained, instructed, and experienced; 2. Supervision of the project execution, installations and materials at an appropriate level of security are used;
14	Installation of high-altitude structures	Fall from high altitude during installation work	1. Violation of occupational safety rules; 2. Use of worn or disorderly protective equipment;	1. Staff trained, instructed, and experienced; 2. Supervision of project implementation, use of appropriate safety equipment (ropes, safety hooks);
Possible accidents and extreme events during operation				

15	WF rotor blades	Damage and/or flinging away of rotor blades	1. Manufacturing defects, unsuitable fasteners; 2. Extreme meteorological phenomena (strong storms, hurricanes, tornadoes); 3. Collision with aircraft flying by; 4. Lightning discharges to the blade when earthing is not properly installed;	1. WF structures are manufactured in stationary companies and purchased only from licensed suppliers; 2. The project assessed the maximum wind speed values at which the WF can operate; the earthing contours of the required resistance are designed; 3. The means for the visibility of the WF, even under low visibility conditions; 4. Recommended no-fly area for recreational and non-self-propelled aircraft (gliders, balloons).
16	WF towers	Collapse of WF towers	1. Manufacturing defects, inappropriate materials; 2. Errors in design and engineering geological surveys; 3. Errors of installers, lack of quality control; 4. Non-compliance with restrictions on working under unallowable weather conditions; 5. Hitting of large vessels against the constructions to be installed; 6. Bumping of large aircraft.	1. WF structures are manufactured in stationary companies and purchased only from licensed suppliers; 2. Contracts for design and construction are concluded with reliable and experienced organisations; 3. Prohibitions to perform works under extreme and catastrophic hydrometeorological conditions; 4. Distances from the edge of the nearest 8 km wide shipping corridors are more than 1 km, to the middle thereof about 6 km. 5. Recommended no-fly area for recreational and non-self-propelled aircraft (gliders, balloons).
17	WF gondola	Fire	1. Overheating of rotor oil; 2. Ignition of connecting cables due to excessive resistance or connection; 3. Lightning discharge when earthing fails; 4. Non-compliance with fire regulations.	1. The required quantity of primary fire-fighting measures; 2. Temperature sensors, automatic control system, remote video surveillance system; 3. The WF gondola is not a structure, therefore, when preparing the technical project, additional measures to avoid losses due to fires shall be foreseen (automatic gas-fighting systems, insurance in case of fire, and other measures).

18	WF gondola	Spill of rotor oil	1. Loss of airtightness due to corrosion; 2. Collision of the aircraft against the WF structures; 3. Manufacturing defect, installation error	1. Personnel trained, and instructed on how to behave in case of an emergency; 2. It is recommended to have a minimum quantity of means of liquidation of a spill at sea (booms, collection measures or sorbents) at the selected site of the WF park (transformer substation; 3. Using fast-degrading oil is recommended. 4. In the event of a fire, the required quantity of primary fire-fighting measures shall be stored at the TP. 5. Temperature sensors, automatic control system, remote video surveillance system.
19.	Electrical equipment	Current leakage	1. Mechanical damage of internal cables during maintenance work; 2. Insufficient level of protection for the cables used; 3. Violation of occupational safety rules	1. Staff trained, instructed, and experienced; 2. Equipment, cables and materials with an appropriate level of safety are used; 3. Periodic inspection and maintenance shall be carried out in accordance with the requirements of the regulatory documents and the approved plan.
20		Fire in electrical equipment of the WF tower		
21	Structures of tower foundation	Weakening and loss of stability of the tower	1. Design errors; 2. Errors in the installation stage of the foundation; 3. Inclusions of thixotropic ground, which can liquefy due to dynamic loads, in places where limnoglacial, silty-dusty sediments are widespread; 4. Detonation of a wandering sunk explosive in the event of hitting the WF underwater structure.	1. Prior to the preparation of the project, the contractor shall carry out detailed engineering-geological surveys; 2. The foundation shall be installed in pre-Quarter rock soils with sufficient bearing capacity; 3. Necessary maintenance at all stages of construction, including the installation of foundation structures; 4. The area has been explored and buried explosives and mines shall be exploded on site (or safely removed) prior to the start of the works; 5. Since unexploded mines and sunk explosives may appear in the explosive-cleaned area due to swell and bottom erosion and migration of sandy outwash, it is recommended to carry out periodic examinations of the bottom, through the involvement of the Lithuanian Armed Forces demining units or third parties with competence for such work, with the coordination of the Lithuanian Armed Forces.

22	Transformer building	Fire in TP electrical equipment	1. Non-compliance with fire regulations; 2. Equipment wear and periodic inspection and maintenance not performed on time; 3. Lightning discharge and damaged earthing contour; 4. Collision of a vessel and damage to electrical equipment; 5. The aircraft hitting the TP body and its damage; 6. Water entering the TP during extreme swell;	1. Personnel trained, and instructed on how to behave in case of an emergency; 2. It is recommended to have a minimum quantity of means of liquidation of a spill at sea (booms, collection measures or sorbents) at the selected site of the WF park (transformer substation); 3. It is recommended to use fast-degradation oil; 4. In the event of a fire, the required quantity of primary fire-fighting measures shall be stored at the TP. 5. Temperature sensors, automatic control system, remote video surveillance system; 6. The technical design shall include automatic fire detection and extinguishing systems, provided that the size of the TP regulates the installation of such systems. 7. During the preparation of the technical design, extreme hydrometeorological phenomena shall be evaluated, including maximum wave height, solar radiation, temperature, wind speed, etc.
23.		Spillage of transformer oil into the water area		
24	Power transmission cables	Cable damage, current leakage	1. Submersible drilling, bottom digging works and other activities requiring harmonisation in the cable protection zone; 2. Detonation of a wandering explosive or mine; 3. Damage to the cable in an area of importance for national defence during military exercises; 4. Intentional actions (sabotage).	1. Use of armoured cables protected against external effects; 2. Any actions which have not been harmonised with its owner shall be prohibited in the protection zone of the underwater cable; 3. Since unexploded mines and sunk explosives may appear in the explosive-cleaned area due to swell and bottom erosion and migration of sandy silt, it is recommended to carry out periodic examinations of the bottom, through the involvement of the demining units of the Lithuanian Armed Forces. 4. The Ministry of National Defence shall be informed of all the infrastructure elements in the areas of importance for national defence and shall not plan any actions likely to damage them. When an unexploded explosive is found during the demining process, it shall not be exploded in the cable safety zone. 5. Monitoring of the territory of the EEZ by the Border Guard forces shall be performed. As the threat of intentional damage to energy infrastructure objects increases, enhanced protection measures shall be needed by also involving military structures.

25, 26, 27	Navigation corridors	Collision of passing vessels with the WF park objects, critical damage	1. Poor visibility, complicated hydrometeorological conditions; 2. Error of the master (skipper) of passing vessel, non-compliance with navigation safety rules; 3. Failure of the vessel, failure of the steering mechanism or engine; 4. Leeway of a drifting vessel to the water area of the offshore WF park.	1. 1. Large vessels whose collision with the objects of the WF park may cause damage to them shall be provided with navigational devices, radio radars and other necessary equipment; 2. Distances from the edge of the nearest 8 km wide shipping corridors are more than 1 km, to the middle thereof about 6 km. 3. The nearest anchorage shall be 10-12 km far-off from the WF power plant park; drifting time to the park shall be sufficient to start the ship's engines.
28		Discharge of oily bilge waters in the water area near the WF park	1. Malignant activity	1. The vessels that have performed such an infringement shall be traced and the master shall be held liable; 2. If the WF park is included in the list of objects that must prepare a local plan for the liquidation of pollution incidents at sea, it will be required to acquire the necessary localisation measures for the dispersion of pollution and to take measures, within its own responsibility, for liquidation of pollution incidents at sea. If the available means are insufficient, the Maritime Rescue Coordination Centre (MRCC) of the Lithuanian Armed Forces must be notified.
29	Fishing zones	Collision of trawling ships with the objects of the WF park	1. Poor visibility, complicated hydrometeorological conditions; 2. An error by the master of the fishing vessel; 3. Non-compliance with the requirements of the established safety zone; 4. Failure of the ship, failure of the engine or steering equipment, the ship becomes uncontrolled.	1. The distances of WFs in offshore WF park are planned for approximately 1 km,and the decision on the authorisation to fish in the park water area shall be taken by the contractor prior to the commencement of operation of the object 2. It is recommended for the offshore WF park establish a safety zone and provide for activities that will be allowed and prohibited, as well as objects that will be allowed and prohibited to carry out these activities (boat size, speed, other parameters, requirements for traffic safety, etc.).
30, 32	Sunk explosives and minefields	The rolled migrating explosive detonates in the water area near the WF tower	1. Explosives sunk due to storms and currents migrate and are rolled to the territory of the WF park, hit the structures of the WF tower and detonate.	11. To perform surveys of unexploded ammunition (UXO) is recommended before the installation of the WF foundation and the renovation of the towers. 2. In case of the detection of a suspicious object, the contractor shall foresee the identification/liquidation of explosives on site or the safe disposal of the explosives to disposal sites. 3. Since unexploded mines and sunk explosives may appear in the explosive-cleaned area due to swell and bottom erosion and

				migration of sandy silt, it is recommended to carry out periodic examinations of the bottom, through the involvement of the demining units of the Lithuanian Armed Forces.
31	Damage to WF during military exercises	Possible damage to WF objects	1. Accidental damage to the WF due to planning error, human error, during military exercises; 2. Damage caused by the explosion of a sunk explosive where it is not possible to pull it at a safe distance from the WF; 3. Accidental damage to the WF during military operations, through the pursuit of unidentified objects and destruction thereof.	1. The Ministry of National Defence shall be informed about the location of the offshore WF park and shall not plan any actions that may damage it; 2. If an unexploded explosive is found at the time of demining, it shall not be exploded at a dangerous distance from the WF; 3. The naval forces of the Lithuanian Armed Forces shall operate in accordance with its plans as safely as possible.
35	Birds	Death of birds, damage to the rotor	1. Entry of a large flock of migratory birds into the rotation zone of the WF blades under poor visibility conditions	1. Measures to increase the visibility of the blades in the presence of fog (bright colours, audible signals, etc.).
Extreme hydrometeorological phenomena				
36	Very strong wind in the economic zone of the Baltic Sea of Lithuania	Damage to the WF blades		1. The project assessed the maximum values of wind speed and other maximum meteorological parameters at which the WF can operate; 2. Service personnel has been trained to carry out activities in case of the occurrence of extreme hydrometeorological phenomena; 3. Drawing up an emergency plan, even if the object does not meet the criteria for economic operators and other bodies whose heads must organise the preparation, coordination and approval of the emergency plans, is recommended.
37	Very thick fog	Impact on ship navigation near the WF park		
38	Very severe storm	Impact on ship navigation near the WF park		
39	Very heavy swell in the Baltic Sea	Impact on ship navigation near the WF park		
40	Hurricane in the economic zone of the Baltic Sea of Lithuania	Damage to the WF blades, impact on navigation near the WF park		

4.10.8. Risk assessment matrix

The chosen risk matrix (Table 4.10.11) was selected taking into account Recommendations R41-02 and IMO recommendations for risk assessment at sea when statistical material is insufficient for quantitative assessment. The chosen risk matrix allows a qualitative description of the frequency of foreseeable events based on knowledge of similar events described in the press, statistics and scientific literature.

5 categories are distinguished in the probabilistic or frequency scale columns of the matrix (from a very rare one that is unknown in global practice, but there is only a theoretical possibility of such an event up to the ones that regularly occur during the operation of the object).

The probabilistic or event frequency scale is defined by the following probabilities of a possible event:

A is a very rare event. This is a more theoretical possibility. Such cases are not known in global practice in this field of industry (An example of such an emergency situation may be the fall of the celestial body into the WF area).

B is a rare event This category includes events that have taken place in the field of this industry, but they are scarce and are only possible in case of coinciding a series of unlikely circumstances (for example, dragging a ship on the roadstead away during a hurricane and sailing it to the park area).

C is possible event These are emergency situations that occur rarely, but regularly, at least once a year in the world, or that are recorded at least once in at least one object of the country.

D is likely event This is an emergency situation that has occurred at least once in a country or occurs regularly in one of the company's installations.

E is frequent event These are emergency situations and incidents that occur on a regular basis during the operation of the installation (for example, a heavy storm).

The risk assessment matrix does not provide for quantification of probability in cases where data are missing for such an assessment. However, if data are sufficient to establish quantitative probability parameters in the global practice, company or terminal statistics, such probability can be determined and presented during the risk assessment.

The scale of consequences distinguishes 5 or 6 categories of effects on the human, property, environmental and company reputation in the lines, they are evaluated in scores from 1 to 5 in descending order (more detailed in Table 4.10.7). A sixth line - 0 points may also be distinguished in the matrix, where there are no harmful effects during incidents at one of the aspects under consideration.

The risk matrix analyses the dependence between the frequency or probability of the hazard (emergency situations) and its consequences caused. This allows emergency situations to be grouped according to importance, to exclude unimportant hazards and to foresee risk mitigation measures for the hazard arising during each emergency situation.

The risk matrix distinguishes high, medium or marginal and low-risk areas where, accordingly, the risk is unacceptable, acceptable as unavoidable (ALARP), by providing respective control measures, and acceptable.

After putting the 40 dangerous factors of risk objects distinguished and evaluated in Table 4.10.9 in the risk matrix, it can be seen that all of them are either in acceptable or acceptable as an unavoidable risk zone that should be subject to financially justified risk mitigation measures.

Risk objects and hazardous factors will be further assessed when commencing activities and conducting a professional risk analysis, drawing up pollution incident liquidation at sea and emergency management plans as well as other planning documents for response to accidents and dangerous situations provided for in the Lithuanian regulatory acts and EU directives.

Table 4.10.11. Risk assessment matrix

Impact (consequences)						**Frequency (probability)**				
						A	**B**	**C**	**D**	**E**
Description		**people**	**property**	**environment**	**reputation**	**Very rare (not known)**	**Rare (known in industry)**	**Possible (fixed)**	**Likely (possible)**	**Frequent (occurred and possible)**
5	Catastrophic consequences	Numerous fatal cases and total loss of ability to work	Very heavy losses in the whole region	Regional adverse impact on the whole ecosystem	Impact on an international scale	ALARP 27				
4	Extremely considerable impact	Rare fatal cases and total loss of ability to work	Significant losses in the enterprise and adjacent areas	Significant impact	Impact at the national level	ALARP 5, 8, 9, 13, 33, 34	ALARP			
3	Significant impact	Serious injuries and health problems	Large losses in the enterprise	Localised impact	Significant impact	21, 24, 25, 26, 31, 32	ALARP 3, 4, 6, 7, 11, 14, 15, 16, 17, 19, 30	ALARP 37, 38, 39, 40	ALARP	
2	Limited impact	Minor injuries and health problems	Small losses	Low but impact is felt	Low impact	6, 7	2, 10, 18, 20, 22, 23	ALARP 1, 12	ALARP 28, 35, 36	ALARP
1	Insignificant impact	Mild injuries and health problems	Small losses	Minor impact	Minor impact		29		ALARP	ALARP
0	No effects	-	-	-	-					

Description		Marking
Unacceptable risk. This degree of risk shows unacceptable fatal cases, losses, and negative impacts on the whole ecosystem and the company's prestige. The hazard must be eliminated or the risk thereof reduced to a tolerable level. **Urgent measures are needed**	High level of risk	Red
Acceptable, but risks must be managed in order to reduce probability and losses. Mandatory planning of risk mitigation measures and preparation of documentation.	The marginal level of risk	ALARP
Acceptable and monitored. Additional security measures are possible when the company's resources allow.	Low level of risk	Green

4.10.9 Assessment of risks and consequences of vessel collisions with wind power plants

The identification and assessment of shipping risks are conducted in accordance with various methods, procedures and regulations, different in different countries and in shipping or risk assessment companies.

SSPA Sweden AB, in the paper Methodology for Assessing Risks to Ship Traffic from Offshore Wind Farms (2008) covers the determination of the legal basis, objectives and methods of risk assessment, hazard identification, risk analysis and assessment thereof, risk mitigation measures, assessment uncertainties and possible inaccuracies and preparedness for emergency situations and their liquidation.

The probability of a collision of navigating vessels with running engines is directly proportional to the intensity of navigation in the environment of the planned WF parks, to the direction of navigation in relation to these parks and possible navigation errors. Among the many possible ways and algorithms to determine probability, this study provides a detailed overview of the methodologies presented by the Maritime Research Institute Netherlands (MARIN), the Germanischer Lloyd (GL) and the Danish company Det Norske Veritas (DNV).

The GL and DNV models multiply potential collisions by a causal factor calculated by estimating the Gauss partition coefficient of possible deviation from the route.

The GL and DNV models multiply potential collisions by a causal factor calculated by estimating the Gauss partition coefficient of possible deviation from the route (Fig. 4.10.12).

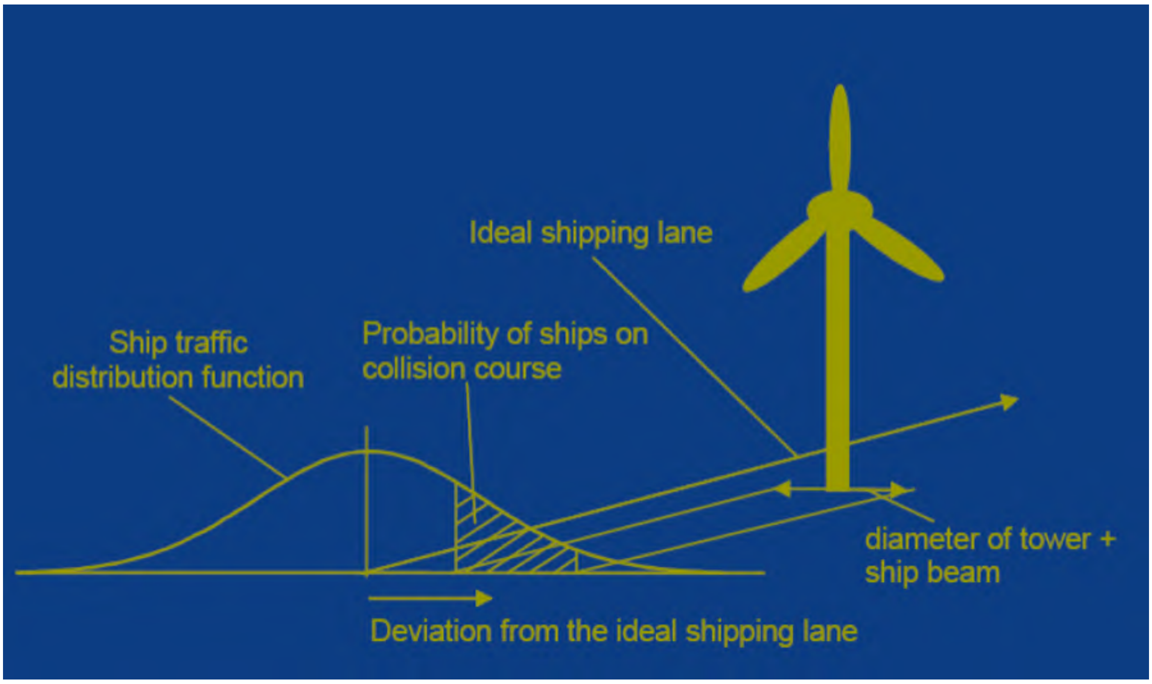

Fig. 4.10.12. Causal factor for the collision of navigating vessels with wind power plants.

The density of standard normal distribution is described in the Gauss function:

$$\varphi(z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}}$$

The graph of standard normal distribution density (Fig. 4.10.13) indicates that the Gauss function reaches a maximum at zero point. The density at this point is 0,3989, which can be calculated because:

- e_0 =1
- square root of 2π = 2,50599281

- 1/2.5059928 ≈ 0,399.

Values with small deviations from the mean are more common than those with large ones. The abscissa scale is measured by standard deviations from the mean (σ). Most values are ± 2σ; almost all data is ± 3σ (the three-sigma rule).

The standard normal distribution function allows calculating probabilities:

$$P(Z < z) = \Phi(z) = \int_{-\infty}^{z} \varphi(t)dt = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-\frac{t^2}{2}} dt$$

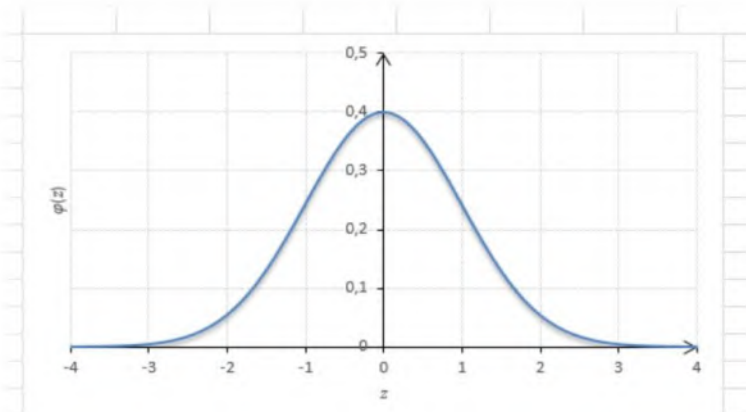

Fig. 4.10.13. Graph of the density of standard normal distribution.

The standard normal distribution function allows calculating probabilities:

$$P(Z < z) = \Phi(z) = \int_{-\infty}^{z} \varphi(t)dt = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-\frac{t^2}{2}} dt$$

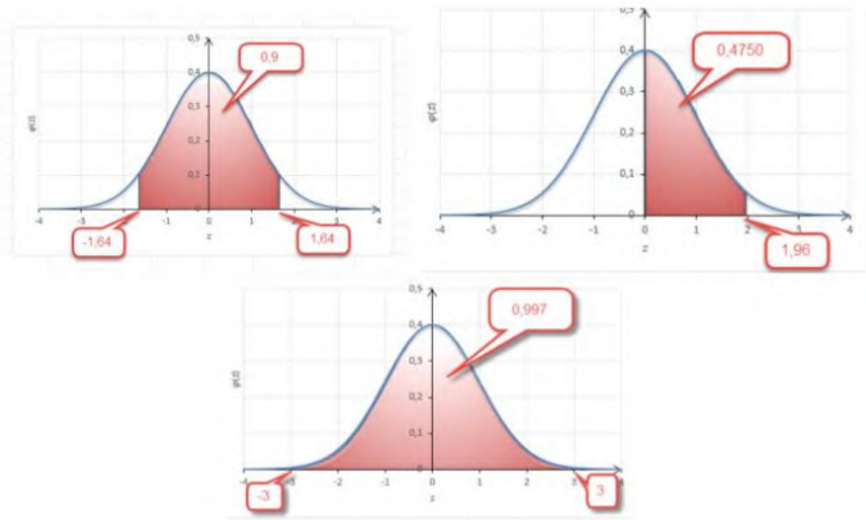

Fig. 4.10.14. Distribution of standard normal density to standard probabilities.

Fig. 4.10.14. shows that 90 % of the normally distributed values fall within the range ± 1.64, 90 % within the range ± 1.96. 99.7 % of the normally distributed values fall within the range ± 3.

The MARIN model multiplies possible potential collisions by the Navigational Error Rate (NER) (Fig. 4.10.15).

In all cases, data on shipping routes, speed limits, meteorological conditions and wind power plant farms as well as the arrangement of specific power plants therein are entered in computerised navigation risk assessment models that determine collision probabilities.

Having evaluated the peculiarities of vessels, age, crew readiness, and a number of other factors, the causal factor or navigational error rate calculated by the specialists of the Danish Technical University reaches 5.29-2.95E-04.

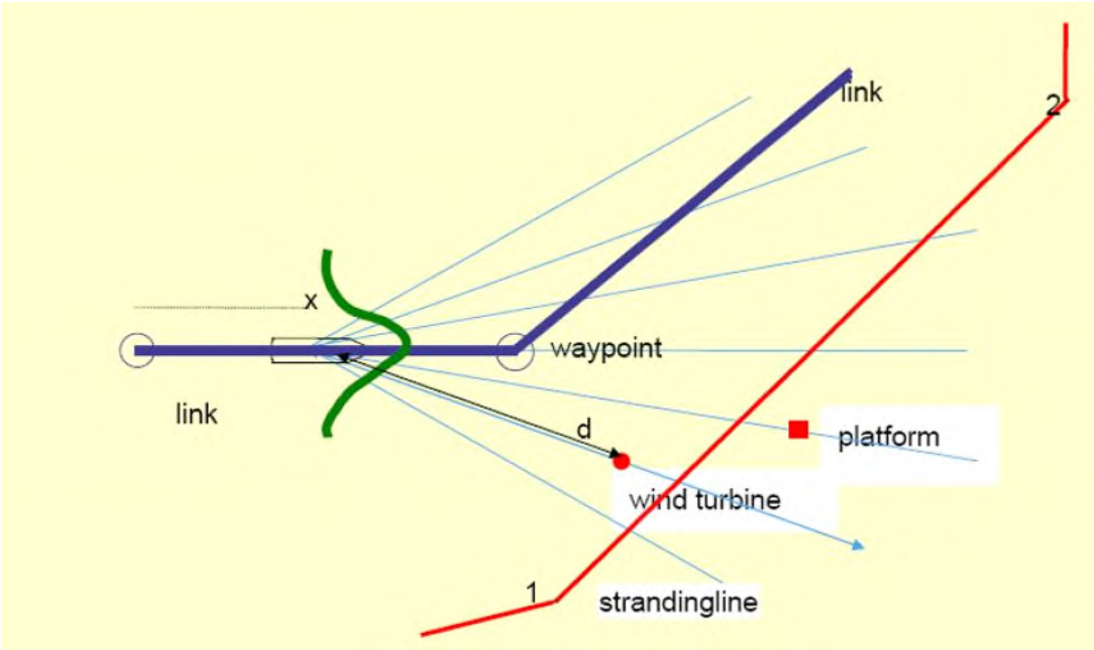

Fig. 4.10.15. Collision navigational error rating.

The probability of ship collisions with planned WFs depends directly on the intensity of shipping. During the voyage, information about their navigation via a satellite or shore-based system installed in Klaipeda and Liepaja is transmitted at intervals of several seconds or minutes depending on the speed of movement of the vessel. ICES and HELCOM apply a grating of 0.05 degrees (about 15 km^2) to analyse the data collected by the vessel monitoring system (VMS) at 1-2 hour intervals.

The intensity in the environment of the port of Klaipeda and PEA site in 2020 was 11,146 vessels. Any vessel passing at a distance of about 1 km from the WF park can be considered as a probable possibility of collision. The shipping corridor is 1-1.6 km away from the boundary of the PEA site; the distance of the most intensive navigation flow is 5.7 km (in the southern) and 4.8 km (northern) parts of the PEA territory.

Collisions with fishing boats, servicing vessels and recreational boats do not pose a significant risk for the WFs. A collision with large vessels, the intensity of which is shown in the footnotes attached to Fig. 4.10.16 in the NE-E shipping corridor, is dangerous.

The probability of collision per year following the adoption of the value of upper average navigation error rate and the intensity of navigation at the expected route of tankers to Būtingė (435 large vessels passing in 2020, introducing a factor of 1.3 for a possible increase in shipping intensity):

$$435 \times 1.3 \times 5.29E\text{-}4 = 0.3$$

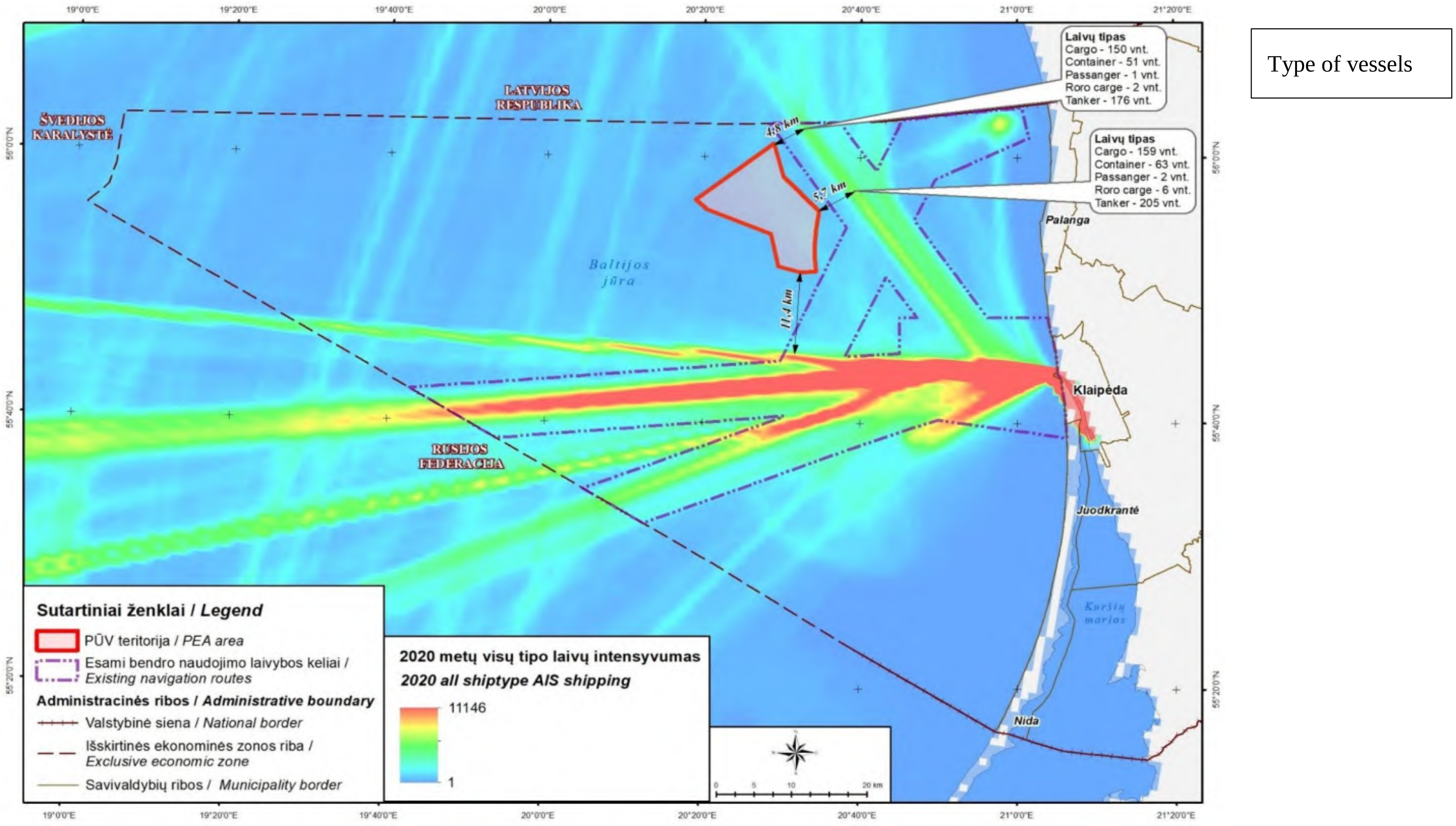

Fig. 4.10.16. Shipping intensity in the wind power park environment in 2020

According to the law of Gaussian deviation distribution, the number of vessels that could find themselves on the edge of the lane about 6 km wide could be conservatively estimated to reach 0.03 %, around 50 m lane near the park area - about 0.17 ships. Then, the probability of collision of passing large vessels that can cause damage to the WF with the wind power plant farm per year is:s:

0.17x5.29E-4=9.0E-05

The probability of a drifting vessel collision may be calculated either after evaluating the probability of a vessel's engine failure, which, depending on the size of the vessel, the number of engines may vary from 2,30E-4 to 5,0E-5 per engine hour or the number of vessels anchored near the WF site. The nearest vessel anchorages are 10.2-12.8 km away. Following the evaluation of the changes in meteorological conditions and the increase in storm winds, the uncontrolled ship may drift 10 to 12 km. The probability of reaching the WF park is reduced by the prevailing directions of the western stormy winds that carry the ship towards the coast.

The probability of a collision between passing ships, even conservatively calculating the number of ships that can find themselves at the edge of the 6 km wide lane (at the territory of the PEA) is equal to 9.0E-5, the frequency is once in approximately 11,000 years. The risk of collision with WF of passing large vessels that can damage WF towers is acceptable.

When preparing the technical design, once the exact arrangement of the WF is clear, the contractor is recommended to conduct a more detailed shipping study and clarify the risk analysis. Also, in the design and construction of the planned WF park, the implementation of the ALARP principle should be recommended; it is appropriate to provide for possible financially reasonable measures to reduce the risk of collisions, in line with world-recognised good practice in the construction of WF parks at sea.

Ramboll-prepared risk analysis (Anholt Offshore Wind Park. Analysis to Risk to Ship Traffic. Ramboll, 2009) the calculated individual risk of death was 6.26-5.27E-08 for crew members of cargo ships and tankers, and 5.32-5.60 E -07 for passengers.

In Lithuania, LSIR and IPRA indicators are used to identify individual risks. Location-specific Individual Risk (LSIR) is the probability that a person hypothetically placed in a certain place, open space (not protected by building structures), 24 hours a day and 365 days a year, will be fatally injured. According to the LSIR indicator, the public unacceptable risk limit is 1.00E-04, the degree of generally acceptable risk in industrial areas <1.00E-05, residential areas <1.00E-06, and socially sensitive areas <1.00E-07.

On shipping routes, people only pass through a dangerous risk area; the time of their stay therein is limited, so the IPRA indicator is to be used. Individual Risk per Annum (IRPA) is the probability that one person will be fatally injured over a period of one year by estimating the actual time of his stay in the analysed location (depending on the duration of his stay in the risk zone). According to the IPRA indicator, the risk degree of acceptable risk in industrial areas is <1.00E-05, residential areas <1.00E-06, and sensitive areas <1.00E-07.

The passing time near the WF park is 2 hours. The annual number of hours is 8,760. The importance of IPRA for passengers would be:

9.0E-05/8760x2=2.05E-08

The value of IPRA for the crew of a passing vessel, considering that it can pass 12 times a year, would be:

9.0E-05/8760x2x12=2.5E-07

The target IPRA risk level is 1.00E-05 for the crew of tankers, dry-cargo carriers and other cargo vessels, and 1.00E-06 for ferry passengers. It is predicted that the marginal annual individual risk values for passengers and ship crew members will not be reached after multiplying the available data on the number of passing ships by a factor of 1.3 (in order to estimate the increase in the number of vessels in the near future).

In addition to the risk of collisions (expected frequency), the second aspect to be assessed is the consequences of collisions.

Environmental impact may result from a collision between the vessel and the WF or the substation. The impact of accidents can lead to pollution of the environment by materials from the power plant or the collided vessel. The impact of collisions depends on a number of factors, such as the type of vessel, the angle of collision, the speed, the electrical design solutions, the type of foundation, etc. If larger vessels, e.g. tankers, collide with the power plant, in most cases it is likely that only the power plant and the foundation will be seriously damaged.

Ramboll rizikos analizė (Anholt Offshore Wind Park. Analysis to Risk to Ship Traffic. Ramboll, 2009), having assessed the collisions of different types of vessels with wind power plants, found that in the case of a collision between dry-cargo cargo and passenger ships, the consequences for the environment are limited and considerable; in the case of collisions with tankers, they can vary from limited to extremely considerable.
The most likely polluting substance in the following cases is oil:

- The discharge of petroleum products (rotor oil) from WFs is not of major concern, as the WF gondola contains a very small amount of oil; a degrading oil is used;
- The oil used in the energy converter substation also does not pose a significant risk of pollution as it is limited in amount. To mitigate this risk, substations should be double-walled;
- The most dangerous environmental impact of oil pollution can be caused by spills from ships.
- The most critical case would be pollution due to a collision with an oil tanker. This could lead to more significant spillage of petroleum products, which are more harmful to the environment due to low evaporation. The consequences of such collisions require the preparation of special accident liquidation procedures (Concerted Action on Offshore Wind Energy in Europe Final Report, 2001).

In addition to the vessels sailing to Klaipeda Seaport, small fishing ships and recreational boats run in the water area. For the determination of fishing ship trawling events and their location in the PEA area, AIS data collected at intervals of 5 minutes applying a 0.005-degree grating (approximately 0.15 km^2) was used. This EIA report (Chapter 4.9.1) provides data on the movements of trawling small fishing ships between 2012 and 2021. This chapter, Fig. 4.10.17, presents data on trawling events in the grating in 2014 when the PEA area had the highest fishing intensity of up to 100 events per year.

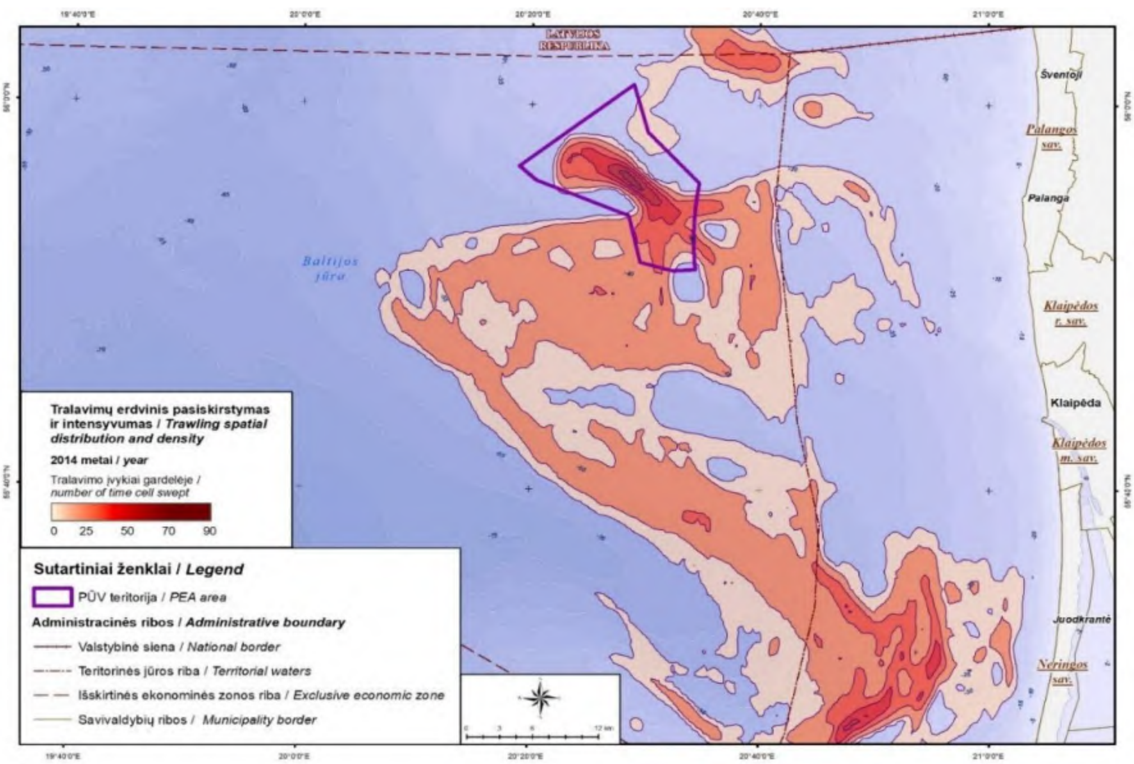

Fig. 4.10.17. The maximum determined intensity of traffic of trawling fishing ships within the PEA area (2014).

Since commercial trawl fishing is not practically carried out in the PEA area (Fig. 4.10.18), this aspect can be ignored. But if the fish stocks are restored during the operation of the WF, it is possible that fish will appear there, and the traffic of small boats using other fishing techniques will be intense if the regulation of the safety zone does not provide for operating bans. Then the possibility and consequences of colliding with the power plant or transformer building tower remain.

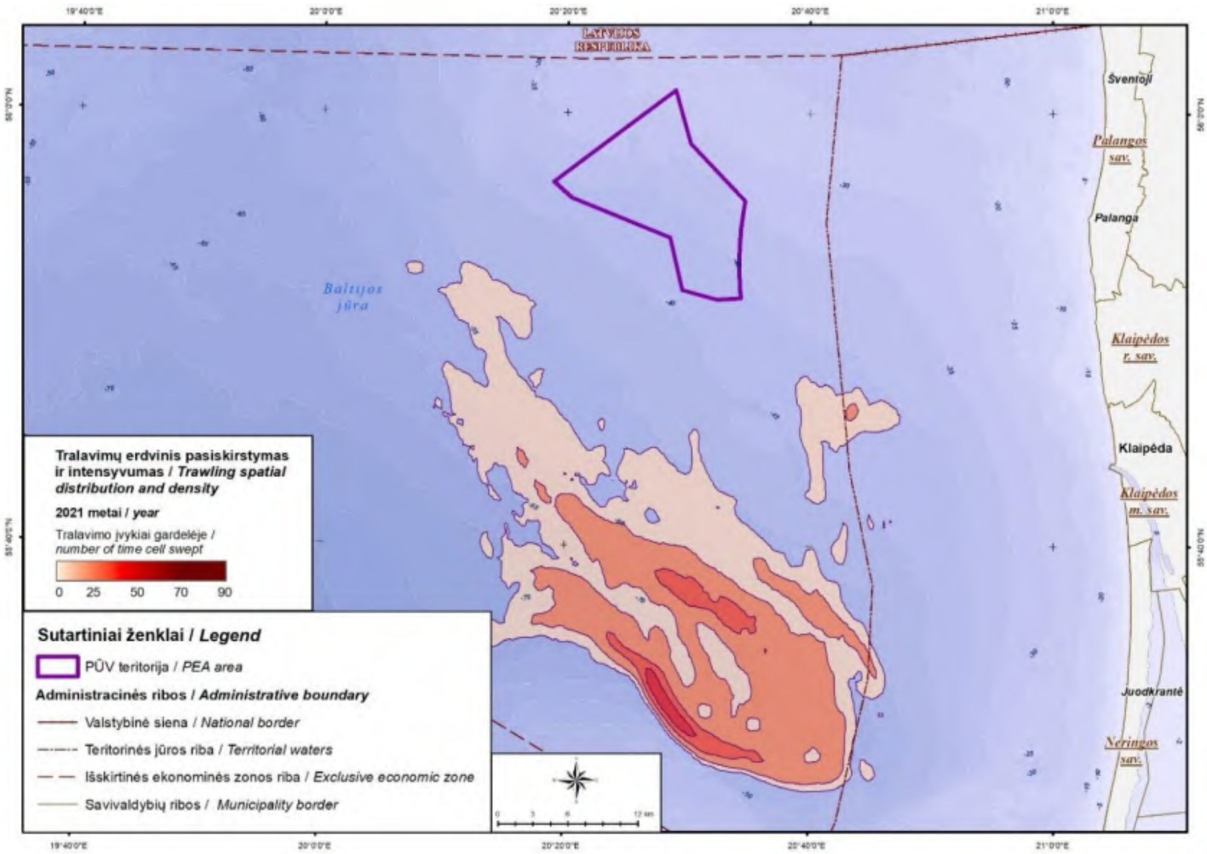

Fig. 4.10.18. The intensity of trawl fishing in the PEA area in 2021.

The navigation of small fishing ships may take place within or approach the PEA area. Old ships with a probability of engine failure of 2.0E-4 are used and the resources are practically exploited. During strong winds, they can lose control and be taken off toward the WF park. Based on an estimate of the number of fishing ships sailing in the PEA area, the probability of such ships colliding with power stations may be as follows:

100x2.0E-4=2.0E-2

The determination of a 100 m protection zone would allow accidental access therein to approximately 10 % of the vessels manoeuvring in the water area. Then the probability can reach:

10x2.0E-4=2.0E-3

After defining a safety zone of 500 m, the chance of accidental entry would be low, about 1 %, the probability of a collision:

1x2.0E-4=2.0E-4

For small fishing ships, if they were allowed to sail in and around the park water area, a collision with power plants is possible once every 50 years, with a protection zone of 100 m once -every 100 years, with a zone of 500 m - once in 5 000 m.

The collision of light fishing boats with WF towers and transformer substations is not considered an event capable of causing significant damage to towers or transformer buildings. Small spills of their diesel fuel would also evaporate quickly and the consequences would be limited.

The traffic of service vessels in the area of the WF park may be of similar or lower intensity. Service vessels will sail at low speeds around the water area, and will moor at designated mooring points. The traffic of the service vessels is considered safe, and the risk of collision thereof is not assessed.

4.10.10 The ALARP principle and risk mitigation measures

Efforts to reduce risks from the upper to the lower limit shall be balanced by considering risk degree mitigation factors such as time, problem complexity, severity and price. The principle of the lowest practically possible degree objectively means the threshold at which further risk mitigation measures are unjustified due to a disproportionate cost-benefit ratio. This principle is illustrated graphically in Fig. 4.10.19.

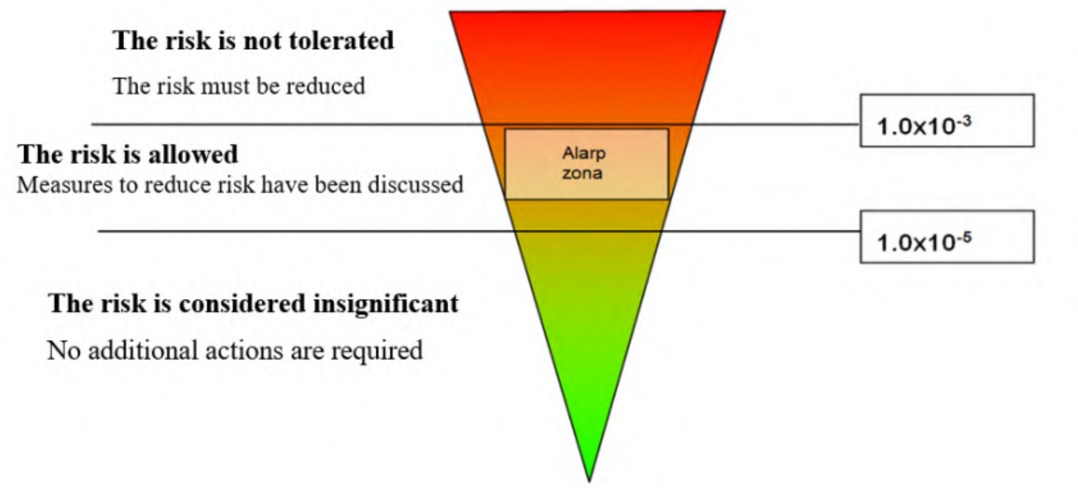

Fig. 4.10.19. The principle of risk reduction (ALARP principle).

Most of the risk factors of the offshore WF park fall within the ALARP zone; these are medium risk factors, which are strongly recommended to be subject to the ALARP principle.

Risk mitigation measures for the selected risk area (technological unit, normative documentation, scenario group, HAZID-specific scenario) include:

- Measures to eliminate hazards;
- Measures to eliminate the causes of occurrence of hazard, the spread of the accident;
- Measures to mitigate impacts and consequences.

During the preparation of the technical design, construction and operation of the WF park, accident prevention measures shall be provided, together with the adaptation of ALARP measures, taking into account existing risk objects and their hazardous factors. ALARP measures are those accident prevention and risk reduction measures that are not regulated as mandatory by national normative documents or EU directives but are inexpensive and efficient, and their introduction allows the risks to be effectively reduced as low as reasonably practical at minimal costs.

ALARP measures are always of a recommendatory nature and usually include:

- Recommendations in the manuals to good practice prepared by the institutions responsible for safety;
- Experience of leading companies in the field of implementation of risk reduction measures;
- The application of best available production methods and state-of-the-art technologies wherever possible;

- Prompt response to changing operating environment conditions (social, economic, natural);
- Additional training for staff, preparedness for emergency situations and response actions.

ALARP measures always pay off; lower probabilities are the most effective, but for reducing the risk of hazardous factors that can cause greater consequences.

In the construction and operation of the WF park in the Lithuanian EEZ, a collision with large passing ships, including tankers (about 200 tankers per year), is rare, but it can cause critical damage to the park objects. Although the calculated probability thereof is low, equal to 9.0E-5, the frequency is once every 11,000 years; a large amount of oil spilled would damage about 10 % of the Lithuanian coast in Šventoji-Palanga section, therefore it is recommended that the ALARP measure establish a maximum protection zone of 300-500 m and mark it periodically with signal sending buoys from the nearest side of the shipping corridor. Activities with limited or negligible impacts should be set in the safety zone and authorised with the operator's consent.

A distinctive feature of this offshore WF park is part of the water area in the sunk minefield. According to the data of demining units of the Lithuanian Armed Forces that carry out demining works, new sunk explosives are present in the areas that have already been cleaned up, which are carried over by temporary or constant currents. ALARP measures and periodic monitoring of the bottom of the WF park territory are recommended in order to spot and destroy migrating explosives in a timely manner.

Extreme hydrometeorological phenomena are common in the operation of WF parks, their potential impact shall be assessed by calculating the structures of foundations, and towers, as well as assessing the conditions for the WF operation and the necessary stop. An additional ALARP measure is recommended for drawing up an emergency management plan covering both the readiness for extreme hydrometeorological events and other possible extremely dangerous events. The developer and the beneficiary (State) are recommended to consider the issue of protection of the WF park by assessing attacks against energy infrastructure objects in the Baltic Sea.

4.10.11 Preventive measures during construction, operation and dismantling

4.10.11.1 Navigation

In order to reduce possible collisions of vessels with WFs or to avoid cable damage, the developer shall impose restrictions on the access of vessels to the WF park water area or the navigation in the water area or near it.

During the preparation of the technical design, interested shipping authorities will also be consulted and decisions will be taken on:

- The establishment of the safety zone, configurations thereof and application to designated vessels during the construction, operation or dismantling of the park;
- The time of the announcement of information and alerts through notifications to seamen or other relevant sources of information;
- Setting of shipping routes within or near the WF park;
- Assigning the sites to the areas to be avoided;
- Installation of surveillance with radar, AIS[31*] (automatic information-identification systems) and/or video surveillance systems;
- Constant watch;

[31*] AIS technology has been developed to increase navigation safety, and reduce ship collisions. These automatic ship identification systems must be installed in all passenger ships and cargo ships of 300 GT (gross tonnage) and larger cargo ships. The possibility of installing this system on smaller ships is currently being considered by the International Maritime Organisation. According to the statistical and navigation-related information received from these ships by the shipping regulatory services via the AIS system, the location, name, size, draft, cargo carried, speed, course and, if necessary, control of the ship's navigation or planned manoeuvres can be "seen" at any time.

- Any other appropriate measures and procedures.

In addition, the developer, in coordination with the Safe Navigation Administration, shall determine the navigational markings of the individual structures of the WF park located on the perimeter of the park and inside, as well as the above and underwater parts thereof (AIS* transceivers, radio beacons, audio alarms, lighting) for the day and night time based on the established procedure for the operation of navigation devices.

All design solutions shall be coordinated with the command of the Lithuanian Armed Forces of the Republic of Lithuania in the areas of state significance and military objects of importance for national security, where military aircraft flights can be carried out. There are no specific restrictions prohibiting the construction and operation of the WF in the selected PEA area.

4.10.11.2 Measures during construction

During the design stage, the developer must establish and coordinate the rules for the navigation of vessels serving the construction with the Safe Navigation Administration and define their routes.

In order to avoid accidents/collisions with vessels normally operated, the site and coordinates of the construction area shall be published through navigational notifications, which are administered and placed in electronic navigation control systems by the Lithuanian Safe Navigation Administration. The construction site shall be illuminated during the night. Continuous navigation surveillance near the construction site (visual from ships involved in construction works and/or by using traffic safety ship on duty, as well as by radar) to help reduce and avoid collision risks shall be foreseen. In order to avoid additional accidents or collisions, the Safe Navigation Administration will have to be informed of the construction dates near shipping lines (particularly relevant during cable laying).

Analogous measures will also be applied at the dismantling stage.

4.10.11.3 Planning of pollution incidents at sea and rescue operations

During operation, the watch shall be carried out 24 hours a day at the central headquarters of the WF park. The operator will have a chart with the GPS (Global Positioning System is a system, which allows determining the coordinates of an object anywhere in the world) and the coordinates of each power plant in the park as well as identification numbers. The same information must be held by the Maritime Rescue Coordination Centre (MRCC) of the Lithuanian Naval Forces, the authority responsible for organising the search and rescue of persons and the response to pollution incidents at sea. In order to ensure rapid and adequate response during the construction and operation of an accident, accident or otherwise, operational procedures (notifications, communication tools, response forces and equipment, procedures for stopping/launching turbines, etc.) will be set out in the plan for human search and rescue and response to pollution incidents of the WF park. The plan will be agreed upon with the authorities concerned. Communication and stopping procedures shall be regularly tested and exercises will be carried out.

Article 23 of the Law on Protection of the Marine Environment of the Republic of Lithuania states: Article 23 of the Law on the Protection of the Marine Environment of the Republic of Lithuania states: Installations, oil and chemical substance terminals, other potential sources of pollution, seaport administrations and municipal administrations must have local Plans for Response to Pollution Incidents coordinated with the institutions authorised by the Government. The Minister of the Environment shall approve the list of institutions and objects that must have local plans for response to pollution incidents.

The list of institutions approved by Order No D1-285 of the Minister of the Environment of 5 April 2011 (as amended on 24 May 2013) and objects that must have local plans for response to pollution incidents currently includes six municipalities of coastal cities and districts and 22 enterprises.

A decision on the inclusion of the planned offshore WF park on the list will have to be taken before commencing its operation, during the preparation of the technical design.

Order No V-104/D1-673/1V-596 of the Minister of National Defence, the Minister for the Environment and the Minister of the Interior of 9 November 2009 (consolidated version in force on 2 July 2022), the plan for response to pollution incidents in the sea area sets out the strategy for the response to pollution incidents at sea, procedures for receiving notifications on pollution incidents and mobilising forces performing liquidation works, the duties of institutions and responsible persons involved in the liquidation of pollution incidents, the principles and schemes for the management and execution of such works, the requirements for the means of communication used during the liquidation operation of pollution incident and recommendations on how to draw up local plans for the response to pollution incidents. Three levels of pollution incidents are distinguished according to the scale of pollution and the forces necessary for response.

The Annexes to this plan include the authorities involved in the response to the pollution incident process, the procedures for reporting the response to pollution incidents and mobilising forces, the general principles for the management of responses to the level 3 pollution incidents, the communication plans for the response to pollution incidents, the general list of forces and measures for liquidation of pollution incidents.

The enterprises included in the list shall prepare local plans for the response to pollution incidents in the marine area in the area of their responsibility. Following the risk analysis of the pollution incidents, the hazardous substances likely to spill into the marine water area, the quantities thereof, the measures needed to stop dispersion and to liquidate the consequences, their quantities and storage areas shall be identified. The extent of pollution, when the available forces are insufficient and the MRCC is contacted regarding the mobilisation and deployment of the national forces for response to pollution incidents.

In construction, servicing and repair, maintenance and other cases when people work at the offshore WF park, preparing for rescue work in the event of accidents and emergency situations is required. It is necessary to provide for the means and routes for evacuation of employees, first aid provision measures and means of delivery to inpatient medical facilities, and methods and means of rescue and evacuation of victims.

Plans for rescue and emergency situations and response to accidents must be prepared before the commencement of the operation of the offshore WF park, during the preparation of the technical design and planning of the construction stage. It is recommended to conduct a risk analysis and prepare an Emergency Management Plan covering the construction, operation and liquidation stages in accordance with the recommendations prepared by the Fire and Rescue Department during the development stage of the technical design.

4.10.11.4 Fire and fire-fighting equipment

WFs shall be constructed in accordance with the requirements of Construction Technical Regulation STR 2.01.01(2):1999 "Essential Building Requirements. Fire safety" and basic requirements for fire safety.

The prevention of fire and other emergency situations shall be subject to the following risk management measures:

- Each WF shall be equipped with an automatic control system. WF control shall be carried out remotely. A comprehensive monitoring system will be able to set all the necessary commands for WF control elements. Taking into account the sensor information received, such as wind speed, wind direction, etc., maximum safety of the WF operation will be ensured;
- Each WF will be equipped with an automatic stopping system. The wind power plants planned to be built will be equipped with a blade rotation stopping system consisting of 2 independent stopping systems. The sensor system designed shall ensure automatic shut-down of the WF (in case of detection of significant deviations from the normal run of operation). The possibility to stop the WF manually will also be foreseen. The stopping system will be equipped with an emergency battery which will supply electrical power in the event of a malfunction of its supply from the power transmission grids;
- WFs will be equipped with storm control mechanisms that will reduce the rotational speed of the WF blades in strong winds (when wind speeds are above 28 m/s);

- Each WF will be equipped with a lightning protection system that transmits the electrical charge to the foundation of the structure (earthing is installed);
- Each WF will be equipped with a signal lighting system. In order to avoid collisions during the dark hours, the WF will be equipped with lighting lamps of special colours which will signal birds and other objects about an obstacle on their way;
- Periodic technical inspection of the WF will be conducted, and scheduled service will be carried out.

The probability of a fire rise in the WF park is insignificant.

A fire can occur in a transformer building where the transformer oil is stored. Transformer oil is not included in the category of flammable liquids, but fires in transformer buildings are possible, so the quantity of primary fire extinguishers will be foreseen during the technical design.

According to STR 1.01.03:2017 "Classification of buildings" and the clarification of the State Territorial Planning and Construction Inspectorate, the structure in the WF park is the WF tower, as well as TP substations, and electric cables with a voltage higher than 110 kV.

The technological equipment shall be installed in the gondola, which is manufactured in the factory and delivered to the installation site in a single module, therefore, according to the regulatory acts of the Republic of Lithuania, it is a product.

Power cables with non-combustible insulation, with a flammability class of at least $D_{ca\ s2,d2,a2}$ shall be used in the WF tower.

Primary extinguishing with gas and powder class ABC fire extinguishers is foreseen. The quantities of fire extinguishers according to Annex No 5 to the General Fire Safety Rules shall be as follows:

Seq. No	Place of storage of fire extinguishers	Computational unit of measurement	The minimum amount of extinguishing agent in fire extinguishers (powder or carbonic acid - in kilograms, water or foam-water mixture - in litres)		
			2 kg (*l*)	4 kg (*l*)	6 kg (*l*)
13.	Special purpose buildings	300 m^2	4	3	2

Arrangement of fire extinguishers normally used in the WF:

- 1 unit of 4 kg is the 1st fire extinguisher placed in the WF tower at the 30 kV switchyard;
- 1 unit of 4 kg is the 2nd fire extinguisher placed in the WF gondola near the elevator;
- 1 unit of 4 kg is the 2nd fire extinguisher placed in the WF gondola control room.

Fires in the WF are rare, their consequences have no possibility of spreading to surrounding objects and adjacent WFs. Therefore, in the case of fires, the extinguishing of burning generator units is not planned. The WF gondola with a generator unit are treated as a product and should not be subject to the requirements of the General Fire Safety Rules. The installation shall be insured and the oil contained therein shall be allowed to burn away in case of fire.

The PEA operator and the technical design developer shall have the right and may provide for the measures to extinguish the fires of WF generator units. In such a case, the preparation of the technical design would provide for an automatic gas-extinguishing system or similar measures to ensure effective firefighting.

4.10.12. Summary

The risk analysis and its assessment were conducted on the basis of "Recommendations R 41-02 for risk assessment of potential accidents of planned economic activities" approved by Order No 367 of the Minister for the Environment of 16 July 2002.

An overview of the literary sources and the publicly available risk assessments of previous offshore WF parks shows that the causes of dangerous events, when assessing them as accidents, are occupational safety violations (40 %), equipment failures 38 %, transport events (9 %), lifting events (7 %) and environmental impacts (6 %). In terms of the significance of their impact on people, nature and property, transport events (collision with large passing vessels) represent the most significant risk, equipment failure, which becomes the cause of lifting events during construction, and environmental effects, including the effects of extreme hydrometeorological phenomena, aggressive environmental corrosion and activities carried out in the environment.

Vulnerable objects in the offshore WF parks are as follows:

- Offshore WF park objects (WFs and their equipment, transformer substations, cables) and service personnel as well as builders during the construction and dismantling stages;
- Economic activities carried out in and nearby the park area;
- Infrastructural objects of ongoing activities and strategic infrastructure ones (cables, pipelines);
- Territories important for state security (marine and air force training grounds, military aircraft flight routes, etc.);
- Existing archaeological finds, including sinking sites of remaining World War II explosives.

Vulnerable objects often present in offshore WF parks are also risk factors (vessels sailing along navigation corridors may also be the cause of WF accidents and their crews can suffer in the event of an accident, and become a vulnerable object). Sunk explosives are a risk factor but also a vulnerable object that can detonate if damaged during the construction of the WF. These and other objects are considered in risk analysis in both aspects.

In assessing possible dangerous events during the construction, operation and dismantling of the offshore WF park, 40 risk factors have been distinguished, which have been qualitatively assessed with the help of the risk matrix. Distinguishing 5 categories on the matrix frequency scale: very rare, rare, possible or highly probable, probable and frequent event. The impact scale distinguishes 6 categories of effects on people, property and the environment in descending order: catastrophic consequences, a quite significant impact, significant impact, limited impact, negligible impact and no impact.

At the time of the assessment, 15 events fell within the acceptable risk area where monitoring of the risk is recommended, but mitigation measures are not necessary. 25 events fell within the ALARP zone: a risk area that is allowed but mandatorily managed, where risk mitigation is subject to financially sound measures that do not entail high costs but effectively reduce risks.

In view of the consequences of accidents and the potential level of human deaths and pollution, the most dangerous risk factors shall be considered possible transport events when passing vessels lose their way from the shipping corridors and enter the WF park area. Damaged structures of the WF towers can cause their collapse and damage the hulls of vessels bumped. Fatal crew or passenger injuries, including deadly traumas after falling overboard, sinking, squeezing, etc. are possible on board passenger ferries or cruise ships. On cargo ships, effects on crews and cargo, on tankers - spills of oil products or crude oil.

All potential risk factors are probable and data on them are available in global practice, and the impact is either absent at all or varies from limited (13 factors) to very high (6 factors), and potentially catastrophic in the event of damage to the tanker section and significant oil spills. The operator shall provide for design and organisational measures to prevent severe injuries and much less fatal events. These are optimal design solutions, certified machinery, trained and certified personnel, operational regulations, and employee instructions, which provide for actions in emergency situations.

The probability of a passing ship collision with WF structures shall be calculated by estimating the density of the standard normal distribution described by the Gaussian function and the ranking of navigational errors of the collision.

Following the evaluation of the distance of the central part of the shipping channel from the location of the PEA and the small number of passing vessels capable of damaging the objects of the WF park, the probability of a collision is 9.0E-05.

The value of individual risk per year for passengers would be 2.05E-08, and seamen of crews 2.5E-07.

It is predicted that the marginal annual individual risk values for passengers and ship crew members are acceptable after multiplying the available data on the number of passing ships by a factor of 1.3 (in order to estimate the increase in the number of vessels in the near future).

In the event of a collision between dry-cargo carriers and passenger ships, the environmental consequences are limited and significant; in the case of collisions between tankers, they may vary from limited to catastrophic. A catastrophic case would be pollution due to a collision with an oil tanker. This could lead to more significant spillage of petroleum products, which are more harmful to the environment due to low evaporation. The consequences of such collisions require the preparation of special accident liquidation procedures (Concerted Action on Offshore Wind Energy in Europe Final Report, 2001).

A Maritime Rescue Coordination Centre (MSCC) has been established in Lithuania, and a plan for response to pollution incidents at sea has been developed, which includes all procedures for preparation, liquidation and mobilisation of forces. The WF park should be included in the number of enterprises that are required to prepare local plans for response to pollution incidents at sea and have the necessary quantity of dispersion limitation and liquidation measures for first-degree spills (up to 7 t). When own forces and means are insufficient, the national forces - the MRCC forces - shall be used.

Collisions of planes with high structures of the WF park are rare or very rare, and the consequences are significant due to the possible death of the crew in the event of a fall. Flights over the WF power plant park will be performed by the Air Forces of the Lithuanian Armed Forces, the Border Guard Department, as well as other rescue aircraft. Organisations conducting the flights shall inform the operator of the WF park about the operations; if necessary, the rotation of blades shall be stopped during rescue operations.

The probability of fire in WF power plant towers is low. Storing the required amount of primary firefighting in the towers or installing an automatic gas-extinguishing system is recommended.

It is recommended to apply ALARP measures to mitigate risks in the course of the activities. These include the use of good practice, best available techniques and use of safe materials, additional training of personnel, determination of a safety zone and its marking with buoys with radio navigational devices to inform passing ships, preparation of the Emergency management plan if the enterprise is not included in the list of objects for which such plans are required, taking into account the location of the sunk minefields near the PEA area and the information provided by the deminers that "migrating" mines may appear in the cleared areas, to carry out a periodic inspection of the bottom of the offshore WF park territory.

The performed risk analysis allows stating that no objects of unacceptable risk and factors have been identified. By applying ALARP measures to control moderate risk factors, the risk posed by possible accidents and emergency situations is permissible. Emergency response, fire-fighting measures and procedures will be provided for in the preparation of the technical design of the PEA. The plan for response to pollution incidents at sea, after enlisting the VE park in the list for which such plans are required, should be drawn up before the start of the construction stage.

5. ANALYSIS OF ALTERNATIVES

5.1. Alternatives examined

The following two main alternatives have been examined in the EIA report:

The 'zero' alternative, i.e. no ongoing activities; and

The project implementation alternative - the installation of an offshore WF park in the maritime territory of Lithuania.

The "zero" alternative, i.e. no ongoing activities, reflects the current situation and the state of the environment when the project is not being implemented. In such a case, changes in the environmental status of the Baltic Sea water area that belongs to Lithuania would not be linked to the development of the PEA.

The project implementation alternative approved by Resolution No 697 of the Government of the Republic of Lithuania, the offshore WF park is being installed and operated in the territory.

Technologic characteristics considered for the alternative of the Project implementation:

Taking into account the development trends of offshore WT high technologies, technical solutions of existing offshore wind farms in the Baltic and North seas, and the economic efficiency aspect related to the implementation of these high technologies, the assessment involved offshore wind turbine models with a capacity of up to 20 MW and more for the installation of the proposed WT farm. The height of such offshore WT may reach up to 350 m. The EIA report has assessed the impact of installation of the models with the maximum technical and physical parameters on the environment when rotor diameter is 320 m and total WT height up to the most elevated blade point is 350 m.

Using the principle of geometrical layout of WTs in the territory based on the diameter of the WT rotor (D) (in wind direction 7–10xD; in the direction perpendicular to wind direction 4–5xD), preliminary up to 90 WTs may be installed in the PEA territory.

PEA territory

The territory proposed for the alternative of the Project implementation is approved by the Resolution no. 697 of LRV. Therefore, other sites for the installation of offshore WT farm are not considered in this EIA.

Alternative measures for minimising the PEA impact on the environment

Measures for minimising the impact on the environment

The assessment of the potential impact of the proposed WT farm on the landscape revealed that, pursuant to the provisions of valid legislation of the Republic of Lithuania, the impact of installation of a WT at the distance of approx. 29.5 km (the distance to the border of WT farm area nearest to the coast) away from the coastline would not exceed the values of a significant impact on the landscape and, thus, the impact of wind turbines on the landscape in this context is **considered to be insignificant**.

With consideration of the nature of the proposed economic activity, i.e. operation of a WT farm in the open seascape where the existing vertical and technogenic dominants are only occasional (ships), the measures for minimising or compensating the impact on the local landscape are complex.

The following is proposed to minimise the potential impact on the landscape:

- Paint the WTs in light colours creating a minimal colour contrast, avoiding white colour contributing to a greater contrast;
- Use paint with special ingredients that would allow avoiding glance and gleam of the structures.
- Assess the possibility of positioning the WT farm perpendicular to the coast (in parallel to the Palanga Bridge axis) and/or position individual WTs in lines (arches).
- With consideration of the established fact that lower WTs (up to 280 m high) would have a lower visual impact, it is proposed for the developer to assess the technical possibilities of choosing lower (up to

280 m) WT models, if such choice would ensure that the WT farm could general an optimum amount of electricity, which is necessary to ensure the objectives of the Lithuanian Energy Independence Strategy.

Measures for the mitigation of impact on benthic habitat

According to the conducted assessment, the most valuable part of the PEA territory, where the significant adverse impact is probable, borders with "Natura 2000" IHPA biogenic reef (1,170) area. The most valuable is the *Mytilus trossulus-Crustacea* community, which forms on a solid ground (boulders, rock bedding) that is common at the north-eastern border of the proposed area.

To mitigate the impact of installation of offshore WTs on the protected benthic habitat and to ensure that the spread and participation of valuable seabed molluscs in the general food chain remains uninterrupted, it is recommended not to plan WT foundations and cable routes in the area of high distribution of *Mytilus trossulus-Crustacea* abundance zone.

For the purpose of maximum use of the proposed area, the Developer may conduct additional investigation of benthic communities (in case of Alternative II) on a seabed segment 1 km wide, closest to the border of the protected area in order to clarify the most valuable sites of benthic habitats and to apply the restrictions for the installation of foundation and cable routes only in the most valuable sites of benthic habitats. It should also be emphasized that only the preservation of the most valuable benthic habitats creates favourable conditions for their distribution on foundations installed in the PEA area that serve as artificial reefs.

Measures for the mitigation of impact on birds and "Natura 2000" area

The EIA phase identified the potential significant impact in the adjacent protected areas, i.e. biosphere reserve of the Klaipėda-Ventspils Plateau, "Natura 2000" IBPA Klaipėda-Ventspils Plateau, on the species of the protected birds in terms of scaring away and excluding from the feeding grounds, which requires mitigation measures. One of the most effective measures for the protection of the wintering bird species is locating the WT installation sites further away from the border of the protected area.

Another measure for the impact mitigation is also to be applied (in case of Alternative II): temporary shut down of the first rows of WTs located the closest to the border of the protected area (up to 2 km away from the border of the protected area at most), when the wintering birds use this area with the most intensity, i.e. about five winter months. The frequency and duration of WT shut downs should be determined according to the actual results of bird monitoring.

According to the established distance of impact of scaring away and excluding, two potential impact mitigation scenarios were considered:

1st scenario, where WTs are installed as a distance of at least 1 km away from the north-western border of "Natura 2000" area (without limiting the installation of other infrastructure elements in this area);

2nd, where WTs are installed as a distance of at least 2 km away from the north-western border of "Natura 2000" area (without limiting the installation of other infrastructure elements in this area).

Based on the results of the conducted environmental impact assessment and the alternatives of mitigation measures, the following three **project implementation alternatives** were formed:

- **Alternative I (technical)**: WT farm development, where WTs are installed in the entire area approved by the Resolution no. 697 of LRV using WT models with **total height of up to 350 m;**
- **Alternative II (balanced)**: WT farm development, where WT installation sites are **located 1 km further away from the border of the protected area using up to 350 m high WT models** (without limiting the installation of other infrastructure elements in this area)**;**
- **Alternative III (environment-friendly)**: WT farm development, where WT installation sites are **located 2 km further away from the border of the protected area using up to 350 m high WT models** (without limiting the installation of other infrastructure elements in this area)**.**

5.2. The comparison of the alternatives examined in terms of their potential impact on individual environmental components

The principles of the concept of sustainable development have been used for internecine comparison of the development alternatives of the offshore WF park. These alternatives are compared with each other using three underlying constituents of sustainable development: economic growth, the well-being of society and the quality of the environment, by ensuring balanced development of all dimensions, without giving priority to one at the expense of the other two[32]:

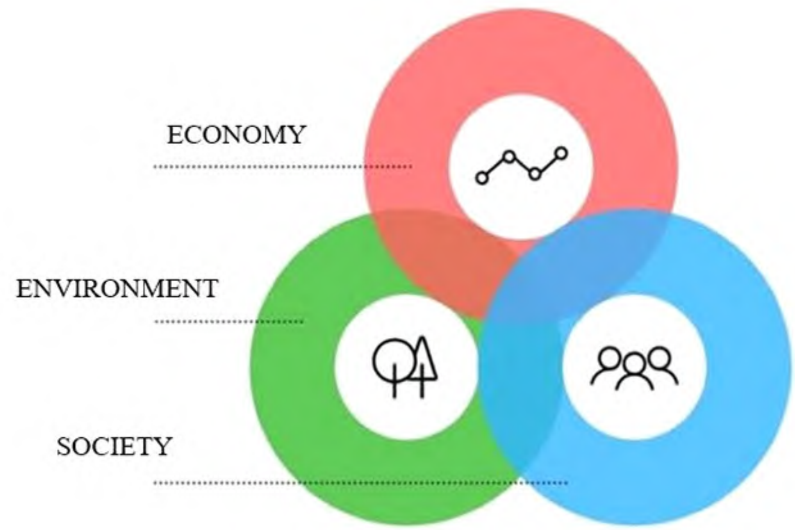

Fig. 5.2.1. The concept of sustainable development (illustration from the Set of Recommendations for Sustainable Development Goals).

The impact of the alternatives on the components of each dimension was assessed considering their significance and the leverage (importance) of the criterion considered in %. The significance of impacts is determined by taking into account the quantitative indicators and qualitative aspects.

Table 5.2.1. Significances of impact assessment

Significance of impact	**Positive effects**	**Negative effects**
Significant	3	-3
Moderately significant	2	-2
Little significant	1	-1
No impact or the impact is neutral, i.e. the impact is equally positive and negative	0	0

The aggregated indicator in the aspect of sustainable development is calculated by summing up indicators of the natural, social and economic environment for which leverage of 1/3 is given (evaluating them equivalently in this way)

[32] Set of Recommendations for Sustainable Development Goals. "Create for Lithuania" project "Towards a Sustainable Lithuania: Integration of Sustainable Development Goals into the National Strategic Documents" http://lrv.lt/uploads/main/documents/files/Darnaus%20vystymosi%20tiksl%C5%B3%20rekomendacij%C5%B3%20rinkinys(1).pdf

Table 5.2.2. Assessment of alternatives to the development of the WF park

		Alternatives under examination					**Weighted impact assessment of alternatives**				
		Alternative 0: The WF park at sea is not developed;	**I. Development of the WF in the entire planing area**	**II. WTs are moved away from the protected area by 1 km distance;**	**III. WTs are moved away from the protected area by 2 km distance;**	**Leverage, %**	**Alternative 0: The WF park at sea is not developed;**	**I. Development of the WF in the entire planing area**	**II. WTs are moved away from the protected area by 1 km distance;**	**III. WTs are moved away from the protected area by 2 km distance;**	**Possible effects and their comparison**
Natural environment											
1	Water	0	0	0	0	10	0,00	0,00	0,00	0,00	Under normal operating conditions, the operation of the wind farm will not have an impact on the quality of seawater, however, temporary changes in water quality are possible during the construction period when installing foundations and laying cables due to a temporary increase in suspended particles (turbidity) in the demersal water column. It is expected that secondary water pollution by chemicals (heavy metals, organic compounds) may occur during the construction stage due to works on the movement of bottom sediments. The area of WF parks is located at depths of more than 30 m, in a stable geological environment, therefore, the impact of foundation structures on the hydrodynamic environment is insignificant. The increase in turbidity will manifest only at the site of the installation of the foundation and the laying of the cable, so its effect is to be assessed as local (demersal layer) and temporary (only at the time of installation), without significant long-term impact on the hydrochemical parameters of water and the seawater quality of the Baltic Sea. In the aspect of the impact on the water, all alternatives are equivalent.
2	Ambient air and climate	0	3	3	3	15	0,00	0,45	0,45	0,45	During the construction and operation of the WF park, emissions of ambient air pollutants are possible from internal combustion engines of servicing vessels. On the high sea, far from the coast and residential or public environments, there are favourable conditions for the dispersion of pollutants, therefore, emissions will be easily dispersed and will not have significant adverse effects on the environment. The use of renewable energy sources is particularly valued in the context of climate impact as a measure of mitigating climate change. The use of wind energy significantly reduces dependence on fossil fuels, its use, as well as CO_2 and other GHG emissions into the ambient air. The use of wind energy plays a significant role in combating climate change by reducing greenhouse gas emissions from the energy sector. In this aspect, the climate impact of all the alternatives under examination is assessed as significantly positive.
3	Seabed	0	-1	-1	-1	10	0,00	-0,10	-0,10	-0,10	In view of the structure of the bottom, the type and prevalence of surface sediment as well as the formation of valuable bottom communities associated with it, it can be concluded that the impact on the bottom can, in principle, be only local and relatively negligible. The main adverse effects are only associated with partial destruction of the bottom and secondary sedimentation at the sites of the installation of foundations and cable routes. The power plants installed in the territory of the PEA (which is more than 29.5 km far off from the coast) will not have a significant impact on the dynamics of the coasts and the dynamics of outwash carry, since the main outwash flow at the coast of Lithuania covers only 1-1.5 km coastal area. The formation of washouts in loose soils (sandy sediments) is characteristic of pole foundation structures. To avoid these washouts, the seabed around the foundation is reinforced with gravel or boulders. Two main methods are used technologically for laying high-voltage cables on the seabed: in the trench or by covering the cable directly on the seabed with massive concrete covers or sand or gravel coating; in all cases, this effect on the seabed is local and minimal. Trenches are dug up to a maximum depth of 2 m (depending on the equipment used) and up to 3 m wide. All alternatives has the same local and temporal impact on the seabed.

		Alternatives under examination					Weighted impact assessment of alternatives				Possible effects and their comparison
		Alternative 0: The WF park at sea is not developed;	I. Development of the WF in the entire planing area	II. WTs are moved away from the protected area by 1 km distance;	III. WTs are moved away from the protected area by 2 km distance;	Leverage, %	Alternative 0: The WF park at sea is not developed;	I. Development of the WF in the entire planing area	II. WTs are moved away from the protected area by 1 km distance;	III. WTs are moved away from the protected area by 2 km distance;	
4	Landscape	0	-2	-2	-2	15	0,00	-0,30	-0,30	-0,30	In terms of landscape, the impact of offshore WTs is assessed on a regional scale, i.e. covering the PEA area itself as well as the territories, which might be affected in terms of landscape or the nature of which conditions the visual perception of WTs in the sea. The assessment of potential impact of WT farm on the landscape revealed that pursuant to the provisions of valid legislation of the Republic of Lithuania, installation of WTs at a great distance from the coastline (distance from the border of WT farm area closest to the coast is approx. 29.5 km) would not exceed the values of significant impact on the landscape and, thus, impact of wind turbines on the landscape is assessed as insignificant in this context. Considering that under good visibility conditions WT farm can be visible from the shore, the impact of all three alternatives is equal based on the total score of significant of visual impact.
5	Biodiversity: Bottom habitats	0	-3	-1*	-1	5	0,00	-0,15	-0,05*	-0,05	The installation of the WT farm will have an impact on the bottom habitats due to the destruction of the bottom during the installation of the WF foundations and laying energy transmission cables as well as the increase in the turbidity of the water. During the operation stage, the negative impact on bottom habitats is negligible. Installed underwater WT structures can become a secondary (artificial) substrate suitable for the attachment of various sedentary aquatic organisms, therefore it will increase diversity of habitats and bottom communities as well as expand the abundance of biomass and species. Studies revealed that the eastern seabed segment of the area, in some place outside the protected area, there is a high distribution of *Mytilus trossulus-Crustacea* abundance zone to be protected remaining. The implementation of Alternative I in this area requires avoiding sites with distribution of valuable bioreef to avoid direct damage to the valuable habitat. Relocating the sites of wind turbine construction further 1 km away from the border of the protected area does not ensure that valuable benthic habitats would not be significantly damaged. (*) However, after conducting additional studies of benthic communities in the remaining 1 km segment and identifying the sites where the formed benthic communities are of special value (without developing this area), Alternative II may be equated with Alternative III in terms of assessment of impact on benthic communities.
6	Biodiversity: Ichthyofauna	0	0	0	0	5	0,00	0,00	0,00	0,00	The greatest impact on individual fish species can only occur during the installation of WT farms and during the removal works of structures. This impact on the fish community will be short-term and (after the application of noise abatement measures during pile driving) insignificant. However, some species with a large swim air bladder, such as Baltic cod, may withdraw from the area because of their sensitivity to noise. However, once the installation (or WT removal works) has been completed, the fish will return to the nutrition area, so only a short-term impact is expected. The avoidance reaction is observed only at a distance of a few metres from WT and only at high wind speeds, which may result in a positive impact on fish populations due to newly emerging artificial reef habitats during the operation period. From anadromous fish species, only twait shad and European smelt are present in the PEA area. The available survey data do not indicate that the PEA area would be on the migratory routes of twait shads, and fish were not detected in the area during migration. Smelt migration to the Curonian Lagoon is known to take place between November and March and the main smelt mobs migrate from the northern side at depths of 6-40 m. It may be assumed that migratory fish routes may change at the time of the installation of the parks or the accumulation of fish in certain places due to adverse conditions (water turbidity or noise) created during construction. However, during the surveys, European smelt in the PEA area was classified as incidental fish species in the community and no large

		Alternatives under examination					Weighted impact assessment of alternatives				
		Alternative 0: The WF park at sea is not developed;	**I. Development of the WF in the entire planing area**	**II. WTs are moved away from the protected area by 1 km distance;**	**III. WTs are moved away from the protected area by 2 km distance;**	**Leverage, %**	**Alternative 0: The WF park at sea is not developed;**	**I. Development of the WF in the entire planing area**	**II. WTs are moved away from the protected area by 1 km distance;**	**III. WTs are moved away from the protected area by 2 km distance;**	**Possible effects and their comparison**
											shoals swimming to spawn were recorded. Effects on fish are assessed as neutral in the case of all alternatives.
7	Biodiversity: Marine mammals	0	0	0	0	5	0,00	0,00	0,00	0,00	Effects on marine mammals are possible during the installation of the WTs, especially during impact pile driving. The presence of wandering marine mammals in the WF park area is scarce, so the installation of the WT farm (after applying the mitigation measures) and operation will not have a significant adverse impact. Effects on marine mammals are assessed as neutral in the cases of all alternatives.
8	Biodiversity: Birds and bats	0	-3	-1*	-1	15	0,00	-0,45	-0,10*	-0,15	Impact on bats is not provided for because the intensity of bat migration greatly reduces as moving away from the shore. The implementation of the Project in the PEA area may result in the effect of disturbance, obstacle and direct collision with WT on wintering and migrating birds. It is estimated that the effect of excluding out of habitat and scaring away is potential for sea ducks feeding on benthic organisms - velvet scooter and long-tailed duck. No significant adverse affect is expected for other wintering, nesting and migrating species of birds. The scaring away effect during bird wintering is potential due to the increase in the shipping intensity during construction or regular transportation of the servicing personnel by vessels or helicopters at the stage of WT operation. It is estimated that relocating WT installation sites further 2 km away from the border of the protected area (Alternative III) is an effective measure allowing for the minimisation of loss of feeding grounds for birds in valuable benthic habitats, it however does not solve the problem of excluding all the bird species from the potential feeding grounds. It is estimated that relocating WT installation sites further 1 km away from the border of the protected area (Alternative II) is sufficient only for the protection of razobill. (*) However, to minimise the impact on birds and avoid damaging valuable feeding grounds, additional studies of benthic communities are required in the remaining 1 km segment to identify the sites where the formed benthic communities are of special value (without developing this area). Alternative II may be equated with Alternative III in terms of assessment of impact on birds once this measure is implemented.
9	Protected and NATURA 2000 sites in the Republic of Lithuania	0	-3	0*	0	20	0,00	-0,60	0,00*	0,00	WT farm area borders with biosphere reserve of the Klaipėda-Ventspils Plateau and "Natura 2000" IBPA and IHPA. There is a potential impact on the protected species of birds due to disturbance and exclusion from habitat with proper feeding grounds. Therefore, there is a great probability of decrease in density of the protected species of birds in "Natura 2000" area, i.e. birds that use the area proposed for WT farm or the adjacent protected area would be forced to leave and search for other feeding grounds. No direct impact on the reefs identified in the protected area is expected; the studies however revealed that valuable reef habitats, which a also suitable for feeding of the protected species of birds, are also present in the PEA area under consideration. A significant physical loss of the seabed due to irreversible changes in the seabed substratum or morphology as well as the destructive effect on bottom biotopes during the construction, operation and dismantling phases of the WT farm are very likely in the identified areas of circalittoral boulder sites and biogenic reefs. The impact of destruction of these habitats is assessed as local significantly adverse. Maintaining a distance of 2 km between the border of the protected area and the nearest WT installation sites and cable routes (Alternative III) would help in avoiding adverse impact on benthic communities (reefs) of the protected areas and on the protected species of birds due to scaring them away from the protected areas. Relocating WT installation sites further 1 km away from the border of the protected area (Alternative II), the impact on valuable benthic habitat and

		Alternatives under examination					Weighted impact assessment of alternatives				Possible effects and their comparison
		Alternative 0: The WF park at sea is not developed;	I. Development of the WF in the entire planing area	II. WTs are moved away from the protected area by 1 km distance;	III. WTs are moved away from the protected area by 2 km distance;	Leverage, %	Alternative 0: The WF park at sea is not developed;	I. Development of the WF in the entire planing area	II. WTs are moved away from the protected area by 1 km distance;	III. WTs are moved away from the protected area by 2 km distance;	
											on the protected species of birds remains. In this case, if bird monitoring conducted during the operation of WT farm establishes a significant impact on the protected species of birds due to scaring them away from the wintering grounds in "Natura 2000" IBPA, it would be required to apply additional protection measures: Temporary shut down of the first rows of WTs located within the distance of 1 km from the protected area during the periods important for bird wintering, i.e. 4-5 months a year. (*) The estimated impact on birds once this additional measure is applied in case of Alternative II and Alternative III would be identical.
						Total	**0,00**	**0,90**	**0,90**	**0,90**	
Social environment and society											
10	Limitation of other maritime activities in the territory of the WF park	0	-1	-1	-1	30	0,00	-0,30	-0,30	-0,30	The territory of the WF park falls within the territories where the wind farm construction sites are coordinated, on condition that the producer of energy from renewable sources signs an agreement with the Lithuanian Armed Forces on part of the investment and other costs. The area of the WF park is situated outside the existing navigation route corridors, port roadsteads and anchorages, so the implementation of the solutions will not have a significant impact on shipping. A certain economic impact of the implementation of the PEA on the fishing business is foreseen due to the resulting fishing restrictions in the WF park area: following the installation of the WF park, trawling will not be allowed due to the risk of damaging the electric transmission cables laid on the bottom. Alternatives II and III are considered to have a relatively lower impact due to the smaller area where fishing restrictions would be established.
11	Cultural heritage	0	0	0	0	15	0,00	0,00	0,00	0,00	Potential adverse effects on cultural heritage sites are likely to occur in areas where remains of possible anthropogenic origin have been identified and additional archaeological research is necessary in order to remove them or to carry out bottom destruction works near them. No reliable archaeological findings have been identified in the survey area, therefore additional archaeological research and/or protection measures for underwater cultural heritage objects are not required to be foreseen. The installation of the WF park will not have a significant negative impact on the underwater cultural heritage.
12	Deposits of mineral resources	0	0	0	0	15	0,00	0,00	0,00	0,00	The PEA area does not overlap with oil, sand or other valuable prevalence zones of minerals, so no negative impact on natural resources is expected either.
13	Social impact on the national and Baltic regional scale due to energy security	0	3	3	3	40	0,00	1,20	1,20	1,20	The installation and operation of the offshore WF park will provide preconditions for increasing the production of energy from renewable energy sources, which is directly in line with the NEIS objectives. According to the Raida 2050 study, it is presumed that the main source of electricity generation in 2050 will be offshore wind power plants (WPP), which will make up about 40 percent of the RES generation structure. The three scenarios foresee that OWF's total installed capacity will be between 1.6 GW and 2.0 GW in 2050. Thus, together with the flexibility measures installed, will achieve the objectives of the NEIS. In this aspect, the impact is assessed as significant positive.
						Total	**0,00**	**0,90**	**0,90**	**0,90**	

		Alternatives under examination					Weighted impact assessment of alternatives				
		Alternative 0: The WF park at sea is not developed;	I. Development of the WF in the entire planing area	II. WTs are moved away from the protected area by 1 km distance;	III. WTs are moved away from the protected area by 2 km distance;	Leverage, %	Alternative 0: The WF park at sea is not developed;	I. Development of the WF in the entire planing area	II. WTs are moved away from the protected area by 1 km distance;	III. WTs are moved away from the protected area by 2 km distance;	Possible effects and their comparison
Economic environment											
14	Investments, creation of job places for the Lithuanian labour market, service sector	0	3	3	3	20	0,00	0,60	0,60	0,60	The implementation of the PEA will have a direct, indirect and induced impact on GDP due to the development of the wind energy industry and other branches of production, the development of engineering services and, in the long term, the potential for investments in research and innovations in the field of wind energy. It is estimated that the development of the WF park could generate up to EUR 1.5 billion of added value at the European level and create up to 8,000 job places (half of them are indirect). The share of value-added and new job places in Lithuania will depend on which part of the value chain will be developed locally. This requires an assessment of the demand for labour force, raw materials, infrastructure and equipment in different parts of the value chain, the capacity of existing industries and labour force, as well as regional and global market trends. The impact in the aspect of the creation of job places and investments is assessed as significant positive.
15	Construction costs	0	3	2*	2	30	0,00	0,90	0,60*	0,60	The installation and integration of the offshore WF park into the Lithuanian transmission grids will require both the internal development of TG and the infrastructure at sea, therefore, the cost of achieving the objectives of the NEIS is unavoidable. At the EIA stage, the installation and operation costs of the WF park are not detailed, however, it can be assumed that they could be relatively lower in the limited area alternatives (II and III) due to the smaller number of installed WFs.
16	Energy independence	0	3	3	3	50	0,00	1,50	1,50	1,50	The NEIS plans to achieve by 2050 that 100 % of the total national electricity consumption would consist of locally produced electricity. The installation of the offshore WF park would significantly contribute to the successful implementation of the NEIS objectives, therefore the impact is assessed as significant positive. In the case of Alternative III, limiting the height of the WF model to 280 m may result in some limitations on the choice of the most efficient WF models and this alternative, therefore, is assessed as a moderately significant positive.
						Total	**0,00**	**3,00**	**2,70***	**2,70**	
Total (generalized indicator in the aspect of sustainable development)							**0,00**	**0,92**	**1,15***	**1,15**	

5.3. Conclusions of the analysis of alternatives

Based on the results of the environmental impact assessment performed and the comparison of the impacts of alternatives on various environmental components, the 2nd alternative of the development of the WF park at sea is assessed most favourably, where the total height of WFs to be installed is up to 350 m in the limited area.

For the implementation of the WF park, the generalized measures for avoiding, reducing and compensating for the negative impact on the environment according to all aspects examined are presented in Table 5.3.1.

Table 5.3.1. Measures for avoiding, reducing and compensating for environmental impact

Environmental component	Measures for avoiding, reducing and compensating for environmental impact
Waste	*Planning stage* • During the technical design of the WF park, the potential amount of waste generated during the construction and operation stage and the management plan will be foreseen. *Operation stage* • During the construction and operation of the WF park, all waste generated will be delivered by ship to the serving ports and handed over to waste managers. *Dismantling stage* • Following the dismantling of the WF park, the majority of the components of the WF park will be adapted for secondary use and, where it is not possible, will be recycled or recovered in designated recovery areas in accordance with the requirements of the legislation of the Republic of Lithuania. During the preparation of the WF dismantling project, a waste-generating management plan must be submitted.
Water	*Construction and operation stage* • Observations of current modes at the access points of the WF park during installation and after the completion of construction works. • Research of polluting substances before construction works (background concentrations), during construction works (foundation, cable laying) and after completion of construction works (3-6 months after completion of works). • During the construction and operation stage of the WF parks, more environmentally friendly corrosion control methods must be used to reduce or prevent the release of heavy metals into the water.
Air	*Construction and operation stage* • Vessels operating in WF parks must comply with the requirements of international organisations (MARPOL).
Underwater noise	*Construction stage* • The use of underwater suppression systems to reduce pile-driving noise: air bubble curtains, soundproofing hoods and silencers, etc. • Repelling animals acoustically before starting to drive piles: 1) The use of additional audible repellent devices, by which marine mammals are scared off from the pile-driving

Environmental component	**Measures for avoiding, reducing and compensating for environmental impact**
	area; and 2) The soft start of pile-driving, i.e. during driving, the impact energy is strengthened gradually, thus simultaneously scaring off the animals and not causing sudden, extremely harmful, potentially injurious noise pulses. • In order to control the adverse effects caused to marine organisms (marine mammals, fish), as well as to assess/control the effectiveness of noise reduction measures at the construction stage, when the WF foundations are being installed, the future developer must pursue the monitoring of underwater noise during the construction of the foundation. The objective of the monitoring is to determine whether the generated noise does not exceed the set limit values (i.e. at a distance of 750 m from the pile being driven in - shall not exceed the levels of 160 dB_{SEL} and 190 $dB_{LP,pk}$). If noise is found to have exceeded the limits set, the works must be stopped and other/additional noise reduction measures must be applied.
Earth: The bottom and depths of the sea	*Planning stage* • In order to preserve valuable bottom communities, it is recommended to prevent the construction of VE in the identified areas of accumulation of valuable bottom biotopes, i.e. in the distribution zone of boulders and gravel and sand sediment of various coarseness (north-western part), where large concentrations of *Mytilus Trosullus* molluscs have been identified. This would prevent a direct negative impact on the quality and recovery of these communities. *Construction stage* • In order to avoid excessive fragmentation of bottom sediment and the emergence of new lithological types due to secondary sedimentation in areas of damaged soil, it is recommended to use environmentally friendly technologies during the excavation of cable trenchers, allowing to minimise the impact on the seabed, and to use the original soil excavated from these trenches as much as possible for backfilling trenches (if construction technologies allow this). • During the design process, avoiding identified objects of possibly anthropogenic origin is suggested; avoiding or providing for bottom dredging works in places where objects of unknown origin are concentrated is recommended. Measures to be applied to mitigate the potential impact on the infrastructure of power plants: • In order to reduce the potential risk to foundations and cables due to bottom washouts, it is proposed to carefully assess the lithological conditions of surface sediment and, if necessary, it is recommended to apply additional reinforcement around the foundation piles during construction; • The future developer shall perform surveys on unexploded ordnance (UXO) before starting detailed design work on WFs and cable routes, which will allow for assessing the location and threats of the historical cable of unidentified origin; • It is recommended not to plan cable routes in areas of large-amplitude bottom relief changes or, in order to avoid possible damage to the power transmission system, to provide partial relief alignment procedures in the places of cable routes.
Landscape	*Planning stage*

<table>
<tr><th>Environmental component</th><th>Measures for avoiding, reducing and compensating for environmental impact</th></tr>
<tr><td></td><td>In order to reduce the potential impact on the landscape, it is proposed to:
Paint the wind power plants in light colours with minimal colour contrast, avoiding white, which would create a higher contrast;
Use a special composition of paint, which would allow for avoiding the gloss of structures and the formation of reflections.</td></tr>
<tr><td>Protected and NATURA 2000 sites</td><td><u>Planning stage</u>
Protection of bottom habitats important for bird feeding and reduction of the impact of wintering bird disturbance by removing the north-eastern edge of the planned park from the protected and Natura 2000 PAST site Klaipeda-Ventspils Plateau at a distance of 2 km, i.e. it is recommended not to plan the WF foundations and cable routes at a distance of at least 2 km from the south-western boundary of the protected area.
<u>Construction stage</u>
If the works are carried out during the wintering of birds (in December-March), to reduce the impact on wintering birds in protected areas, the routes of vessels installing the WF park should be selected while avoiding Natura 2000 PAST areas.
<u>Operation stage</u>
If a negative impact more significant than provided for during EIA is detected, to assume additional measures to minimise the impact, such as temporary shut-down of part of WTs for the most intensive period of bird migration in autumn or spring and/or wintering (the number and sites of WTs to be shut down will be verified based on monitoring results). The impact (scaring away of the protected area) is to be considered significant when the abundance of birds protected in the “Natura 2000” IBPA area, i.e. the number and/or density of protected bird species individuals in the monitored area, reduces by more than 20% from the natural long-term (10 year) population fluctuation.</td></tr>
<tr><td>Seabed habitats</td><td><u>Planning stage</u>
In order to reduce the impact of the installation of offshore WFs on the protected bottom habitat and to ensure that the distribution of valuable bottom molluscs and their participation in the overall food chain remains uninterrupted, it is recommended not to plan the construction of WF foundations and cable routes at the high abundance of Mytilus trosullus zone.</td></tr>
<tr><td>Fish</td><td><u>Construction stage</u>
Analogous to those applied to marine mammals used to reduce the intensity of noise emitted by impulse noise sources, as well as audible deterrence measures applied.
<u>Dismantling stage</u>
During operation, a positive impact on fish due to secondary habitats forming on the foundations of the WF is expected. During the operation of the park and the monitoring of fish and seabed communities, having ascertained that the formed secondary habitats have had a significant positive impact, the application of compensatory measures during the dismantling stage is proposed: such measures would include the installation of</td></tr>
</table>

Environmental component	Measures for avoiding, reducing and compensating for environmental impact
	artificial habitats of an analogous area, using boulders of 0.1-1 m near the WFs being dismantled. Habitats should be installed at a distance of at least 50 m from the WFs being dismantled and within two years after the WFs dismantling date at the latest. The shape of the habitat is not fixed and must be selected considering the possible intensity of fishing with the bottom trawls and the direction.
Birds	<u>*Planning stage*</u> • Due to the expected significant impact on velvet scoters and long-tailed ducks and their wintering areas, it is recommended to distract the planned park boundary, north-eastern edge, from the protected and Natura 2000 PAST site Klaipeda-Ventspils Plateau at a distance of 1 km (assuming the stopping of part of the WT during the wintering of birds) or 2 km away (without the temporary shutdown of the WTs). <u>*Construction stage*</u> • In order to reduce the impact on wintering birds, it is recommended to carry out the WF installation works, the installation of foundation piles, outside the wintering of sea birds, i.e. from April to October. If it is not technologically possible to drive the piles in warm time, sound suppressing measures should be used. • During the construction stage, if works are carried out during the wintering of birds (in December-March), to reduce the impact on wintering birds in protected areas, the routes of vessels installing the WF park should be selected while avoiding Natura 2000 PAST sites. <u>*Operation stage*</u> • If the aviation rules do not conflict with the illumination of the WF, green light lamps should be used. In such a way, the attraction of potential bird migrants to the area of the WF park is reduced, and their risk of dying as a result of the operation of the WF is decreased either. • To reduce the cumulative impact on sea birds, it is encouraged to compensate for the adverse effects of other activities, such as mitigation of impacts in fisheries by reducing by-catches of sea birds. By-catches of sea birds shall be reduced by selecting safer fishing gear by contributing financially to the implementation of fishing measures safer for sea birds, financing safer fishing, and temporary cessation of fishing. • Another compensatory measure is the introduction of nature conservation measures in protected areas and the financing of applied research at wintering and breeding sites for sea birds. • To carry out the monitoring of birds and bats during construction and 3 years after construction is recommended. Thereafter, monitoring shall be repeated every 5 years over a period of 2 years. If a more significant negative impact is identified than was foreseen during the EIA procedure, additional impact-mitigating measures should be taken, such as the temporary stopping of WFs during the most intensive bird migration period in autumn or spring.
Marine mammals	<u>*Construction stage*</u>

<table>
<tr><th>Environmental component</th><th>Measures for avoiding, reducing and compensating for environmental impact</th></tr>
<tr><td></td><td>If possible, the construction of the foundations should be planned in such a way that in the winter season, when the highest probability of detecting sea porpoises migrating behind fish in LIEZ, the piles would not be driven in.
Repelling animals acoustically before starting to drive piles: 1) The use of additional audible repellent devices, by which marine mammals are scared off from the pile-driving area; and 2) The soft start of pile-driving, i.e. during driving, the impact energy is strengthened gradually, thus simultaneously scaring off the animals and not causing sudden, extremely harmful, potentially injurious noise pulses.
Use of technical means to reduce pulsed noise during pile-driving: bubble curtains, which are installed around the pile-driving site. This measure can reduce the distance of extreme impact on harbour porpoises by up to 90 %. In the PEA area, with the use of these means, installing the bubble curtain at a 50 m radius around the pile driving site as well as ensuring the air supply of at least 1 m 3/m/min is recommended. <u>Construction and operation stage</u> Another measure is pile "sleeves" made of various materials or a steel pipe, which is pulled on the pile and the pile does not come into contact with water during pile driving, and the impulse noise loses most of its energy when moving to another medium. Also, one of the possible options is the Noise Mitigation System (NMS) under constant development which also suppresses low-frequency noise.
If possible, the use of only common navigation routes and designated navigation corridors for navigation to and from the PEA area during the construction and maintenance of the WF park is recommended. This would allow for the concentration of noise in a given area and to reduce possible disturbances in the feeding of marine mammals.
One of the measures to reduce noise emissions during WF operation is to select turbines that emit lower noise. It is recommended to replace the gearbox with direct-drive turbines that have a more than 4-fold difference in the effect on marine mammal behaviour according to Stöber and Thomsen.</td></tr>
<tr><td>Immovable cultural values</td><td> <u>Planning stage</u> Before designing the WF foundation and cable laying routes, it is recommended to perform additional archaeological research of identified objects using underwater robots and/or divers; or "isolate" marked objects and not plan bottom digging works at their finding locations (including a 10 m diameter safety zone). Once the surveys have determined or denied the archaeological value of the objects identified and the origin of the dangerous obstacles has been clarified, the entire territory may be used for the development of the power plants.</td></tr>
<tr><td>Material values</td><td> <u>Operation stage</u> The provision of support to local communities in accordance with the procedure laid down in the legal acts of the Republic of Lithuania. The administrator of the contribution shall pay the funds collected in accordance with the procedure and conditions laid down by the Government to the designated coastal municipalities. Municipal councils shall decide, in accordance with the procedure laid down by them, on the use of funds to meet the social, economic and environmental needs of local communities and residents.</td></tr>
</table>

Environmental component	**Measures for avoiding, reducing and compensating for environmental impact**
	Dismantling stage • Given the historical importance of the PEA area for fishing, and considering that the operation of the WF is temporary, it is important that, at the end of the operation of the WF park, during the dismantling of the power plants, the foundation structures at the bottom do not become artificial obstacles to fishing gear, i.e. the foundation should be dismantled to the level of the former bottom relief, thus avoiding the potential impact due to caught and lost fishing equipment, which becomes a secondary source of pollution at sea, and has an adverse impact on marine resources (becomes a passive catch gear).

6. OBSERVATION (MONITORING)

The application of observation (monitoring) measures is appropriate for the implementation of the PEA – WE farm in Lithuanian waters of the Baltic Sea.

Monitoring dimensions are presented in the EIA report. It is expected that the observation program will have to be prepared and agreed with the Environmental Protection Agency prior to the onset of the offshore WE farm construction and it will also have to include the monitoring of WE and TS construction and cable laying impact on the seabed, water quality and living nature.

6.1. Recommendations for the monitoring of underwater noise

The observation of underwater noise must be carried out during the construction phase when WE foundations are installed. The purpose of the monitoring is to monitor whether the generated noise does not exceed the limit values (laid down in section 4.3.4) in order to control negative impact on marine organisms (sea mammals, fish) as well as to evaluate / monitor the effectiveness of the measures taken to reduce noise. At present, in practice, it is relied on two main standards: ISO 18406 and DIN SPEC 45653 (Remmers and Belmann, 2016; Belmann et al., 2020).

Methodology, procedures and measurement systems, that should be used when measuring the underwater acoustic sound produced by pile driving, the use of percussion hammers, are presented in ISO 18406 document "Underwater acoustics. The measurement of radiated underwater sound from percussive pile driving".

Measurement methods for the effectiveness of noise reduction systems in situ, including measurement distances, are presented in DIN SPEC 45653 "Offshore wind farms. Determining the losses of underwater control measures during pile driving" specification. According to this standard, it is recommended to carry out underwater noise measurement at the distance of 750 m and 1,500 m from the pile driving place; the number of hydrophones and the set-up of the measurement system is outlined.

The system of underwater noise observation depends greatly on the type of foundation chosen and the procedures of pile driving, therefore the exact scheme of underwater noise monitoring must be prepared together with the technical project of pile installation.

6.2. Water monitoring

In order to choose right technological solutions for WE farm development and to evaluate the impact of planned WE constructions on hydrodynamic environment, it is reasonable to provide current measurements in the vicinity of the planned farm prior to the onset of construction works (for the evaluation of background conditions) and after the completion of construction works.

At the time of WE farm installation, local and temporary impact on water quality is possible due to additional water pollution with chemical substances (heavy metals, petroleum hydrocarbon, polyaromatic hydrocarbons), which happens due to intensified shipping. In order to evaluate the compliance of polluting substance concentrations with the values of good environmental status, it is reasonable to incorporate the studies of polluting substances into the environment monitoring program by planning their performance prior to construction works (background concentrations), at the time of construction works (the construction of foundations, laying of cables) and after the completion of construction works (3–6 months after the completion of works).

6.3. Zoobenthos monitoring

At the time of WE farm construction, the monitoring of Zoobenthos habitats must be carried out immediately after the installation in order to evaluate the impact of construction on different habitats (infauna, epibenthos). The collection of samples should be carried out at 5–7 places of investigation in the

PEA area in accordance with quantitative and qualitative methods (Van Veen, Draga, Video) and at 3 referral points by using a quantitative evaluation method (Van Veen).

At the time of WE farm operation, the monitoring of Zoobenthos habitats is carried out at 6–7 places (Van Veen, Draga). Observation of changes in the vertical gradient (on poles) is carried out by using video, overgrowth plates (from different horizons as far as it is possible technically).

6.4. Seabed monitoring

Detailed seabed investigations will be carried out prior to the WE farm construction at the specific cable laying routes and at the places of foundation construction. At the time of operation, the developer will carry out the planned monitoring of foundation constructions and cable routes in order to ensure that there is no physical damage, cables are not exposed to the surface or otherwise physically affected (by anchors, at the time of trawling, etc.), therefore other, additional seabed observation measures are not required. However, seabed investigations (in addition to other environmental compartments) must be carried out before and after WE farm dismantling works. It is recommended to carry out complete seabed morphology and side-scan sonar investigations at installed / dismantled cable routes and separately at the places of each foundation construction.

At the time of WE farm installation, local and temporary impact on seabed sediment quality is possible due to additional accidental pollution with chemical substances (heavy metals, petroleum hydrocarbon, polyaromatic hydrocarbons), which happens due to intensified shipping. In order to evaluate the potential impact of WE farm construction and operation on changes in the geochemical situation and to ensure the compliance of seabed sediment quality with the values of good environmental status, after the completion of WE farm construction works, it is reasonable to provide the planned (taking place during the entire operation) studies of polluting substances (every 6–12 months, or less frequently if research results show no substantial contamination) in the seabed sediments, as well as immediately after WE farm dismantling works. The places of sediment sample collection to be provided in the vicinity of installed / dismantled cable routes and each foundation construction place.

6.5. Seabird and bat monitoring

Bird and bat observation should be carried out for 2 full years until the onset of WE farm construction (at the time of EIA development). During the construction and 3 years after the onset of WE farm operation. Throughout the whole WE farm operating period, full year studies are conducted, at least every 5 years from last observations by study extent applied before construction. The research objectives include the determination of species composition and abundance of migratory and passage migrant, also resting, feeding and forming aggregations birds in the territory. To evaluate the significance of investigated territory for the birds and the potential impact of WE farm.

Offshore surveys of migratory and passage migrant birds must be carried out during autumn and spring migration when they are conducted in combination with a radar and visual observations during a daytime, as well as with bird sound registration by means of sound recording equipment or by listening or recording with microphones at night. During a total of at least 20 observation days (on 24-hour basis, including nights) per year, observations have to be carried out.

Offshore surveys of resting and feeding seabirds are carried out all year round, every month. The offshore surveys are carried out by transects from a vessel or a plane when birds floating or resting on the water are counted, at least 7 % of WE farm territory and at least 2 km outside WE farm boundaries. It is preferable for the transect survey waters to be arranged in parallel along the maximum depth gradient or in a north-south direction. Distances between transects have to reach 2km in the study area of potential WE farm, while outside its boundaries, distances between transects can reach 4 km.

Autumn and spring bird migration in the sea is observed in one WE farm place, preferably in the central part of WE farm. Calm weather, when wind speed is no greater than 8–9 m/s, is selected for observations. A vessel has to keep the position (with a help of dynamical positioning system or anchor) in one place together with a vertically enabled radar. A radar has to be oriented perpendicularly to the bird migration direction. The observations begin in the morning (at dawn) or in the evening (at dusk) and has to cover the entire dark or light period. The shortest observation period has to be at least 24 hours. After the completion of WE farm construction, the observations can be carried out from the platform located in WE farm.

For bat monitoring, bat recording detectors have to be installed in the planned WE farm territory on top of existing constructions or buoys and bat migration activity has to be recorded. Bat monitoring has to also be carried out accordingly in the coastal areas in order to evaluate migration differences.

Bird and bat monitoring coverage is determined in "The description of detailed criteria of wind farm significant adverse effects on birds and bats, prevention and elimination of damage to birds and bats by the application of measures and research requirements", therefore the developer will be obliged to comply with it as well as specify / adjust monitoring coverage in case of changes to the description.

6.6. Marine mammal monitoring

The parameters monitored at different WE construction stages (1. planning; 2. installation; 3. operation; 4. decommissioning):

- seal and porpoise observation to determine the occurrence and prevalence of different species, and possible seal species diversity in the PEA and adjacent areas (1-4);
- estimation of the total and relative abundance of seals and porpoises in the PEA area (1-4);
- estimation of habitat usage by seals and porpoises in the PEA and adjacent areas (1-4);
- noise level of anthropogenic origin in the PEA area (2-4).

6.7. Fish monitoring

The parameters monitored at different WE construction stages (1. planning; 2. installation; 3. operation; 4. decommissioning):

- estimation of the total and relative abundance as well as community structure of different species in the PEA and adjacent areas (1-4);
- estimation of fish species occurrence, prevalence, species diversity in the PEA and adjacent areas (1-4);
- prevalence and condition of seabed habitats in the PEA area (1, 2, 4);
- noise level in the PEA area (2–4);
- concentrations of pollutants in fish detectable in the PEA area (2–4);
- observation of invasive species in the areas of potential impact in the PEA area (2–4).

Some of the monitored parameters can be modified by using modern monitoring techniques: fish telemetry, acoustic observations of fish or species detection by using environmental DNR studies.

7. INFORMATION ON POTENTIAL CROSS-BORDER IMPACT

The Convention on Environmental Impact Assessment in a Transboundary Context of the Environment of the United Nations Economic Commission for Europe (hereinafter - the Espoo Convention) stipulates that a transboundary EIA shall be carried out when a PEA is included in Annex I to the Espoo Convention.

According to the second amendment to the Espoo Convention (Decision III/7 of 4 June 2004), large installations using WFs for energy production are included in Annex I to the Convention.

Pursuant to Clause 1 of Resolution No 900 of the Government of the Republic of Lithuania of 28 July 2000 on granting powers to the Ministry of the Environment and its subordinate institutions, the process of cross-border EIA harmonisation and publicity is coordinated by the Ministry of the Environment.

The Ministry of the Environment, in accordance with Article 3 of the Espoo Convention, at the stage of preparation of the EIA program, notified Poland, Latvia, Estonia, Finland, Sweden, Denmark and Germany of the installation and operation of the offshore WF park with installed capacity up to 700 MW in the Lithuanian maritime area by letters No (10)-D8(E)-7691 and No (10)-D8(E)-7692 of 9 December 2021 on the planned economic activity in Lithuania, and by letter No (10)-D8(E)-7954 of 17 December 2021, in accordance with Article 7 of the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area, the Secretariat of the Helsinki Convention, Poland, Latvia, Estonia, Finland, Sweden, Denmark, Germany and Russia.

By letter No (10)-D8(E)-801 of 10 February 2022 and by letter No (10)-D8(E)-1271 of 8 March 2022, the Ministry of the Environment informed that Latvia, Denmark, Sweden and Finland had expressed their wish to participate in the transboundary environmental assessment procedures and submitted comments and proposals. Estonia informed that it would not participate in the transboundary environmental impact assessment procedures, but submitted proposals and expressed a wish to receive environmental impact assessment documents, indicating that such an exchange of information and documentation is important for assessing the overall environmental impact of WF projects developed in the Baltic Sea. Germany did not respond to the notification. Poland has requested that the EIA report on the planned economic activity, the installation and operation of the offshore WF park with an installed capacity of up to 700 MW in Lithuania's maritime territory, be submitted in paper and electronic format.

In accordance with letter No (10)-D8(E)-1271 of the Ministry of the Environment of 8 March 2022, the EIA programme was revised in light of comments from foreign countries.

From the territory of the PEA to the Latvian EEZ is about 2.8 km, to the Swedish EEZ about 77 km, to the EEZ of the Russian Federation about 40 km.

According to the results of the environmental impact assessment carried out, effects on environmental components such as water, ambient air, seabed, cultural values and public health are only local (on a local scale). The transboundary impact of the PEA is, according to its specificity, most relevant in the following respects:

- biodiversity (particularly bird migrations);
- the landscape: visual impact;
- the impact on international maritime navigation;
- possible restrictions on the surveys and extraction of oil deposits stratifying in the seabed;
- impact on fishing.

7.1. Potential effects on biodiversity

Effects on birds

The WF park can become an obstacle for birds and bats migrating across the Baltic Sea. It is known that anseriformes, cranes, loons, passeriformes and other birds migrate intensively over Lithuanian territorial waters.

According to bird observations carried out at the time of preparation of the EIA, significant adverse effects on bird species such as velvet scoters and long-tailed ducks have been identified due to their scaring away from areas used for wintering and nutrition.

No significant impact is expected on other wintering, breeding or migrating bird species. Migration through the planned WF park is not intensive during both autumn and spring, and various groups of birds fly through the park. Due to its geographical location, the main migratory flows are concentrated on the coast at the land, so only a small proportion of birds use the open sea to migrate to breeding sites northernmost or wintering areas southernmost. The offshore WFs park should not affect migrating cranes, ansers, ducks, passeriformes.

The planned WF park can have minimal influence on bird species migrating above the sea, which will require birds to change their migration directions or bypass the WF park, as well as possible deaths due to a direct collision with the WF blades can occur.

On the Latvian side, an analogous offshore WF park is planned. The cumulative effect of analogous activities will be similar to that determined for this park. To date, there is not enough data allowing assessing the wintering areas of sea birds located on the Latvian side, which makes the cumulative impact on wintering birds difficult to estimate.

In the migration aspect, the planned WF park on the Lithuanian side and the planned WF parks on the Latvian side should not have a significant summary effect on migratory birds in light of the surveys carried out and the nature of migration determined.

It is likely that benthic-feeding species that depend on the habitat may be most affected, thus the effect can be significant for velvet scoters if similar numbers of velvet scoters winter on the Latvian side as in Lithuania.

Effects on bats

According to the observations of bat migrations carried out within the scope of the EIA, the adverse effects of the WF park on bats are not expected, as the intensity of bat migration decreases significantly as moving away from the shore. Surveys have shown that very intensive migration takes place up to 300 m from the coast at Palanga, above Palanga bridge, but just 5-7 km toward the sea from the coast in Butingė, less than 10 % of bat migration intensity registered at the end of Palanga bridge is counted. The intensity of migration in Būtingė (at a distance of 5-7 km from the coast) was very low and did not reach even the migration intensity recorded in eastern Lithuania. Based on these data, it is likely that the migration of bats 20-30 km from the coast at the PEA site does not occur, and can only be reached by single individuals who fly aimlessly.

Effects on fish

The greatest impact on individual fish species can only occur during the installation of WF parks and during the removal works of structures. This impact n the fish community will be short-term and insignificant, related to the location of the execution of works, i.e. local. Following the completion of the installation (or WFs dismantling works), the fish will return to the nutrition area. The avoidance reaction is observed only at a distance of a few metres from WF and only at high wind speeds, which may result in a positive impact on fish populations due to newly emerging artificial reef habitats during the operation period. On a transboundary scale, the impact on fish is unlikely.

From anadromous fish species, only twait shad and European smelt are present in the PEA area. The available survey data do not indicate that the PEA area would be on the migratory routes of twait shads, and fish were not detected in the area during migration. Smelt migration to the Curonian Lagoon is known to take place between November and March and the main smelt mobs migrate from the northern side at depths of 6-40 m. It may be assumed that migratory fish routes may change at the time of the installation of the parks or the accumulation of fish in certain places due to adverse conditions (water turbidity or noise) created during construction. However, during the surveys, European smelt in the PEA area was classified as incidental fish species in the community and no large shoals swimming to spawn were recorded.

Effects on marine mammals

The impact of the offshore WF park on marine mammals is mainly due to the noisy WF installation works, in particular, the impact of pile-driving-generated noise. Surveys carried out within the scope of the EIA confirmed that marine mammals are not continuously monitored in the area of the planned WF park, but may wander in. It is expected that the protection of marine mammals during the construction and dismantling stages of the WF park requires impact mitigation measures, especially the noise suppression of pile driving.

The noise impact on marine mammals (grey seals and harbour porpoises) propagated during the operation of the WF parks is insignificant and, if the behaviour is affected, it manifests at a maximum distance of several hundred metres from WF.

The summary effect of similar activities, i.e. impact of offshore WF parks on marine mammals with the planned WF park in Latvian waters, is only possible if the installation and dismantling works of several parks in adjacent water areas take place simultaneously. In this way, mammals may not be able to access part of their nutritional areas, as well as changes in fish migration localities and their accumulation places. In such cases, the succession of installation of different parks should be determined, both at the national and cross-border levels, which would allow for a reduction in the cumulative impact.

7.2. Impact on the landscape: visual impact

The territory of the PEA is about 30 km far off from the coastline of the Republic of Latvia. At this distance, offshore WFs will be difficult to distinguish from coast-based observation platforms. According to the landscape impact assessment, the visual impact is assessed as negligible (i.e. no impact) when observed from Pape beach of Latvia.

In the development of offshore wind farm parks and the assessment of their impact on the landscape, it is necessary to pay attention to the fact that similar activities are planned on the Latvian side: the installation of renewable energy wind power parks at the northern border with the Republic of Lithuania is foreseen by the Republic of Latvia (according to the Maritime Spatial Plan of the Republic of Latvia approved on 14 May 2019).

Following the implementation of both projects, the horizontal viewing angle of offshore WF parks may increase. This cumulative effect will be more relevant to the resort of Palanga than to the settlements located on the Latvian coast.

7.3. Impact on international maritime navigation

The Baltic Sea Lithuanian water area is crossed by two main navigation routes with a width of 4 nautical miles approved in the HELCOM Copenhagen Declaration of 2001 and officially mapped.

The PEA area does not fall within the designated international navigation routes, port roadsteads or anchorage areas and therefore no significant impact on shipping and international shipping routes is foreseen.

The conclusions of the risk analysis carried out in the EIA report allow stating that there is no significant risk of ship collision with WFs. The probability of a passing ship collision with WF structures shall be calculated by estimating the density of the standard normal distribution described by the Gaussian function and the ranking of navigational errors of the collision. Following the evaluation of the distance of the central part of the shipping channel from the location of the PEA and the small number of passing vessels capable of damaging the objects of the WF park, the probability of a collision is 9.0E-05. The value of individual risk per year for passengers would be 2.05E-08, and seamen of crews 2.5E-07. The predicted marginal values of annual individual risk per year for passengers and ship crew members are acceptable.

In the event of a collision between dry-cargo carriers and passenger ships, the environmental consequences are limited and significant; in the case of collisions between tankers, they may vary from limited to catastrophic. A catastrophic case would be pollution due to a collision with an oil tanker. This could lead to more significant spillage of petroleum products, which are more harmful to the environment due to low evaporation. The consequences of such collisions require the development of special emergency response procedures.

7.4. Transboundary effects due to possible restrictions on oilfield exploration

The PEA area does not overlap with the boundaries of promising structures for oil extraction. However, promising structures for oil extraction are known in the maritime territory of the Republic of Latvia. The distance from the PEA to the maritime border with Latvia is around 2.8 km, so the impact on the oil resources of the Republic of Latvia and the prospective extraction thereof is unlikely.

7.5. Effects on fishing

According to the classification of the International Council for the Exploration of the Sea, the Lithuanian maritime territory falls within statistical rectangles 41H10, 40H10, 40G9 and 39H10 of the 26th ICES fishing area, where fish are caught by trawling and set nets. The PEA area falls within fishing rectangles 41H10 and 40H10, where the areas used for fishing with trawl are located.

In the period from 2015 to 2018, 9 vessels registered in Lithuania and 14 fishing trawlers registered in neighbouring foreign countries (Latvia and Russia) were fishing with trawls in the PEA area. Between 2015 and 2017, in terms of fishing effort, the PEA area was dominated by foreign vessels with a share of total fishing effort between 52 % and 87 %. Since 2018, the ratio of trawling efforts in the PEA area has been redistributed. The registered share of trawlers in Lithuania accounted for between 63 % and 100 % of the total fishing effort area.

The installation of the WF park will result in fishing restrictions in the area, the trawling will not be possible due to the risk of damage to the power transmission cables laid on the bottom.

It should be noted that the area under analysis covers fishing areas on the high seas that are not allocated to individual undertakings. Therefore, in the event of restrictions during the construction and operation of the WF park, fishing can be carried out in adjacent areas and fishermen will not suffer losses.

8. DESCRIPTION OF PROGNOSTICATION METHODS, EVIDENCE APPLIED TO IDENTIFY AND ASSESS SIGNIFICANT ENVIRONMENTAL IMPACTS, INCLUDING PROBLEMS

8.1. EIA methods and data sources

The environmental impact assessment of the planned WF park was conducted on the basis of the methodologies in force in Lithuania, approved evaluation and mathematical modelling programmes, foreign and Lithuanian research materials, publications of EU countries, the methodologies and recommendations presented therein, archival and published sources of statistical information on environmental components. Information on the current state of the environment was collected using officially available databases and the experience of EIA promoters in the monitoring of similar activities.

8.1.1. Official sources of databases and other data used during the environmental impact assessment of planned economic activities

Seq. No	Data source	Data used	Data source
1	Supplement of the Master Plan of the territory of the Republic of Lithuania (2015) with a part of the maritime areas	A maritime infrastructure corridor, areas for the development of wind energy, a zone important for military observations	Ministry of Environment of the Republic of Lithuania
2.	Concretized solutions to the Master Plan of the territory of the Republic of Lithuania.	Drawing of "Responsible use of sea and coast"	Ministry of Environment of the Republic of Lithuania
3.	A chart of territorial and economic waters of the Republic of Lithuania (No LT282001)	Sunk ships, obstacles, anchorages, harbour roadsteads, shipping routes, restricted use areas, military areas, area of sunk chemical weapons, soil dumps	Lithuanian Transport Safety Administration:
4.	State Cadastre of Protected Areas	Protected areas, Natura 2000 BAST and PAST	State Service for Protected Areas under this Ministry of Environment
4.	Information System of Protected Species (SRIS)	Sites of protected species (plants, mushrooms, animals)	
5.	Register of Cultural Values	Cultural heritage objects and their protection zones	Department of Cultural Heritage under the Ministry of Culture
6.	Georeference Base of Cadastre Spatial Data Set (GPRK)	Boundaries of municipalities, built-up areas	Ministry of Agriculture of the Republic of Lithuania
7.	Map of Lithuanian water area for fishing	Trawling routes, bottom sediments	Žaromskis R., Repečka R., Gulbinskas S., 2005.
8.	Correction of the special plan for the management of the continental part of the coastline. Solutions	Recreational land	Ministry of Environment of the Republic of Lithuania
9.	Areas of the Republic of Lithuania where the design and construction works of wind power plants (high structures) may be restricted	The area where the design and construction work of wind farms are prohibited. The area where wind farm sites are coordinated on condition.	Military Cartography Centre of the Lithuanian Armed Forces
10.	State Geological Information System (GEOLIS), Underground Register	Potential oil structures	Lithuanian Geological Survey under the Ministry of Environment
11.	National Landscape Management Plan (approved by Order No D1-	Landscape Management Areas	Ministry of Environment of the Republic of Lithuania

Seq. No	Data source	Data used	Data source
	703 of the Minister for the Environment of 2 October 2015)	The Visual Aesthetic Potential of the Landscape.	
12.	Database of Special Land Use Conditions	Airport Security Areas	National Land Service under the Ministry of Agriculture
13.	TPD Register	Territorial planning documents approved and under preparation	State Territorial Planning and Construction Inspectorate under Ministry of Environment of the Republic of Lithuania
14.	HELCOM GIS portal	Intensity of navigation	HELCOM
15.	Bathymetric map of the Central Baltic Sea, scale 1:500 000. LGT series of Marine Geological Maps. Red. Leonora-Živilė Gelumbauskaitė	Bathymetric data	LITHUANIAN INSTITUTE OF GEOLOGY, the GEOLOGICAL SURVEY OF LITHUANIA, the GEOLOGICAL SURVEY OF SWEDEN, the SWEDISH MARITIME ADMINISTRATION

Mathematical models used in the EIA:

In order to characterise the conditions of the high seas, the two-dimensional digital model system MIKE 21 was used to model wave dispersion. The wave model NSW (Near-shore Spectral Wind-Wave Module) of this system was used to model wind-induced wave dispersion parameters on the Baltic coast (MIKE, 2002). The ECMWF (European Centre for Medium-Range Weather Forecasts, www.ecmwf.int) data for the period 2016-2018 (inclusive) were used for the high sea wave model.

WindPRO 3.3 software was used to evaluate the visual impact on the landscape; the analysis of the WF visibility (VMK and HMK) was carried out using the ZVI model. The WF visualisation in photos was prepared using the photomontage model.

8.2. Ongoing field research within the scope of the environmental impact assessment

The expert assessment was used for environmental impact assessment and field research was conducted in the area analysed.

Water

For the assessment of the hydrological environment, data from the hydrometeorological parameter monitoring systems EOLOS FLS200 installed in the PEA area were used.

Water samples for contamination testing were taken in May 2022 using the Hydrobios bathometer at 5 testing stations (see Fig. 4.1.9. VP1, VP3, VP4, VP8, VP10) from two horizons: surface (at a depth of about 0.5 m) and demersal (about 0.5 m from the surface of the seabed). Polluting substances (petroleum products C10-C40, polycyclic aromatic hydrocarbons, heavy metals As, Cd, Cr, Cu, Ni, Pb, V, Zn, Hg) were determined in an accredited laboratory of UAB "Vandens tyrimai" (according to LST EN ISO/IEC 17025:2018).

Vertical variation of hydrochemical parameters (pH, dissolved oxygen, suspended substances) in different survey sites is shown in the profiles presented in Annex 5 to the EIA Report.

Ambient air and climate

Data from the hydrometeorological parameter monitoring systems installed in the PEA area - EOLOS FLS200 (EOLOS, 2022(a), (b), (c), (d) and (e), see Fig. 4.2.1) were used for the assessment of meteorological conditions. Measurements of wind strength and directions in different parts and heights of the area were made. The northern wind mode is represented by E01 meteorological station readings and the southern one is represented by E06.

Underwater noise

2 underwater noise monitoring systems with a multi-directional hydrophone operating in the frequency range from 20 Hz to 60 kHz (SoundTrap ST600STD, Ocean Instruments, New Zealand) were introduced to determine the peculiarities of underwater noise dispersion in the PEA area. The main objective of the research was to determine the current conditions of underwater noise levels in order to assess future possible changes in the marine environment caused by anthropogenic activities during construction, operation and liquidation.

Acoustic data were collected in accordance with international measurement standards (BSH, 2011; Dekeling et al, 2014a, b, c; Van der Graaf et al., 2012), as well as the updated HELCOM Guidelines for Continuous Noise Monitoring (HELCOM 2021), with a noise recorder positioned approximately 5 m above the seabed. Detailed analysis of acoustic data was carried out in 1/3 octave bands with centre frequencies from 20 Hz to 20 kHz, which complies with HELCOM recommendations (HELCOM, 2021) and international standards as well as recommendations of expert groups (EU TG-Noise, HELCOM EG-Noise) in the field of underwater acoustical data analysis.

The result of the calculation of power spectrum density (PSD) [dB re 1 μPa2/Hz] for specific 1/3 octave frequency bands given in the form of boxplots (MATLAB®) reflects the overall statistical information on noise data (Fig. 4.3.1). In the diagram, the central red line denotes the median value in each blue-marked rectangle (box), the lower and upper limits of which determine the first quartile (Q1) and the third quartile (Q3) respectively, i.e. 25 and 75 percentiles. By definition, the distance between Q1 and Q3 makes half of all observations (interquartile range - IQR). The so-called "whiskers" values (black dotted) are set by default to 1.5 of the interquartile range, i.e. $\Delta Q=1,5*IQR$. If the observed minimum is greater than the lower "whisker" $Q1-\Delta Q$ value and/or the observed maximum is less than the upper "whisker" $Q3+\Delta Q$, the length of the whiskers is limited by the corresponding observed extreme values.

Earth: The bottom and depths of the sea

Bottom sediment samples were taken for geochemical analysis at 10 testing stations in the area of the planned WF park (see Fig. 4.4.2.1). The samples were taken with Van Veen grab (bottom coverage area $0,1\ m^{-2}$).

Polluting substances (petroleum products C10-C40, PAH, heavy metals - As, Cd, Cr, Cu, Ni, Pb, Zn, Hg) were determined in an accredited laboratory (according to LST EN ISO/IEC 17025:2018) of UAB "Vandens tyrimai". The assessment of the chemical status of the Lithuanian Baltic Sea water area according to the concentrations of polluting substances in sediment was guided by Order No D1-194 of the Minister for the Environment of the Republic of Lithuania of 4 March 2015 "On the approval of the properties of the good environmental condition of the marine area of the Republic of Lithuania" and the average annual values of pollutants in the bottom sediments of good environmental status specified therein.

During lateral scanning, an acoustic survey of the surface of the bottom (Seabed Research, Part II, 2022) was carried out and a catalogue of acoustic reflections from bottom objects, a diagram of geological structures and distribution limits of different types of sediments was compiled (see Fig. 4.4.8). The preliminary classification of objects is based exclusively on visual assessment.

Seabed habitats

Surveys on the taxonomic composition, abundance and biomass of macroinvertebrates were conducted in accordance with LST EN ISO 16665:2014 Water quality - Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna and LST EN ISO 19493:2007 Water quality - Guidance on marine biological surveys of hard-substrate communities and HELCOM recommendations (HELCOM, 1988; HELCOM, 2014). The main principles and recommendations set out in the Guidelines for the environmental impact studies on marine biodiversity for offshore wind farm projects in the Baltic Sea Region have been taken into account.

Fifty-four sampling sites were selected on the basis of data from multibeam echosounder and side-scan sonar (see Fig. 4.6.2.1). Three background survey sites (stations 37, 38, 48) approximately 1 nautical mile from the boundaries of the PEA area have also been selected out of 54. For the assessment of the species composition, abundance and biomass of benthic invertebrates in the PEA area, two testing methods have been combined: quantitative - sediment sampling of the bottom with a suction dredger and qualitative - dredge.

A total of 106 bottom sediment samples were taken from depths of 30.1 to -43.1 m from 9 to 11 March 2022 (1-3 repetitions per site), using a suction dredger at 48 sites, a dredge at 6 sites, and in 2 places with a suction dredger and dredge.

At sea, quantitative samples were taken with Van Veen-type suction dredger (bottom coverage area 0.1 m-2) by taking 2-3 samples from each site. In hard-bottom areas where Van Veen suction dredger could not be used, a dredge was used, by taking 1 semi-quantitative sample while the ship was sailing slowly at a speed of 5 minutes per nautical mile. If the sample failed to be taken, the test was repeated by extending the dredging time up to 10 minutes. A sieve of 500 µm mesh (approved by the manufacturer) was used to rinse the samples. Invertebrates with the bottom residues were transferred into plastic containers and fixed with a 4 % formaldehyde solution neutralised with sodium tetraborate. A stereo microscope was used in the laboratory to calculate and characterise the abundance of each invertebrate species or taxon (magnification 7-230 times).

The calibrated laboratory analytical scales of precision class I (accuracy 0.0001 g) were used for the formalin wet weight of invertebrates. The lengths of Macoma balthica and Mytilus trossulus shells were measured with the digital calliper (L, mm) with an accuracy of 0.01 mm.

The animals were described to the lowest possible taxon level. The taxonomic nomenclature corresponds to the European Register of Marine Species (ERMS, http://www.marbef.org/data/erms.php) and the World Register of Marine Species (WoRMS, http://www.marinespecies.org).

The abundance and biomass of individuals of each counted and weighed species/taxon of each quantitative (Van Veen) sample were converted into an area unit m^2. The organisms of each sample taken by the dredge were counted, the dominant species were distinguished, and the taxonomic composition was determined. As the ship was sailing at the same speed at all dredging sites and at the same time interval, the abundance and biomass of the dominant species of different sites were relatively scored (from 1 to 10).

Observations of birds

Monthly censuses of birds perching on the water and feeding in the PEA area and neighbouring areas were carried out in all seasons of the year. Censuses during the warm season, when the days are long enough, were carried out from the ship, and in the cold period from the plane.

Censuses from the ship were carried out from May to October inclusive, by sailing along selected transects. The censuses were carried out in accordance with the program ESAS - European Seabird-at-Sea (GARTHE & HÜPPOP 1996, 2000) and the methodology of BSH guidelines of StUK4 (BSH 2013).

The censuses were conducted while sailing by the intended transect plan and monitoring the birds from the vessel. The plan of transects (see Fig. 4.6.4.2) consists of 6 transects with a length of 25.9 km. The length of all transects is 155 km. The transects are at a distance of 4 km from each other in parallel. The transects' plan covers an area of 533 km².

Not only individual species were registered, but also, if possible, additional information such as birds' age, gender, breeding dress, behaviour, relationship with other bird species or objects, flight height and direction.

Censuses from the plane. Resting birds were captured using digital video technology developed by the company HiDef.

Digital video recordings were made when flying by a two-engine high-wing propeller plane (Partenavia P 68). The plane is equipped with four high-definition video camera systems that take an average of 7 photos per second and can reach a resolution of two centimetres on the sea surface. Photos of each camera are assigned a numbering, which is then used for analysis (camera photos are divided into two parts). The camera system is not directed vertically downwards (depending on the position of the sun can be turned aslope or even in the opposite direction of the plane's flight direction), therefore the interference and reflections caused by the sun can be reduced. The outer chambers cover a bandwidth of 143 m, whereas each inner one covers a bandwidth of 129 m wide, and all together effectively cover a width of 544 m. In order to avoid double counting of the individuals captured by video cameras, the distance between each band under observation is 20 m wide. Thus, the 544 m wide observation field is distributed within a width of 604 m. Such a modern monitoring system has been used for the first time not only in Lithuania but also in all Baltic States.

The transect plan (see Fig. 4.6.4.5) consists of 1,339 km long transects and 4 shorter 19.07 km long transects, which intervene among the long ones to cover the park area of the planned WF. The length of all transects is 583.28 km. Long transects are 4 km far-off from each other and short ones are 2 km from the long ones. The transects' plan covers the area of 2,340 km².

At the data processing stage, the birds were identified from video material collected on the plane. Often, it was possible to identify birds in photographs up to the species. Due to the similarity of some species (e.g. common murre and razorbill, common and Arctic tern, red-throated and black-throated loons), it is not always possible to identify the exact species of the bird. However, it is usually possible to identify up to individuals belonging to a group of species consisting of two (or several) closely related bird species. In addition to identifying the species, other information such as the bird's position, age, gender, behaviour (swimming or flying) and the direction of the flight were identified.

During the warm season, mammals were observed in the area of the PEA together with bird censuses from the vessel and during the cold period from the plane. Also, data from mammal sound monitoring stations installed at sea were collected for the months of May 2022 until November 2022.

The censuses of marine mammals

Censuses of mammals from the vessel was conducted together from May to October inclusive, sailing by selected transects (see section 4.6.4.). From November 2021 to April 2022, the censuses by means of the vessel was not performed due to too short daylight hours for such censuses (this period is compensated by the census from the plane). The censuses were carried out in accordance with the program ESAS - European Seabird-at-Sea (GARTHE & HÜPPOP 1996, 2000) and the methodology of BSH guidelines of StUK4 (BSH 2013).

Censuses from the plane. The censuses were conducted while sailing by the intended transect plan and monitoring the mammals from the vessel. The transects plan consists of 625.9 km long transects with a total length of 155 km. The transects are 4 km far-off from each other and cover an area of 533 km².

Marine mammals sailing or resting on the water's surface were captured using digital video recording technology developed by HiDef company (see section 4.6.4.).

The transect plan consists of 1,339 km long transects and 4 shorter 19.07 km long transects, which intervene among the long ones to cover the park area of the planned WF. The length of all transects is 583.28 km. Long transects are 4 km far-off from each other and short ones are 2 km from the long ones. The transects' plan covers the area of 2,340 km².

Between November 2021 and April 2022, six censuses by plane were performed and two aerial censuses were conducted in February because bad weather conditions prevented the performance of the census in January.

Acoustic monitoring of harbour porpoise sounds In the PEA area, the monitoring of harbour porpoises using acoustic devices was conducted between 1 May 2022 and 13 November 2022. F-POD acoustic receivers were used for monitoring (Chelonia Ltd.) 8 F-POD receivers were evenly arranged throughout the PEA area, which captured high-frequency signals of harbour porpoises within a 400 m radius. 5 m receivers were raised from the bed on anchoring systems designed for this purpose. The detection of the signals of the harbour porpoises was conducted by automated algorithms installed in the equipment.

Archaeological research in the PEA region

An acoustic photo was taken in the PEA region using the side scan sonar. The expert underwater archaeologist, by analysing acoustic data, selected 183 images that were further evaluated to determine their potential cultural value and to attribute or reject them as valuable heritage objects.

8.3. Environmental impact assessment problems and possible inaccuracies

There were no problems at the time of the preparation of the EIA that would prevent the identification and assessment of potential environmental impacts.

PUBLIC INFORMATION AND CONSULTATIONS

Public information during the EIA program development stage

Informing the public about the prepared EIA program is carried out in accordance with the provisions of the second section of chapter 5 of the description of the procedure for assessing the impact of planned economic activities on the environment.

Information for the public about the opportunity to get acquainted with the EIA program and submit proposals has been published:

- submitted by e-mail to EPA, with a request to publish on the website;

- submitted by e-mail to the municipal administrations of Palanga city, Klaipėda city and Klaipėda district, with a request to publish on the websites and notice boards of the administrations;

- published on the website of the Ministry of Energy of the Republic of Lithuania;

- published on the website of Public Enterprise "Coastal Research and Planning Institute",

- published in Klaipėda, Banga, Palanga tiltas newspapers.

During the coordination phase of public information and participation in the EIA program, five letters received with comments and suggestions from the interested public regarding the EIA environmental impact assessment program have been registered, an evaluation of the proposals of the interested public has been carried out, and answers are provided to those who submitted proposals. It should be noted that the comments of UAB "Ignitis renewables" forwarded by the Environmental Protection Agency on 12/22/2021 (EPA letter No. 12/01/2021 (30.2)-A4E-13939) (submitted to EPA on 11/22/2021 letter No. REN_SR_19) are identical to those received from UAB "Ignitis renewables" (2011-11-19 letter No. REN_SR_18), which are registered and evaluated according to the procedure provided in the Description.

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ANNEXES

Annex 1

Letter of Approval of the Environmental Impact Assessment Programme (in Lithuanian)

APLINKOS APSAUGOS AGENTŪRA

Biudžetinė įstaiga, A. Juozapavičiaus g. 9, LT-09311 Vilnius, tel.8 70662008, el. p. aaa@gamta.lt, http://aaa.lrv.lt.
Duomenys kaupiami ir saugomi Juridinių asmenų registre, kodas 188784898

VšĮ Pajūrio tyrimų ir planavimo institutui
el. p. info@corpi.lt

2022-04- Nr. (30.2)-A4E-
Į 2022-04-12 Nr. S22-049

DĖL POVEIKIO APLINKAI VERTINIMO PROGRAMOS TVIRTINIMO

Išnagrinėjome poveikio aplinkai vertinimo dokumentų rengėjo VšĮ Pajūrio tyrimų ir planavimo instituto parengtą Energetikos ministerijos planuojamos ūkinės veiklos (toliau – PŪV) – iki 700 MW įrengtosios galios jūrinių vėjo elektrinių parko įrengimo ir eksploatacijos Lietuvos jūrinėje teritorijoje poveikio aplinkai vertinimo programą (toliau – PAV programa), suinteresuotos visuomenės pasiūlymų įvertinimą ir poveikio aplinkai vertinimo subjektų išvadas.

Palangos miesto savivaldybės administracija 2021-12-01 raštu Nr. (4.21.E) D3-3911 pritarė PAV programai. Klaipėdos rajono savivaldybės administracija 2021-11-10 raštu Nr. (5.1.28 E) A5-5106 nurodė poveikio aplinkai vertinimo ataskaitoje (toliau – PAV ataskaita) pateikti informaciją apie II pasaulinio karo metu nuskandintų cheminių ginklų galimas vietas Baltijos jūroje ir įvertinti PŪV teritoriją šiuo atžvilgiu bei PAV ataskaitoje numatyti atlikti Baltijos jūros dugno tyrimus PŪV teritorijoje dėl galimo teritorijos užteršimo cheminiais ginklais ir minomis. Klaipėdos miesto savivaldybės administracija 2021-11-09 raštu Nr. (4.36E)-R2-2863 pritarė PAV programai. Nacionalinio visuomenės sveikatos centro prie Sveikatos apsaugos ministerijos Klaipėdos departamentas 2021-11-04 raštu Nr. (3-11 14.3.2 Mr)2-129991 pritarė PAV programai. Priešgaisrinės apsaugos ir gelbėjimo departamento prie Vidaus reikalų ministerijos Klaipėdos apskrities priešgaisrinė gelbėjimo valdyba 2021-11-09 raštu Nr. 9.4-3-2754 pritarė PAV programai. Kultūros paveldo departamento prie Kultūros ministerijos Klaipėdos skyrius 2021-10-29 raštu Nr. (9.38-Kl)2Kl-1183 pritarė PAV programai.

Aplinkos apsaugos agentūros (toliau – Agentūra) 2021-12-31 raštu Nr. (30.2)-A4E-15520 į poveikio aplinkai vertinimo procesą poveikio aplinkai vertinimo subjekto teisėmis pakviestos valstybės institucijos: VĮ Klaipėdos valstybinio jūrų uosto direkcija 2022-01-06 raštu Nr. UD-9.1.4E-38 pastabų PAV programai neturėjo; Neringos savivaldybės administracija 2022-01-11 raštu Nr. V15-73 pritarė PAV programai; Lietuvos geologijos tarnyba bei Žuvininkystės tarnyba prie Žemės ūkio ministerijos išvadų dėl papildytos PAV programos per nustatytą terminą nepateikė, todėl vadovaujantis Planuojamos ūkinės veiklos poveikio aplinkai vertinimo įstatymo (toliau – PAV įstatymas) 8 straipsnio 7 dalimi laikoma, kad PAV programai pritarė; Valstybinė saugomų teritorijų tarnyba prie Aplinkos ministerijos 2022-04-08 raštu Nr. (4)-V3-567 pritarė PAV programai.

Agentūra 2021-10-25 raštu Nr. (30.2)-A4E-12206 kreipėsi į Aplinkos ministeriją dėl tarpvalstybinio poveikio aplinkai vertinimo procedūrų taikymo PŪV. Aplinkos ministerija 2021-11-05 raštu Nr. (10)-D8(E)-6898 konstatavo, kad PŪV privaloma atlikti tarpvalstybinio poveikio aplinkai vertinimo procedūras. Aplinkos ministerija, vadovaudamasi Espo konvencijos 3 straipsniu, 2021-12-09 raštais Nr. (10)-D8(E)-7691 ir Nr. (10)-D8(E)-7692 apie Lietuvoje PŪV notifikavo Lenkiją, Latviją, Estiją, Suomiją, Švediją, Daniją ir Vokietiją, o 2021-12-17 raštu Nr. (10)-D8(E)-7954, vadovaudamasi Helsinkio konvencijos dėl Baltijos jūros baseino jūrinės aplinkos apsaugos 7 straipsniu – Helsinkio konvencijos sekretoriatą, Lenkiją, Latviją, Estiją, Suomiją, Švediją, Daniją, Vokietiją ir Rusiją. Aplinkos ministerija 2022-02-10 d. raštu Nr. (10)-D8(E)-801 ir 2022-03-08 raštu Nr. (10)-D8(E)-1271 informavo, kad Latvija, Danija, Švedija, Suomija išreiškė norą dalyvauti tarpvalstybinio poveikio aplinkai vertinimo procedūrose ir pateikė pastabas ir pasiūlymus. Estija informavo, kad tarpvalstybinio poveikio aplinkai vertinimo procedūrose nedalyvaus, tačiau pateikė pasiūlymų ir išreiškė pageidavimą gauti poveikio aplinkai vertinimo dokumentus, nurodydama, kad toks pasikeitimas informacija ir dokumentais svarbus vertinant suminį vėjo elektrinių projektų, vystomų Baltijos jūroje, poveikį aplinkai. Vokietija į notifikaciją neatsakė. Lenkija paprašė, kad PŪV PAV ataskaita būtų pateikta popieriniu ir elektroniniu formatu. PAV ataskaitoje bus įvertinti poveikį patiriančių valstybių pasiūlymai.

Išnagrinėję ir įvertinę Jūsų parengtą PAV programą ir remdamiesi poveikio aplinkai vertinimo subjektų išvadomis, vadovaudamiesi PAV įstatymo 8 straipsnio 9 dalimi, šią PAV programą tvirtiname. Jūrinis vėjo elektrinių parkas ir jo jungtis su sausumoje esančiu elektros perdavimo tinklu ir susijusia infrastruktūra (toliau – Jungtis) yra neatsiejamos PŪV dalys. Atsižvelgiant į tai, kad šiuo metu nėra žinoma jūrinio vėjo elektrinių parko Jungties koridoriaus vieta, nustačius jo vietą, PAV įstatymo nustatyta tvarka Jungties įrengimui bus atliekama atranka dėl poveikio aplinkai vertinimo.

Rengiant PAV ataskaitą būtina vadovautis Planuojamos ūkinės veiklos poveikio aplinkai vertinimo tvarkos aprašo, patvirtinto Lietuvos Respublikos aplinkos ministro 2017 m. spalio 31 d. įsakymu Nr. D1-885 ,,Dėl planuojamos ūkinės veiklos poveikio aplinkai vertinimo tvarkos aprašo patvirtinimo“, nuostatomis. Taip pat PAV ataskaitoje prašome vadovautis Lietuvos Respublikos bendruoju planu, patvirtintu Lietuvos Respublikos Vyriausybės 2021 m. rugsėjo 29 d. nutarimu Nr. 789 „Dėl Lietuvos Respublikos teritorijos bendrojo plano patvirtinimo“.

Šį atsakymą Jūs turite teisę apskųsti Agentūrai (A. Juozapavičiaus g. 9, Vilnius 09311) Viešojo administravimo įstatymo nustatyta tvarka per vieną mėnesį nuo jo įteikimo dienos arba Seimo kontrolieriui dėl valstybės tarnautojų piktnaudžiavimo, biurokratizmo ar kitaip pažeidžiamų žmogaus teisių ir laisvių viešojo administravimo srityje per vienerius metus nuo šio atsakymo įteikimo dienos (Gedimino g. 56, 01110 Vilnius) Seimo kontrolierių įstatymo nustatyta tvarka.

Direktorė Milda Račienė

Skirmantė Stankevičienė, tel. 8 620 85561, el. p. skirmante.stankeviciene@gamta.lt
Laima Prudnikovienė, tel. 8 665 55456, el. p. laima.prudnikoviene@gamta.lt

DETALŪS METADUOMENYS	
Dokumento sudarytojas (-ai)	Aplinkos apsaugos agentūra, A. Juozapavičiaus g. 9, LT-09311 Vilnius
Dokumento pavadinimas (antraštė)	Dėl poveikio aplinkai vertinimo programos tvirtinimo (iki 700 MW įrengtosios galios jūrinių vėjo elektrinių parko įrengimo ir eksploatacijos Lietuvos jūrinėje teritorijoje poveikio aplinkai vertinimo programa)
Dokumento registracijos data ir numeris	2022-04-29 Nr. (30.2)-A4E-4964
Dokumento specifikacijos identifikavimo žymuo	ADOC-V1.0, GEDOC
Parašo paskirtis	Pasirašymas
Parašą sukūrusio asmens vardas, pavardė ir pareigos	MILDA RAČIENĖ, Direktorė
Parašo sukūrimo data ir laikas	2022-04-28 17:20:11
Parašo formatas	Parašas, pažymėtas laiko žyma
Laiko žymoje nurodytas laikas	2022-04-28 17:21:28
Informacija apie sertifikavimo paslaugų teikėją	ADIC CA-A
Sertifikato galiojimo laikas	2021-09-21 - 2024-09-20
Parašo paskirtis	Registravimas
Parašą sukūrusio asmens vardas, pavardė ir pareigos	Danguolė Petravičienė, Vyriausioji specialistė
Parašo sukūrimo data ir laikas	2022-04-29 08:23:09
Parašo formatas	Trumpalaikis skaitmeninis parašas, kuriame taip pat saugoma sertifikato informacija
Laiko žymoje nurodytas laikas	
Informacija apie sertifikavimo paslaugų teikėją	RCSC IssuingCA
Sertifikato galiojimo laikas	2021-01-07 - 2023-01-07
Pagrindinio dokumento priedų skaičius	0
Pagrindinio dokumento pridedamų dokumentų skaičius	0
Programinės įrangos, kuria naudojantis sudarytas elektroninis dokumentas, pavadinimas	Elektroninė dokumentų valdymo sistema VDVIS, versija v. 3.04.02
El. dokumento įvykius aprašantys metaduomenys	
Informacija apie elektroninio dokumento ir elektroninio (-ių) parašo (-ų) tikrinimą (tikrinimo data)	El. dokumentas atitinka specifikacijos keliamus reikalavimus. Visi dokumente esantys elektroniniai parašai galioja. Tikrinimo data: 2022-04-29 08:24:15
Elektroninio dokumento nuorašo atspausdinimo data ir ją atspausdinęs darbuotojas	2022-04-29 atspausdino Danguolė Petravičienė
Paieškos nuoroda	

Annex 2

Documents supporting the qualification of the developers of the Environmental Impact Assessment (in Lithuanian)

KODAS: 7108

KLAIPĖDOS UNIVERSITETAS

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LIETUVOS RESPUBLIKA KLAIPĖDOS UNIVERSITETAS

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Ректор /подпись/

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УП "МПФ" Гознака. Зак. 1365-01

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oraz po złożeniu wymaganych egzaminów uzyskał stopień naukowy

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LIETUVOS RESPUBLIKA

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LIETUVOS RESPUBLIKA * KLAIPĖDOS UNIVERSITETAS *

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PRIE SVEIKATOS APSAUGOS MINISTERIJOS

VISUOMENĖS SVEIKATOS PRIEŽIŪROS VEIKLOS

LICENCIJA

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Baltijos pr. 107-18, Klaipėdos m., Klaipėdos m. sav.

verstis šios rūšies licencijuojama visuomenės sveikatos priežiūros veikla:

poveikio visuomenės sveikatai vertinimu

Direktorius A.V. Juozas Galdikas

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Raseiniuose,

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2015 UAB „LODVILA" 01572

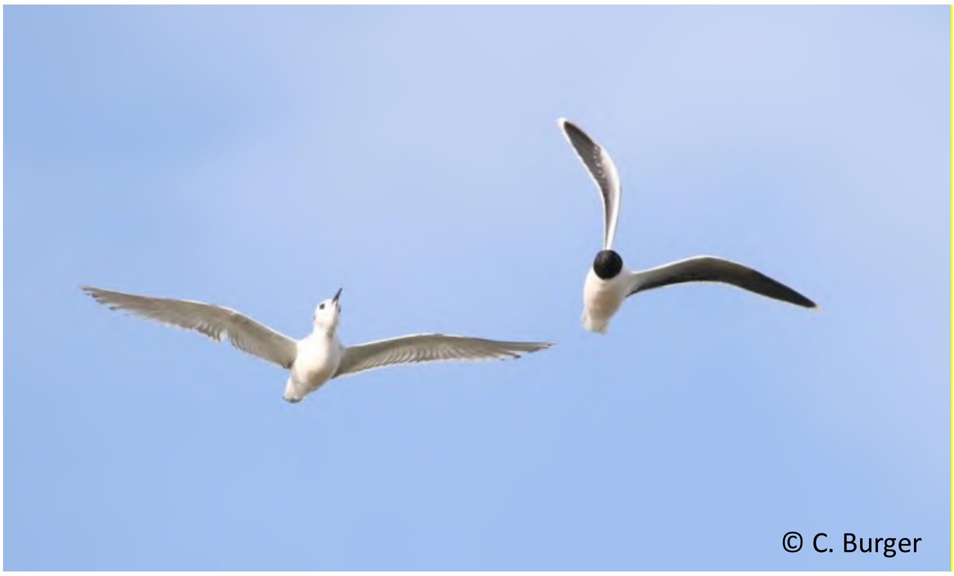
Annex 3

BioConsult SH. 2022. Bird Survey Report

Survey Report Lithuania

Resting Birds

Report September 2021 - September 2022


© C. Burger

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V2.0

Husum, November 2022

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CONTENTS

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1 INTRODUCTION

On behalf of PI Coastal Research and Planning Institute (CORPI), BioConsult SH conducted digital aerial surveys and vessel-based surveys between September 2021 and September 2022 on resting/local birds, using data collection and analysis methods comparable to Germany. The goal was to determine the abundance and spatial distribution of resting seabirds in an area within the exclusive economic zone (EEZ) of Lithuania, where the development of a wind farm (OWF) is planned. In this report, the results of the first year of surveys, including 6 digital aerial surveys and 7 ship-based surveys are presented.

1.1 Description of the project area

The planned wind farm area is located around 29 km west of the coast of Lithuania (Figure 1.1). It is bordering the Special Protection Area (SPA) "Klaipėdos–Ventspilio plynaukštė", which extends to the east of the planned OWF area. Relevant bird species in this SPA are Red-throated Diver, Long-tailed Duck, Velvet Scoter, Common Guillemot and Razorbill.

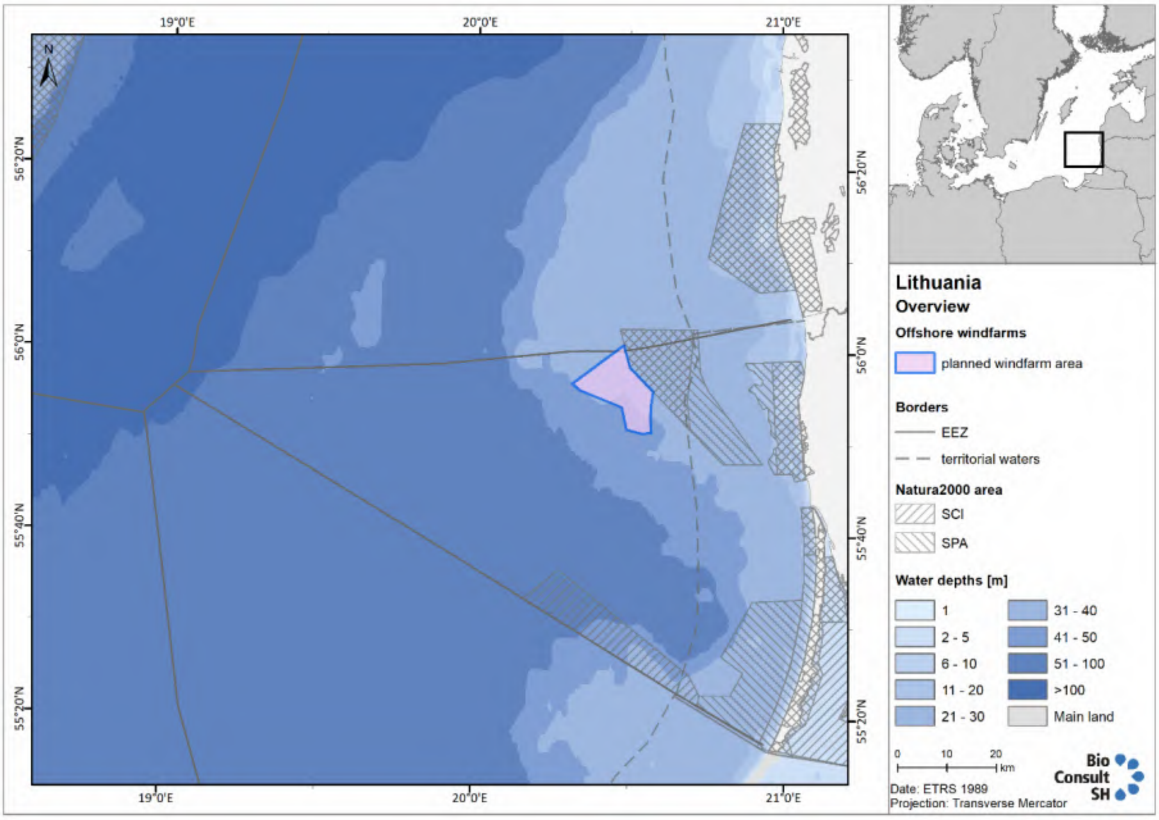

Figure 1.1 Overview of the study area in Lithuania.

2 METHODS

2.1 234Aerial surveys using digital videos

2.1.1 Description of the survey transects

This report uses seabird abundances and distributions obtained from a total of 6 airplane-based digital surveys conducted between November 2021 and April 2022. The survey area is referred to as the study site and corresponds to the area covered by the transects.

The transect design includes 13 transects with transect lengths of 39 km and 4 shorter transects in between, to cover the planned wind farm area, with a transect lengths of 19.07 km. In total, a transect length of 583.28 km is reached. The long transects run parallel to each other and are separated by 4 km, the shorter transects are located in between at a distance of 2 km. The area covered by the transect design is 2,340 km² (Table 2.1, Table 2.2, Figure 2.1).

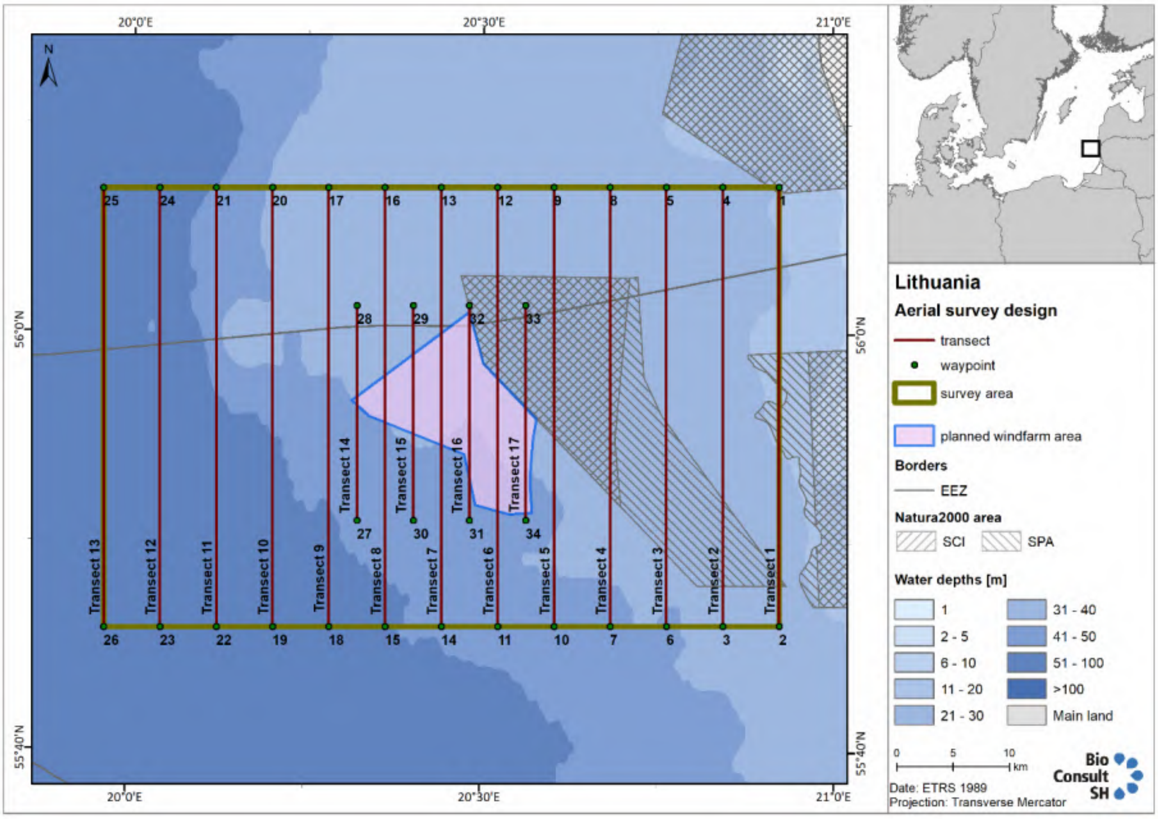

Figure 2.1 Aerial survey transect design for the survey area, including the planned wind farm area (outlined in light pink).

Table 2.1 Geographical coordinates and length of aerial survey transects in the study area

Transect	Waypoint	Latitude	Longitude
1	1	56° 7.099' N	20° 55.360' E
1	2	55° 46.074' N	20° 55.401' E
2	3	55° 46.069' N	20° 50.620' E
2	4	56° 7.094' N	20° 50.535' E
3	5	56° 7.086' N	20° 45.710' E
3	6	55° 46.061' N	20° 45.838' E
4	7	55° 46.051' N	20° 41.057' E
4	8	56° 7.075' N	20° 40.885' E
5	9	56° 7.061' N	20° 36.060' E
5	10	55° 46.037' N	20° 36.275' E
6	11	55° 46.020' N	20° 31.494' E
6	12	56° 7.044' N	20° 31.236' E
7	13	56° 7.024' N	20° 26.411' E
7	14	55° 46.000' N	20° 26.713' E
8	15	55° 45.977' N	20° 21.932' E
8	16	56° 7.001' N	20° 21.587' E
9	17	56° 6.974' N	20° 16.762' E
9	18	55° 45.951' N	20° 17.151' E
10	19	55° 45.921' N	20° 12.370' E
10	20	56° 6.944' N	20° 11.938' E
11	21	56° 6.911' N	20° 7.114' E
11	22	55° 45.889' N	20° 7.589' E
12	23	55° 45.853' N	20° 2.809' E
12	24	56° 6.875' N	20° 2.290' E
13	25	56° 6.836' N	19° 57.464' E
13	26	55° 45.815' N	19° 58.026' E
14	27	55° 51.056' N	20° 19.453' E
14	28	56° 1.336' N	20° 19.274' E
15	29	56° 1.361' N	20° 24.086' E
15	30	55° 51.080' N	20° 24.245' E

Transect	Waypoint	Latitude	Longitude
16	31	55° 51.102' N	20° 29.036' E
16	32	56° 1.382' N	20° 28.899' E
17	33	56° 1.401' N	20° 33.712' E
17	34	55° 51.121' N	20° 33.828' E

Table 2.2 Overview of the digital aerial surveys carried out in the study area between November 2021 and February 2022.

Date of the aerial survey	Distance (km)	Effort (km²)	Coverage (%)
09.11.2021	572.05	310.81	13.3
17.12.2021	564.33	306.57	13.1
12.02.2022	573.1	304.31	13.0
27.02.2022	571.65	297.51	12.7
11.03.2022	571.06	310.22	13.3
12.04.2022	571.31	310.4	13.3
Sum	Total: 3,423.5	Total: 1,839.8	Average: 13.1

2.1.2 Data collection

The recording of resting birds was performed using the digital video technology developed by the company HiDef (http://hidef.bioconsult-sh.de), explained in detail in Weiß et al. (2016), and summarized in the following paragraphs.

A twin-engined, high-wing propeller-driven aircraft (Partenavia P 68) was used for the acquisition of digital videos. This aircraft is equipped with four high-resolution video camera systems which take approximately seven images per second and can achieve a resolution of two cm at sea surface. Since the camera system is not directed vertically downwards (depending on the sun position, it can be slightly inclined or even set against the flight direction), interferences arising from solar reflections (glare) can be effectively reduced. The external cameras (indicated by A and D, Figure 2.2) cover a strip of 143 m width while the internal ones cover a width of 129 m each, resulting in 544 m effectively covered. There is however about 20 m distance between each strip to avoid double counting of individuals detected by the cameras. Thus, the total recorded strip of 544 m is distributed over a width of 604 m (see Figure 2.2).

The aircraft flew at a mean speed of approx. 220 km/h (120 knots) at an altitude of 549 m. A GPS device (Garmin GPSMap 296) records the position every second which permits to geographically assign a location to the images and the birds registered on them. The collected data were stored on mobile hard disks for subsequent review and analysis.

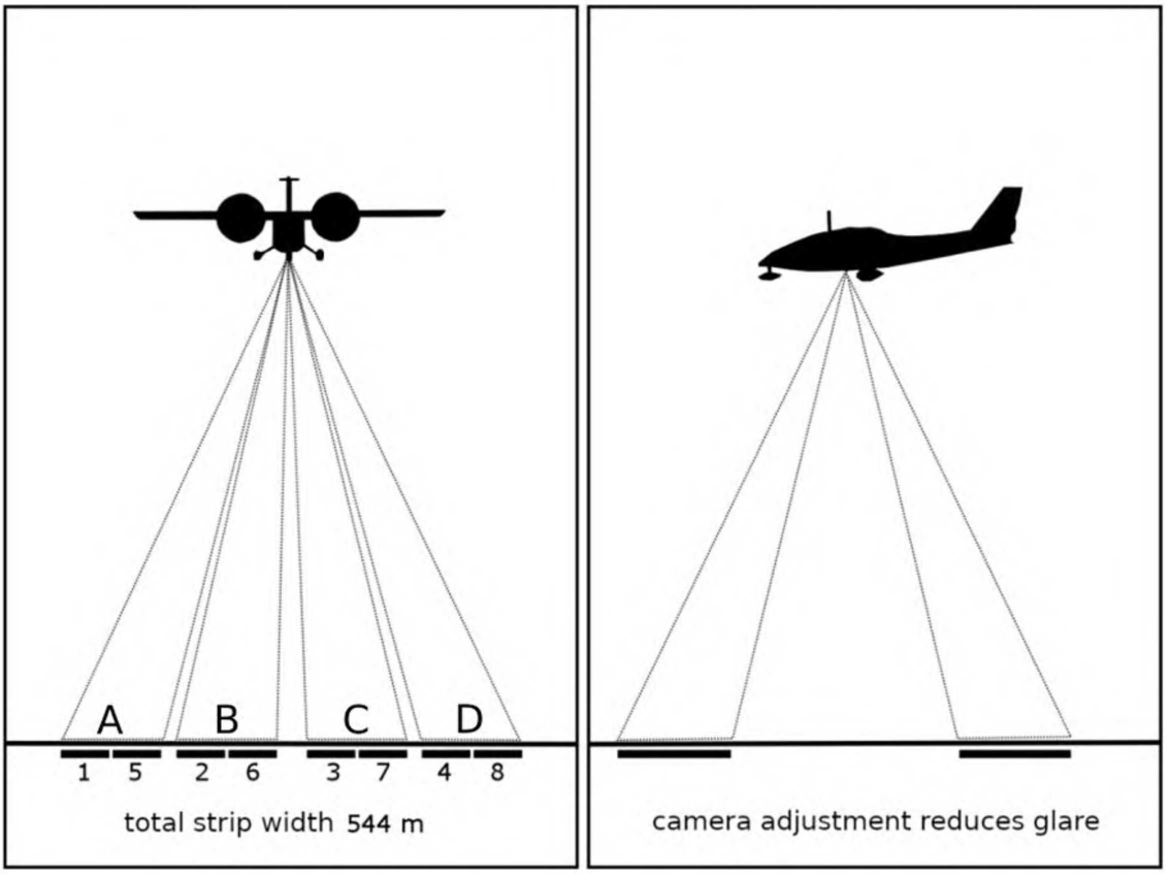

Figure 2.2 The HiDef Camera-System. The four cameras (A to D) cover an effective strip width of 544 m of the sea surface at a flight altitude of 549 m (left: frontal view; right: side view). The numbering indicates the camera images as they are used in the evaluation (the images from each camera are divided into two halves).

2.1.3 Data processing

To facilitate the detection of objects, the video sequences taken from each camera were split into two halves so that each half of the picture fitted the width of a large monitor. The video files were then processed, using an image capture and management software (StreamPix) for analysis. First, the images were examined and all the detected objects (birds, mammals, ships, etc.) were marked and pre-sorted for subsequent identification. To guarantee a consistently high quality, 20% of each film was randomly selected and processed again by another reviewer. If both reviewers agreed over 90% of the cases in that film, any discrepancy was rechecked, and the film approved for the next analysis step. If not, the film was reanalysed from scratch. Sections of the footage that could not be assessed due to backlight or the presence of clouds were not considered for further analysis.

The next step involved the identification of the previously marked objects (birds). This was done by experienced observers. Often birds can be identified on the images to species level. Because of the strong similarities between some species (e.g., common guillemot and razorbill, common and Arctic tern, and red-throated and black-throated diver), it is not always possible to identify the individuals to species level. However, it is usually possible to identify individuals as belonging to a species group formed by two (or few) closely related species. In addition to the identification, other information such as position, age, behaviour (swimming or flying) and flight direction were determined whenever possible. Environmental parameters (air turbidity, sea state, solar reflection, and water turbidity) were recorded every 500 images (approx. 4 km). In a second step for quality control, 20% of the objects identified were re-assessed by a second reviewer. All discrepancies between the first and second identification process were checked again by a third expert. If there was agreement by at least 90%, the data collected was released for further analysis. If agreement was lower than 90%, systematic errors (e.g., problems in determining specific species groups) were corrected and all objects viewed in the film concerned were re-identified.

2.1.4 Data analysis

All detected resting birds were either assigned a species or species group category (see below). Among these, relevant species/species groups were defined based on the frequency of occurrence in the survey area and the importance of the area as habitat for species according to reference literature. A list of all recorded species and their abundances is provided in the appendix A.1.

The individuals not identified to species level in the aerial surveys were initially grouped into a larger taxonomic group of very similar species. Examples of these are common guillemot/razorbill and unidentified divers (red-throated and black-throated diver). These “two species” species groups include a large proportion of the resting birds not identified to species level. Other resting birds, that could not be assigned to any of the previously mentioned or other two-species group, are in most cases identified to family level.

2.1.5 Calculation of densities

Densities (ind./km²) were calculated for all relevant resting bird species and species groups. To calculate densities the number of detected individuals of each species/taxon in each survey is divided by the area covered by the transects (“effort”). As the effect of the aircraft on any flight behaviour of the birds is negligible, no correction factors are applied to the abundances of species from aerial surveys. Therefore, it is assumed that all individuals are captured by the images.

The spatial distribution was determined for all surveys together or seasonally according to the species-specific classification by Garthe et al. (2007) and displayed using grid density maps. In short, a grid was laid over the survey area with its grid cells aligned with the EEA grid (EEA 2019). The individual cells consist of rectangles with edge lengths of 4 km. In total, a grid of 101 cells was created for the SHP01 survey area. Also, pinpoint-maps for individual surveys were produced and can be found in the Appendix.

2.2 Ship-based surveys

This report uses seabird abundances and distributions obtained from a total of 7 ship-based surveys conducted between September 2021 and September 2022.

The transect design includes 6 transects with transect lengths of 25.9 km. In total, a transect length of 155 km is reached. The transects run parallel to each other and are separated by 4 km. The area covered by the transect design is 533 km² (*Figure 2.3*).

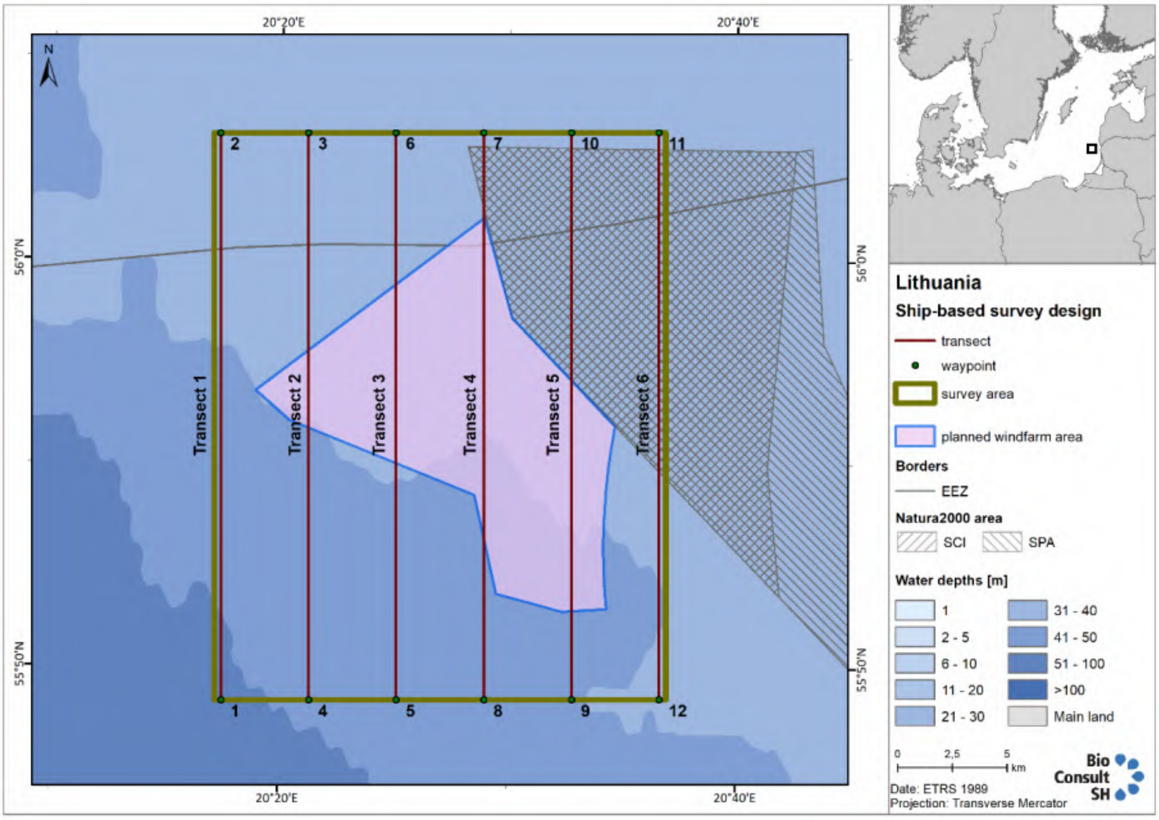

Figure 2.3 Transect design for ship-based resting bird monitoring from November 2021 to February 2022. The total study area covers 533 km².

Table 2.3 *Geographical coordinates and length of ship transects in the study area*

Transect	Waypoint	Latitude	Longitude
1	1	55° 49.16' N	20° 17.53' E
1	2	56° 03.10' N	20° 17.27' E
2	3	56° 03.12' N	20° 21.12' E
2	4	55° 49.18' N	20° 21.36' E
3	5	55° 49.20' N	20° 25.19' E
3	6	56° 03.14' N	20° 24.98' E
4	7	56° 03.16' N	20° 28.83' E
4	8	55° 49.22' N	20° 29.02' E
5	9	55° 49.23' N	20° 32.85' E
5	10	56° 03.17' N	20° 32.68' E
6	11	56° 03.19' N	20° 36.54' E
6	12	55° 49.25' N	20° 36.68' E

Unfavourable sea state conditions or poor visibility meant that on occasion individual sections of the survey area could not be recorded or were excluded from the evaluation. The transect distance recorded and the degree of coverage of the survey area per sailing are shown in Table 2.4.

Table 2.4 Overview of the seven ship-based surveys carried out in the study area between September 2021 and September 2022.

Survey	Distance [km] covered	Effort [km²]	Ship	% Coverage
28.09.2021	107.7	64.62	Baltic Explorer	12.1
09.10.2021	141.0	84.6	Baltic Explorer	15.9
05.05.2022	132.3	79.38	Baltic Explorer	14.9
23.06.2022	163.5	98.1	Lilian	18.4
21.07.2022	160.2	96.12	Lilian	18.0
28.08.2022	164.4	98.64	Lilian	18.5
18.09.2022	165.0	99.0	Lilian	18.6

2.2.1 Detection methodology

The surveys were performed closely on the basis of the methodology used in the European Seabird-at-Sea programme (GARTHE & HÜPPOP 1996, 2000) and the BSH guidelines of StUK4 (BSH 2013). The censuses were performed on board the ships *Baltic Explorer* (Utility Vessel, length 45.6 m)) and *Lilian (Ex Coast Guard Ship, length 27 m)*.

Ships were sailing at a speed of between 7.5 and 10 knots. Two observers on each of the port and starboard sides recorded all swimming and flying birds in a 300 m wide transect parallel to the keel line of the ship. The boundary of the transect area to the stern of the ship was formed by a line perpendicular to the keel from the viewpoint of the observers.

In addition to the species affiliation, further information such as age, sex, moulting condition, behaviour, association with other species or ships, flight altitude and flight direction of the birds observed were determined where possible. In addition, the distance to the keel line was estimated for all swimming individuals or assigned to a distance category from A to E (Table 2.5); flying birds are always assigned the code F.

Table 2.5 Distance classes for swimming birds.

Distance range (m)	Band (ESAS-Code)
0 – 50	A
51 – 100	B
101 – 200	C
201 – 300	D
> 300	E

For flying birds, the so-called snapshot method was used. Here, birds are considered to be "in the transect" only if they are flying over the section to either side of the ship at the moment of the snapshot. The section of the transect that is deemed valid for snapshot acquisition is determined by the width of the transect (300 m perpendicular to the direction of travel) and the distance between the front and the rear ends of the route that is travelled within a defined time unit. At ten knots, this is approx. 300 m in one minute. At ship speeds between eight and twelve knots, snapshots are performed every full minute in accordance with StUK4. The distance to the front of the snapshot site is then approx. 250 m at eight knots and about 370 m at twelve knots. Thus, a transect area of 300 m (to the side) x 300 m (to the front) is usually recorded on both sides of the ship. All flying birds outside this site and those that are not flying within the 300 m for the full minute are treated as outside the transect. This method of data collection for flying birds prevents frequent and particularly fast flying birds from being overestimated in terms of quantity or being counted multiple times (GARTHE & HÜPPOP 1996).

Some species/species groups are characterized by the fact that they sometimes take flight while still far ahead of the ship (up to over 1 km) and are therefore often missed by the naked eye. For example, divers, common scoters, and grebes have high flight distances (BELLEBAUM et al. 2006; SCHWEMMER et al. 2011). In order to collect data on these species nevertheless, an area within the range 500 to 2500 m (in the direction of travel) was scanned with binoculars by one person of the observation team from the bow of the ship (the "bow observer"). As the distance from the observer increases, the error in distance estimation also increases, and therefore it is often not possible to make the precise distance estimations perpendicular to the keel line (see above) that are required. The birds that take flight while far ahead of the ship were classified as either "inside" or "outside" the transect area, because the actual densities of individuals might otherwise be significantly underestimated. However, even with continuous observation with binoculars, many divers and scoters would only be spotted in flight ahead of the ship. In such cases it is not certain whether the birds took flight as a result of disturbance by the ship or if they were in fact flying across the survey area.

In addition to the data collection of the birds within the transect, all birds that were spatially and/or temporally outside the transect were also recorded. In this way, less common species that might otherwise not be recorded can also be taken into account. However, the results of these censuses are not included in the calculations of monthly and seasonal densities, but they are included in the list of species in the annex A.1.

2.2.2 Assessment methodology

The number of swimming individuals recorded in the ship-based transect surveys was corrected for data collection errors (see Table 2.6). The most frequent resting bird species and species groups densities (ind./km²) were calculated. For this purpose, the number of all birds counted within the transect per species/species group (taking into account the correction factors for swimming/diving birds, see below) was divided by the respective area total for the respective survey.

To show the spatial distribution of resting birds, the survey area was covered with grid of cells with a 4 x 4 km side length. The annex additionally contains pinpoint maps of sightings (A.2, A.3).

2.2.3 Correction factors

Because swimming birds are more easily overlooked by the observer with increasing distance, the individual numbers recorded are adjusted with a correction factor (GARTHE et al. 2007, 2009). Only the numbers of swimming and diving individuals are corrected (GARTHE et al. 2007) and not those of flying birds. The factors used for correcting the population densities are shown in Table 2.6.

Table 2.6 Correction factors for swimming/diving birds according to values from the literature (GARTHE et al. 2007, 2009) as well as the correction factors used for the calculation of the densities. For Long-tailed Duck, no correction factor was applied.

Correction factors	Correction factors used for the calculations
Divers	**1.7**
Little Gull	**1.7**
Common Gull	**1.7**
Lesser black-backed Gull	**1.6**
Herring Gull	**1.7**
Common Guillemot	**2.1**
Razorbill	**2.0**

3 RESULTS

3.1 Species composition and abundance

As already described in the methods, the two survey methods covered different periods respectively and are not comparable, but complementary. The number of resting birds recorded by each type of survey is summarised in Table 3.1. Few species dominate the communities in each case.

Table 3.1 Bird counts and percentages of all resting bird species during the digital aerial surveys and the ship-based transect surveys in the survey area between September 2021 and September 2022. Number of individuals for the ship-based surveys include only those counted within the transect area. In the results section, species that represent at least 0.5% of abundance in any of the survey methods are further described.

Species		Aerial Surveys		Ship-based surveys	
		N° ind.	%	N° Ind. (WT)	%
Red-throated Diver	*Gavia stellata*	576	4.1	12	0.3
Black-throated Diver	*Gavia arctica*	33	0.2	27	0.6
Unidentified diver	*Gavia sp.*	58	0.4	15	0.4
Great Crested Grebe	*Podiceps cristatus*	5	0	-	
Slavonian Grebe	*Podiceps auritus*	1	0	-	
Red-necked/Great Crested Grebe	*Podiceps grisegena/Podiceps cristatus*	4	0	-	
Slavonian / Black-necked Grebe	*Podiceps auritus/Podiceps cristatus*	1	0	-	
Great Cormorant	*Phalacrocorax carbo*	12	0.1	5	0.1
King Eider	*Somateria spectabilis*	1	0		
Long-tailed Duck	*Clangula hyemalis*	2,859	20.4	28	0.7
Common Scoter	*Melanitta nigra*	26	0.2	3	0.1
Velvet Scoter	*Melanitta fusca*	7,763	55.3	-	
Common/Velvet Scoter	*Melanitta nigra/M. fusca*	103	0.7	-	
Little Gull	*Hydrocoloeus minutus*	625	4.4	3,307	77.3
Black-headed Gull	*Chroicocephalus ridibundus*	11	0.1	4	0.1
Unidentified small gull		13	0.1	-	
Common Gull	*Larus canus*	108	0.8	221	5.2
Lesser Black-backed Gull	*Larus fuscus*	4	0	36	0.8
Herring Gull	*Larus argentatus*	288	2.0	350	8.2
Common/Herring Gull	*Larus canus/L. argentatus*	2	0	-	

Species		Aerial Surveys		Ship-based surveys	
		N° ind.	**%**	**N° Ind. (WT)**	**%**
Great Black-backed Gull	*Larus marinus*	5	0	1	0
Unidentified large gull	*Larus (magnus) sp.*	7	0.05	-	
Black-legged Kittiwake	*Rissa tridactyla*	3	0	-	
Unidentified gull	*Larus sp.*	10	0.1	-	
Sandwich Tern	*Thalasseus sandvicensis*	1	0	-	
Common Tern	*Sterna hirundo*	-		0	0
Arctic Tern	*Sterna paradisae*	-		9	0.2
Unidentified tern	*Sterna sp.*	-		1	0
Unidentified tern/gull		2	0	-	
Common Guillemot	*Uria aalge*	762	5.4	191	4.5
Razorbill	*Alca torda*	521	3.7	65	1.5
Common Guillemot/ Razorbill	*Uria aalge/Alca torda*	228	1.6	-	
Black Guillemot	*Cepphus grylle*	2	0	-	
Unidentified auk	*Alcidae*	5	0	1	0
Total		**14,039**	**100**	**4,276**	**100**

The following table shows the density of the most common species and groups in each of the months surveyed by the two methods.

Table 3.2 Monthly mean densities (ind./km²) of selected species/species groups recorded in the survey area during digital aerial surveys from November 2021 to April 2022 The densities from February represent the combined densities of both surveys from that month. The indication "0" means that no individual of this species was found in that month.

Survey Method	**Digital aerial surveys**					
Species/Species-group	**Nov 21**	**Dec 21**	**Feb 22**	**Mar 22**	**Apr 22**	**Max**
Red-throated Diver	0.02	0.05	0.42	**0.57**	0.41	**0.57**
Black-throated Diver	0	0	0.02	0.01	**0.06**	**0.06**
Long-tailed Duck	0.35	1.27	**2.76**	1.83	0.43	**2.76**
Common Scoter	0	0.01	0	0.01	**0.07**	**0.07**
Velvet Scoter	0.91	**9.21**	7.25	0.89	0.05	**9.21**
Little Gull	**0.86**	0.61	0.16	0.07	0.17	**0.86**
Black-headed Gull	0	<0.01	0	0	**0.03**	**0.03**
Common Gull	**0.11**	0.09	0.03	0.05	0.05	**0.11**
Lesser Black-backed Gull	0	0	0	0	**0.01**	**0.01**
Great Black-backed Gull	0	0.01	0	0	**0.01**	**0.01**
Herring Gull	**0.22**	0.19	0.11	0.19	0.13	**0.22**
Common-/ Arctic Tern	0	0	0	0	0	**0**
Common Guillemot	0.47	0.60	0.2	0.27	**0.73**	**0.73**
Razorbill	0.47	0.18	0.21	**0.54**	0.07	**0.54**
Divers	0.04	0.06	0.46	**0.64**	0.53	**0.64**
Ducks	**0.10**	0	0.01	0	0.02	**0.10**
Gulls	**0.34**	0.29	0.14	0.24	0.20	**0.34**
Auks	**1.05**	0.84	0.57	0.95	0.97	**1.05**
No. of surveys	**1**	**1**	**2**	**1**	**1**	

Table 3.3 Monthly mean densities (ind./km²) of selected species/species groups recorded in the survey area during the ship-based transect surveys between Sep 2021 and Sep 2022 (there were no ship-based transect surveys between Nov 2021 and April 2022). The indication "0" means that no individual of this species was found in that month.

Survey Method	**Ship-based transect surveys**							
Species/Species-group	**Sep 21**	**Oct 21**	**May 22**	**Jun 22**	**Jul 22**	**Aug 22**	**Sep 22**	**Max.**
Red-throated Diver	0.03	0.03	**0.15**	0	0	0	0.01	**0.15**
Black-throated Diver	0.05	0.09	**0.23**	0	0	0	0.08	**0.23**
Long-tailed Duck	0.02	0	**0.34**	0	0	0	0	**0.34**
Common Scoter	0	0	**0.04**	0	0	0	0	**0.04**
Velvet Scoter	0	0	0	0	0	0	0	**0**
Little Gull	0.11	1.11	0.07	0.09	**36.1**	16.4	1.51	**36.1**
Black-headed Gull	0	0	0	0	**0.06**	0	0	**0.06**
Common Gull	0.05	0.42	0.02	0.01	**2.11**	0.90	0.10	**2.11**
Lesser Black-backed Gull	0	0	0.26	0	0	0.01	**0.29**	**0.29**
Great Black-backed Gull	0	0	0	0	0	**0.02**	0	**0.02**
Herring Gull	0.42	0.43	0.13	0.05	1.60	**1.85**	1.05	**1.85**
Common-/ Arctic Tern	0	0.02	0	0	0	0.04	**0.07**	**0.07**
Common Guillemot	0.03	0.95	0.33	0	0.09	1.13	**1.67**	**1.67**
Razorbill	0.12	**1.28**	0.13	0	0	0	0	**1.28**
Divers	0.08	0.12	**0.57**	0	0	0	0.09	**0.57**
Ducks	0.02	0	**0.38**	0	0	0	0	**0.38**
Gulls	0.47	0.85	0.41	0.06	**3.71**	2.78	1.44	**3.71**
Auks	0.16	**2.23**	0.46	0	0.09	1.13	1.67	**2.23**
No. of surveys	**1**	**1**	**1**	**1**	**1**	**1**	**1**	

3.1.1 Digital aerial surveys

A total of six surveys were conducted between November 2021 and April 2022 (see Table 2.2). During this period, 15,711 birds belonging to 29 species were recorded, of which 14,039 were resting birds (Table 3.1). There were 433 resting birds which could not be identified to species level (only 3.1% of the total). Nonetheless, resting birds could be classified into 20 species.

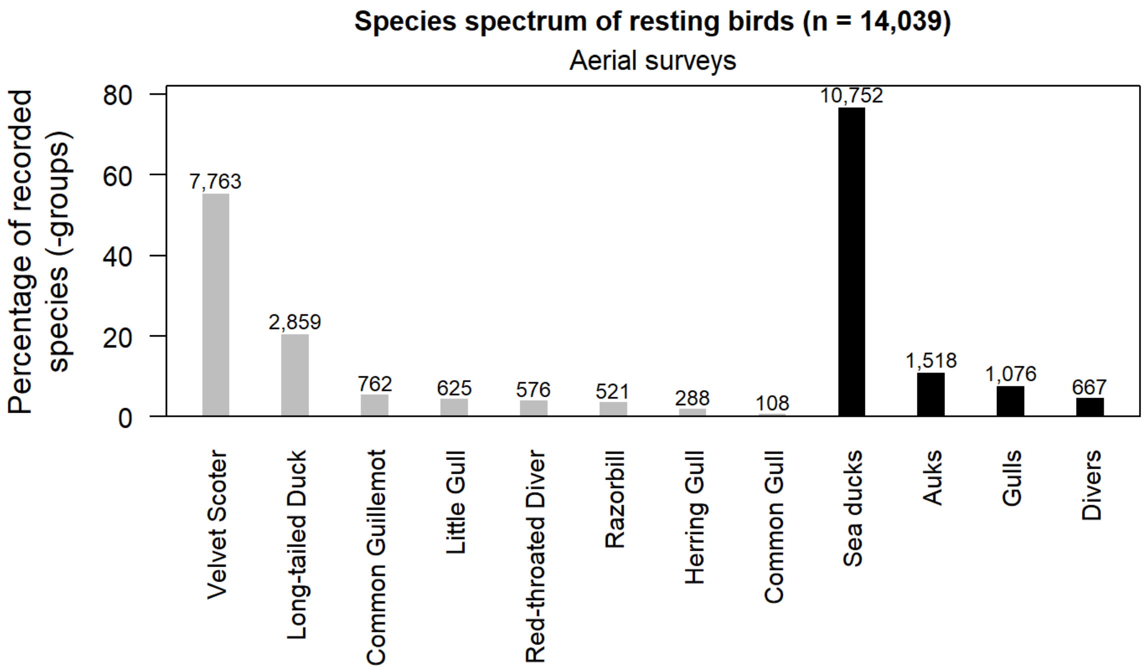

Figure 3.1 *Percentage of the most common species or species groups representing at least 0.5% of the total number of resting birds recorded during aerial surveys in the survey area between November 2021 and April 2022 (number of individuals shown above each bar). Species are depicted in grey, species groups in black.*

Sea ducks dominated the resting bird community making up 76.6% of the total. Auks and gulls followed representing 10.1% and 7.7% respectively. Divers (mainly Red-throated Divers) contributed 4.7% to the sum of birds observed in the survey period (Figure 3.1). In terms of species, two species made up over 75% of the total. Velvet Scoters were the most recorded species with 55.3% of the total number of birds while Long-tailed Ducks contributed 20.4% (Figure 3.1). All other species, including Little Gulls, Common Guillemots and Razorbills contributed each less than 6% of the total (see Table 3.1).

3.1.2 Ship-based surveys

In the seven ship-based transect surveys conducted between September 2021 and September 2022 (November to April not covered) a total of 5,206 birds were observed belonging to 26 species. In total, 5,162 resting birds were observed, 4,276 of which occurred within the transect area and are used for further analysis here (Table 3.1). These birds correspond to 14 species (within the transect area) and only 17 of these resting birds could not be assigned to any species or species group and remained as unidentified (0.4%).

As with the aerial surveys, there was a strong dominance of one species, in this case the Little Gull, which contributed with 86.7% to the total number of birds. Other gulls, such as the Herring Gull and the Common Gull, made up less than 9% respectively and Common Guillemots and Razorbills made up less than 5% each (Figure 3.2). In contrast to the aerial surveys, sea ducks were not abundant here. Other species represented less than 1% (Lesser Black-backed Gull, Long-tailed Duck and Black-throated Diver). Overall, gulls made up 91.6% of the total number of birds observed, whereas auks, divers and sea ducks represented only 6.0%, 1.3% and 0.7% of the whole, respectively.

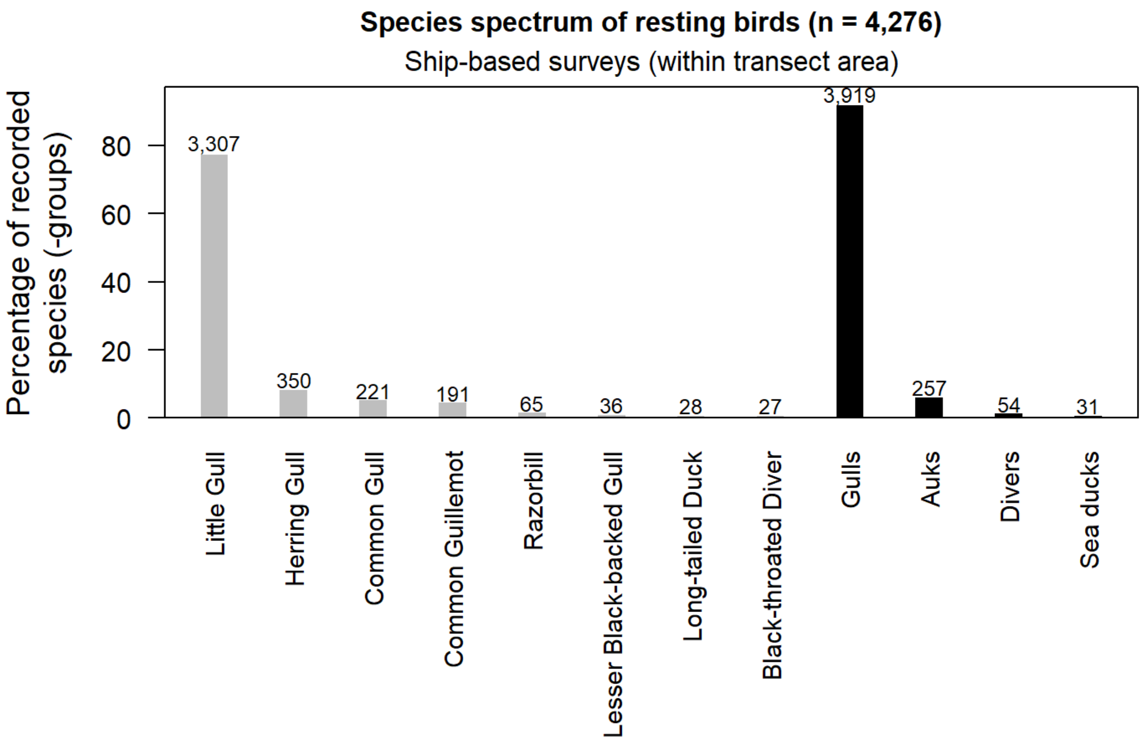

Figure 3.2 Percentage of the most common species or species groups representing at least 0.5% of the total number of resting birds recorded during ship-based transect surveys in the survey area within the transect area between September 2021 and September 2022 (period between November 2021 and April 2022, not surveyed, number of individuals shown above each bar). Species are depicted in grey, species groups in black.

3.2 Frequency and distribution of most common species

In this chapter, all waterbird species that represented at least 0.5% of the total number of birds surveyed by the two different methods are further described. Each species description is followed by a distribution map of four seasons covered during the surveys for each survey method and a graph showing how their densities vary across the months. In addition, a full list of maps of all surveys can be found in the appendix for these species. The species' ranges and population sizes are obtained from the most recent available data (AEWA CSR 8) of species factsheets from Wetlands International (http://wpe.wetlands.org, accessed on 05.10.2022). Their conservation status is based on Birdlife International (2017), IUCN Red List Europe (http://www.iucnredlist.org, accessed 10.10.2022) and Annex I of the EU Bird Directive (EUROPEAN UNION 2010).

All pinpoint maps can be found in the Appendix A.2 and A.3.

3.2.1 Red-throated Diver

Red-throated Diver – *Gavia stellata*	**LI: Rudakaklis naras**
Biogeographic population: NW Europe (win)	
Breeding range: Arctic and boreal W Eurasia, Greenland	
Non-breeding range: NW Europe	
Population size: 210,000 – 340,000	
1% value: 3,000	
Conservation status:	EU Birds Directive, Annex I: listed EU SPEC Category: SPEC 3 IUCN Red List Category, Global & Europe: Least Concern
Trend: DEC?	Trend quality: Reasonable
Key food: fish	

As the name indicates divers are strongly linked to aquatic environments where they dive to obtain their food, which mainly consists of fish. Of the five species of divers existing in the world, two of them commonly occur in the North and Baltic Sea (HEMMER 2020). All divers are migratory, breeding near northern freshwater lakes and spending the winter season at sea. In this section, we concentrate on the most common diver observed during the surveys, the Red-throated Diver. These divers are distributed across the Arctic, occupying boreal areas in Europa, Asia and North America. The population that occurs in the survey area is the Northwest European population. According to the most recent estimates by Wetlands International, the population size of this population ranges between 210,000 and 340,000 and may be declining.

Two important wintering areas are the Irbe Strait and the Gulf of Riga. Skov and colleagues (2011) mention that largest concentrations of both species of divers are found in the area extending from the Irbe Strait along the coasts of Lithuania, Latvia and Estonia up into the Pomeranian Bay. The Pomeranian Bay is also considered an important wintering area in the Baltic Sea, probably because of its suitability as a spawning, nursery and feeding ground for many fish species. Zanders (*Sander lucioperca*) and herrings (Clupeidae spp.) constitute most of the consumed biomass of Red-throated Divers in winter and spring in the Baltic Sea (GUSE et al. 2009).

At the global scale, Red-throated Divers are not considered endangered, however, divers in general are considered among the most vulnerable seabird species to many anthropogenic factors, and the species is included in the Annex I of European Union (EU) Birds Directive (Council Directive 2009/147/EC on the conservation of wild birds, EUROPEAN UNION 2010) and in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (UNEP/AEWA SECRETARIAT 2019).

Among the main threats that affect divers are oil spills, bycatch in fish nets and habitat degradation (MENDEL et al. 2008a). Moreover, both ship traffic and offshore wind farms exert negative effects on divers and the birds show strong avoidance behaviour towards offshore wind farms (DIERSCHKE et al. 2016; HEINÄNEN et al. 2020).

Density and distribution of Red-throated Divers in the survey area

During the six digital aerial surveys between November 2021 and April 2022, a total of 576 Red-throated Divers were recorded whereas during the seven ship-based transect surveys between September 2021 and September 2022 (excluding the months between Nov 2021 until April 22) only 12 individuals were observed within the transect area (Table 3.1). During aerial surveys, also 58 unidentified divers were observed (8.7% of all divers), and during ship surveys 15 unidentified divers (27.8% of all divers). This rather high percentage during ship surveys is not considered here for species-specific density estimations and thus, densities will be somewhat underestimated.

For Red-throated Divers, a maximum monthly density of 0.57 ind./km² was recorded in March 2022 during the aerial surveys. The maximum density of Red-throated Divers during the ship-based transect surveys was observed in May 2022 at 0.15 ind./km² (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.3).

Spatially, the distribution of Red-throated Divers from the digital aerial surveys shows that they were present in most of the surveyed area at very low densities (< 0.5 ind./km²) during winter. In spring, however higher densities were observed, but mainly towards the east of the study area. Nonetheless, grid cells with densities ranging between 2 and 5 ind./km² were observed at the border of the planned OWF in spring.

The ship-based surveys showed the highest densities during spring, especially towards the southwest of the survey area but outside the planned wind farm. In fact, the highest density (between 2 and 5 ind./km²) was observed only within a single grid cell in spring 2022. Red-throated Divers were only present at low densities in autumn 2021 and autumn 2022, but their densities were low and limited to a few grid cells outside the planned OWF.

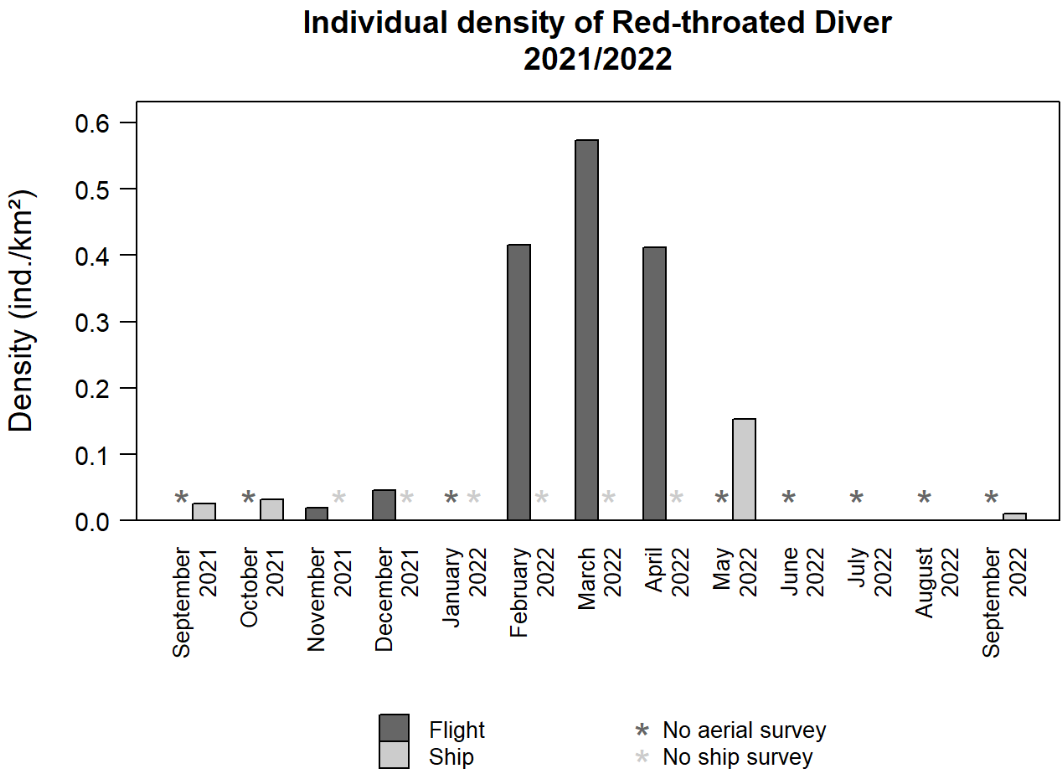

Figure 3.3 Monthly densities of Red-throated Divers during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

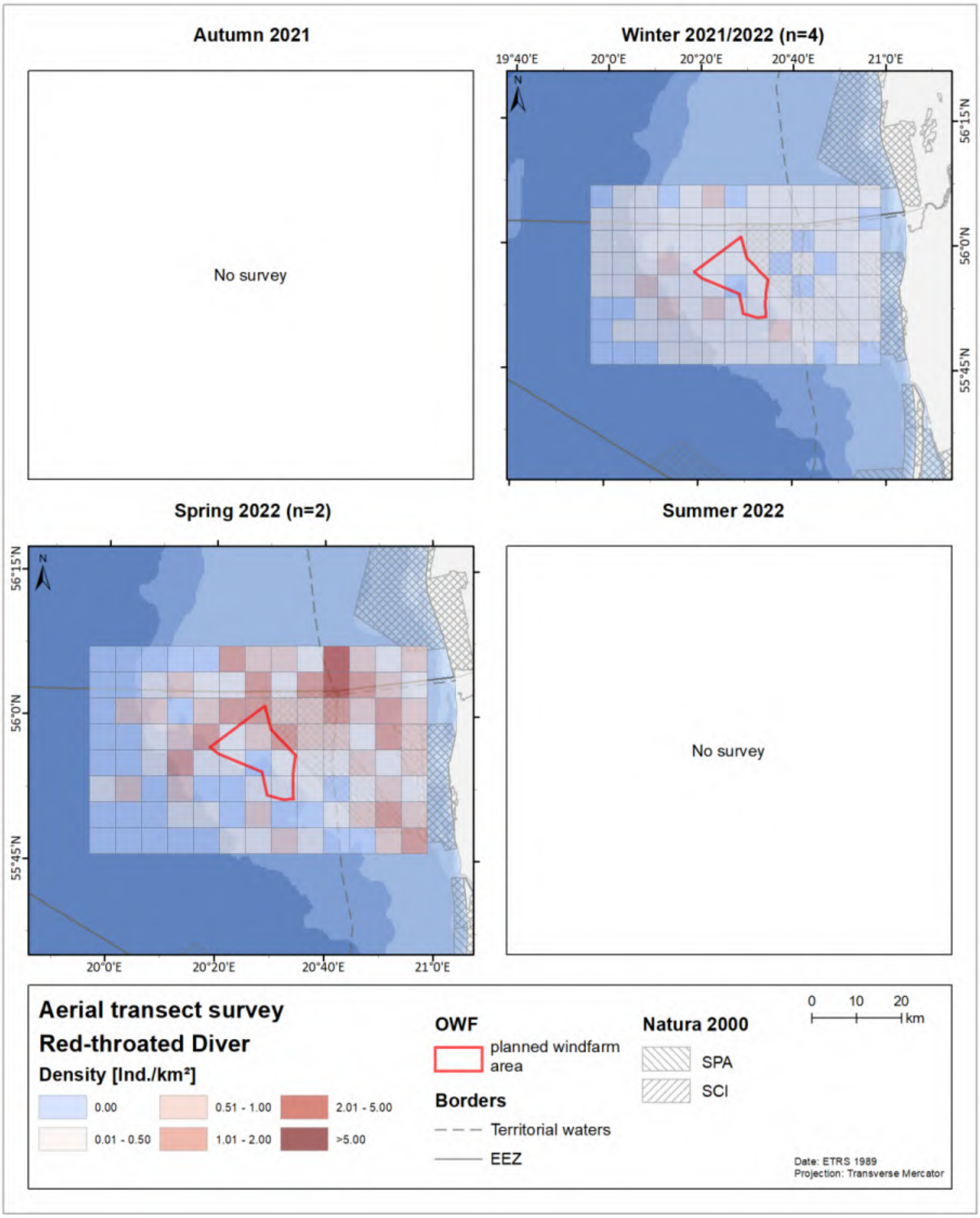

Figure 3.4 Distribution of Red-throated Divers in the survey area per season during the digital aerial surveys between November 2021 and April 2022.

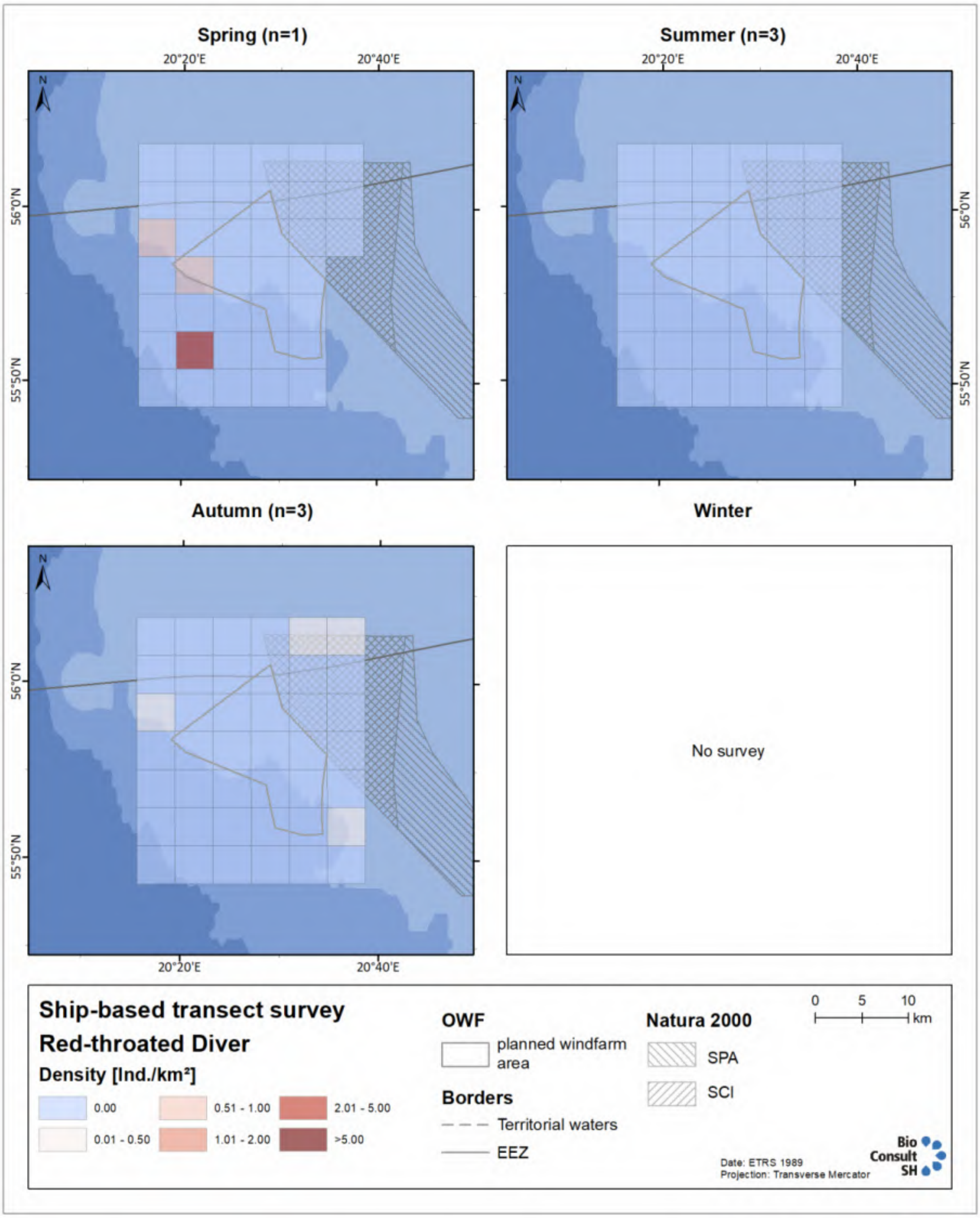

Figure 3.5 Distribution of Red-throated Divers in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

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3.2.2 Black-throated Diver

Black-throated Diver – *Gavia arctica*	**LI: Juodakaklis naras**
Biogeographic population: Northern Europe & Western Siberia/Europe	
Breeding range: N Europe & W Siberia	
Non-breeding range: Coastal NW Europe, Mediterranean, Black & Caspian Seas	
Population size: 390,000 - 590,000	
1% value: 4,800	
Conservation status:	EU Birds Directive, Annex I: listed EU SPEC Category: SPEC 3 IUCN Red List Category, Global & Europe: LC
Trend: DEC?	Trend quality: Poor
Key food: fish	

The Black-throated Divers (also known as Arctic Divers/Loons) are also breeding in the Arctic and boreal zone and are distributed from Northwest Europe to Northeast Siberia and Northwest Alaska. There are two subspecies recognized, the nominate subspecies is estimated to range between 390,00 to 590,000 individuals, and the population is apparently decreasing. Black-throated Divers, as the other diver species occurring in the region, are a sensitive species and affected by many anthropogenic factors.

Density and distribution of Black-throated Divers in the survey area

Similar numbers of Black-throated Divers were registered during the ship surveys (27 individuals, within the transect area) as during the digital aerial surveys (33 individuals, Table 3.1). The densities were higher during the ship surveys than during the digital aerial surveys. This species of divers was only present in the last aerial surveys (Feb-Apr), with small densities ranging between 0.01 and 0.06 ind./km² (max in April 2022). The monthly densities of Black-throated Divers during ship-based transect surveys were larger and ranged from 0.05 (in September 2021) to 0.23 ind./km² in May 2022 (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.6).

During the aerial surveys, Black-throated Divers were present in low densities and scattered across the survey area, but with no specific patterns (Figure 3.7). In spring, a few Black-throated Divers were also observed just outside of the planned wind farm. During the ship-based transect surveys, higher densities were recorded especially in spring. In this season, these divers were mainly distributed towards the east of the survey area, closer to the coast, coinciding with the presence of shallower waters. Two grid cells showed high densities (between 2 and 5 ind./km²), one of these grid cells was located in the centre of the area of the planned wind farm. During autumn, the distribution was more scattered, densities ranged between 0.5 and 2 ind./km², but Black-throated Divers were not spotted within the area of the planned OWF (Figure 3.8).

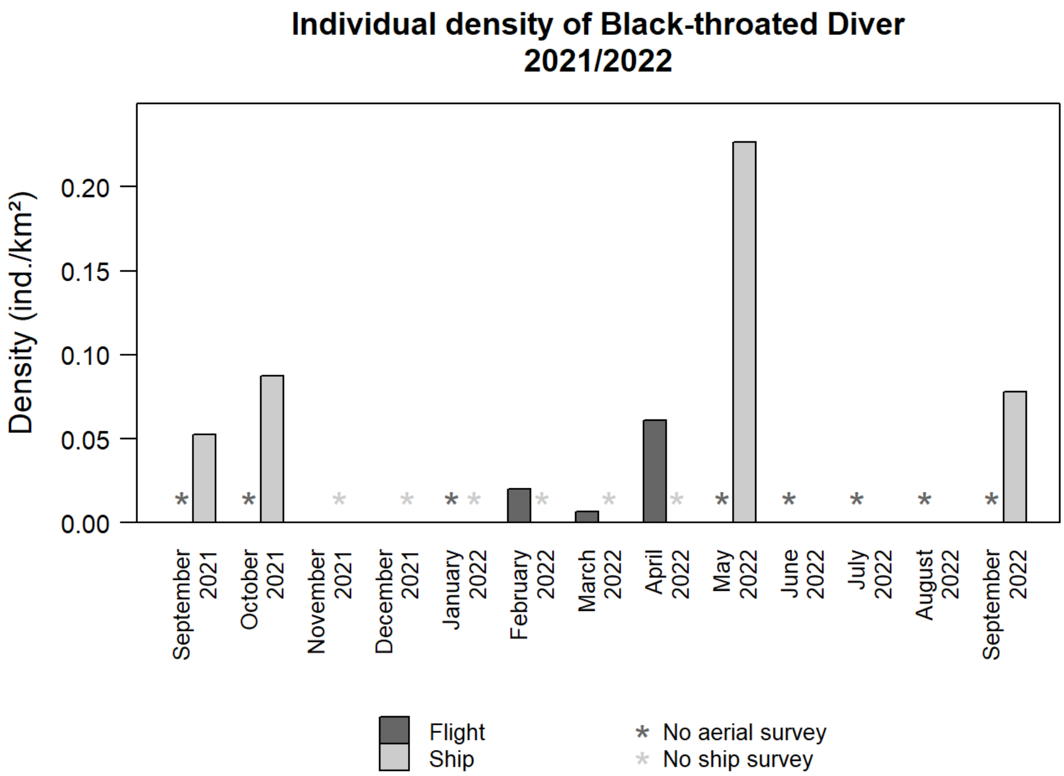

Figure 3.6 Monthly densities of Black-throated Divers during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

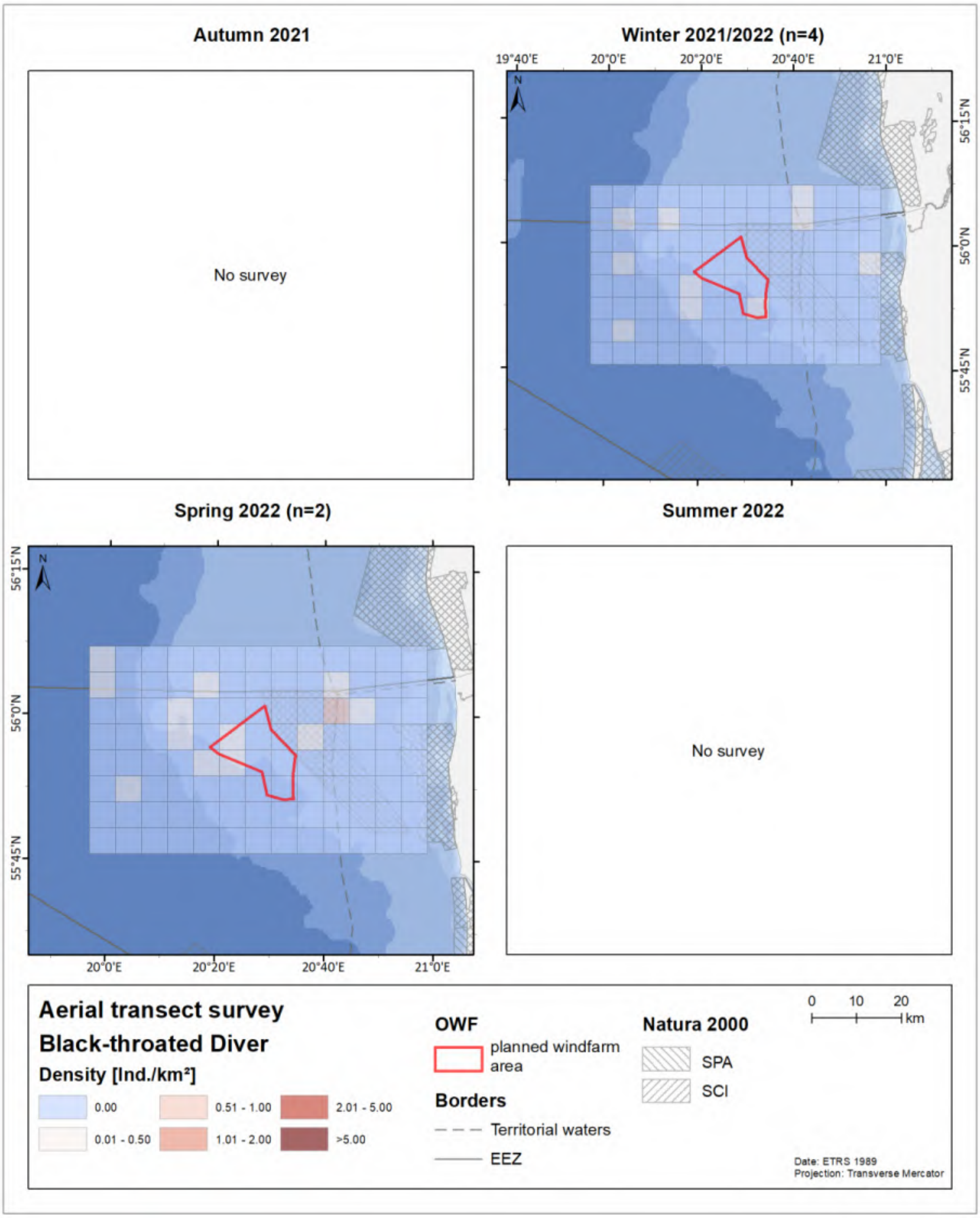

Figure 3.7 Distribution of Black-throated Divers in the survey area per season during the digital aerial surveys between November 2021 and April 2022.

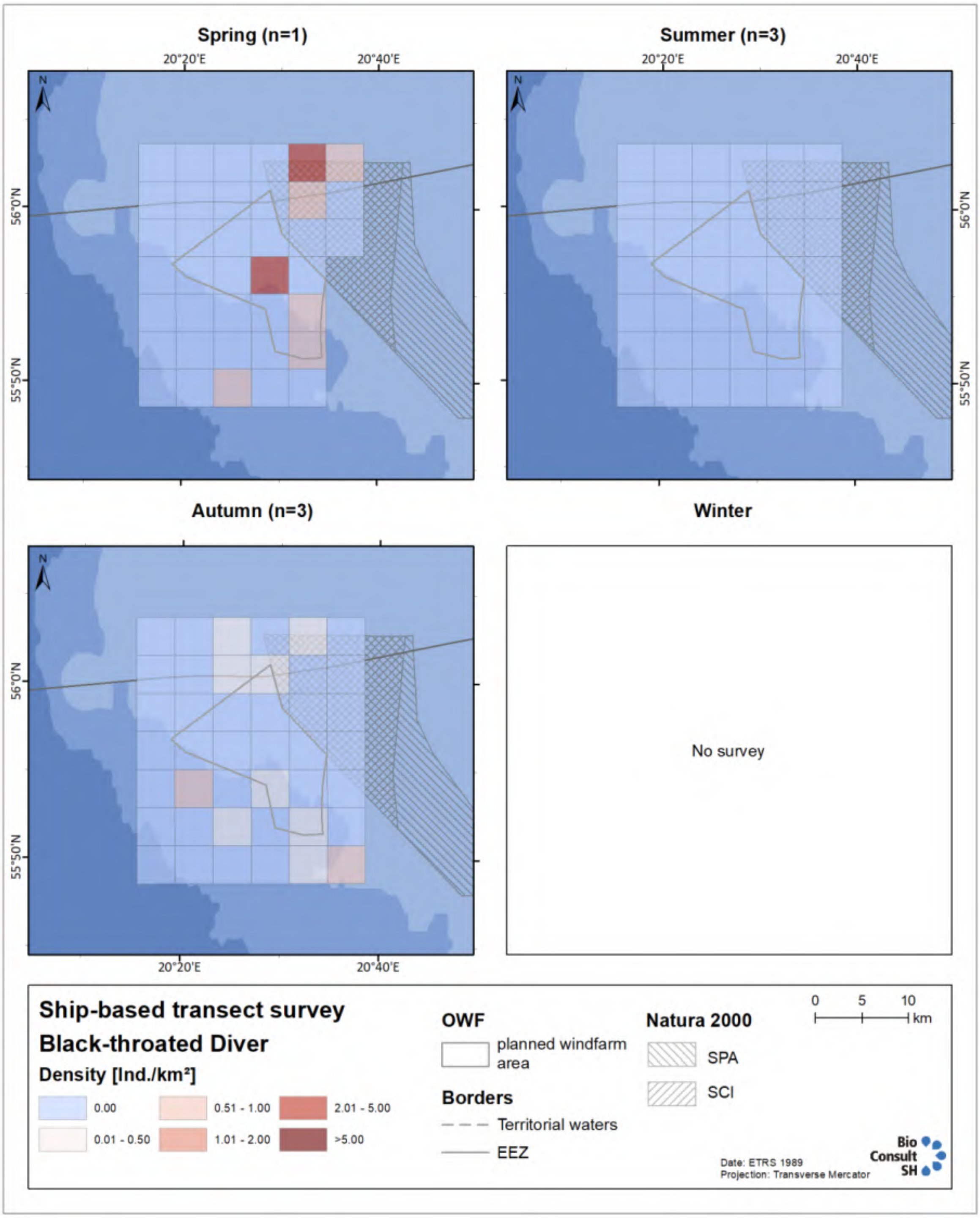

Figure 3.8 Distribution of Black-throated Divers in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

3.2.3 Long-tailed Duck

Long-tailed Duck: – *Clangula hyemalis*	LI: Ledine antis
Biogeographic population: Western Siberia/North Europe	
Breeding range: W Siberia, N Europe	
Wintering / core non-breeding range: N Atlantic, Baltic, N Seas, C European Lakes	
Population size: 1,600,000	
1% value: 16,000	
Conservation status:	EU Birds Directive, Annex I: not listed EU SPEC Category: SPEC 1 IUCN Red List Category: VU (Global), LC (Europe)
Trend: STA?	Trend quality: Reasonable
Key food: mollusks, crustaceans and small fish	

Long-tailed Ducks are the most common duck species in the tundra zones and were the second most common species during the digital aerial surveys. They have a circumpolar distribution and breed in Arctic Eurasia and North America. Whereas no subspecies are recognized, Wetlands International recognizes four large populations. Almost two decades ago the world population was estimated at 6.2 – 6.75 million of individuals, currently this number has almost halved. The population breeding in Europe and occurring in the survey area has a size estimated at 1.6 million with a stable trend, preceded however by long periods of decreasing trend. The Baltic Sea holds about 90% of the birds wintering in Europe and three areas here are of particular importance: The Gulf of Riga/Irbe Strait, Hoburgs and Midsjö Banks and the Pomeranian Bay (DURINCK et al. 1994). Long-tailed Ducks are mainly found wintering in waters at depths of 10-35 m. The migration to the wintering grounds in the Baltic Sea starts in September/October and continues until December with a peak in November. Return movements to breeding areas start in March and by late May most birds have headed towards the White Sea (SKOV et al. 2011). They are opportunistic feeders and consume a wide range of resources including benthic macrofauna. In the Baltic, stomach analyses have shown that their diet includes bivalves such as *Ceratoderma* spp, *Mya arenaria*, *Mytilus edulis* and *Macoma baltica* and small fish and crustaceans or polychaetes. They dive to find their food at depths in the range of 20-30 m (MENDEL et al. 2008a). Long-tailed Ducks have been reported to partly avoid OWF (DIERSCHKE et al. 2016) and are somewhat sensitive to ship traffic (FLIESSBACH et al. 2019a).

Density and distribution of Long-tailed Ducks in the survey area

Large numbers of Long-tailed Ducks were observed during the aerial surveys (2,859 individuals) whereas during the ship-based surveys only 28 individuals were spotted (Table 3.1). During the aerial surveys, the largest densities of these ducks were observed in February 2022 with 2.76 ind./km², and the lowest in November 2021 (0.35 ind./km²). During the ship surveys however, they were less common and were only observed in two months: 0.02 ind./km² in September 2021 and 0.34 ind/km² in May 2022 (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.9).

The distribution of Long-tailed Ducks was concentrated towards the north-eastern part of the survey area, during both survey methods and in aerial surveys, some of these grid cells with very high densities (> 20 ind./km²) were overlapping with the eastern border of the planned wind farm. Densities were larger and the ducks were thus present in many more grid cells during the aerial surveys, even within the area of the planned wind farm (< 5 ind./km²). Nonetheless, their distribution mainly coincides with the location of the Natura2000 area and shallower waters.

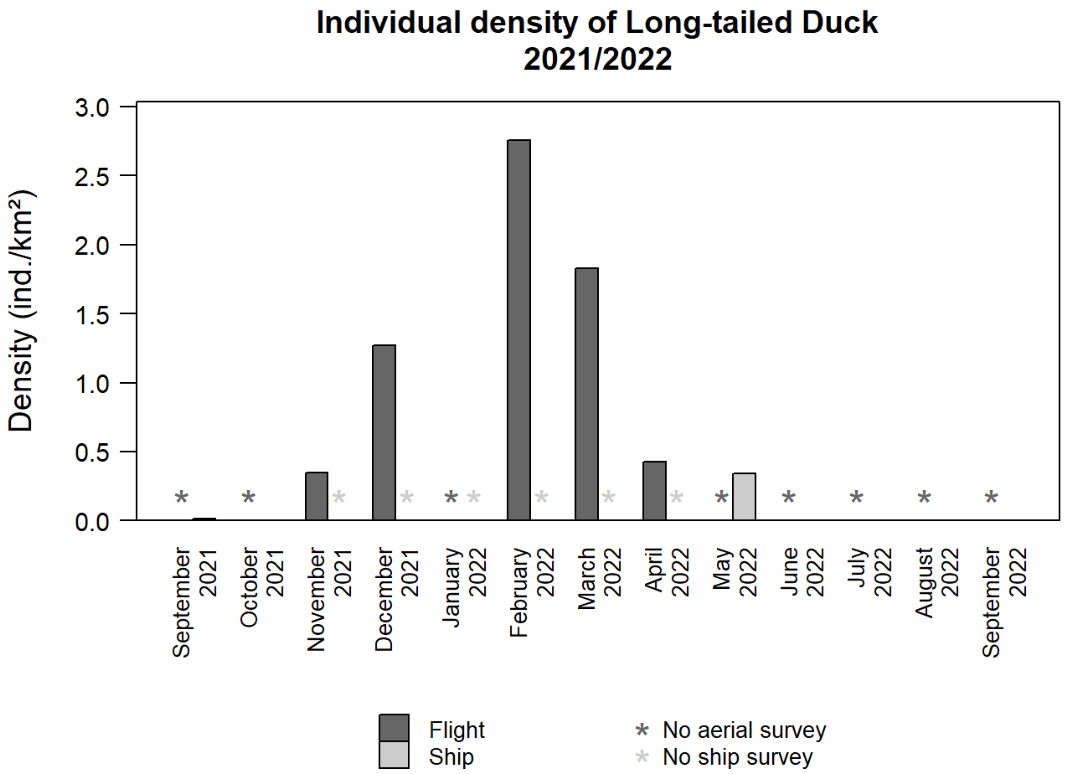

Figure 3.9 Monthly densities of Long-tailed Ducks during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

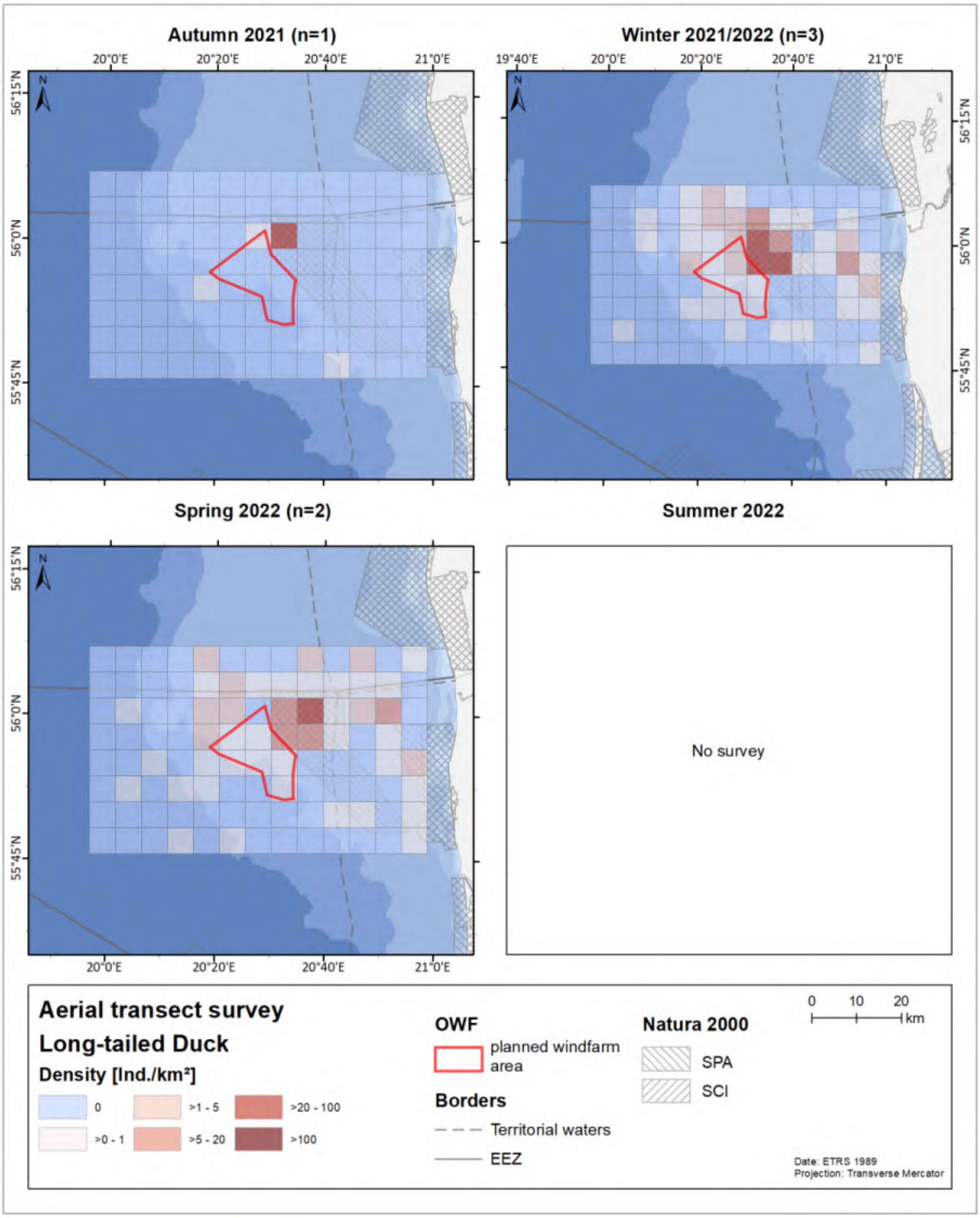

Figure 3.10 Distribution of Long-tailed Ducks in the survey area per season during the digital aerial surveys between November 2021 and April 2022.

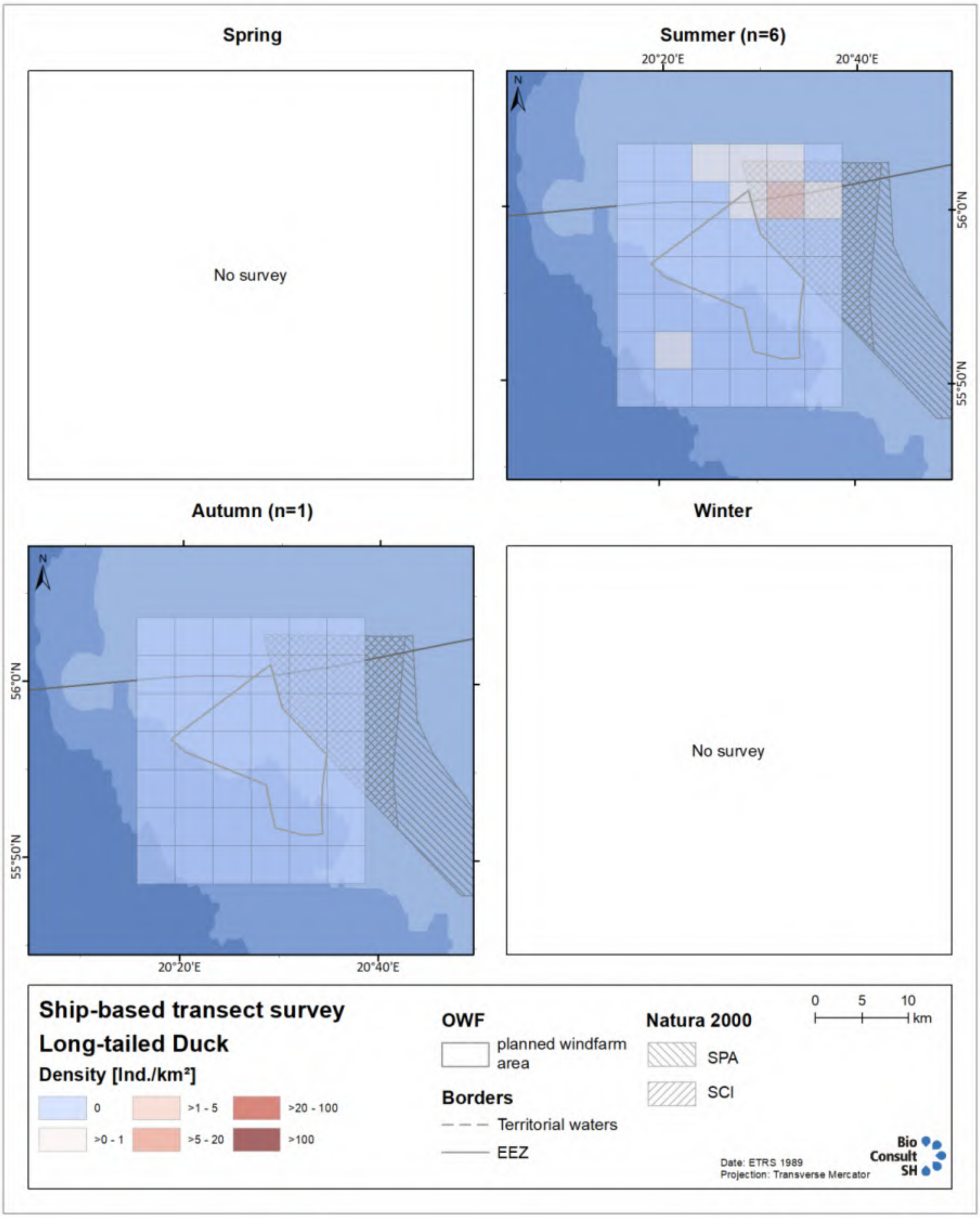

Figure 3.11 Distribution of Long-tailed Ducks in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

3.2.4 Velvet Scoter

Velvet Scoter – *Melanitta fusca*	LI: Paprastoji nuodegule
Biogeographic population: Western Siberia & Northern Europe/NW Europe	
Breeding range: W Siberia, N Europe	
Wintering / core non-breeding range: Baltic, W Europe	
Population size: 220,000 – 410,000	
1% value: 3,000	
Conservation status:	EU Birds Directive, Annex I: not listed EU SPEC Category: SPEC 1 IUCN Red List Category: VU (Global & Europe)
Trend: INC?	Trend quality: Reasonable
Key food: mollusks, crustaceans	

The European population of Velvet Scoters is estimated to range between 220,000 to 410,000 with a tendency to increase. They are not listed in any category of conservation.

Velvet Scoters mainly breed in northern parts of Fennoscandia and western Russia, and to a lesser extent along the Baltic Sea coast of Sweden, Finland, Russia and Estonia (MENDEL et al. 2008a). Durinck et al (1994) mentioned that about 93% of the European population was wintering in the Baltic Sea. Birds start the migration to their wintering areas in September and migrate back to their breeding grounds around March, but the last birds may leave the wintering areas only in May (MENDEL et al. 2008a).

Velvet Scoters are thought to prefer waters with depths below 20 m. Often, the larger abundances are found in shallow waters (5-10 m of depth). Nonetheless, they tend to be more common in deeper waters (20-30 m) than the two other common species: Common Scoters and Long-tailed Ducks. Velvet Scoters feed mainly on mussels, but fish, polychaetes and crustaceans also make up part of their diet (MENDEL et al. 2008a).

Not much is known about the response of Velvet Scoters to OWF, but some weak avoidance can be expected, similar to the closely related Common Scoter (DIERSCHKE et al. 2016). Also, Velvet Scoters are sensitive to ship traffic, but less so than Common Scoters (FLIESSBACH et al. 2019a).

Density and distribution of Velvet Scoters in the survey area

Velvet Scoters were only present during the aerial surveys which took place in autumn 2021 and winter 2021/2022. A total of 7,763 Velvet Scoters were then recorded over the four surveys and it was the most common species. The densities were highest in December 2021 with 9.21 ind./km², in February 2022 they were still high at 7.25 ind./km² and were lowest in April 2022 (0.05 ind./km², **Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.12).

Spatially, Velvet Scoters were also concentrated towards the eastern part of the survey area coinciding with shallower waters. Only in autumn 2021, one grid cell with a density between 1 and 5 ind./km² was observed on the western edge of the survey area. The higher (very large) densities (> 20 ind./km²) were all observed in the east, and most of them within the SPA and SCI protected areas. In winter 2021/2022 when the largest densities occurred, Velvet Scoters were observed also within the limits of the planned OWF at high densities whereas in spring 2022 when the densities decreased, they also occurred within the area of the planned OWF but at lower densities (Figure 3.13).

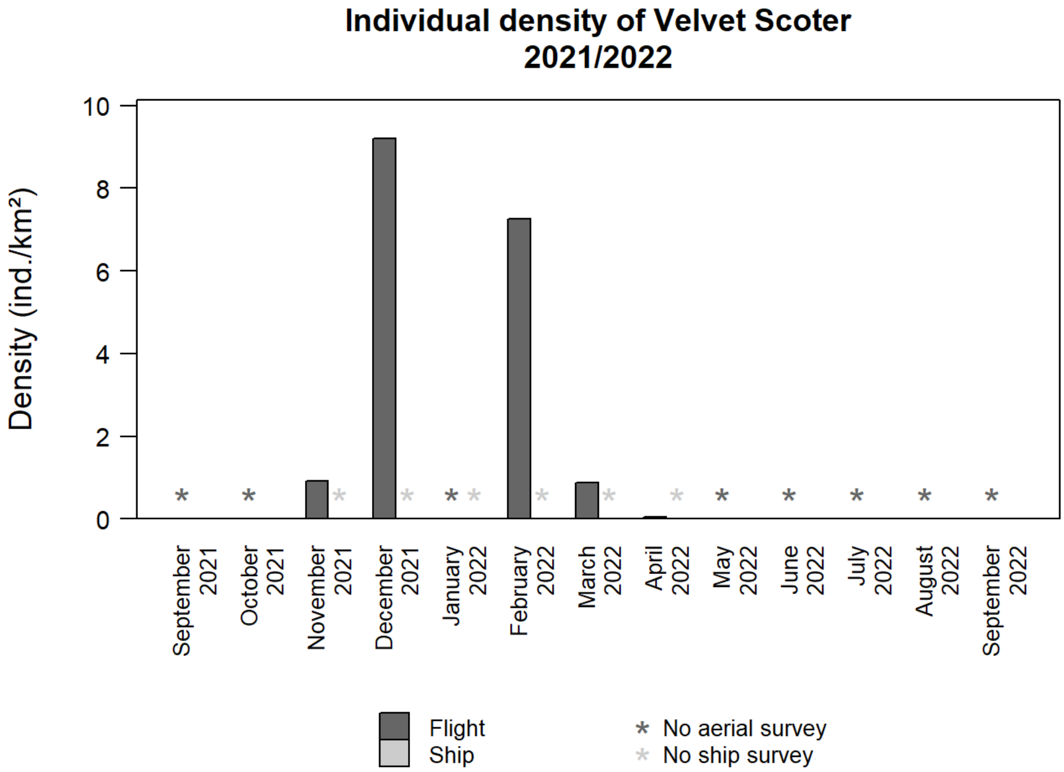

Figure 3.12 Monthly densities of Velvet Scoters during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

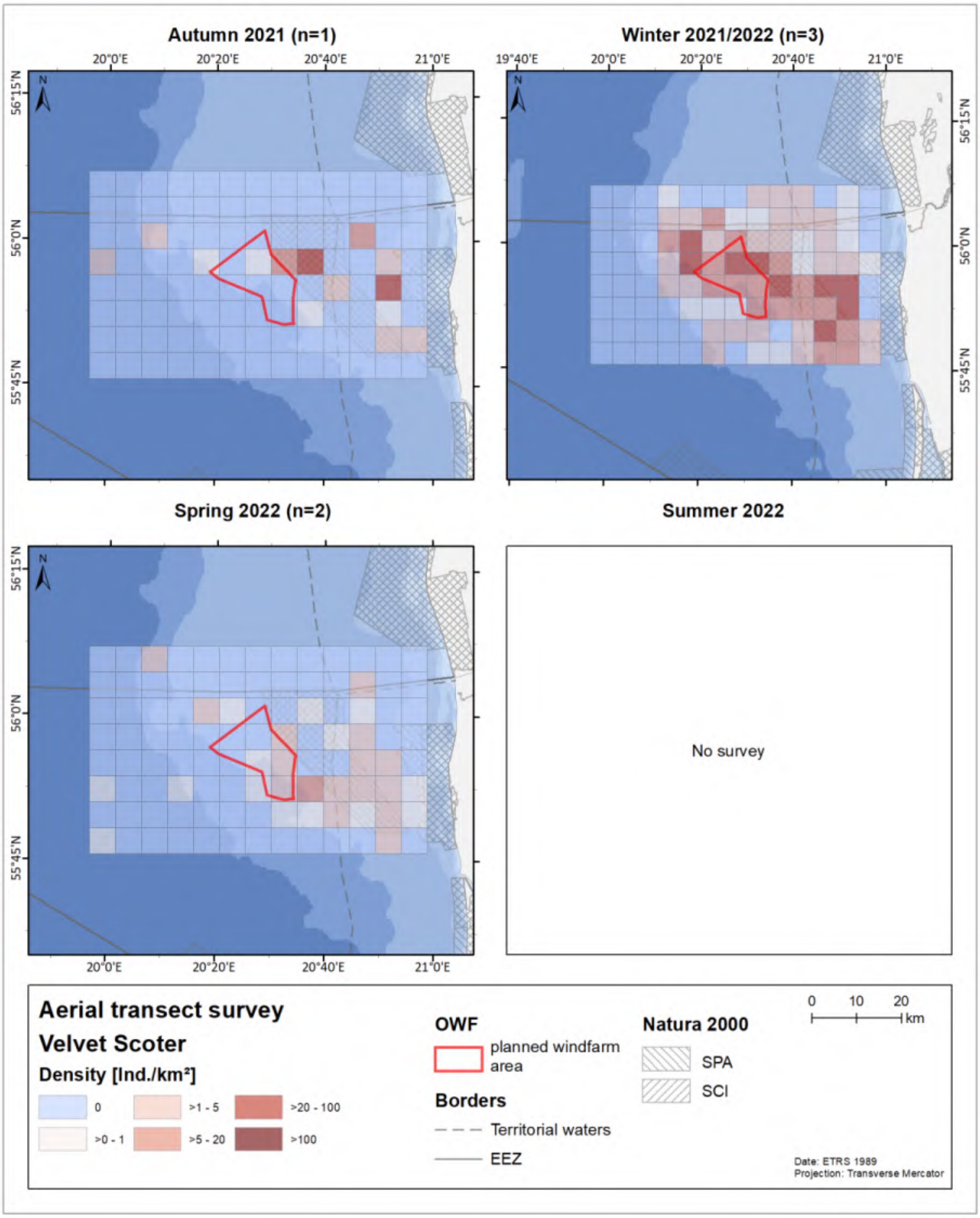

Figure 3.13 Distribution of Velvet Scoters in the survey area per season during the digital aerial surveys between November 2021 and April 2022.

3.2.5 Little Gull

Little Gull – *Hydrocoloeus minutus*	**LI: Mažasis kiras**
Biogeographic population: Central & E Europe & W Mediterranean	
Breeding range: N Scandinavia, Baltic States, W Russia, Belarus, Ukraine	
Wintering / core non-breeding range: W Europe, NW Africa	
Population size: 96,000 – 180,000	
1% value: 1,300	
Conservation status:	EU Birds Directive, Annex I: listed EU SPEC Category: SPEC 3 IUCN Red List Category, Global & Europe:LC
Trend: DEC	Trend quality: Reasonable
Key food: mostly insects, some crustaceans, mollusk and small fish	

Little Gulls are distributed in Europe, west Asia and North America. The population that occurs in the survey area is the Central European population breeding in North Scandinavia to the Baltic Sea and Belarus and west Russia. Little Gulls are migratory, and their wintering grounds extend to west Europe and Northwest Africa (MENDEL et al. 2008a). Within the Baltic, the main wintering areas are the Gulf of Riga, the Irbe Strait, the southwestern part of the Baltic among others (DURINCK et al. 1994). In late July and August, Little Gulls arrive from their breeding grounds to the coast of Lithuania, Latvia and Poland to moult (DURINCK et al. 1994). Little Gulls occur mainly at water depths ranging between 20 and 50 m, but they may also occur at much deeper waters (up to 100 m, DURINCK et al. 1994). Their diet mainly consists of insects and small fish. The European population is estimated at 96,000 to 180,000 individuals with a decreasing trend. Little Gulls are reported to be weakly affected by OWF, showing some avoidance behaviour (DIERSCHKE et al. 2016).

Density and distribution of Little Gulls in the survey area

Little Gulls were the most commonly recorded species during the ship-based surveys. A total of 3,307 individuals were observed during the seven ship-based surveys within the transect area, while during the aerial surveys, 625 individuals were recorded. During ship surveys, Little Gulls were mainly observed in autumn, especially during 2022. The highest density was observed in July 2022 (36.1 ind/km²) and the lowest density in September 2022 with 1.51 ind./km². The maximum density in 2021 (October) was 1.11 ind/km². Little Gulls were recorded during all surveys (during aerial and ship-based surveys), but at very varying densities. Densities of ship-based surveys during May and June 2022 were very low, below 0.1 ind./km². During the aerial surveys, the highest density was observed in November 2021 at 0.86 ind./km².

Spatially, Little Gulls preferred the offshore areas. During the aerial surveys, the highest densities (grid cells of up to 5.0 ind./km²) were observed to the west of the planned OWF both in winter and spring. Within the limits of the planned OWF there were sightings of Little Gulls, but the densities were lower (up to 0.5 ind./km²). The main difference between winter and spring was that during the former the distribution of Little Gulls was more widespread. During the ship-based surveys in autumn, Little Gulls occurred at very high densities throughout the study area. High densities were also observed within the limits of the planned OWF. In July 2022 when the highest densities occurred, Little Gulls were present over all the survey area with no defined pattern and at large densities (> 5. Ind./km², A.3.4).

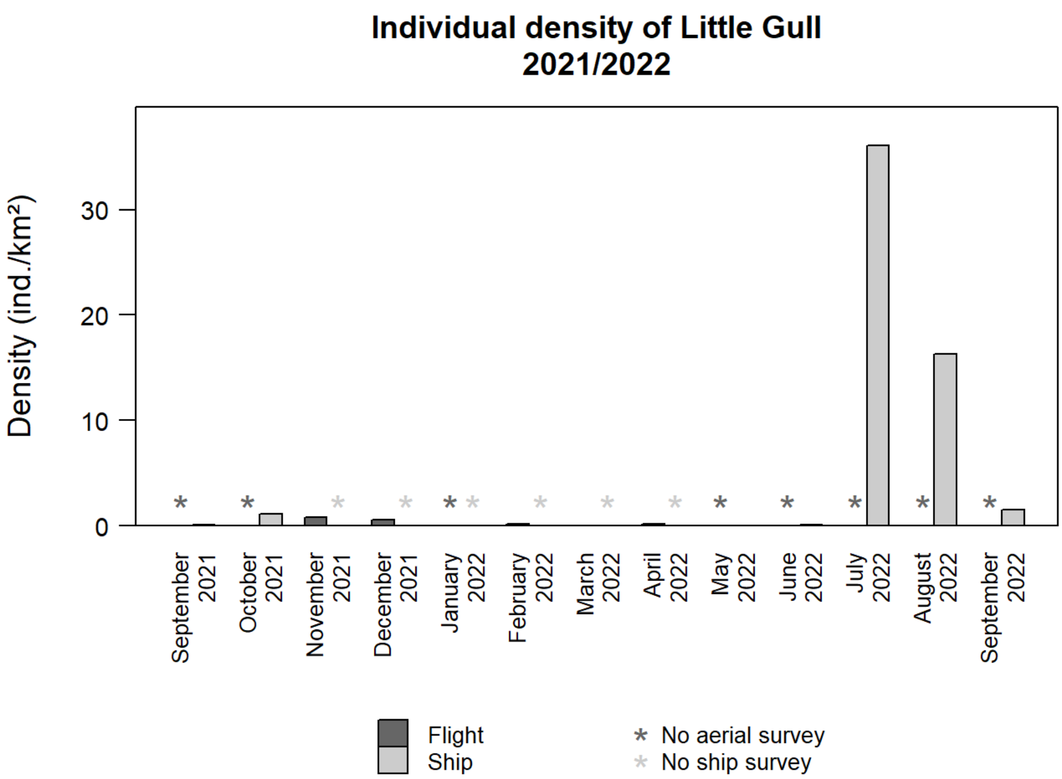

Figure 3.14 Monthly densities of Little Gulls during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

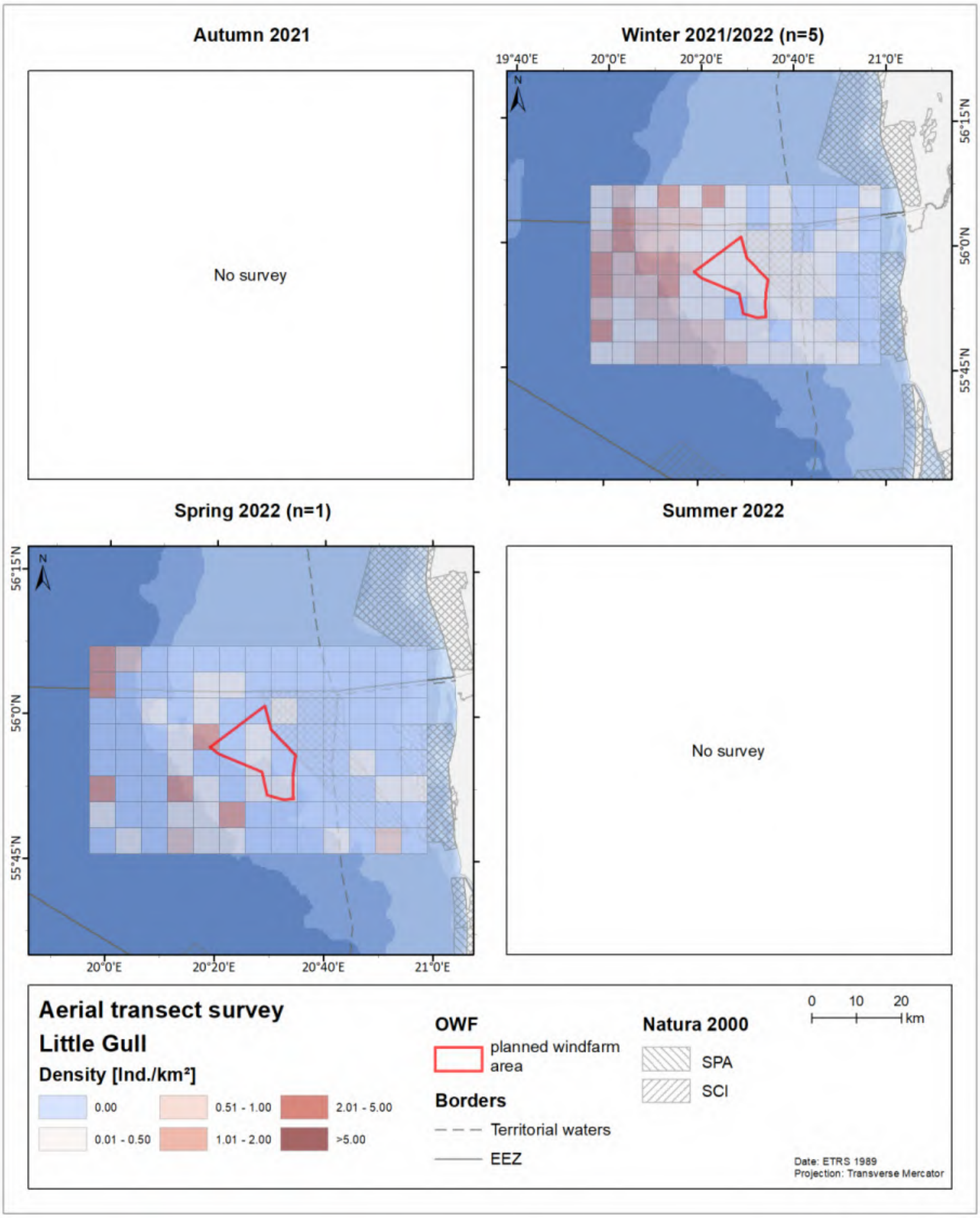

Figure 3.15 Distribution of Little Gulls in the survey area during the digital aerial surveys between November 2021 and April 2022.

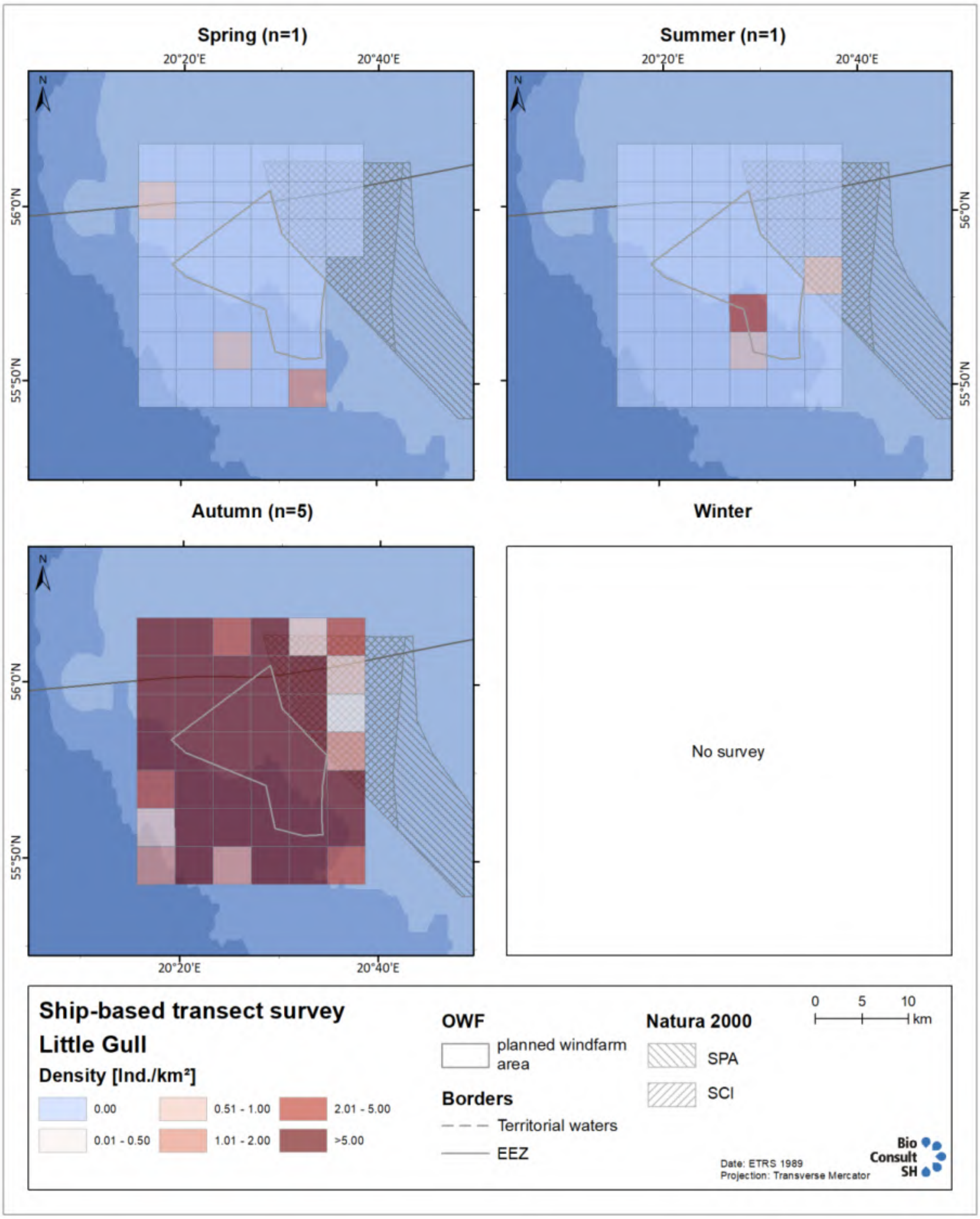

Figure 3.16 Distribution of Little Gulls in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

3.2.6 Common Gull

Common Gull – ***Larus canus***	**LI: Paprastasis kiras**
Biogeographic population: *canus*, NW & C Europe/Atlantic coast & Mediterranean *heinei,* NE Europe & Western Siberia/Black Sea &Caspian	
Breeding range: *canus*: Iceland, Ireland, UK, eastwards to White Sea *heinei:* NW Russia, West and Central Siberia E to R. Lena	
Wintering / core non-breeding range: *canus*: Europe to N Africa; *heinei*: SE Europe, Black & Caspian Seas	
Population size: *canus*: 1,400,000 - 2,000,000	*heinei*: 2,200,000 – 3,500,000
1% value: *canus*: 16,400	*heinei:* 16,400
Conservation status:	EU Birds Directive, Annex I: not listed EU SPEC Category: Non-SPEC^{E} IUCN Red List Category: LC (Global & Europe)
Trend: DEC?/DEC?	Trend quality: Reasonable/Reasonable
Key food: opportunistic	

The Common Gull is a medium-sized gull that breeds in the Palearctic, from Eurasia to western North America. The species has four subspecies and two of them may occur in the survey area. The nominate form: *canus* breeds from Iceland to Fennoscandia and winters from Central Europe to North Africa. The subspecies *L. c. heinei* breeds from Northeast Europe and Western and Central Siberia and winters in Northwest Russia down to the Black Sea and the Caspian area. Durinck and colleagues (1994) mention that less than 4% of the *canus* subspecies winters offshore in the Baltic Sea and that high densities are often only recorded around the Gulf of Riga and to the north and northwest coast of Bornholm. They are generalist feeders with a large variety of food prey from terrestrial and marine ecosystems (MENDEL et al. 2008a). They are also ship-followers and feed on fish discards. The sizes of the European populations of both relevant subspecies are summarized in the reference chart above these lines. Despite being relatively numerous both subspecies are showing potential declining trends.

Density and distribution of Common Gulls in the survey area

A total of 108 Common Gulls were recorded over the six aerial surveys. The highest density was recorded in November 2021 with 0.11 ind./km². During ship-based surveys, the highest density was recorded in July 2022 with 2.11 ind./km² (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.17).

Spatially, Common Gulls were distributed quite evenly across the aerial survey area, without any local concentrations (Figure 3.18). During ship surveys, individuals were distributed across the whole survey area in autumn, but with varying densities (Figure 3.19).

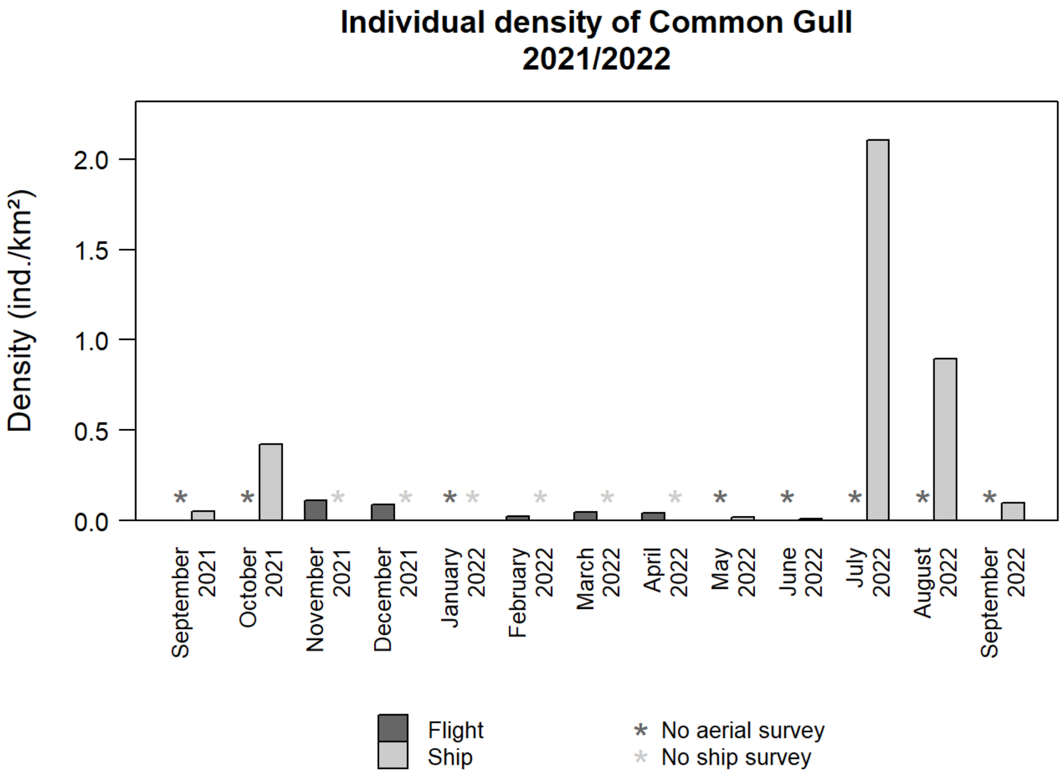

Figure 3.17 Monthly densities of Common Gulls during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

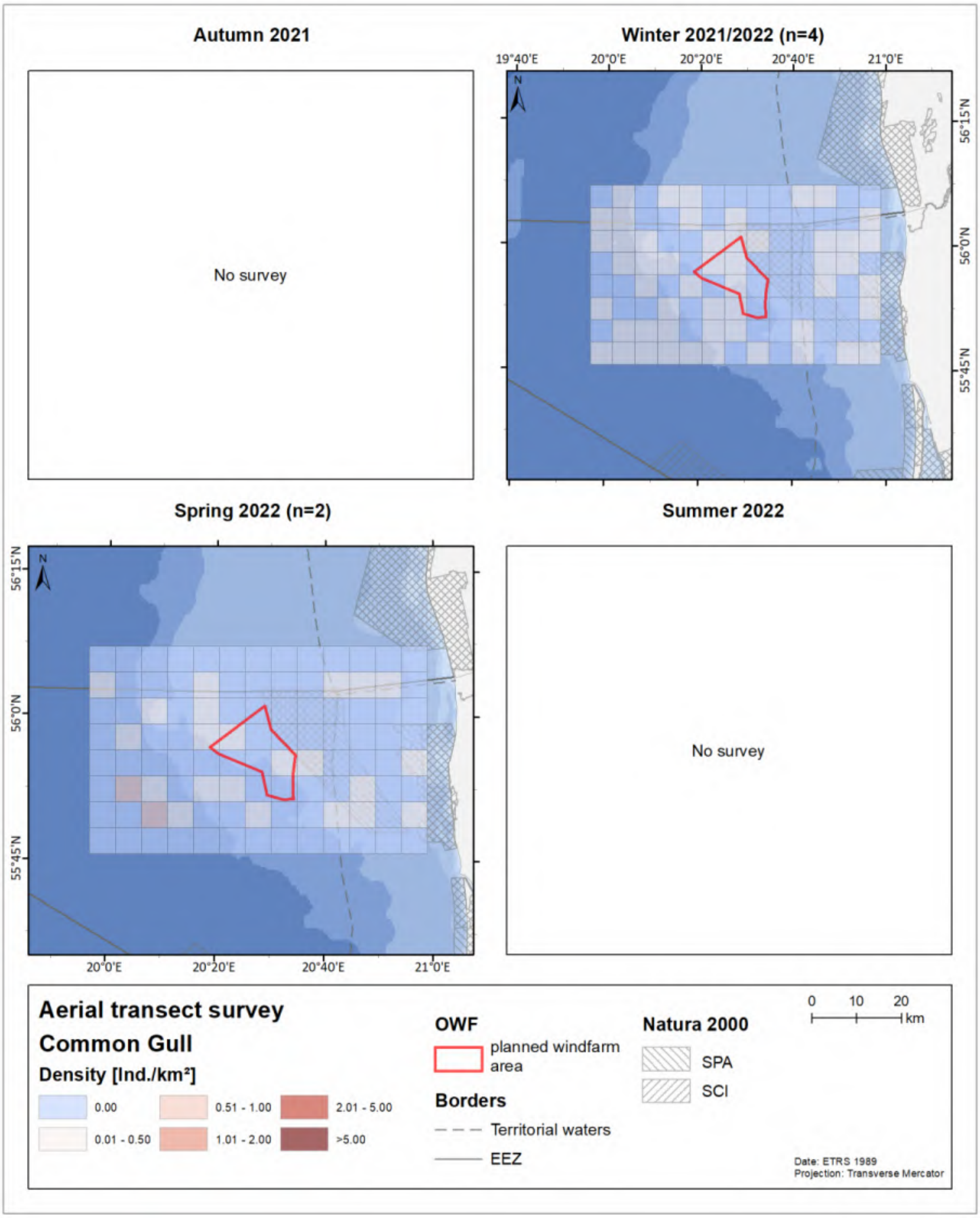

Figure 3.18 Distribution of Common Gulls in the survey area during the digital aerial surveys between November 2021 and April 2022.

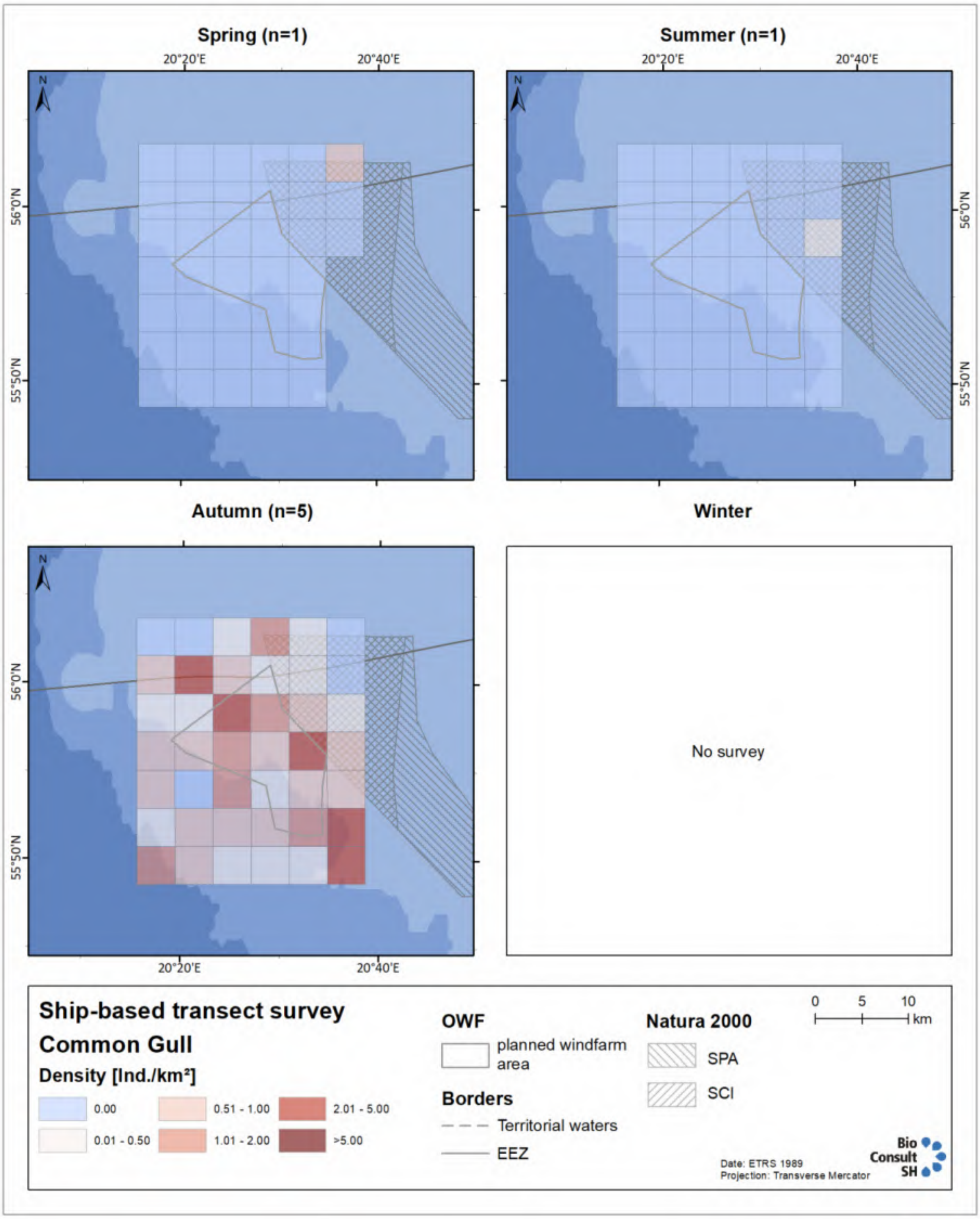

Figure 3.19 Common Gull distribution in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

3.2.7 Lesser Black-backed Gull

Lesser Black-backed Gull – *Larus fuscus*	LI: Silkinis kiras
Biogeographic population: *fuscus, NE Europe/Black Sea, SW Asia & Eastern Africa*	
Breeding range: N Norway, E Sweden, E Denmark, Finland, Estonia, W Russia E to White	
Wintering / core non-breeding range: E Africa S to Tanzania (+ few SW Asia)	
Population size:40,000 - 73,000	
1% value: 540	
Conservation status:	EU Birds Directive, Annex I: not listed EU SPEC Category: Non-SPEC[E] IUCN Red List Category: LC (Global & Europe)
Trend: DEC	Trend quality: Reasonable
Key food: omnivores: fish, insects, molluscs, seeds, small mammals, carrion, etc.	

The Lesser Black-backed Gull is distributed from West Europe (Iceland to Spain) up to Northwest Europe. Wetlands International recognizes five subspecies, but only the nominate form *L. f. fuscus* breeds from northern Norway, Sweden and Finland and eastwards to the White Sea and is the main subspecies expected to occur in the survey area. The subspecies is a long-distance migrant and spends the winter in equatorial Africa reaching even Tanzania. *L. f. fuscus* breeds in colonies on coasts or lakes but also as solitary pairs, especially on inland waters. The population has experienced a long-term decline over its entire range and the population size is estimated to range now between 40,000 and 73,000 individuals. The species is omnivorous but eats predominantly fish. As other gulls, they are also ship-followers and are very successful at getting their food from fishing ships (MENDEL et al. 2008a). The Lesser Black-backed Gull is less sensitive to anthropogenic factors. Nonetheless, they may be affected by oil spills and by the reduction of food due to fisheries, and getting trapped in nets (MENDEL et al. 2008a).

Density and distribution of Lesser Black-backed Gull in the survey area

Only 4 Lesser Black-backed Gulls were recorded during the six aerial surveys, all of them were registered in April 2022. Thus, the density was very low in that month: 0.01 ind./km². During ship-based surveys, 36 individuals were recorded. Here, the highest density was recorded in September 2022 with 0.29 ind./km². (**Fehler! Verweisquelle konnte nicht gefunden werden.**,Figure 3.20).

Since so few Lesser Black-backed Gulls were recorded during the digital aerial surveys, no spatial pattern can be described. Spatially, Lesser Black-backed Gulls were distributed quite evenly across the ship-based survey area during autumn (Figure 3.21). During spring, individuals occurred only in three grid cells in the western part of the study area, indicating local flocks, overlapping with the area of the planned wind farm.

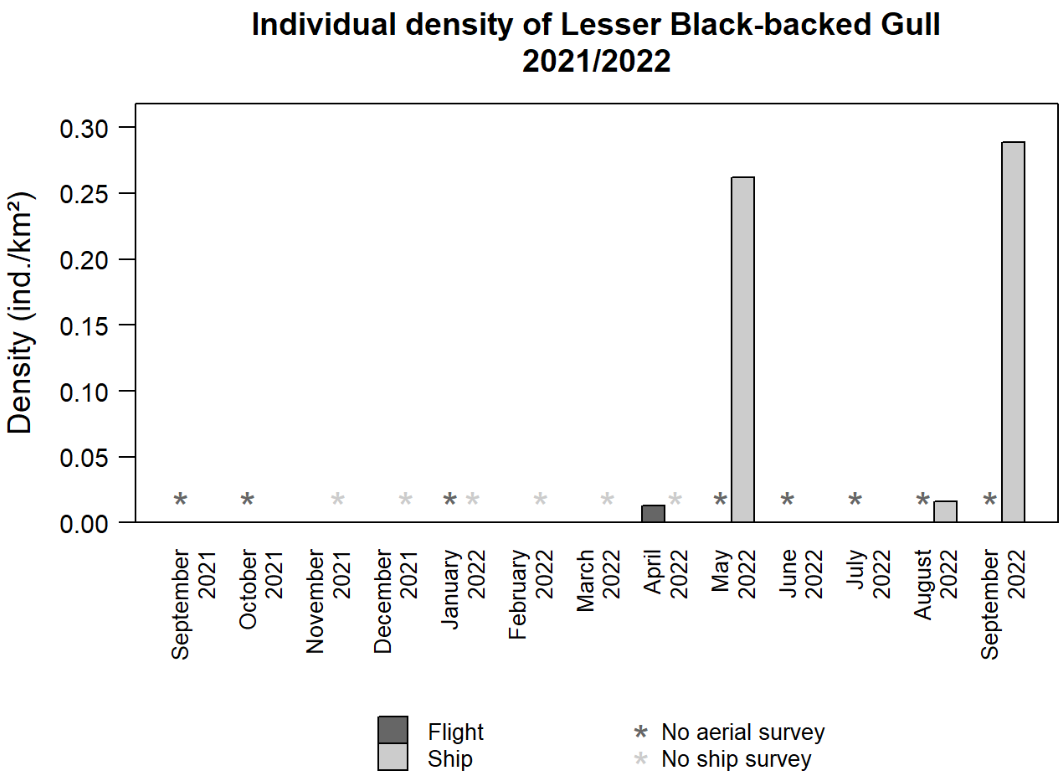

Figure 3.20 *Monthly densities of Lesser Black-backed Gulls during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.*

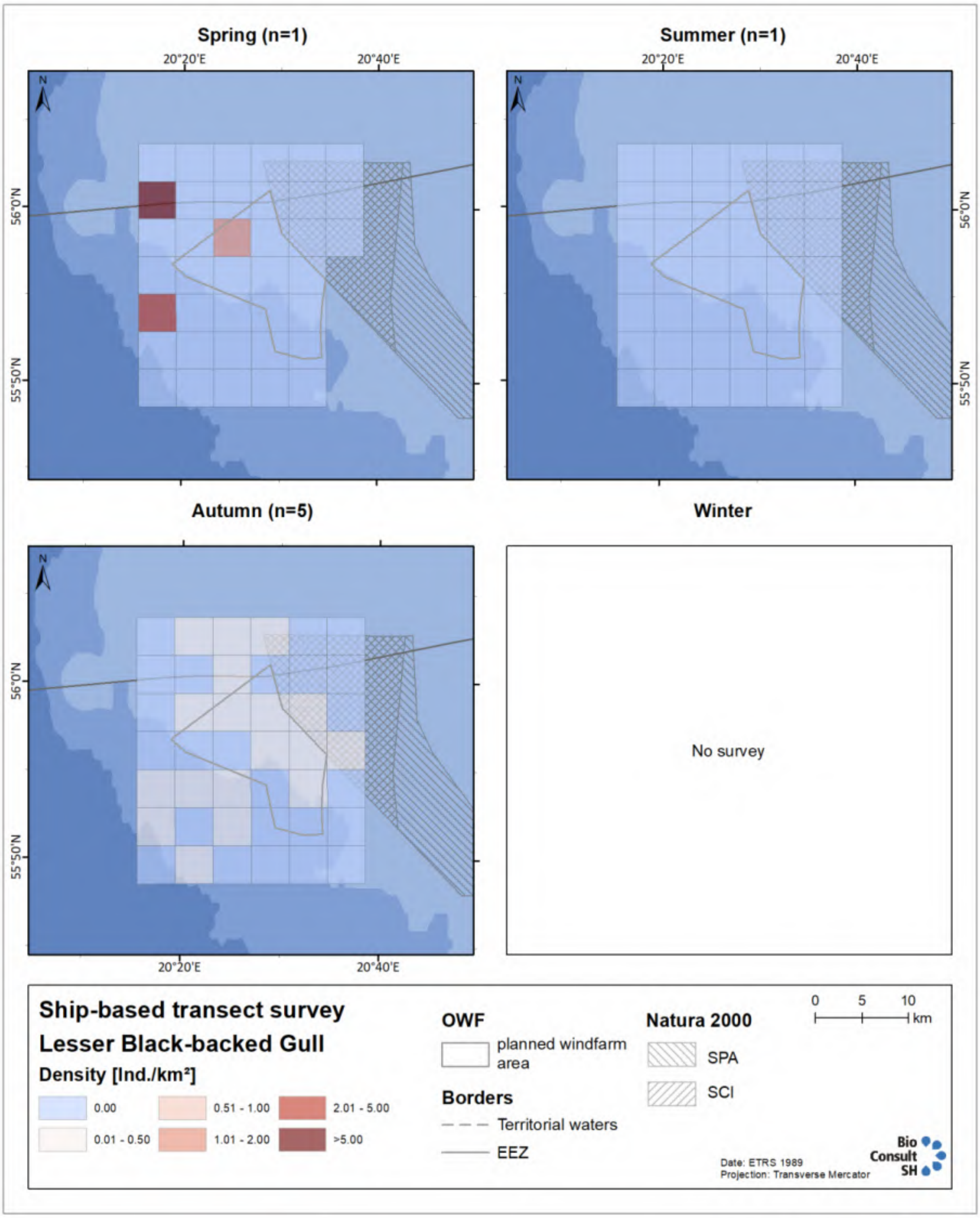

Figure 3.21 Lesser Black-backed Gull distribution in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

3.2.8 Herring Gull

Herring Gull – *Larus argentatus*	**LI: Sidabrinis kiras**
Biogeographic population: *argentatus*, North & North-west Europe*	
Breeding range: Denmark & Fenno-Scandia to E Kola Peninsula	
Non-breeding range: N & W Europe	
Population size: 860,000 – 1,000,000	
1% value: 9,300	
Conservation status:	EU Birds Directive, Annex I: not listed EU SPEC Category: SPEC 2 IUCN Red List Category: LC (Global & Europe)
Trend: DEC	Trend quality: Reasonable
Key food: various different food sources	

The Herring Gull is a very widespread species in the northern hemisphere. There are two subspecies and the nominate form is the one distributing in the survey area. It breeds from Fennoscandia and Denmark to Svalbard. The other subspecies is distributed west from *L. a. argentatus* and can be found until Iceland. The species is partly migratory with birds occurring further north migrating and birds occurring further south being resident. Their diet is opportunistic and diverse, but their main prey are invertebrates. They are also ship-followers feeding on fish discard (MENDEL et al. 2008a). The population size has been decreasing in the recent years and is currently estimated at 860,000 to 1 million individuals.

Density and distribution of Herring Gulls in the survey area

During the six aerial surveys, the highest density of Herring Gulls was recorded in November 2021 with 0.22 ind./km². During ship-based surveys, the highest density was recorded in August 2022 with 1.85 ind/km², but also July and September showed densities of >1 ind/km² (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.17), while the other months had much lower densities (with the exception of July 2022 with a density of 1.60 ind/km²).

Spatially, Herring Gulls were distributed with low densities quite evenly across the aerial survey area, without any local concentrations (Figure 3.23). During ship surveys, individuals were distributed across the whole survey area (and planned wind farm area) in autumn, but with varying densities (Figure 3.24).

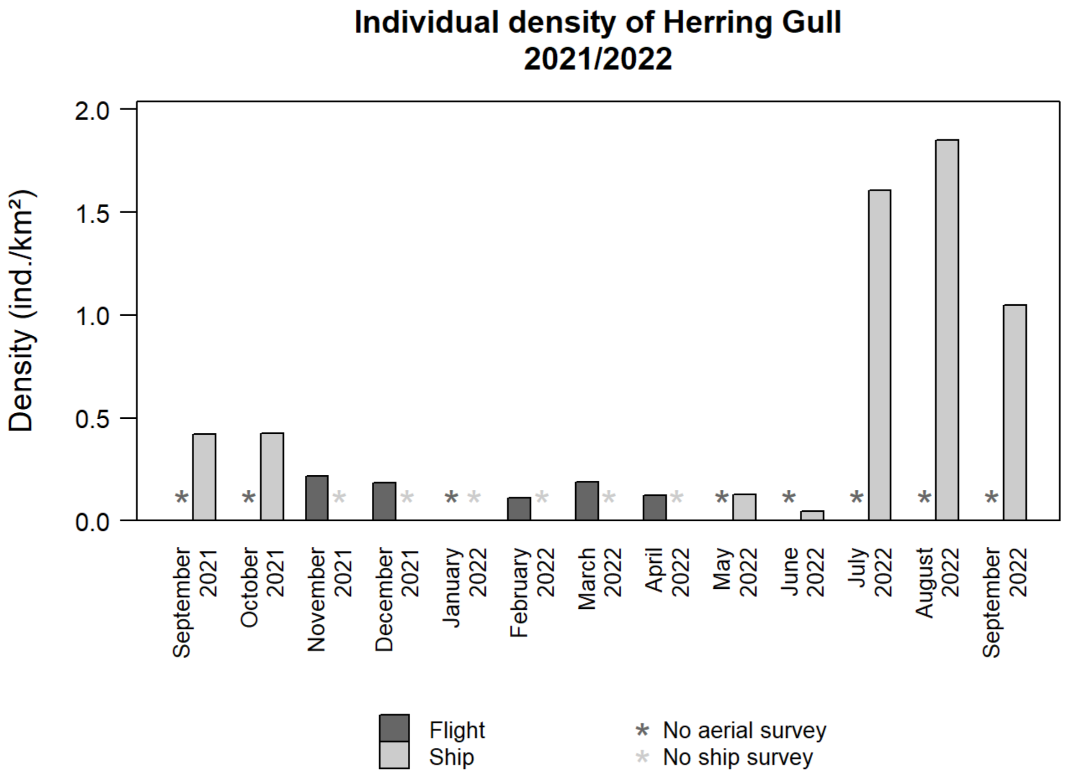

Figure 3.22 Monthly densities of Herring Gulls during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

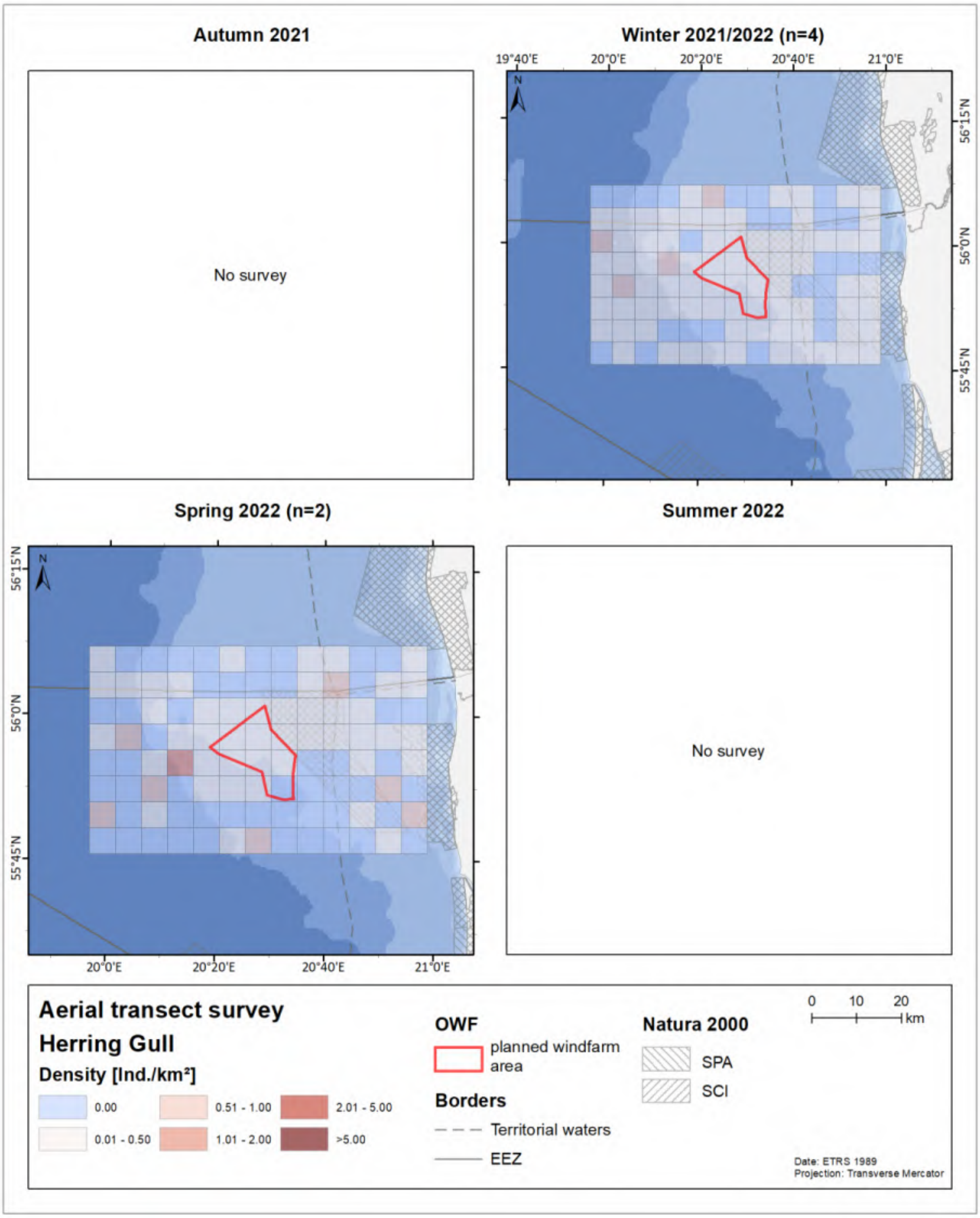

Figure 3.23 Distribution of Herring Gulls in the survey area during the digital aerial surveys between November 2021 and April 2022.

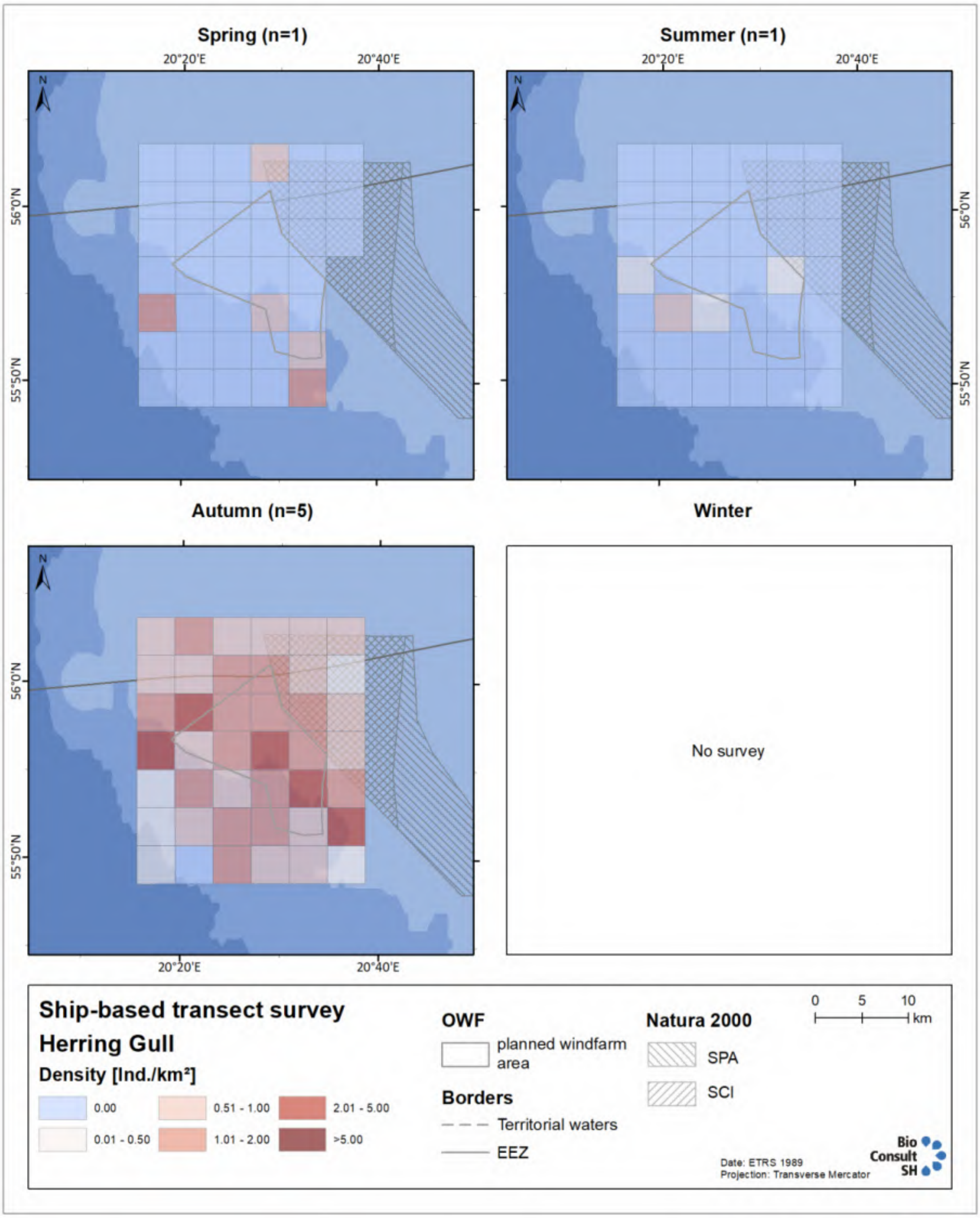

Figure 3.24 Herring Gull distribution in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

3.2.9 Common Guillemot

Common Guillemot – *Uria aalge*	**LI: Laibasnapis narunelis**
Biogeographic population: aalge, Baltic Sea*	
Breeding range: Sweden, Denmark, Finland	
Non-breeding range: Baltic Sea	
Population size: 77,000 – 100,000	
1% value: 880	
Conservation status:	EU Birds Directive, Annex I: not listed EU SPEC Category: SPEC 3 IUCN Red List Category: LC (Global & Europe)
Trend: INC	Trend quality: Good
Key food: fish	

For Common Guillemots it is somewhat unclear to which extent the North Atlantic flyway populations can be divided into sub-populations. MENDEL et al. (2008a) used an estimate for the Baltic Sea breeding population of 50,000 individuals. During winter, the highest densities in the Danish Baltic Sea are found in the central Kattegat (PETERSEN & NIELSEN 2011) with about 76,500 individuals for the year 2008. These birds are assumed to mostly originate from breeding colonies in the North Sea or Atlantic (MENDEL et al. 2008a). Common Guillemots have been found to avoid OWF, but responses varied from weak avoidance to strong avoidance in some cases (DIERSCHKE et al. 2016; PESCHKO et al. 2020).

Density and distribution of Common Guillemots in the survey area

During the six digital aerial surveys between November 2021 and April 2022, a total of 762 Common Guillemots were recorded whereas during the seven ship-based transect surveys between September 2021 and September 2022 (excluding the months between Nov 21 until April 22) 191 individuals were observed within the transect area (Table 3.1). During aerial surveys, also 137 unidentified auks (or Common Guillemot/Razorbill) were observed (14.9% of all auks). These are not considered here, and thus calculated densities for both species are somewhat underestimated.

During aerial surveys, the highest density was recorded in April 2022 with 0.73 ind./km². During ship-based surveys, the highest density was recorded in September 2022 with 1.67 ind/km² (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.25).

Common Guillemots were widely distributed across the study area, especially during autumn (ship-based surveys) and winter (aerial surveys, Figure 3.26, Figure 3.27). The highest densities were mainly found in some distance from the coast, in deeper waters, and indviduals were also recorded inside the planned OWF, at relatively high densities during both ship-based and aerial surveys.

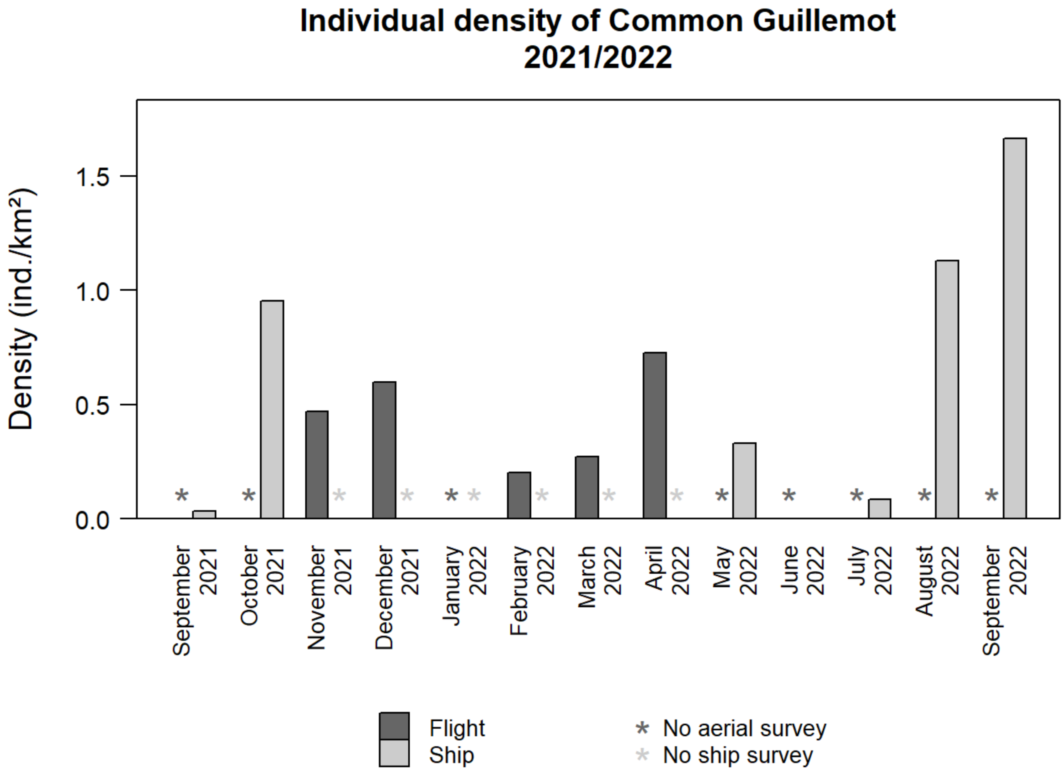

Figure 3.25 Monthly densities of Common Guillemots during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

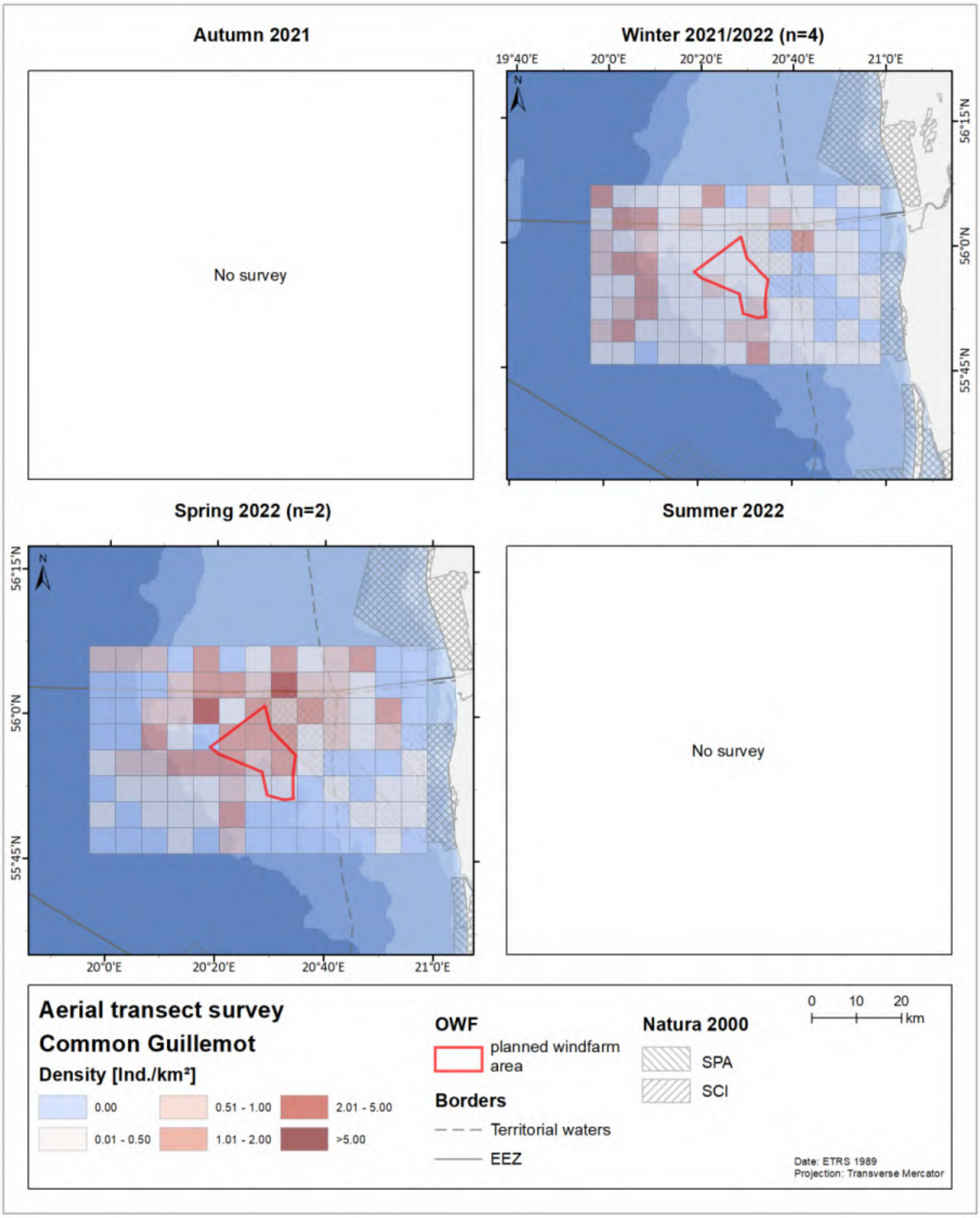

Figure 3.26 Distribution of Common Guillemots in the survey area during the digital aerial surveys between November 2021 and April 2022.

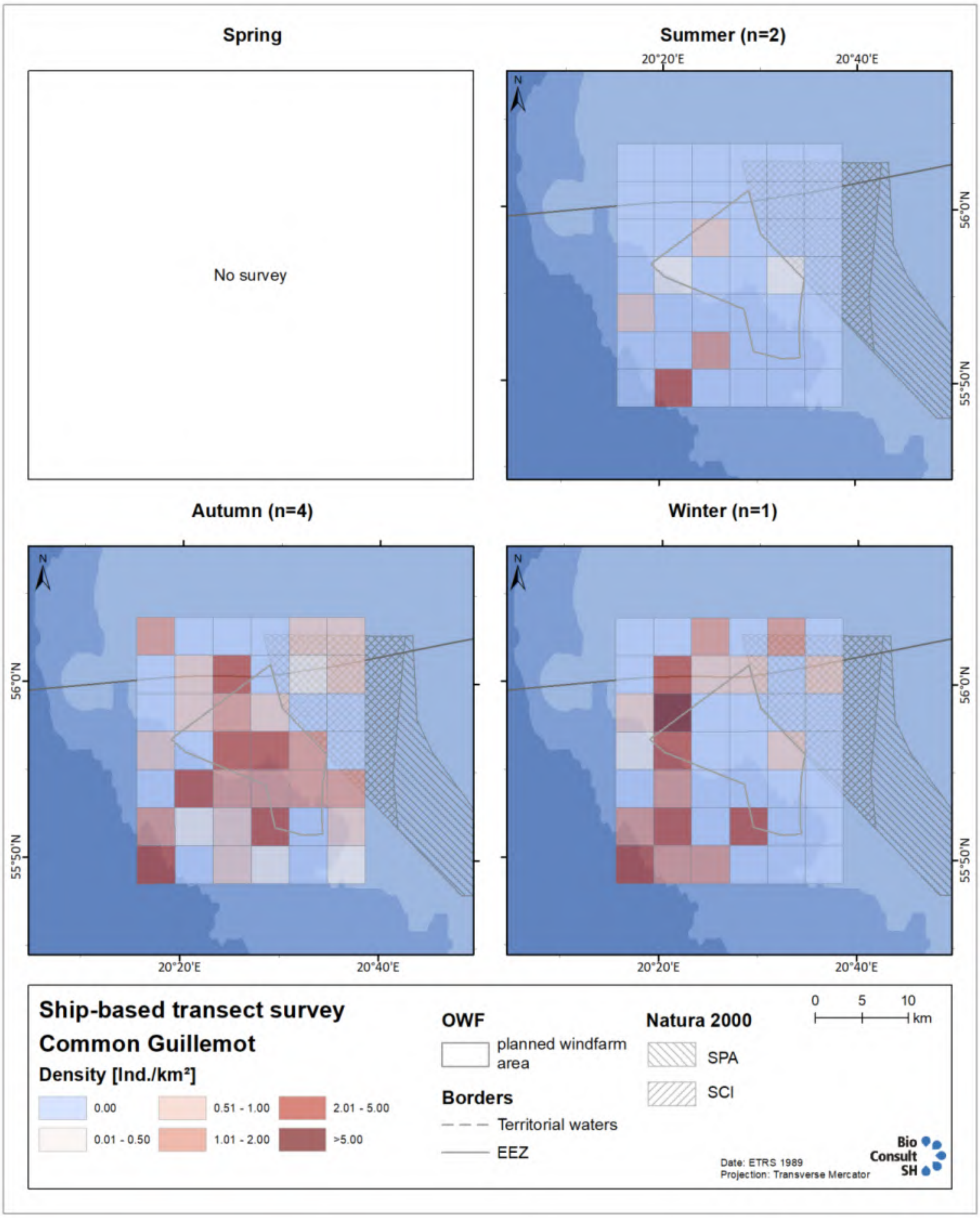

Figure 3.27 Distribution of Common Guillemot in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

3.2.10 Razorbill

Razorbill – *Alca torda*	**LI: Alka**
Biogeographic population: *torda*, E Atlantic	
Breeding range: -	
Wintering / core non-breeding range: -	
Population size: 290,000 – 350,000	
1% value: 13,800-	
Conservation status:	EU Birds Directive, Annex I: not listed EU SPEC Category: 1 IUCN Red List Category: LC (Global & Europe)
Trend: INC	Trend quality: Reasonable
Key food: mainly fish	

Razorbills are distributed in the Holarctic from North Europe to the East and West coasts of the Atlantic. They are adapted to life at sea and spend their whole life in the marine environment (like the Common Guillemot). They breed mainly on edges of steep cliffs or on small isolated islands and most often in large colonies (MENDEL et al. 2008a). There are two subspecies of Razorbills and three populations. The subspecies *torda*, is the one that occurs in the survey area. The size of the breeding 'East Atlantic' biogeographical population is estimated at 290,000-350,000 individuals for the period between 2008 and 2018. In total, however, the European population might range between 519,000 - 1,070,000 individuals according to BirdLife International (2021). The diet of Razorbills is dominated by fish, especially sprats which also constitutes the major component of the diet of its chicks (Lyngs, 2001). Like Common Guillemots, Razorbills have been found to avoid OWF, but the extent of avoidance varied (DIERSCHKE et al. 2016).

Density and distribution of Razorbill in the survey area

During the digital aerial surveys between November 2021 and April 2022 a total of 521 Razorbills were recorded whereas during the seven ship-based transect surveys between September 2021 and September 2022 (excluding the months between Nov 21 until April 22) 65 individuals were observed within the transect area (Table 3.1). As mentioned previously, also 137 unidentified auks (or Common Guillemot/Razorbill) were observed (14.9% of all auks) during aerial surveys. These are not considered here, and thus calculated densities for this species are probably somewhat underestimated.

During aerial surveys, the highest density was recorded in March 2022 with 0.54 ind./km². During ship-based surveys, the highest density was recorded in October 2021 with 1.28 ind/km² (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Figure 3.28).

During aerial surveys, Razorbills were distributed across the whole study area, but with somewhat higher densities in some distance from the coast, in deeper waters. During ship-based surveys, occurence seemed more patchy during winter, but also here the highest density (>5 ind./km²) was reached on the western edge of the survey area. In lower densities Razorbills were also recorded inside the planned OWF.

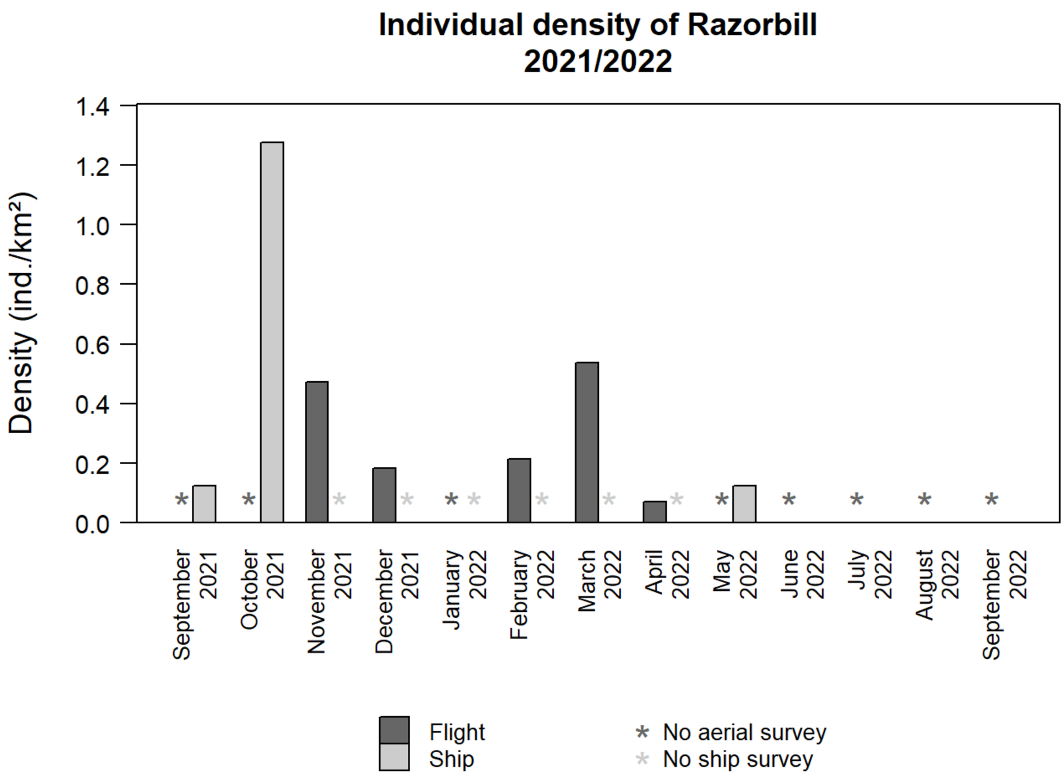

Figure 3.28 Monthly densities of Razorbills during aerial and ship-based transect surveys in the survey area between September 2021 and September 2022.

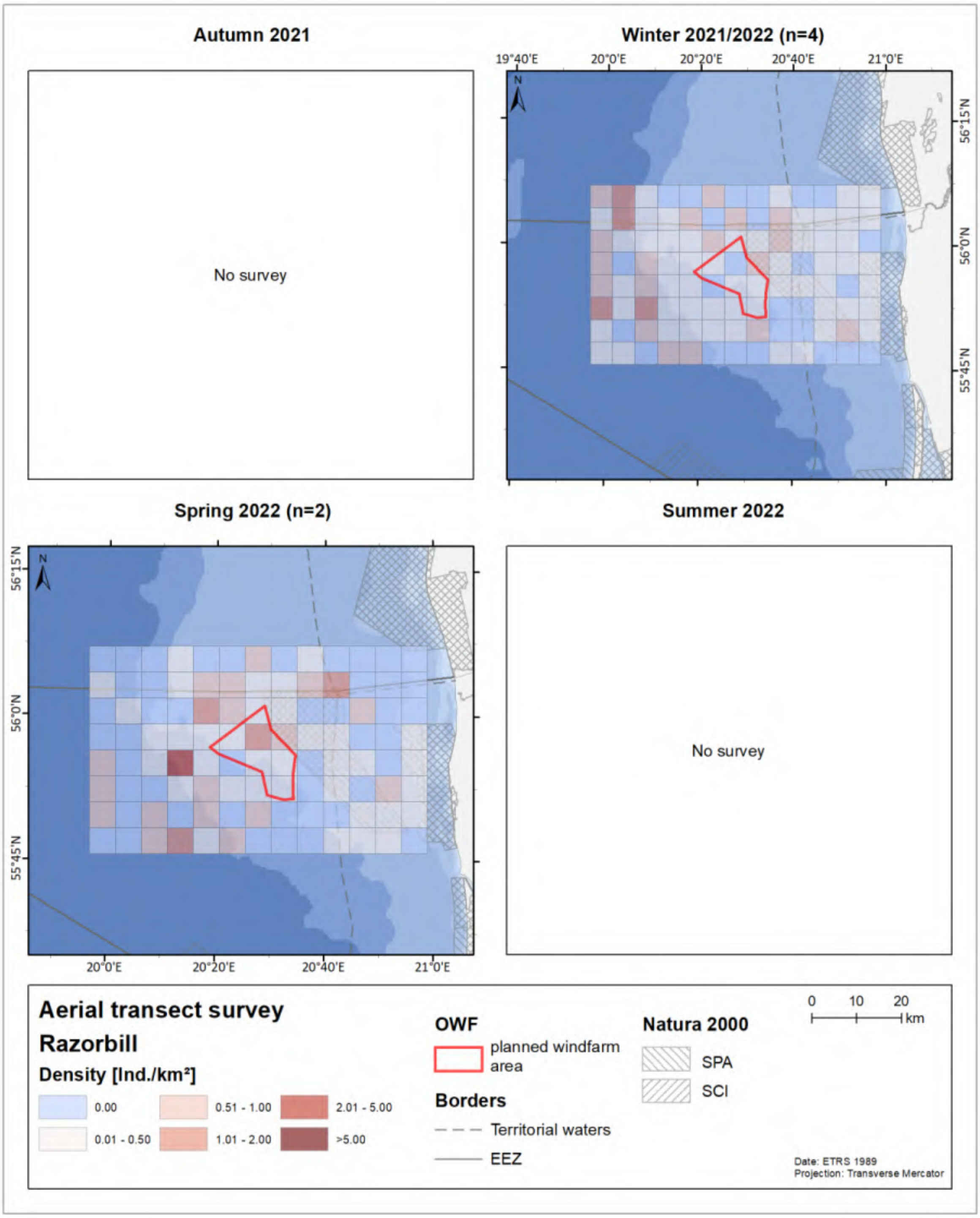

Figure 3.29 Distribution of Razorbills in the survey area during the digital aerial surveys between November 2021 and April 2022.

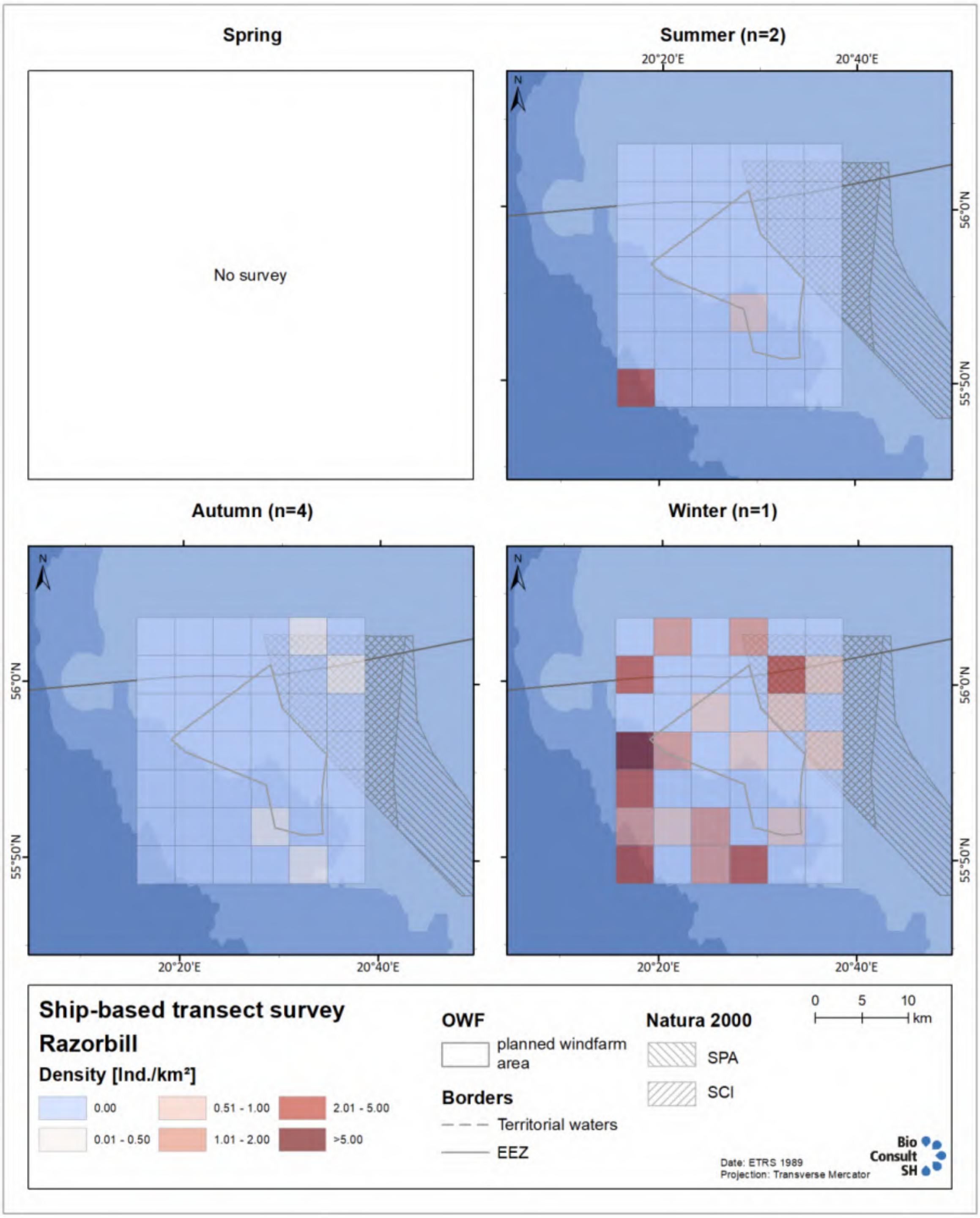

Figure 3.30 Distribution of Razorbills in the survey area per season during the ship-based transect surveys between September 2021 and September 2022.

4 DISCUSSION

4.1 Critique of methods

Data was collected during 6 digital aerial surveys and 7 ship-based surveys from September 2021 to September 2022. The two methods each have advantages and disadvantages. For example, during aerial surveys, a very large area can be covered with a uniform collection effort, while the ship survey area is usually relatively small. Moreover, animal movement and deterrence effects are known from ships (FLIESSBACH et al. 2019b), while they are negligible for digital aerial surveys, since disturbance to birds from a high-flying airplane is minimal (ŽYDELIS et al. 2019). One of the drawbacks of digital aerial surveys is however related to the identification of dark or small species such as Razorbills, Guillemots, and Common and Arctic Terns, which may be difficult to detect on the images and/or distinguish from each other. During ship surveys, these species can often be distinguished more easily. These differences need to be taken into account when comparing bird densities between ship and aerial surveys.

Many factors can influence the distribution and the seasonal occurrence of resting birds. These include environmental factors such as season, local weather conditions during the collection date and preceding days, feeding resources and anthropogenic factors such as fishing and shipping. Furthermore, each survey is conducted over a short period of time and over a relatively small area, when compared to the Baltic Sea as a whole. It only represents a snapshot of what is happening, and a high degree of temporal and spatial variability is expected. Consequently, any short-term population shift away from or into the survey area can lead to considerable fluctuations in the population estimates of the species under consideration.

4.2 Species abundance and distribution

The results of the ship-based and digital aerial surveys during the first year of the study were largely in line with expectations, but also showed a few unexpected patterns. Water depth in the study area varied, with greater water depth towards the West, and this was also reflected in the species range and distribution.

The study area included (only partly for ship surveys) the Special Protection Area (SPA) "Klaipėdos–Ventspilio plynaukštė", which extends to the east of the planned OWF area (EUROPEAN ENVIRONMENT AGENCY 2015). The SPA was designated for the protection of reefs, and as a place of regular wintering aggregations of Long-tailed Ducks, Velvet Scoters and Razorbills The standard data form also gives site evaluations for the species Red-throated Diver and Common Guillemot.

In the Baltic Sea, **divers** are found as winter visitors and migrants (MENDEL et al. 2008b). In Lithuanian waters, a key wintering area for the Red-throated Diver is located at the coast of Lithuania and reaching further North, with a core area off the Latvian coast (SKOV et al. 2011). In the SPA standard data form, a low density of only between 0.06 and 0.16 ind./km² is given. During aerial surveys, medium densities of Red-throated Divers were found within the study area. The highest densities were found during late winter (February) and during spring. Divers were found distributed across the whole study area during winter and concentrated in the eastern half of the area during spring, but still including the OWF footprint. Given the rather average densities (max. 0.57 ind./km²), the study area does not seem to be of high importance to this species. Nevertheless, as divers react very sensitive to anthropogenic disturbances like OWF, with displacement distances of up to 10-15 km in some studies (DIERSCHKE et al. 2016; MENDEL et al. 2019; HEINÄNEN et al. 2020), also individuals resting within the nearby SPA will likely be disturbed by the planned OWF.

Sea ducks were mainly recorded during aerial surveys, as these covered the relevant time period (no ship surveys during winter and early spring) and the study area also reached far to the east, into shallower waters. Of the sea duck species, **Long-tailed Ducks** were the second most abundant species. In general, the coasts of Lithuania are important wintering areas for this species, although the highest densities are reached in other parts of the Baltic Sea (SKOV et al. 2011). During aerial surveys, Long-tailed Ducks were frequently recorded in medium densities of up to 2,8 ind./km². In the SPA standard data form, a density of between 6.3 and 23.2 ind./km² is given. As expected, most birds were recorded within the SPA, but in some cases also within the borders of the planned OWF. Long-tailed Ducks have been shown to avoid wind farms and are sensitive to ship traffic, which might lead to habitat loss (DIERSCHKE et al. 2016). Although displacement distances vary somewhat, some habitat loss within the SPA can be expected with the currently planned OWF.

Velvet Scoters were the most abundant species during aerial surveys, with high densities during December and February (up to 9.21 ind./km²). In the SPA standard data form, a density of between 31.3 and 89.8 ind./km² is given and thus, the highest densities in this study would be expected within the SPA. However, especially during the surveys in December and February, rather high numbers of birds were recorded outside of the SPA, within the planned OWF area and just to the West, in an area of deep water > 30 m. This finding is in contrast to studies reporting Velvet Scoters occurring in water depth between 10 and 30 m (SKOV et al. 2011). In the present study, Velvet Scoters were absent only on the westernmost transect lines, with even deeper water. During the aerial surveys, birds appear to have shifted their expected occurrence from within the SPA more towards the West. It is however unclear, whether the observed distribution is a frequent pattern also in other years and this would require further investigations. As Velvet Scoters are sensitive to anthropogenic disturbances (DIERSCHKE et al. 2016), birds are expected to be displaced from the area of the planned OWF as well as from parts of the SPA, which borders the planned OWF area.

Of all gull species recorded during the surveys, **Little Gull** was by far the most abundant species. However, this was due to high densities during two ship surveys in autumn 2022, where a maximum of 36.1 ind./km² was recorded. No aerial surveys were conducted during this time period. Little Gulls were distributed across the whole ship study area, including the planned OWF area. As high densities were recorded during two subsequent surveys, birds seem to make consistent use of the area in autumn, although the area has not been identified as an important area by Durinck et al. (1994). More data would thus be needed to estimate the importance as a resting area for Little Gulls. As this species shows weak avoidance behaviour towards OWF, some displacement from the planned OWF area can be expected.

Of the auks, **Common Guillemots** were recorded in the study area more often than **Razorbills**, especially during ship surveys. During aerial surveys, about 15% of auks could only be identified as Common Guillemot/ Razorbill (only one unidentified auk during ship surveys). Common Guillemots occurred in the area almost throughout the year with varying densities, while the occurrence of Razorbills was more limited to the winter half of the year with no records between June and August.

Both species were distributed across the whole study area, with lower numbers closer to the coast and higher numbers far offshore in the western part of the study area. In the SPA standard data form, both species are listed to occur with a maximum number of 100 individuals and thus a density of 0.3 ind./km². The maximum densities in this study were found during ship surveys, and these densities were much higher, with max. 1.67 ind./km² (Common Guillemot) and 1.28 ind./km² (Razorbill), suggesting that the study area is of some importance for these species. Durinck et al. (1994) also listed the Lithuanian coast as an important location for Razorbills (not for Common Guillemots) with densities between 0.1 and 0.99 ind./km². As both species show avoidance of OWF, with varying distances, birds are expected to be displaced from the area of the planned OWF as well as parts of the SPA at the border the planned OWF area.

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A APPENDIX

A.1 Species Lists

*Table A. 1 Overview of the total number of registered species in the aerial survey area from November 2021 to April 2022 , including number of individuals and indications of the status of the species in the area (Resting/Migration [R/M]: Species that can occur as resting and migrating birds in the survey area; Migration [M]: Species, that occur as migrating birds only) as well as conservation or hazard categories (VSchRL: EU Bird Directive, Annex I; EUR-Gef: European Red List Category; EU27-Gef.: EU27 Red List Category (Status: 2017); AEWA: Categories of the Agreement on the Conservation of African-Eurasian Migrants (Status: 2019); Red List Lithuania: *indicates that the species is listed (https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/9f3de7d2aa8811ea8aadde924aa85003, accessed 13.10.2022).*

Species	Name in Lithuanian	Status	Ind. ∑	EU Directive	EUR-Cat.	EU28-Cat.	AEWA	Red List Lithuania
Red-throated Diver	Rudakaklis naras	R/M	576	Annex I	LC	LC	C (1)	
Black-throated Diver	Juodakaklis naras	R/M	33	Annex I	LC	LC	B 2c	*
unidentified diver		R/M	58					
Great Crested Grebe	Ausuotasis kragas	R/M	5		LC	LC	C 1	
Slavonian Grebe	Raguotasis kragas	R/M	1	Annex I	NT	VU	A 1b	*
Red-necked/Great Crested Grebe		R/M	4					
Slavonian / Black-necked Grebe		R/M	1					
Great Cormorant	Didysis kormoranas	R/M	12		LC	LC	C1	
Bean Goose	Želmenine žasis	M	17		LC	VU	A 3c	
Greylag Goose	Pilkoji žasis	M	6		LC	LC	C1 / B 1	
Mallard	Didžioji antis	M	21		LC	LC	C 1c	
Greater Scaup	Žiloji antis	M	23		LC	EN	B 2c	
King Eider	Skiauteretoji gaga	R/M	1		LC	N/A	C 1	
Long-tailed Duck	Ledine antis	R/M	2,859		LC	LC	A 1b	*
Common Scoter	Juodoji antis	R/M	26		LC	N/A	B 2a	
Velvet Scoter	Paprastoji nuodegule	R/M	7,763		VU	VU	A 1b	*
Common/Velvet Scoter		R/M	103					
Common Goldeneye	Paprastoji klykuole	M	4		LC	LC	C 1	
Red-breasted Merganser	Vidutinis danciasnapis	M	6		NT	NT	A 3cc	*
Goosander	Didysis danciasnapis	M	11		LC	LC	C 1	

Species	Name in Lithuanian	Status	Ind. ∑	EU Directive	EUR-Cat.	EU28-Cat.	AEWA	Red List Lithuania
unidentified duck		M	1					
Common Kestrel	Paprastasis pelesakalis	M	1		LC	LC		*
Little Gull	Mažasis kiras	R/M	625	Annex I	LC	LC	B 1	*
Black-headed Gull	Rudagalvis kiras	R/M	11		LC	VU	B 2c	
Common Gull	Paprastasis kiras	R/M	108		LC	LC	C 1	
unidentified small gull		R/M	13					
Lesser Black-backed Gull	Silkinis kiras	R/M	4		LC	LC	C 1	
Herring Gull	Sidabrinis kiras	R/M	288		LC	VU	B 2c	
Common/ Herring Gull		R/M	2					
Great Black-backed Gull	Balnotasis kiras	R/M	5		LC	NT	C 1	
Black-legged Kittiwake	Tripirštis kiras	R/M	3		VU	EN	A 1b	
unidentified large gull		R/M	7					
unidentified gull		R/M	10					
Sandwich Tern	Margasnape žuvedra	R/M	1	Annex I	LC	LC	C 1	
Tern/small gull		R/M	2					
Common Guillemot	Laibasnapis narunelis	R/M	762		LC	LC	C 1	
Common Guillemot/ Razorbill		R/M	228		LC	LC		
Black Guillemot	Taiste	R/M	2		LC	LC	C 1	
Razorbill	Alka	R/M	521		LC	LC	A 4	
unidentified auk		R/M	5					
Chaffinch	Paprastasis kikilis	M	84		LC	LC		
Unidentified finch		M	415					
unidentified songbird		M	941					
unidentified bird			142					
Total			**15,711**					

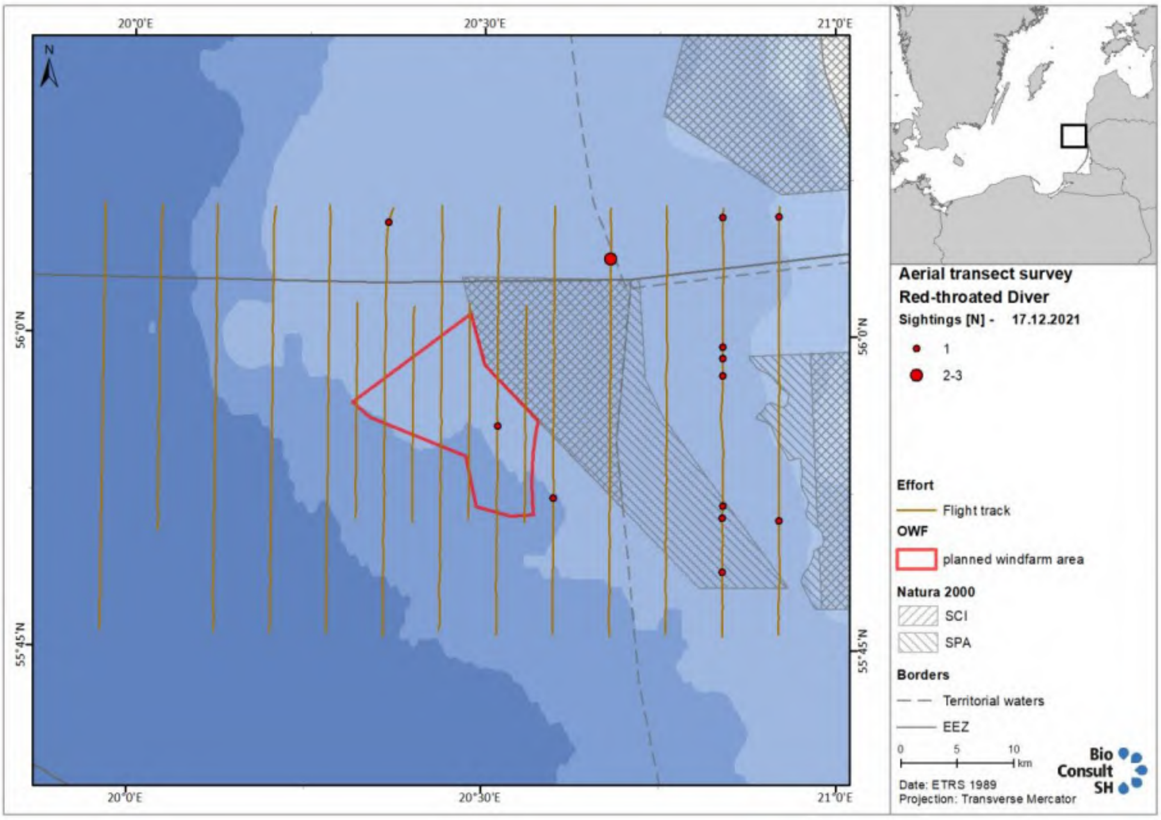
*Table A. 2 Overview of the total number of registered species in the ship-based survey area from September 2021 to September 2022 , including number of individuals (total and in transect) and indications of the status of the species in the area (Resting/Migration [R/M]: Species that can occur as resting and migrating birds in the survey area; Migration [M]: Species, that occur as migrating birds only) as well as conservation or hazard categories (VSchRL: EU Bird Directive, Annex I; EUR-Gef: European Red List Category; EU27-Gef.: EU27 Red List Category (Status: 2017); AEWA: Categories of the Agreement on the Conservation of African-Eurasian Migrants (Status: 2019); Red List Lithuania: *indicates that the species is listed (https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/9f3de7d2aa8811ea8aadde924aa85003, accessed 13.10.2022).*

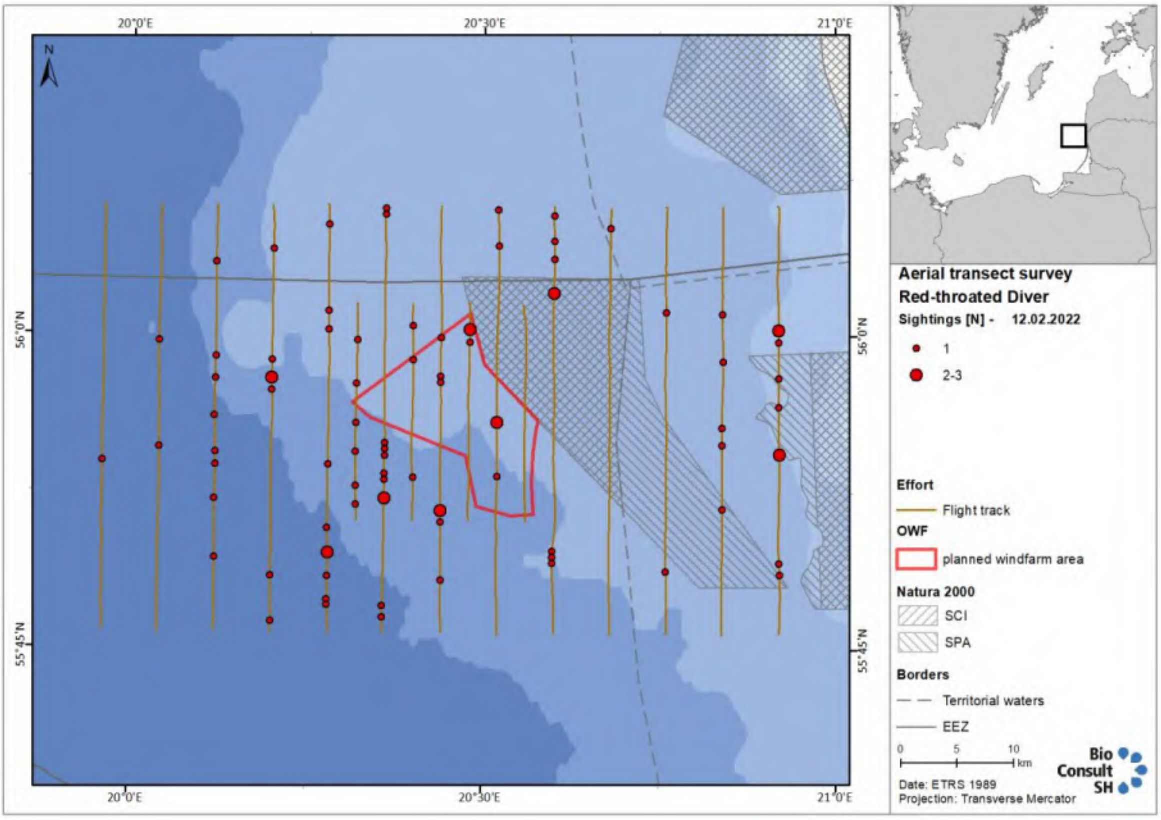
Species	Common name in Lithuanian	Status	Ind. ∑	Ind. transect	VSchRL	EUR-Cat.	EU28-Cat.	AEWA	Red List Lithuania
Red-throated Diver	Rudakaklis naras	R/M	18	12	Annex I	LC	LC	C (1)	
Black-throated Diver	Juodakaklis naras	R/M	44	27	Annex I	LC	LC	B 2c	*
unidentified diver		R/M	35	15					
Great Cormorant	Didysis kormoranas	R/M	49	5		LC	LC	C 1	
Greater White-fronted Goose	Baltakakte žasis	M	5	0	Annex I (ssp albifrons)	LC	LC	C 1	
Greater Scaup	Žiloji antis	M	2	0		LC	EN	B 2c	
Long-tailed Duck	Ledine antis	R/M	33	28		LC	LC	A 1b	*
Common Scoter	Juodoji antis	R/M	11	3		LC	N/A	B 2a	
Eurasian Golden Plover	Dirvinis sejikas	M	4	4	Annex I	LC	LC	B 2c	
Sanderling	Smiltinukas	M	10	10		LC	LC	C 1	
Ruddy Turnstone	Akmene	M	1	1		LC	EN	A 3c	
Little Gull	Mažasis kiras	R/M	3,975	3,307	Annex I	LC	LC	B 1	*
Black-headed Gull	Rudagalvis kiras	R/M	5	4		LC	VU	B 2c	
Common Gull	Paprastasis kiras	R/M	233	221		LC	LC	C 1	
Lesser Black-backed Gull	Silkinis kiras	R/M	45	36		LC	LC	C 1	
Herring Gull	Sidabrinis kiras	R/M	428	350		LC	VU	B 2c	
Great Black-backed Gull	Balnotasis kiras	R/M	1	1		LC	NT	C 1	
Common Tern	Upine žuvedra	R/M	2	0	Annex I	LC	LC	C 1	
Arctic Tern	Arktine žuvedra	R/M	18	9	Annex I	LC	LC	C1	
unidentified tern		R/M	1	1					
Common Guillemot	Laibasnapis narunelis	R/M	196	191		LC	LC	C 1	
Razorbill	Alka	R/M	65	65		LC	LC	A 4	
unidentified auk		R/M	3	1					
Short-eared Owl	Baline peleda	M	1	1	Annex I	LC	LC		*
Eurasian Skylark	Dirvinis vieversys	M	1	1		LC	LC		
Western Yellow Wagtail	Geltonoji kiele	M	6	6		LC	LC		
White Wagtail/ Pied Wagtail	Baltoji kiele	M	7	7		LC	LC		
unidentified wagtail		M	1	1					
European Robin	Liepsnele	M	4	4		LC	LC		

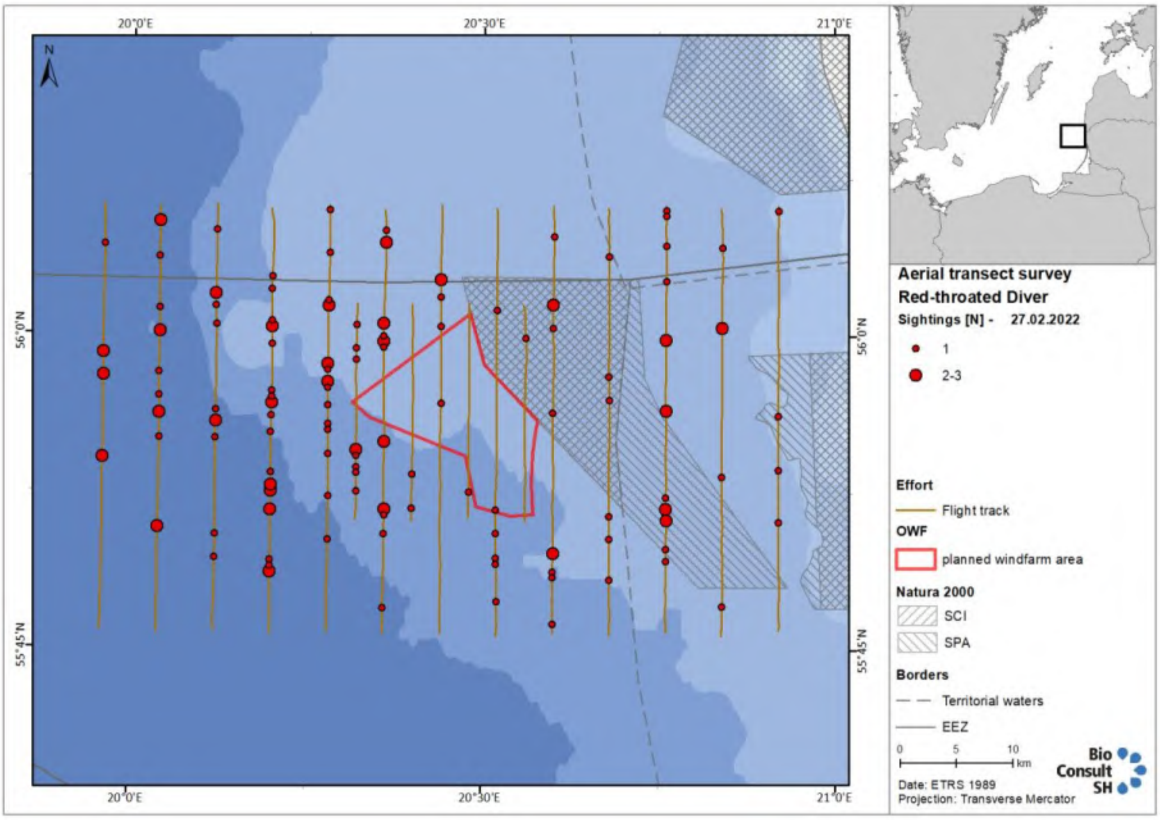
Species	Common name in Lithuanian	Status	Ind. ∑	Ind. transect	VSchRL	EUR-Cat.	EU28-Cat.	AEWA	Red List Lithuania
Goldcrest	Paprastasis nykštukas	M	2	2		LC	LC		
Total			**5,206**	**4,313**					

A.2 Species Distribution Maps Aerial Surveys

A.2.1 Red-throated Diver (*Gavia stellata)*



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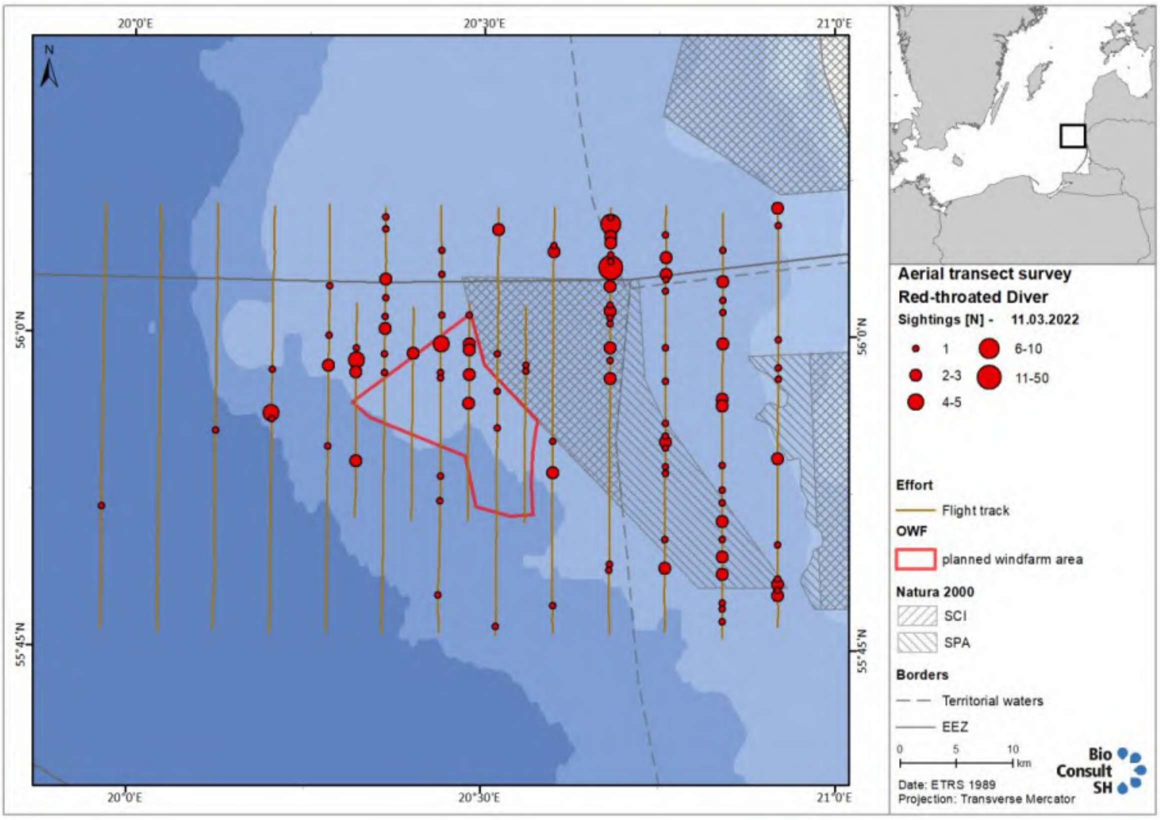
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Red-throated Diver
Sightings [N] - 27.02.2022
1
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator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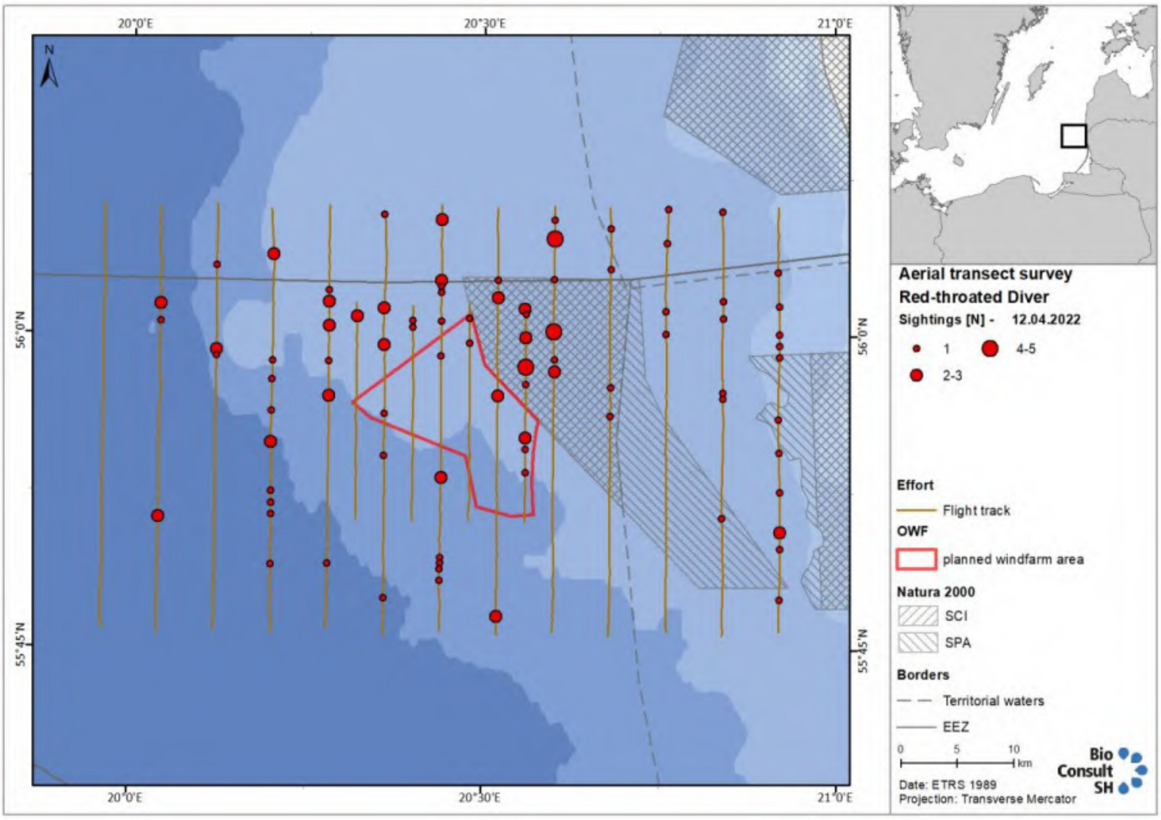
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Red-throated Diver
Sightings [N] - 11.03.2022
1
2-3
4-5
6-10
11-50
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator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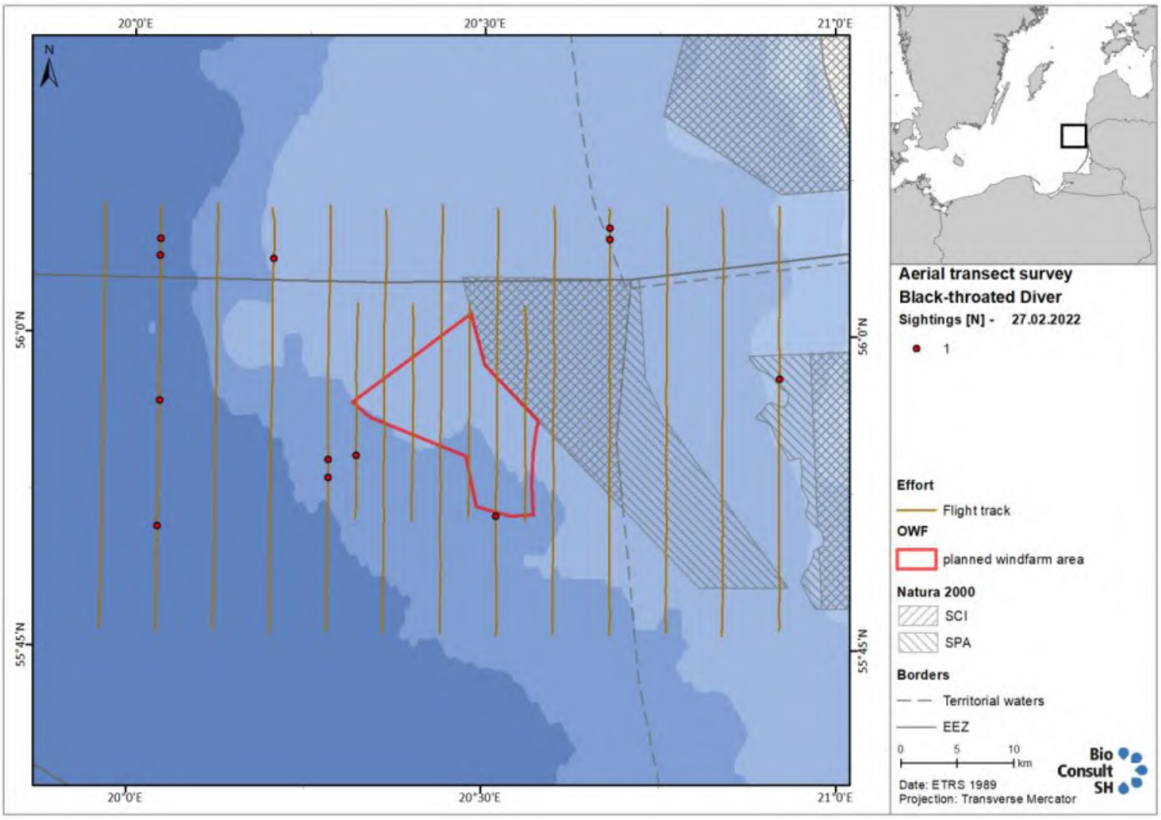
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Red-throated Diver
Sightings [N] - 12.04.2022
1
2-3
4-5
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

A.2.2 Black-throated Diver (*Gavia arctica*)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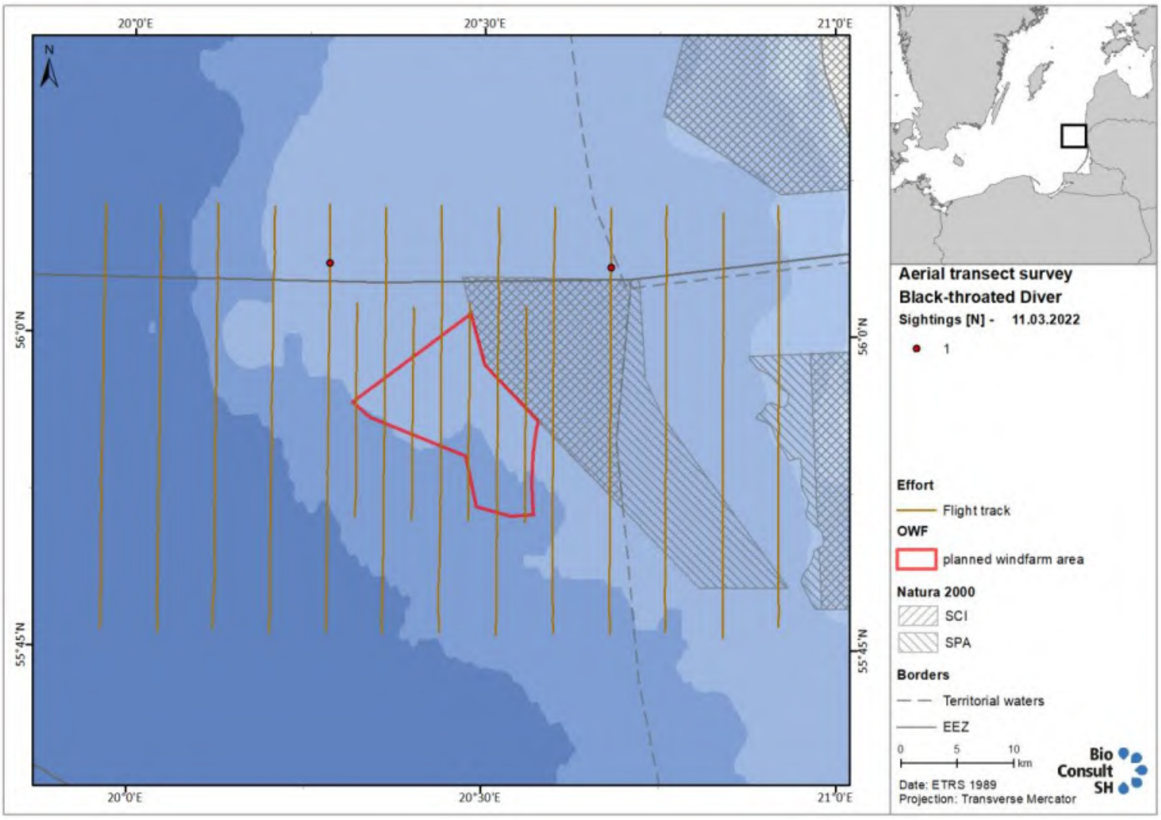
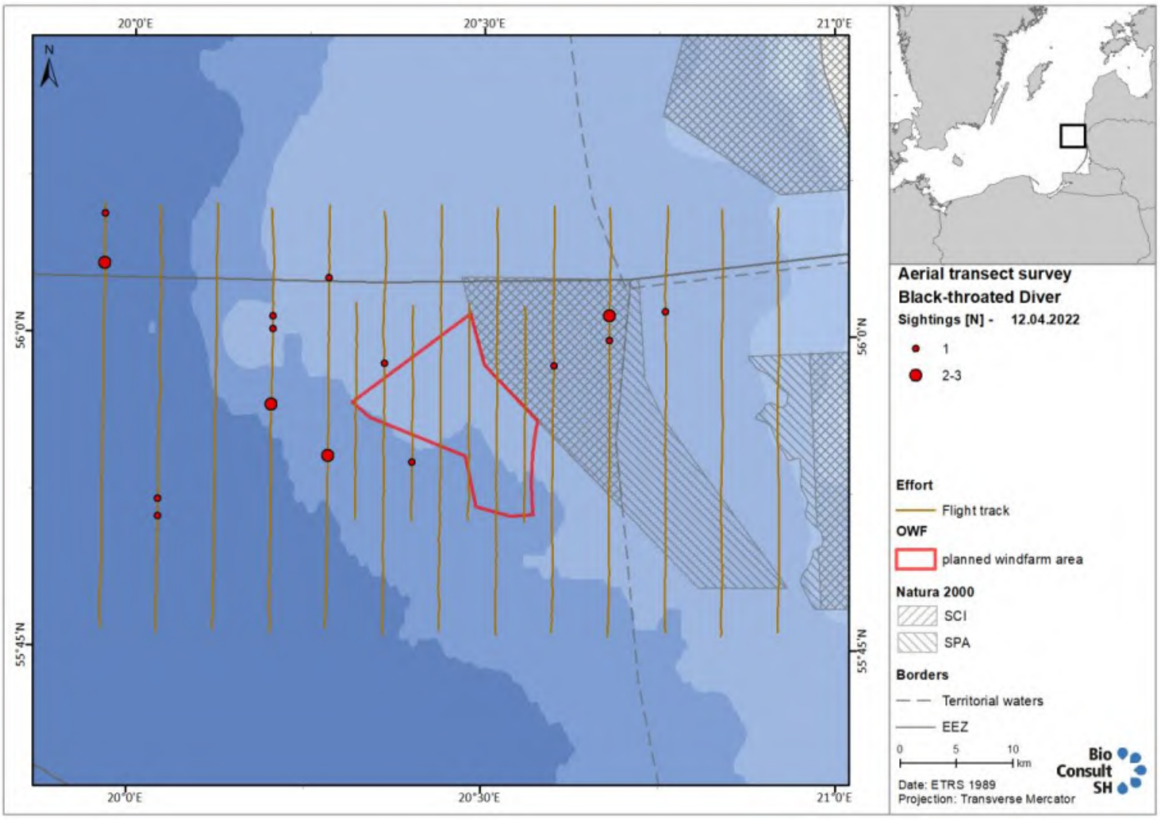
Black-throated Diver
Sightings [N] - 27.02.2022
1
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
Date: ETRS 1989
Projection: Transverse Mercator


Aerial transect survey
Black-throated Diver
Sightings [N] - 11.03.2022
1
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
Date: ETRS 1989
Projection: Transverse Mercator



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20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Black-throated Diver
Sightings [N] - 12.04.2022
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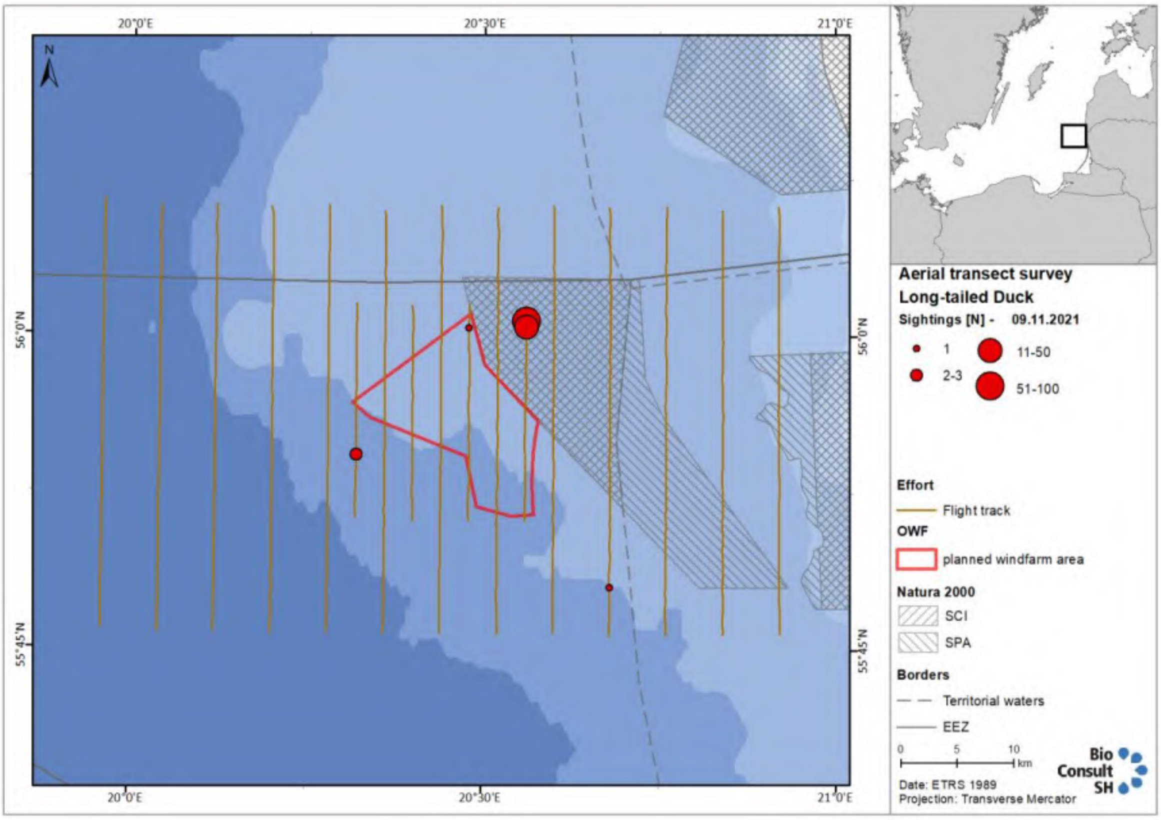
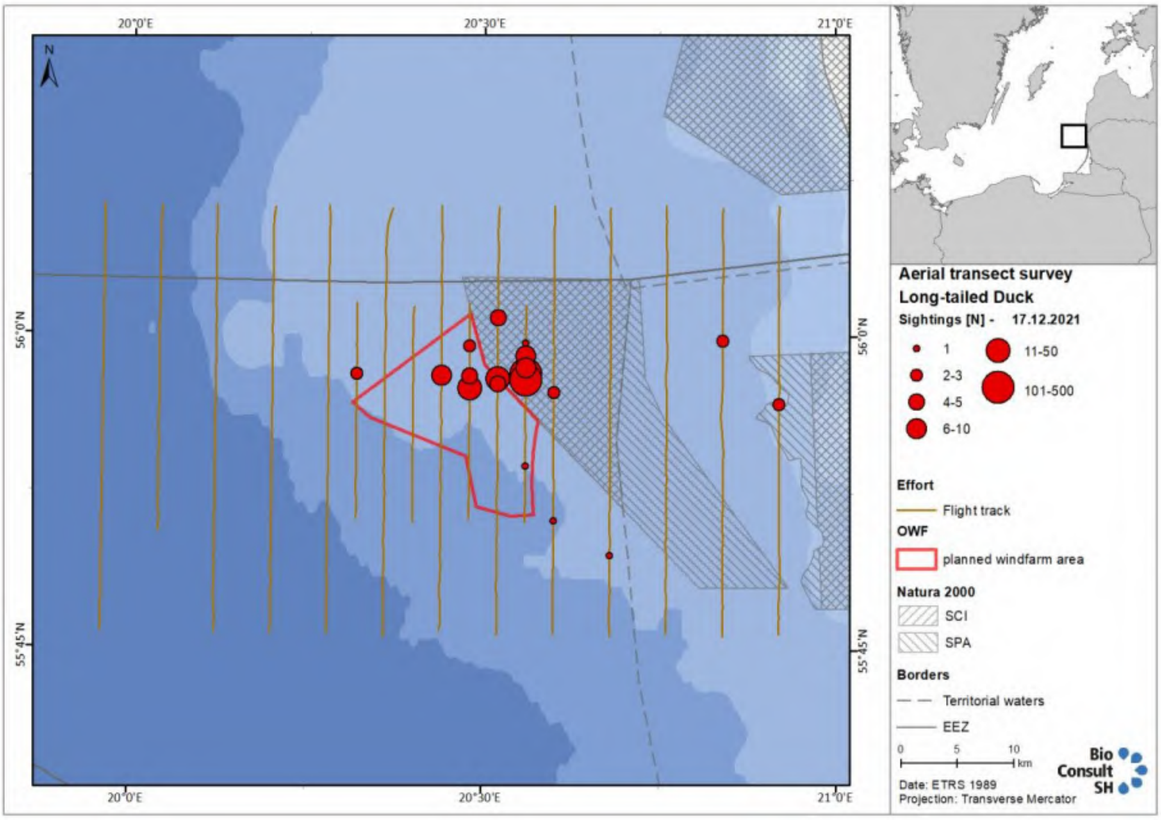
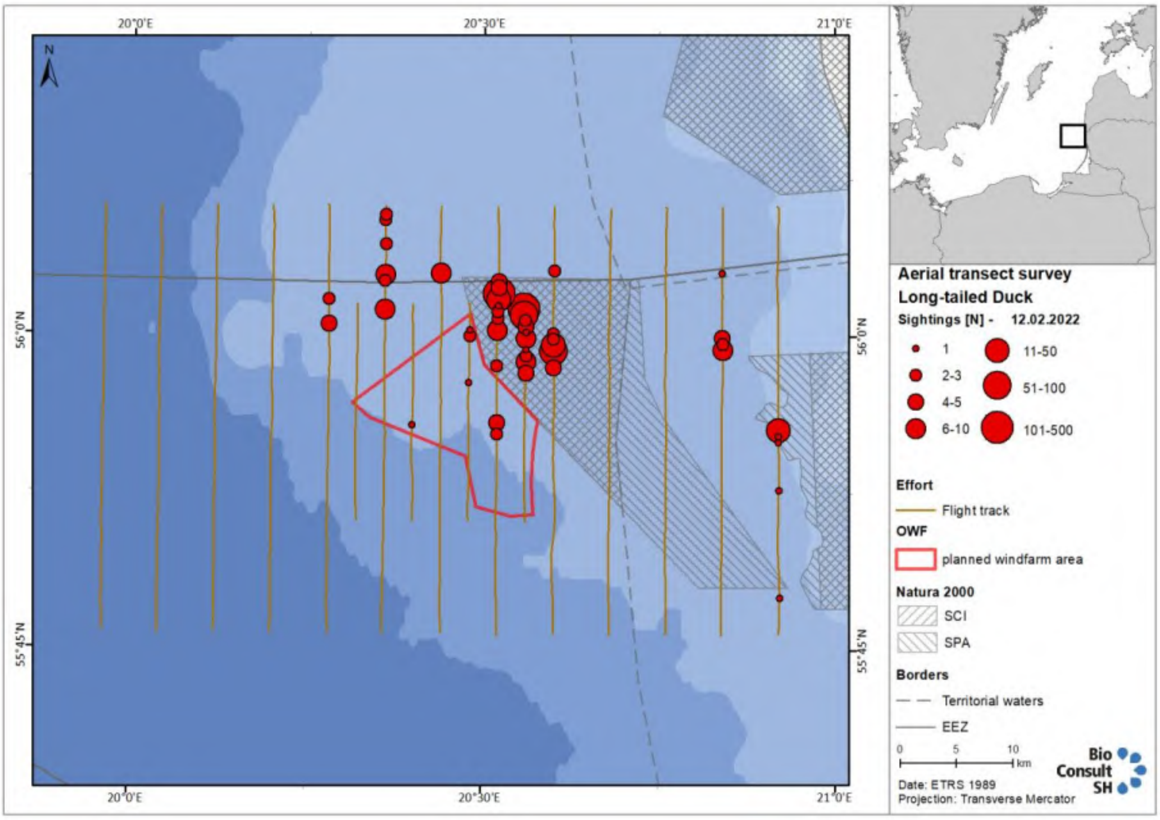
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Bio Consult SH
Date: ETRS 1989
Projection: Transverse Mercator

A.2.3 Long-tailed Duck (*Clangula hyemalis*)



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21°0'E
56°0'N
55°45'N
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Aerial transect survey
Long-tailed Duck
Sightings [N] - 12.02.2022
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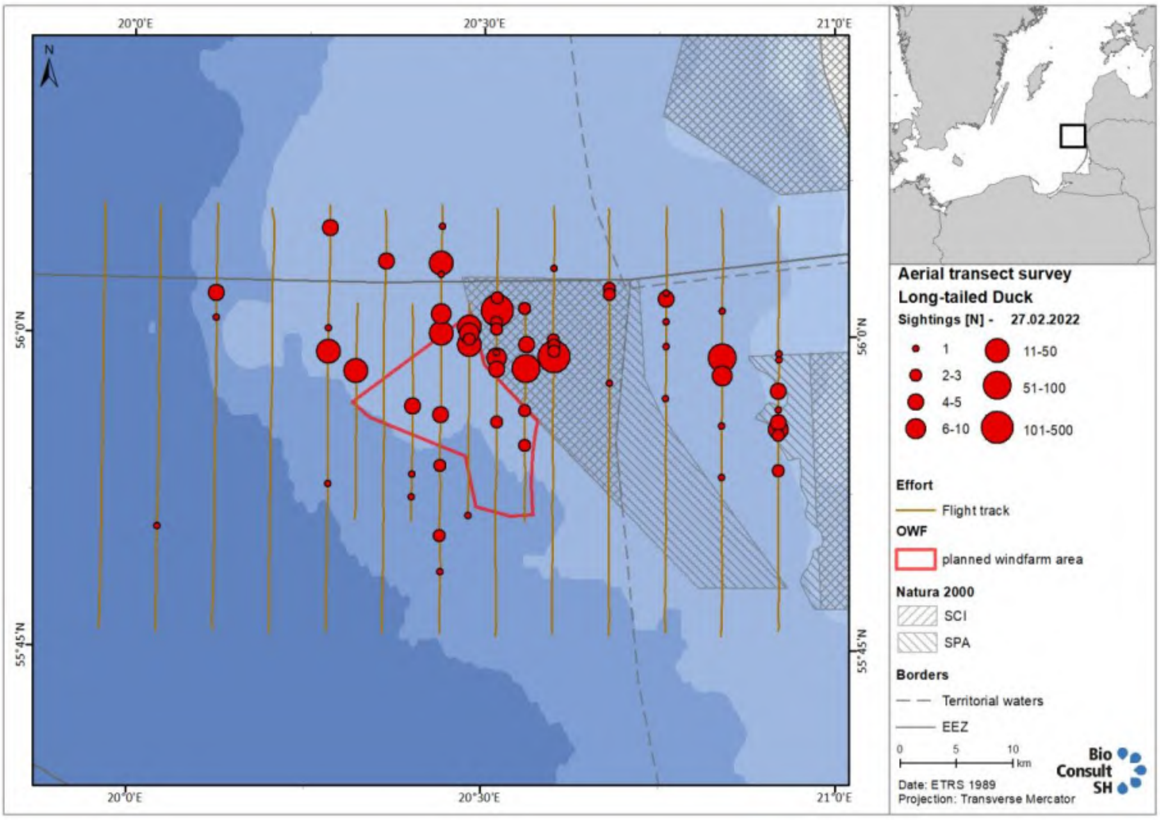
4-5
6-10
11-50
51-100
101-500
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH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56°0'N
55°45'N
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Aerial transect survey
Long-tailed Duck
Sightings [N] - 27.02.2022
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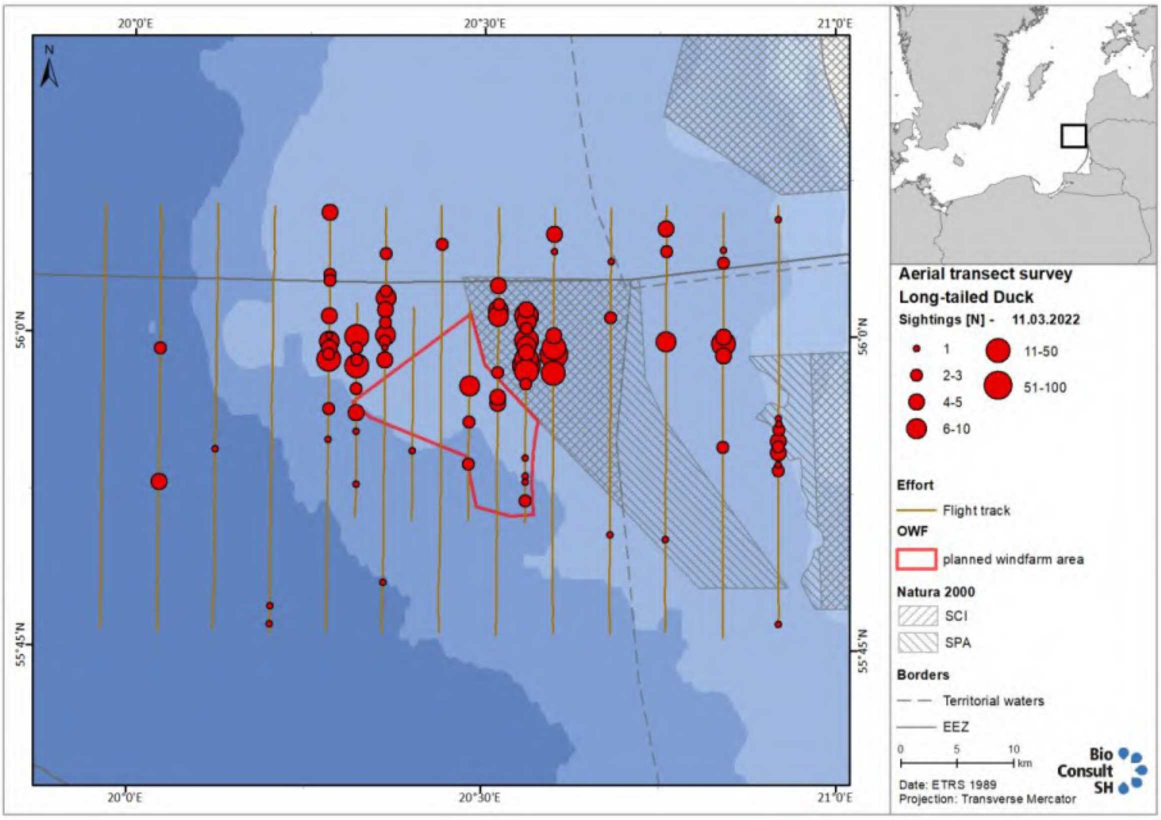
4-5
6-10
11-50
51-100
101-500
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH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Aerial transect survey
Long-tailed Duck
Sightings [N] - 11.03.2022
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Flight track
OWF
planned windfarm area
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SCI
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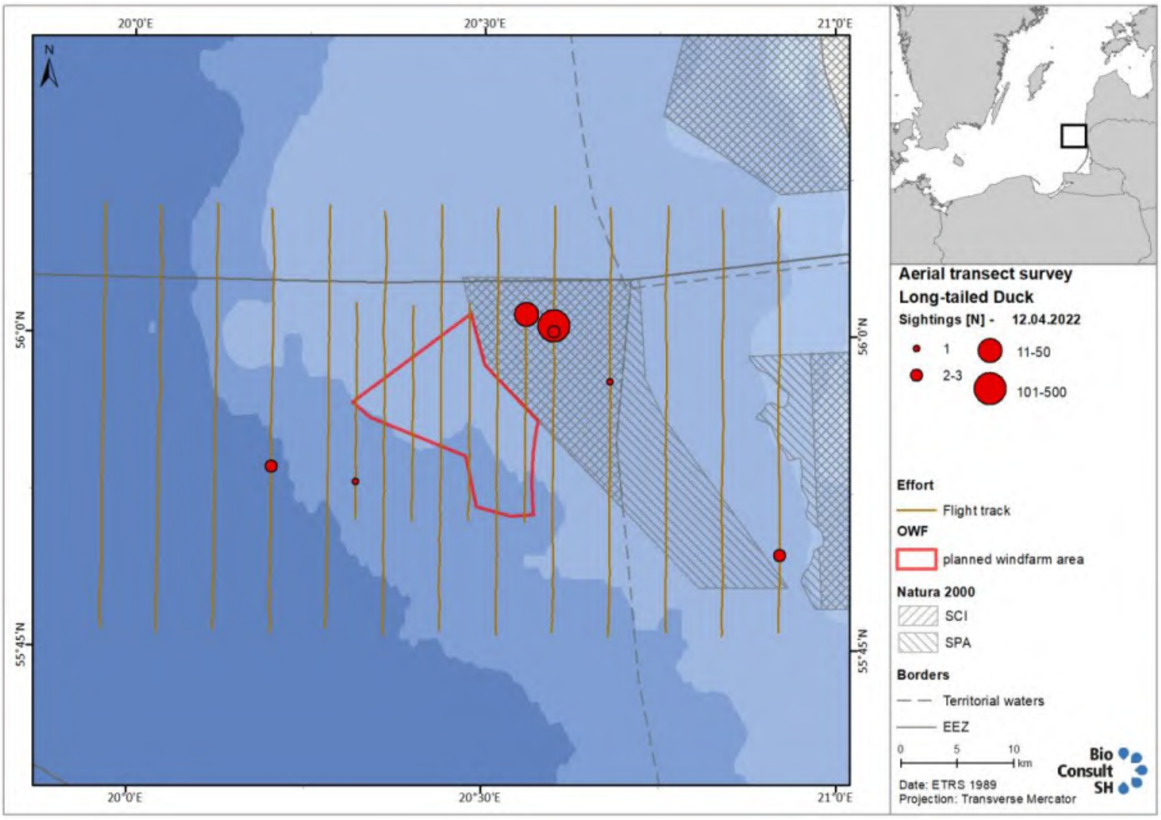
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH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Aerial transect survey
Long-tailed Duck
Sightings [N] - 12.04.2022
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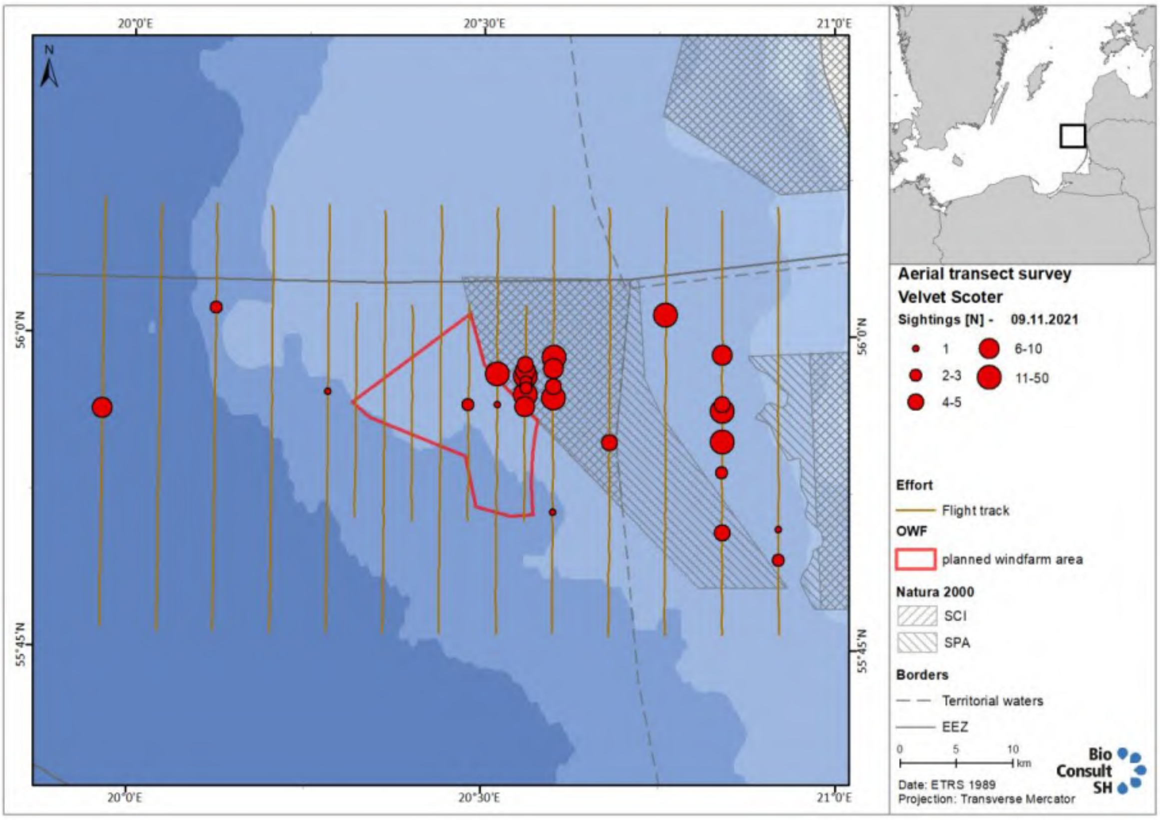
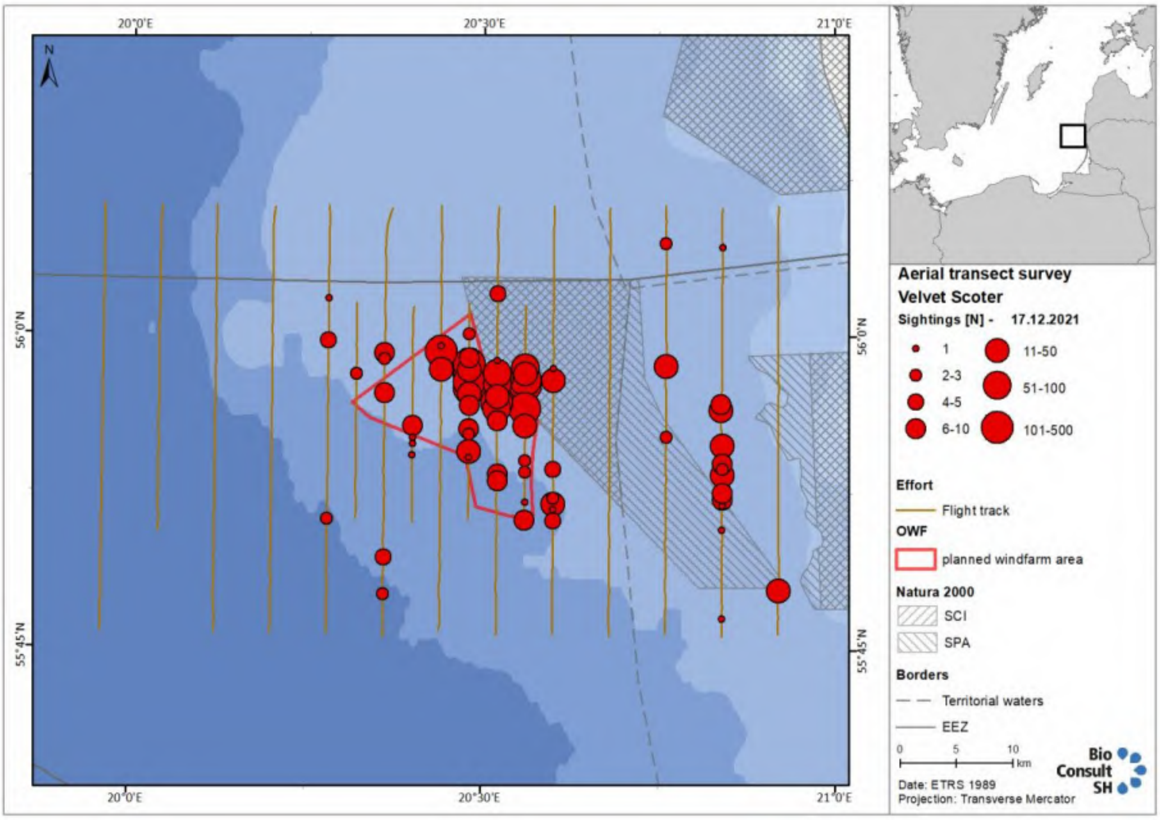
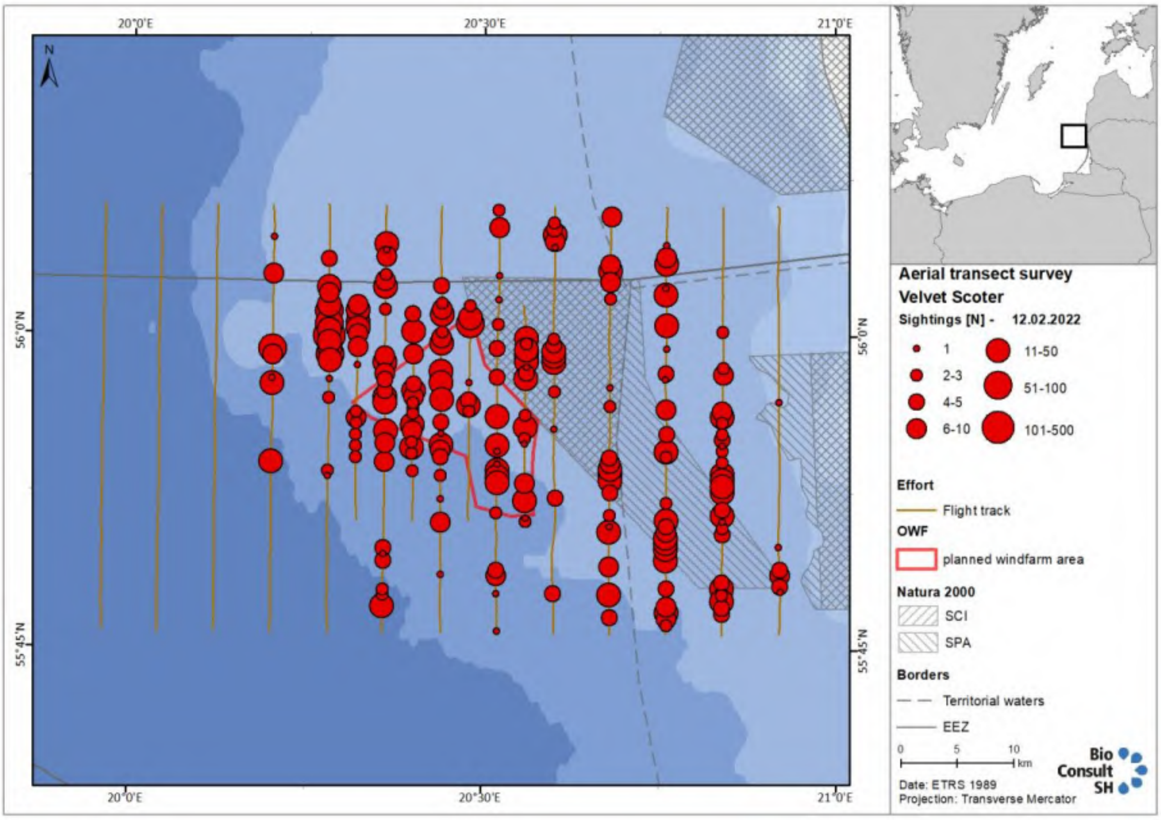
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

A.2.4 Velvet Scoter (*Melanitta fusca*)



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55°45'N
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Aerial transect survey
Velvet Scoter
Sightings [N] - 12.02.2022
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Flight track
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planned windfarm area
Natura 2000
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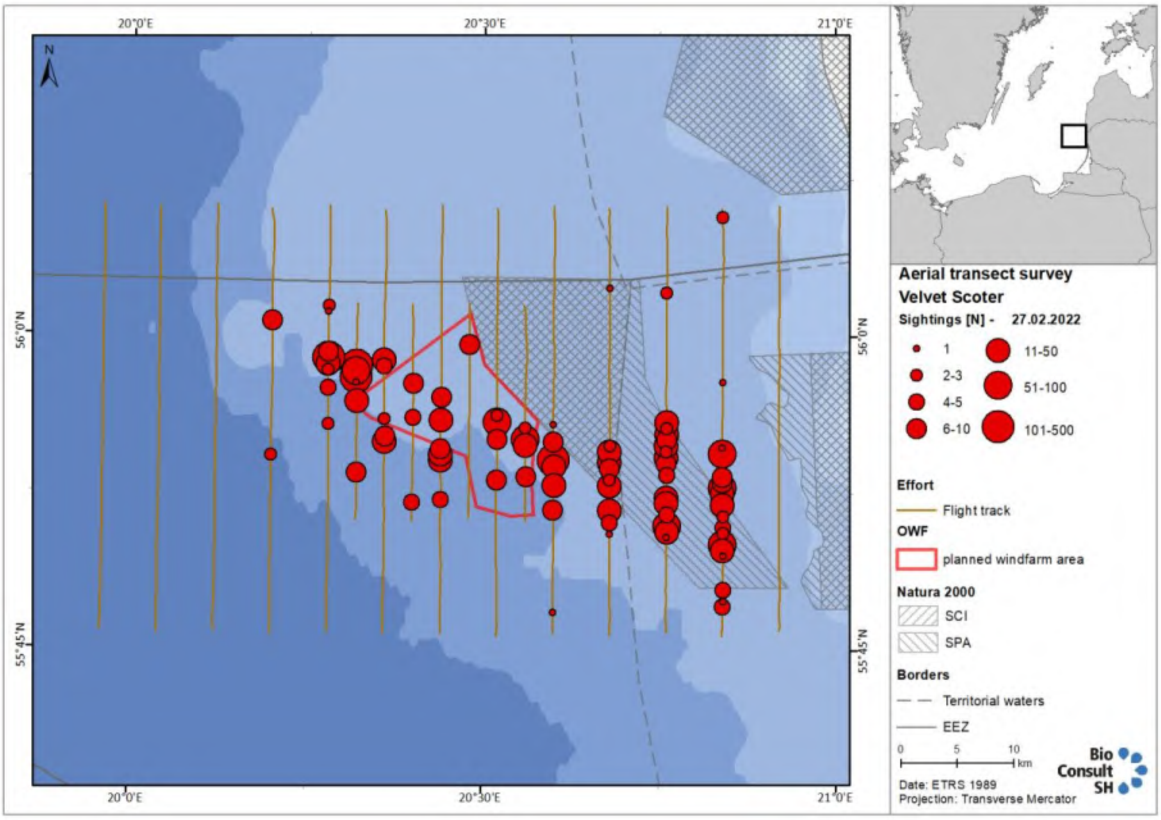
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH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Aerial transect survey
Velvet Scoter
Sightings [N] - 27.02.2022
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51-100
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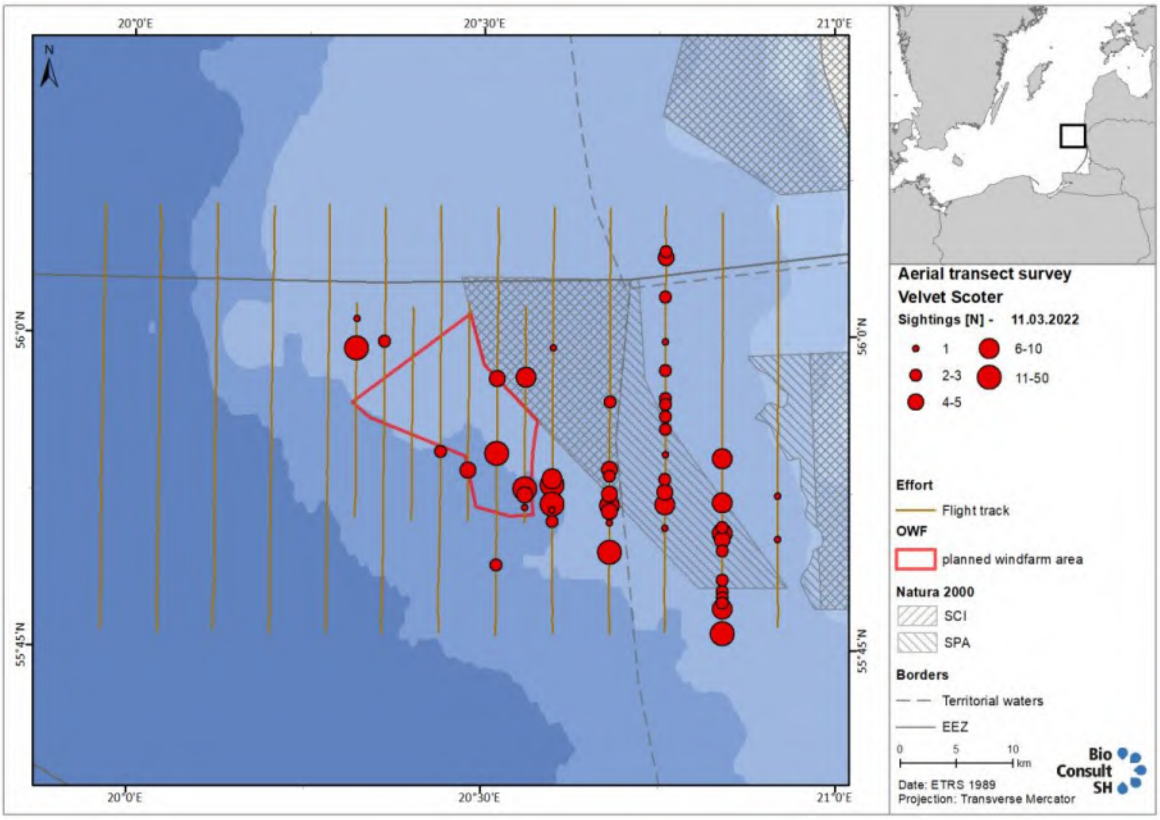
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH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21°0'E
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56°0'N
55°45'N
Aerial transect survey
Velvet Scoter
Sightings [N] - 11.03.2022
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Effort
Flight track
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planned windfarm area
Natura 2000
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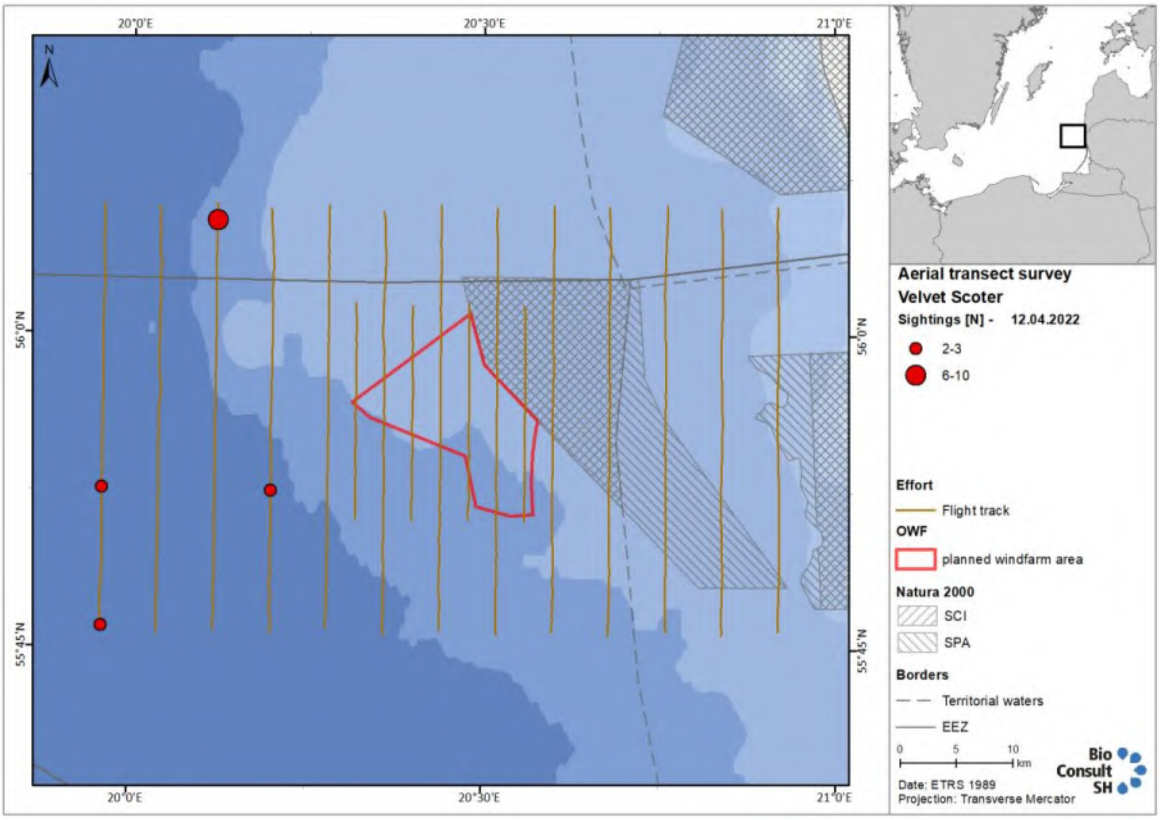
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator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Aerial transect survey
Velvet Scoter
Sightings [N] - 12.04.2022
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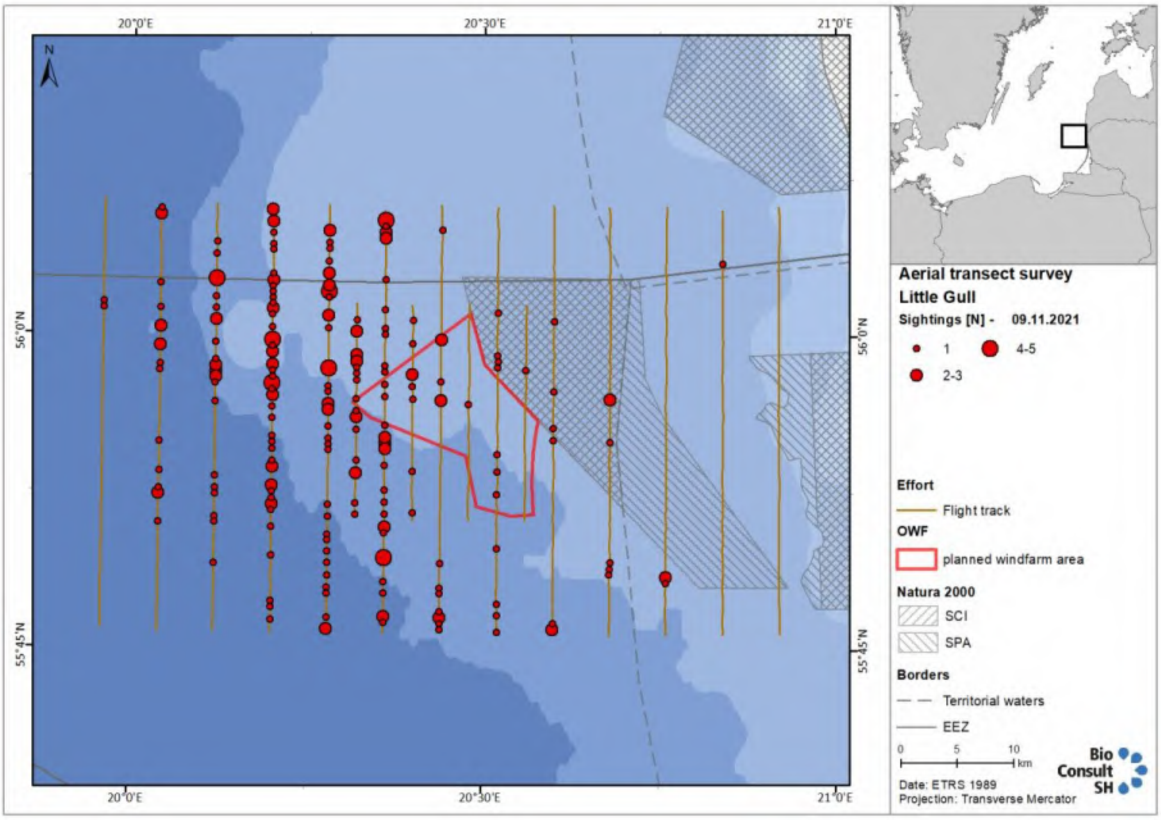
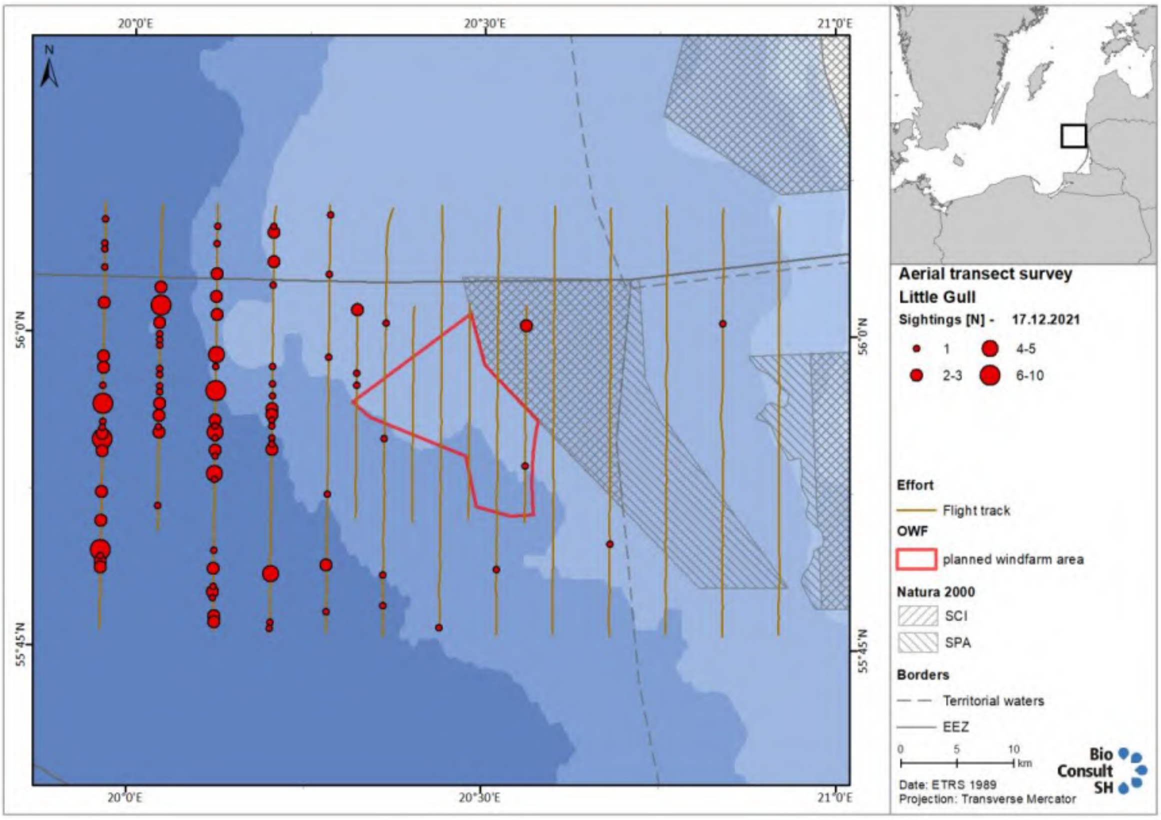
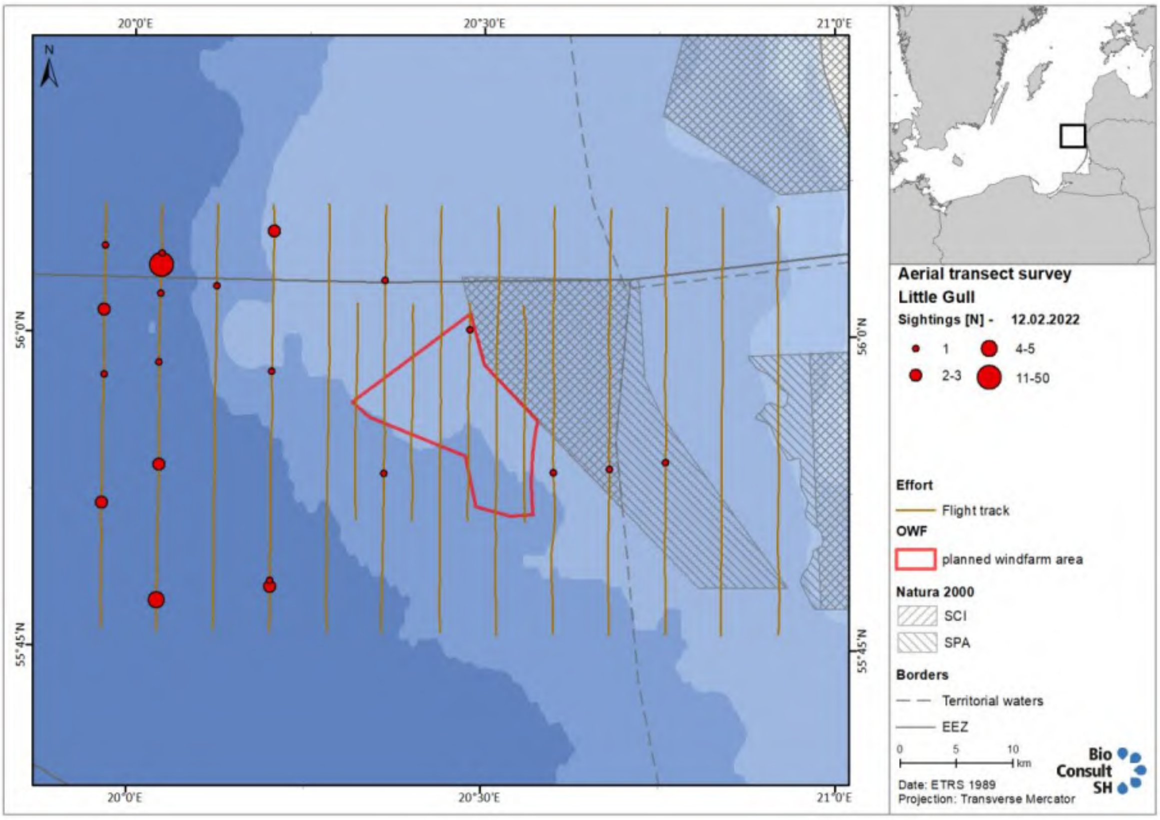
6-10
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

A.2.5 Little Gull (*Hydrocoloeus minutus*)



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Little Gull
Sightings [N] - 12.02.2022
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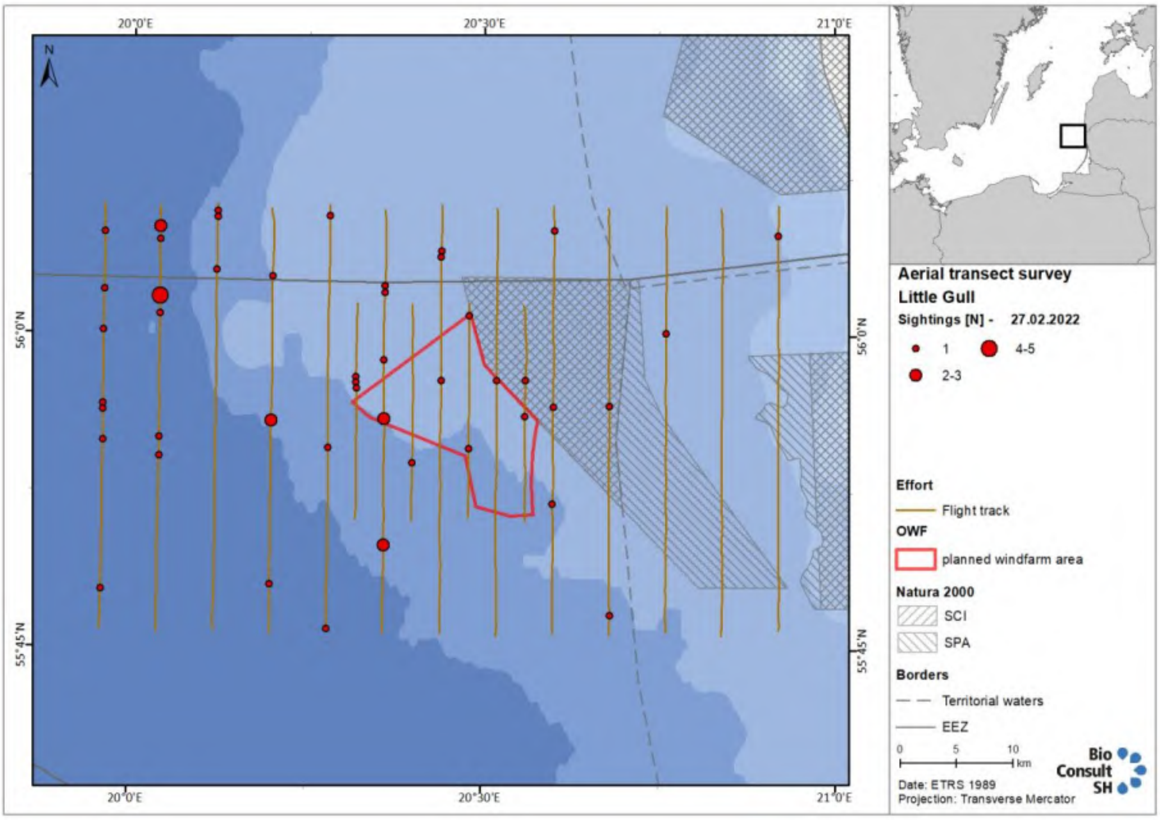
4-5
11-50
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH
20°0'E
20°30'E
21°0'E
56°0'N
55°45'N


Aerial transect survey
Little Gull
Sightings [N] - 27.02.2022
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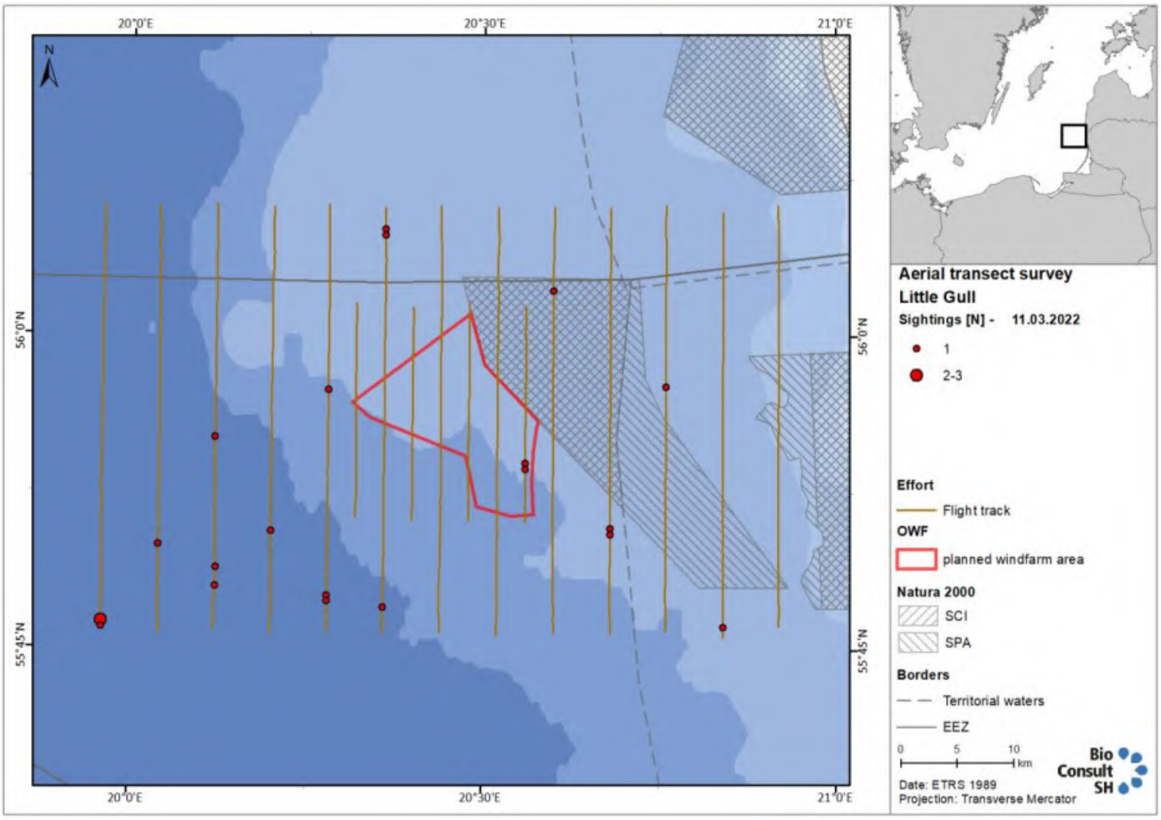
2-3
4-5
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH
20°0'E
20°30'E
21°0'E
56°0'N
55°45'N


20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
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Aerial transect survey
Little Gull
Sightings [N] - 11.03.2022
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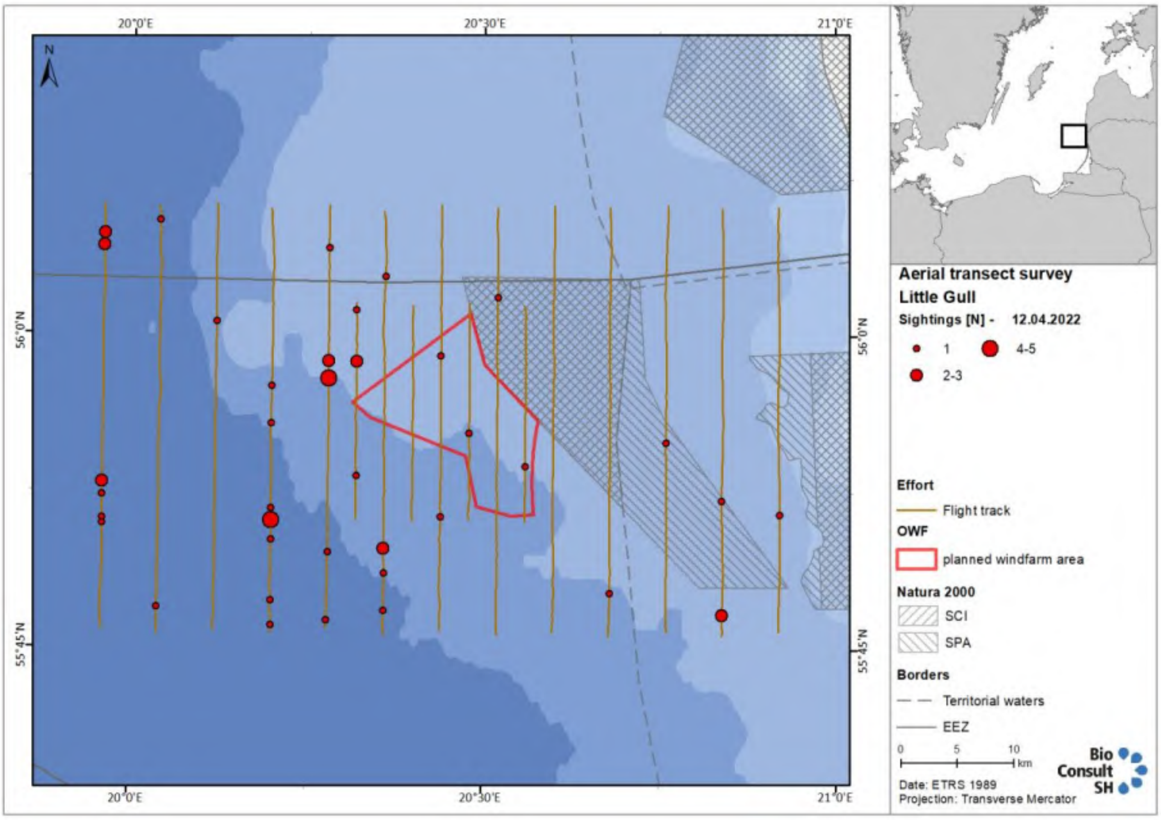
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH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21°0'E
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55°45'N
N
Aerial transect survey
Little Gull
Sightings [N] - 12.04.2022
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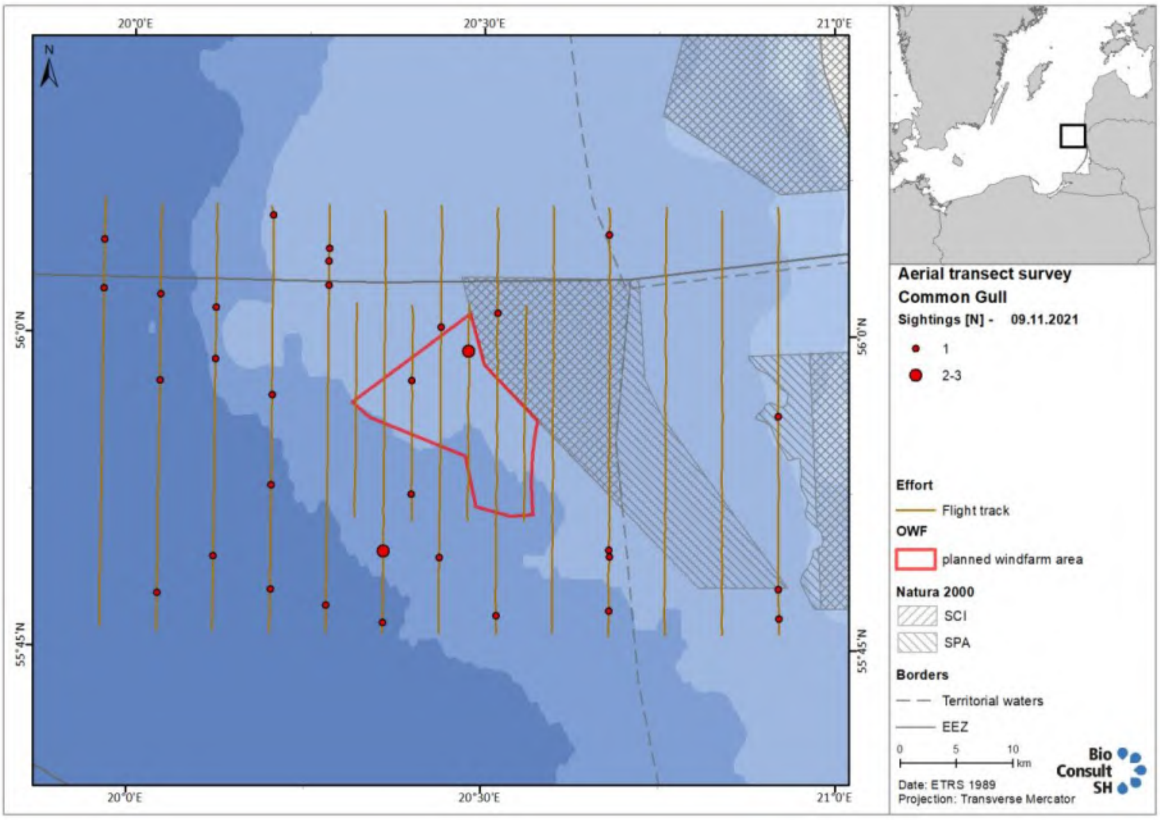
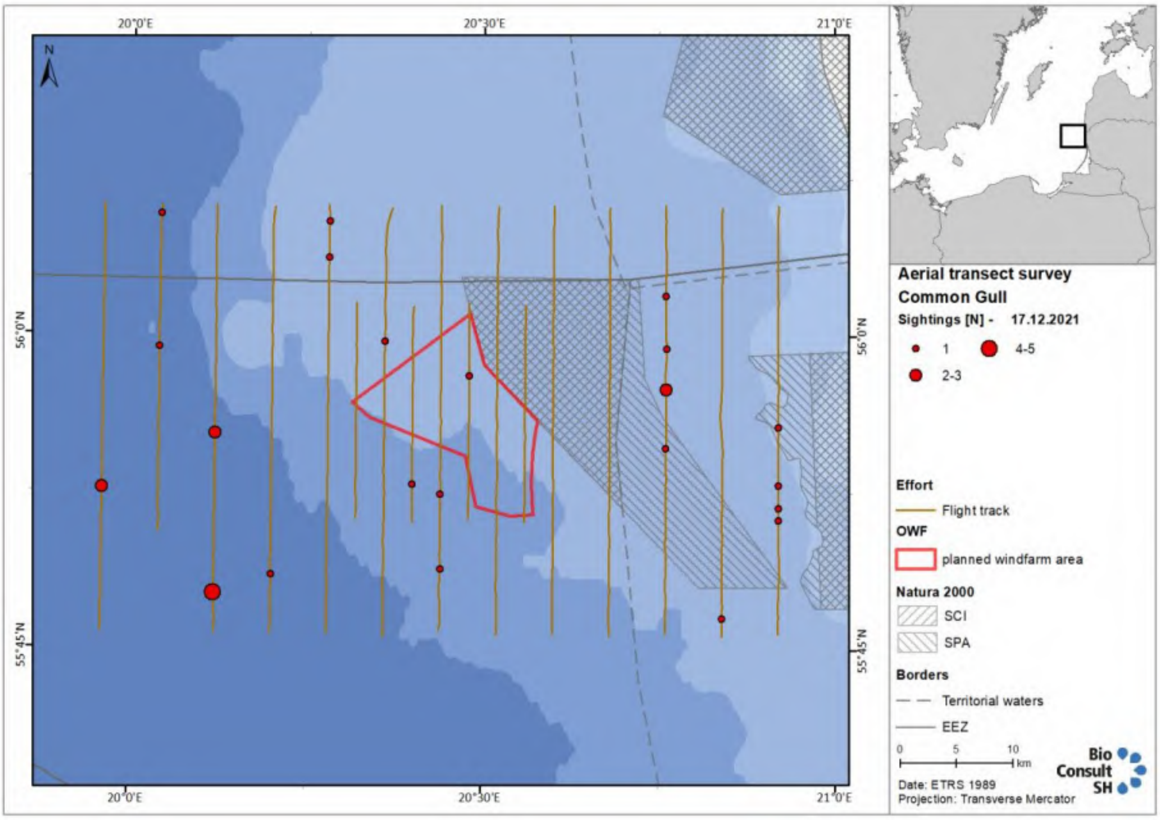
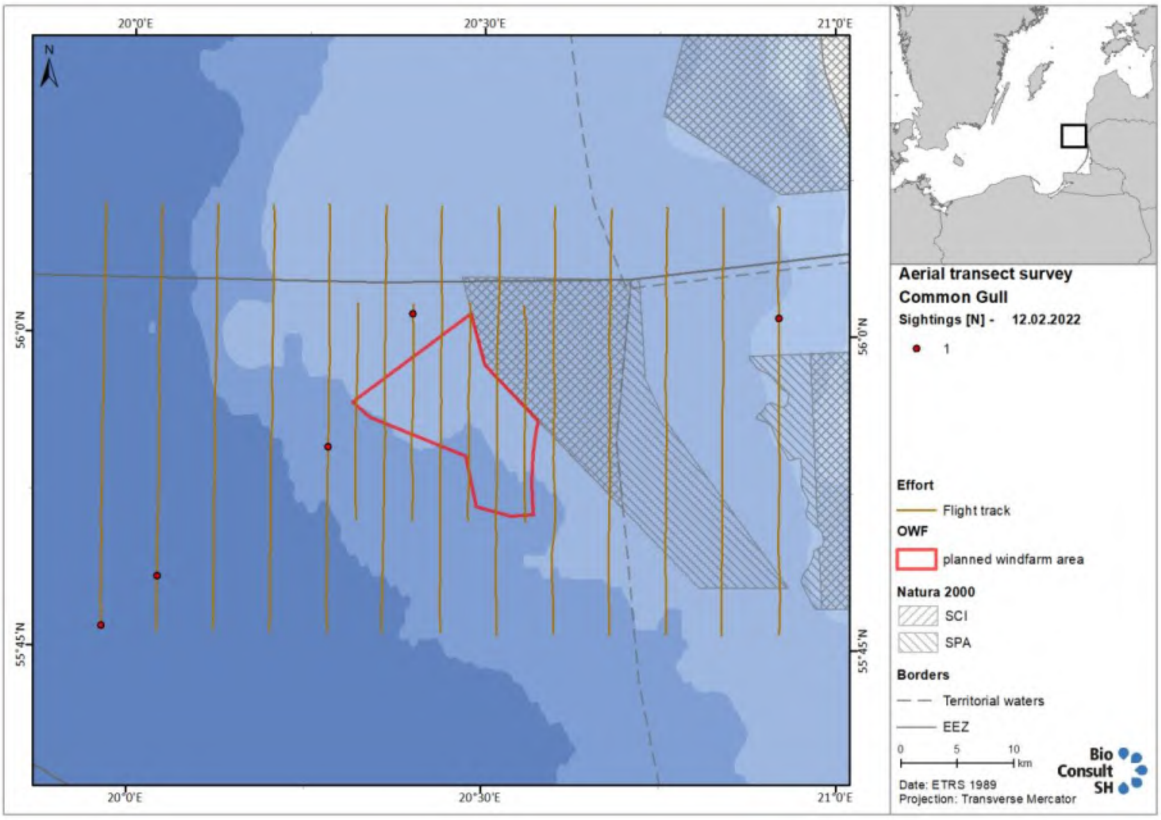
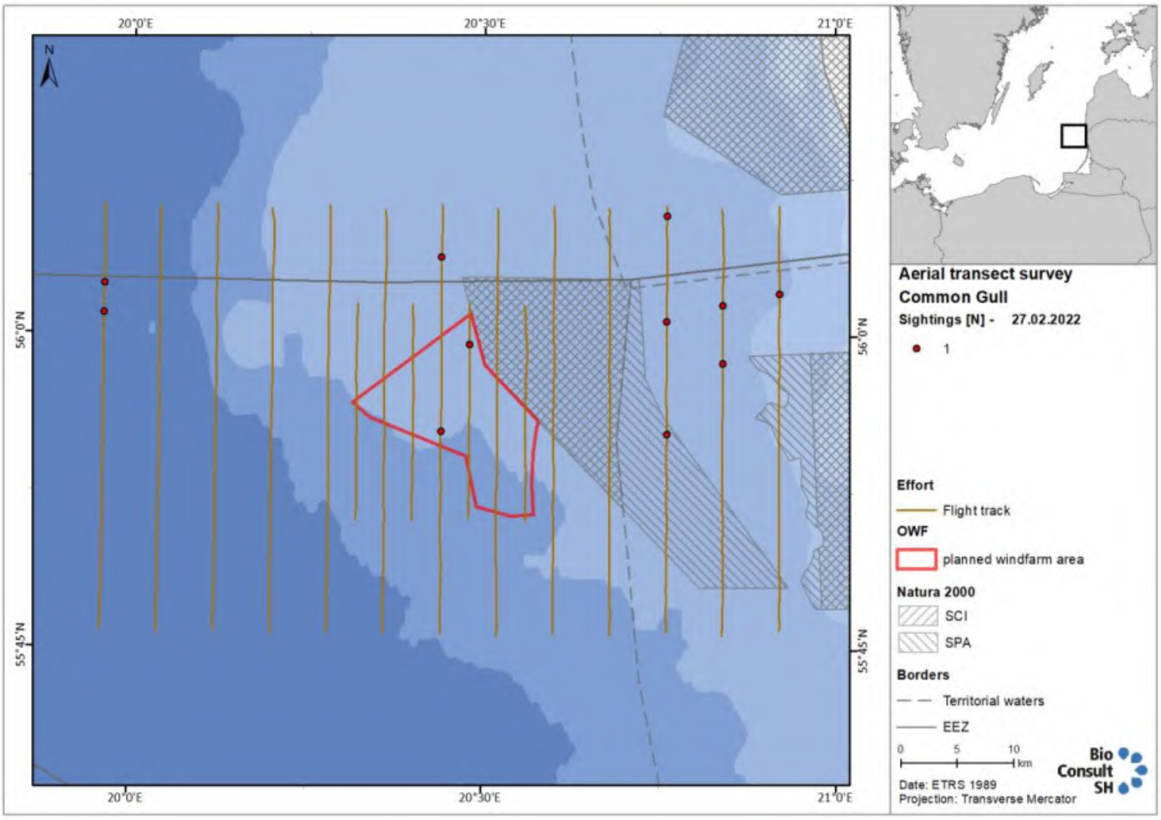
4-5
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

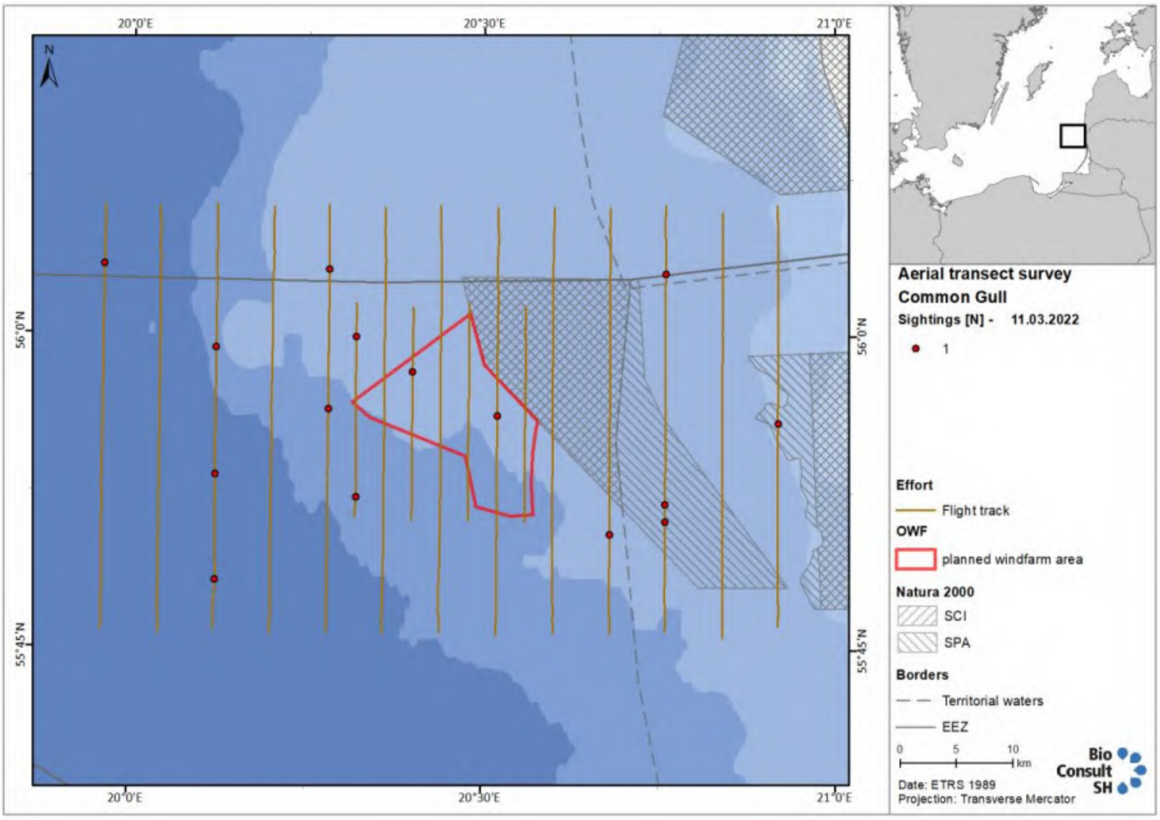
A.2.6 Common Gull (*Larus canus*)

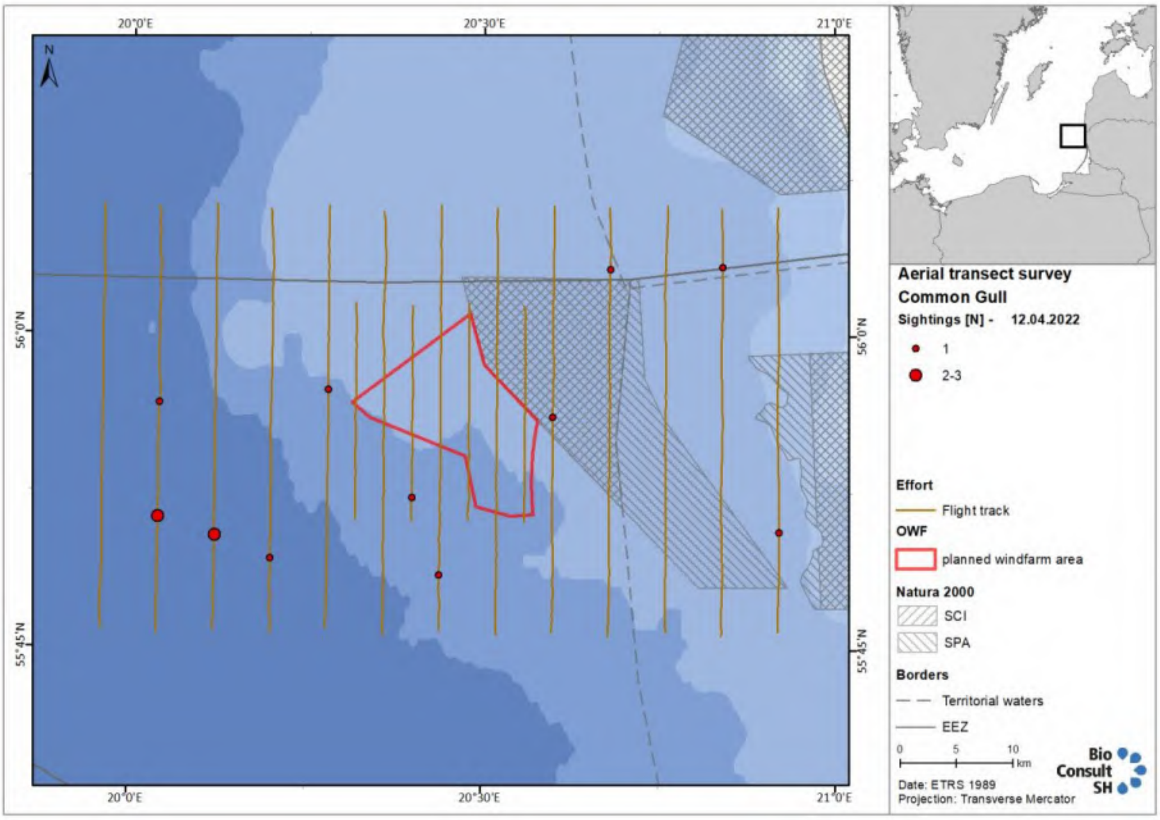




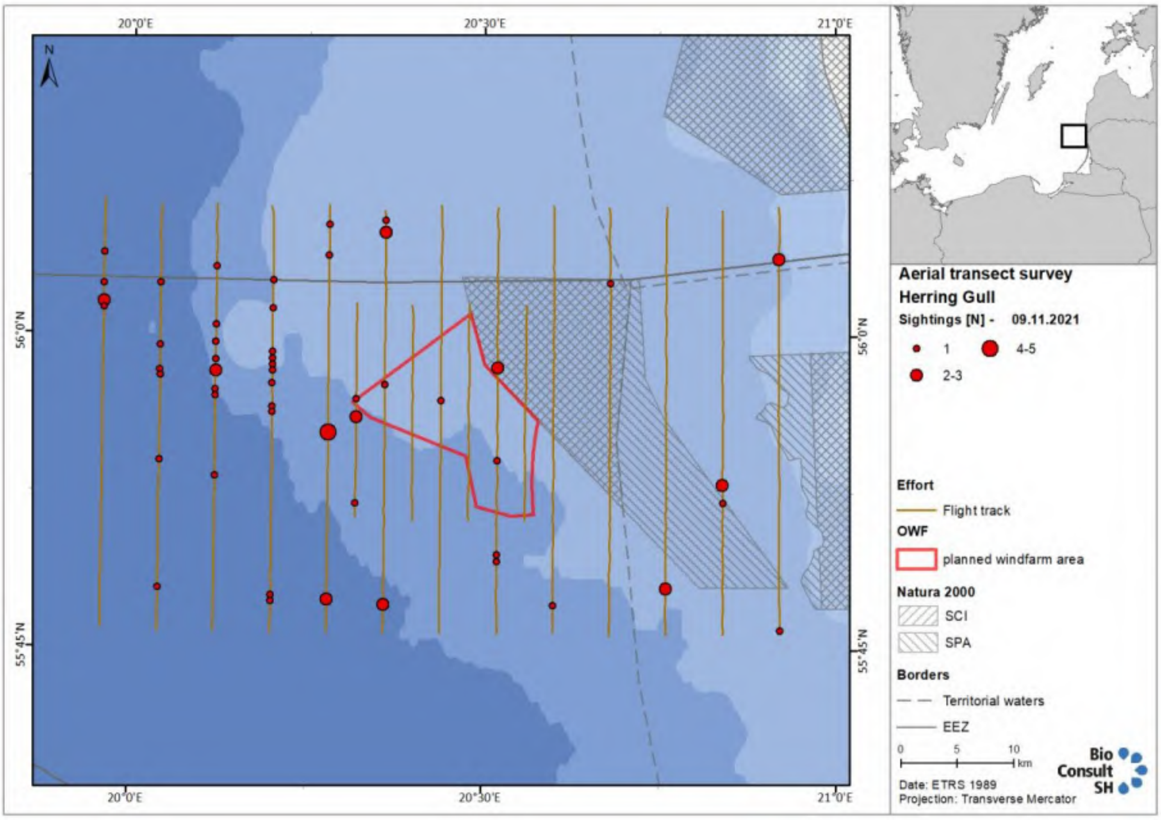

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Common Gull
Sightings [N] - 12.02.2022
1
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Bio Consult SH
Date: ETRS 1989
Projection: Transverse Mercator

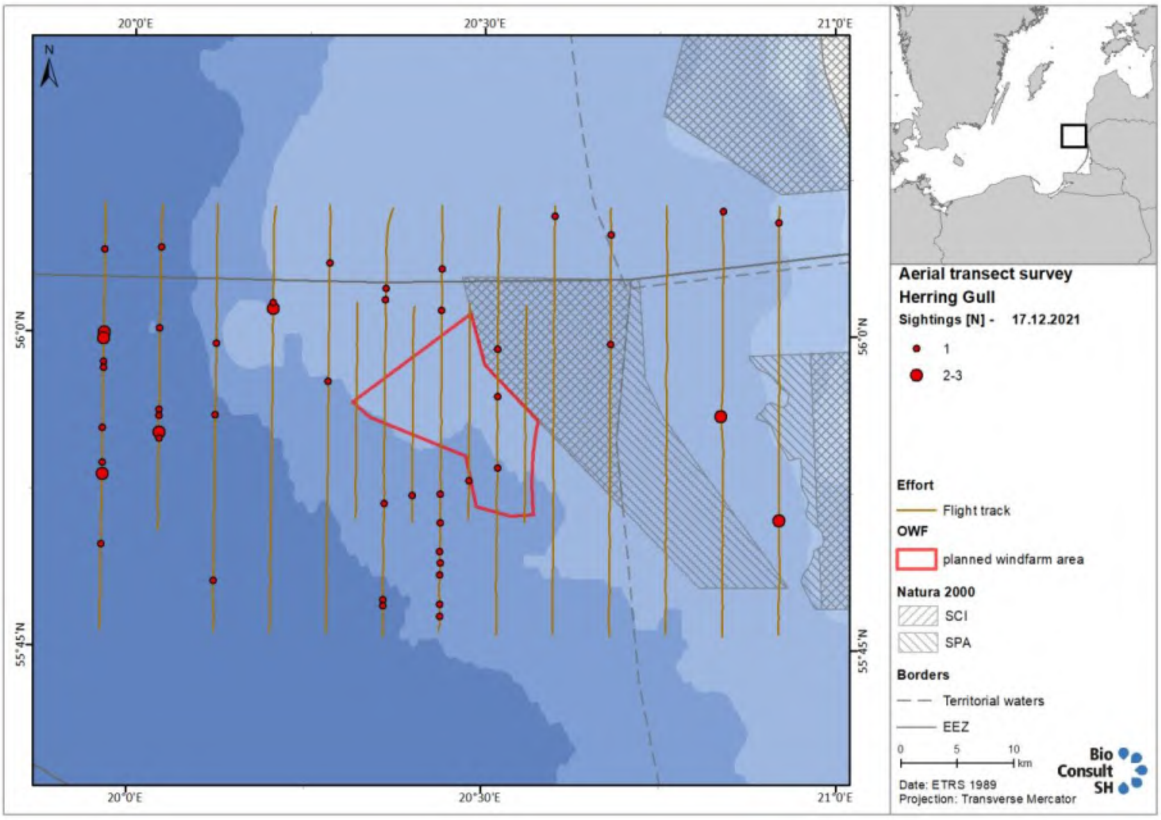

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Common Gull
Sightings [N] - 27.02.2022
1
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Bio Consult SH
Date: ETRS 1989
Projection: Transverse Mercator

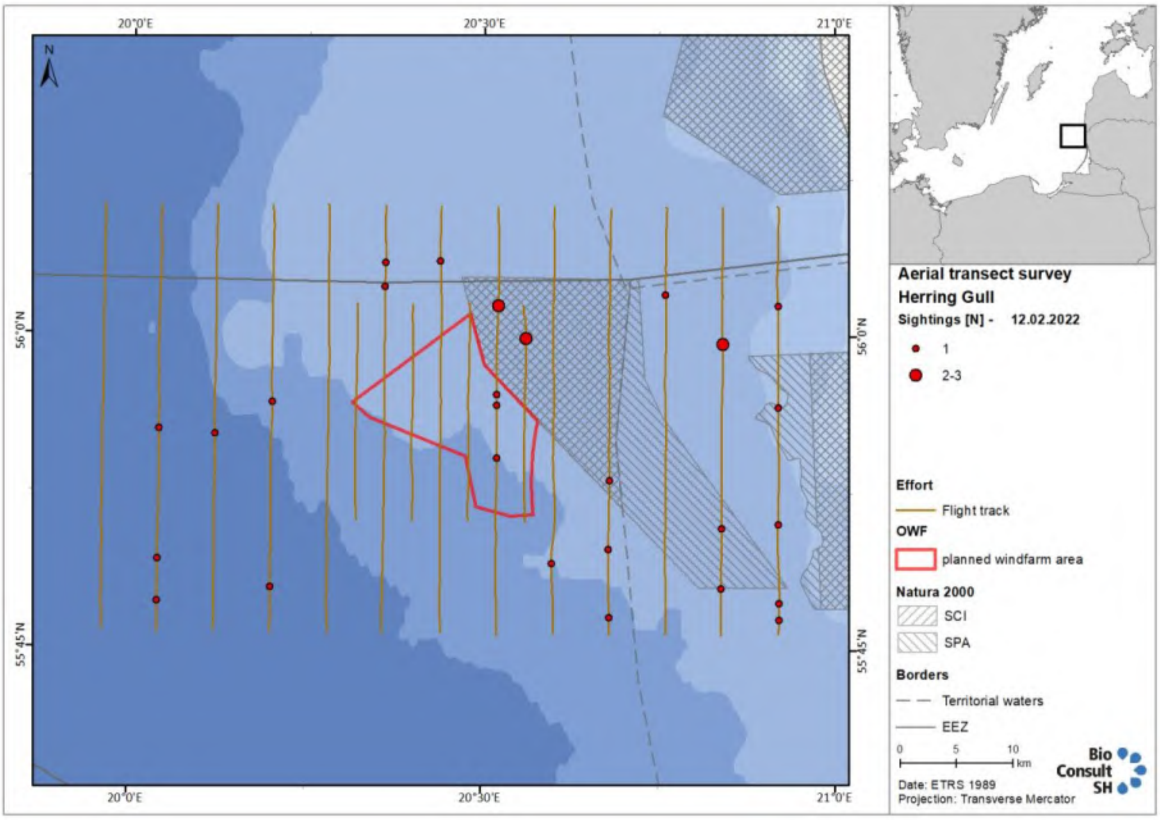

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Common Gull
Sightings [N] - 11.03.2022
1
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

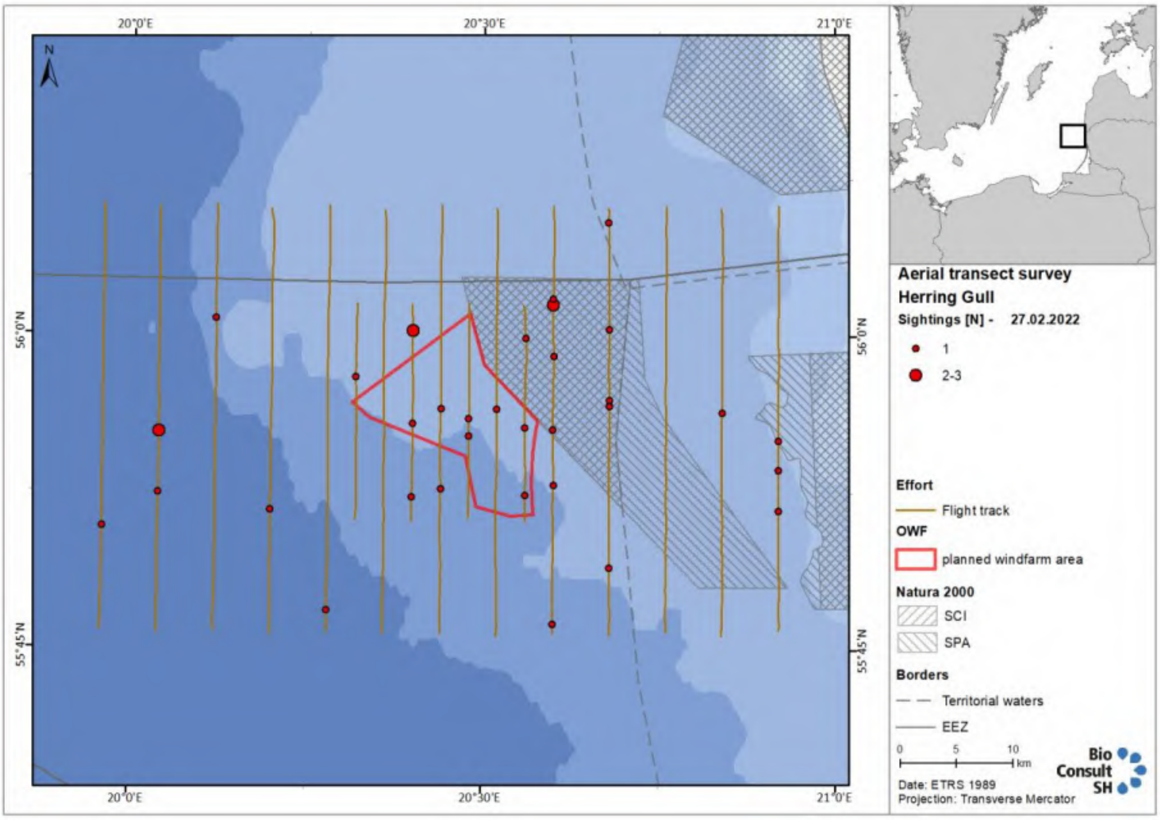

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Common Gull
Sightings [N] - 12.04.2022
1
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

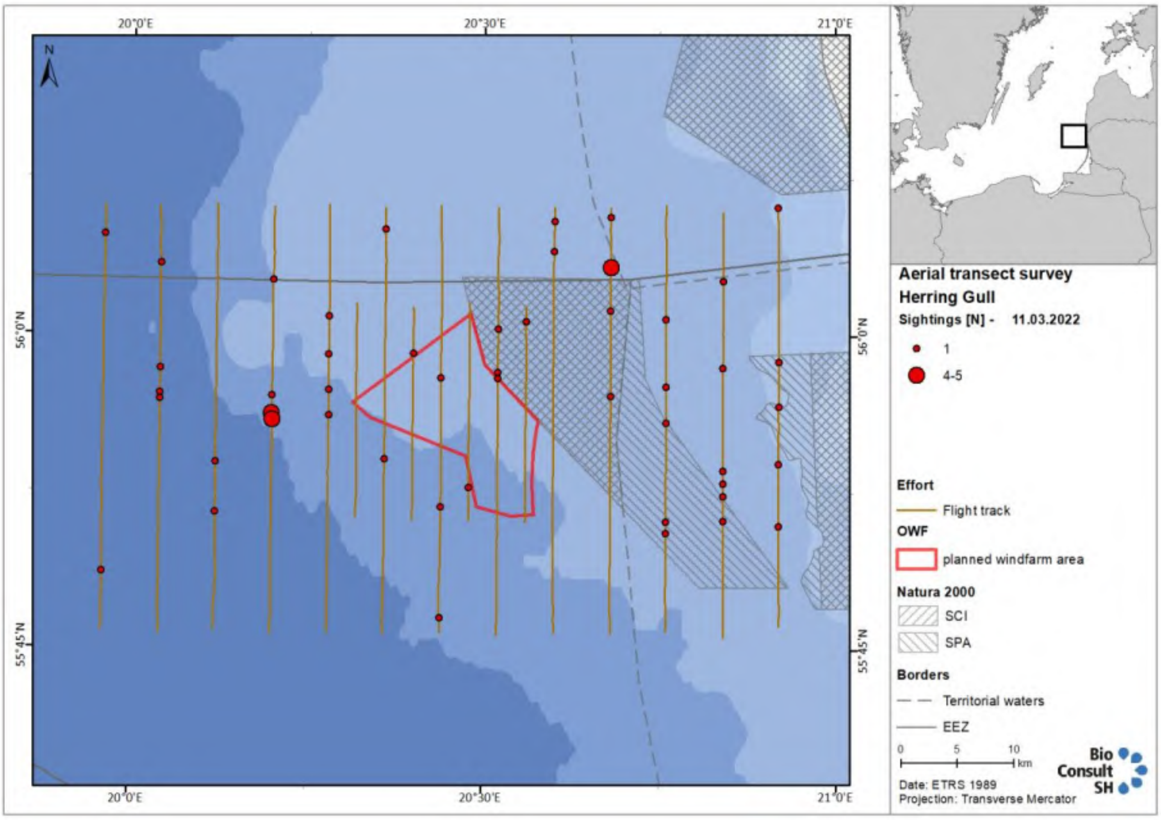
A.2.7 Herring Gull (*Larus argentatus*)

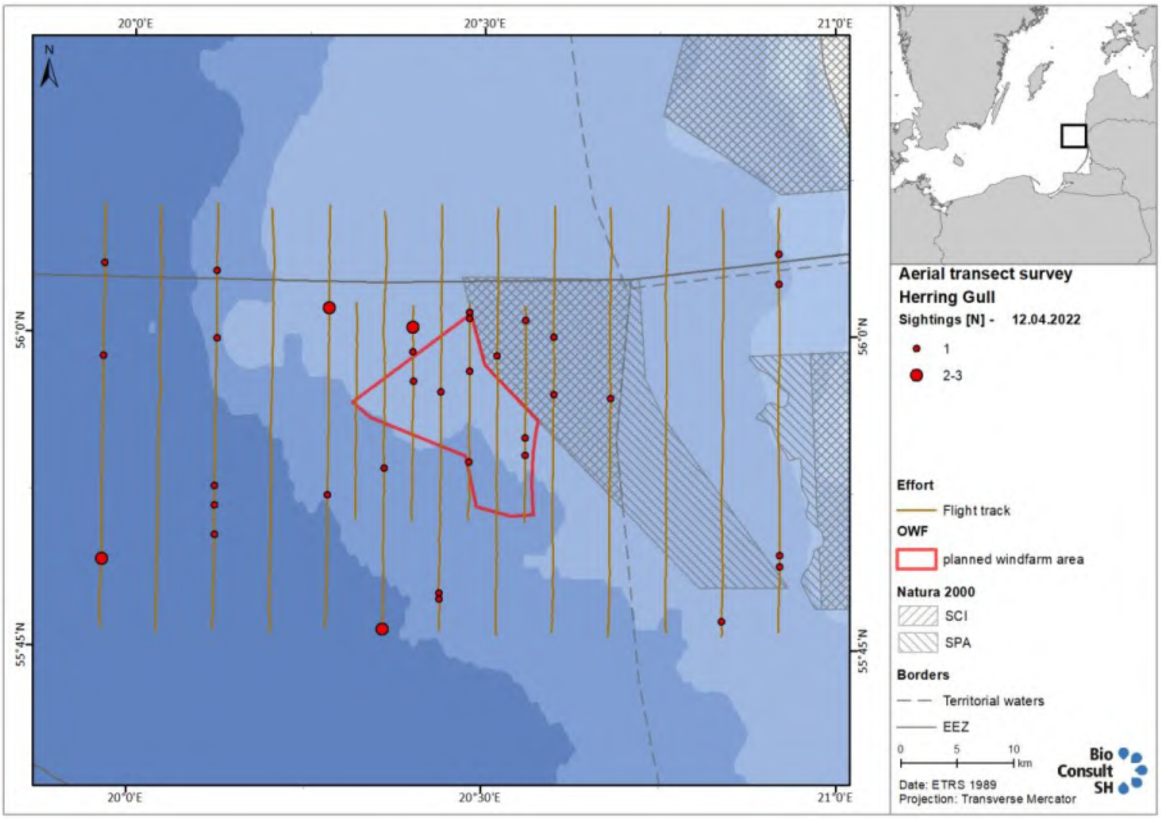




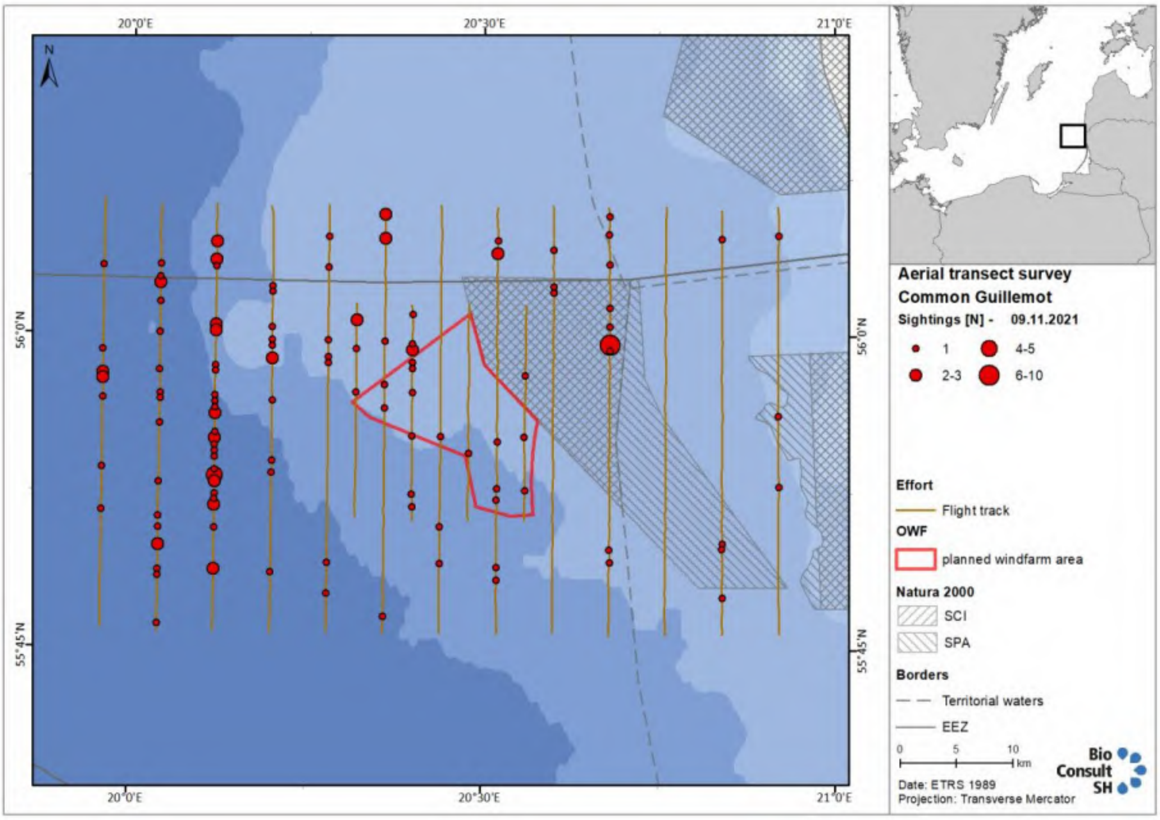

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Herring Gull
Sightings [N] - 12.02.2022
1
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

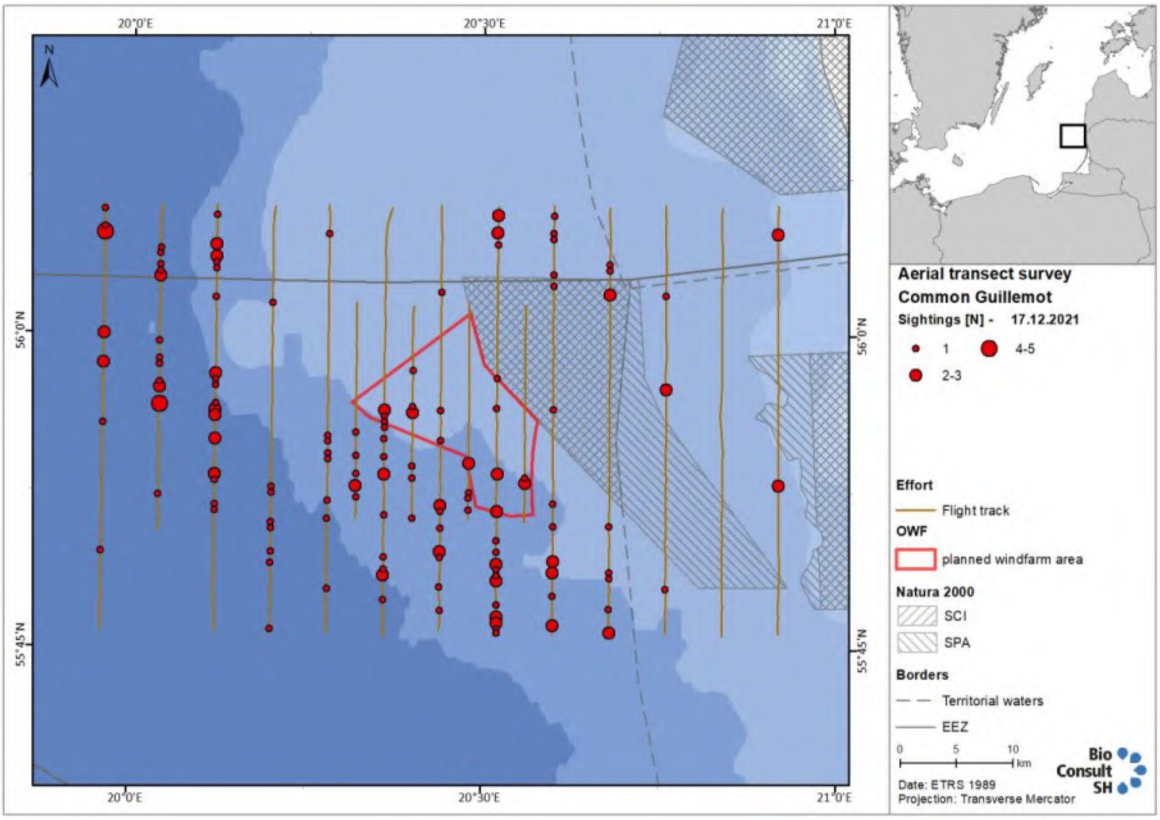

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Herring Gull
Sightings [N] - 27.02.2022
1
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

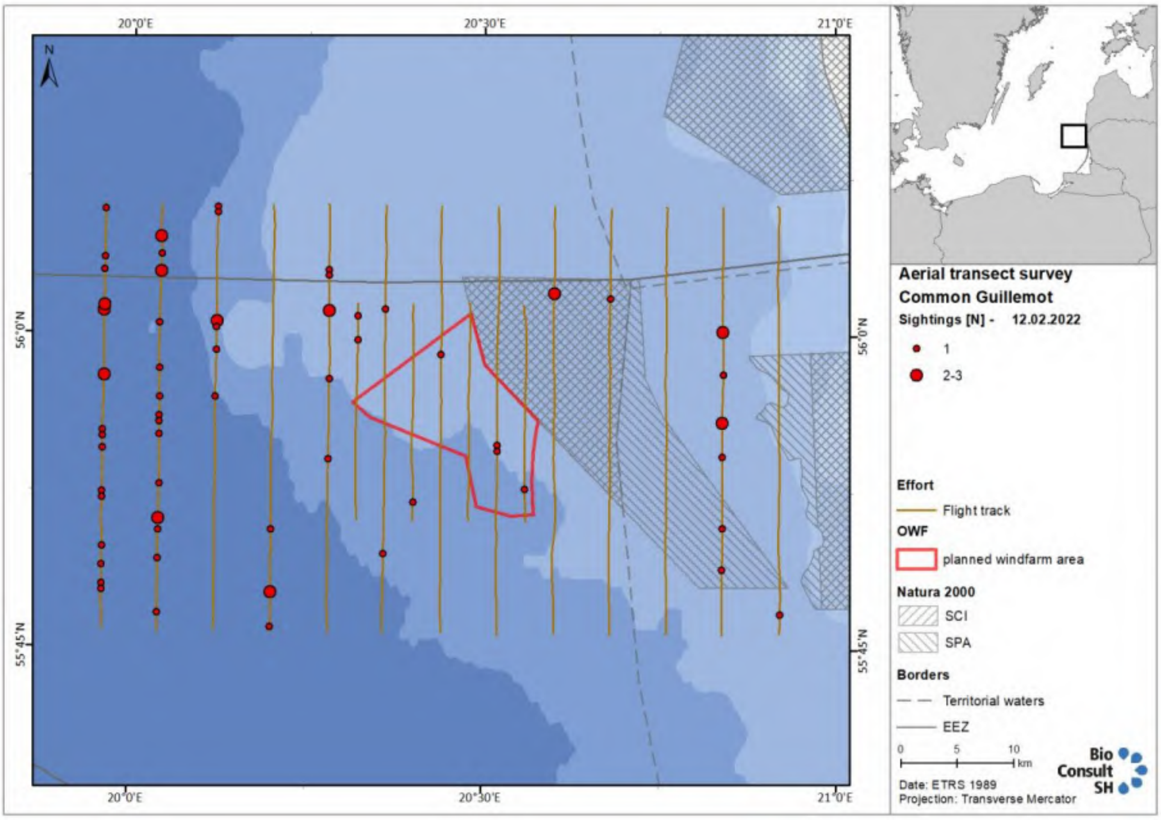

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Herring Gull
Sightings [N] - 11.03.2022
1
4-5
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

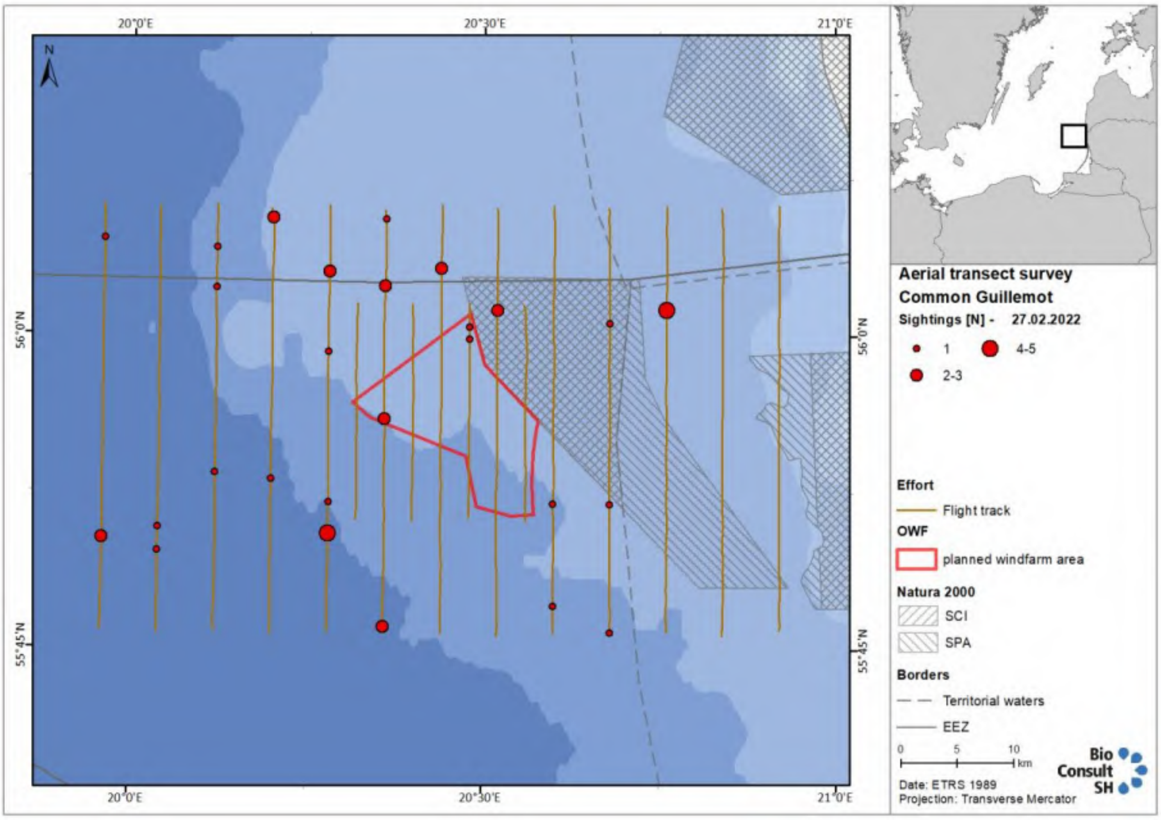

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Herring Gull
Sightings [N] - 12.04.2022
1
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

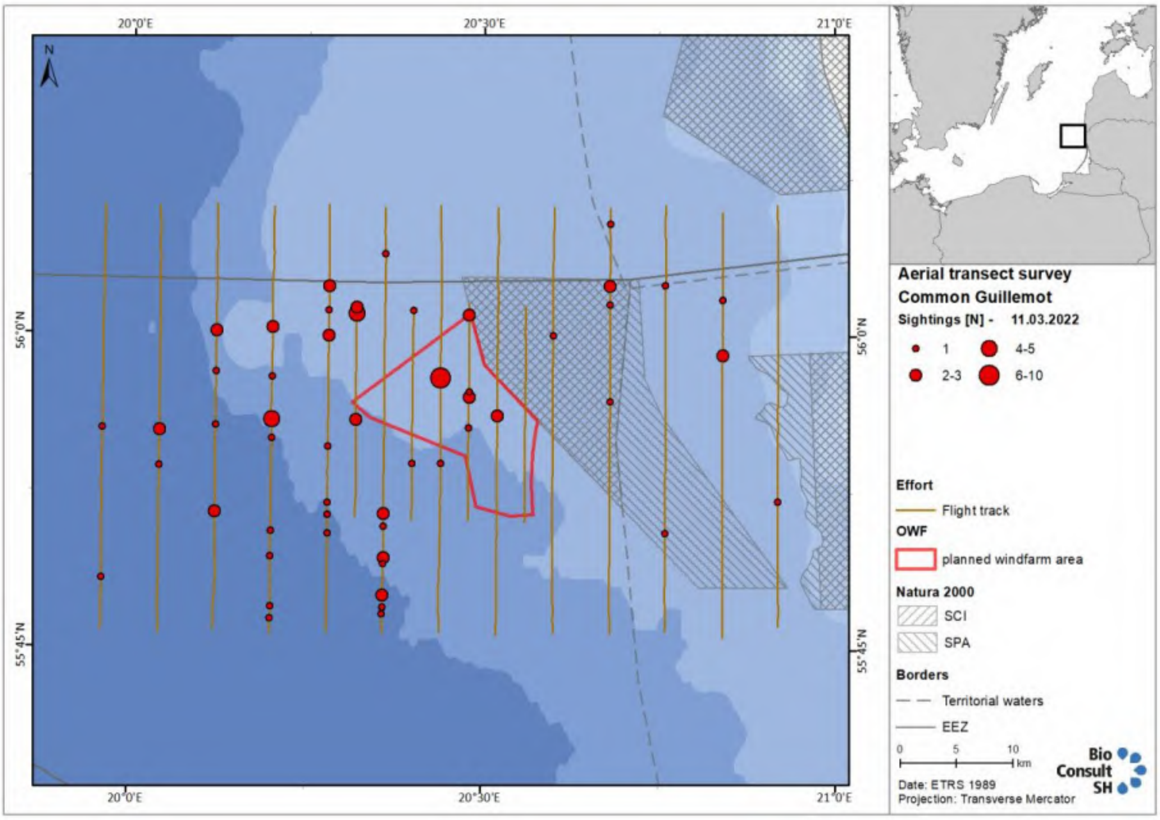
A.2.8 Common Guillemot (*Uria aalge*)



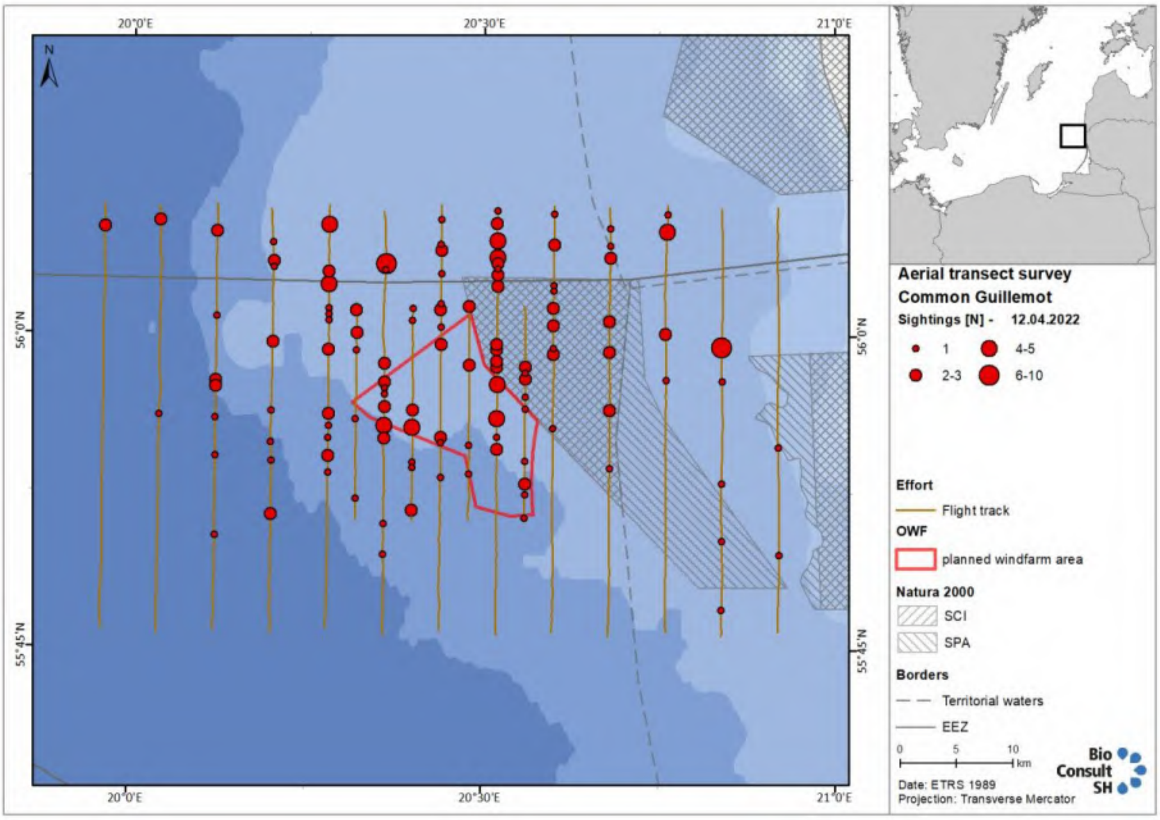



20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Common Guillemot
Sightings [N] - 12.02.2022
1
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Bio Consult SH
Date: ETRS 1989
Projection: Transverse Mercator


20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
N
Aerial transect survey
Common Guillemot
Sightings [N] - 27.02.2022
1
4-5
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Bio Consult SH
Date: ETRS 1989
Projection: Transverse Mercator

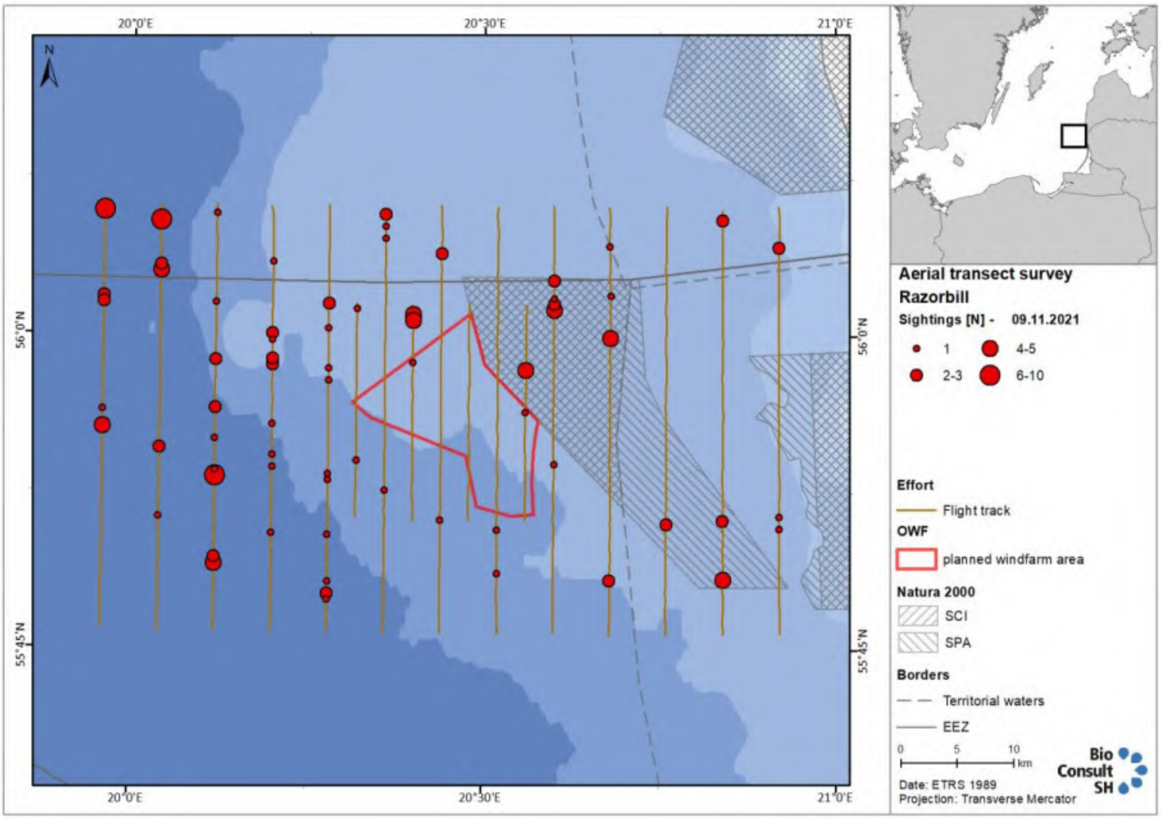


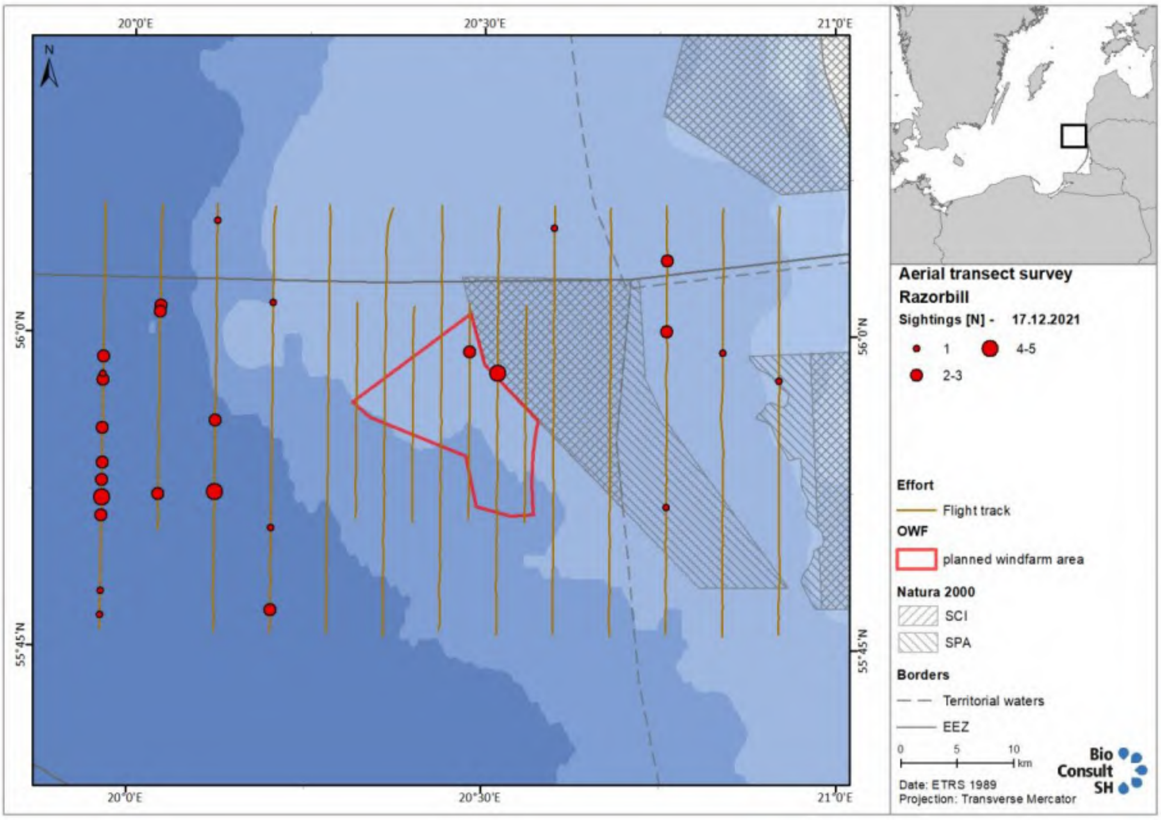
20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Common Guillemot
Sightings [N] - 11.03.2022
1
2-3
4-5
6-10
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

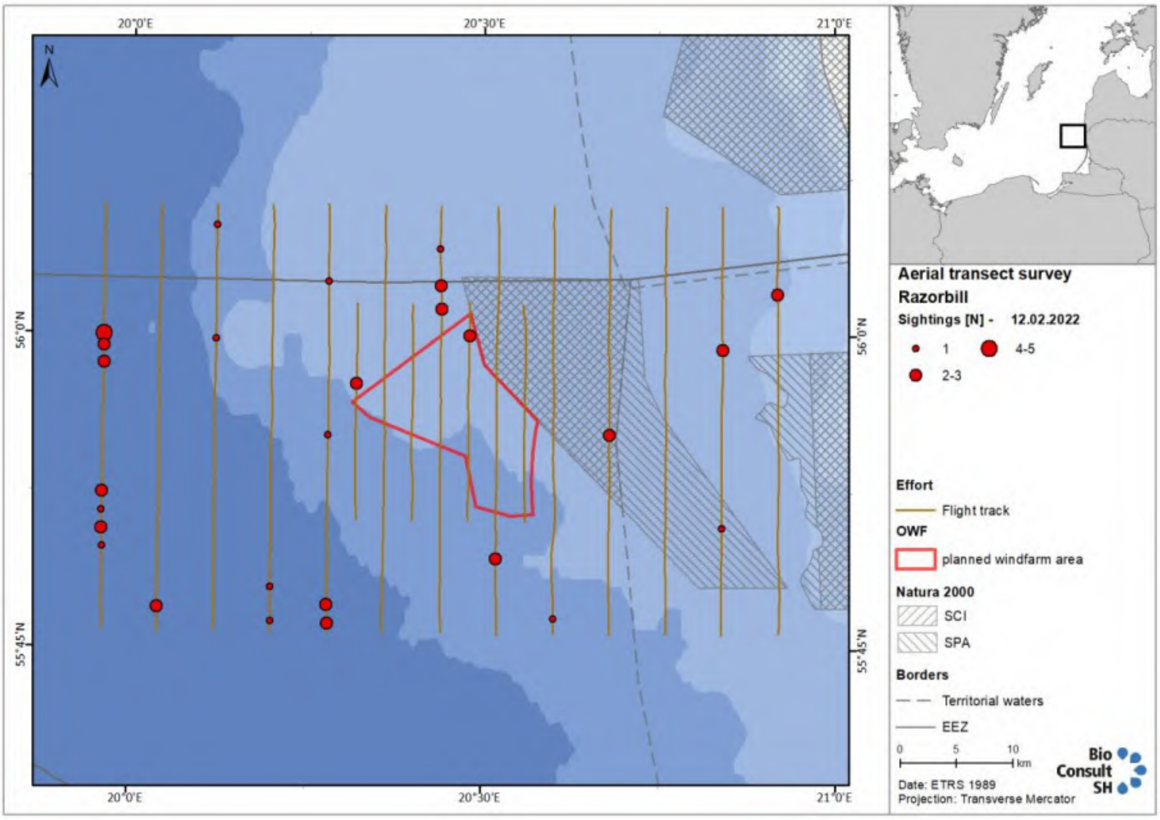


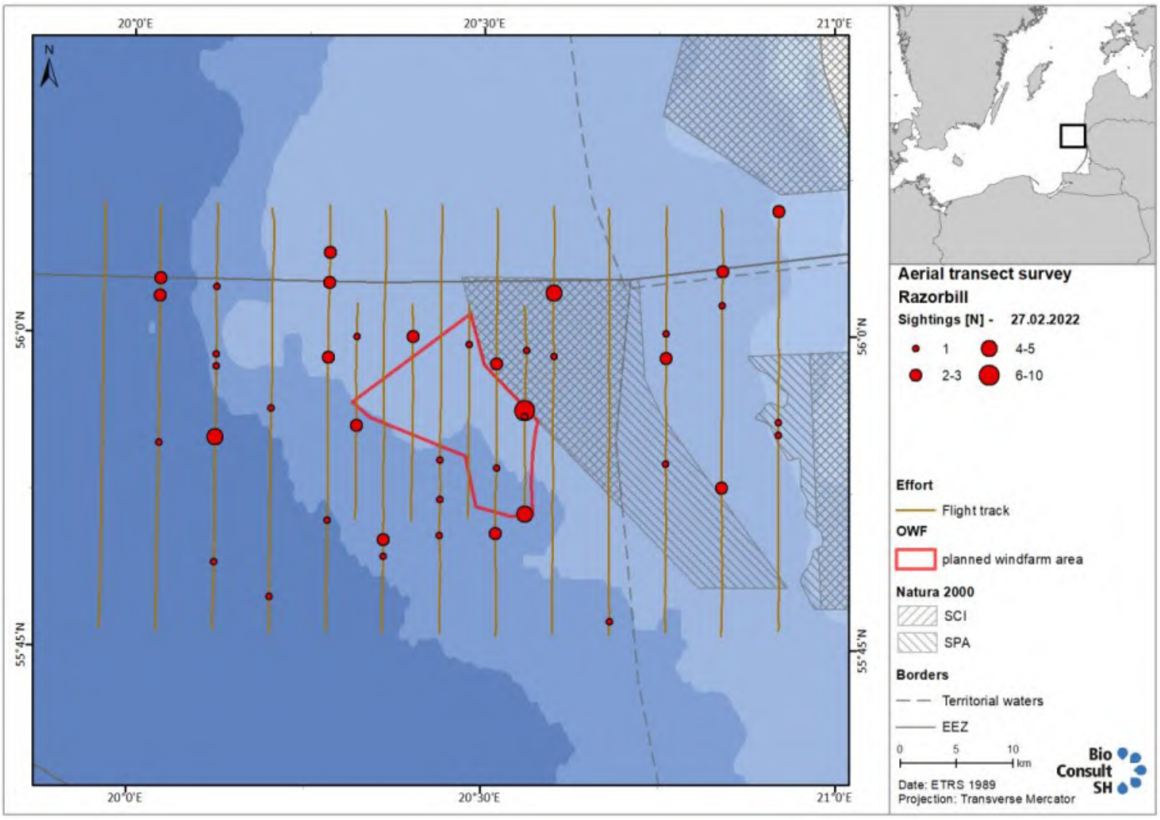
20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Common Guillemot
Sightings [N] - 12.04.2022
1
2-3
4-5
6-10
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

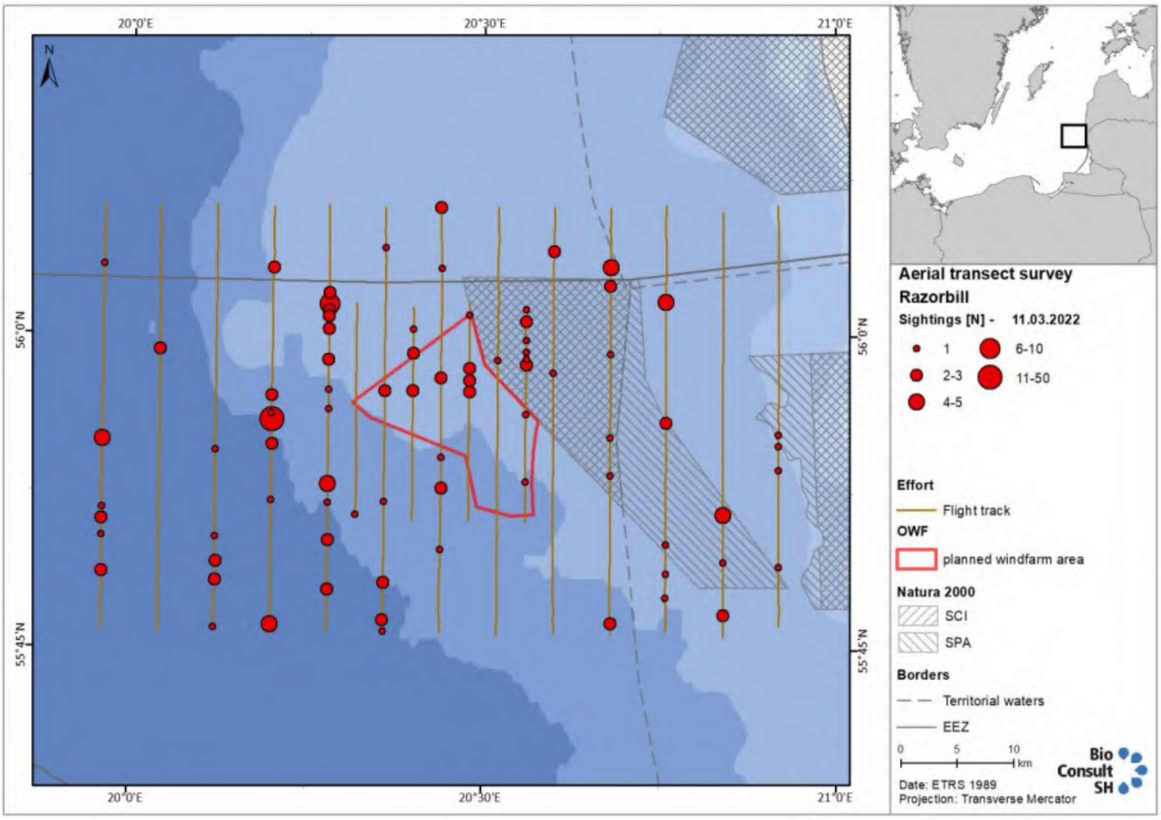
A.2.9 Razorbill (*Alca torda*)

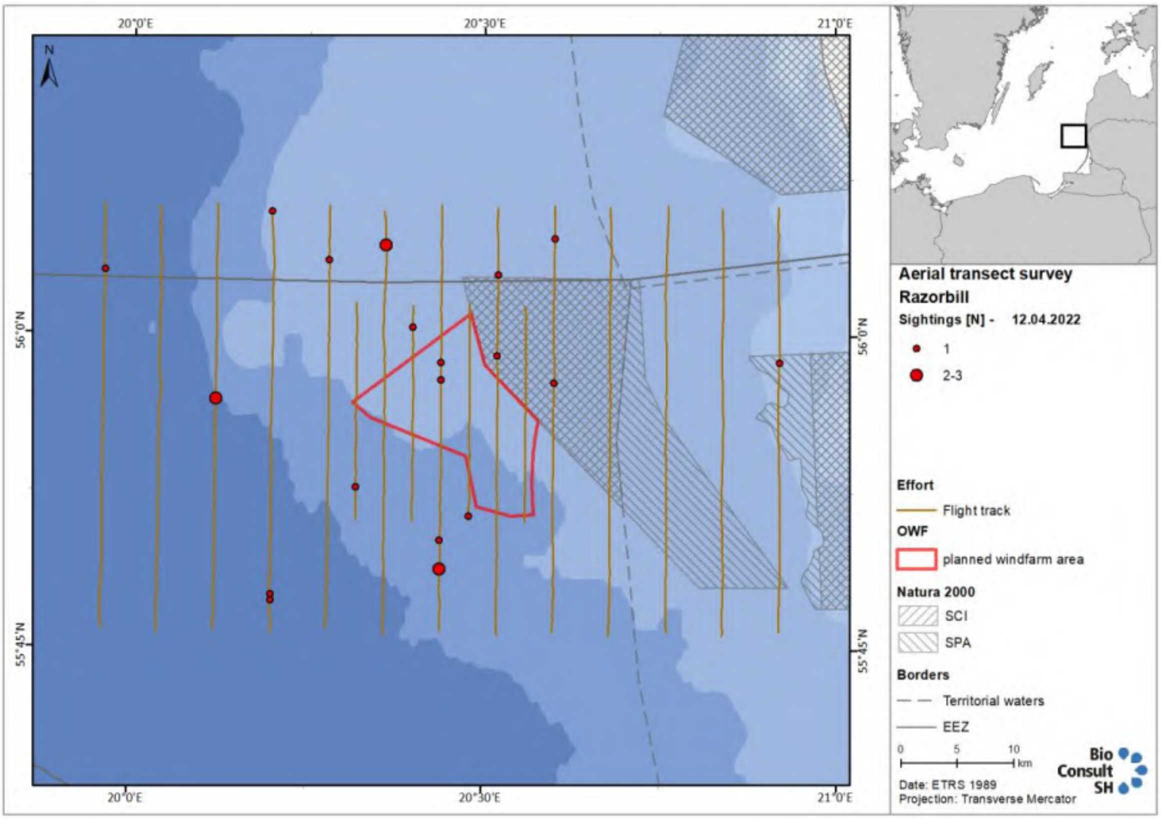





20°0'E
20°30'E
21°0'E
N
56°0'N
55°45'N
Aerial transect survey
Razorbill
Sightings [N] - 12.02.2022
1
2-3
4-5
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

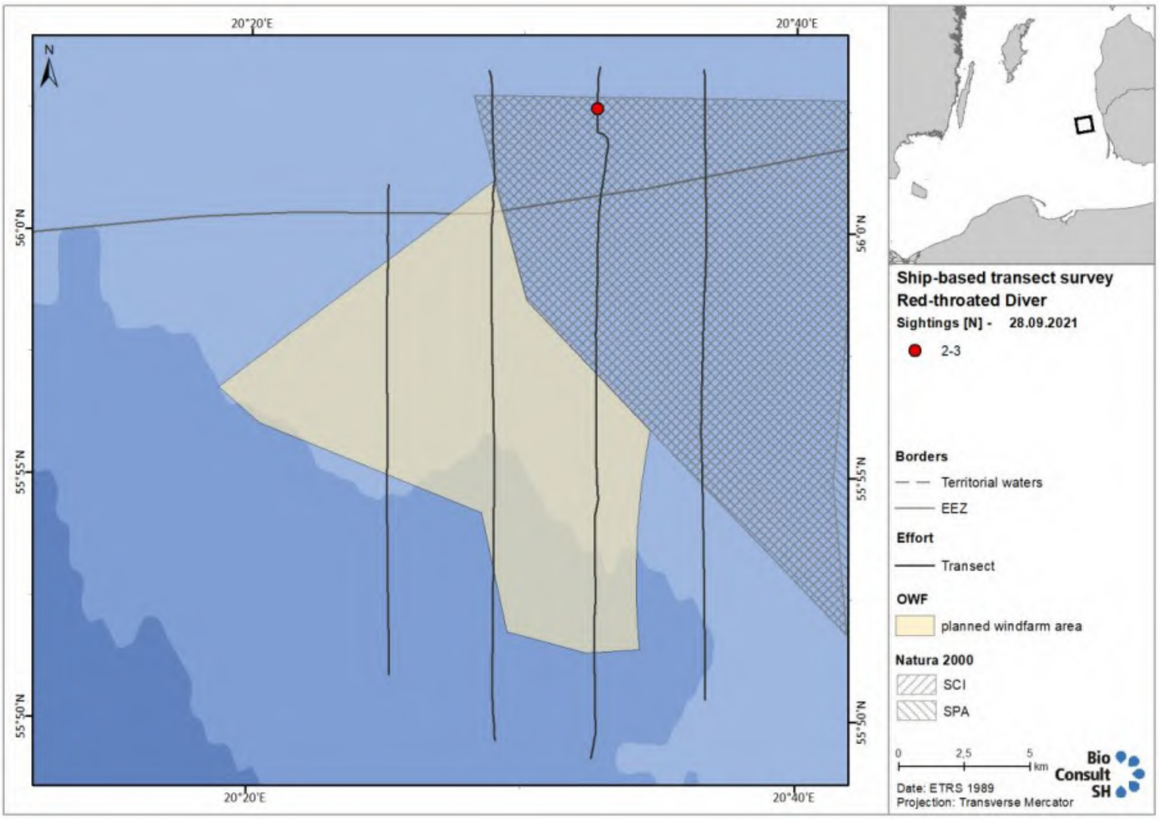

20°0'E
20°30'E
21°0'E
N
56°0'N
55°45'N
Aerial transect survey
Razorbill
Sightings [N] - 27.02.2022
1
2-3
4-5
6-10
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

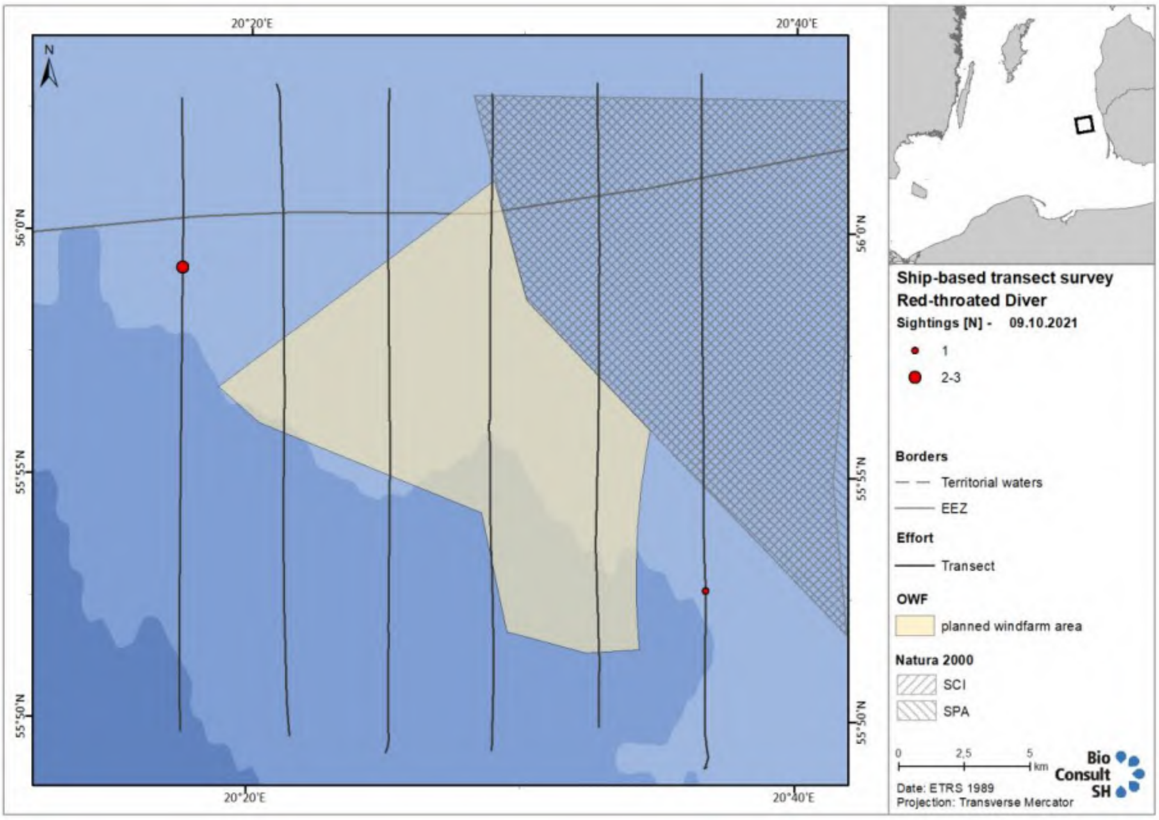

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Razorbill
Sightings [N] - 11.03.2022
1
2-3
4-5
6-10
11-50
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

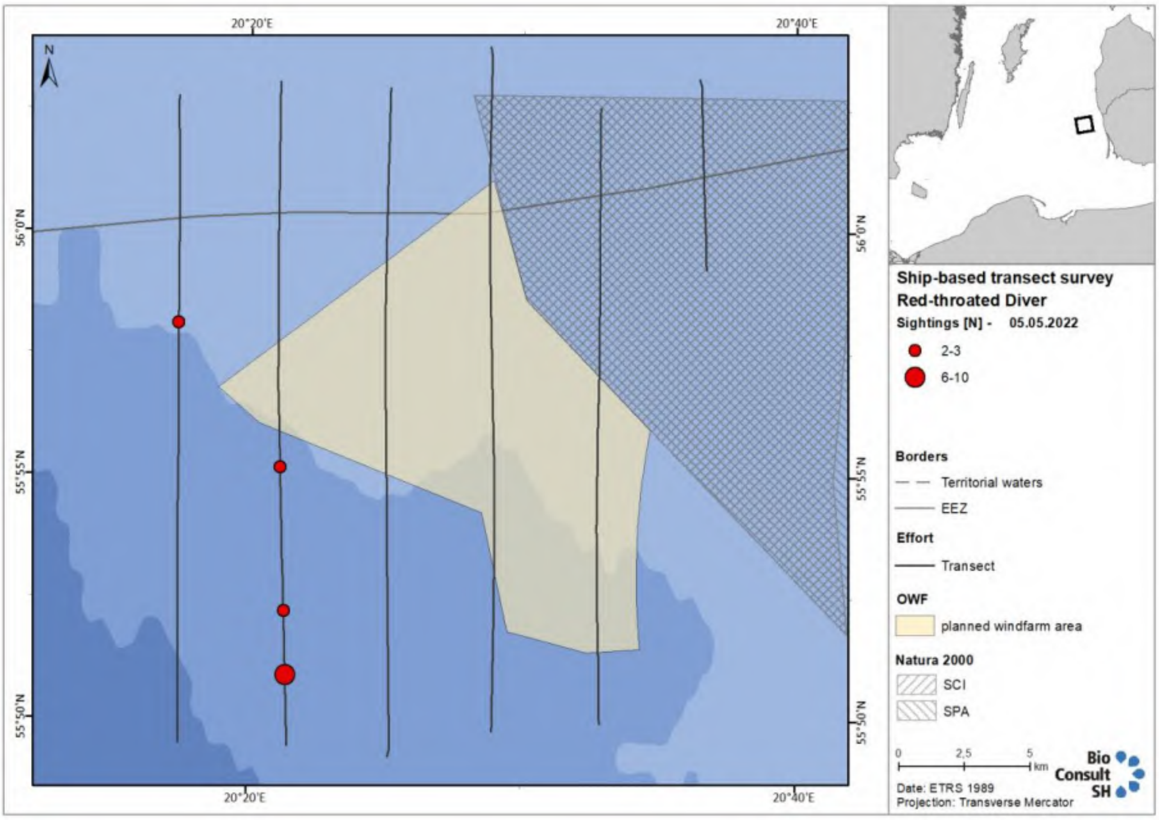

20°0'E
20°30'E
21°0'E
56°0'N
55°45'N
Aerial transect survey
Razorbill
Sightings [N] - 12.04.2022
1
2-3
Effort
Flight track
OWF
planned windfarm area
Natura 2000
SCI
SPA
Borders
Territorial waters
EEZ
0 5 10 km
Date: ETRS 1989
Projection: Transverse Mercator

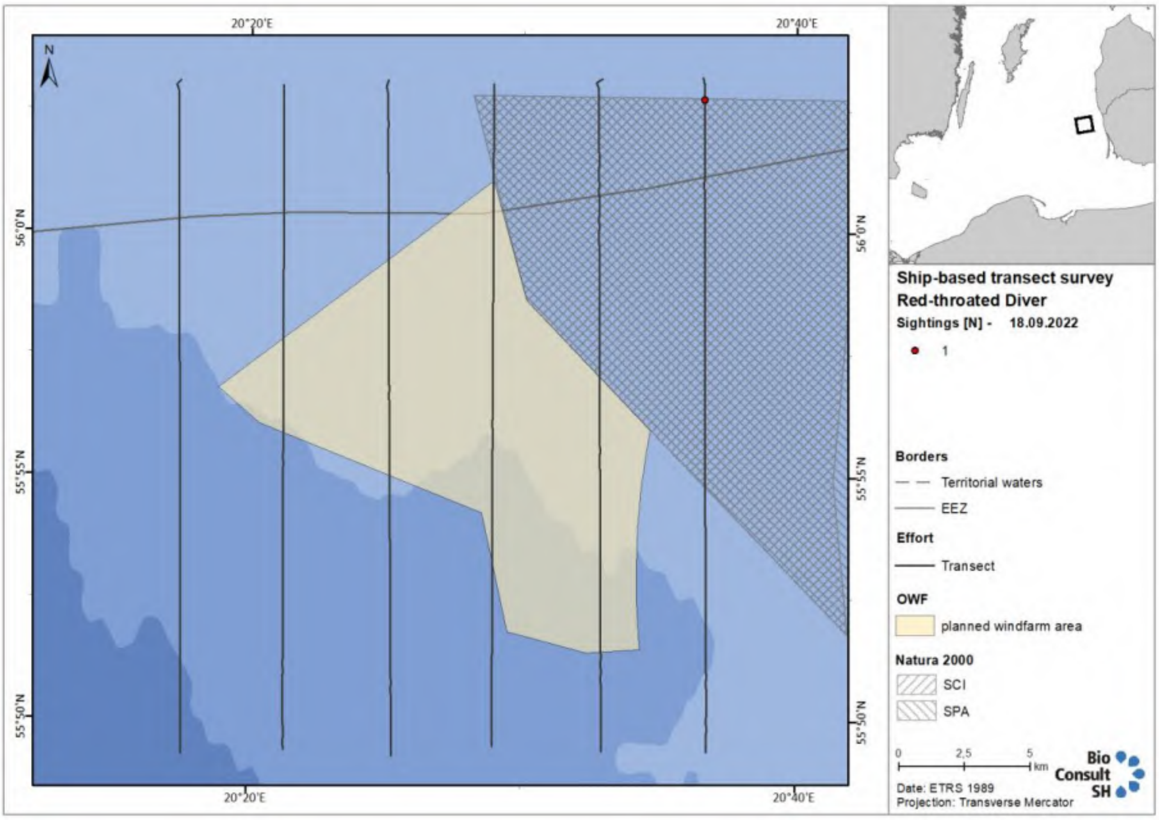
A.3 Species Distribution Maps Ship Surveys

A.3.1 Red-throated Diver (*Gavia stellata)*

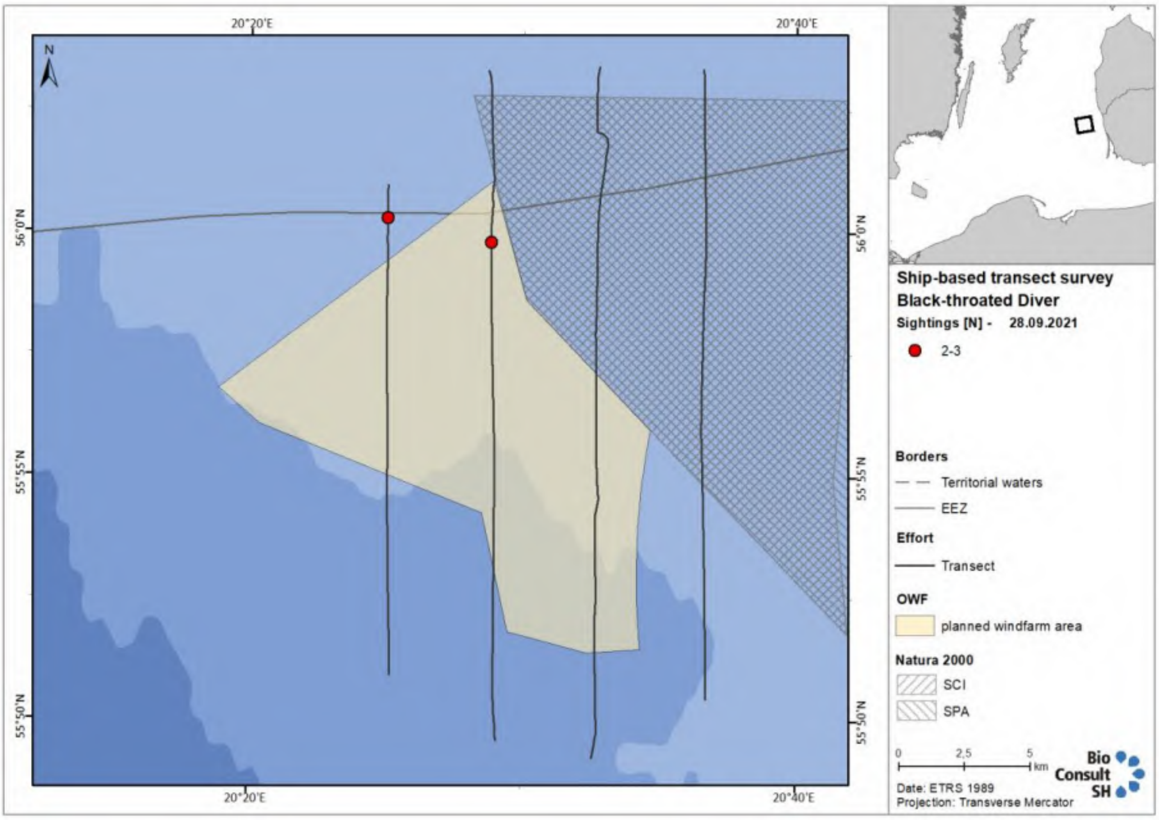


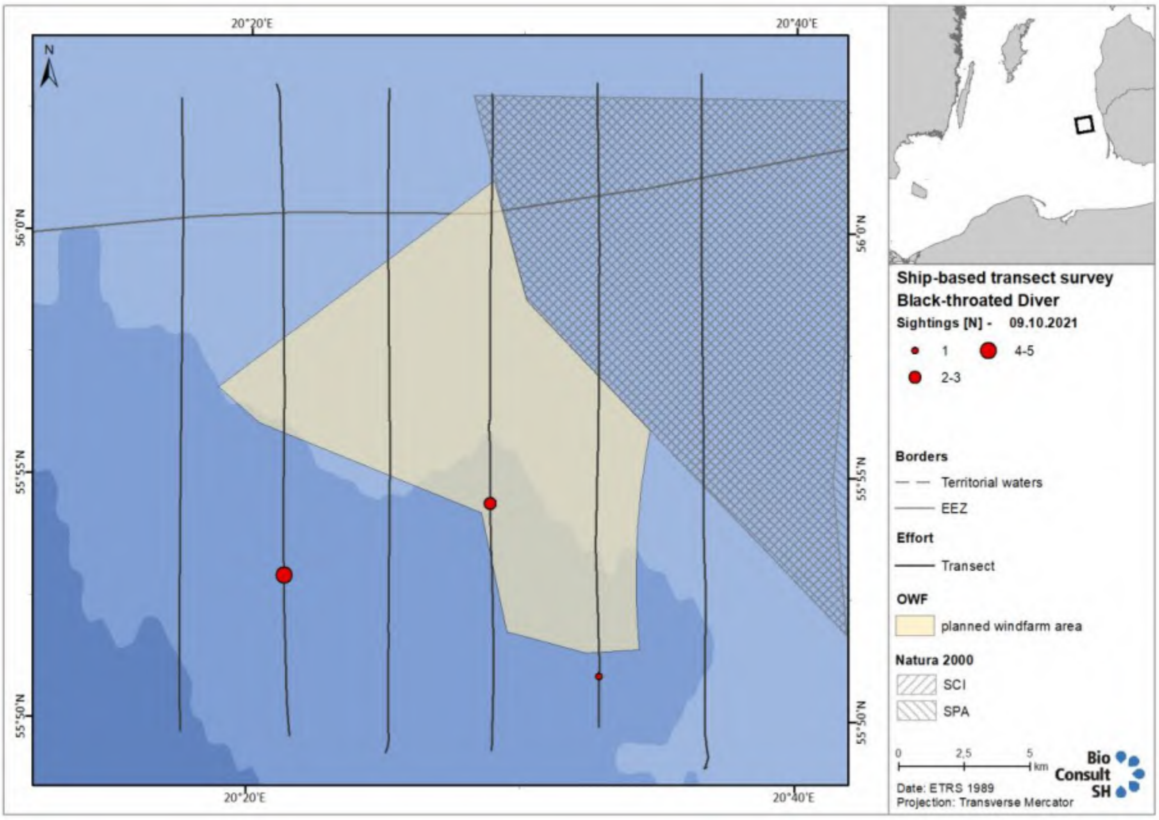


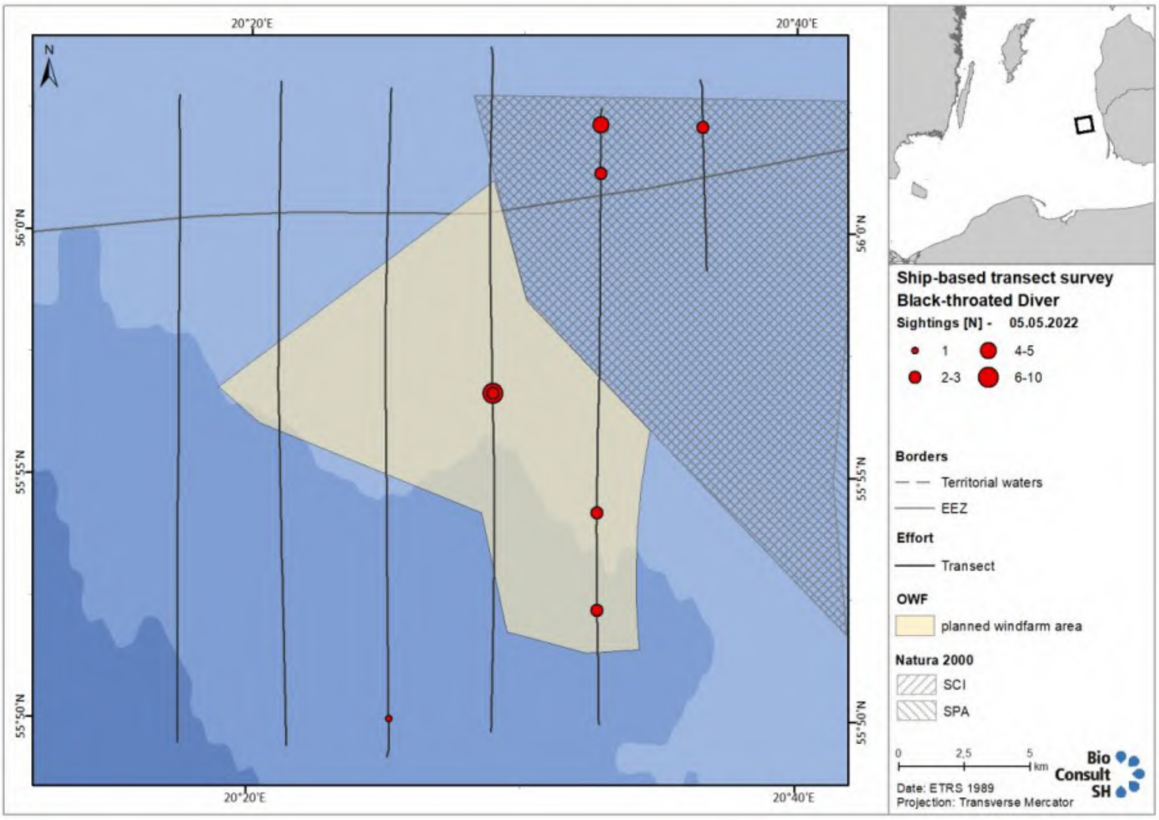

20°20'E
20°40'E
N
56°0'N
55°55'N
55°50'N
Ship-based transect survey
Red-throated Diver
Sightings [N] - 05.05.2022
2-3
6-10
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

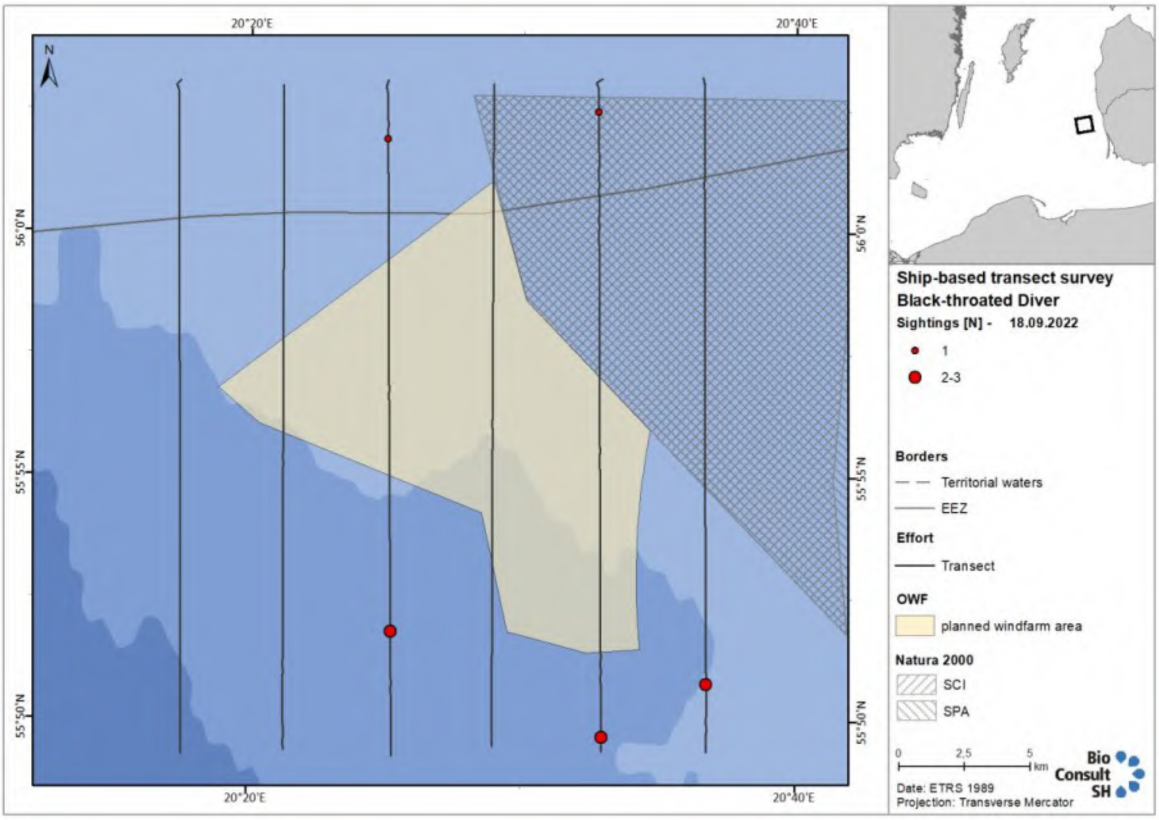

20°20'E
20°40'E
N
56°0'N
55°55'N
55°50'N
Ship-based transect survey
Red-throated Diver
Sightings [N] - 18.09.2022
1
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

A.3.2 Black-throated Diver (*Gavia arctica*)

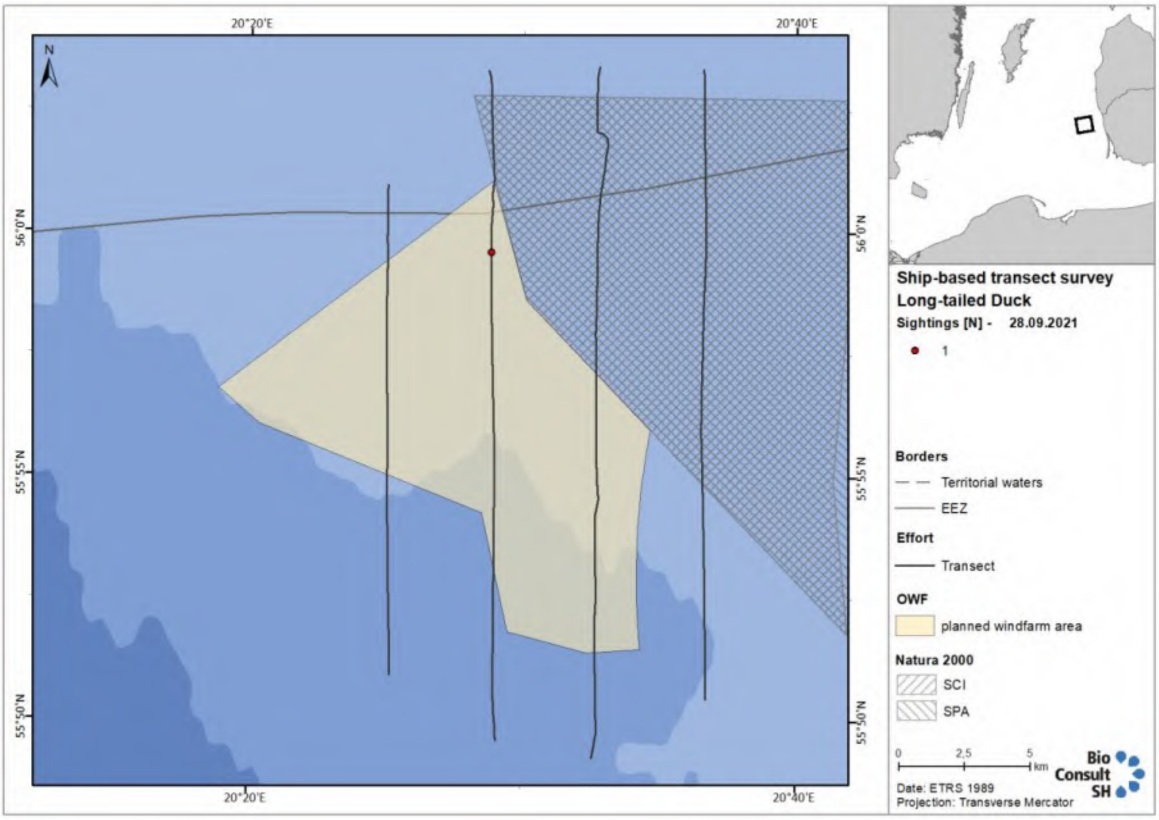


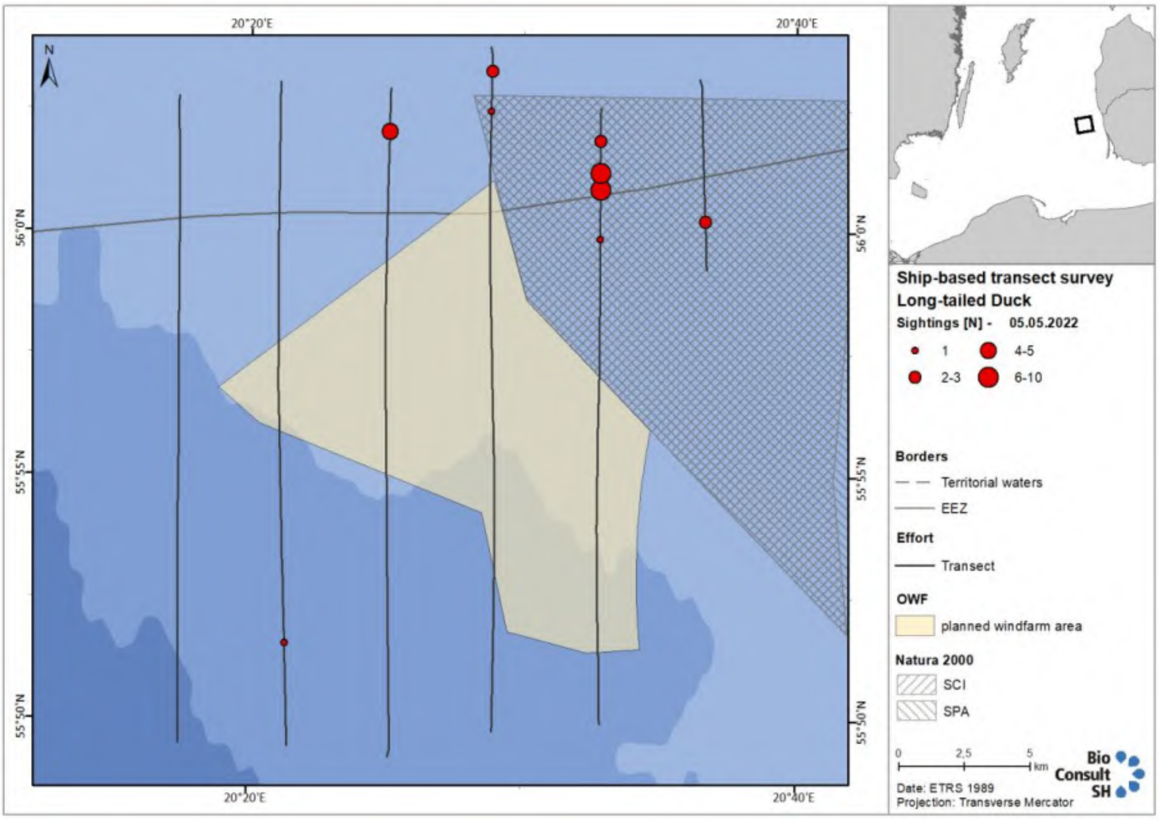



20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Black-throated Diver
Sightings [N] - 05.05.2022
1
4-5
2-3
6-10
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0
2,5
5
km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

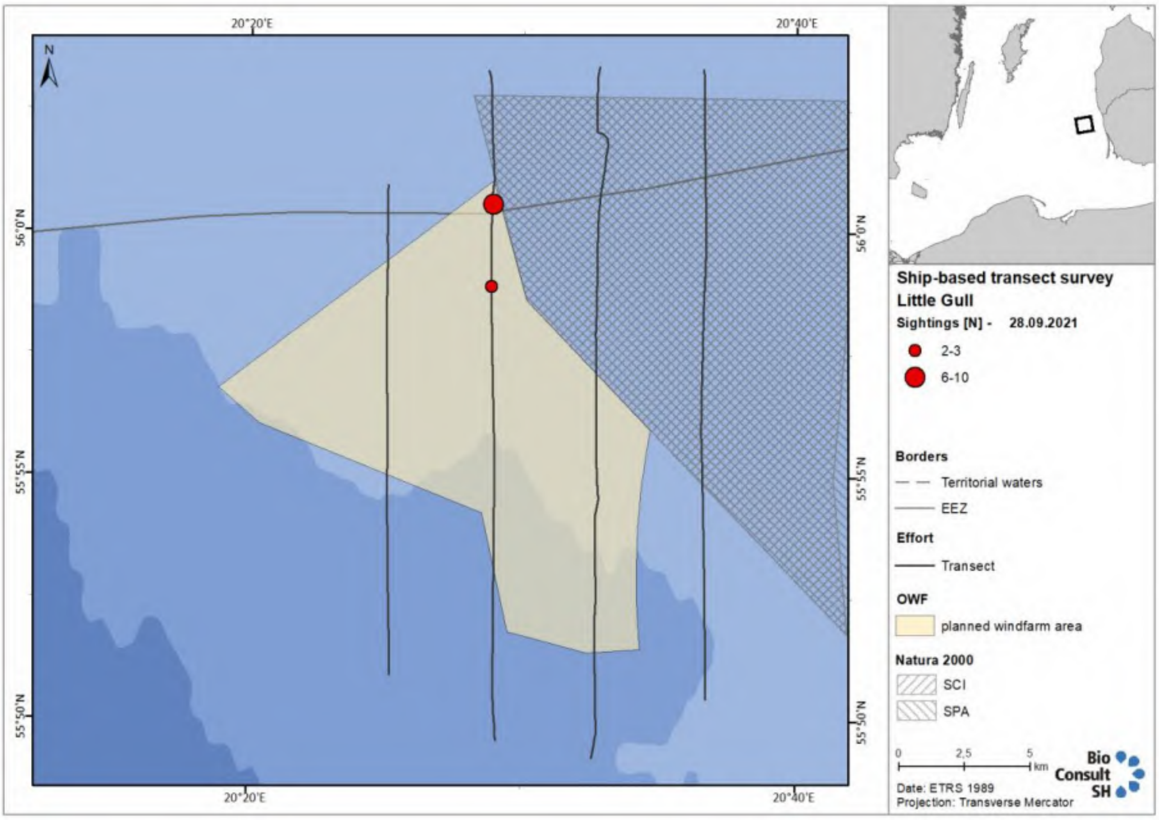

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Black-throated Diver
Sightings [N] - 18.09.2022
1
2-3
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0
2,5
5
km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

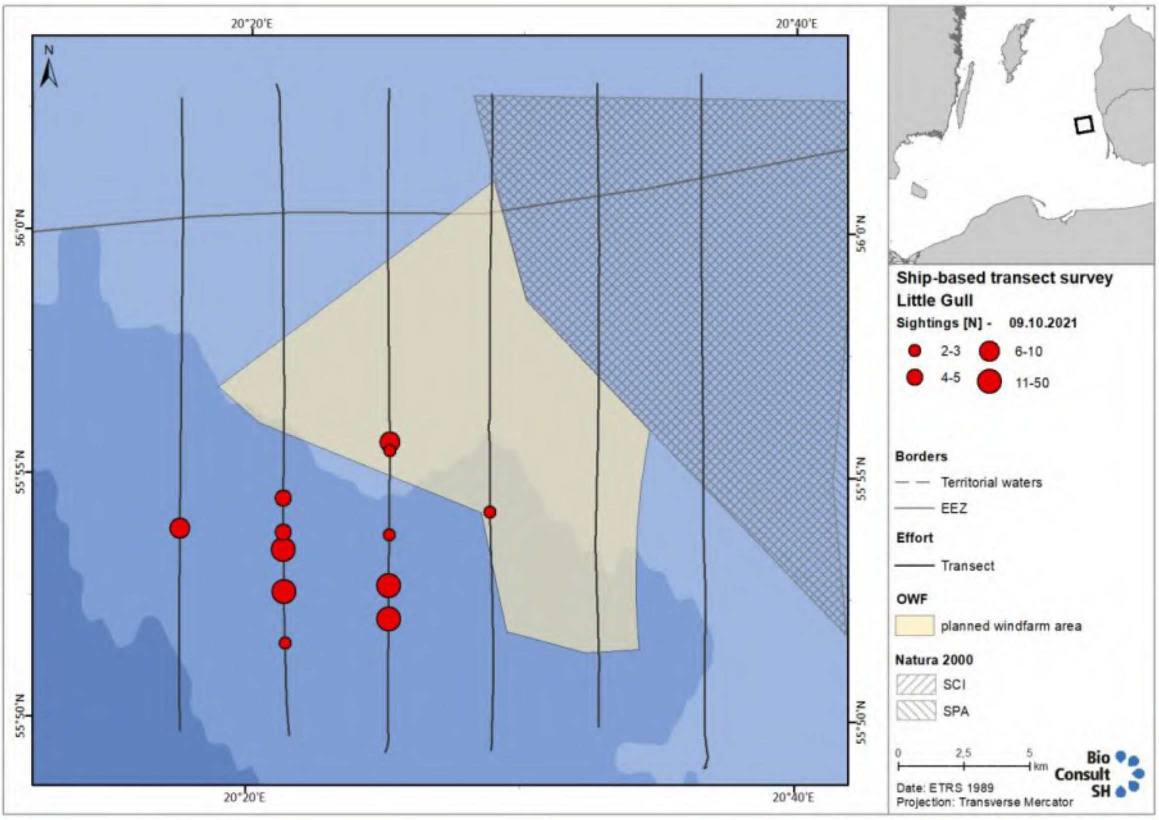
A.3.3 Long-tailed Duck (*Clangula hyemalis*)

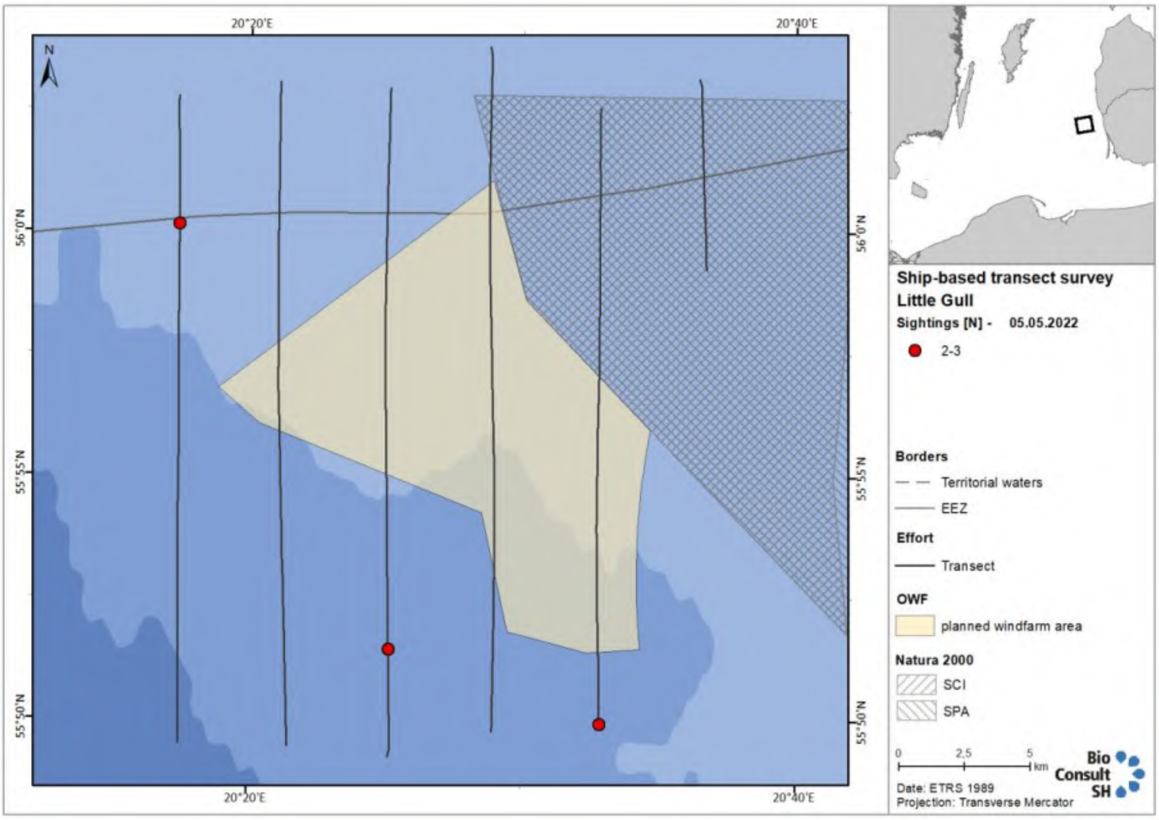


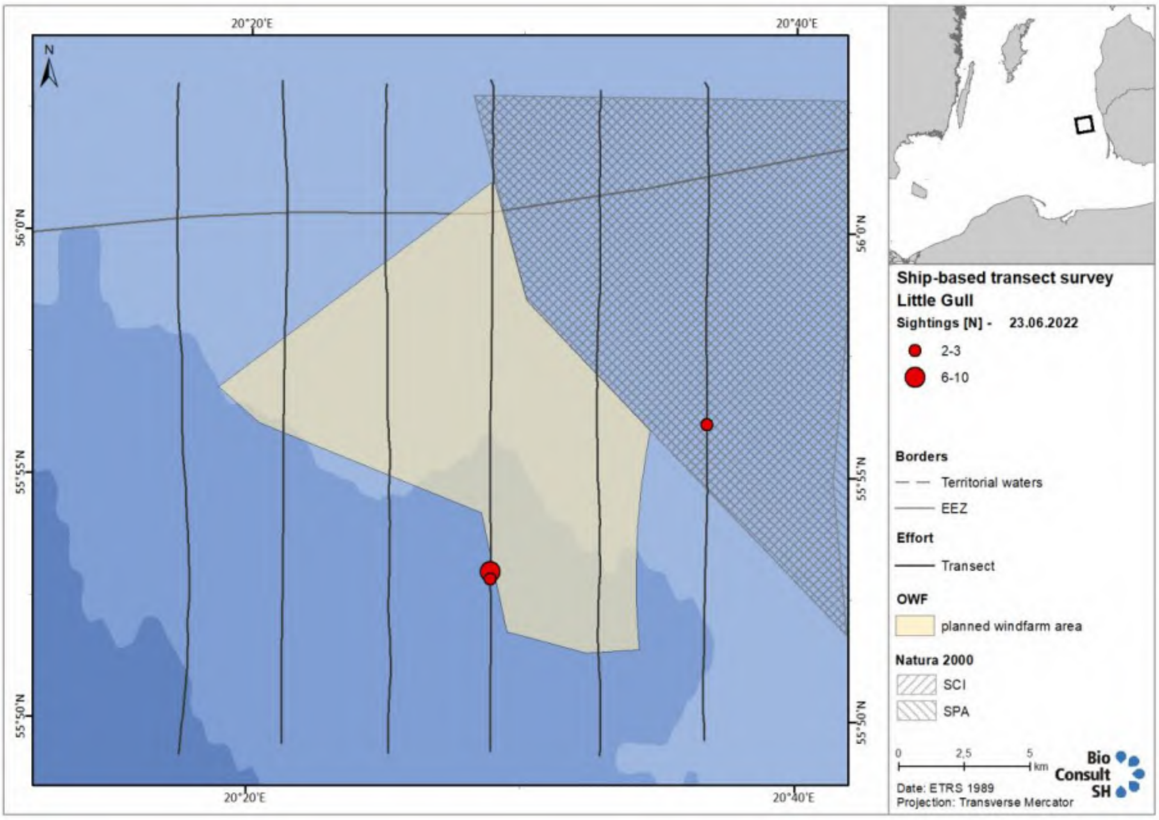


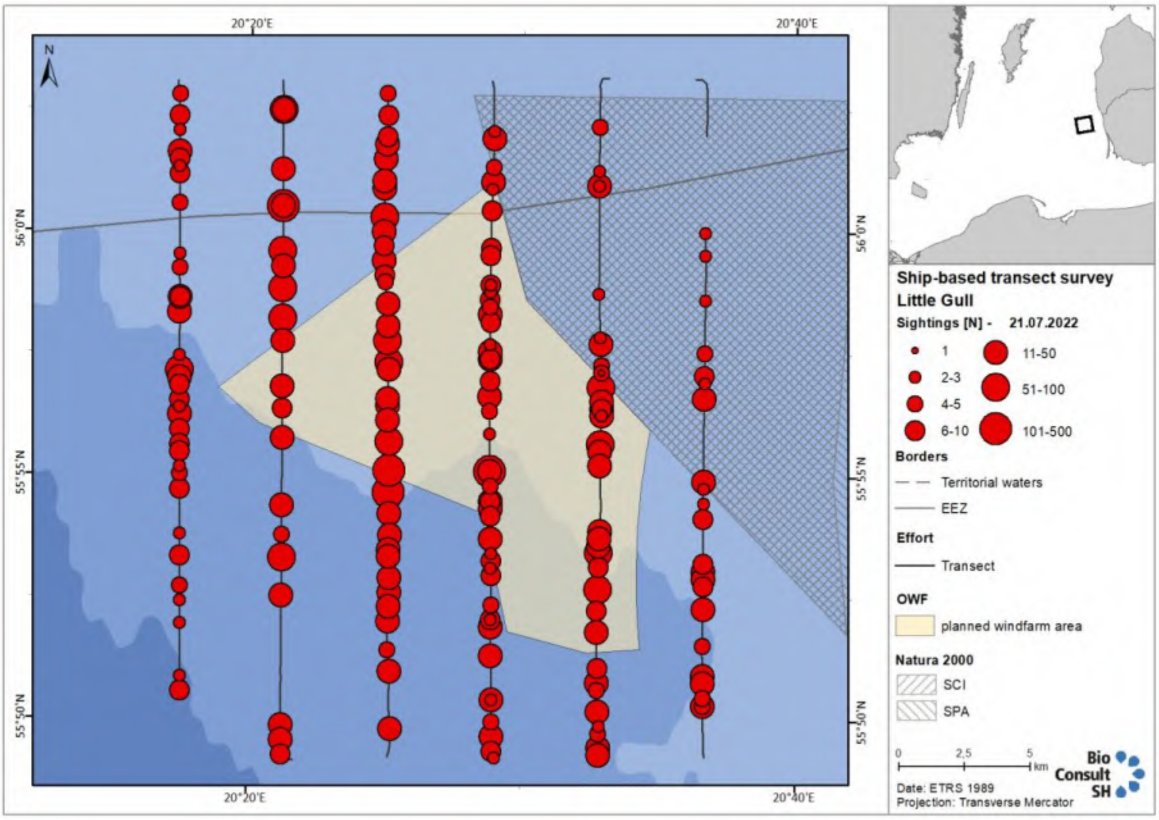
A.3.4 Little Gull (*Hydrocoloeus minutus*)

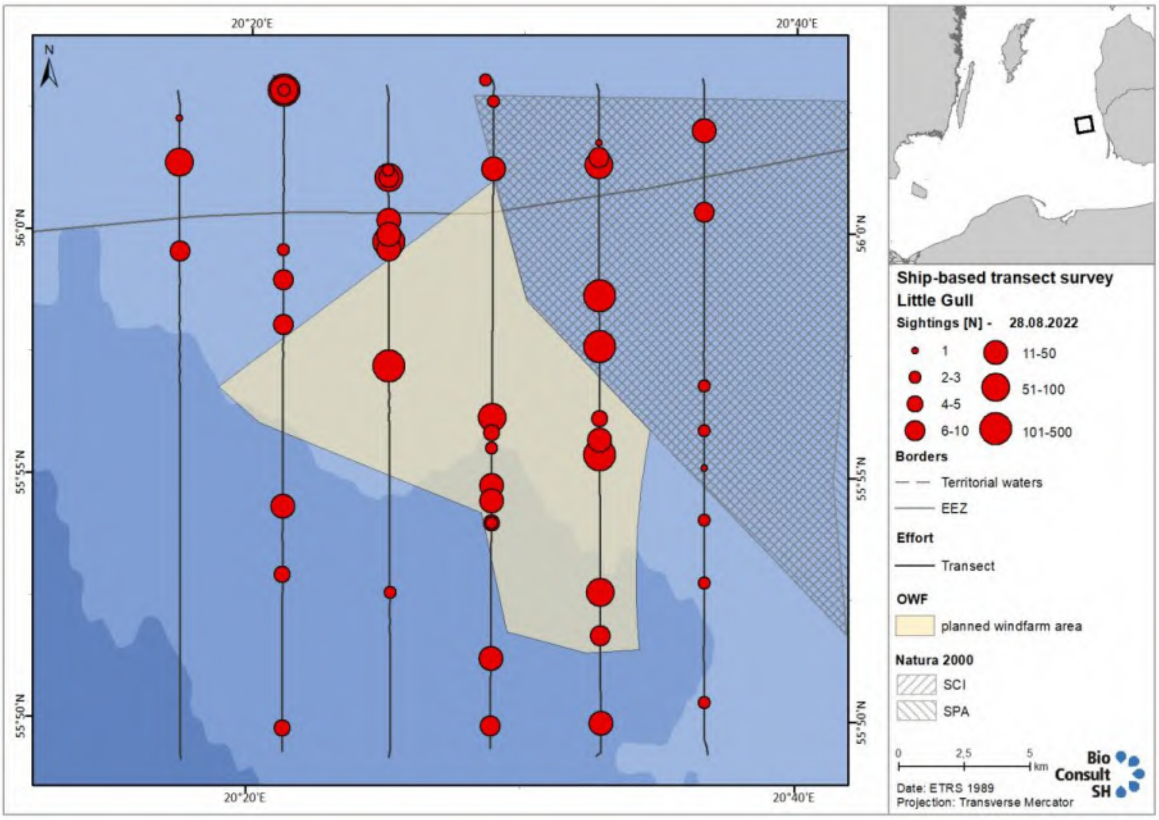


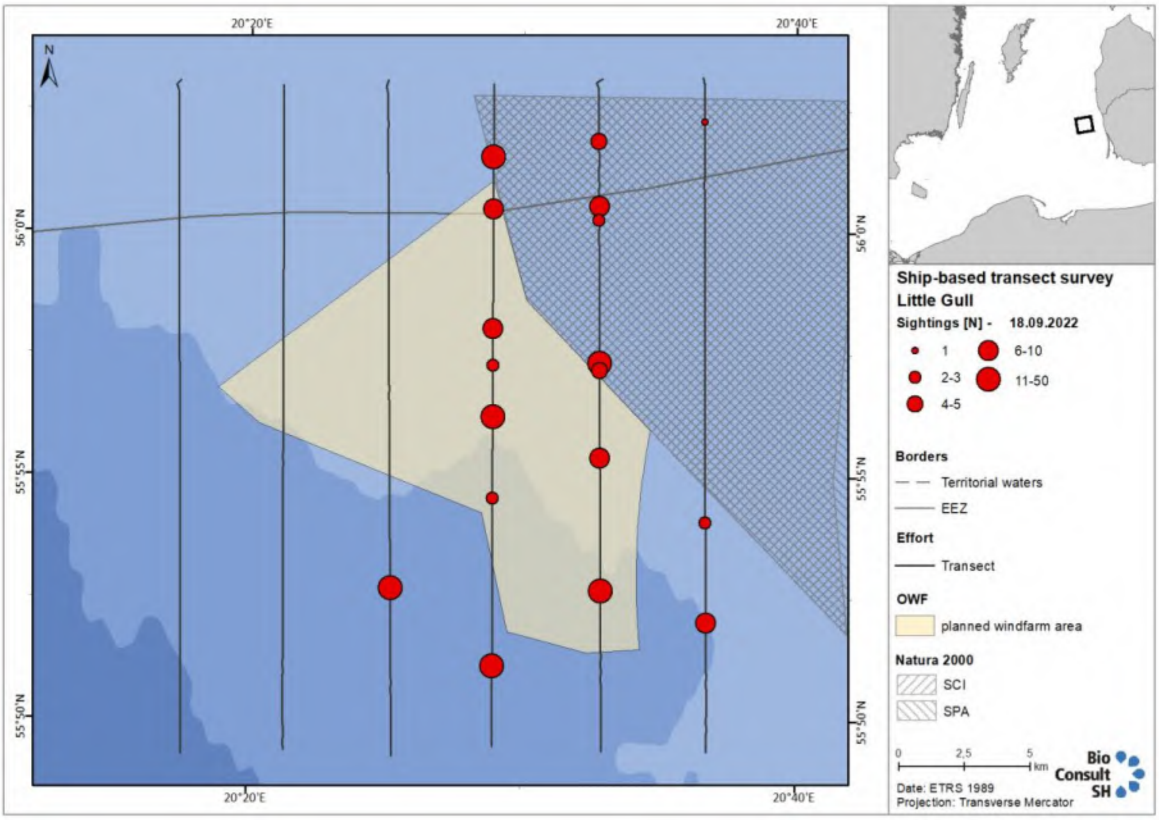



20°20'E
20°40'E
N
56°0'N
55°55'N
55°50'N
Ship-based transect survey
Little Gull
Sightings [N] - 05.05.2022
2-3
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

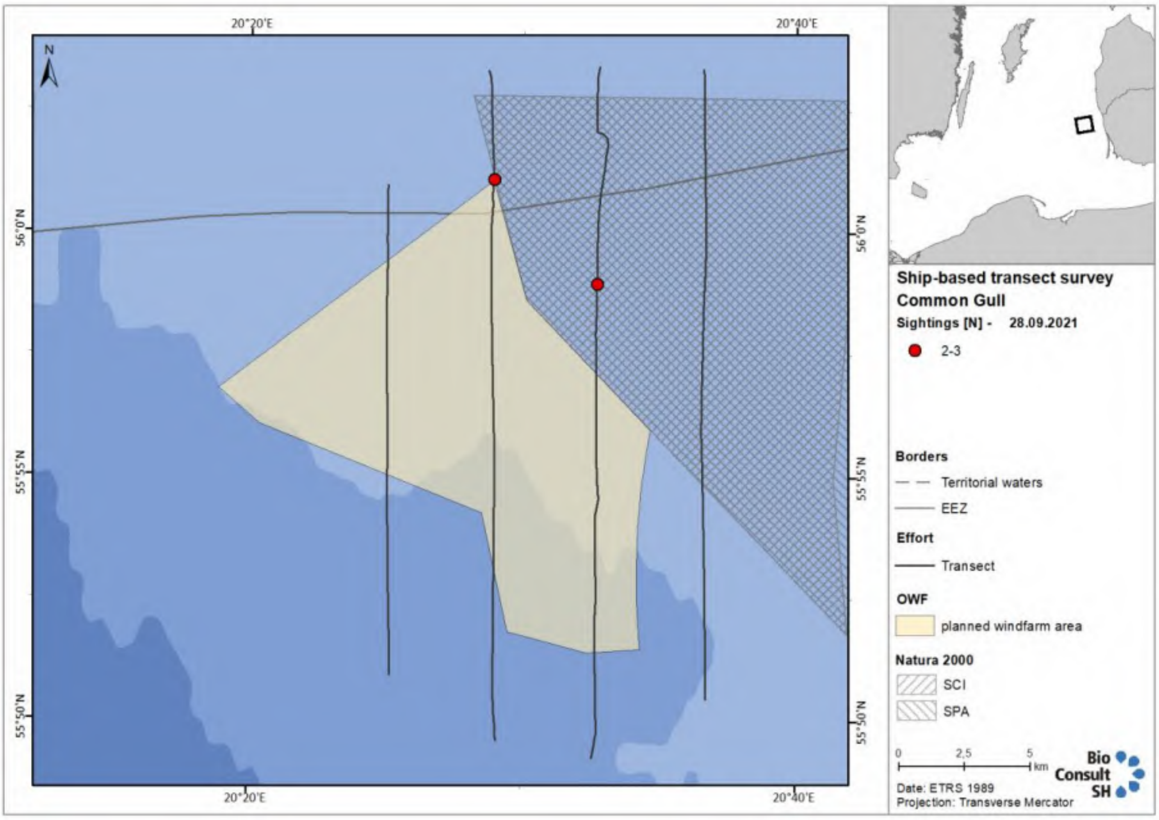

20°20'E
20°40'E
N
56°0'N
55°55'N
55°50'N
Ship-based transect survey
Little Gull
Sightings [N] - 23.06.2022
2-3
6-10
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

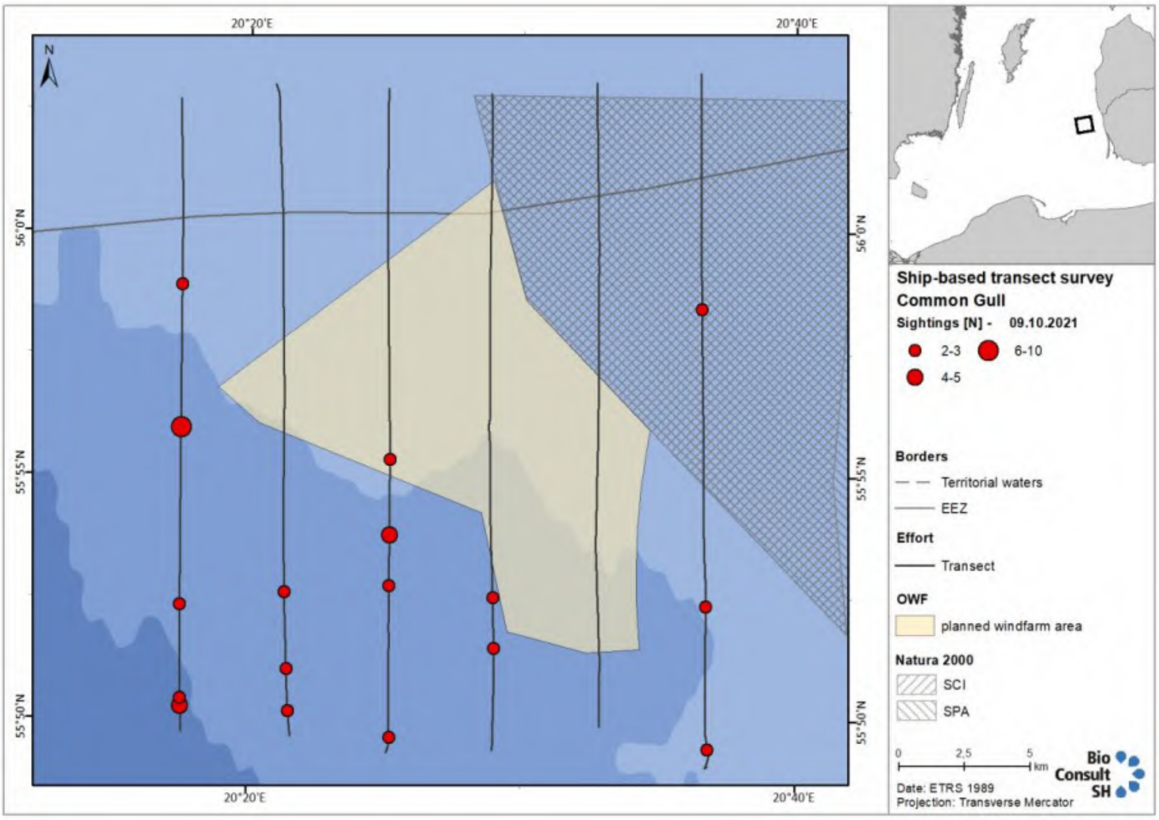

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Little Gull
Sightings [N] - 21.07.2022
1
2-3
4-5
6-10
11-50
51-100
101-500
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

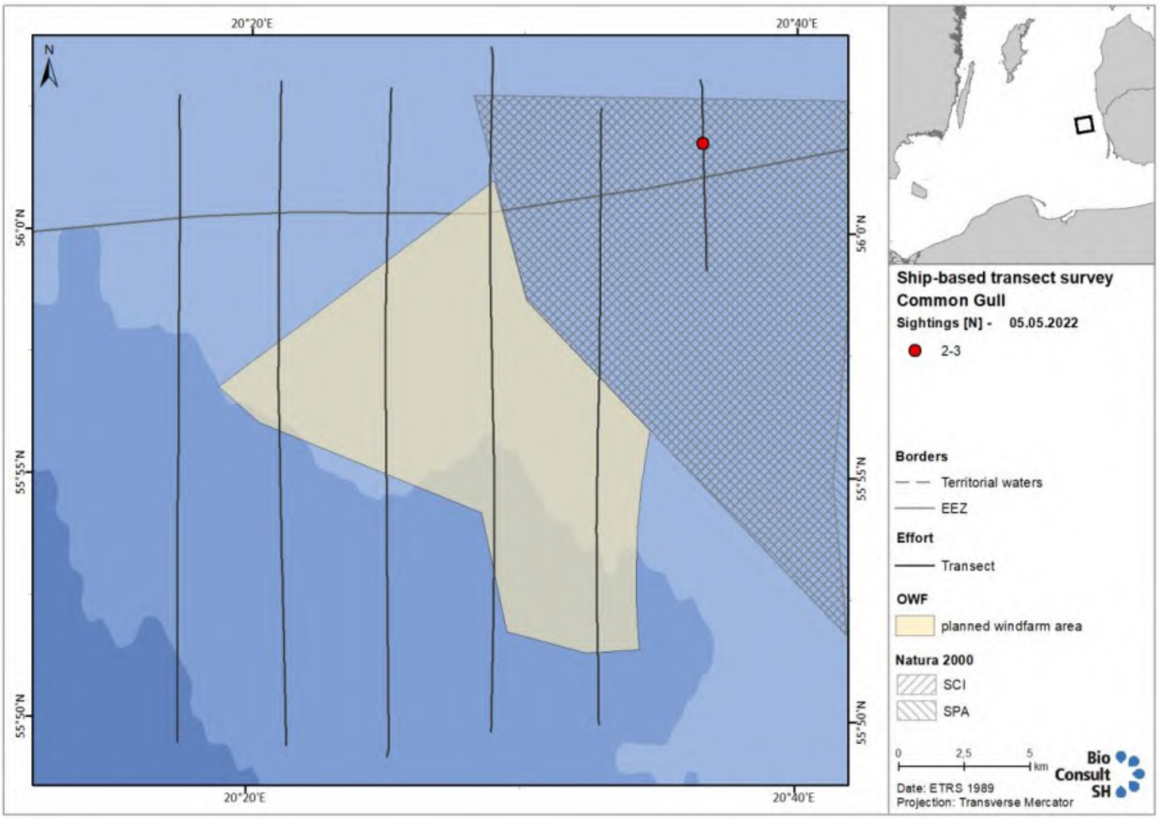

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Little Gull
Sightings [N] - 28.08.2022
1
2-3
4-5
6-10
11-50
51-100
101-500
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

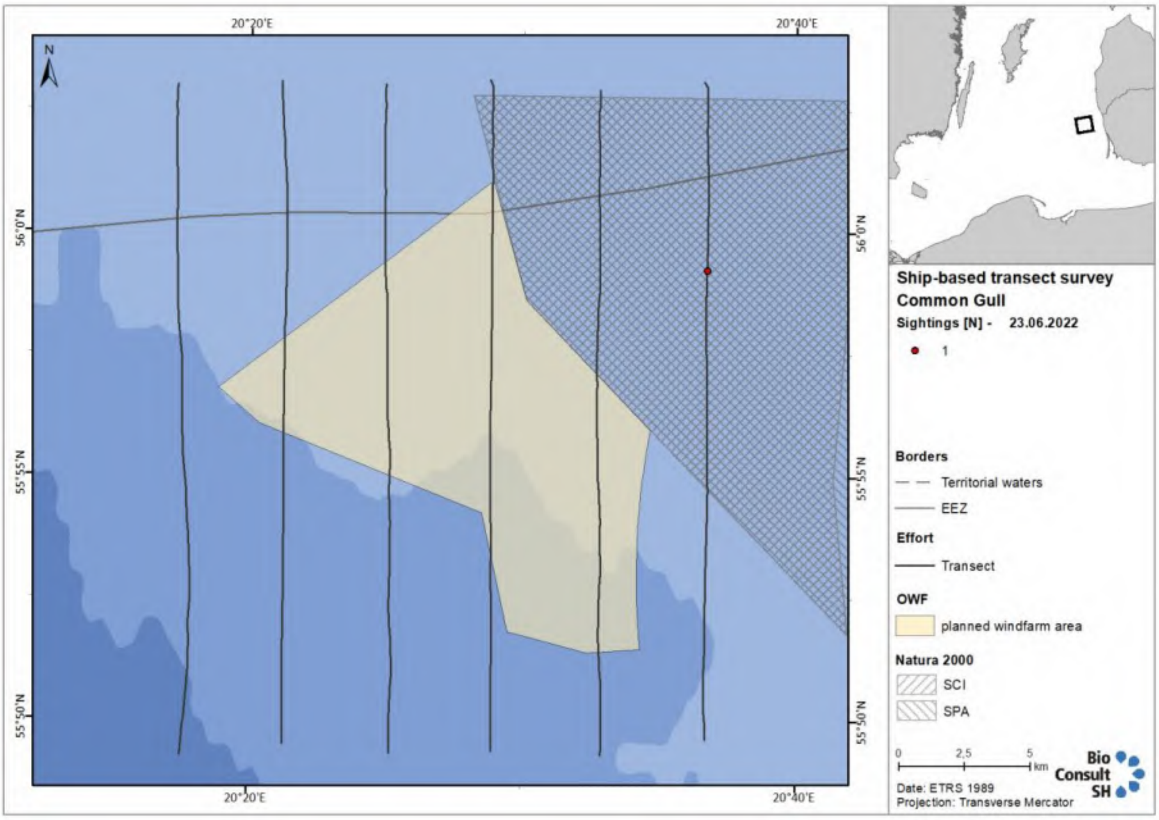

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Little Gull
Sightings [N] - 18.09.2022
1
2-3
4-5
6-10
11-50
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

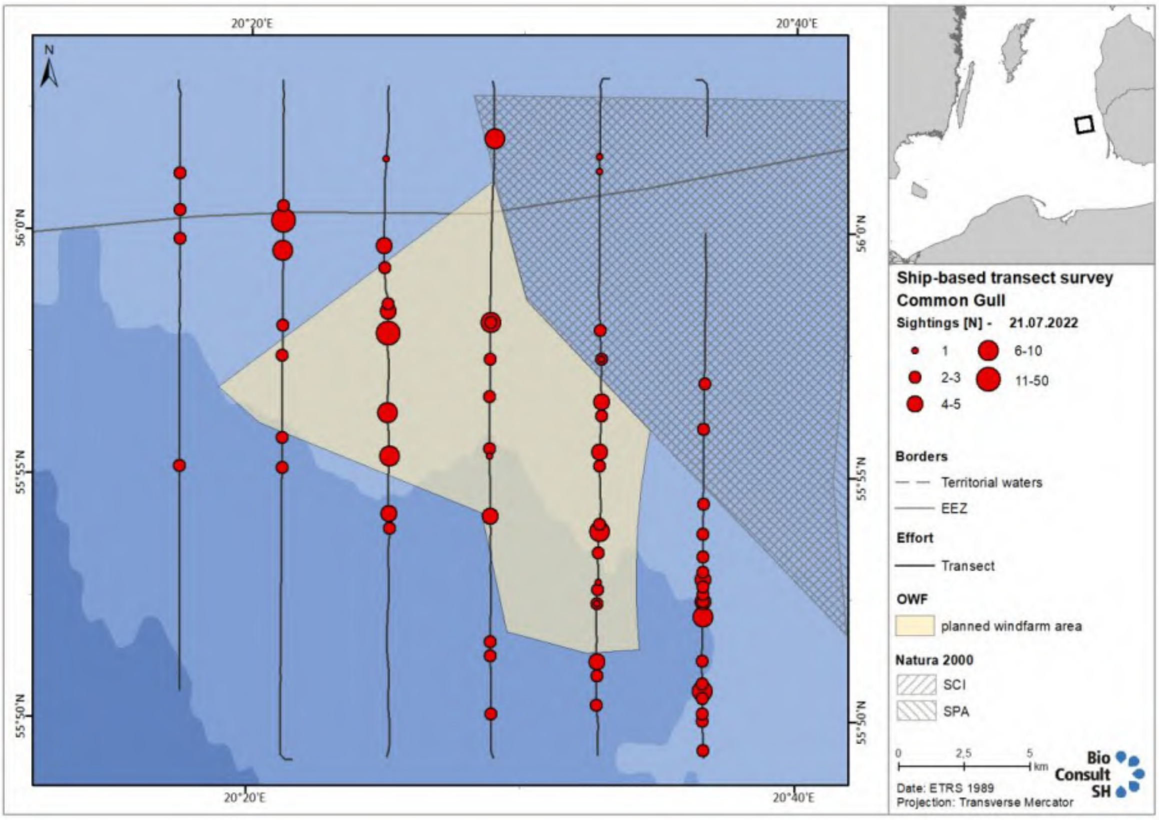
A.3.5 Common Gull (*Larus canus*)

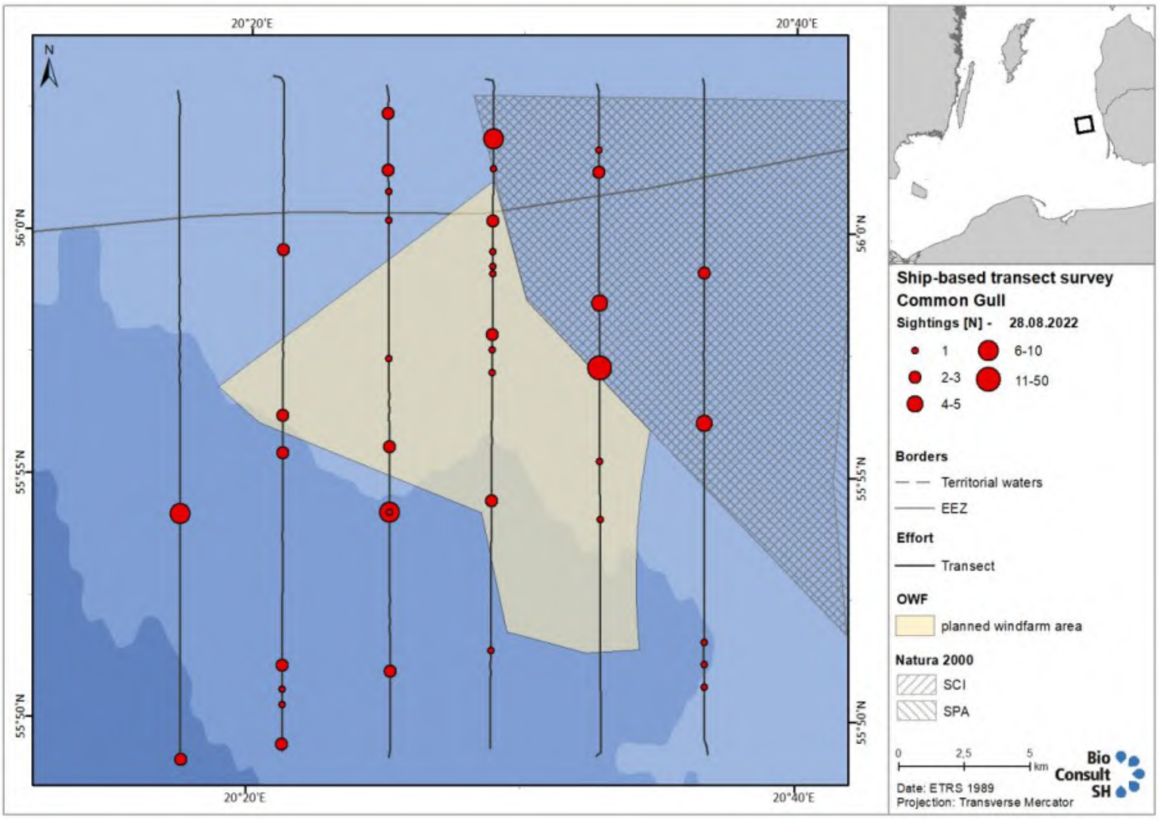


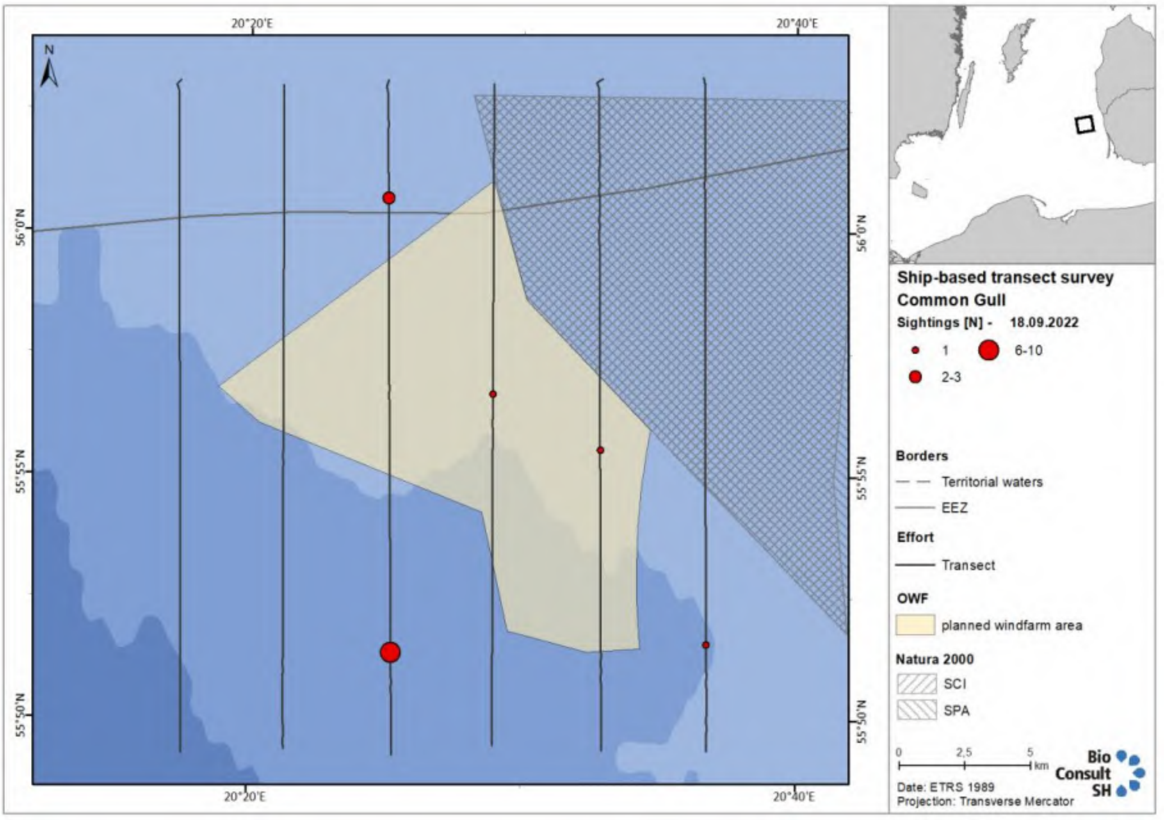



20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Gull
Sightings [N] - 05.05.2022
2-3
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH


20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Gull
Sightings [N] - 23.06.2022
1
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

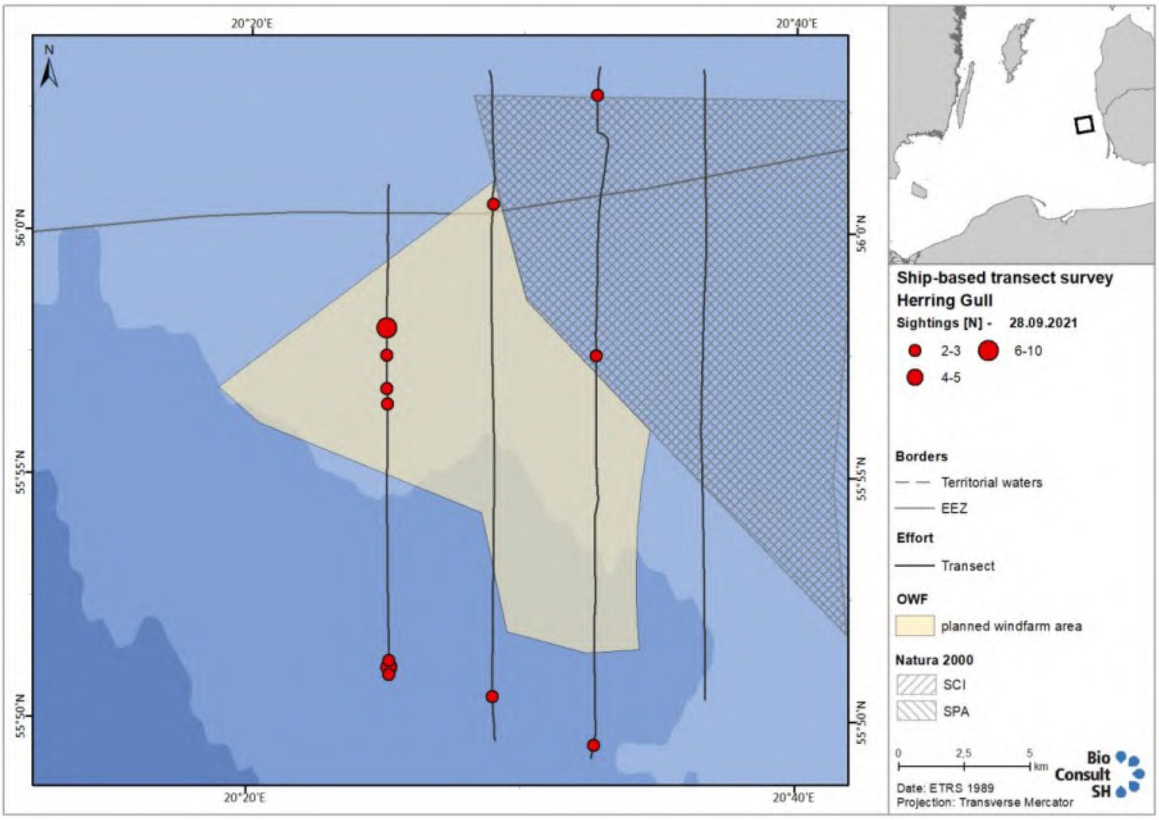

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Gull
Sightings [N] - 21.07.2022
1
2-3
4-5
6-10
11-50
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

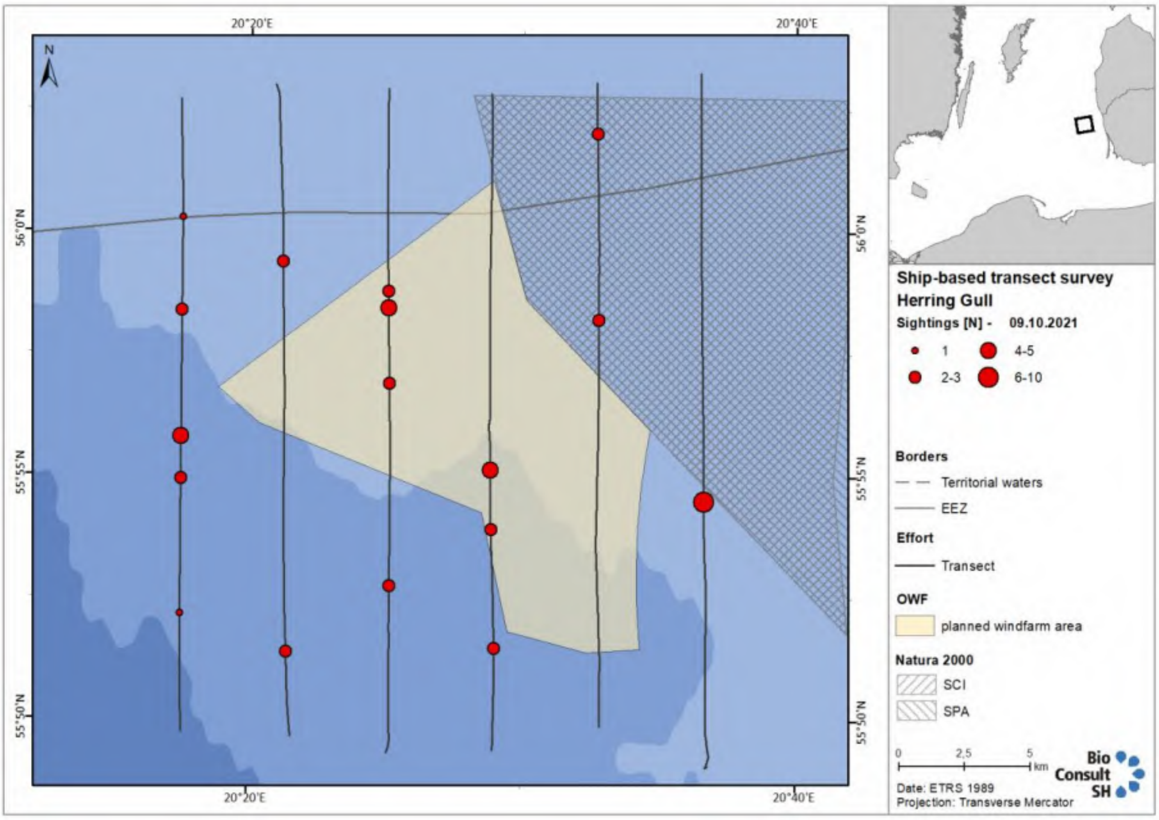

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Gull
Sightings [N] - 28.08.2022
1
2-3
4-5
6-10
11-50
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

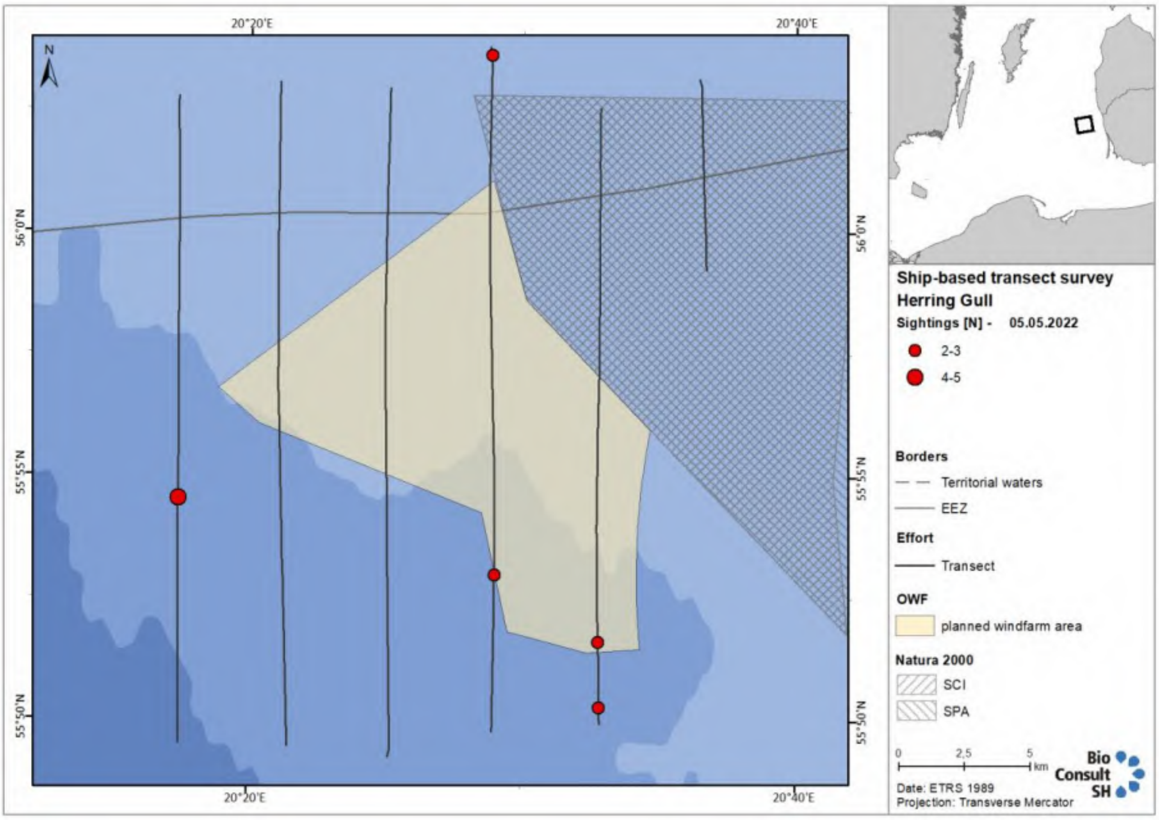


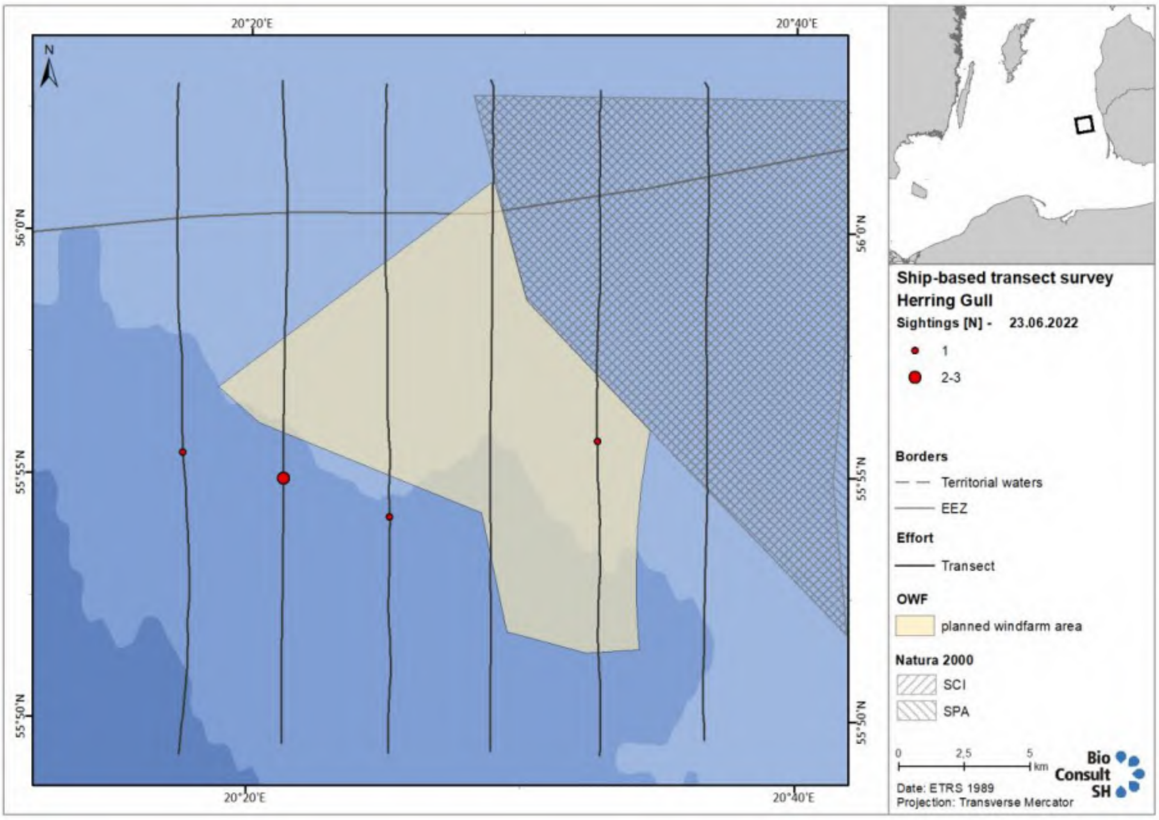
20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Gull
Sightings [N] - 18.09.2022
1
2-3
6-10
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

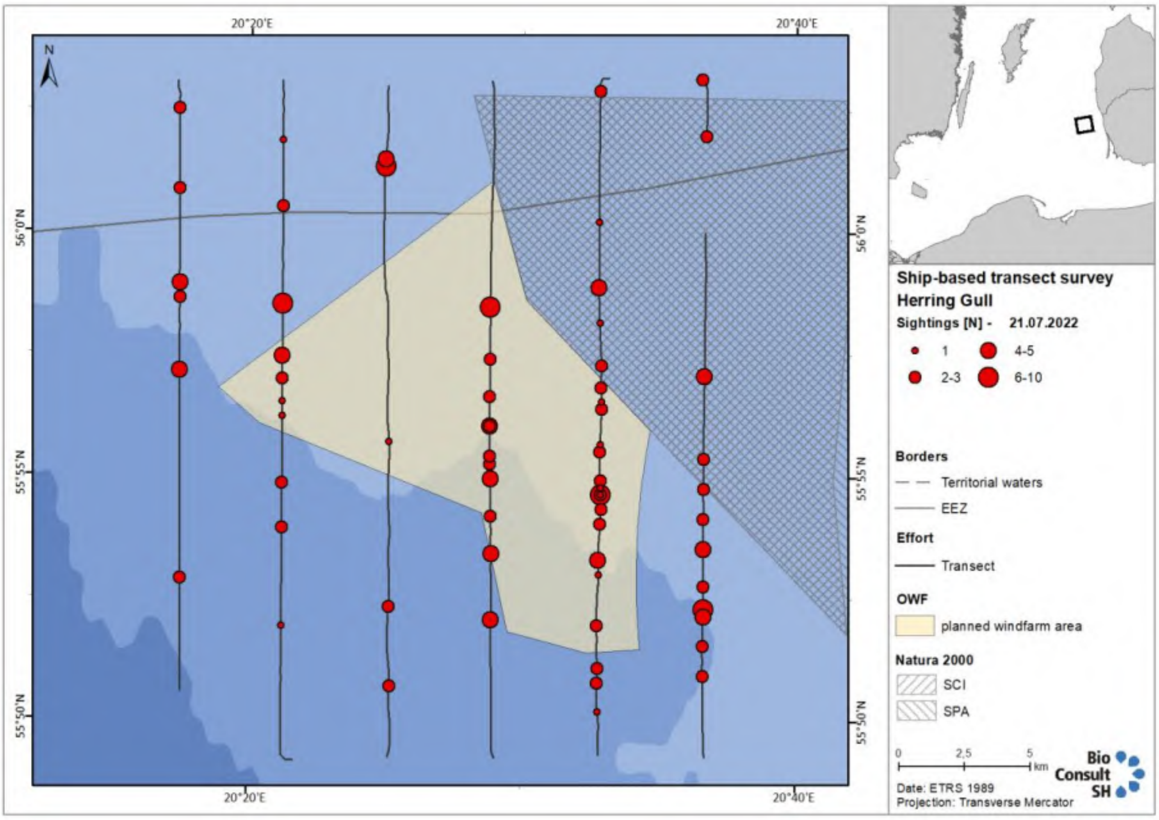
A.3.6 Herring Gull (*Larus argentatus*)

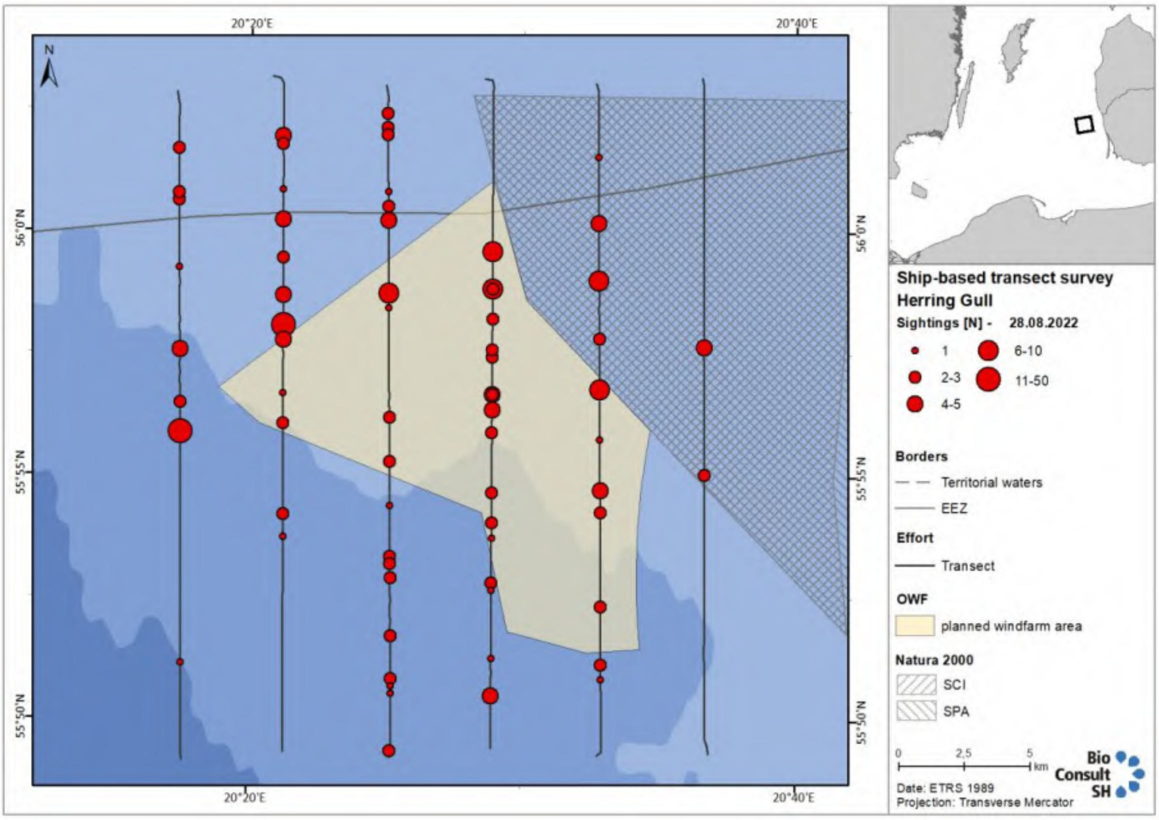


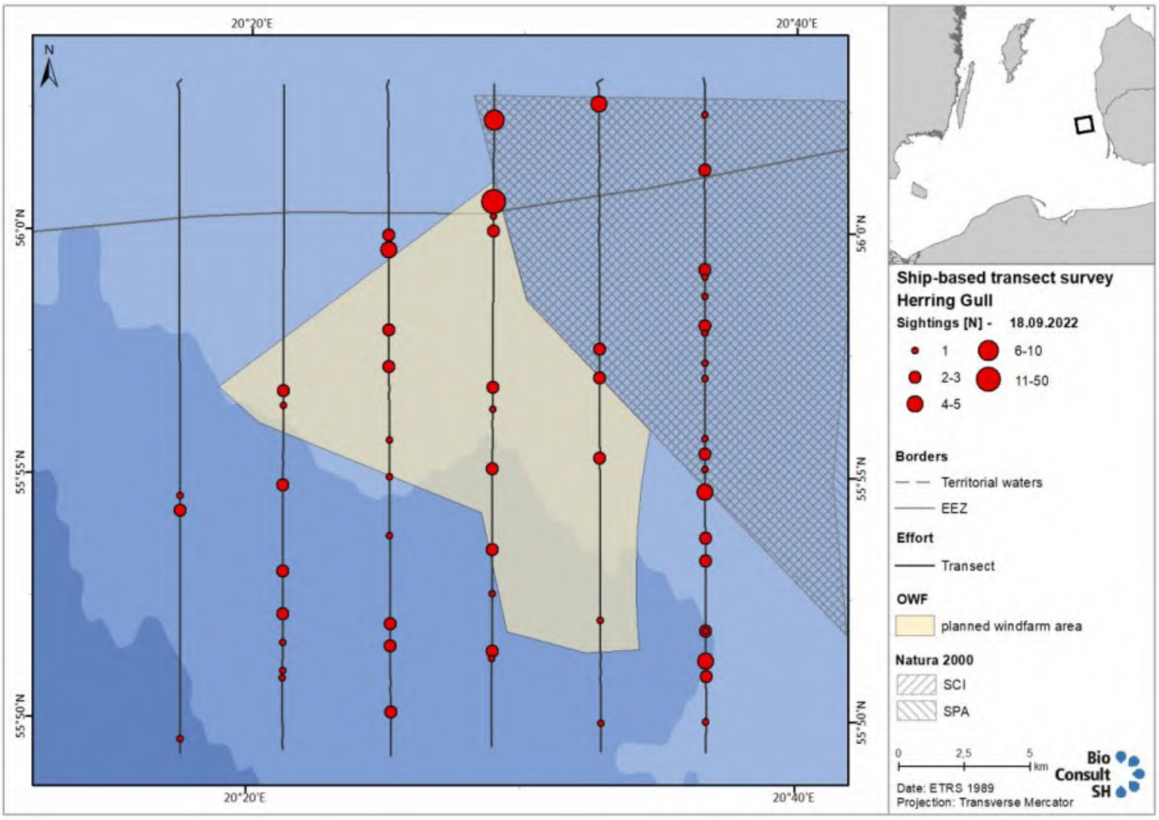



20°20'E
20°40'E
N
56°0'N
55°55'N
55°50'N
Ship-based transect survey
Herring Gull
Sightings [N] - 05.05.2022
2-3
4-5
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Bio Consult SH
Date: ETRS 1989
Projection: Transverse Mercator

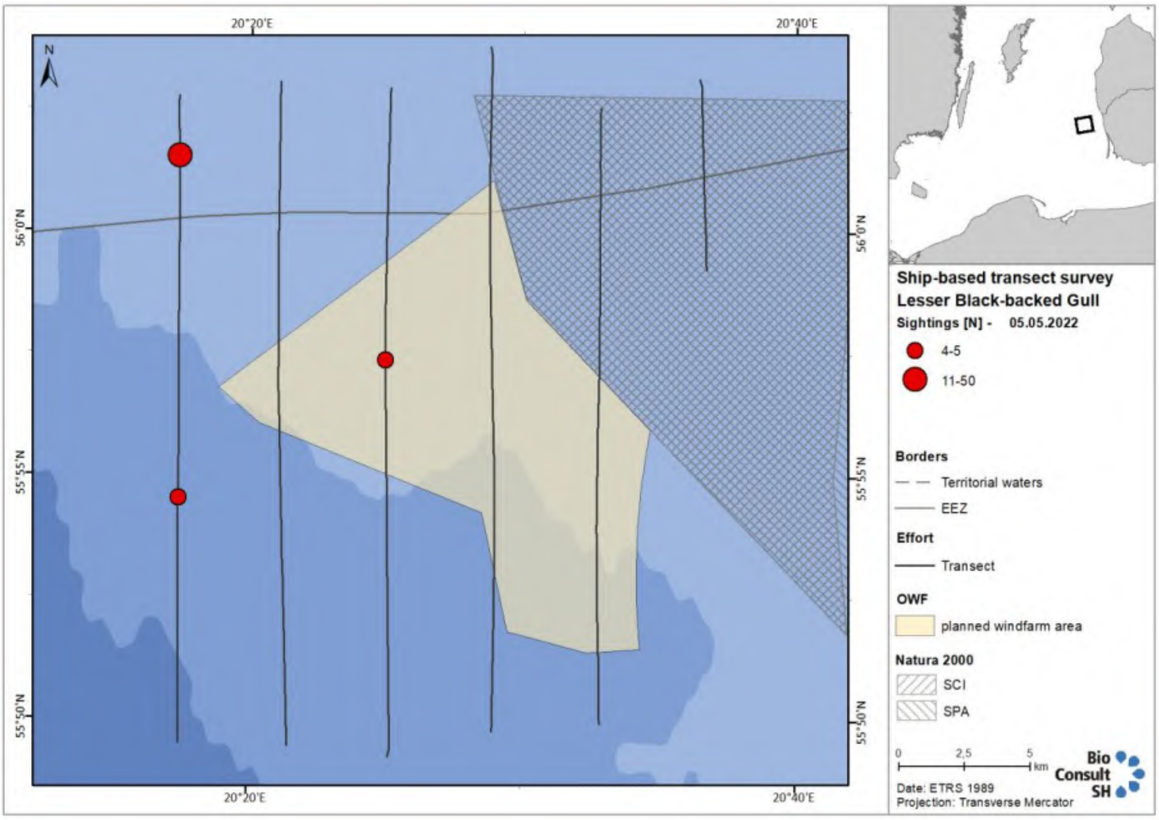

20°20'E
20°40'E
N
56°0'N
55°55'N
55°50'N
Ship-based transect survey
Herring Gull
Sightings [N] - 23.06.2022
1
2-3
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Bio Consult SH
Date: ETRS 1989
Projection: Transverse Mercator

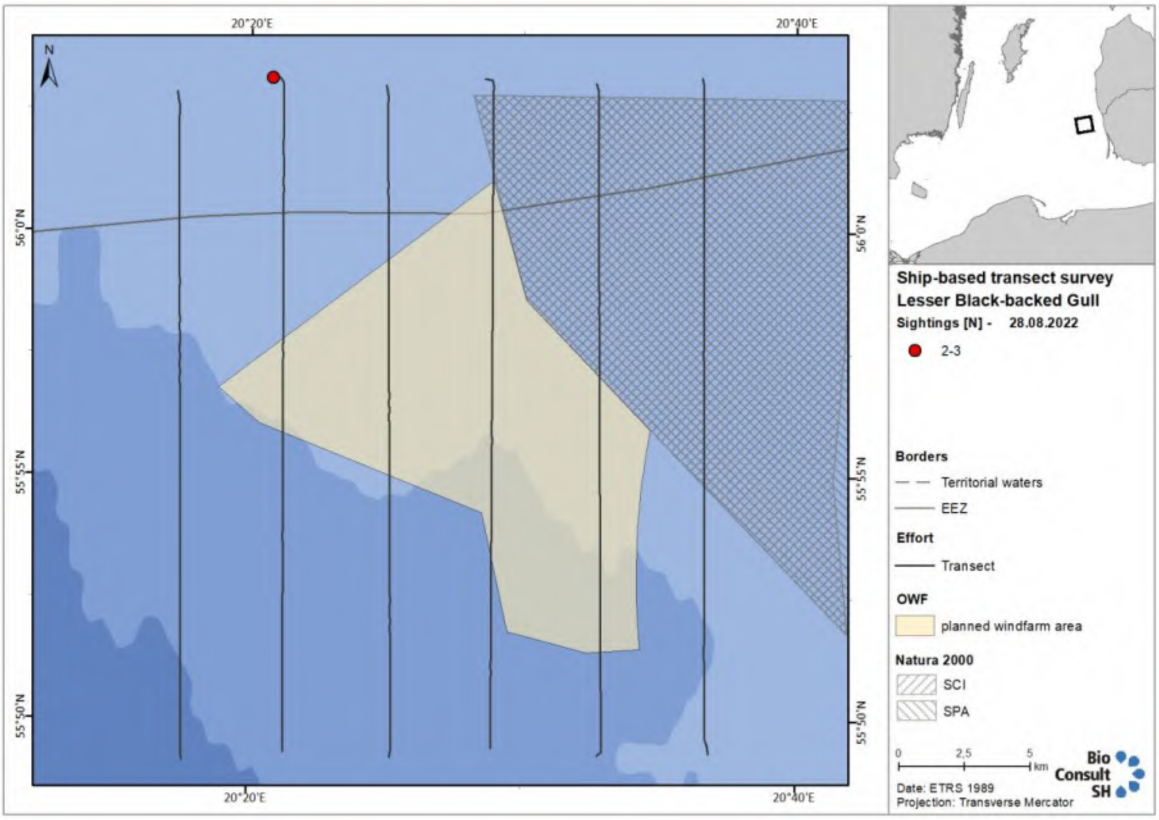

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Herring Gull
Sightings [N] - 21.07.2022
1
2-3
4-5
6-10
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0
2,5
5
km
Date: ETRS 1989
Projection: Transverse Mercator

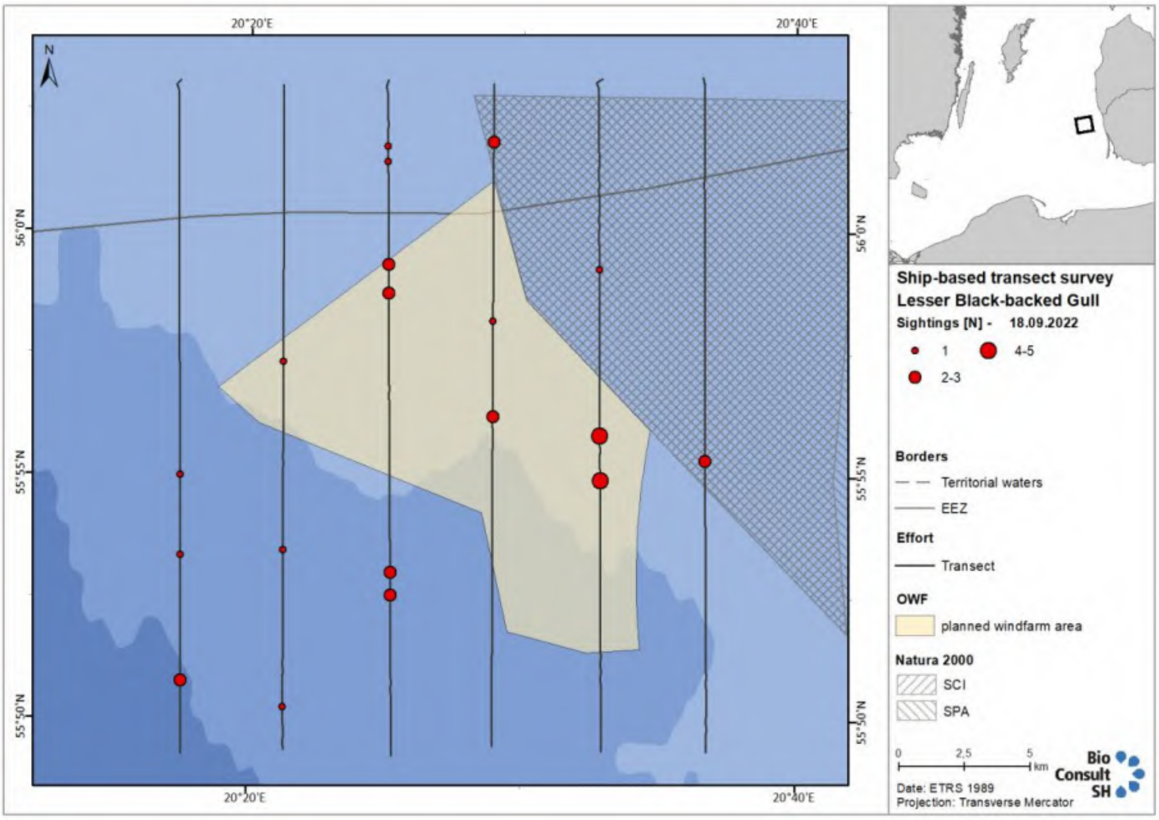

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Herring Gull
Sightings [N] - 28.08.2022
1
2-3
4-5
6-10
11-50
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0
2,5
5
km
Date: ETRS 1989
Projection: Transverse Mercator


20°20'E
20°40'E
N
56°0'N
55°55'N
55°50'N
Ship-based transect survey
Herring Gull
Sightings [N] - 18.09.2022
1
2-3
4-5
6-10
11-50
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0
2,5
5
km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

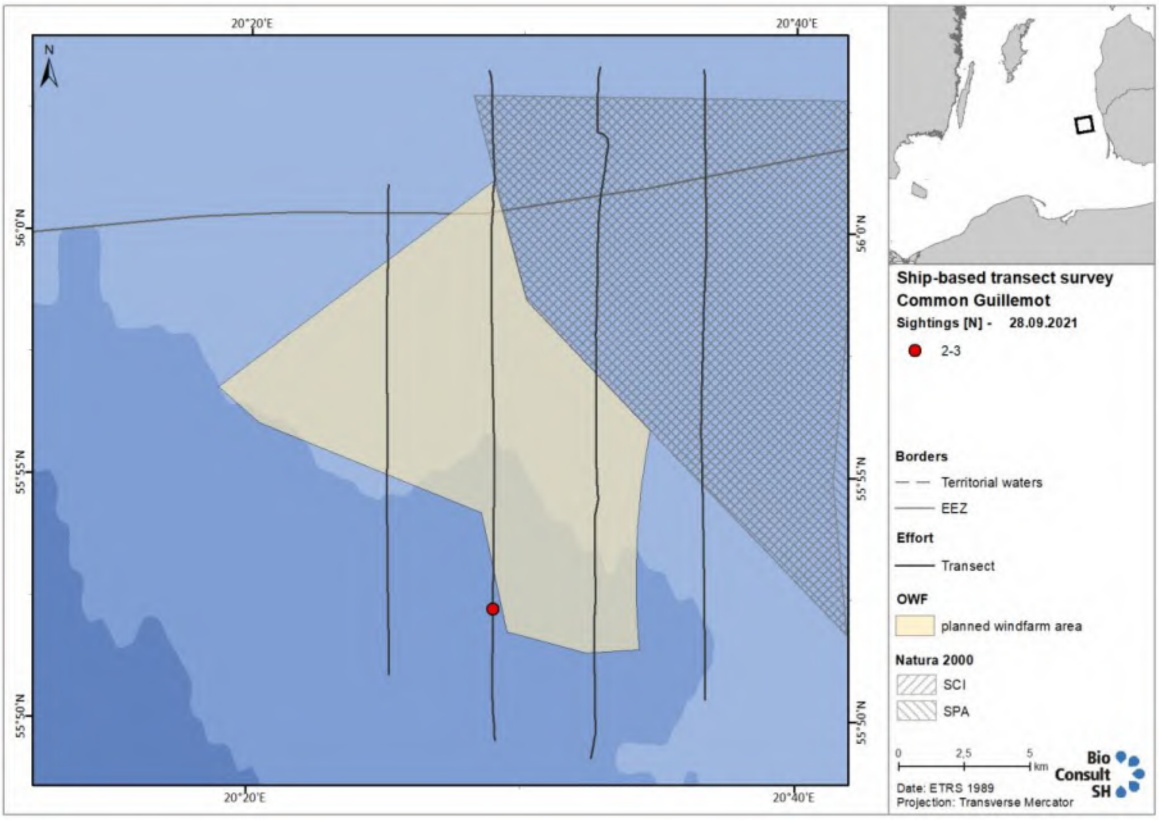
A.3.7 Lesser Black-backed Gull (*Larus fuscus*)

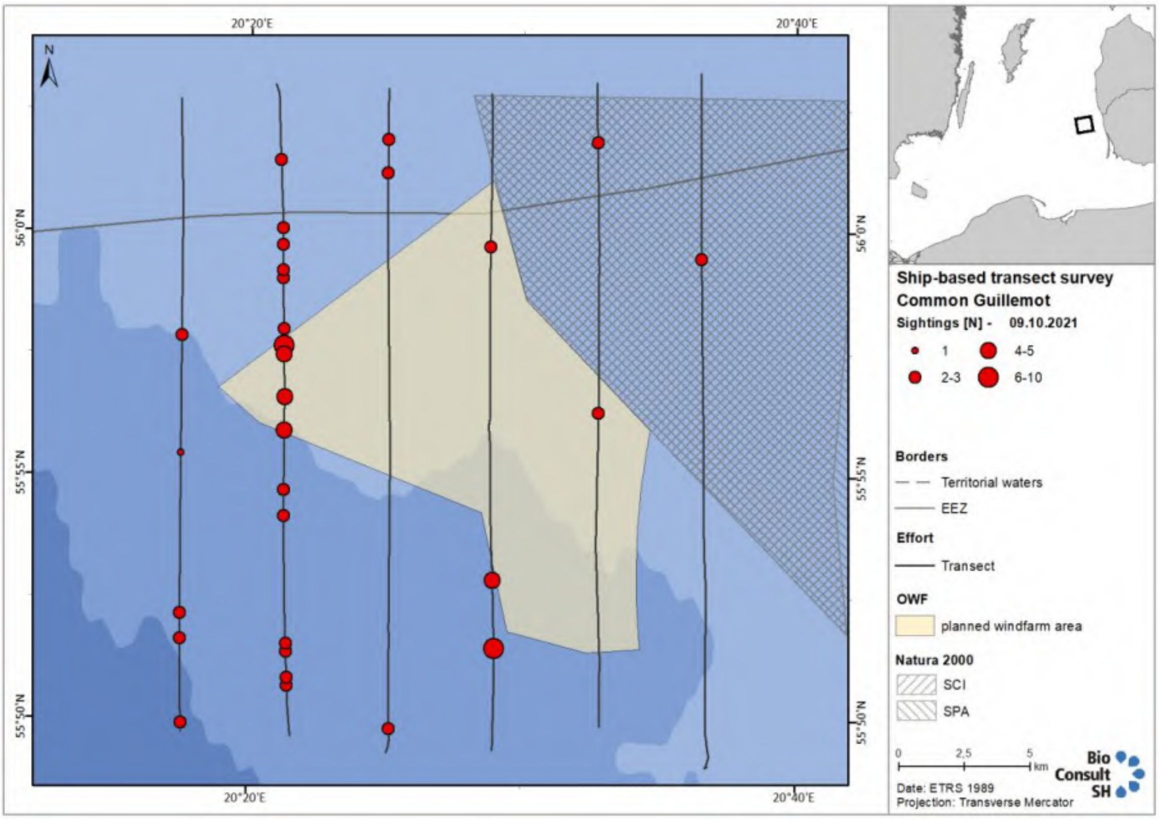

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Lesser Black-backed Gull
Sightings [N] - 05.05.2022
4-5
11-50
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

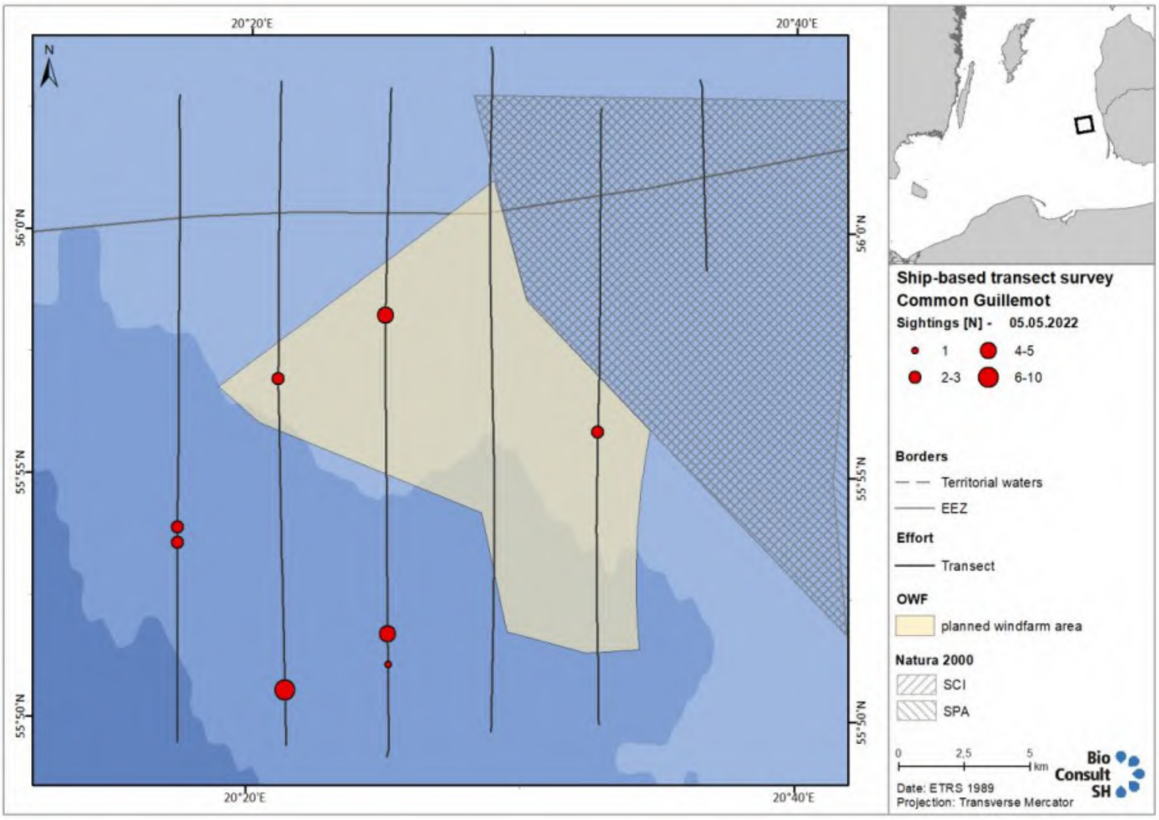

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Lesser Black-backed Gull
Sightings [N] - 28.08.2022
2-3
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator

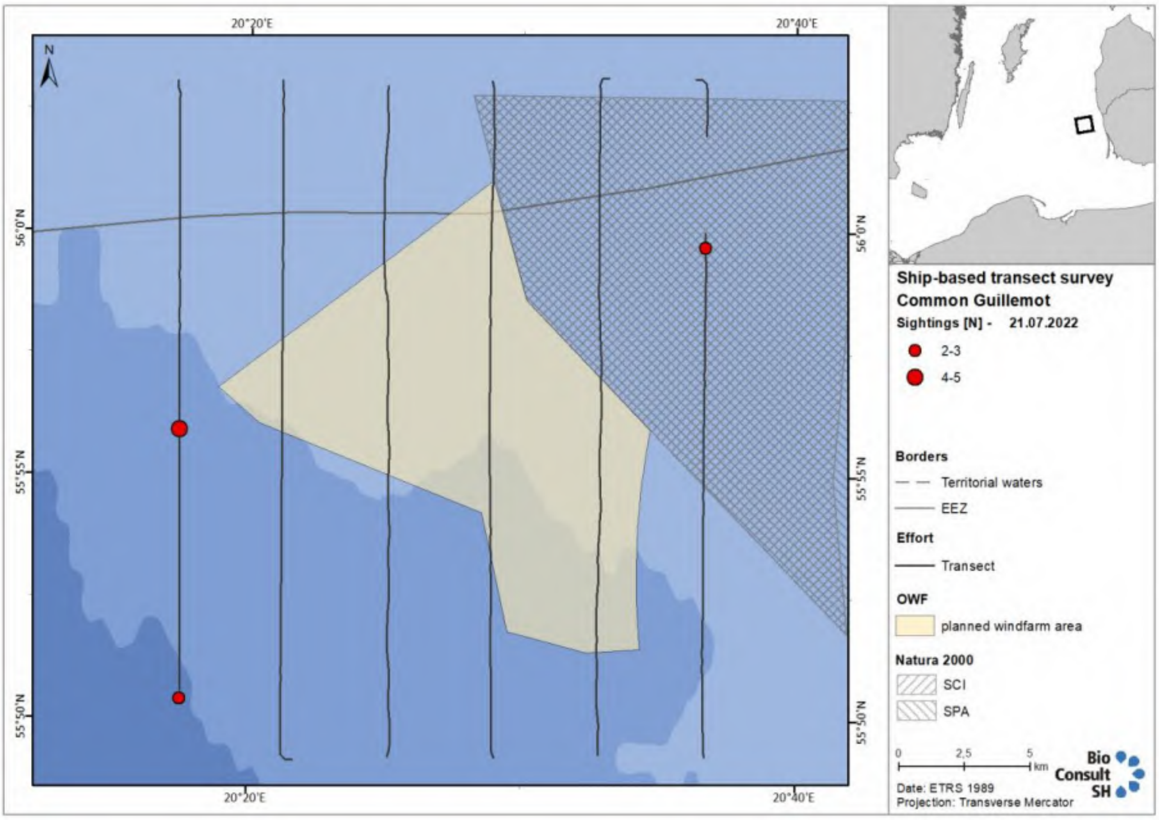

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Lesser Black-backed Gull
Sightings [N] - 18.09.2022
1
4-5
2-3
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

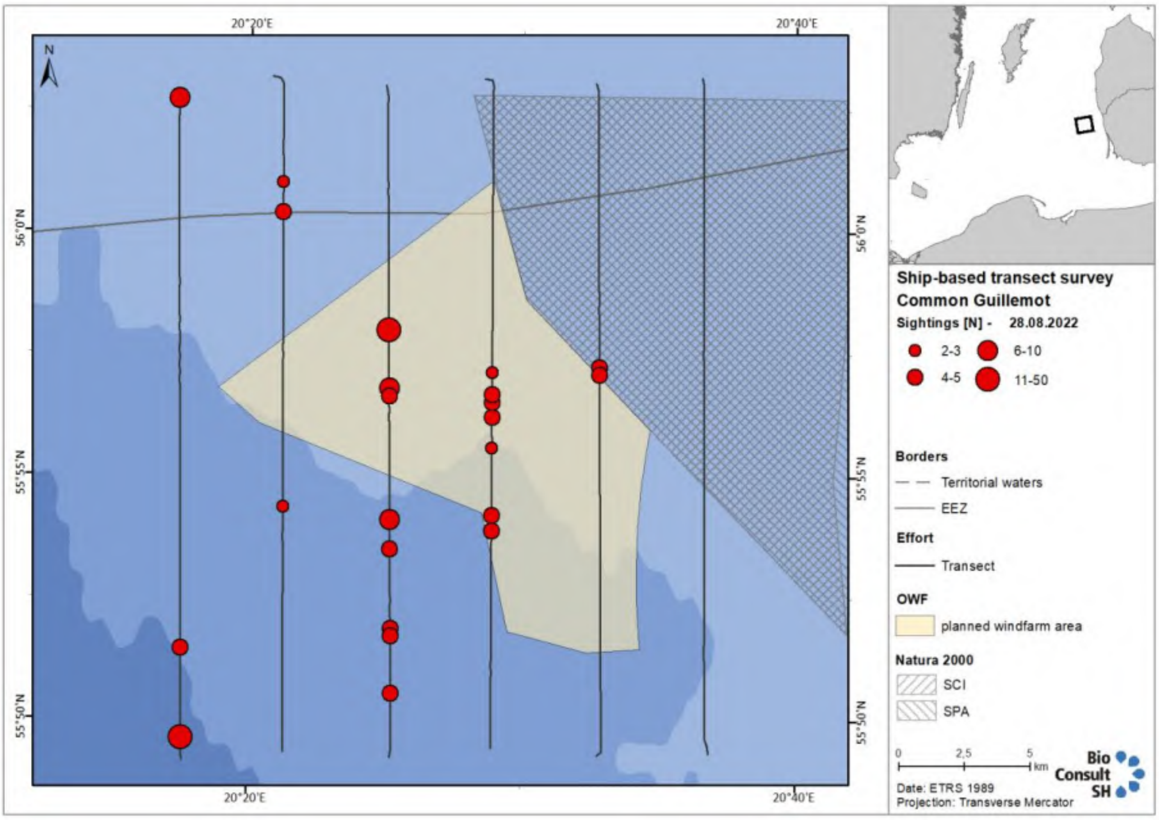
A.3.8 Common Guillemot (*Uria aalge*)

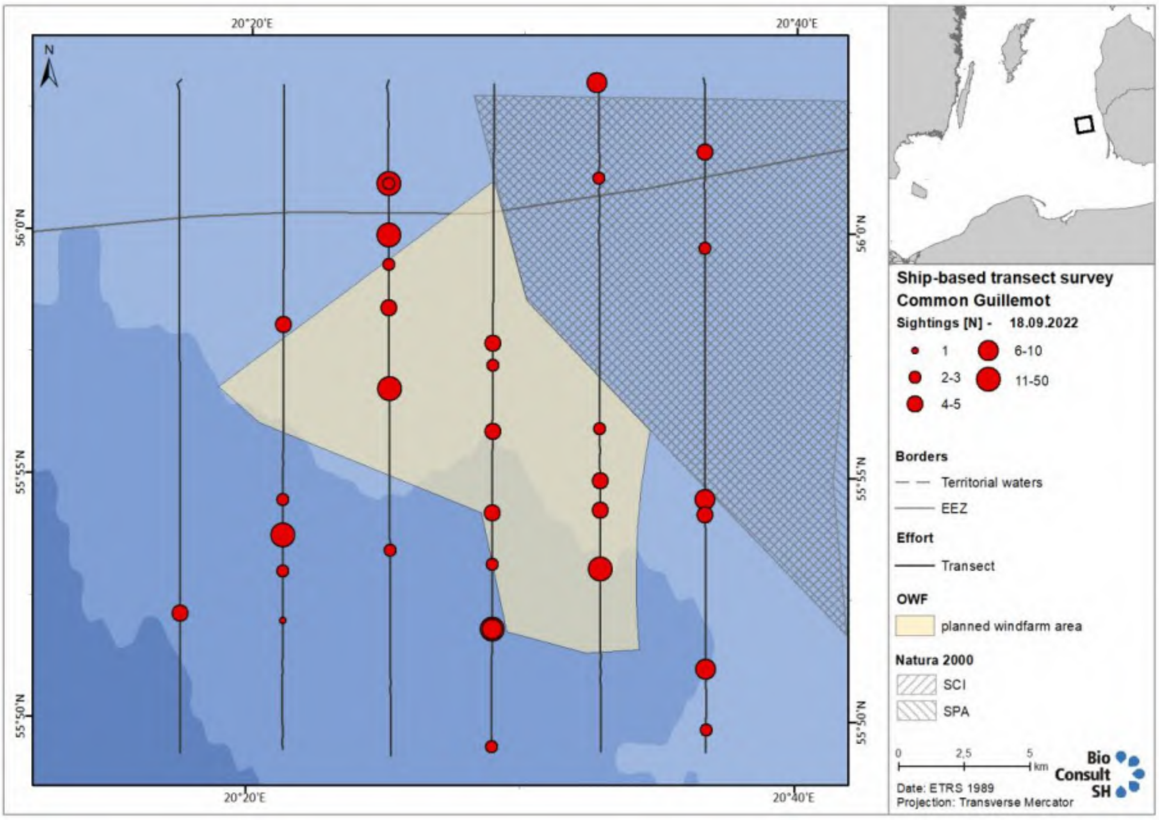




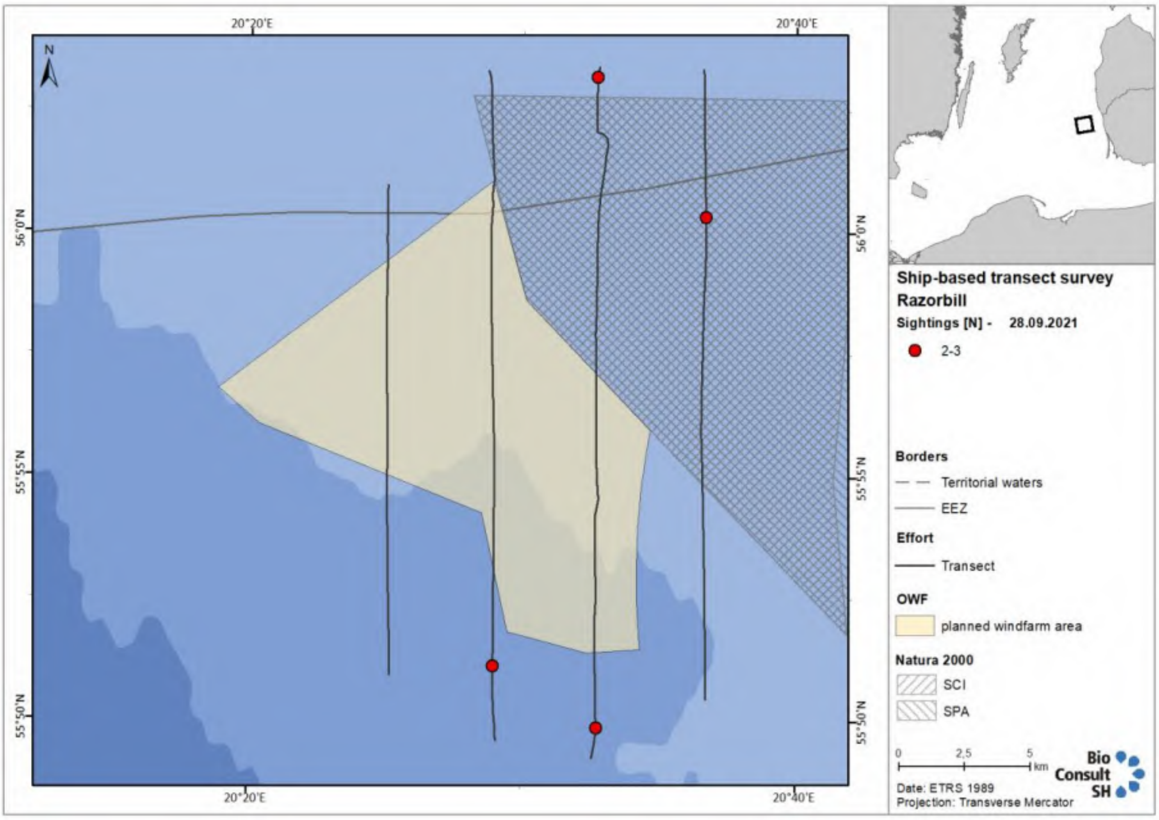

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Guillemot
Sightings [N] - 05.05.2022
1
2-3
4-5
6-10
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

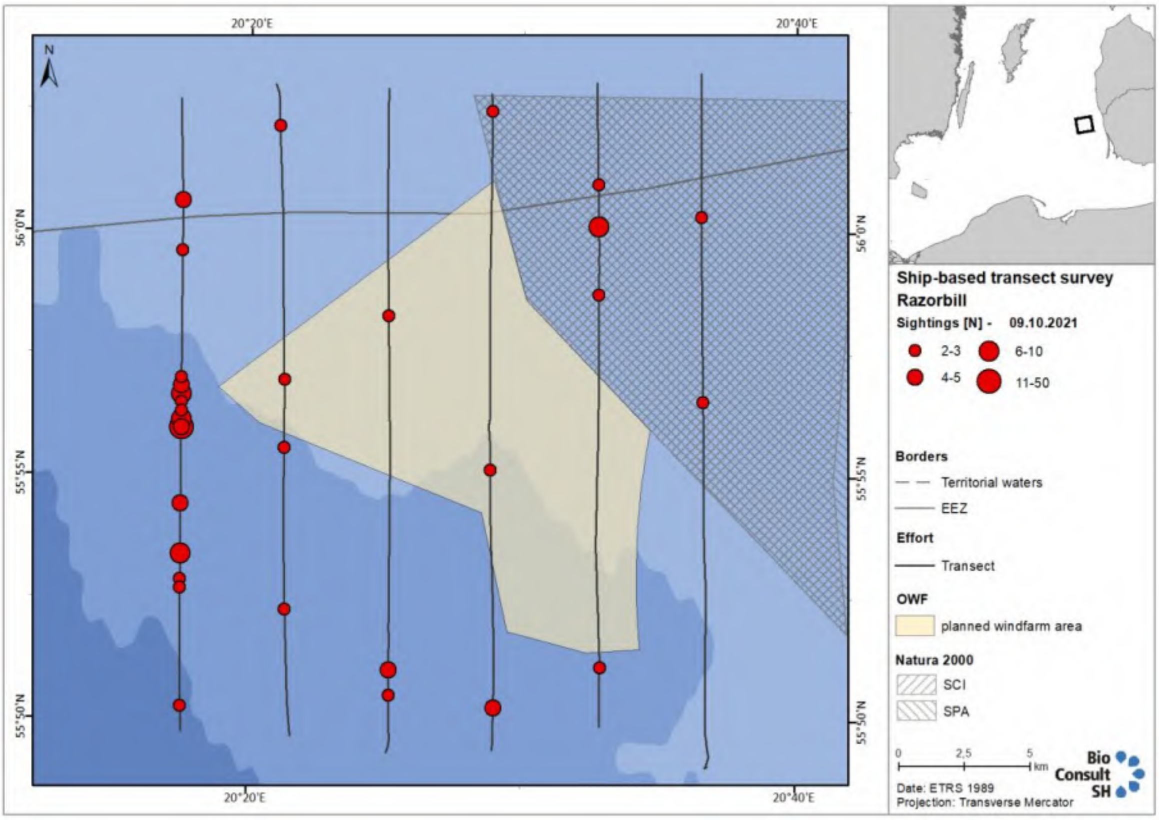

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Guillemot
Sightings [N] - 21.07.2022
2-3
4-5
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

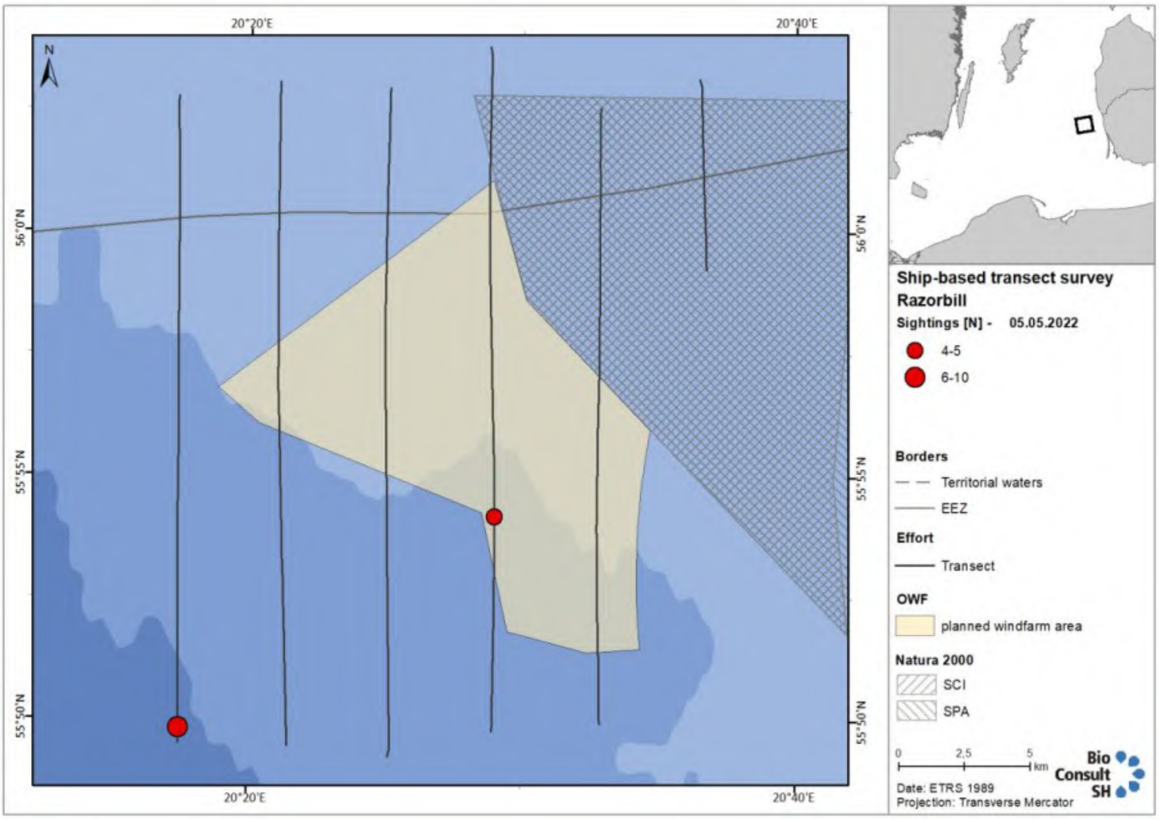

20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Guillemot
Sightings [N] - 28.08.2022
2-3
6-10
4-5
11-50
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH


20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Common Guillemot
Sightings [N] - 18.09.2022
1
6-10
2-3
11-50
4-5
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

A.3.9 Razorbill (*Alca torda*)






20°20'E
20°40'E
56°0'N
55°55'N
55°50'N
N
Ship-based transect survey
Razorbill
Sightings [N] - 05.05.2022
4-5
6-10
Borders
Territorial waters
EEZ
Effort
Transect
OWF
planned windfarm area
Natura 2000
SCI
SPA
0 2,5 5 km
Date: ETRS 1989
Projection: Transverse Mercator
Bio Consult SH

Annex 4

Visualisation of Offshore Wind Farm from Onshore Observation Sites (in Lithuanian)

4 PRIEDAS: 350 m aukščio VE (90 elektrinių) vizualizacijos iš vertintų regyklų skirtingais metų laikais

VšĮ „Pajūrio tyrimų ir planavimo instituto“ specialistai atliko planuojamo įrengti jūrinių vėjo elektrinių (toliau-VE) parko vizualizacijas iš aktualių regyklų. Vizualizacijos buvo atliktos naudojantis WindPro (versija 3.5) programinės įrangos „Vizual Photomontage“ plėtiniu. Planuojamų VE vizualizacijoms atlikti priimtos sąlygos:

- Fotofiksacijos atliktos apžvalgos vietose (lentelė Nr. 1) skirtingais metų laikais, skirtingu paros metu ir vyraujant skirtingoms oro sąlygoms. Atvaizduojamų VE apšvietimo sąlygas nusako saulės padėtis danguje, kuri priklauso nuo fotografavimo laiko ir vyravusių orų sąlygų (debesuotumas, matomumo sąlygos);
- Atliekant planuojamų VE vizualizacijas priimta, kad matomumo sąlygos yra geriausios, t.y. matomumas jūroje yra virš 30 km ir visos planuojamos VE bus matomos;
- Fotofiksacijai objektyvo židinio nuotolis priimtas 50 mm, kuris atspindi žmogaus akies matymo lauką;

Pastaba. Atsižvelgiant į Palangos savivaldybės atstovų ateityje planuojamą atverti vaizdą į jūrą (pašalinant šalia esančius želdinius) ties apžvalgos vieta Nr. 2 – Alkos kalnas, planuojamos įrengti VE, kurios šiuo metu yra užstojamos želdinių yra atvaizduotos raudona spalva.

1 lentelė. Planuojamo įrengti Jūrinių vėjo elektrinių parko vizualizacijoms naudojamos foto fiksacijų informacija.

Nr.	Jūrinių vėjo elektrinių parko apžvalgos vieta	Apžvalgos vietos koordinatės	Foto fiksacijos data	Fotografavimo taško altitudė (virš jūros lygio), m
1	Papės paplūdimys	315127, 6228454	2022 m., rugpjūčio 19 d., 10 val. 47 min	2,3
2	Alkos kalnas	317719, 6215747	2022 m., gegužės 3 d., 8 val. 57 min; 2022 m., liepos 19 d., 9 val. 29 min; 2022 m., spalio 31 d., 9 val. 58 min;	6,3
3	Apžvalgos aikštelė prie Žvejo dukrų	317432, 6214301	2022 m., gegužės 3 d., 6 val. 47 min; 2022 m., rugpjūčio 13 d., 15 val. 50 min; 2022 m., spalio 31 d., 9 val. 42 min;	7,2
4	Išėjimas ties neįgaliųjų paplūdimiu	317477, 6211481	2022 m., rugpjūčio 13 d., 15 val. 28 min;	6,2
5	Išėjimas ties Jūratės g.	315913, 6202720	2022 m., rugpjūčio 13 d., 14 val. 22 min;	5,2
6	Palangos tilto apžvalgos aikštelė	315661, 6202326	2022 m., kovo 11 d., 11 val. 55 min; 2022 m., gegužės 18 d., 21 val. 39 min; 2022 m., rugpjūčio 8 d., 9 val. 29 min; 2022 m., rugpjūčio 12 d., 21 val. 4 min; 2022 m., rugpjūčio 13 d., 13 val. 59 min; 2022 m., spalio 12 d., 18 val. 26 min; 2022 m., spalio 31 d., 8 val. 33 min.	7,5

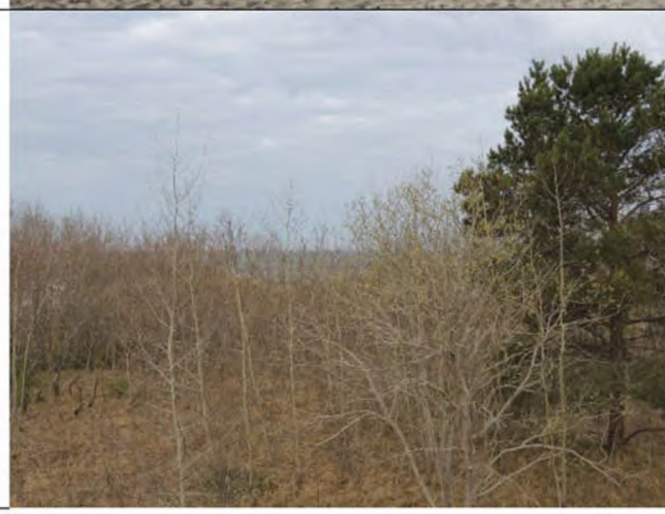
Nr.	Jūrinių vėjo elektrinių parko apžvalgos vieta	Apžvalgos vietos koordinatės	Foto fiksacijos data	Fotografavimo taško altitudė (virš jūros lygio), m
7	Palangos tiltas	315277, 6202401	2022 m., kovo 11 d., 12 val. 4 min; 2022 m., gegužės 18 d., 21 val. 16 min; 2022 m., liepos 12 d., 23 val. 57 min; 2022 m., spalio 10 d., 18 val. 31 min; 2022 m., spalio 31 d., 8 val. 40 min;	5,0
8	Paplūdimys (išėjimas iš Dariaus ir Girėno g.)	315655, 6201565	2022 m., rugpjūčio 13 d., 13 val. 49 min	3,2
9	Birutės kalnas	315733, 6200770	2022 m., gegužės 3 d., 7 val. 18 min; 2022 m., rugpjūčio 13 d., 13 val. 41 min; 2022 m., rugpjūčio 13 d., 13 val. 41 min; 2022 m., rugpjūčio 18 d., 20 val. 30 min; 2022 m., spalio 31 d., 9 val. 6 min;	17,5
10	Olandų kepurė	316140, 6188763	2022 m., rugpjūčio 19 d., 12 val. 18 min; 2022 m., rugpjūčio 19 d., 12 val. 18 min;	13,1
11	Klaipėdos uosto šiaurinis molas	316793, 6181101	2022 m., rugpjūčio 19 d., 12 val. 50 min;	3,3

Vizualizacijų žiūrėjimo ypatumai:

Siekiant kuo tiksliau atkartoti žmogaus akiai artimą vaizdinių suvokimą svarbu teisingai žiūrėti į atliktas vizualizacija (nuotraukas). Nuotraukų dirbtinis didinimas (ar mažinimas) gali smarkiai iškreipti vaizdą (ir objektų suvokimą), todėl rekomenduojama, kad parengtos vizualizacijos būtų stebimos su specialistų pagalba ir remiantis standartine žiūrėjimo instrukcija (A4 formato nuotraukos turi būti žiūrimos iš 29 cm atstumo).

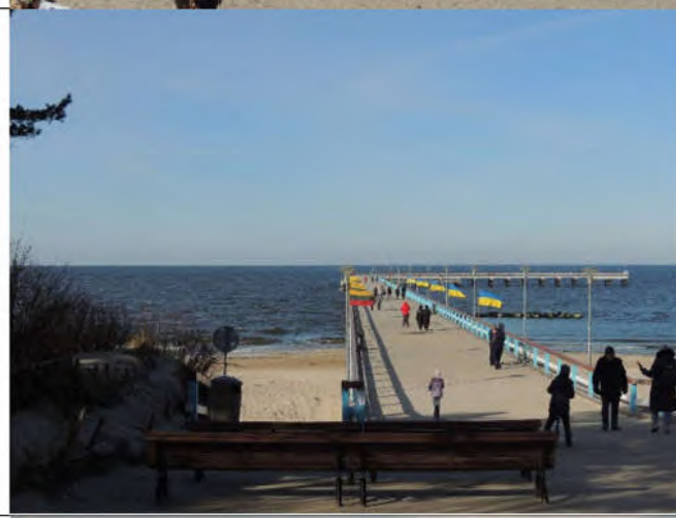
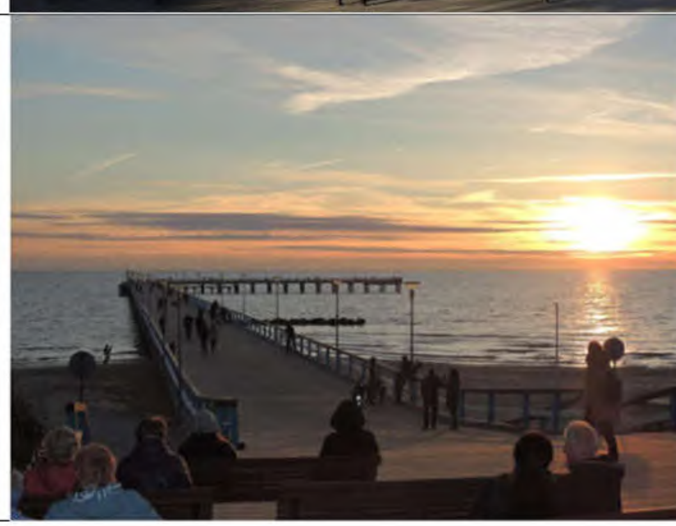
Projekto viešinimo metu bus parengtas stendas su vizualizacijomis, kurias padės stebėti kraštovaizdžio specialistai.

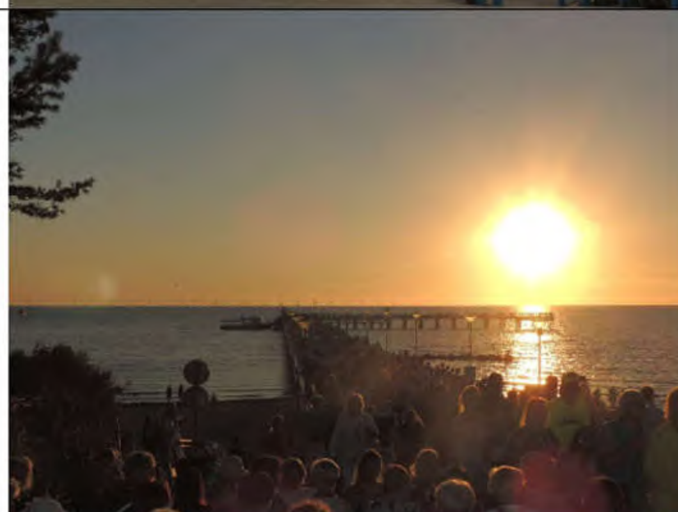
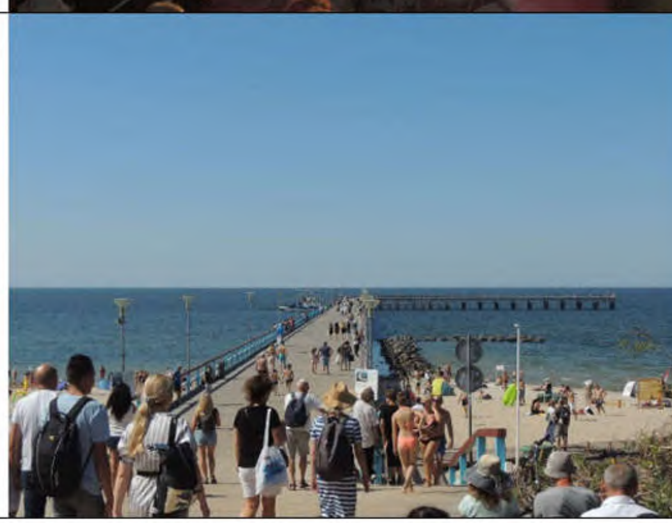
Atliktų vizualizacijų sąvadas:

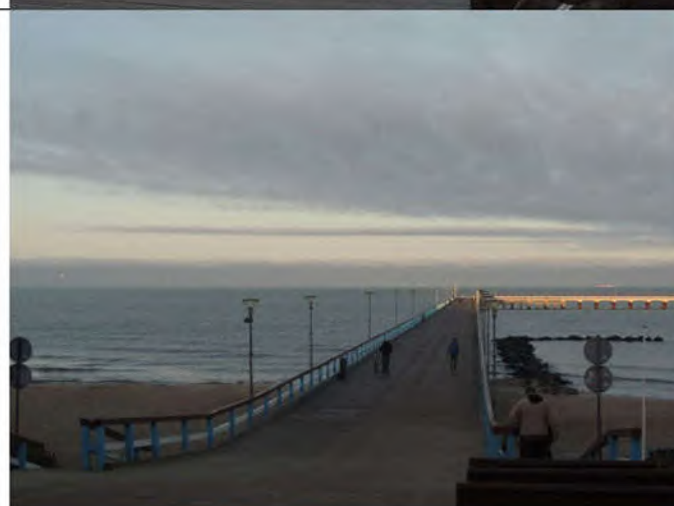
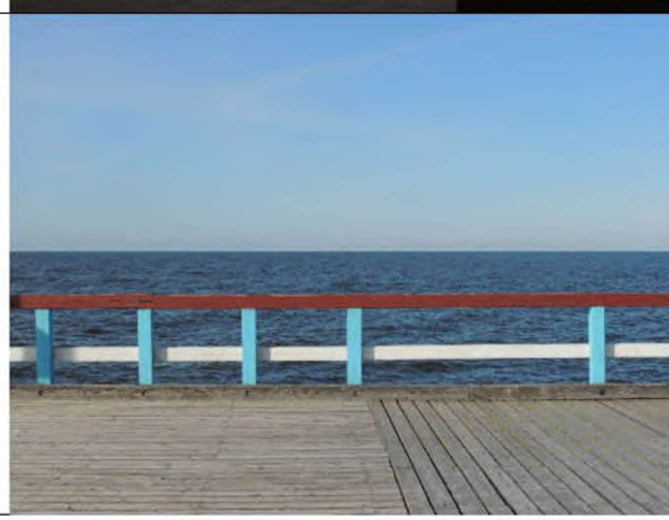
Papės paplūdimys	koordinatės *315127, 6228454* **Fotografavimo data –** 2022 m., rugpjūčio 19 d., 10 val. 47 min **Fotografavimo azimutas –** 225º **Fotografavimo taško altitudė (virš jūros lygio) –** 2,3 m	
Alkos kalnas	koordinatės *317719, 6215747* **Fotografavimo data –** 2022 m., gegužės 3 d., 8 val. 57 min **Fotografavimo azimutas –** 270º **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *317719, 6215747* **Fotografavimo data –** 2022 m., liepos 19 d., 9 val. 29 min **Fotografavimo azimutas –** 270º **Fotografavimo taško altitudė (virš jūros lygio) –** 6,3 m	

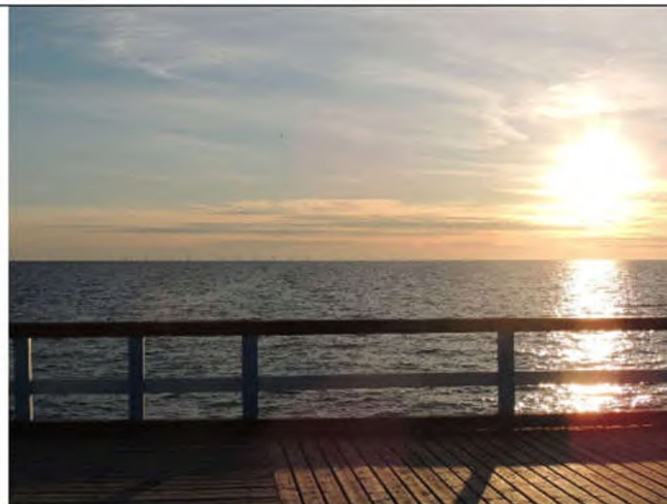
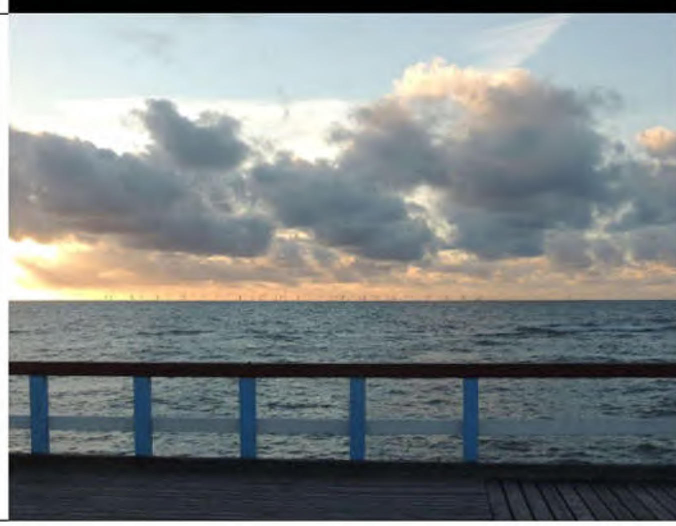
	koordinatės *317724, 6215748* **Fotografavimo data –** 2022 m., spalio 31 d., 9 val. 58 min **Fotografavimo azimutas –** 265° **Fotografavimo taško altitudė (virš jūros lygio) –** 6,3 m	
Apžvalgos aikštelė prie Žvejo dukrų	koordinatės 3*17433, 6214311* **Fotografavimo data –** 2022 m., spalio 31 d., 9 val. 42 min **Fotografavimo azimutas –** 255° **Fotografavimo taško altitudė (virš jūros lygio) –** 6,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės 3*17432, 6214301* **Fotografavimo data –** 2022 m., rugpjūčio 13 d., 15 val. 50 min **Fotografavimo azimutas –** 250° **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	

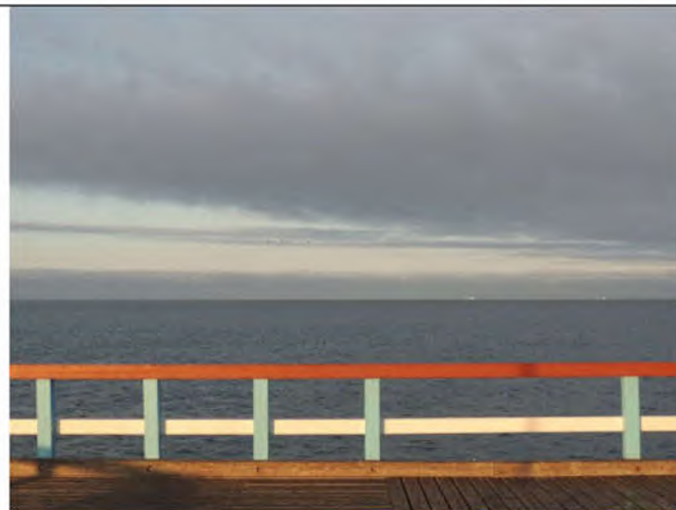
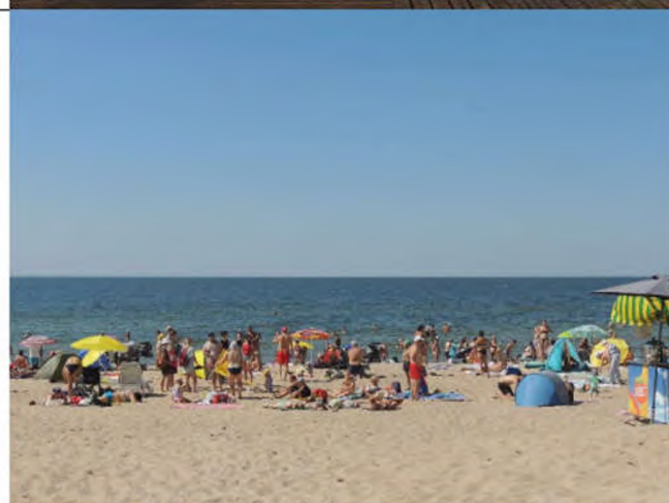
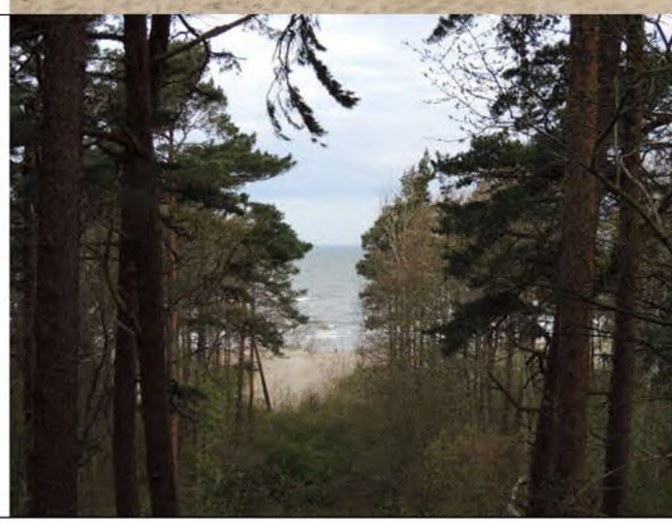
	koordinatės 3*17433, 6214311* **Fotografavimo data –** 2022 m., spalio 31 d., 9 val. 42 min **Fotografavimo azimutas –** 255º **Fotografavimo taško altitudė (virš jūros lygio) –** 6,5 m	
Neįgaliųjų paplūdimys	koordinatės *317477, 6211481* **Fotografavimo data –** 2022 m., rugpjūčio 13 d., 15 val. 28 min **Fotografavimo azimutas –** 260º **Fotografavimo taško altitudė (virš jūros lygio) –** 6,2 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *317468, 6211455* **Fotografavimo data –** 2022 m., spalio 31 d., 11 val. 20 min **Fotografavimo azimutas –** 260º **Fotografavimo taško altitudė (virš jūros lygio) –** 6,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	

Palanga, Jūratės g.	koordinatės *315913, 6202720* **Fotografavimo data –** 2022 m., rugpjūčio 13 d., 14 val. 22 min **Fotografavimo azimutas –** 275º **Fotografavimo taško altitudė (virš jūros lygio) –** 5,2 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
Palangos tilto apžvalgos aikštelė	koordinatės *315661, 6202326* **Fotografavimo data –** 2022 m., kovo 11 d., 11 val. 55 min **Fotografavimo azimutas –** 275º **Fotografavimo taško altitudė (virš jūros lygio) –** 7,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *315657, 6202324* **Fotografavimo data –** 2022 m., gegužės 18 d., 21 val. 39 min **Fotografavimo azimutas –** 290º **Fotografavimo taško altitudė (virš jūros lygio) –** 7,2 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	

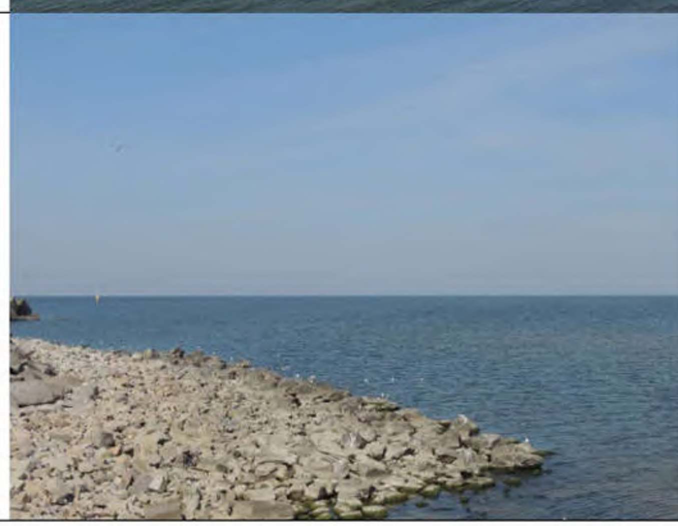
	koordinatės *315650, 6202335* **Fotografavimo data –** 2022 m., rugpjūčio 8 d., 9 val. 29 min **Fotografavimo azimutas –** 275° **Fotografavimo taško altitudė (virš jūros lygio) –** 6,3 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *315661, 6202326* **Fotografavimo data –** 2022 m., rugpjūčio 12 d., 21 val. 4 min **Fotografavimo azimutas –** 280° **Fotografavimo taško altitudė (virš jūros lygio) –** 7,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *315659, 6202334* **Fotografavimo data –** 2022 m., rugpjūčio 13 d., 13 val. 59 min **Fotografavimo azimutas –** 275° **Fotografavimo taško altitudė (virš jūros lygio) –** 7,1 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	

	koordinatės *315659, 6202334* **Fotografavimo data –** 2022 m., spalio 12 d., 18 val. 26 min **Fotografavimo azimutas –** 265° **Fotografavimo taško altitudė (virš jūros lygio) –** 7,1 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *315659, 6202334* **Fotografavimo data –** 2022 m., spalio 31 d., 8 val. 33 min **Fotografavimo azimutas –** 270° **Fotografavimo taško altitudė (virš jūros lygio) –** 7,1 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
Palangos tiltas	koordinatės *315277, 6202401* **Fotografavimo data –** 2022 m., kovo 11 d., 12 val. 4 min **Fotografavimo azimutas –** 275° **Fotografavimo taško altitudė (virš jūros lygio) –** 5 m **Fotografavimo aukštis –** 1,7 m nuo tilto dangos	

	koordinatės *315277, 6202401* **Fotografavimo data –** 2022 m., gegužės 18 d., 21 val. 16 min **Fotografavimo azimutas –** 280° **Fotografavimo taško altitudė (virš jūros lygio) –** 5 m **Fotografavimo aukštis –** 1,7 m nuo tilto dangos	
	koordinatės *315277, 6202401* **Fotografavimo data –** 2022 m., liepos 12 d., 23 val. 57 min **Fotografavimo azimutas –** 275° **Fotografavimo taško altitudė (virš jūros lygio) –** 5 m **Fotografavimo aukštis –** 1,7 m nuo tilto dangos	
	koordinatės *315277, 6202401* **Fotografavimo data –** 2022 m., spalio 10 d., 18 val. 31 min **Fotografavimo azimutas –** 275° **Fotografavimo taško altitudė (virš jūros lygio) –** 5 m **Fotografavimo aukštis –** 1,7 m nuo tilto dangos	

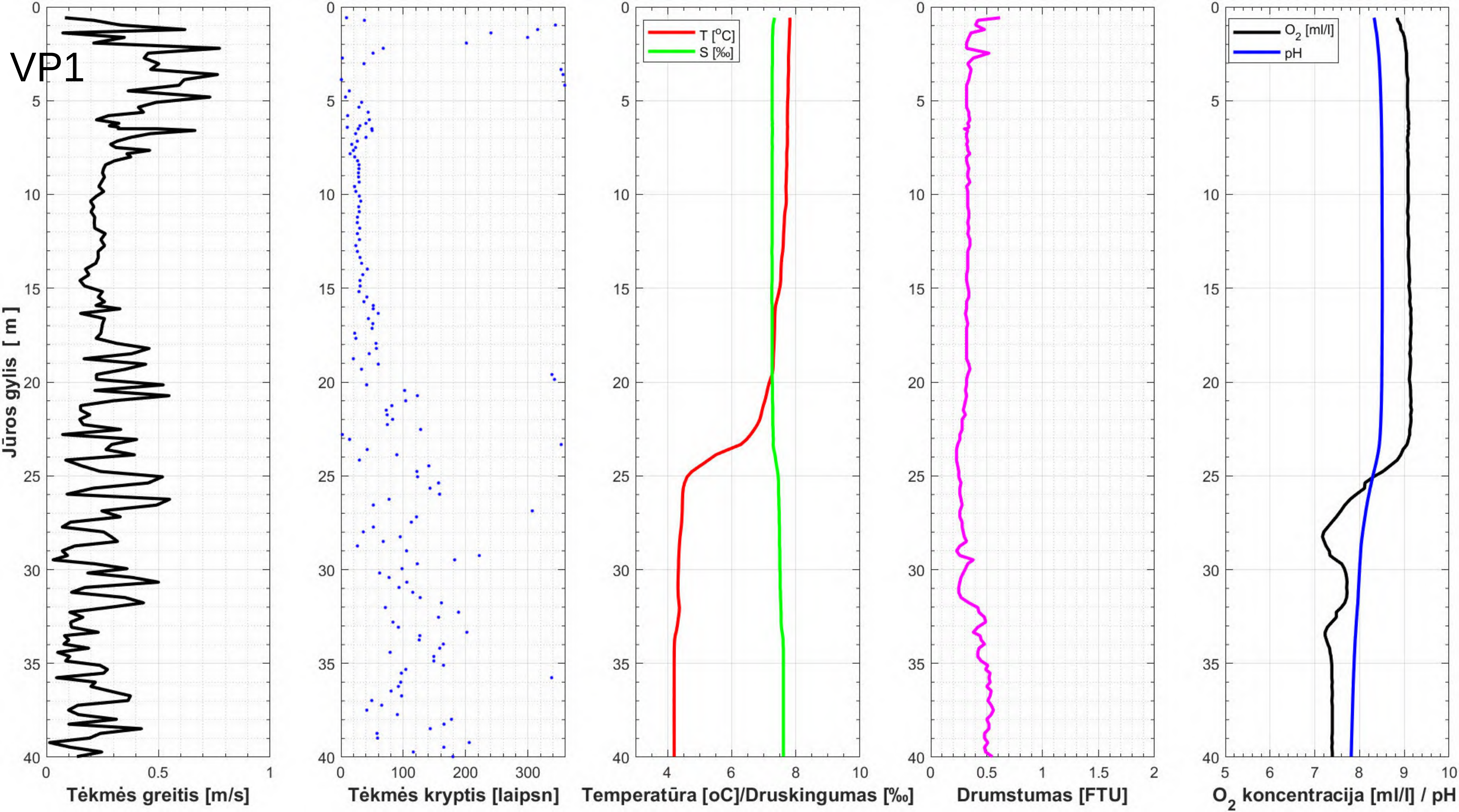
	koordinatės *315277, 6202401* **Fotografavimo data –** 2022 m., spalio 31 d., 8 val. 40 min **Fotografavimo azimutas –** 275° **Fotografavimo taško altitudė** (virš jūros lygio) **–** 5 m **Fotografavimo aukštis –** 1,7 m nuo tilto dangos	
Palanga, Dariaus ir Girėno g.	koordinatės *315655, 6201565* **Fotografavimo data –** 2022 m., rugpjūčio 13 d., 13 val. 49 min **Fotografavimo azimutas –** 275° **Fotografavimo taško altitudė (virš jūros lygio) –** 3,2 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
Birutės kalnas	koordinatės *315733, 6200770* **Fotografavimo data –** 2022 m., gegužės 3 d., 7 val. 18 min **Fotografavimo azimutas –** 290° **Fotografavimo taško altitudė (virš jūros lygio) –** 17,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	

	koordinatės *315733, 6200770* **Fotografavimo data –** 2022 m., rugpjūčio 13 d., 13 val. 41 min **Fotografavimo azimutas –** 290° **Fotografavimo taško altitudė (virš jūros lygio) –** 17,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *315733, 6200770* **Fotografavimo data –** 2022 m., rugpjūčio 18 d., 20 val. 30 min **Fotografavimo azimutas –** 290° **Fotografavimo taško altitudė (virš jūros lygio) –** 17,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *315733, 6200770* **Fotografavimo data –** 2022 m., spalio 31 d., 9 val. 6 min **Fotografavimo azimutas –** 290° **Fotografavimo taško altitudė (virš jūros lygio) –** 17,5 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	

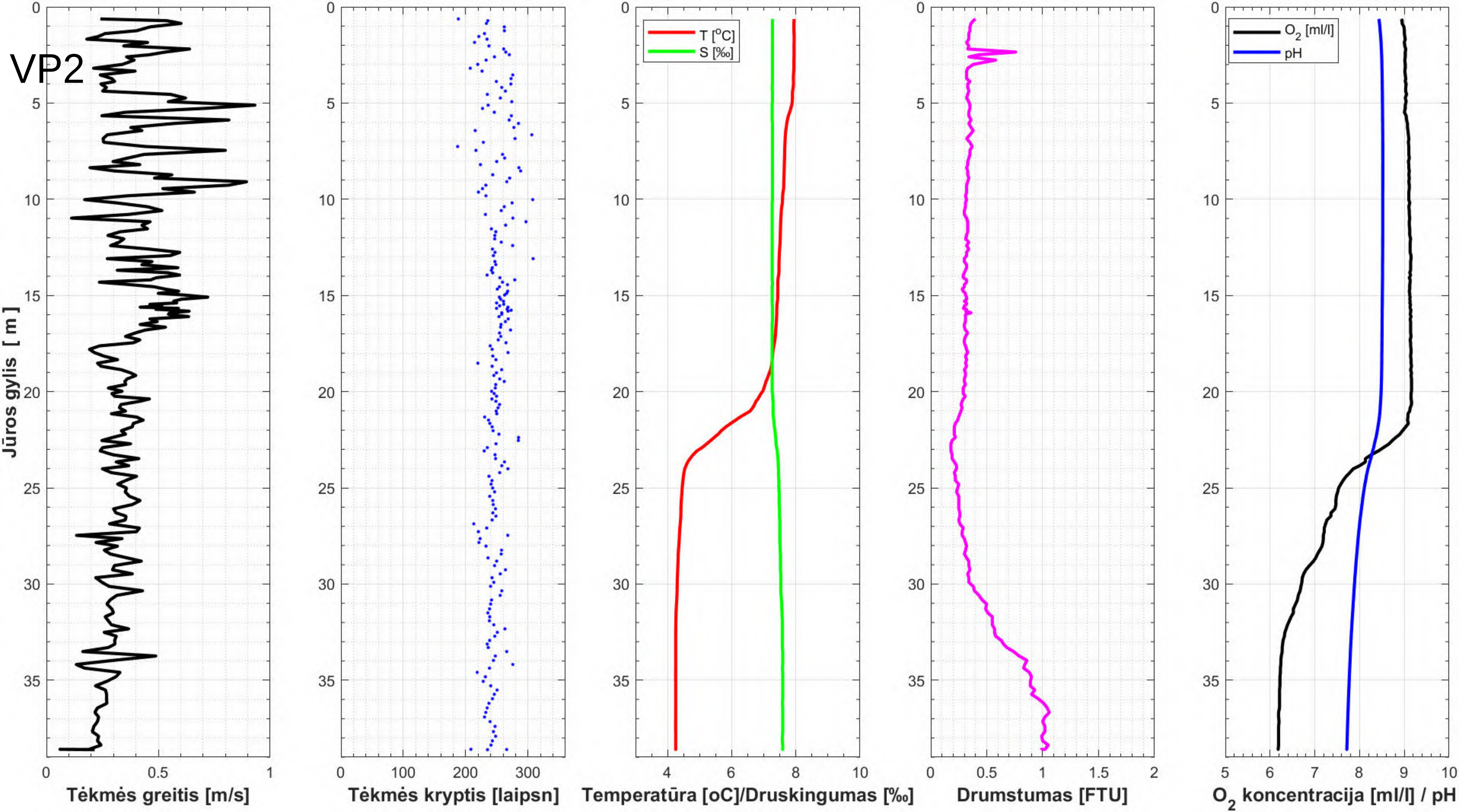
Olandų kepurė	koordinatės *316140, 6188763* **Fotografavimo data –** 2022 m., rugpjūčio 19 d., 12 val. 18 min **Fotografavimo azimutas –** 315° **Fotografavimo taško altitudė (virš jūros lygio) –** 13,1 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
	koordinatės *316140, 6188763* **Fotografavimo data –** 2022 m., rugpjūčio 19 d., 12 val. 18 min **Fotografavimo azimutas –** 295° **Fotografavimo taško altitudė (virš jūros lygio) –** 13,1 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	
Klaipėdos uosto šiaurinis molas	koordinatės *316793, 6181101* **Fotografavimo data –** 2022 m., rugpjūčio 19 d., 12 val. 50 min **Fotografavimo azimutas –** 320° **Fotografavimo taško altitudė (virš jūros lygio) –** 3,3 m **Fotografavimo aukštis –** 1,7 m nuo žemės paviršiaus	

Annex 5

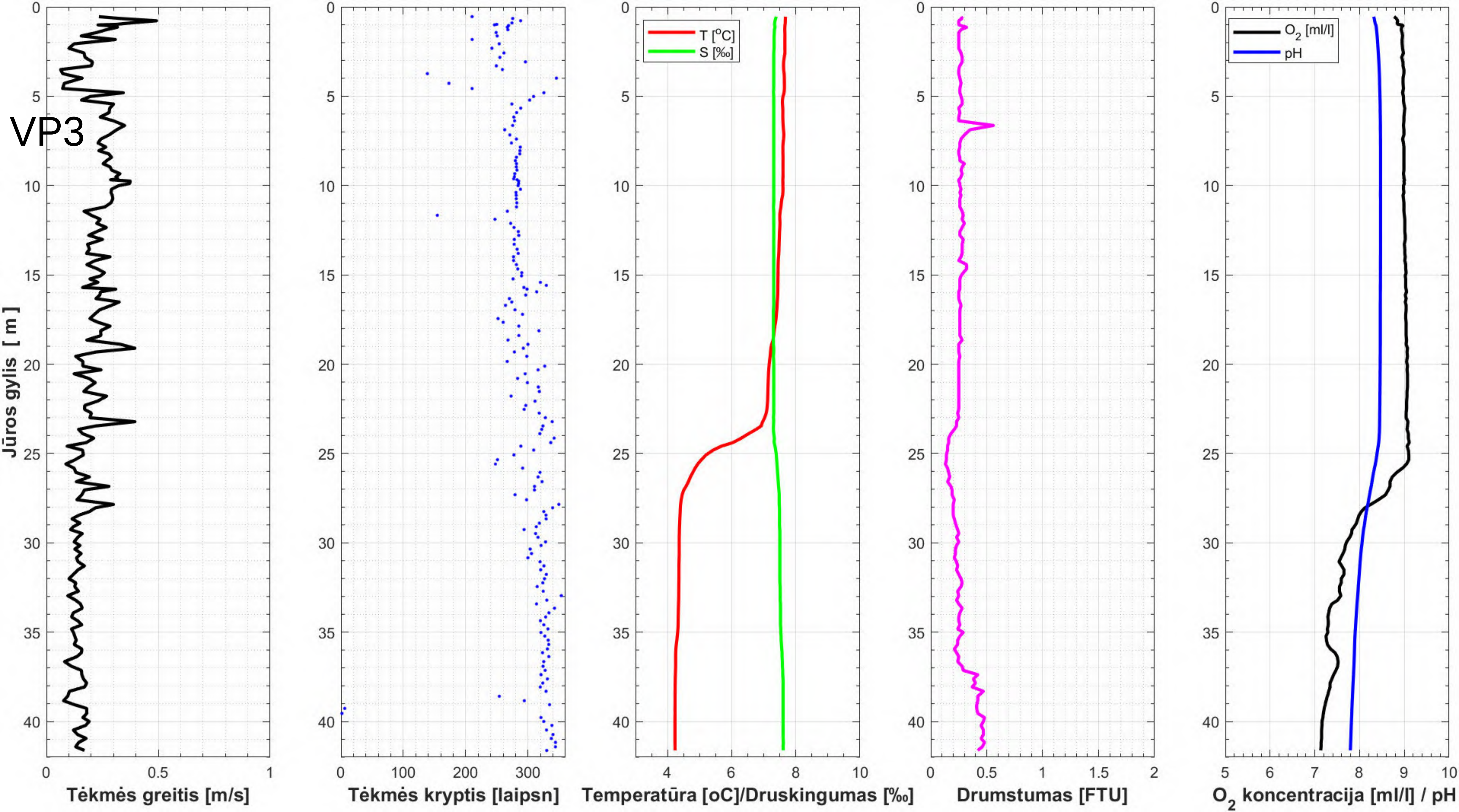
Vertical distribution profiles of hydrological and hydrochemical parameters



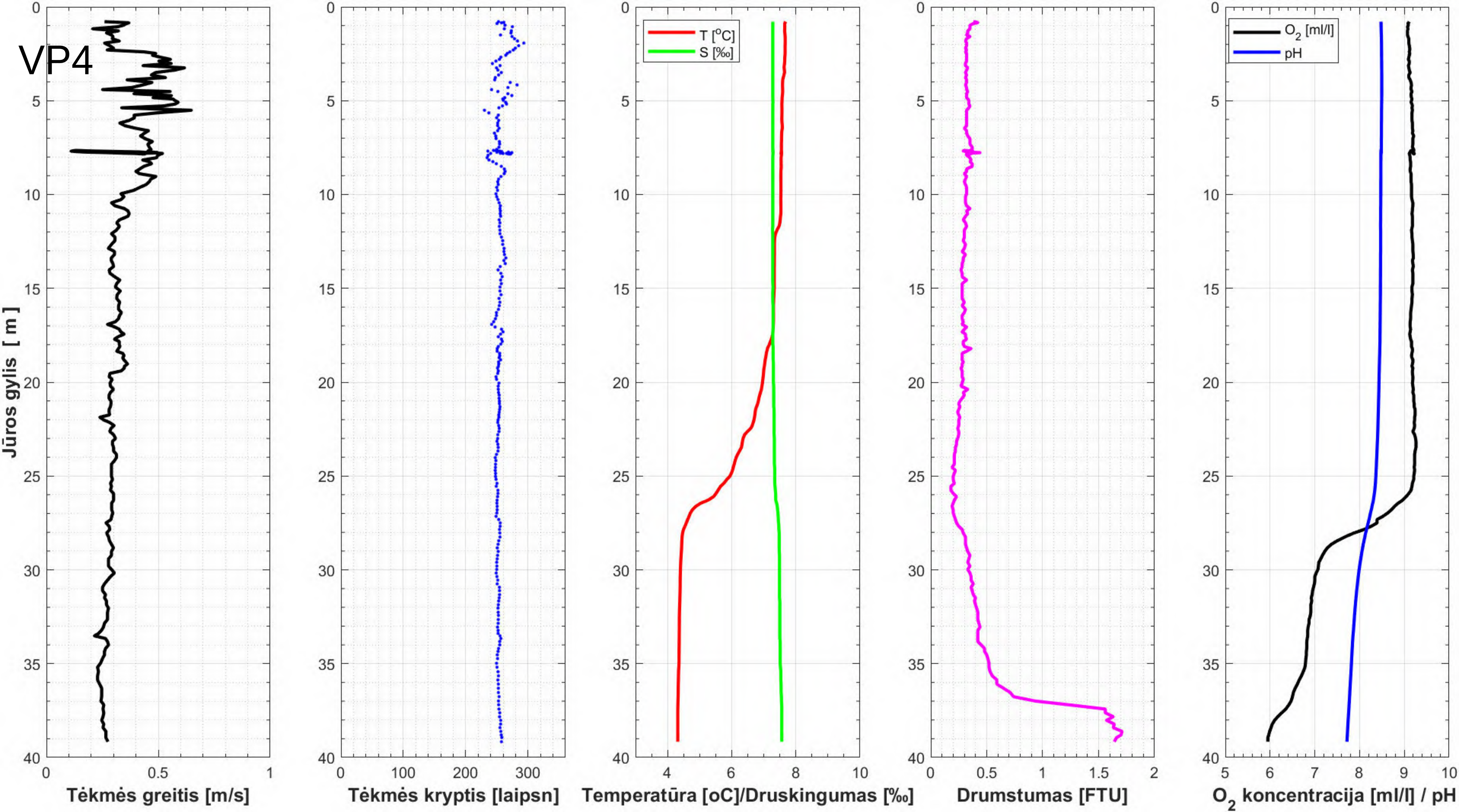
VP1
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH



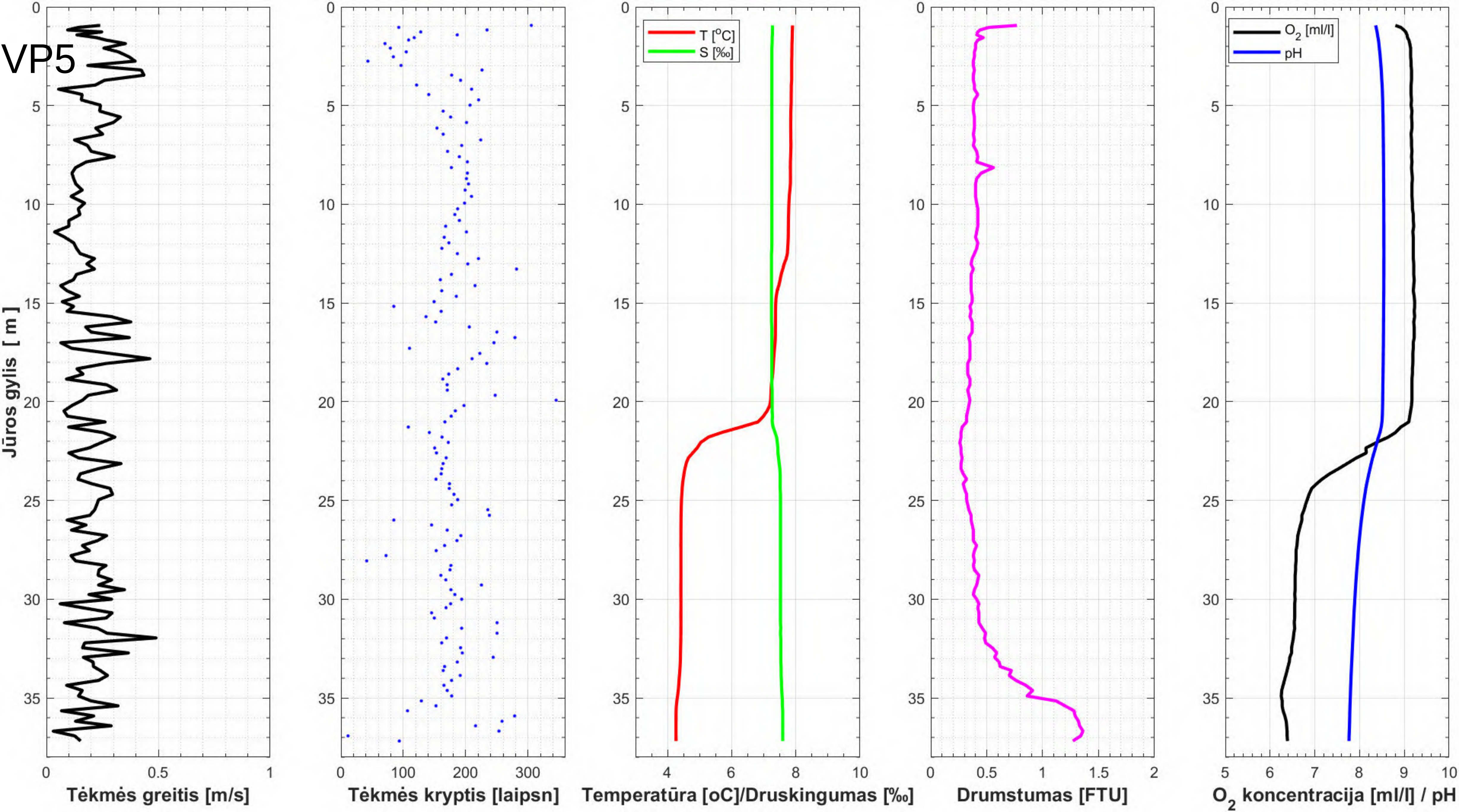
VP2
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH



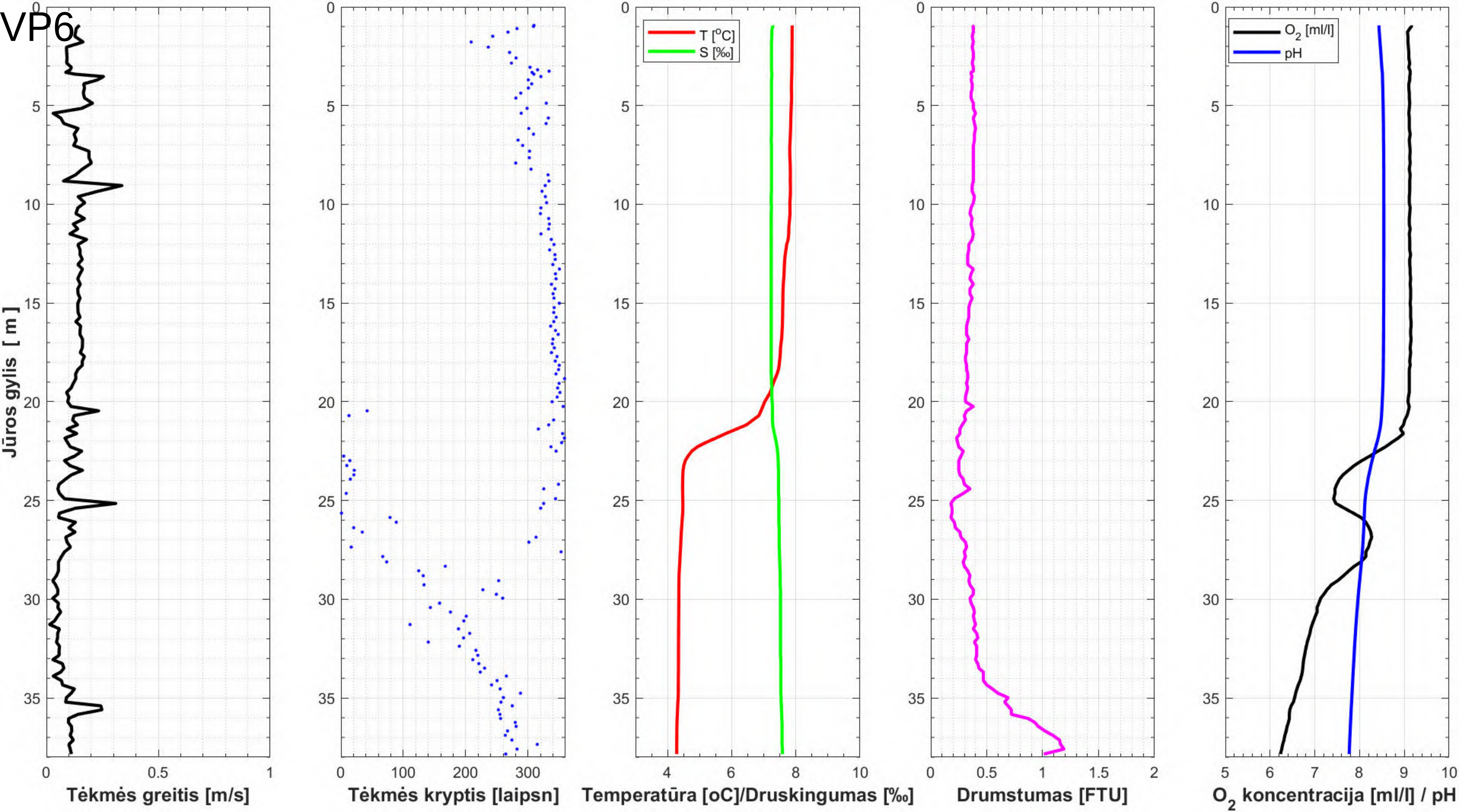
VP3
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH

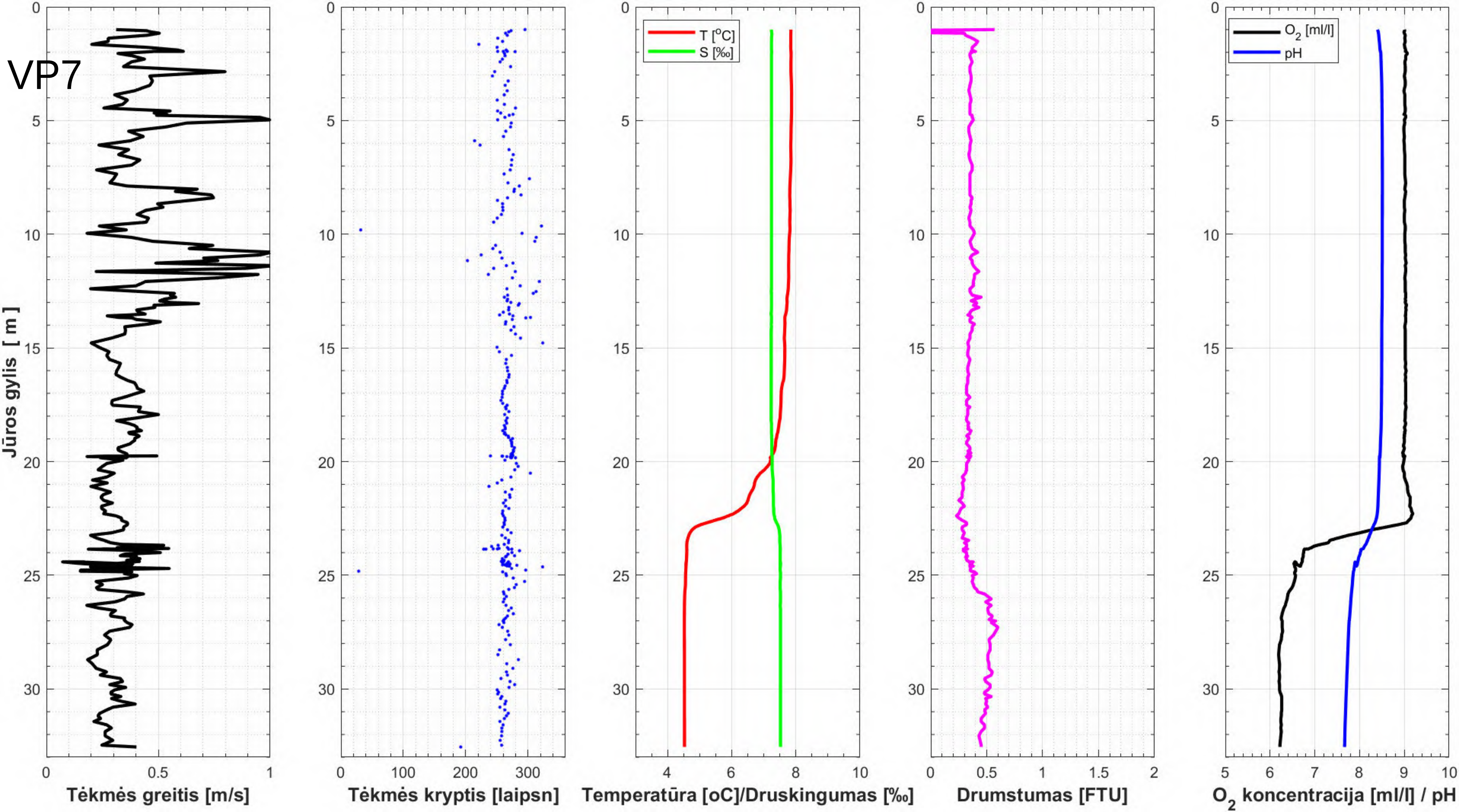


VP4
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH

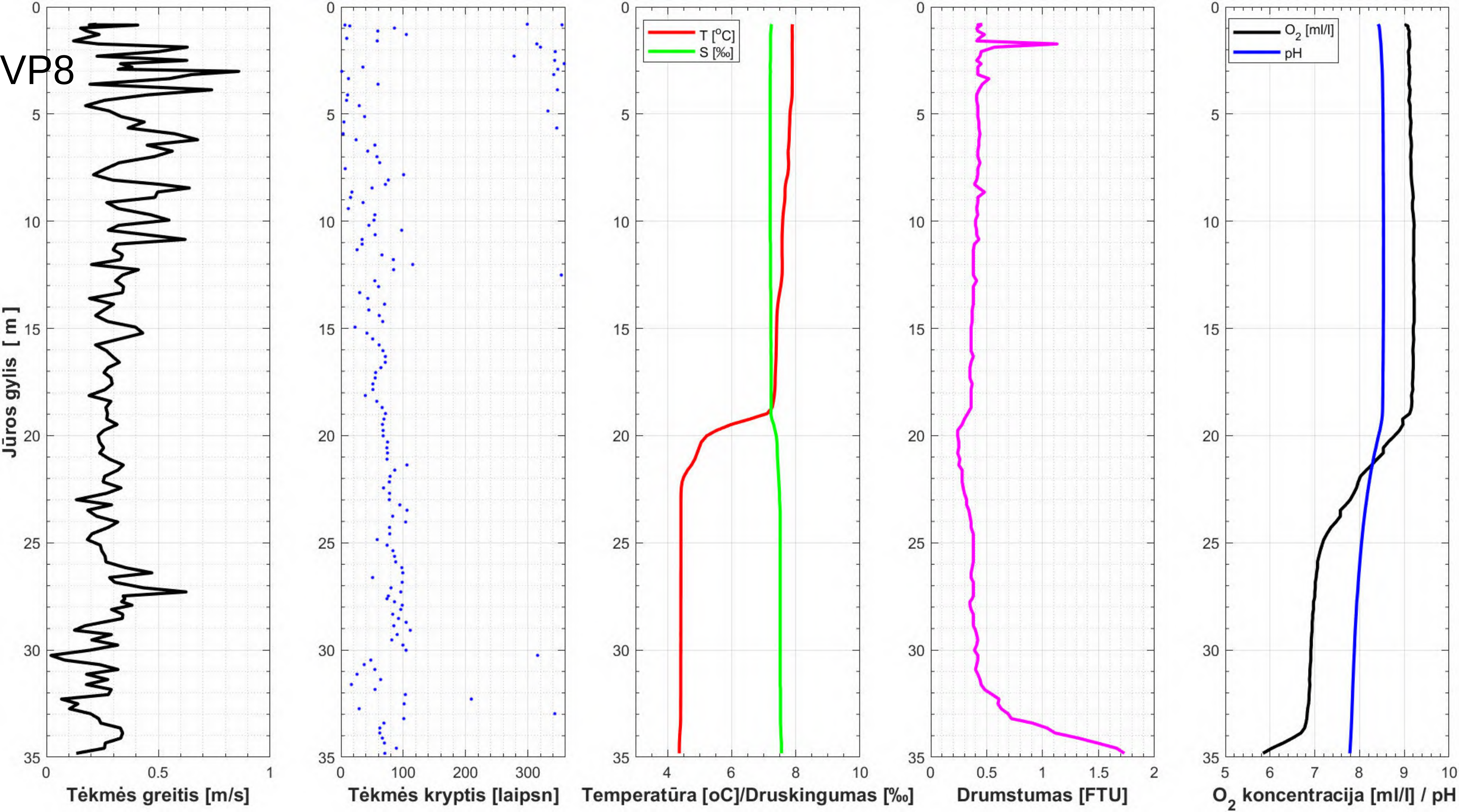


VP5
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH

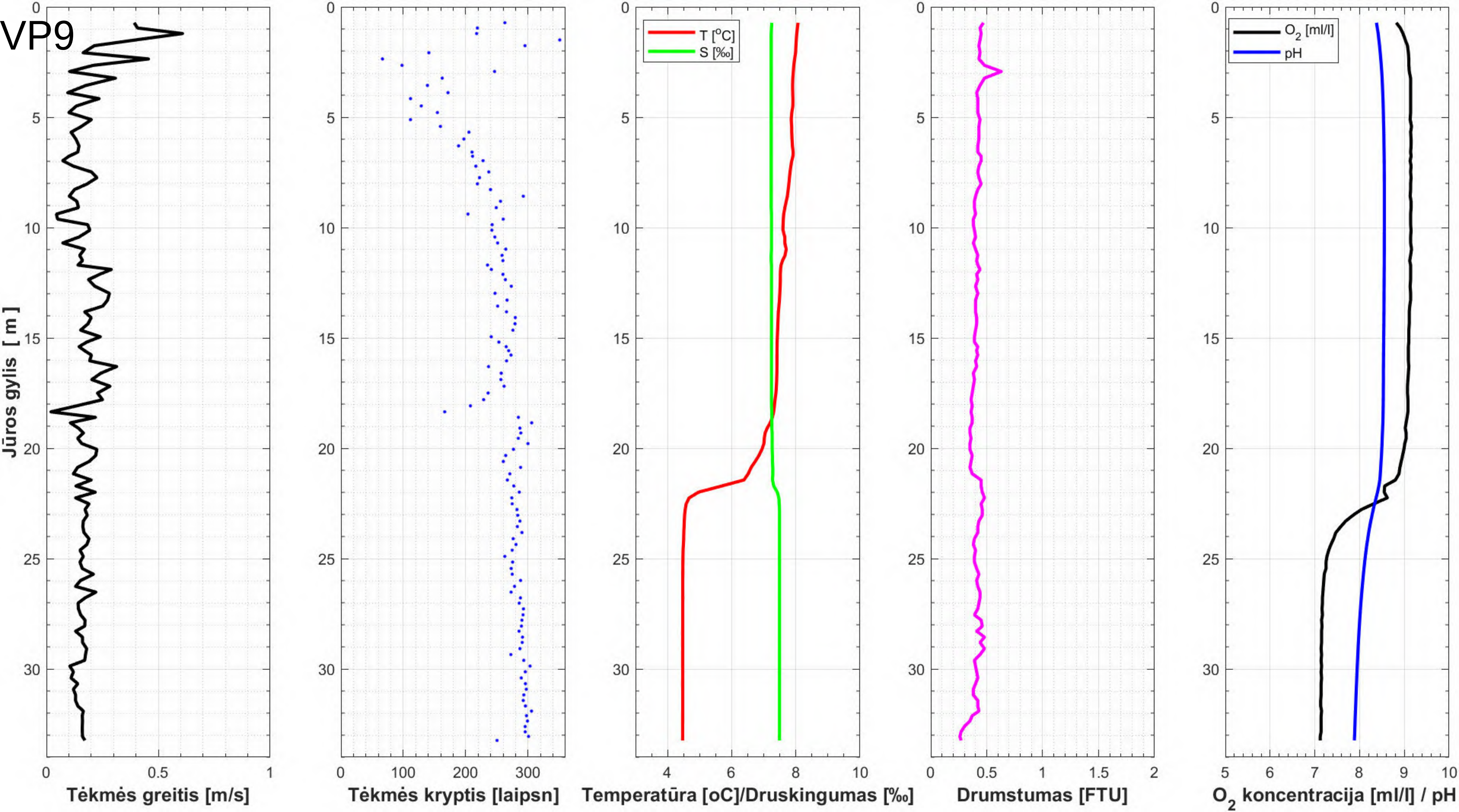

VP6
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH

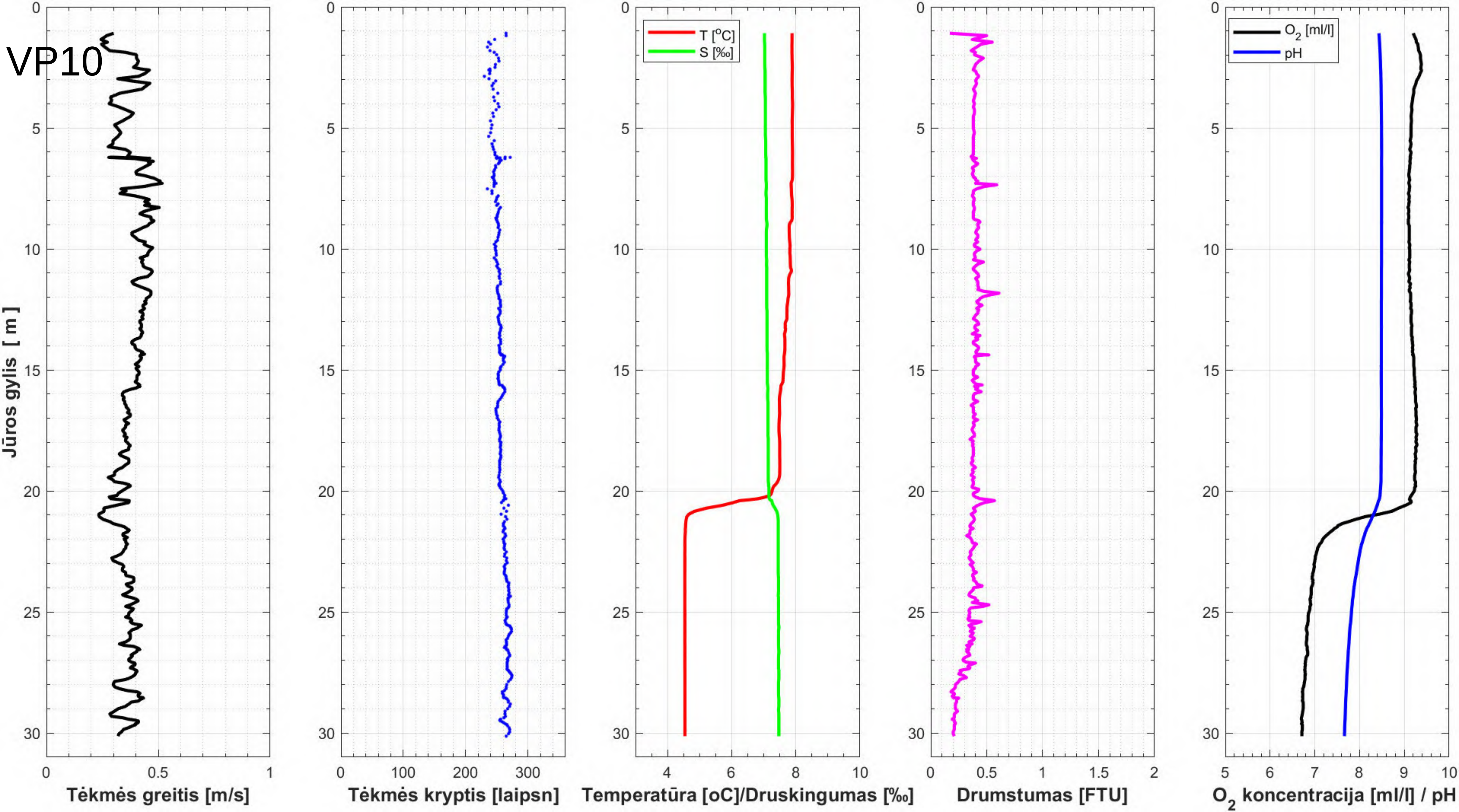


VP7
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O_2 [ml/l]
pH
O_2 koncentracija [ml/l] / pH

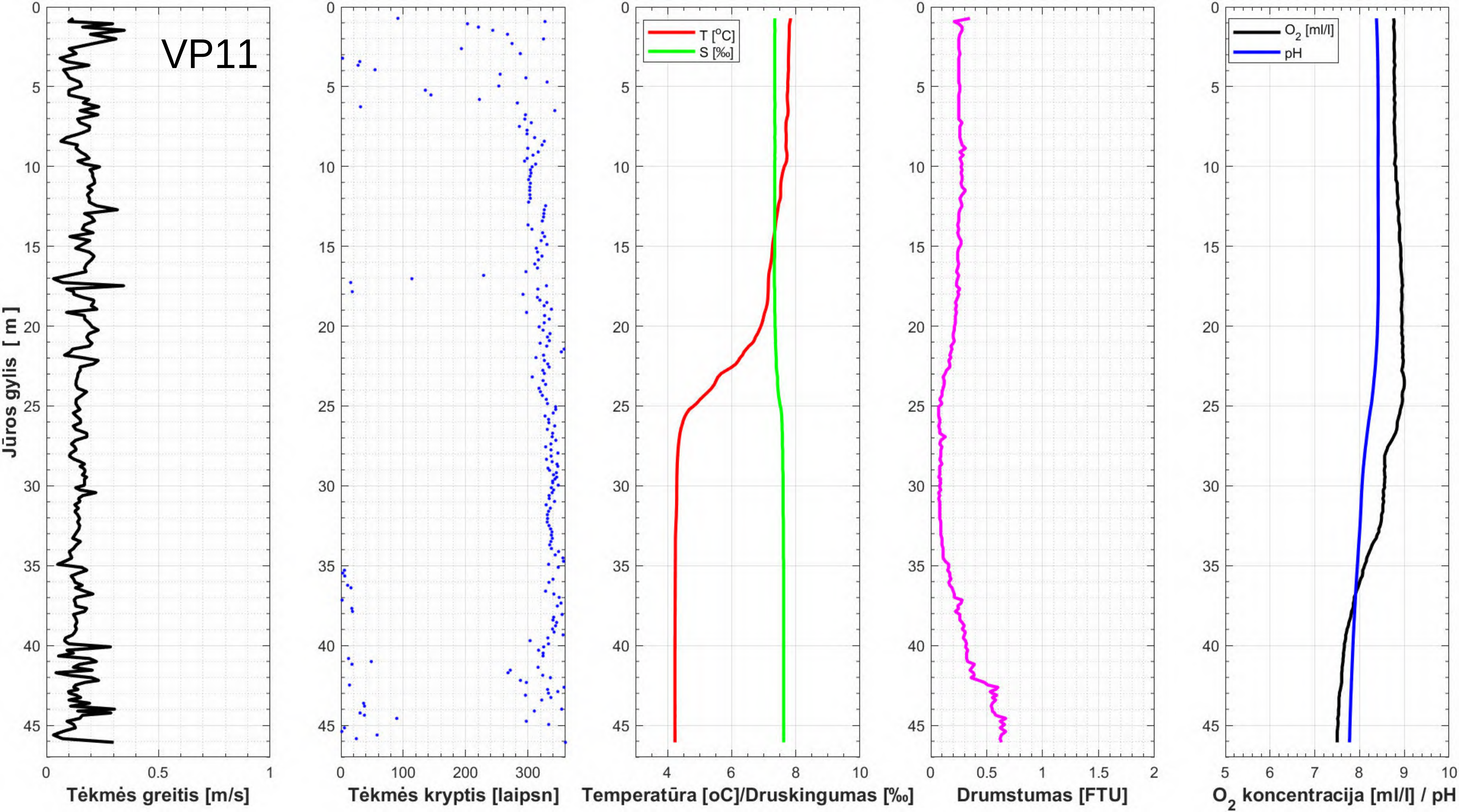


VP8
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH


VP9
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH



VP10
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH


VP11
Jūros gylis [m]
Tėkmės greitis [m/s]
Tėkmės kryptis [laipsn]
T [°C]
S [‰]
Temperatūra [oC]/Druskingumas [‰]
Drumstumas [FTU]
O2 [ml/l]
pH
O2 koncentracija [ml/l] / pH