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Environmental report for the draft maritime spatial plan for the German Exclusive Economic Zone in the Baltic Sea

– unofficial translation –

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List of abbreviations

AC	Alternating Current (alternating current)
AI	Confidence Interval
AIS	Automatic identification system (for ships)
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
EEZ	Exclusive Economic Zone
BBergG	Federal Mining Act
BfN	Federal Agency for Nature Conservation
BFO	Federal Offshore Plan
BFO-N	Federal Sectoral Plan Offshore North Sea
BFO-O	Federal Offshore Baltic Sea Plan
BGBl	Federal Law Gazette
BNatSchG	Law on nature conservation and landscape management (Federal Nature Conservation Act)
Federal Network Agency	Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway
BSH	Federal Maritime and Hydrographic Agency
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CTD	Conductivity, Temperature, Depth Sensor
DC	Direct Current (direct current)
DDT	Dichlorodiphenyltrichloroethane
EIA	Environmental impact assessment
EMSON	Survey of marine mammals and seabirds in the German EEZ of the North Sea and Baltic Sea
ERASNO	Monitoring of resting birds in the German EEZ of the North and Baltic Sea
EnWG	Law on electricity and gas supply (Energy Act)
EUNIS	European Nature Information System
EUROBATS	Agreement on the conservation of European bat populations
FEP	Area development plan
FFH	Flora Fauna Habitat
FFH DIRECTIVE	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)
HCB	Hexachlorobenzene
HELCOM	Helsinki Convention
IBA	Important bird area
ICES	International Council for the Exploration of the Sea
IfAÖ	Institute for Applied Ecosystem Research
IOW	Leibniz Institute for Baltic Sea Research Warnemünde
IUCN	International Union for Conservation of Nature and Natural Resources (Weltnaturschutzunion)

IWC	International Whaling Commission
K	Kelvin
kn	Knot
MARPOL	International Convention for the Prevention of Pollution from Ships
MINOS	Marine warmbloods in the North and Baltic Seas: Principles for the assessment of wind turbines in the offshore sector
MSRL	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)
NAO	North Atlantic Oscillation
NN	Normal zero
O-NEP	Offshore grid development plan
OSPAR	Oslo-Paris Agreement
OWP	Offshore wind farm
PAH	polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
POD	Porpoise Click Detector
PSU	Practical Salinity Units
R & D	Research and development
RL	Red List
ROP	Spatial development plan
ROP 2009	Regional development plan for the German EEZ 2009
ROP-E	Draft spatial development plan for the German EEZ 2021
SeeAnlV	Ordinance on Installations on the seaward side of the German territorial sea (Offshore Installations Ordinance)
SEL	Sound event level
SPA	Special Protected Area
SPEC	Species of European Conservation Concern (Important species for bird conservation in Europe)
StUK4	Standard "Investigation of the effects of offshore wind energy plants".
StUKplus	"Ecological accompanying research on the alpha ventus off-shore test field project
SUP	Strategic Environmental Assessment
SUP-RL	Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (SEA Directive)
TFEU	Treaty on the Functioning of the European Union
TOC	Total Organic Carbon (total organic carbon)

TSO	Transmission System Operator
UVPG	Law on environmental impact assessment
UBA	Federal Environment Agency
UVS	Environmental impact study
VARS	Visual Automatic Recording System
V-RL	Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (Birds Directive)
WTG	Wind turbine
WindSeeG	Act on the development and promotion of offshore wind energy (Wind Energy at Sea Act - WindSeeG)

1 Introduction

1.1 Legal bases and tasks of the environmental assessment

Maritime spatial planning in the German Exclusive Economic Zone (EEZ) is the responsibility of the Federal Government under the Regional Planning Act (ROG)[1]. In accordance with section 17 subsection 1 of the ROG, the competent Federal Ministry, the Federal Ministry of the Interior, Building and Community (BMI), in agreement with the federal ministries concerned, draws up a Spatial Plan for the German EEZ as a statutory instrument. In accordance with section 17 subsection 1 sentence 3 of the ROG, the Federal Maritime and Hydrographic Agency (BSH) carries out the preparatory procedural steps for drawing up the Spatial Plan (ROP) with the consent of the BMI. When the ROP is drawn up, an environmental assessment is carried out in accordance with the rules of the ROG and, where applicable, those of the Act on Environmental Impact Assessment (UVPG)[2], the so-called Strategic Environmental Assessment (SEA).

A Strategic Environmental Assessment, including the preparation of an environmental report, is needed to update, amend, and cancel existing Spatial Plans from 2009 from sections 7 subsections 7, 8 of the ROG in conjunction with section 35 subsection 1 no. 1 of the UVPG in conjunction with no. 1.6 of Annex 5.

According to Art. 1 of the SEA Directive 2001/42/EC, the aim of the Strategic Environmental Assessment is to ensure a high level of environmental protection in order to promote sustainable development and to contribute to ensuring that environmental considerations are adequately taken into account during the preparation and adoption of plans well in advance of the actual project planning. According to section 8 of the ROG, the Strategic Environmental Assessment has the task of determining the probable significant impacts of the implementation of the plan and to describe and evaluate them in an environmental report at an early stage. It serves to ensure effective environmental precautions in accordance with the applicable laws and is performed according to uniform principles and with public participation. All factors under section 8 subsection 1 of the ROG are to be considered:

- Human beings, including human health,
- Fauna, flora and biodiversity,
- Area, soil, water, air, climate and landscape,
- Cultural heritage and other material assets and
- Interrelationships between the above-mentioned factors.

In the context of spatial planning, definitions are mainly specified in the form of priority and reservation areas and other objectives and principles.

The requirements and content of the environmental report to be prepared are specified in Annex 1 to section 8 subsection 1 of the ROG.

Accordingly, the environmental report consists of an introduction, a description and assessment of the environmental impacts identified in the environmental review pursuant to section 8 subsection 1 of the ROG and additional information.

According to no. 2d of Annex 1 to section 8 of the ROG, other planning options that may be expressly considered should also be cited, taking into account the objectives and the geographical scope of the ROP.

1.2 Brief description of the content and main objectives of the Site

[1] Of 22 December 2008 (BGBl. I p. 2986), last amended by Article 159 of the Ordinance of 19 June 2020 (BGBl. I p. 1328).

[2] In the version published on 24 February 2010, BGBl. I p. 94, last amended by Article 2 of the Act of 30 November 2016 (BGBl. I p. 2749).

Development Plan

According to section 17 subsection 1 of the ROG, the Spatial Plan for the German EEZ is to establish rules, taking into account any interrelationship between land and sea as well as safety aspects

1. to ensure safety and ease of navigation,
2. for other economic uses,
3. for scientific uses and
4. to protect and improve the marine environment.

According to section 7 subsection 1 of the ROG, Spatial Plans for a specific planning area and a regular medium-term period must contain rules as **objectives and principles** of spatial planning for the development, organisation and safeguarding of the area, in particular for the uses and functions of the area.

Under section 7 subsection 3 of the ROG, these rules may also designate areas. For the EEZ these may be the following areas:

Priority areas intended for certain spatially significant functions or uses and excluding other spatially significant functions or uses in the area, where these are incompatible with the priority functions or uses.

Reservation areas, which are to be reserved for certain spatially significant functions or uses, to which particular weight is to be attached when weighing them up against competing spatially significant functions or uses.

Suitability areas for the marine area in which certain spatially significant functions or uses do not conflict with other spatially significant interests, whereby these functions or uses are excluded elsewhere in the planning area.

In the case of priority areas, it may be stipulated that they also have the effect of suitability areas under section 7 subsection 3 sentence 2 no. 4 of the ROG.

According to section 7 subsection 4 of the ROG, the Spatial Plans should also contain those rules on spatially significant planning and measures by public bodies and persons under private law under section 4 subsection 1 sentence 2 of the ROG which are suitable for inclusion in Spatial Plans and which are necessary for the coordination of spatial requirements and which can be secured by objectives or principles of spatial planning.

1.3 Relationship to other relevant plans, programmes and projects

In Germany there is a tiered planning system of spatial planning by the Federal Spatial Planning Act (Bundesraumordnung) as well as by state and regional planning to coordinate all spatial requirements and concerns arising in a given area. According to section 1 subsection 1 sentence 2 of the ROG, this system is used to coordinate different spatial requirements in order to reconcile conflicts arising at the respective planning level and to make rules for individual uses and functions of the space.

The tiered system allows the planning to be further specified by the subsequent planning levels. According to section 1 subsection 3 of the ROG, the development, organisation and safeguarding of the subspaces should be integrated into the conditions and requirements of the overall area, and the development, organisation and safeguarding of the overall area should take into account the conditions and requirements of its subspaces.

The Federal Ministry of the Interior, Building and Community (BMI) is responsible for regional planning at the federal level in the EEZ. In contrast, the respective federal state is responsible for state planning for the entire area of the state, including the respective coastal sea.

In addition to spatial planning for the respective areas of responsibility, there are sectoral plans based on sectoral laws for certain specific planning areas. Sectoral plans serve to define details for the respective sector, taking into account the requirements of spatial planning.

1.3.1 Spatial plans in adjacent areas

In the interests of coherent planning, coordination processes with the plans of the coastal federal states and neighbouring states are advisable and must be taken into account in the cumulative assessment of impacts on the marine environment. At present, the state spatial planning for Schleswig-Holstein is being updated. Regional spatial planning programmes of the coastal regions are taken into account, provided that significant rules are made for the coastal sea.

1.3.1.1 Schleswig-Holstein

In Schleswig-Holstein, the State Development Plan (LEP S-H) is the basis for the state's spatial development. The Ministry of the Interior, Rural Areas, Integration and Equality of the state Schleswig-Holstein (MILIG) is responsible for drawing it up and amending it. The current 2010 LEP S-H forms the basis for the spatial development of the state until 2025. The state of Schleswig-Holstein has initiated the procedure for updating the 2010 LEP S-H and carried out a participation procedure in 2019.

1.3.1.2 Mecklenburg-Western Pomerania

For the state of Mecklenburg-Western Pomerania, the highest state planning authority is the Ministry for Energy, Infrastructure and Digitalisation of Mecklenburg-Western Pomerania. It is responsible for spatial planning at the state level, including the coastal sea.

The current State Spatial Development Programme of Mecklenburg-Western Pomerania (LEP M-V) came into force on 9 June 2016.

1.3.1.3 Denmark

Denmark is at an advanced stage of the spatial planning process. Denmark is currently drafting the first Spatial Plan as a comprehensive plan for the North Sea and the Baltic Sea, which will be binding and cover a time frame up to 2050.

1.3.1.4 Sweden

Sweden is in the final phase of its first Spatial Plan. This plan is divided into three planning areas and describes two different levels, the national level and the municipal level. The Swedish plans are more of a management character and are not binding.

1.3.1.5 Poland

In Poland, the first Spatial Plan is currently being prepared and is also in its final phase. The Polish plan covers a planning area with three regions. The planning horizon of the binding plan is 2030.

1.3.2 MSFD programme of measures

Each Member State must develop a Marine Strategy to achieve good status for its marine waters, in Germany for the North Sea and the Baltic Sea. The key to this is the establishment of a programme of measures to achieve or maintain a good state of the environment and the practical implementation of this programme of measures. The establishment of the programme of measures (BMUB, 2016) is regulated in Germany by Section 45h of the Federal Water Act

(WHG). Under Objective 2.4 "Oceans with sustainably and carefully used resources", the current Marine Strategy Framework Directive (MSFD) Programme of Measures mentions maritime spatial planning as a contribution of existing measures to achieving the operational objectives of the MSFD. In addition, the catalogue of measures also formulates a concrete review mandate for updating of spatial plans with regard to measures for the protection of migratory species in the marine area. Both the environmental objectives of the MSFD and the MSFD programme of measures are taken into account in the SEA.

1.3.3 Management plans for nature conservation areas EEZ

In September 2017, the Regulations on the designation of the Fehmarn Belt (NSGFmbV), Kadet Trench (NSGKdrV), and Bay of Pomerania – Rönnebank (NSGPBRV) nature reserves came into force. According to the ordinances, the measures necessary to achieve the conservation objectives established for the nature conservation areas are presented in management plans. These plans are drawn up by the Federal Agency for Nature Conservation (BfN) in consultation with the neighbouring states and the technically affected public agencies, and with the participation of the interested public and the nature conservation associations recognised by the Federation.

On 16 June 2020, BfN initiated the participation procedure under section 7 subsection 3 of the NSGFmbV, section 7 subsection 3 of the NSGKdrV and section 11 subsection 3 of the NSGPBRV on the management plans for the nature conservation areas in the German Baltic Sea EEZ. As part of the participation procedure, a hearing on the drafts was held on 17 August 2020.

1.3.4 Tiered planning procedure for offshore wind energy and power lines (central model)

For some uses in the German EEZ, such as offshore wind energy and power cables, a multi-tiered planning and approval procedure – i.e. divided into several tiers – is envisaged. In this context, the instrument of maritime spatial planning is at the highest and primary level. The Spatial Plan is the forward-looking planning instrument which coordinates the most diverse interests of users in the fields of industry, science and research as well as protection claims. A Strategic Environmental Assessment must be carried out when the Spatial Plan is drawn up. The SEA for the ROP is related to various downstream environmental assessments, in particular the directly downstream SEA for the Site Development Plan (SDP).

The next level is the SDP. Within the framework of the so-called central model, the SDP is the control instrument for the orderly expansion of offshore wind energy and electricity grids in a tiered planning procedure. The SDP has the character of a sectoral plan. The sectoral plan is designed to plan the use of offshore wind energy and electricity grids in a targeted manner and as optimally as possible under the given framework conditions – in particular the requirements of regional planning – by defining areas and sites as well as locations, routes and route corridors for grid connections or for transboundary cables (interconnectors). In principle, a Strategic Environmental Assessment is carried out in parallel with the establishment, updating and modification of the SDP.

In the next step, the sites for offshore wind turbines defined in the SDP undergo preliminary inspection. If the requirements of section 12 subsection 2 of the Offshore Wind Act (WindSeeG) are met, the site investigation is followed by the determination of the suitability of the site for the construction and operation of offshore wind turbines. The site investigation is also accompanied by a Strategic Environmental Assessment.

If a site is deemed suitable for the use of offshore wind energy, the site is put out to tender and the winning bidder or the authorised entity can submit an application for approval (planning approval or planning permission) for the erection and operation of offshore wind turbines on the site specified in the SDP. As part of the planning approval procedure, an environmental impact assessment is carried out if the prerequisites are met.

While the sites defined in the SDP for the use of offshore wind energy undergo preliminary investigation and are put out for tender, this is not the case for defined sites, routes and route corridors for grid connections or transboundary cables (interconnectors). Upon application, a planning approval procedure including an environmental assessment is usually carried out for the construction and operation of grid connection lines. The same applies to transboundary cables (interconnectors).

Under section 1 subsection 4 of the UVPG, the UVPG also applies where federal or state legislation does not specify the environmental impact assessment in more detail or does not comply with the essential requirements of the UVPG.

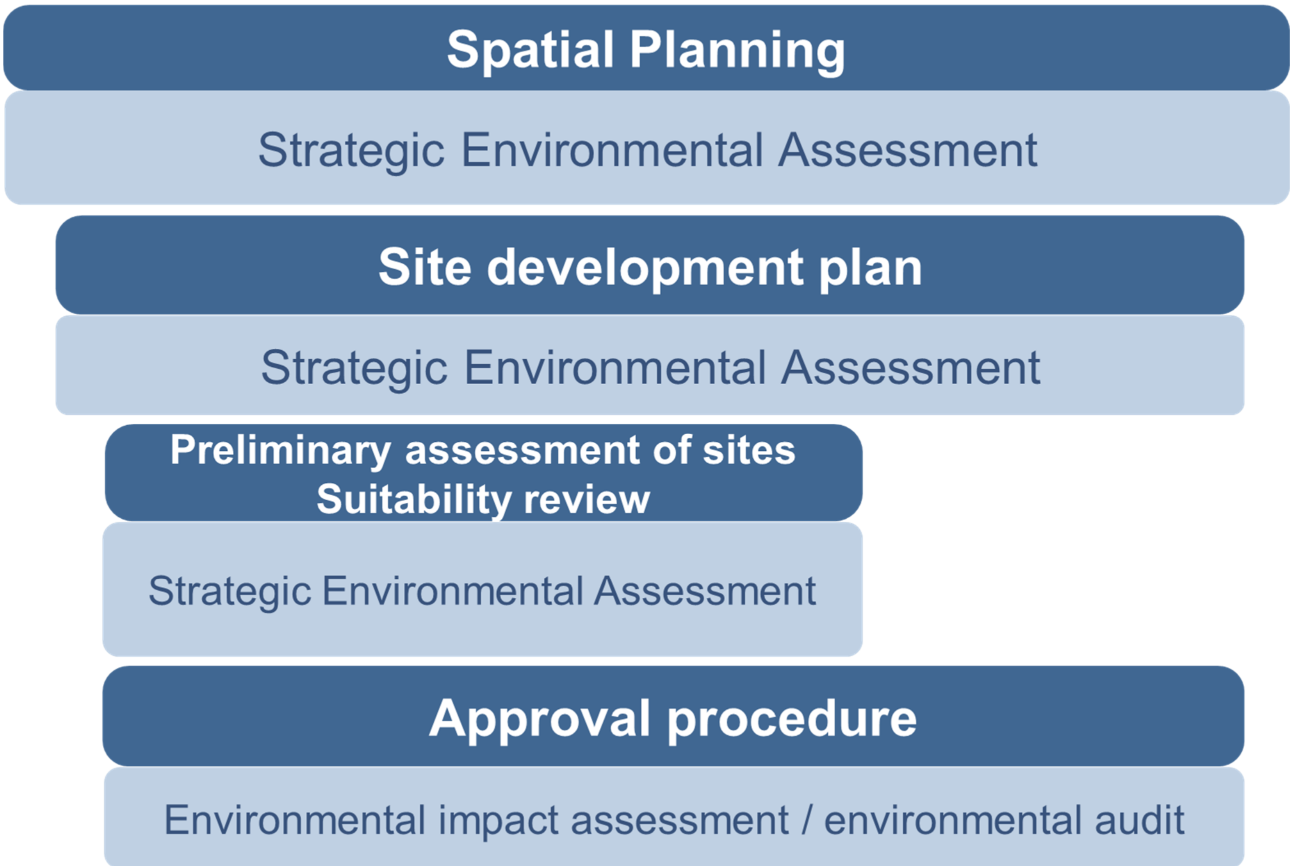


Figure 1: Overview of the tiered planning and approval procedure in the EEZ.

In the case of multi-tiered planning and approval procedures, it follows from the relevant legislation (e.g. Spatial Planning Act, WindSeeG and Federal Mining Act (BBergG)) or, more generally, from section 39 subsection 3 of the UVPG that, in the case of plans, at which of the stages of the process certain environmental impacts are to be assessed should be determined when the scope of the investigation is defined. In this way, multiple assessments are to be avoided. The nature and extent of the environmental impacts, technical requirements, and the content and subject matter of the plan must be taken into account.

In the case of subsequent plans and subsequent approvals of projects for which the plan sets a framework, the environmental assessment pursuant to section 39 subsection 3 sentence 3 of the UVPG shall be limited to additional or other significant environmental impacts as well as to necessary updates and more detailed investigations.

As part of the tiered planning and approval process, all reviews have in common that environmental impacts on the factors specified in section 8 subsection 1 of the ROG and section 2 subsection 1 of the UVGP are considered, including their interrelationships.

According to the definition in section 2 subsection 2 of the UVPG, environmental impacts within the meaning of the UVPG are direct and indirect impacts of a project or the implementation of a plan or programme on the factors.

According to section 3 of the Environmental Impact Assessment Act, environmental assessments comprise the identification, description and assessment of the significant impacts of a project or a plan or programme on the factors. They serve to ensure effective environmental protection in accordance with the applicable laws and are carried out according to uniform principles and with public participation.

In the offshore sector, the special avifauna have become established as sub-categories of the legally protected fauna, flora and biodiversity: seabirds/resting and migratory birds, benthos, biotopes, plankton, marine mammals, fish and bats.

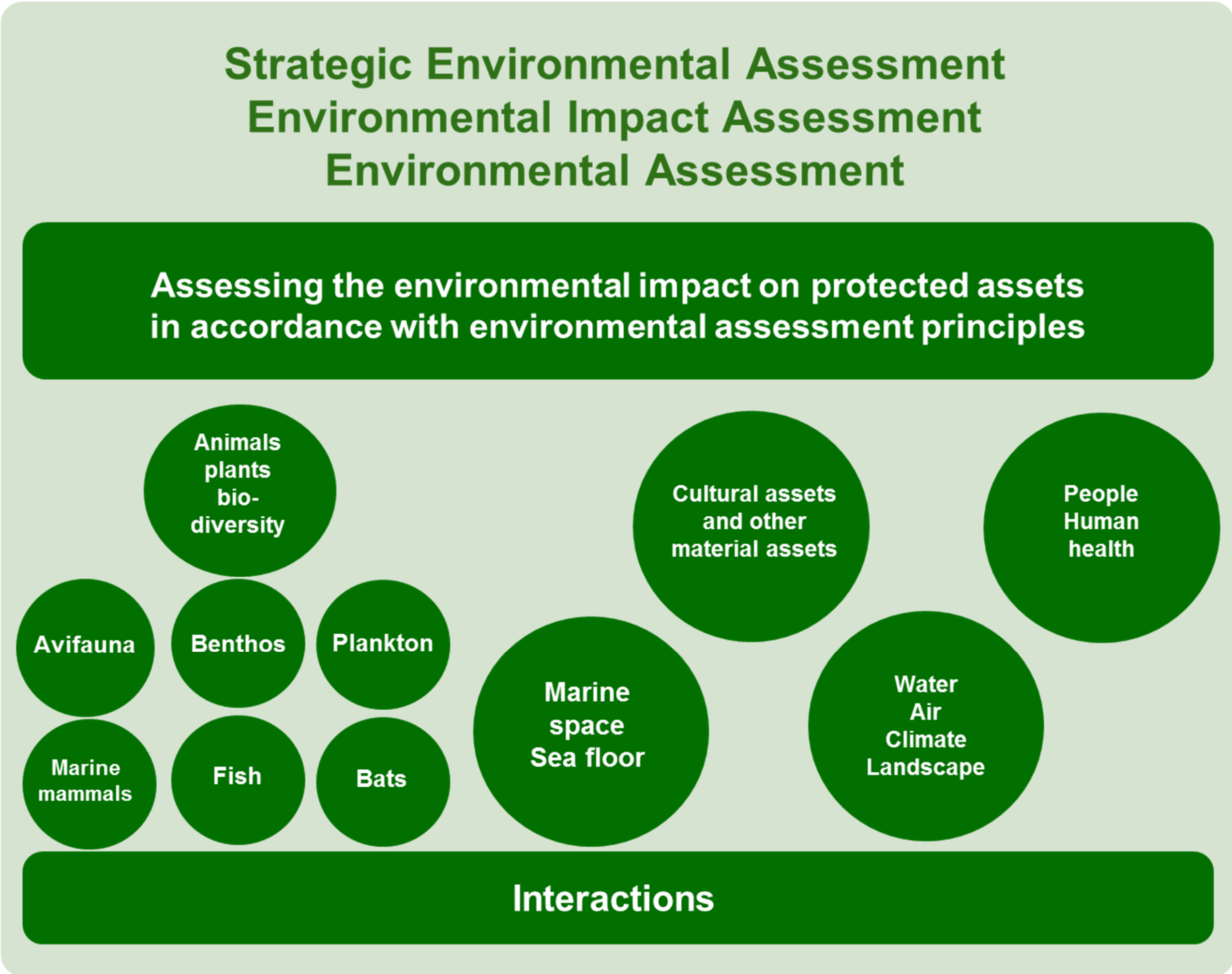


Figure 2: Overview of the factors in the environmental assessments.

In detail, the tiered planning procedure is as follows:

1.3.4.1 Maritime spatial planning (EEZ)

The Maritime Spatial Planning instrument is at the highest and primary level. For sustainable spatial development in the EEZ, the BSH prepares, on behalf of the competent Federal Ministry, a Spatial Plan which comes into force in the form of statutory ordinances.

The Spatial Plans should **define specifications**, taking into account possible interrelationships between land and sea and safety aspects,

- to ensure the safety and ease of navigation,
- for further economic uses,
- for scientific uses and
- to protect and improve the marine environment.

In the context of spatial planning, definitions are mainly specified in the form of priority and reservation areas and other objectives and principles. According to section 8 subsection 1 of the ROG, when drawing up Spatial Plans, the body responsible for the Spatial Plan must carry out a Strategic Environmental Assessment in which the probable significant impacts of the respective Spatial Plan on the factors, including interrelationships, must be identified, described and evaluated.

The **aim of** the spatial planning instrument is to optimise overall planning solutions. A wider spectrum of uses and functions is considered. Fundamental strategic questions should be clarified at the beginning of a planning process. Thus the instrument primarily functions as a management planning instrument for the planning administrative bodies, and within the framework of the legal provisions, in order to create a framework for all uses which is compatible with the spatial and natural environment as far as possible.

In spatial planning, the **depth of investigation** is generally characterised by a greater breadth of investigation, i.e. a fundamentally greater number of planning options, and a lesser depth of investigation in terms of detailed analyses. Above all, regional, national and global impacts as well as secondary, cumulative and synergetic effects are taken into account.

The **focus** is therefore on possible cumulative effects, strategic and large-scale planning options and possible transboundary impacts.

1.3.4.2 Site Development Plan

The next level is the Site Development Plan (SDP).

The **rules** to be made by the SDP and reviewed within the framework of the SEA are derived from section 5 subsection 1 of the WindSeeG. The plan mainly specifies areas and sites for wind turbines as well as the expected generation capacity on the sites. In addition, the SDP also specifies routes, route corridors and locations. Planning and technical principles are also laid down. Although these also serve, among other things, to reduce environmental impacts, they may in turn lead to impacts, so that an assessment is required as part of the SEA.

With regard to the SDP's **objectives,** it deals with the fundamental questions of the use of offshore wind energy and grid connections on the basis of the legal requirements, especially with the need, purpose, technology and the identification of sites and routes or route corridors. The plan therefore primarily has the function of a management planning instrument in order to create a spatially and, as far as possible, environmentally compatible framework for the implementation of individual projects, i.e. the construction and operation of offshore wind turbines, their grid connections, interconnectors and cross-connections between converter/transformer platforms.

The **depth of the investigation of** likely significant environmental effects is characterised by a wider scope of investigation, i.e. a larger number of alternatives and, in principle, a lower depth of investigation. At the level of sectoral planning, detailed analyses are generally not yet performed. Above all, local, national and global impacts as well as secondary, cumulative and synergistic impacts in the sense of an overall view are taken into account.

As in the case of the maritime spatial planning instrument, the investigation **focuses** on possible cumulative effects as well as possible transboundary impacts. In addition, the SDP focuses on strategic, technical and spatial alternatives, especially for the use of wind energy and power lines.

1.3.4.3 Suitability assessment as part of the site investigation

The next step in the tiered planning procedure is the suitability assessment of sites for offshore wind turbines.

In addition, the power to be installed is determined on the site in question.

When determining suitability, there will be examination pursuant to section 10 subsection 2 of the WindSeeG to ensure that the criteria for the inadmissibility of the determination of a site in the Site Development Plan pursuant to section 5 subsection 3 of the WindSeeG or, insofar as they can be assessed independently of the later design of the project, the interests relevant for the planning approval pursuant to section 48 subsection 4 sentence 1 of the WindSeeG do not conflict with the construction and operation of offshore wind turbines on the site.

Both the criteria of section 5 subsection 3 of the WindSeeG and the concerns of section 48 subsection 4 sentence 1 of the WindSeeG require an examination of whether the marine environment is endangered. With regard to the latter concerns, it must be examined in particular whether pollution of the marine environment as defined by Article 1 subsection 1 no. 4 of the United Nations Convention on the Law of the Sea is not of concern and that bird migration is not endangered.

The site investigation with the suitability assessment and determination is thus the instrument that connects the SDP and the individual approval procedure for offshore wind turbines. It refers to a specific site designated in the SDP and is thus much smaller than the SDP. It is distinguished from the plan approval procedure by the fact that an assessment approach is to be applied regardless of the later specific type of installation and layout. Thus, the impact prognosis is based on model parameters, e.g. in two scenarios or ranges of scenarios which are intended to represent possible realistic developments.

Compared to the SDP, the SEA of the suitability assessment is thus characterised by a smaller assessment area and a greater **depth of investigation**. In principle, fewer and spatially limited alternatives are seriously considered. The two primary alternatives are the determination of the suitability of a site and the determination of its (possibly partial) unsuitability (see section 12 subsection 6 of the WindSeeG). Restrictions on the type and extent of development, which are included as specifications in the determination of suitability, are not alternatives in this sense.

The **focus of** the environmental assessment within the framework of the suitability assessment is on the consideration of the local impacts of a development with wind turbines in relation to the site and the location.

1.3.4.4 Approval procedure (planning approval and planning permission procedure) for offshore wind turbines

The next step after the site investigation is the approval procedure for the installation and operation of offshore wind turbines. After the investigated site has been put out to tender by the Federal Network Agency (BNetzA), the winning bidder can, with the acceptance of the bid by the BNetzA, submit an application for planning approval or – if the prerequisites are met – for planning permission for the construction and operation of offshore wind turbines including the necessary ancillary installation on the site investigated.

In addition to the legal requirements of section 73 subsection 1 sentence 2 of the Administrative Procedure Act (VwVfG), the plan must include the information contained in section 47 subsection 1 of the WindSeeG. The plan may only be established under certain conditions listed in section 48 subsection 4 of the WindSeeG, and only if, inter alia, the marine environment is not endangered, in particular if there is no cause for concern about pollution of the marine environment within the meaning of Article 1 subsection 1 no. 4 of the Convention on the Law of the Sea and if bird migration is not endangered.

Under section 24 of the UVPG, the competent authority prepares a summary

- of the environmental impacts of the project,
- the characteristics of the project and of the site, which are intended to prevent, reduce or offset significant adverse environmental effects,

- measures to prevent, reduce or offset significant negative environmental impacts, and
- substitution measures for interventions in nature and the landscape.

Under section 16 subsection 1 of the UVPG, the project developer must submit a report to the competent authority on the expected environmental impacts of the project (EIA report), which must contain at least the following information:

- a description of the project, including information on the location, nature, scale and design, size and other essential characteristics of the project,
- a description of the environment and its components within the scope of the project,
- a description of the characteristics of the project and of the location of the project to exclude, reduce or offset the occurrence of significant adverse environmental effects of the project,
- a description of the measures planned to prevent, reduce or offset any significant adverse effects of the project on the environment and a description of planned substitution measures,
- a description of the expected significant environmental effects of the project,
- a description of the reasonable alternatives, relevant to the project and its specific characteristics, that have been considered by the developer and the main reasons for the choice made, taking into account the specific environmental effects of the project; and
- a generally understandable, non-technical summary of the EIA report.

Pilot wind turbines are dealt with only in the context of the environmental assessment in the approval procedure and not at upstream stages.

1.3.4.5 Approval procedure for grid connections (converter platforms and submarine cable systems)

In the tiered planning procedure, the establishment and operation of grid connections for offshore wind turbines (converter platform and submarine cable systems, if applicable) are examined at the level of the approval procedures (planning approval and planning permission procedures) in implementation of the regional planning requirements and the specifications of the SDP at the request of the respective project executing agency - the responsible Transmission System Operator (TSO).

According to section 44 subsection 1 in conjunction with section 45 subsection 1 of the WindSeeG, the construction and operation of facilities for the transmission of electricity require planning approval. In addition to the legal requirements of section 73 subsection 1 sentence 2 of the VwVfG, the plan must include the information contained in section 47 subsection 1 of the WindSeeG. The plan may only be approved under certain conditions listed in section 48 subsection 4 of the WindSeeG and only if, inter alia, the marine environment is not endangered, in particular if there is no cause for concern about pollution of the marine environment within the meaning of section 1 subsection 1 no. 4 of the Convention on the Law of the Sea and bird migration is not endangered.

Moreover, according to section 1 subsection 4 of the UVPG, the requirements for the environmental impact assessment of offshore wind turbines, including ancillary installations, apply accordingly to the performance of the environmental assessment.

1.3.4.6 Interconnectors

According to section 133 subsection 1 in conjunction with subsection 4 of the BBergG, the construction and operation of an underwater cable in or on the continental shelf requires a permit

- from a mining point of view (by the competent state mining authority) and
- concerning the arrangement of use and occupation of waters above the continental shelf and the airspace above these waters (by the BSH).

Pursuant to section 133 subsection 2 of the BBergG, the above-mentioned permits may only be refused if there is a risk to the life or health of persons or property or an impairment of overriding public interests which cannot be prevented or compensated for by a time limit, conditions or requirements. An impairment of overriding public interests exists in particular in the cases specified in section 132 subsection 2 no. 3 of the BBergG. Pursuant to section 132 subsection 2 no. 3 b) and d) of the BBergG, an impairment of overriding public interests with regard to the marine environment exists in particular if the flora and fauna would be impaired in an unacceptable manner or if there is reason to believe that the sea will be polluted.

According to section 1 subsection 4 of the UVPG, the essential requirements of the UVPG must be observed for the construction and operation of interconnectors.

Tabular overview of environmental audits: Focus of the investigations

Maritime spatial planning SEA	FEP SEA	Preliminary study SEA suitability test	Approval procedure (planning approval or planning permission) grid connections EA	Approval procedure Transboundary submarine cable systems EA
Strategic planning for designations	**Strategic planning for designations**	***Strategic decision on suitability of sites for OWF***	**Request for environmental assessment**	**Request for environmental assessment**
Specifications and subject matter				
Priority and reservation areas • To ensure the safety and efficiency of navigation, • To further economic uses. especially offshore wind energy and pipelines • To enable scientific uses and to protect and improve the marine environment Objectives and principles Application of the ecosystem approach	• Areas for offshore wind turbines • Areas for offshore wind turbines, including the expected capacity to be installed • Platform locations • Routes and route corridors for submarine cable systems • Technical and planning principles	• Verification of the suitability of the site for the construction and operation of wind turbines, including the capacity to be installed • On the basis of the available and collected data (STUK) as well as other information that can be determined with reasonable effort • Specifications in particular on the type, extent and location of the development	• The construction and operation of platforms and interconnectors • In accordance with the requirements of maritime spatial planning and the site development plan	• The construction and operation of transboundary submarine cable systems • According to the requirements of regional planning and the FEP
Environmental impact analysis				
Analyses (identifies, describes and assesses) the likely significant effects of the plan on the marine environment	Analyses (identifies, describes and assesses) the likely significant environmental effects of the plan on the marine environment	Analyses (determines, describes and evaluates) the likely significant environmental impacts of the construction and operation of wind turbines, which can be assessed independently of the later design of the project, on the basis of model assumptions	Analyses (determines, describes and evaluates) the environmental impacts of the specific project (platform and connecting undersea cable, if applicable).	Analyses (identifies, describes and evaluates) the environmental impacts of the specific project.
Objective				
Aims at the optimisation of overall planning solutions, i.e. comprehensive packages of measures. Consideration of a wider range of uses.	For the use of offshore wind energy, addresses the fundamental questions of • Needs or statutory objectives • Purpose • Technology • Capacities • Finding locations for platforms and tracks.	For the use of wind turbines, deals with the fundamental questions of • Capacity • Suitability of the area	Deals with questions regarding the concrete design ("how") of a project (technical equipment, construction - building permits). Assesses the environmental compatibility of the project and formulates conditions for this.	Deals with questions regarding the concrete design ("how") of a project (technical equipment, construction - building permits). Assesses the environmental impact

Begins at the beginning of the planning process to clarify strategic issues of principle, i.e. at an early stage when there is even greater scope for action.	Searches for environmentally sound packages of measures without absolutely assessing the environmental compatibility of the planning.	Provides information on the site required by law for the submission of bids. Searches for environmentally sound packages of measures without assessing the environmental compatibility of the specific project.		of the project and also formulates conditions.
Essentially functions as a controlling planning instrument of the planning administrative bodies to create an environmentally compatible framework for all uses.	Acts mainly as a steering planning instrument to create an environmentally sound framework for the realisation of individual projects (wind turbines and grid connections, transboundary submarine cables)	Acts as an instrument between the FEP and the approval procedure for wind turbines on a specific site.	Serves primarily as a passive assessment instrument that reacts to requests from the project developer.	Serves primarily as a passive assessment instrument that reacts to requests from the project developer.
Assessment depth				
Characterised by a wider scope of study, i.e. a larger number of alternatives to be assessed, and less depth of study (no detailed analyses) Considers spatial, national and global impacts as well as secondary, cumulative and synergistic impacts in the sense of a comprehensive perspective .	Characterised by a wider scope of study, i.e. a larger number of alternatives to be assessed, and less depth of study (no detailed analyses) Takes into account local, national and global impacts as well as secondary, cumulative and synergistic impacts in the sense of an overall view.	Characterised by a smaller assessment area, greater depth of study (detailed analyses). The determination of suitability may include specifications for the subsequent project, in particular with regard to the type and extent of the development of the site and its location.	Characterised by a narrower scope of study (limited number of alternatives) and greater depth of study (detailed analyses). Assesses the environmental compatibility of the project and formulates conditions for this. Considers primarily local impacts in the vicinity of the project.	Characterised by a narrower scope of study (limited number of alternatives) and greater depth of study (detailed analyses). Considers primarily local impacts in the vicinity of the project.
Focus of the assessment				
Cumulative effects Overall perspective Strategic and large-scale alternatives Possible transboundary effects	**Cumulative effects** Overall perspective Strategic, technical and spatial alternatives Possible transboundary effects	**Local effects in** relation to the site and its location.	Environmental impacts of turbines, construction and operation Turbine dismantling Study in relation to the specific installation design. Intervention, compensation and replacement measures.	Environmental impacts of turbines, construction and operation Study in relation to the specific installation design. Intervention, compensation and replacement measures.
Approval procedure (plan approval or plan permit) for wind turbinesEIA				
Assessment subject				

Environmental impact assessment on request for

- The installation and operation of wind turbines
- The site defined and pre-examined in the FEP
- According to the designations of the FEP and the specifications of the preliminary study.

Environmental impact assessment

Analyses (determines, describes and evaluates) the environmental impacts of the specific project (wind turbines, platforms and internal cabling of the wind farm, if applicable)

Under Section 24 UVPG, the competent authority prepares a summary

- Of the environmental impacts of the project,
- Of the characteristics of the project and of the site, which are intended to prevent, reduce or offset **significant adverse environmental effects,**
- Of the measures to prevent, reduce or offset **significant negative environmental impacts**, and
- Of the replacement measures in the event of interference with nature and landscape (note: exception under Section 56 subsection 3 BNatSchG

Objective

Addresses the questions of the specific design ("how") of a project (technical equipment, construction).

Serves primarily as a passive assessment instrument that reacts to requests from the tender winner/project developer.

Assessment depth

Characterised by a narrower scope of study, i.e. a limited number of alternatives, and greater depth of study (detailed analyses).

Assesses the environmental compatibility of the project on the site under study and formulates conditions for this.

Considers mainly local effects in the vicinity of the project.

Focus of the assessment

The main focus of the assessment is formed by:

- Environmental impacts from construction and operation.
- Assessment in relation to the specific installation design.
- Installation dismantling.

Figure 3: Overview of key aspects of environmental assessments in planning and approval procedures.

1.3.5 Cables

The spatial planning instrument is at the top tier. In this framework, areas or corridors for pipelines and data cables are defined.

According to section 8 subsection 1 of the ROG, the probable significant impacts of the rules on pipelines on the factors must be determined, described and evaluated.

According to section 133 subsection 1 in conjunction with subsection 4 of the BBergG, the construction and operation of a transit pipeline or underwater cable (data cable) in or on the continental shelf requires a permit

- from a mining point of view (by the competent state mining authority) and
- concerning the arrangement of use and occupation of waters above the continental shelf and the airspace above these waters (by the BSH).

Pursuant to section 133 subsection 2 of the BBergG, the above-mentioned permits may only be refused if there is a risk to the life or health of persons or property or an impairment of overriding public interests which cannot be prevented or offset by a time limit, conditions or requirements. An impairment of overriding public interests exists in particular in the cases specified in section 132 subsection 2 no. 3 of the BBergG. Pursuant to section 132 subsection 2 no. 3 b) and d) of the BBergG, an impairment of overriding public interests with regard to the marine environment exists in particular if the flora and fauna would be impaired in an unacceptable manner or if there is reason to believe that the sea will be polluted.

Under section 133 subsection 2a of the BBergG, the construction and operation of a transit pipeline which is also a project as defined in section 1 subsection 1 no. 1 of the UVPG is subject to an environmental impact assessment in the approval procedure with regard to the arrangement of the use and occupation of the waters above the continental shelf and the airspace above these waters in accordance with the UVPG.

According to section 1 subsection 4 of the UVPG, the essential requirements of the UVPG must be observed for the construction and operation of data cables.

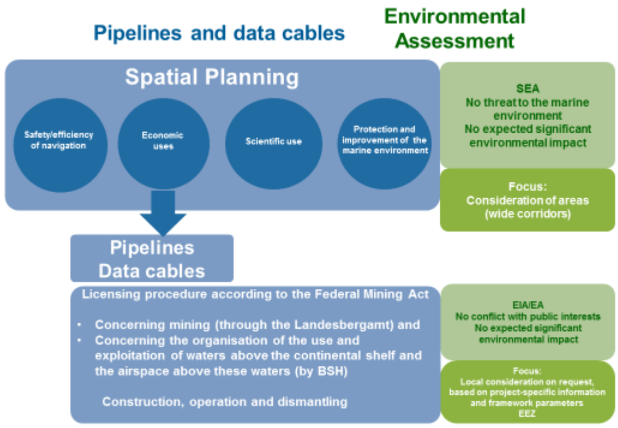


Figure 4: Overview of the focal points of the environmental assessment for pipelines and data cables.

1.3.6 Raw material extraction

In the German North and Baltic Seas, various mineral resources are sought and extracted, e.g. sand, gravel and hydrocarbons. As a primary instrument, spatial planning deals with possible large-scale spatial definitions, possibly including other uses. The anticipated significant environmental impacts are reviewed (cf. also Chapter 1.5.4.3).

During implementation, the extraction of raw materials is regularly divided into different phases–- exploration, development, operation and aftercare phase.

The exploration serves the purpose of exploring raw material deposits in accordance with section 4 subsection 1 of the BBergG. In the marine area it is regularly carried out by geophysical surveys, including seismic surveys and exploration drilling. In the EEZ, the extraction of raw materials includes the extraction (loosening, release), processing, storage and transport of raw materials.

According to the Federal Mining Act, mining permits (permission, licence) must be obtained for exploration on the continental shelf. These grant the right to explore for and/or extract mineral resources in a defined field for a specified period of time. Additional permits in the form of operating plans are required for development (extraction and exploration activities) (cf. section 51 of the BBergG). For the establishment and management of an operation, main operating plans must be drawn up for a period not normally exceeding 2 years, which must be continuously updated as required (section 52 subsection 1 sentence 1 of the BBergG).

In the case of mining projects requiring an EIA, the preparation of a general operating plan is mandatory, and a planning approval procedure must be carried out for its approval (section 52 subsection 2a of the BBergG). Framework operation plans are generally valid for a period of 10 to
30 years.

Pursuant to section 57c of the BBergG in conjunction with the Ordinance on the Environmental Impact Assessment of Mining Projects (UVP-V Bergbau), the construction and operation of production platforms for the extraction of oil and gas in the area of the continental shelf require an EIA. The same applies to marine sand and gravel extraction on mining sites of more than 25 ha or in a designated nature conservation area or Natura 2000 area.

The licensing authorities for the German North Sea and Baltic Sea EEZ are the State Mining Authorities.

1.3.7 Shipping

In the context of spatial planning, the shipping sector is regularly defined in terms of areas (priority and/or reservation areas), objectives and principles. There is no tiered planning and approval process for the shipping sector, as is the case for the offshore wind turbines, grid connections, interconnectors, pipelines and data cables.

With regard to the consideration of likely significant effects of the rules on the shipping sector, reference is made to Chapter 1.5.4.3

1.3.8 Fisheries and marine aquaculture

Fisheries and aquaculture are considered as concerns in the context of spatial planning. There is no tiered planning and approval process.

With regard to the consideration of the likely significant impacts, reference is made to Chapter 1.5.4.3

1.3.9 Marine scientific research

Marine and maritime scientific research is considered as a matter of concern in the context of spatial planning. There is no tiered planning and approval process.

With regard to the consideration of the likely significant impacts, reference is made to Chapter 1.5.4.3

1.3.10 National and alliance defence

National and alliance defence is considered a concern in the context of spatial planning. There is no tiered planning and approval process.

With regard to the consideration of the likely significant impacts, reference is made to Chapter 1.5.4.3

1.3.11 Leisure

The issue of leisure is also considered. There is no tiered planning and approval process.

With regard to the consideration of the likely significant impacts, reference is made to Chapter 1.5.4.3

1.4 Presentation and consideration of environmental protection objectives

The ROP is drawn up and the SEA implemented with due regard for the objectives of environmental protection. These provide information on the state of the environment that is to be achieved in the future (environmental quality objectives). The objectives of environmental protection can be found in an overview of the international, EU and national conventions and regulations dealing with marine environmental protection, on the basis of which the Federal Republic of Germany has committed itself to certain principles and objectives. The environmental report will contain a description of how compliance with the requirements is checked and what specifications or measures are taken.

1.4.1 International conventions on the protection of the marine environment

The Federal Republic of Germany is a party to all relevant international conventions on marine environmental protection.

1.4.1.1 Globally applicable conventions that are wholly or partly aimed at protecting the marine environment

- 1973 Convention for the Prevention of Pollution from Ships, as amended by the 1978 Protocol (MARPOL 73/78)
- 1982 United Nations Convention on the Law of the Sea
- Convention on the prevention of marine pollution by dumping of waste and other matter (London, 1972) and the 1996 Protocol

1.4.1.2 Regional conventions on marine environmental protection

- 1992 Convention on the Protection of the Marine Environment of the Baltic Sea Area (Helsinki Convention)

1.4.1.3 Factor-specific agreements

- 1979 Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)
- 1979 Convention on the Conservation Of Migratory Species Of Wild Animals (Bonn Convention)

Under the Bonn Convention, regional agreements for the conservation of the species listed in Appendix II were concluded in accordance with
Art. 4 no. 3 of the Bonn Convention:

- 1995 Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)
- 1991 Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)
- 1991 Agreement on the Conservation of Seals in the Wadden Sea
- 1991 Agreement on the Conservation of European Bat Populations (EUROBATS)
- 1993 Convention on Biological Diversity

1.4.2 Environmental and nature conservation requirements at the EU level

As relevant EU legislation must be taken into account:

- Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning (MSP Directive)
- Council Directive 337/85/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (Environmental Impact Assessment Directive, EIA Directive)
- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)
- Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive, WFD)
- Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (Strategic Environmental Assessment Directive, SEA Directive)
- 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, MSFD),
- Directive 2009/147/EC of the European Parliament and of the Council on the conservation of wild birds (Birds Directive).

1.4.3 Environmental and nature conservation requirements at the national level

There are also various legal provisions at national level, the requirements of which must be taken into account in the environmental report:

- Law on nature conservation and landscape management (Federal Nature Conservation Act - BNatSchG)
- Water Resources Act (WHG)
- Law on Environmental Impact Assessment (UVPG)
- Regulation on the designation of the Fehmarn Belt nature conservation area, Regulation on the designation of the Kadet Trench nature conservation area and Regulation on the designation of the Eastern German Bay - Rönnebank" nature conservation area in the Baltic Sea EEZ
- Management plans for the nature conservation areas in the German Baltic Sea EEZ (participation procedure not yet completed)
- Energy and climate protection targets of the Federal Government

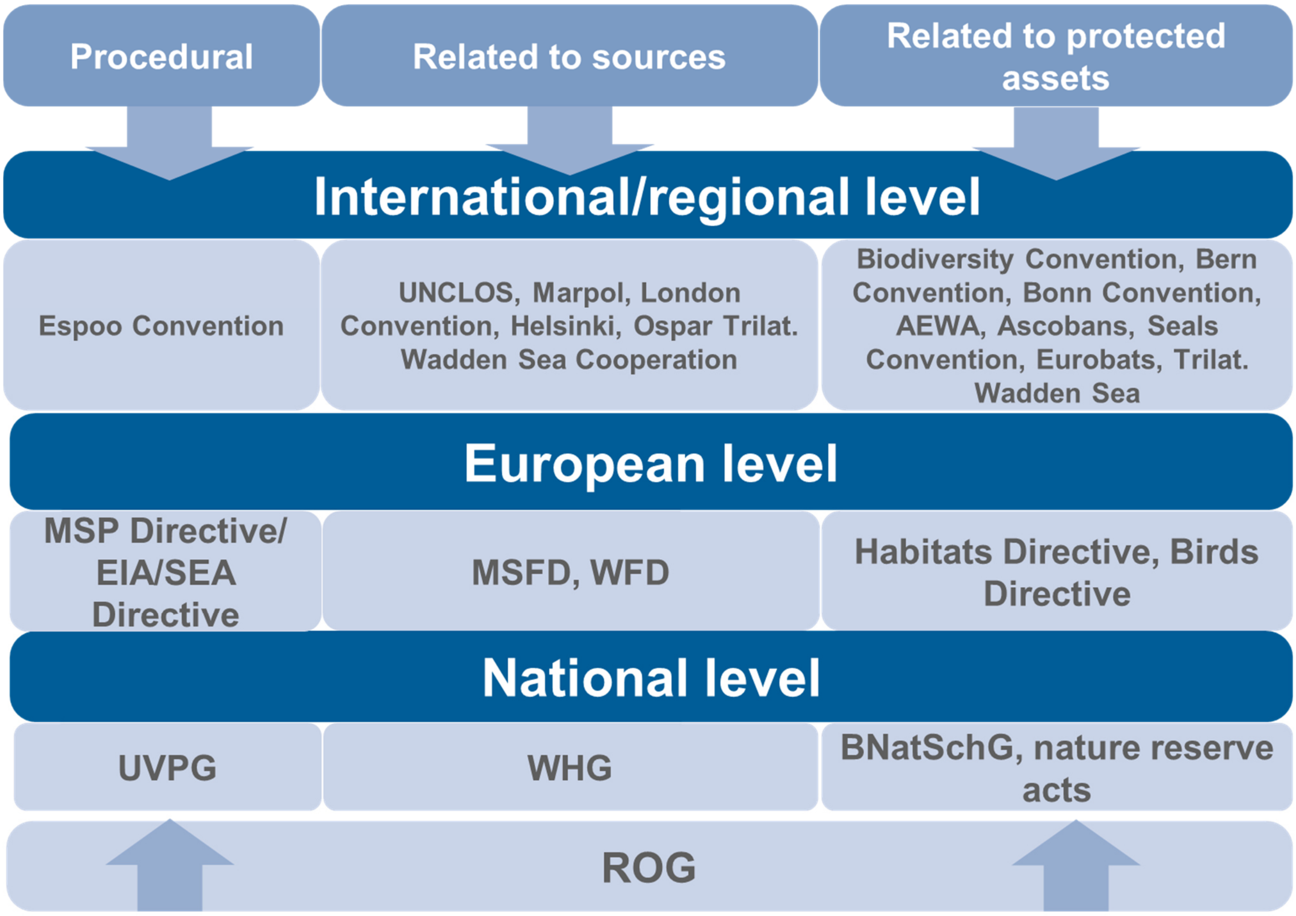


Figure 5: Overview of the levels of standardisation of the relevant legal acts for SEA.

1.4.4 Support for the objectives of the Marine Strategy Framework Directive

Spatial planning can support the implementation of individual objectives of the MSFD and thus contribute to the good status of the environment in the North Sea and Baltic Sea.

In the setting of objectives and principles, the following environmental objectives (BMUB, 2016) are taken into account:

- Environmental objective 1: Oceans unaffected by anthropogenic eutrophication: to be taken into account in the objectives and principles for ensuring the safety and ease of navigation.
- Environmental objective 3: Oceans without deterioration of marine species and habitats due to the impact of human activities: consideration in the objectives and principles relating to offshore wind turbines and nature conservation
- Environmental objective 6: Oceans without adverse effects from anthropogenic energy inputs: consideration in the objectives and principles for offshore wind turbines and pipelines

In the environmental assessment, avoidance and mitigation measures are formulated to support objectives 1, 3 and 6.

In addition, the Spatial Plan counteracts the deterioration of the environment by making certain uses possible only in geographically defined areas and for a limited period of time. The principles of environmental protection must be taken into account. At the permit level, the design of the use is specified in detail, if necessary with conditions, in order to avert negative impacts on the marine environment.

An essential basis of the MSFD is the ecosystem approach regulated in section 1 subsection 3 of the MSFD, which ensures the sustainable use of marine ecosystems by managing the overall burden of human activities in a way that is compatible with the achievement of Good Environmental Status. The application of the ecosystem approach is outlined in Chapter 4.3.

1.5 Strategic Environmental Assessment methodology

In principle, different methodological approaches can be considered when conducting the Strategic Environmental Assessment. The present environmental report builds on the methodology already applied in the Strategic Environmental Assessment of the federal sectoral plans and the Site Development Plan with regard to the use of offshore wind turbines and electricity grid connections.

For all other uses for which specifications are made in the ROP, such as shipping, extraction of raw materials and marine research, sector-specific criteria are used to assess possible impacts.

The methodology is mainly based on the rules of the plan to be examined. Within the framework of this SEA, it is determined, described and evaluated for each of the specifications whether the specifications are likely to have significant impacts on the factors concerned. According to section 1 subsection 4 of the UVPG in conjunction with section 40 subsection 3 of the UVPG, the competent authority shall provisionally assess the environmental impacts of the specifications in the environmental report with a view to effective environmental precautions in accordance with the applicable laws. Criteria for the assessment are to be found, inter alia, in Annex 2 of the Spatial Planning Act.

The object of the environmental report is the description and assessment of the likely significant impacts of the implementation of the ROP on the marine environment for rules on the use and protection of the EEZ. The examination is carried out in each case on the basis of the factors.

According to section 7 subsection 1 of the ROG, Site Development Plans must contain rules as objectives and principles of spatial planning on the development, organisation and safeguarding of the space, in particular on the uses and functions of the space. Under section 7 subsection 3 of the ROG, these rules may also designate areas.

Rules on the following uses are the subject of the environmental report, in particular

- Shipping
- Offshore wind energy
- Cables
- Raw material extraction
- Fisheries and marine aquaculture
- Marine research

Under section 17 subsection 1 no. 4 of the ROG, rules for the protection and improvement of the marine environment (nature conservation / marine landscape / open space) also play a role.

1.5.1 Investigation area

Two separate environmental reports are produced for the North Sea and Baltic Sea EEZs. The description and assessment of the state of the environment in this environmental report refers to the Baltic Sea EEZs, for which the Site Development Plan makes rules. The SEA study area covers the German EEZ (Figure 7).

The adjoining territorial waters and the adjacent areas of the neighbouring states are not covered by this plan, but they are considered in the cumulative and transboundary consideration – and where necessary – in the impact assessment under this SEA.

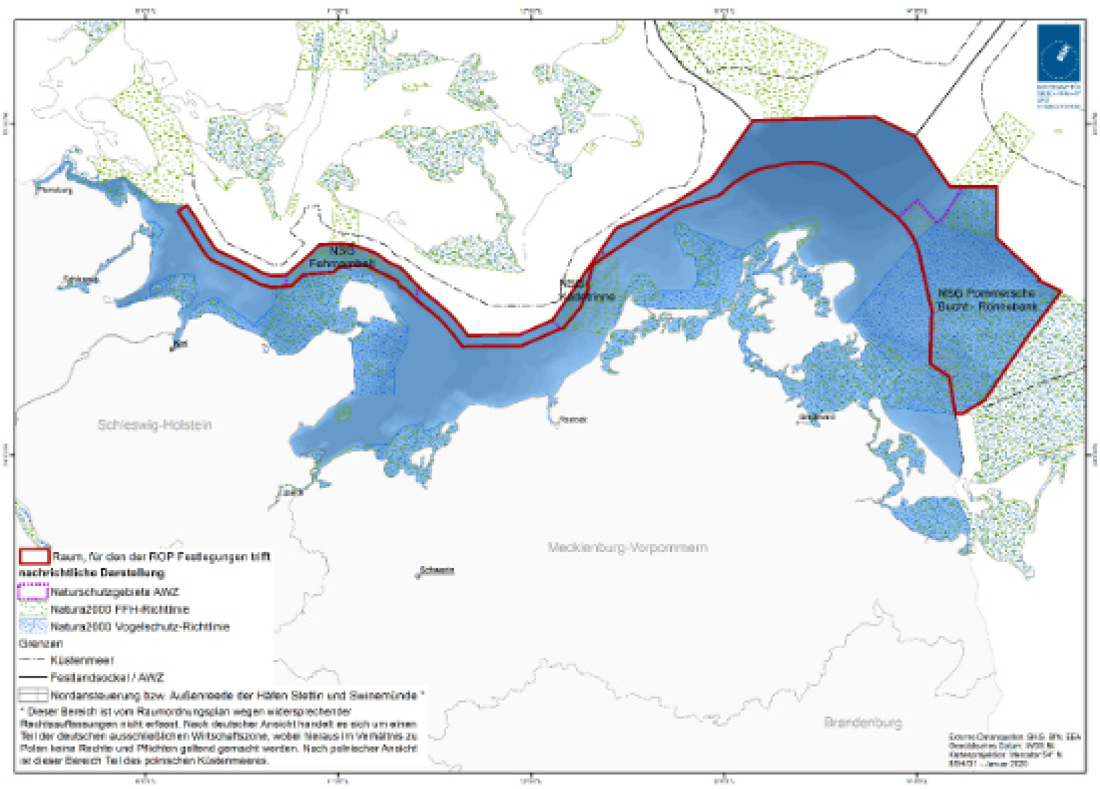


Figure 6: Boundary of the investigation area for the Baltic Sea SEA EEZ.

1.5.2 Implementation of the environmental assessment

The assessment of the likely significant environmental effects of the implementation of the Spatial Plan shall include secondary, cumulative, synergistic, short-, medium- and long-term, permanent and temporary, positive and negative effects in terms of the factors. Secondary or indirect effects are those which are not immediate and therefore may take effect after some time and/or in other places. Occasionally consequential effects or interrelationships are referred to.

Possible impacts of the plan implementation are described and evaluated in relation to the factors. A uniform definition of the term "significance" does not exist, since it is an "individually determined significance" which cannot be considered independently of the "specific characteristics of plans or programmes" (SOMMER, 2005, 25f.). In general, significant impacts can be understood to be effects that are serious and significant in the context under consideration.

According to the criteria of Annex 2 of the ROG, which are decisive for the assessment of the likely significant environmental impacts, significance is determined by

- "the probability, duration, frequency and irreversibility of the effects;
- the cumulative nature of the effects;
- the transboundary nature of the effects;
- the risks to human health or the environment (e.g. in the event of accidents);
- the scale and spatial extent of the impacts;
- the importance and sensitivity of the area likely to be affected, due to its specific natural characteristics or cultural heritage, exceeded environmental quality standards or limit values and intensive land use;
- the impact on sites or landscapes whose status is recognised as protected at the national, Community or international level".

Also relevant are the characteristics of the plan, in particular

- the extent to which the plan sets a framework for projects and other activities in terms of location, type, size and operating conditions or through the use of resources;
- the extent to which the plan influences other plans and programmes, including those in a planning hierarchy;
- the importance of the plan for the integration of environmental considerations, in particular with a view to promoting sustainable development;
- the environmental issues relevant to the plan;
- the relevance of the plan for the implementation of Community environmental legislation (e.g. plans and programmes relating to waste management or water protection) (Annex II SEA Directive)

In some cases, further details on when an impact reaches the materiality threshold can be derived from sectoral legislation. Thresholds were developed under the law in order to be able to make a delimitation.

The description and assessment of potential environmental impacts is carried out for the individual spatial and textual specifications on the use and protection of the EEZ in relation to the factors, including the status assessment.

Furthermore, where necessary, a differentiation is made based on different technical designs. The description and assessment of the likely significant impacts of the implementation of the plan on the marine environment also relate to the factors presented. All contents of the plan that could potentially have significant environmental impacts are examined.

Both permanent and temporary, e.g. construction-related, effects are considered. This is followed by a presentation of possible interrelationships, a consideration of possible cumulative effects and potential transboundary impacts.

The following factors are considered with regard to the assessment of the state of the environment:

- Area
- Soil
- Water
- Plankton
- Biotopes
- Benthos
- Fish
- Marine mammals
- Avifauna
- Bats
- Biodiversity
- Air
- Climate
- Landscape
- Cultural heritage and other material assets
- Human beings, in particular human health
- Interrelationships

In general, the following methodological approaches are used in environmental assessment:

- Qualitative descriptions and assessments
- Quantitative descriptions and assessments
- Evaluation of studies and technical literature, expert opinions
- Visualizations
- Worst-case assumptions
- Trend assessments (e.g. on the state of the art of systems and the possible development of shipping traffic)
- Assessments by experts/the professional community

An assessment of the impacts resulting from the rules of the plan is made on the basis of the status description and status assessment and the function and significance of the individual areas for the individual factors on the one hand, and the impacts resulting from these rules and the resulting potential impacts on the other. A prognosis of the project-related impacts when the ROP is implemented is based on the criteria of intensity, range and duration or frequency of the effects (cf. Figure 7). Further assessment criteria are the probability and reversibility of the impacts, as specified in Annex 2 to section 8 subsection 2 of the ROG.

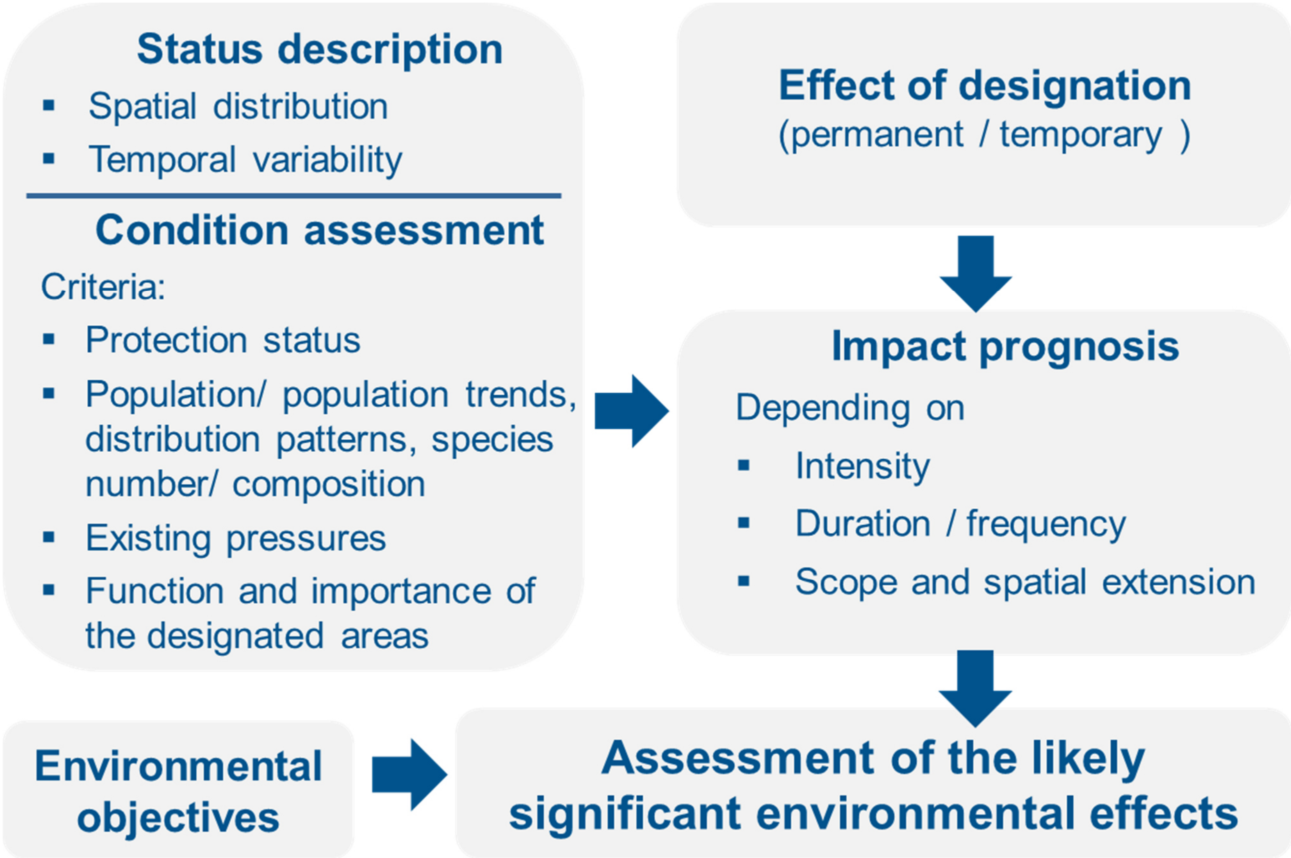


Figure 7: General methodology for assessing likely significant environmental impacts.

1.5.3 Criteria for the status description and assessment

The status of the individual factors is assessed on the basis of various criteria. For the protected assets of area/soil, benthos and fish, the assessment is based on the aspects of rarity and vulnerability, diversity and uniqueness, and legacy impacts. The description and assessment of marine mammals and marine and resting birds are based on the aspects listed in the figure. Since these are highly mobile species, an approach analogous to that for the factors area/soil, benthos and fish is not appropriate. For seabirds, resting birds and marine mammals, the criteria used are protection status, assessment of occurrence, assessment of spatial units and legacy impacts. For migratory birds, the aspects of rarity, threat and legacy impacts are taken into account, as are the aspects of occurrence assessment and the area's significance for bird migration over a large area. There is currently no reliable data basis for a criteria-based assessment of bats as a protected species. The biodiversity factor is evaluated in text form.

The following is a summary of the criteria that were used for the status assessment of the respective factor. This overview deals with the factors which can be meaningfully delimited on the basis of criteria and which are considered in the focus area.

Area/Soil

Aspect: Rarity and threat
Criterion: Percentage of sediments on the seabed and distribution of the morphological inventory of forms.
Aspect: Diversity and uniqueness
Criterion: Heterogeneity of the sediments on the sea floor and development of the morphological inventory of forms.
Aspect: Legacy impacts
Criterion: Extent of the anthropogenic legacy impacts of the sediments on the sea floor and the morphological inventory of forms.

Benthos

Aspect: Rarity and threat
Criterion: Number of rare or endangered species based on the Red List species identified (Red List by RACHOR et al. 2013).
Aspect: Diversity and uniqueness
Criterion: Number of species and composition of the species communities. The extent to which species or communities characteristic of the habitat occur and how regularly they occur is assessed.
Aspect: Legacy impacts
For this criterion, the intensity of fishing exploitation, which is the most effective disturbance variable, will be used as a benchmark. Eutrophication can also affect benthic communities. For other disturbance variables, such as vessel traffic, pollutants, etc., there is currently a lack of suitable measurement and detection methods to be able to include them in the assessment.

Biotopes

Aspect: Rarity and threat
Criterion: national conservation status and threat of biotopes according to the Red List of Endangered Biotopes in Germany (FINCK et al., 2017)
Aspect: Legacy impacts
Criterion: Hazard due to anthropogenic influences.

Fish

Aspect: Rarity and threat
Criterion: Proportion of species considered endangered according to the current Red List of marine fish (THIEL et al. 2013) and for the diadromous species on the Red List of freshwater fish (FREYHOF 2009) and assigned to Red List categories.
Aspect: Diversity and uniqueness
Criterion: The diversity of a fish community can be described by the number of species (α-Diversity, 'Species richness'). The species composition can be used to assess the specific nature of a fish community, i.e. how regularly habitat-typical species occur. Diversity and specificity are compared and assessed between the Baltic Sea as a whole and the German EEZ, as well as between the EEZ and individual areas.
Aspect: Legacy impacts
Criterion: By-catch of target species and by-catch, as well as seabed disturbance in the case of seabed-disturbing fishing methods, fisheries are considered to be the most effective disturbance to the fish community and therefore serve as a measure of the pressure on fish communities in the Baltic Sea. There is no assessment of stocks on a smaller spatial scale such as the German Bight. The input of nutrients into natural waters is another path through which human activities can affect fish communities. For this reason, eutrophication is used to assess the legacy impacts.

Marine mammals

Aspect: Protection status
Criterion: Status under Annex II and Annex IV of the Habitats Directive and the following international protection agreements: Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, CMS), ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas), Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)
Aspect: Assessment of occurrence
Criteria: Stock, stock changes/trends based on large-scale surveys, distribution patterns and density distributions
Aspect: Assessment of spatial units

Criteria: Function and importance of the German EEZ and the areas defined in the ROP for marine mammals as migration areas, feeding grounds or breeding grounds
Aspect: Legacy impacts
Criterion: Hazards due to anthropogenic influences and climate change.

Seabirds and resting birds

Aspect: Protection status
Criterion: Status according to Annex I of the Birds Directive, European Red List from BirdLife International
Aspect: Assessment of occurrence
Criteria: Baltic Sea stock and EEZ stock, large-scale distribution patterns, abundances, variability
Aspect: Assessment of spatial units
Criteria: Function of the areas defined in the ROP for relevant breeding birds, migrants, as resting areas, location of protected areas
Aspect: Legacy impacts
Criterion: Hazards due to anthropogenic influences and climate change.

Migratory birds

Aspect: The importance of bird migration over a large area
Criterion: Guidelines and areas of concentration
Aspect: Assessment of occurrence
Criterion: Migration activity and its intensity
Aspect: Rarity and threat
Criterion: Number of species and endangered status of the species involved according to Annex I of the Birds Directive, Bern Convention of 1979 on the Conservation of European Wildlife and Natural Habitats, Bonn Convention of 1979 on the Conservation of Migratory Species of Wild Animals, AEWA (African-Eurasian Waterbird Agreement) and SPEC (Species of European Conservation Concern).
Aspect: Legacy impacts
Criterion: Prior pollution/hazards due to anthropogenic influences and climate change.

1.5.4 Assumptions used to describe and assess the likely significant impacts

The description and assessment of the likely significant impacts of the implementation of ROP-E on the marine environment is carried out for the individual rules on the use and protection of the EEZs on a factor basis, taking into account the status assessment described above. The following table lists, on the basis of the main impact factors, those potential environmental impacts which arise from the respective use and which are to be examined both as a legacy impact, in the event of non-implementation of the plan, or as an anticipated significant environmental impact resulting from the rules in the ROP. The effects are differentiated according to whether they are permanent or temporary.

Table 1: Overview of potentially significant impacts of the uses defined in the ROP-E.

Use	Effect	Potential effect	Protected Assets																
			Benthos	Fish	Sea birds and resting birds	Migratory birds	Marine mammals	Bats	Plancton	Biotoptype types	Biodiversity	Soil	Surface	Water	Air	Climate	Humans/ health	Cultural and material goods	Landscape
Maritime uses with designations in the maritime spatial plan																			
Areas for offshore wind energy	Placement of hard substrate (foundations)	Habitat change	x							x	x	x						x	
		Loss of habitat and land	x	x						x	x	x	x					x	
		Attraction effects, increase in species diversity, change in species composition		x							x								
		Change in hydrological conditions		x										x					
	Scouring/sediment relocation	Habitat change								x		x	x						
	Sediment swirls and turbidity plumes (construction phase)	Impairment	x t																
		Physiological effects and scaring effects		x t															
	Resuspension of sediment and sedimentation (construction phase)	Impairment	x t																
	Noise emissions during pile driving (construction phase)	Impairment / scaring effect		x t			x t												
		potential disruption/damage		x t			x t												
	Visual disturbance due to construction work	Local scaring and barrier effects			x t														
	Obstacle in airspace	Scaring effects, loss of habitat			x														
		Barrier effect, collision			x	x		x											x
	Light emissions (construction and operation)	Attraction effects, collision			x	x		x											x
	wind farm related shipping traffic (maintenance, construction traffic)	see shipping	x	x	x	x	x	x	x	x	x	x	x t	x	x	x	x	x	
Cables Routes for submarine cable systems and pipelines	Introduction of hard substrate (stone fill)	Habitat change	x							x		x						x	
		Loss of habitat and space	x							x		x	x					x	
	Heat emissions (current-carrying cables)	Impairment/displacement of cold water-loving species	x								x								
	Magnetic fields (current-carrying cables)	Impairment	x																
		Impairment of the orientation behaviour of individual migratory species		x															
	Turbidity plume (construction phase)	Impairment	x t																
		Physiological effects and scaring effects		x t															
Shipping	Underwater Sound	Impairment / scaring effect		x			x												
	Emissions and discharges of hazardous substances (accidents)	Impairment/ damage	x	x	x		x		x	x	x	x		x			x		
	Physical disturbance during anchoring	Impact on the seabed	x t							x t		x t	x t					x	
	Emission of air pollutants	Impairment of air quality			x	x		x							x	x	x		
	Introduction and spread of invasive species	Change in species composition	x	x							x								
	Bringing in waste	Impairment/ damage	x	x	x		x							x			x		
	Risk of collision	Collision				x	x												
	Visual agitation	Impairment / scaring effect			x														

Use	Effect	Potential effect	Protected Assets																
			Benthos	Fish	Sea birds and resting birds	Migratory birds	Marine mammals	Bats	Plancton	Biotoptype types	Biodiversity	Soil	Surface	Water	Air	Climate	Humans/ health	Cultural and material goods	Landscape
Maritime uses with designations in the maritime spatial plan																			
Raw materials Sand and gravel mining / Seismic investigations	Removal of substrates	Veränderung von Habitaten	x	x						x	x	x						x	
		Lebensraum- und Flächenverlust	x	x						x	x	x	x					x	
	Turbidity plumes	Impairment	x t																
		Physiological effects and scaring effects		x t															
	Physical disturbance	Impact on the seabed	x							x		x	x						
	Underwater sound during seismic surveys	Impairment / scaring effect		x t			x t												
Marine Research	Sampling of selected species	Reduction of stocks		x															
		Deterioration of the food base																	
	Physical disturbance by trawls	Impairment/ damage	x							x		x							
Maritime uses without designations in the maritime spatial plan																			
National defense	Underwater sound	Impairment / scaring effect		x t			x t												
	Introduction of hazardous substances	Impairment	x	x	x		x			x	x	x		x			x		
	Risk of collision	Collision					x												
	Surface sound	Impairment / scaring effect			x	x		x									x		
Recreation (-traffic)	Taking of species (fishing)	Reduction of stocks		x															
	Underwater Sound	Impairment / scaring effect		x			x												
	Emission of air pollutants	Impairment of air quality			x	x		x							x	x	x		
	Bringing in waste	Impairment	x	x	x		x							x			x		
	Visual agitation	Impairment / scaring effect			x														
Aquakultur	Introduction of nutrients	Impairment	x	x					x					x					
	Installation of fixed installations	Habitat change	x	x						x									x
		Loss of habitat and land	x	x									x						x
Fischerei	Sampling of selected species	Reduction of stocks		x							x								
		Deterioration of the food base			x		x												
	Bycatch	Reduction of stocks		x			x												
	Physical disturbance by trawls	Impairment / damage	x							x		x							

x potential impact on the factor

x t potential temporary impact on the factor

In addition to the impacts on the individual factors, cumulative effects and interrelationships between factors are also examined.

1.5.4.1 Cumulative assessment

According to Art. 5 subsection 1 of the SEA Directive, the environmental report also includes an assessment of cumulative effects. Cumulative impacts arise from the interrelationship of various independent individual effects which either add up as a result of their interrelationship (cumulative effects) or reinforce each other and thus generate more than the sum of their individual effects (synergistic effects) (e.g. SCHOMERUS et al., 2006). Both cumulative and synergetic effects can be caused by the coincidence of effects in time and space. The impact can be reinforced by similar uses or different uses with the same effect, thereby increasing the impact on one or more factors.

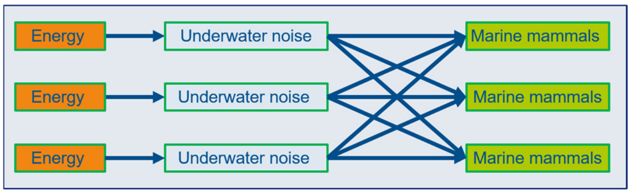


Figure 8: Exemplary cumulative effect of similar uses.

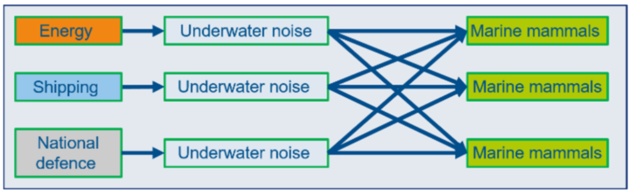


Figure 9: Exemplary cumulative effect of different uses.

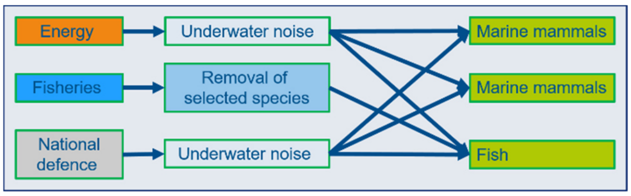


Figure 10: Exemplary cumulative effect of different uses with different impacts.

In order to examine the cumulative effects, it is necessary to assess the extent to which the rules of the plan, when taken together, can be expected to have a significant adverse effect. An examination of the rules is performed on the basis of the current state of knowledge within the meaning of Art. 5 subsection 2 of the SEA Directive.

1.5.4.2 Interrelationships

In general, impacts on a factor lead to various consequences and interrelationships between the factors. The essential interdependence of the biotic factors exists via the food chains. Due to the variability of the habitat, interrelationships can only be described in very imprecise terms overall.

1.5.4.3 Specific assumptions for the assessment of the likely significant environmental effects

In detail, the analysis and examination of the respective rules are as follows:

Offshore wind energy

With regard to the priority and reservation areas for offshore wind energy, a worst-case consideration is generally assumed. In this SEA, certain parameters are assumed in the form of bandwidths spatially separated into zones 1 and 2 and zones 3 to 5. In detail, these are, for example, the power output per installation [MW], hub height [m], rotor diameter [m] and total height [m] of the installations.

As input parameters, the SEA takes particular account of

- installations already in operation or undergoing the licensing procedure (as reference and legacy impacts)
- Transfer of the average parameters of the installations commissioned in the last 5 years on the sites defined in the SDP 2019
- Forecast of certain technical developments for the additional priority and reservation areas for offshore wind energy defined in the ROP on the basis of the parameters shown in the

- Table 2. It should be noted that these are only partly estimation-based assumptions, as project-specific parameters are not or cannot be checked at the SEA level.

Table 2: Parameters for the consideration of areas for offshore wind energy

Wind Turbine Generator (WTG) Parameters	**Bandwidth** *Zones 1 and 2*		**Bandwidth** *Zone 3 to 5*	
	from	to	from	to
Output per turbine [MW]	5	12	12	20
Hub height [m]	100	160	160	200
Rotor diameter [m]	140	220	220	300
Total height [m]	170	270	270	350

For grid connection systems in the Baltic Sea EEZ, the capacity is between 250 and 300 MW. The route length varies between 14 and 24 km. A width of 1 m is assumed for the cable trench of submarine cable systems.

For the route corridors for pipelines, transboundary submarine cable systems or data cables, the cable lengths result from the specifications. For pipelines, a width of 1.5 m is assumed for the assessment of environmental impacts for the overlying pipeline plus 10 m each for impairments due to "reef effect" and sediment dynamics.

For other uses, evaluation criteria or parameters for the environmental assessment are to be developed or specified in the further procedure.

Shipping

In order to assess the environmental impact of shipping, it is necessary to examine what additional effects can be attributed to the rules of the Spatial Plan.

The priority areas identified must be kept free of construction. This control in the ROP-E should prevent or at least reduce collisions and accidents. Based on the rules in the ROP, the frequency of traffic in the priority areas is expected to increase, in particular due to the increase in offshore wind farms along the shipping routes. Vessel movements on the shipping routes SN1 to SN17 and SO1 to SO5 vary considerably, with the most heavily used route SN1 sometimes carrying more than 15 vessels per km² per day, while on the other, narrower routes there are usually about 1-2 vessels per km² per day (BfN, 2017).

The BSH has commissioned an expert report on the traffic analysis of shipping traffic, which is expected to include current evaluations.

The presentation of the general effects of shipping is described in Chapter 2 as a legacy impact, especially for birds and marine mammals. The effects of service traffic to the wind farms are dealt with in the chapter on wind energy.

Raw material extraction

When assessing the potential environmental impact of raw material extraction, a distinction must be made between sand and gravel extraction and hydrocarbon extraction.

Sand and gravel extraction

Sand and gravel are extracted by means of floating suction dredgers. The extraction field is driven over in strips of approx. 2 m width and the subsoil is extracted to a depth of approx. 2 m. The seabed between the excavation strips remains undisturbed. During mining, a sediment-water mixture is pumped on board the suction dredger. The sediment in the desired grain size is screened out and the unused portion is returned to the sea on site. Turbidity plumes result from the mining and discharge. Potential temporary effects result from the turbidity plumes, which can lead to impairments and deterrence of the marine fauna. Potential permanent effects arise from the removal of substrates, and physical disturbance causes habitat and area loss, habitat alteration and seabed degradation.

Sand and gravel extraction is carried out on the basis of operational plans on sub-areas of the approved approval fields.

Gas production

Exploratory and production wells are drilled for the exploration and development of gas deposits. Drilling through the rock lying above the deposit results in drilling abrasion. This is brought to the surface by means of drilling fluids. The drilling fluids have either a water or oil base. If a water-based drilling fluid is used, it is discharged into the sea together with the cuttings. If oil-based drilling fluids are used, they are disposed of on land together with the cuttings.

Seismic methods are used in the exploration of hydrocarbon reservoirs, which lead to scare effects in marine mammals.

Operationally induced material discharges into the sea result from the discharge of production and spray water, waste water from the sewage treatment plant and from the shipping traffic. Production water is essentially reservoir water that may contain components from the underground, such as salts, hydrocarbons and metals. As the deposit ages, the amount of gas in the production water increases. Production water can also contain chemicals that are used in mining to improve extraction or to prevent corrosion of production equipment. The production water is discharged into the sea after treatment in accordance with the state of the art and compliance with national and international standards.

Marine research

The designated areas for scientific marine research correspond to standard investigation areas ("boxes") of the Thuenen Institute in the North Sea and the Baltic Sea. In the Baltic Sea, scientific by-catches have been taking place several times a year for over thirty years, for which sampling is done for research outside the boxes under the BALTBOX, BITS and COBALT programmes. The data records form an important basis for assessing long-term changes in the bottom fish fauna (commercial and non-commercial species) of the Baltic Sea, caused by natural (e.g. climatic) influences or anthropogenic factors (e.g. fisheries).

Bottom trawls and beam trawls are used in the Baltic Sea. Details on the gear used, the expense, and the catch quantities can be found in the respective cruise reports on the research trips of the Thuenen Institute.

Effects are to be expected from the equipment used, in particular on the soil/sediment and the habitats affected by it. For this purpose, fish of various ages and sizes are taken.

Table 3: Parameters for the consideration of marine research

Frequency of surveys per year/ number of hauls/ duration per haul (approximate values, vary from trip to trip)	2 / in the range of approx. 40 - 50 (GSBTS only) / 30 min.
Gear used (target species)	Standardised bottom trawl catches, using high-density otter trawls (bottom fishing communities) 2-metre beam trawl (epibenthos) Van-Veen grab sampler (Infauna)
Catches	Total quantities for all (sampled) boxes (partly with other research activities) in double-digit tonnes

Nature conservation / marine landscape / open space

The rules on nature conservation in the Spatial Plan are not expected to have any significant negative environmental impacts.

The rules contribute to the long-term preservation and development of the marine environment in the EEZ as an ecologically intact open space over a large area. The size of the defined area is of particular importance in this context. Keeping the protected areas free of uses that are incompatible with nature conservation also contributes to the protection of open space and the marine landscape on a large scale.

The guiding principles of the careful and economical use of natural resources in the EEZ, as well as the application of the precautionary principle and the ecosystem approach, are intended to avoid or reduce impairments to the balance of nature.

The Spatial Plan all objectives.

National and alliance defence

The ROP-E contains textual rules on national and alliance defence.

1.6 Data sources

The basis for the SEA is a description and assessment of the state of the environment in the study area. All factors must be included. The data source is the basis for the assessment of the probable significant environmental impacts, the assessment under site and species protection law and the assessment of alternatives.

According to section 8 subsection 1 sentence 3 of the ROG, the environmental assessment refers to what can reasonably be required on the basis of the current state of knowledge and generally accepted assessment methods and the content and level of detail of the Spatial Plan.

Under section 40 subsection 4 of the UVPG, information available to the competent authority from other procedures or activities may be included in the environmental report if suitable for the intended purpose and sufficiently up-to-date.

On the one hand, the environmental report describes and assesses the current state of the environment and presents the likely development if the plan is not implemented. It also forecasts and assesses the likely significant environmental effects of implementing the plan.

The basis for assessing potential impacts is a detailed description and assessment of the state of the environment. The description and assessment of the current state of the environment and the likely development in the event of non-implementation of the plan will be carried out with regard to the following factors

- Area/Soil
- Water
- Plankton
- Biotopes
- Benthos
- Fish
- Marine mammals
- Avifauna
- Bats
- Biodiversity
- Air
- Climate
- Landscape
- Cultural heritage and other material assets
- Humans, especially human health
- Interrelationships between factors.

1.6.1 Overview of data source

The data and knowledge situation has improved significantly in recent years, in particular as a result of the extensive data collection in the context of environmental impact studies and construction and operational monitoring for the offshore wind farm projects and accompanying ecological research.

This information also forms an essential basis for the monitoring of the 2009 Spatial Plans under section 45 subsection 4 of the UVPG. Accordingly, the results of monitoring are to be made available to the public and taken into account when the plan is reinstated. The results of plan-associated monitoring of the current plans are summarised in the status report on the update of spatial planning in the German North Sea and Baltic Sea EEZ, which is published in parallel (Chapter 2.5).

In general terms, the following data sources are used for the environmental report:

- Data and findings from the operation of offshore wind farms
- Data and findings from approval procedures for offshore wind farms, submarine cable systems and pipelines
- Results of the site investigation
- Results of the monitoring of Natura 2000 sites
- Mapping instructions for section 30 biotopes
- Initial and progress assessment of the MFSD
- Findings and results from R&D projects commissioned by BfN and/or BSH and from accompanying ecological research
- Results from EU cooperation projects, such as Pan Baltic Scope and SEANSE
- Studies/ Technical literature
- Current red lists
- Opinions of the technical authorities
- Opinions of from the (professional) community

A detailed overview of the individual data and knowledge bases has been included in the annex
to the summary consideration.

1.6.2 Indications of difficulties in compiling the documents

According to No. 3a Annex 1 to section 8 subsection 1 of the ROG, indications of difficulties encountered in compiling the information, such as technical gaps or lack of knowledge, must be presented. There are still gaps in knowledge in some places, particularly with regard to the following points:

- Long-term effects from the operation of offshore wind farms
- Effects of shipping on individual factors
- Effects of research activities
- Data for assessing the state of the environment of the various protected areas in the outer EEZ.

In principle, forecasts on the development of the living marine environment after the ROP has been carried out remain subject to certain uncertainties. There is often a lack of long-term data series or analytical methods, e.g. for combining extensive information on biotic and abiotic factors, in order to better understand complex interrelationships of the marine ecosystem.

In particular, there is a lack of detailed area-wide sediment and biotope mapping outside the nature reserves of the EEZ. As a result, a scientific basis on which to assess the effects of the possible use of strictly protected biotope structures is lacking. At present, sediment and biotope mapping is being carried out on behalf of the BfN and in cooperation with the BSH, research and higher education institutions and an environmental office, with a spatial focus on the nature conservation areas.

In addition, for some factors there is a lack of scientific assessment criteria, both with regard to the assessment of their status and with regard to the impacts of anthropogenic activities on the development of the living marine environment, in order to fundamentally consider cumulative effects over time and space.

Various R&D studies are currently being carried out on behalf of the BSH on assessment approaches, including those for underwater noise. The projects serve the continuous further development of a uniform, quality-assured basis of marine environmental information for assessing the potential impacts of offshore installations.

The environmental report will also list specific information gaps or difficulties in compiling the documents for the individual factors.

1.7 Application of the ecosystem approach

The application of the ecosystem approach contributes to the achievement of "sustainable spatial development that reconciles the social and economic demands on the spatial environment with its ecological functions and leads to a sustainable, balanced order over a large area" (section 1 subsection 2 of the ROG). The application of the ecosystem approach is a requirement under section 2 subsection 3 no. 6 p. 9 of the ROG with the aim of controlling human activities, sustainable development and supporting sustainable growth
(cf. section 5 subsection 1 of the MSPD in conjunction with section 1 subsection 3 of the Marine Strategy Framework Directive).

Recital 14 of the MSPD specifies that spatial planning should be based on an ecosystem approach in accordance with the MSFD. It is also clear here - as in Preamble 8 of the MSFD - that sustainable development and use of the seas should be compatible with a good state of the environment.

According to Art. 5 para. 1 of the Maritime Spatial Planning Directive, Member States "shall take into account economic, social and environmental aspects in the preparation and implementation of maritime spatial planning in order to support sustainable development and growth in the maritime domain, applying an ecosystem approach, and to promote the coexistence of relevant activities and uses. “

Art. 1 para. 3 of the MSFD specifies that "Marine strategies shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations. “

The ecosystem approach allows a holistic view of the marine environment, recognising that humans are an integral part of the natural system. Natural ecosystems and their services are considered together with the interrelationships resulting from their use. The approach is to manage ecosystems within the "limits of their functional capacity" in order to safeguard them for use by future generations. In addition, understanding ecosystems enables effective and sustainable use of resources.

Comprehensive understanding, protection and improvement of the marine environment and an effective and sustainable use of resources within the limits of sustainability will safeguard marine ecosystems for future generations. The ecosystem approach can therefore contribute - at least in part - to good environmental status in the marine environment.

Based on the so-called twelve Malawi principles of the Biodiversity Convention, the ecosystem approach has also been concretised by the HELCOM-VASAB working group on maritime spatial planning and specified for marine spatial planning (HELCOM/VASAB, 2016). The key elements formulated there represent a suitable approach for structuring the application of the ecosystem approach in the Spatial Plan for the German EEZ.

The combination of content-related and process-oriented key elements is intended to promote an overall picture that is as comprehensive as possible:

- Best available knowledge and practice;
- Precautions;
- Alternative development;
- Identification of ecosystem services;
- Prevention and mitigation;
- Relational understanding;
- Participation and communication;
- Subsidiarity and coherence;
- Adaptation.

The application of the ecosystem approach aims at a holistic perspective, the continuous development of knowledge about the oceans and their use, the application of the precautionary principle and flexible, adaptive management or planning. One of the greatest challenges is dealing with gaps in knowledge. Understanding the cumulative effects that the combination of different activities can have on species and habitats is of great importance for sustainable use. It is important for the planning process to promote communication and participation processes in order to use the broadest possible knowledge base of all stakeholders and to achieve the greatest possible acceptance of the plan.

Figure 11 shows how the application of the ecosystem approach is understood. The approach is applied equally in the planning process, the ROP and in the Strategic Environmental Assessment (SEA). The SEA has proven to be the central instrument for applying the ecosystem approach (Altvater, 2019) and offers versatile points of reference in the content- and process-oriented key elements (see below).

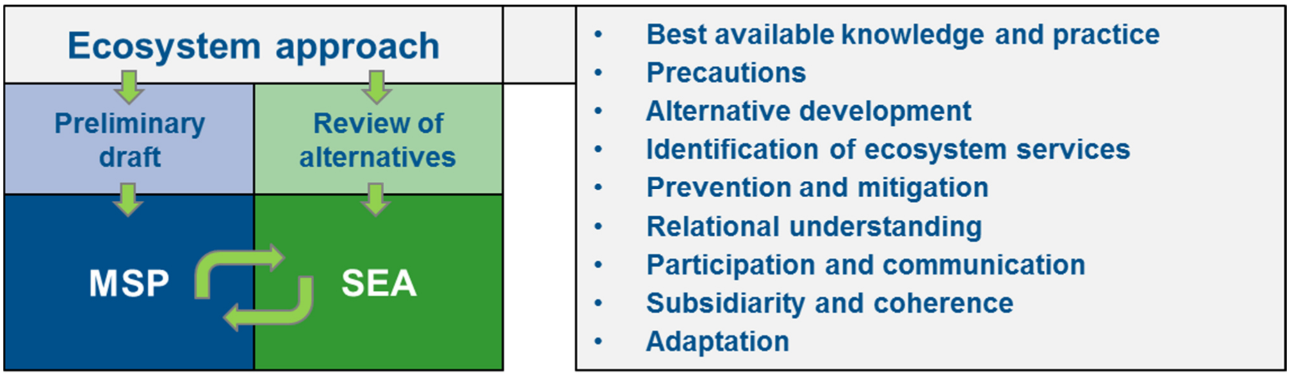


Figure 11: The ecosystem approach as a structuring concept in the planning process, the ROP and the Strategic Environmental Assessment

The ecosystem approach is anchored in the mission statement as the basis of the Spatial Plan. Its importance is also explicitly emphasised in the following principles:

- General requirements for economic uses, Principles Best Environmental Practice (8.1) and Monitoring (8.2)
- Principle of nature conservation Preservation of the EEZ as a natural area (5)

The graphic and textual rules on marine nature conservation make a fundamental contribution to the protection and improvement of the state of the marine environment (see ROP model). In addition, the ROP's rules promote the resilience of the marine environment to the impacts of economic uses and to the changes caused by climate change.

A quantification of the sustainability of the ecosystem cannot be conclusively considered due to a lack of data and knowledge. This represents a task for the future development of the ecosystem approach. Even if quantification is not possible at present, SEA and cumulative consideration must ensure that the ROP and the rules of economic uses contained therein do not exceed the limits of ecosystem functioning.

The assessment of the likely significant environmental impacts of the implementation of the Spatial Plan is methodologically described in Chapter 4. The ecosystem approach does not itself constitute an assessment, but does cover a large number of important aspects and instruments for sustainable spatial development. Of these, the SEA serves comprehensively to identify, describe and assess the impacts on the marine environment.

Application of the key elements

The ecosystem approach is highly complex due to its diversity and the comprehensive view of the relationship between the marine environment and economic uses. The key elements also interact with each other, underlining the interconnectedness and holistic perspective. Figure 12 shows the abstract form the relationships between the key elements. This approach becomes tangible and applicable when viewed at the level of the individual key elements, in particular those of the HELCOM/VASAB Directive (2016).

The application in the Spatial Plan for the German EEZ is based on the understanding that this approach needs to be continuously developed. Existing gaps in knowledge and the need for conceptual broadening result in the need to consider the ecosystem approach as a permanent task of further development.

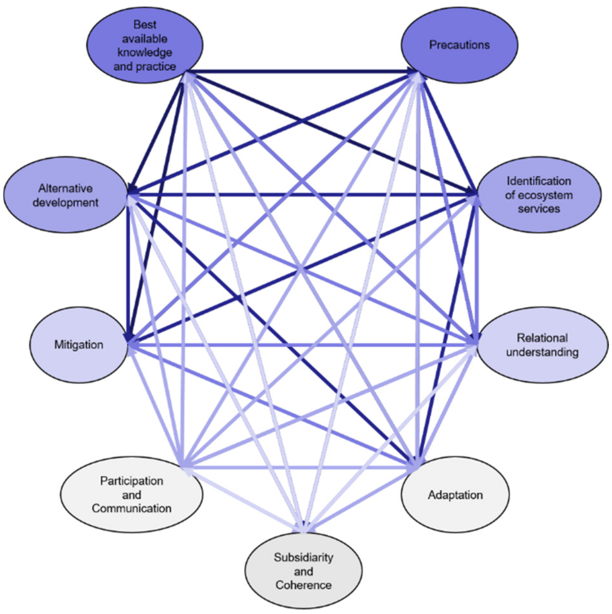


Figure 12: Networking between the key elements.

Best available knowledge and practice

"The allocation and development of human uses will be based on the most recent knowledge of ecosystems as such and the practice of the best possible protection of the components of the marine ecosystem" (HELCOM/VASAB, 2016).

The use of the current (sound) state of knowledge is fundamentally indispensable for planning processes and forms the basis of the planning understanding of the updating of the Spatial Plan. This key element thus also affects the other elements mentioned, such as the precautionary principle, the avoidance and reduction of impacts and the understanding of interrelationships.

As part of the update process, the knowledge base is supplemented by the sector-specific expertise of the stakeholders through an early and comprehensive participation process. Thematic workshops and technical discussions with various stakeholders were held even before the concept for the update was developed.

The Scientific Advisory Board (WiBeK) for the continuation of maritime spatial planning in the North Sea and Baltic Sea EEZ advises from a scientific perspective, among other things, on questions of content, the procedure and the participation process.

Results from projects and findings on procedures for plan preparation in neighbouring countries within the framework of international cooperation are taken into account for the process of plan preparation. In addition to improving the level of knowledge, this contributes to the key element of "subsidiarity and coherence".

In-house research and development, such as databases and other tools, are developed, validated and applied at the BSH for a wide range of uses, e.g. MARLIN and MarineEARS. These can support the planning process and the subsequent plan monitoring with well-founded information and make an important contribution to the continuous improvement of the state of knowledge.

The following stipulations of the spatial development plan promote the use of the current state of knowledge in economic uses as a basic guideline:

- General requirements for economic uses Principle of best environmental practice (8.1);
- Shipping, principle of protection of the marine environment (3);
- Offshore wind energy, principle of protection of the marine environment (6.1);
- Marine research, principle of protection of the marine environment (5).

The SEA is based on very detailed and comprehensive data on all relevant biological and physical aspects and conditions of the marine environment, in particular from EIA studies and monitoring of offshore wind farm projects according to StUK, scientific research activities and from national and international monitoring programmes.

Precautions

"Far-sighted, anticipatory and preventive planning should promote sustainable use in marine areas and eliminate risks and hazards of human activities to the marine ecosystem. Those activities which, on the basis of current scientific knowledge, may have significant or irreversible impacts on the marine ecosystem and the effects of which, in whole or in part, may not be sufficiently foreseeable at present, require special careful consideration and risk weighting". (HELCOM/VASAB, 2016).

The precautionary principle has a high priority in spatial planning, particularly because of the complexity of marine ecosystems, far-reaching chains of effects and existing gaps in knowledge. This is already emphasised in the ROP's mission statement.

The rules of the Spatial Plan make it clear that the precautionary principle is taken into account as a fundamental requirement in the case of economic uses (Principle 5, Nature conservation / marine landscape / open space) and for the following uses:

- Shipping, shipping priority areas objective (1);
- General requirements for economic uses Decommissioning objective (3), principle of land conservation (2) and best environmental practice (8.1);
- Lines, Marine environment principle (8);
- Fisheries and marine aquaculture Sustainable management principle (2);
- Nature conservation principle Preservation of the EEZ as a natural area (5).

In the SEA, the significance of the impacts of the ROP's rules on uses on the factors is examined (Chapter 4).

Alternative development

"Reasonable alternatives should be developed to find solutions to avoid or reduce negative impacts on the environment and other areas, as well as on ecosystem goods and services". (HELCOM/VASAB, 2016).

The consideration of alternatives was given a high priority in the process of updating the Spatial Plans and was integrated into the contribution at an early stage.

In the conception for the further development of the Spatial Plans (BSH, 2020) three planning options were developed as overall spatial planning alternatives, which represent the utilisation requirements of the different sectors from different perspectives:

- Planning option A: Perspective on traditional uses
- Planning option B: Climate protection perspective
- Planning option C: Marine nature conservation perspective

The alternatives presented as planning options are integrated approaches which take into account spatial and content-related dependencies and interrelationships over a large area.

The early and comprehensive consideration of several planning options represents an essential planning and review step in updating the Spatial Plans.

A preliminary assessment of selected environmental aspects was carried out before this environmental report was prepared. The preliminary assessment of selected environmental aspects in the sense of an early examination of variants and alternatives should support the comparison of the three planning options from an environmental point of view.

The design and preliminary assessment of selected environmental aspects were consulted, so that the knowledge and assessments of the stakeholders involved were included in the planning process.

An alternative assessment is carried out in the SEA (cf. Chapter 9). The focus is on the conceptual/strategic design of the plan, and in particular on spatial alternatives.

Identification of ecosystem services

"To ensure a socio-economic assessment of impacts and potentials, the ecosystem services provided must be identified". (HELCOM/VASAB, 2016).

The identification of ecosystem services is an important step for the further development of the Spatial Plan and the ecosystem approach in maritime spatial planning. Ecosystem services can contribute to a broader understanding and illustrate the multiple functions that ecosystems can provide. Particularly noteworthy are their function as natural carbon sinks and other contributions to climate protection and adaptation. This need should be taken into account in future updates of the Spatial Plan and the development of the necessary tools should be continued.

With the MARLIN (Marine Life Investigator) specialist application, BSH is currently developing a large-scale, high-resolution information network on marine ecological data from environmental investigations within the framework of environmental impact studies, site investigations and monitoring of offshore wind farm projects. Various data analyses at different spatial and temporal levels are possible in order to support the tasks of the BSH in line with requirements. MARLIN also combines the integrated marine ecological data with various environmental data to support the understanding of the impacts and interrelationships of marine ecosystem services.

In the future, MARLIN will serve as a validated basis for ecosystem modelling to better assess the impact of cumulative effects. For example, in future it will be possible to consider all offshore wind farm processes and to carry out large-scale studies. Building on this, it may then be possible to identify ecosystem services. MARLIN's holistic approach enables new approaches to the analysis and modelling of ecological patterns and processes and creates a platform for the development and application of advanced tools for marine management and regulation.

Prevention and mitigation

"The measures are intended to prevent, reduce and as fully as possible offset any significant negative environmental impact [of the implementation of the plan]. (HELCOM/VASAB, 2016).

The ROP's mission statement defines the contribution to the protection and improvement of the state of the marine environment by also specifying how to avoid or reduce disturbances and pollution from uses.

The rules of the Spatial Plan illustrate this consideration with measures to avoid and reduce negative impacts of individual uses:

- Shipping, principle of protection of the marine environment (3);
- General requirements for economic uses Principle of best environmental practice (8.1);
- Offshore wind energy, principle of protection of the marine environment (6.1);
- Management, principle of crossing avoidance (5) and marine environment (8);

- Raw material extraction, principle of divers (3);
- Nature conservation, principle of conservation area for divers (2) and conservation area for harbour porpoise (3).

In the SEA, measures to avoid, reduce and offset significant negative impacts of the implementation of the Spatial Plan are presented in detail in Chapter 8.

Relational understanding

"There is a need to consider various impacts on the ecosystem caused by human activities and interrelationships between human activities and the ecosystem and between different human activities. These include direct/indirect, cumulative, short-/long-term, permanent/ temporary and positive/negative effects and interrelationships, including sea/land interrelationships". (HELCOM/VASAB, 2016).

The understanding of interrelations and interdependencies is of great importance for the tasks of spatial planning and the planning process. In this sense, the mission statement of the ROP emphasises the holistic approach and includes the consideration of land-sea relations.

In the Strategic Environmental Assessment, this is taken up and examined in Chapters 4.8 Interrelationships and 4.9 Cumulative consideration.

For technical support, the BSH is currently developing the MARLIN (Marine Life Investigator) specialist application as a large-scale, high-resolution information network for marine ecological data from environmental investigations within the framework of environmental impact studies, site investigations and monitoring of offshore wind farm projects. Various data analyses at different spatial and temporal levels are possible in order to support the tasks of the BSH as required. MARLIN also combines integrated marine ecological data with various environmental data. MARLIN's holistic approach enables new directions for the analysis and modelling of ecological patterns and processes and creates a platform for the development and application of advanced tools for marine management and regulation. This will support the understanding of impacts and interrelationships.

Further experience, e.g. on cumulative consideration, has been gained in European cooperation projects (Pan Baltic Scope, SEANSE) and will be incorporated into the further conceptual development, as will findings from the participation process.

An overview of the project results can be found on the respective pages:

- http://www.panbalticscope.eu/results/reports/
- https://northseaportal.eu/downloads/

Participation and communication

"All relevant authorities and stakeholders as well as a wider public should be involved in the planning process at an early stage. The results are to be communicated. " (HELCOM/VASAB, 2016).

This key element is an example of the networking and relationships between the key elements. The knowledge gained can contribute to all other key elements.

As part of the update process, participation and communication have been carried out intensively right from the start. Early and comprehensive participation therefore contributes significantly to broadening the knowledge base through the sector-specific expertise of stakeholders and evaluations received.

The basis for this was the development of a participation and communication concept. In the course of the update, topic-specific workshops and technical discussions were held with representatives at the sectoral level. On 18 and 19 March 2020, the concept and draft of the study framework were consulted in the participation meeting (scoping).

Interim results and information on stakeholder meetings are communicated on the BSH's blog "Offshore aktuell" (wp.bsh.de).

Additional support for the process is provided by the Scientific Advisory Board (WiBeK). The WiBeK for the continuation of maritime spatial planning in the Exclusive Economic Zone in the North and Baltic Seas has been advising from a scientific perspective since 2018, among other things, on questions of content, the course of the procedure and the participation process.

Subsidiarity and coherence

"Maritime spatial planning, with an ecosystem approach as the overarching principle, will be carried out at the most appropriate level and will seek coherence between the different levels (HELCOM/VASAB, 2016).

Spatial planning aims to produce coherent plans in the North and Baltic Seas through coordination with coastal countries and partners from neighbouring countries. Many years of bilateral exchange, participation in the HELCOM and VASAB working group on maritime spatial planning and cooperation in international projects on maritime spatial planning contribute to this.

Project results and findings on procedures for plan preparation in neighbouring countries within the framework of international cooperation are taken into account for the process of plan preparation. The international consultation procedures represent a further contribution.

The ROP's mission statement sets forth this cooperation as a contribution to coherent international marine spatial planning and coordinated planning with coastal countries.

At the level of definitions, Principles 3 and 4 for pipelines emphasise this sectoral coordination requirement for the planning of transboundary linear structures.

In the context of SEA, the transboundary effects on the adjacent areas of the neighbouring states are considered (Section 4.10).

Adaptation

"Sustainable use of the ecosystem should be an iterative process involving monitoring, review and evaluation of both the process and the outcome". (HELCOM/VASAB, 2016).

Monitoring and evaluation within the framework of spatial planning for the German EEZ take place at various levels.

The first step will be to evaluate the plan and its implementation. A monitoring and evaluation concept will be developed for this purpose.

In addition, the SEA lists in Chapter 10 the planned measures for monitoring the effects of the implementation of the Spatial Plan on the environment.

The effects of economic uses on the marine environment are to be investigated and evaluated at the project level by means of effect monitoring. This is laid down in Principle 8.2 of the General Requirements for Economic Uses in the ROP.

Summary

In sum and beyond, the key elements and their implementation in the planning process, the ROP and the SEA show how the ecosystem approach as an overall concept supports the holistic perspective of spatial planning and thus contributes to the protection and improvement of the state of the marine environment.

1.8 Taking climate change into account

Anthropogenic climate change as one of the greatest challenges facing society is of particular importance for changes in the oceans and their use. Figure 13 illustrates the links between climate change, the marine ecosystem, uses and maritime spatial planning, including as a tool for achieving sustainable development goals.

In changing seas, the consideration and integration of climate impacts in maritime spatial planning (MSP) is of great importance in order to do justice to the precautionary and forward-looking nature of MSP and to develop long-term sustainable plans.

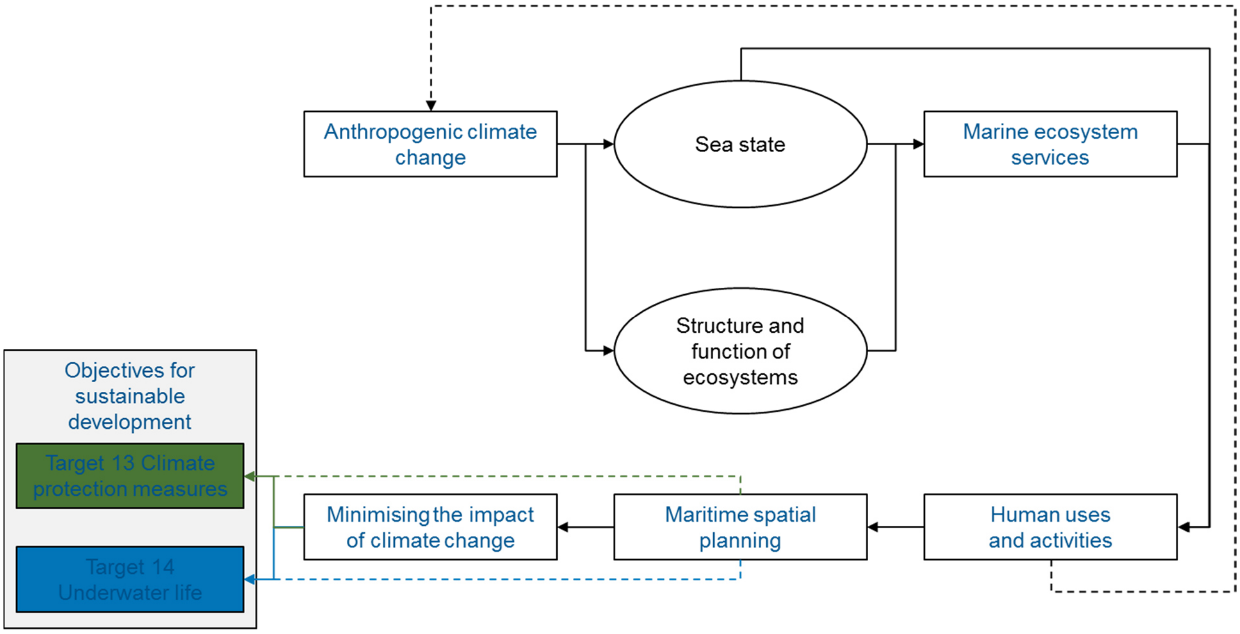


Figure 13: Representation of the interrelationships between climate change, marine ecosystems and maritime spatial planning, according to (Frazão Santos, 2020)

Climate change will alter the physical, chemical and biological conditions in the North and Baltic Seas. This will inevitably have an impact on marine ecosystems, their structure and functions, which may also change ecosystem services. The changes may also have a direct impact on the uses to which they are put, e.g. shipping, renewable energy or extraction of raw materials (Frazão Santos, 2020).

The following table shows projections for some relevant parameters.

Table 4: Climate projections for selected parameters [1] (UBA, in preparation), [2] (IPCC, 2019), [3] (Pity N, in preparation)

	North Sea	**Baltic Sea**
Increase in mean sea surface temperature for 2031-2060 (in the 50th percentile of the RCP8.5 scenario compared to 1971-2000)[1]	1 – 1.5 °C	1.5 – 2 °C
Increase in mean sea surface temperature for 2071-2100 (in the 50th percentile of the RCP8.5 scenario compared to 1971-2000)[1]	2.5 – 3 °C	2.5 – 3.5 °C
Global sea level rise 2100 (RCP8.5 scenario vs. 1986-2005)[2]	61 – 110 cm	61 – 110 cm
Increase in extreme wind speeds (RCP8.5 scenario compared to 1971-2000)[3]	0 - 0.5 m/s	No significant increases for the most part

As a contribution to climate protection, the rules on offshore wind energy should be mentioned at the outset. Assuming that the current CO_2 avoidance factor of electricity from offshore wind energy is continued (UBA, 2019) to 2040, this results in an average annual CO_2 avoidance potential of 62.9 Mt CO_2 equivalents per year for the period between 2020 and 2040. By way of comparison, the annual emissions from power plants in the energy industry in 2016 were 294.5 Mt CO_2 equivalents per year (BMU, 2019). Table 5: Calculation of the CO2 avoidance potential of the rules on offshore wind energy. shows the abatement potential for the years 2020, 2040 and the annual average for the entire period.

Table 5: Calculation of the CO_2 avoidance potential of the rules on offshore wind energy.

	Installed capacity	Full load hours	Annual electricity production	CO_2 avoidance factor	CO_2 avoidance
	GW	h/a	GWh/a	g CO2eq/kWh	Mt CO2eq/a
2020	7.2	3800	27360	701	19.2
2040	40	3800	152000	701	106.6
Average annual CO_2 avoidance					62.9

Furthermore, keeping open the priority areas of nature conservation and the potential of ecosystems as natural carbon sinks contribute to climate protection. The designation of priority and reservation areas of nature conservation can also serve to strengthen the resilience of ecosystems and thus support the precautionary principle.

The mission statement shows that the use of climate-friendly technologies in the ocean supports energy security and the achievement of national and international climate targets.

The development of risk and vulnerability analyses to climate change and adaptation measures in the relevant sectors should be communicated to spatial planning. The holistic perspective of spatial planning can help to coordinate the compatibility of measures with other uses and marine nature conservation and to avoid conflicts.

To promote this, a dialogue could be initiated to ensure that a joint discussion takes place in a spatial planning forum with stakeholders from the sectors.

In order to fully integrate climate change into MSP, institutional strengthening, including international cooperation in the North and Baltic Seas, is necessary. Projects in particular offer the opportunity to develop coherent approaches with neighbouring countries or to use joint data pools, for example.

One focus should be on the conceptual development of marine ecosystem services and, above all, the potential of natural carbon sinks.

2 Description and assessment of the state of the environment

In accordance with Section 8 of the Spatial Planning Act (Raumordnungsgesetz, ROG) along with Annexes 1 and 2 to Section 8 of the Spatial Planning Act, the environmental report contains a description of the characteristics of the environment and the current state of the environment in the strategic environmental assessment (SEA) investigation area. The description of the current state of the environment is necessary in order to be able to forecast expected changes once the plan is implemented. The review concerns the factors listed in Section 8 Subsection 1 of the Spatial Planning Act, and interactions between them. The presentation is problem-oriented. The focus is therefore on possible legacy impacts, elements of the environment requiring special protection, and on those factors which will be more strongly affected by the implementation of the plan. In spatial terms, the description of the environment is based on the respective environmental impacts of the plan. Depending on the type of influence and the factor concerned, these impacts vary in extent and may extend beyond the boundaries of the plan.

2.1 Seabed/Area

2.1.1 Area as a factor

Seabed and area are considered together as factors. Where useful or necessary, area as a factor is dealt with in more detail.

2.1.2 Data availabilty

The map on sediment distribution in the western Baltic Sea (BSH/IOW, 2012) is one of the most important sources for the description of surface sediments in the German Baltic Sea EEZ. It is based on interpolation of data from surveys at selected points. In order to obtain more precise information, in particular on the location and distribution of coarse sand, fine gravel, and residual sediments (including gravel, stones and boulders), the sediment in the area has been gradually mapped over recent years using hydroacoustic methods. The resulting detailed maps and illustrations of the type and extent of seabed topography, as well as of small-scale changes to topography and sediment at the seabed surface, are not given by the BSH/IOW map on sediment distribution (BSH / IOW, 2012), due to the point-based nature of the data. In particular, the distribution of coarse sediments (gravel and stony residual sediment) appears to be greater than that shown on the BSH/IOW map (BSH / IOW, 2012). The same applies to the distribution of stones and boulders.

These sediment distribution maps are not yet available for the entire Baltic Sea EEZ. All results are available for the Fehmarnbelt conservation area, and the Kadetrinne conservation area is largely complete. The results of the exploratory surveys in the Arkona Sea and the Pommersche Bucht - Rönnebank area of conservation are not yet available for the entire area. Further information comes from data and reports from site investigations and from investigations by the BSH itself.

The description of the near-surface seabed structure is mostly based on boreholes, cone penetration tests, and reports from site investigations, as well as the literature, investigations and evaluations by the BSH.

The data and information used to describe the distribution of pollutants in the sediment, suspended particulate matter and turbidity, as well as nutrient and pollutant distributions were collected during the annual monitoring expeditions by the BSH in cooperation with the Leibniz Institute for Baltic Sea Research (IOW).

2.1.3 Geomorphology and sedimentology

The Baltic Sea is an arm of the Atlantic Ocean and is connected to the North Sea via the Great Belt, the Little Belt and the Øresund. The planning area under consideration is the German Baltic Sea EEZ.

The late glacial and post-glacial development of the Baltic Sea is linked to global sea-level rise and land uplift as a result of rebound of the earth's crust, and may be divided into four major stages:

- Baltic Ice Lake (up to 10,200 ago),
- Yoldia Sea (10,200–9,300 years ago),
- Ancylus Lake (9,300–8,000 years ago) and
- Littorina Sea (8,000 years ago–present day).

The seabed topography is distinguished by its characteristic basin and sill structure. This sequence of basins and sills is illustrated by Figure 14 on bathymetry in the German Baltic Sea (below). It serves as a basis for the structure of the geomorphological and sedimentological description in this environmental report.

In light of the basin and sill division of the Baltic Sea, eight sub-areas were defined using geological, geomorphological and oceanographic criteria:

- Bay of Kiel
- Fehmarn Belt
- Bay of Mecklenburg
- Darss Sill
- Arkona Basin
- Kriegers Flak
- Adlergrund
- Oder Bank.

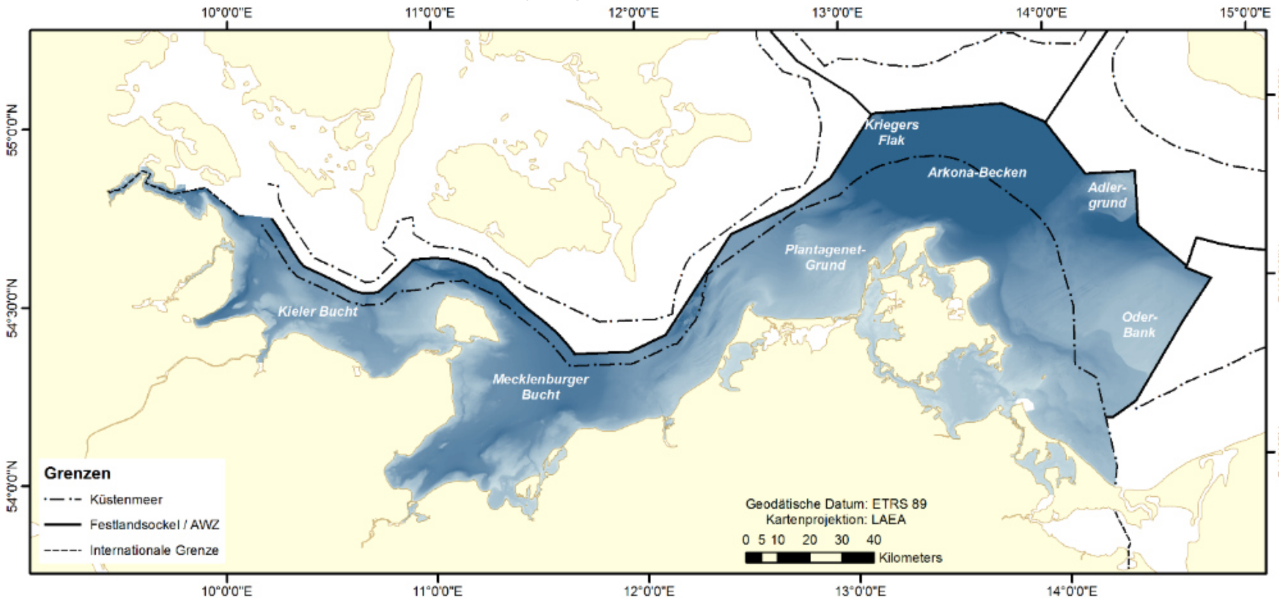


Figure 14: Representation of the seabed bathymetry (Bathymetry, BSH/IOW, 2012) in the German Baltic Sea. The Bay of Kiel and the Bay of Mecklenburg together form the Belt Sea. The dark blue areas indicate basins (e.g. Bay of Mecklenburg or Arkona Basin), the shallower areas are correspondingly lighter shades of blue (e.g. Plantagenetgrund, Adlergrund or Oder Bank).

Bay of Kiel The Bay of Kiel forms the western part of the Belt Sea. It lies in the western Baltic Sea at the southern end of the Little and the Great Belt. The Fehmarn Belt and Fehmarn Sound form the eastern boundary. The Bay of Kiel is a typical Förde coast, whose narrow, deeply incised bays were formed by erosive activity during the Weichselian glaciation.

Water depths range from 5 m on the Stoller Grund to over 35 m in the Vinds Grav channel near Fehmarn. Average water depths are between 15 m and 20 m. Several shoals represent remnants of a former land surface, which now protrude from the surrounding seabed as "drowned" terminal moraine remnants. In the northern part of the Bay of Kiel, there is a system of channels running from west to east, consisting of the Vejsnæs Channel south of the Danish island of Ærø, which has its eastern continuation in Vinds Grav at the western end of the Fehmarn Belt via several smaller channels. The maximum water depths are over 30 m in the Vejsnæs Channel and up to 42 m in Vinds Grav.

Figure 15 shows the sediment distribution on the seabed in the Bay of Kiel. Residual sediment deposits (coarse sand, gravel and stone deposits) are mainly found in a narrow strip along large parts of the coast of Schleswig-Holstein, on shoals in the Bay of Kiel and west of Fehmarn. Mud deposits (mostly silt, but also clays) are mainly found in the deeper areas of the western Bay of Kiel (Eckernförde Bay, Flensburg Firth and the deeper areas of the EEZ). In the central part of the Bay of Kiel, fine and medium sands dominate, which transition to silty sands and silts in the depression west of Fehmarn.

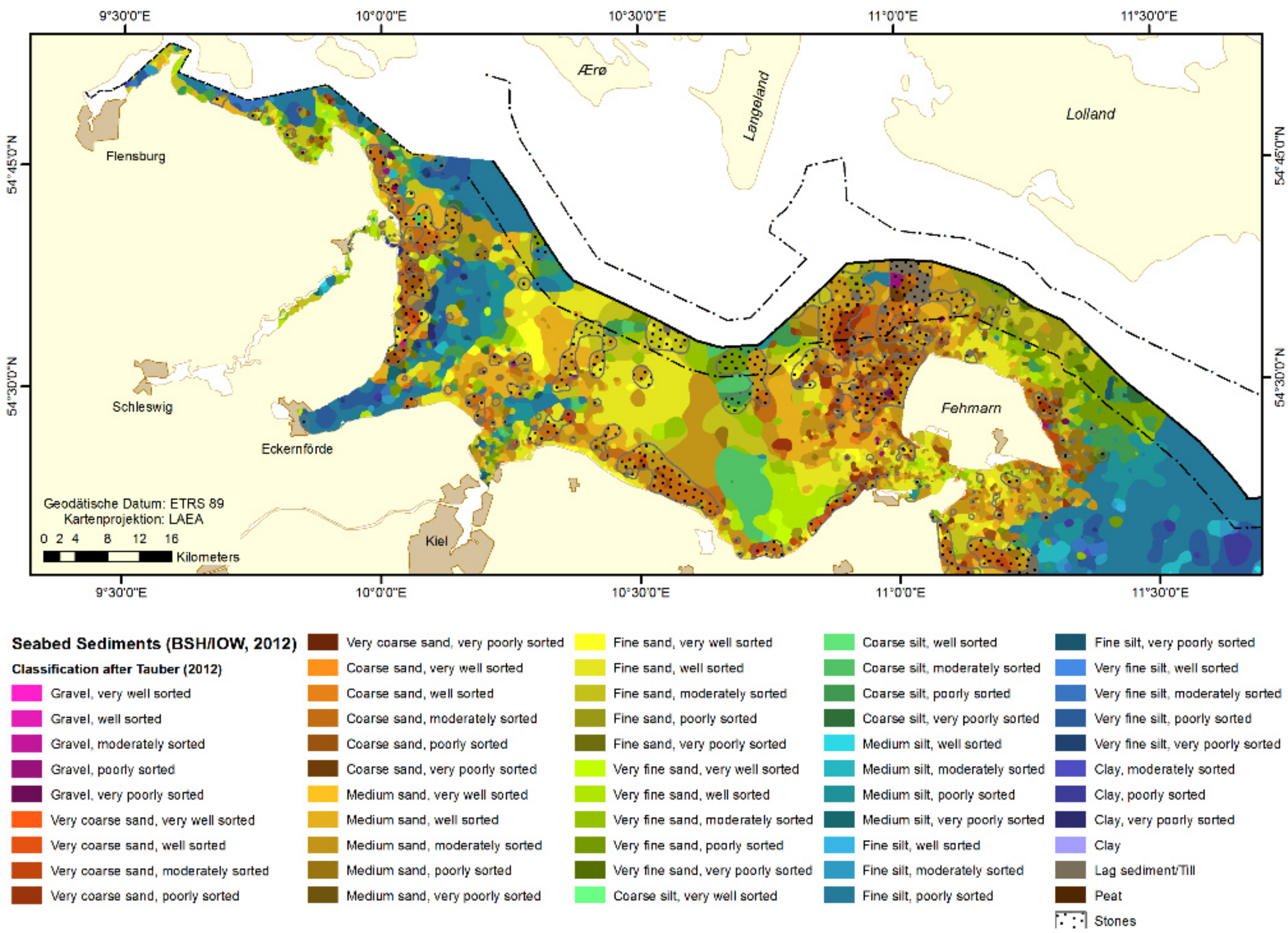


Figure 15: Sediment distribution on the seabed in the area of the Bay of Kiel (BSH / IOW, 2012).

It is relevant for the geological structure of the upper seabed that the Bay of Kiel was only flooded by the Baltic Sea in the course of the Littorina Transgression about 8,000 years ago. According to ATZLER (Atzler, 1995), the Holocene sedimentary cover consists of late glacial sands and varved clays in addition to the sedimentary distribution already described. While the sands occur exclusively in the outer area of the Firth of Kiel, the varved clays were deposited in old channel systems distributed over the entire Bay of Kiel. The Holocene sediments lie on a Weichselian till, 4–5 m thick, which consists of a newer and an older unit and reaches a maximum thickness of 70 m in the Kossauer Channel (west of Fehmarn). Locally, Weichselian glaciofluvial sands are intercalated in the boulder clay, which can carry numerous stones and boulders.

In large parts of the Bay of Kiel, Saalian till and glaciofluvial sands follow under the Weichselian deposits, which in turn are usually located on older glacial or Tertiary clays and sands. Several large Pleistocene channel systems occur in this sea area. Although they are largely filled in today, some of them are still preserved as slight depressions in the sea floor and correlate with the recent distribution of silt.

Fehmarn Belt

The 18–24 km wide Fehmarn Belt plays a central role in the water exchange between the Belts and the Baltic Sea basins to the east. The exchange between North Sea and Baltic Sea water takes place mainly via the Great Belt–Fehmarn Belt system.

The average water depths in this strait are between 15 m and 25 m. At the western entrance, the former push moraine of the Öjet rises to a water depth of 10 m. It narrows the cross section of the Fehmarn Belt in such a way that the resulting high current velocities have further cleared Vinds Grav (formed when Lake Ancylus overflowed) to a depth of 42 m.

As a result of the hydrodynamic conditions in the western part of the Fehmarn Belt, several giant ripple fields have developed in the western Fehmarn Belt. These giant ripple fields can be seen in Figure 16 as elongated sandy structures running from SW to NE, deposited on coarse to residual sediments. The giant ripple fields occur at a water depth of 11–18 m and consist mainly of medium sand. They have ridge heights of up to 2 m and wave spacings of 60–70 m. Smaller structures with a spacing of 25 m can be found in water depths of 24 m.

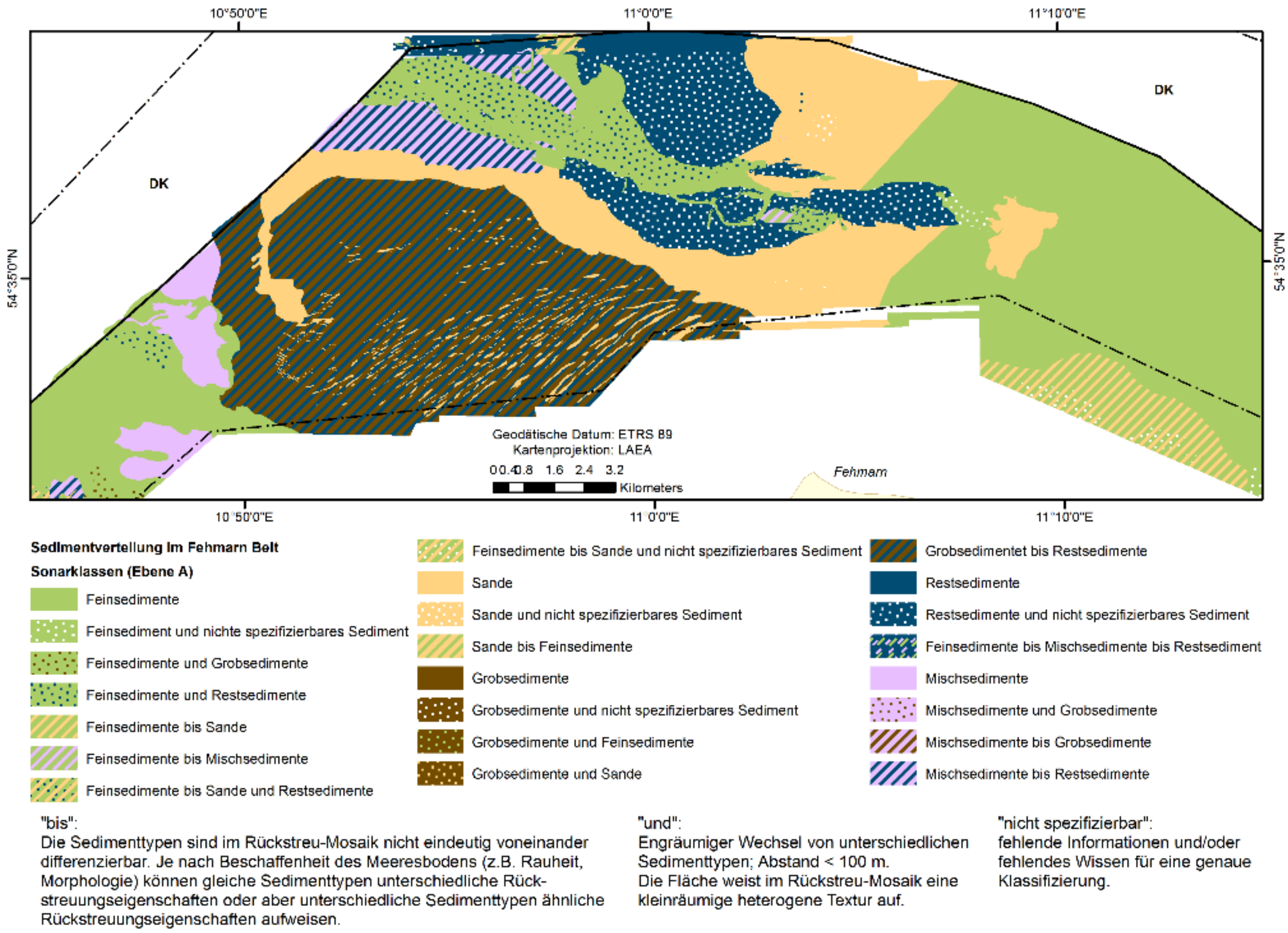


Figure 16: Sediment distribution on the seabed in the western part of the Fehmarn Belt. The sediment distribution map is based on side scan sonar recordings. The sediment classification of level A is based on the simplified ternary system for clastic sediment types described by Folk (1954). Source: Project "Sediment mapping EEZ"; Höft, D., Feldens, A., Tauber, F., Schwarzer, K., Valerius, J., Thiesen, M., Mulckau, A. (in prep.): Map of sediment distribution in the German EEZ (1:10,000), Federal Maritime and Hydrographic Agency; Papenmeier, S., Valerius, J., Thiesen, M., Mulckau, A. (in prep.): Map of sediment distribution in the German EEZ (1:10,000). Federal Maritime and Hydrographic Agency.

The giant ripples lie on a continuous layer of residual sediments consisting mainly of stones at varying densities (Figure 17).

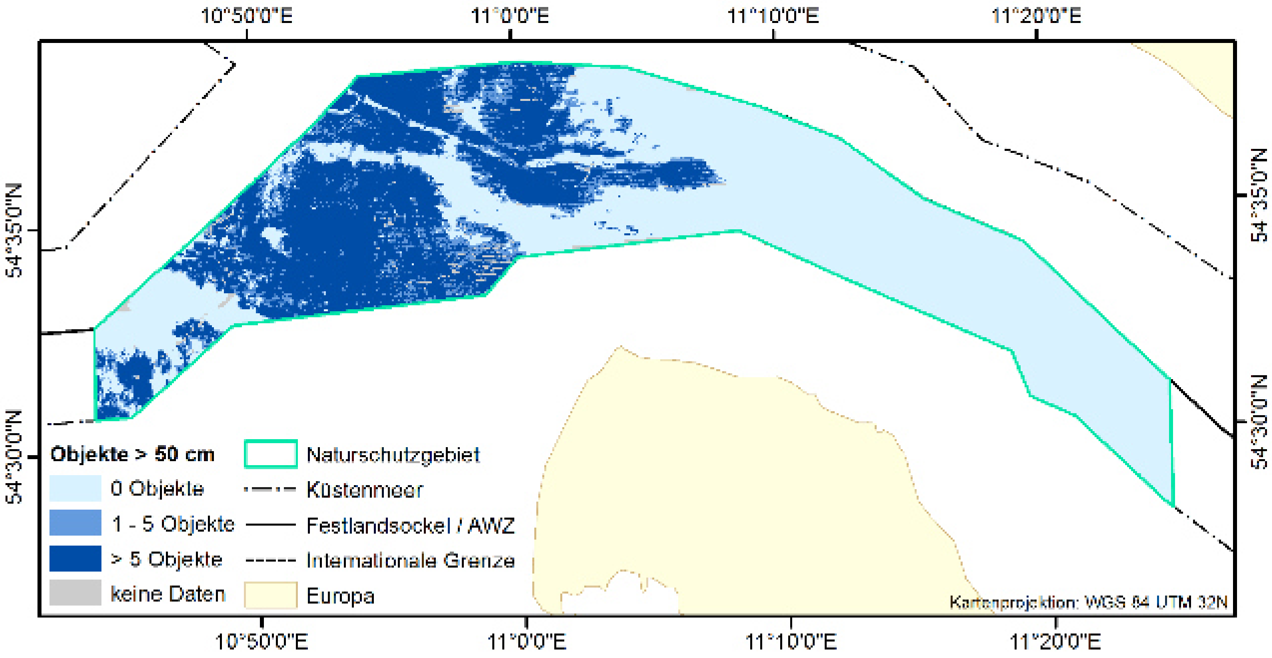


Figure 17: Representation of the layer density of objects (stones or boulders above a size of about 50 cm) in the area of the Fehmarn Belt nature conservation area. The basis of the representation is the 100x100 m EU grid, which was divided into 50x50 m grid cells. Shown is the number of objects per 50x50 m grid cell. Source: Project "Sediment Mapping EEZ"; Höft, D., Richter, P., Valerius, J., Schwarzer, K. Meier, F., Thiesen, M., Mulckau, A. (in prep.): Map of boulder distribution in the German EEZ, Federal Maritime and Hydrographic Agency.

Occasionally there may also be till on the seabed. In the eastern Fehmarn Belt, the surface of the till drops eastwards and residual sediments or medium sands transition to fine and ultra-fine sands and silt, which are increasingly overlaid by silt towards the Bay of Mecklenburg.

Figure 18 shows a geological profile section of the Fehmarn Belt between Puttgarden and Rødbyhavn. Above Tertiary clays and Cretaceous limestones lies a 6 to 57 m thick till, which in turn is overlaid by up to 9 m thick basin clays of the central Fehmarn Belt. In the shallow water areas along the edge of the channel, mainly sandy and silty gyttjas and peat are found, whose stepped displacement is associated with deep-seated faults in the Tertiary clays and Pleistocene till. The disturbance-induced settlement and deposition of this sedimentary unit probably took place simultaneously, so that the tectonic movements influenced the late and post-glacial sedimentation.

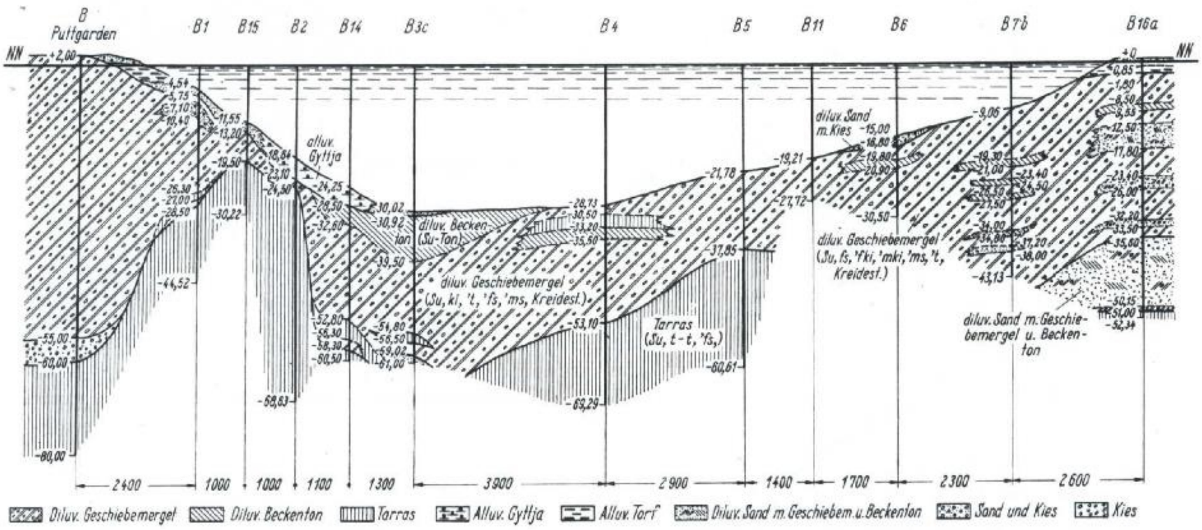


Figure 18: Geological profile section through the Fehmarn Belt between Puttgarden and Rødbyhavn (RUCK, 1969)

Bay of Mecklenburg

To the east of the Fehmarn Belt is the Bay of Mecklenburg, which, according to KOLP (1976), is bounded roughly by the 20 m contour of the Darss Sill and the Fehmarn Belt. The Bay of Mecklenburg is on average slightly deeper than the Bay of Kiel, but considerably shallower than the Arkona Basin. The maximum water depth is around 28 m. In contrast to the Bay of Kiel, the Bay of Mecklenburg and the Arkona Basin lack pronounced channel structures in their present-day seabed topography.

The distribution of the surface sediments clearly shows the basin character of the Bay of Mecklenburg (Figure 19). In the centre of the bay, below the 20 m depth contour, is the mud zone. The mud consists mainly of (mostly poorly sorted) fine and medium silts. In general, the thickness of the silt increases towards the centre of the basin to between 5 m and 10 m.

Towards the edge of the basin, above the 20 m depth contour, the mud transitions to fine and medium sands, and in some places coarse sands and residual sediments. Larger deposits of coarse sands, gravel and residual sediments (stones, boulders) occur in the shallow water zones south of Fehmarn and in the south-eastern area of the Bay of Mecklenburg (north-west of the island of Poel, Figure 19). In the northeast of the Bay of Mecklenburg, the sediments transition to silty fine and ultra-fine sands in the direction of the Darss Sill.

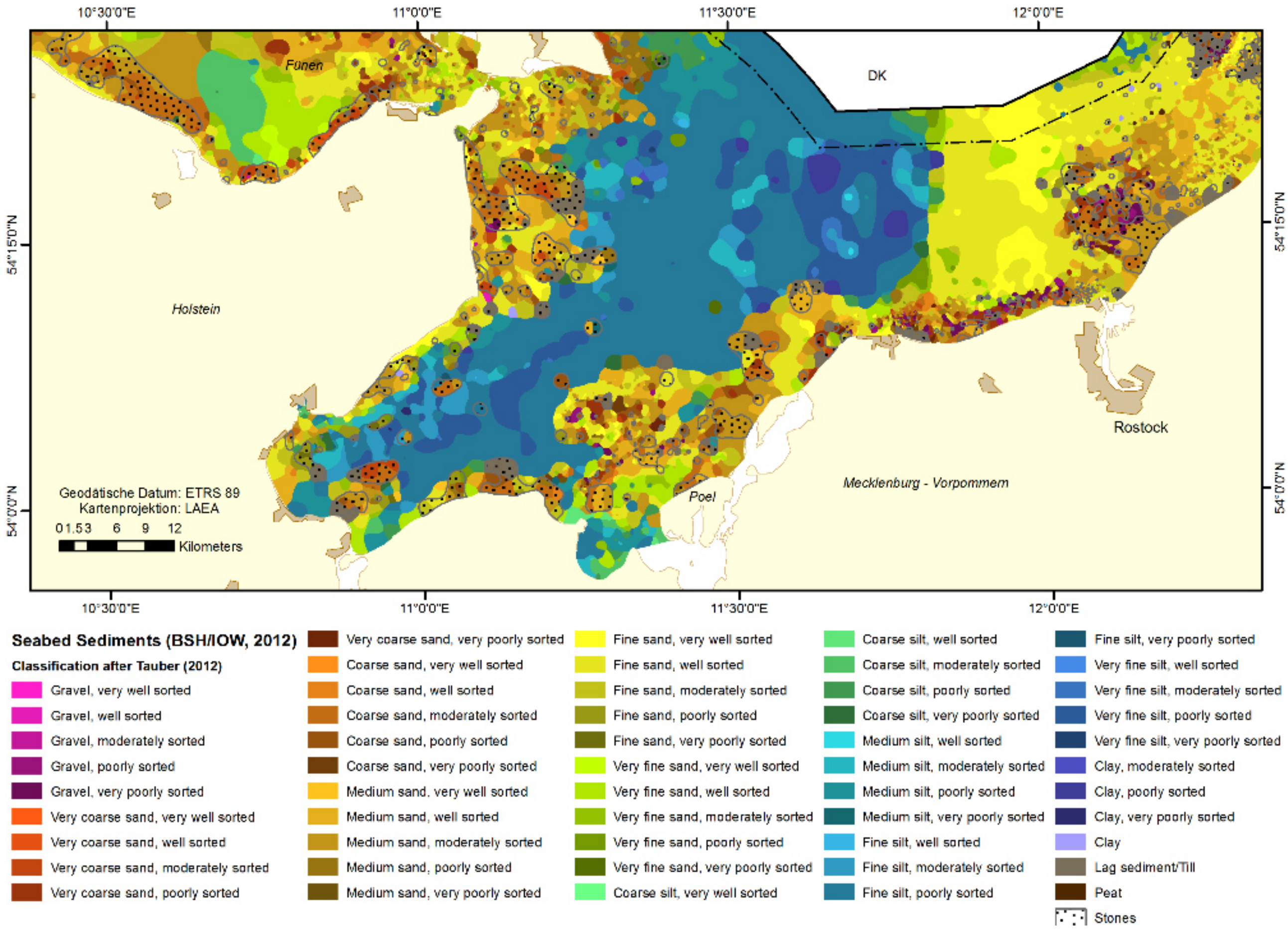


Figure 19: Sediment distribution in the Bay of Mecklenburg area (BSH/IOW, 2012). The edge of the mud (blue colours in the centre of the basin) follows the 20 m contour quite closely. The EEZ in the area of the Bay of Mecklenburg lies entirely in the northern part of the mud zone.

The Quaternary base of the Bay of Mecklenburg probably consists of Tertiary sediments and lies at depths of between 50 and 120 m below sea level. This is followed by till, which can be divided into two units similar to those in the Bay of Kiel or the Arkona Basin. The lower till is probably between 20 and 120 m thick. The upper boulder clay, on the other hand, is less thick at around one metre. It is grey to grey-brown in colour and contains numerous chalk and flint boulders. The deepest parts of the Bay of Mecklenburg and the Fehmarn Belt contain sediments from the early Baltic Ice Lake (W2), which largely follow the morphology of the till. In water depths over 20 m, late glacial sediments from the late Baltic Ice Lake phase (W3) occur. They consist of stratified clays which transition to fine sands towards the basin margin. In the deeper areas they too follow the morphology of the underlying layers; outside these late glacial basins they are horizontally deposited. The Early Holocene freshwater formations of the W4 unit are 1 to 2 m thick in the central Bay of Mecklenburg and are lithologically extraordinarily diverse: in addition to grey medium to coarse sands and grey clayey silt, there are peat gyttjas and peats as well as highly calcareous gyttjas and sea chalk. In these sediments, the surface of which has been partially eroded, plant remains often occur. The most recent deposits are Littorina-period and later marine sediments (W5). These level the topography of the subsurface seabed and are generally up to 7 m thick, but can be over 10 m thick locally. This unit wedges out towards the edge of the basin and transitions to thin sands. The basis of the silt is a transgression contact, which can often only be recognised by the presence of different species of molluscs.

Darss Sill

The Darss Sill is the sea area between the peninsula Fischland-Darß and the Danish islands of Falster and Møn. From an oceanographic point of view, it is bounded on both sides by the 20 m depth contour (KOLP, 1976). It represents a raised area with an average water depth of 17 m, which separates the deeper mud accumulation areas of the Bay of Mecklenburg and the Arkona Basin. In a geological sense, the Darss Sill is narrower, it being an approximately 12 km wide strip between Fischland-Darß and Falster, which is enclosed by two submarine moraine ranges (Darss Sill in the sense of the German term "Darßer Schwelle") and merges to the east into the Falster-Rügen Plateau (KOLP, 1965).

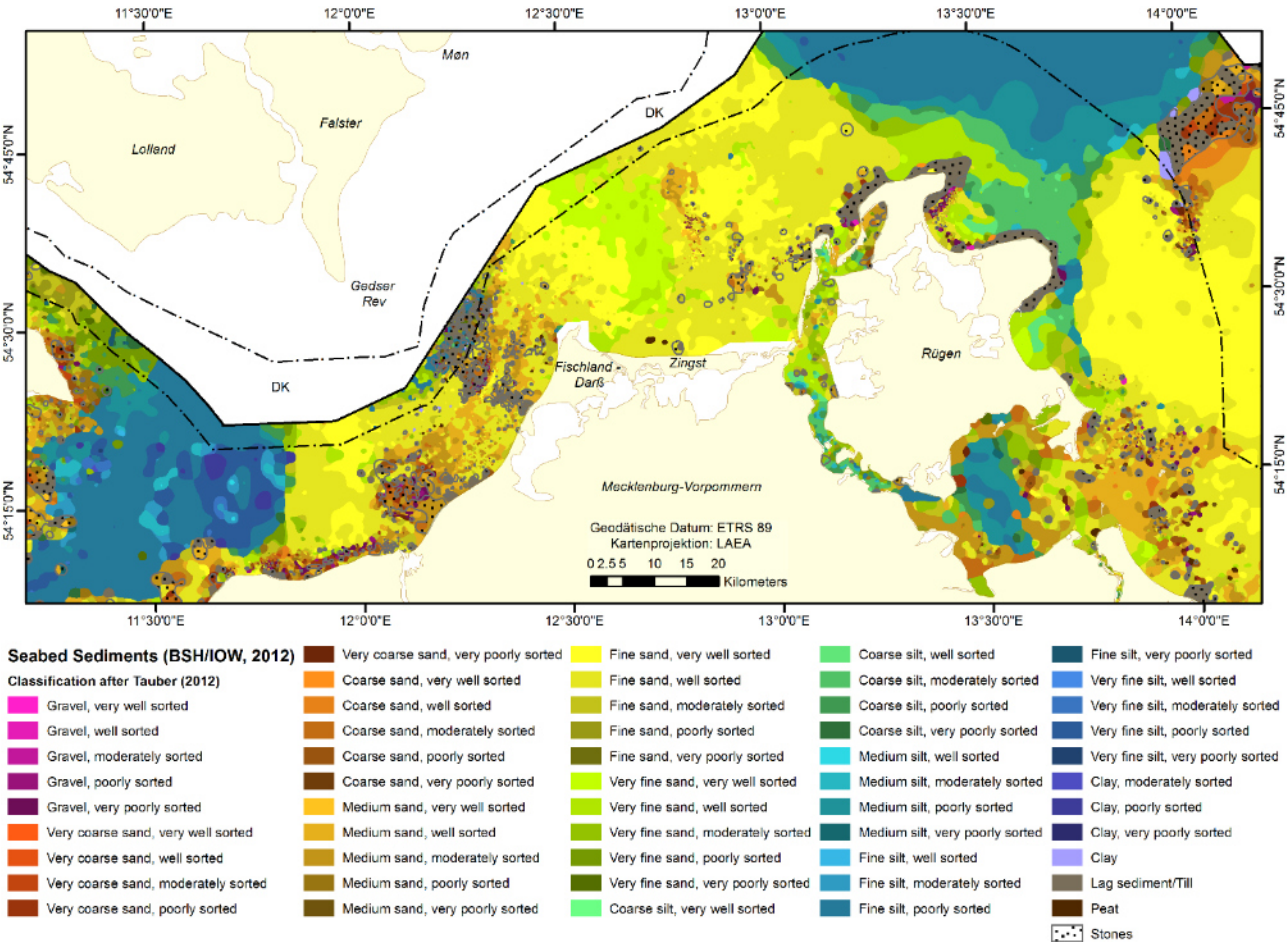


Figure 20: Sediment distribution on the seabed in the area of the Darss Sill between the Bay of Mecklenburg in the west and the Arkona Basin in the east. The Darss Sill in the narrowest sense is characterised by a submarine ridge of till running from the steep bank between Wustrow and Ahrenshoop in a north-westerly direction to Gedser Rev (Falster, DK).

The Darss Sill in the narrow sense of the "Darßer Schwelle" and the Falster-Rügen Plateau show significant morphological differences. The topography of the Darss Sill in the narrow sense is characterised by striking, small-scale changes in morphology. The characteristic element is a submarine ridge of till, which runs from the steep bank between Wustrow and Ahrenshoop in a north-westerly direction to Gedser Rev (Figure 20). The trench system of the Kadet Channel is cut into this ridge to a depth of 32 m. Southeast of the Kadet Channel itself, the V-shaped, elongated Grenztal channel runs parallel to it with a maximum water depth of 22 m. The water depths are mainly between 10 and 20 m, although closely bounded 2 to 3 m high elevations of the seabed can be observed, especially on the flanks. Depending on seabed conditions, the strong bottom currents have created a strongly varying, small-scale topography in the deepest parts of the Kadet Channel, which on closer inspection consists of three channels. Here, in irregular succession, till ridges of 1 to 2 m in height alternate with flat fine sand and muddy areas. Mixed sediments occur throughout the entire course of the Kadet Channel. The Kadet Channel is subject to aperiodic silt sedimentation, whereby interruption or removal occurs when the thermocline between salty deep water and surface water (with lower salinity) becomes ineffective during strong inflows, and presumably outflows. The highest and steepest elevations are observed in the central part of the Kadet Channel. The channels have an irregular trough and are characterised by very steep slopes in places. Giant ripples with ridge spans of about 400 m are observed in the channels (SHD, 1987; DIESING and SCHWARZER, 2003). Comparable structures with crest heights of up to 5 m are found on the Darss Sill (LEMKE et al., 1994). The morphological structures indicate distinct sedimentary-dynamic processes similar to those in the Fehmarn Belt and Danish Belts.

The Darss Sill in the narrow sense consists of an elevated layer of till, on top of which, especially on the flanks of the channels, there is a varying density of stone and boulder cover. In contrast, the bottom and flanks of the Grenztal channel are free of residual sediments. Here, more than 10 m thick sands are deposited above the boulder clay. An elongated sand ridge at a water depth of 14 to 15 m separates the Grenztal Channel from the Kadet Channel system (TAUBER and LEMKE, 1995).

Gedser Rev (Falster Island, DK) is the submarine southern spur of Falster Island and is the geological-morphological continuation of the wide elevated layer of till on the Danish side. It is characterised by a clear dichotomy in terms of its morphology and sediment distribution. The south-western slope has an irregular, densely stone and boulder covered till surface with local elevations. Extending the south-western slope, a 50 to 60 cm thick gravel layer is found on Gedser Rev at depths of 8 to 10 m, which was subject to extraction for construction purposes over a long period of time (KOLP, 1966).

The Falster-Rügen Plateau, which borders the Darss Sill to the east, is much flatter. With the exception of the Plantagenetgrund, which rises to a water depth of less than 8 m, and a channel structure to the north in the direction of the Arkona Basin, it has hardly any morphological structure. It is mainly covered by calcareous fine sand with humus particles and tiny plant remains, as well as layers of peat. The sands are between 10 m and 50 m. They largely level out the Late Glacial topography (TAUBER et al., 1999).

The foundation consists of three till horizons, which are presumably Elsterian, Saalian and Weichselian. Elsterian till (unit 1a) has been recorded in the area of the Kadet Channel, but is not directly exposed on the seabed. It is brownish grey to greenish in colour and is very firm. Its thickness varies between 2 and 26 m. The Saalian till (unit 1b) is firm, grey and contains numerous chalk deposits. It occurs almost on the entire Darss Sill in the narrow sense. Its thickness ranges from a few decimetres in deep channels to a maximum of 26 m. In the deeper sections of the Kadet Channel, the middle till is deposited under a thin layer of silt or residual sediments. The Weichselian till (unit 1c) is clearly visible in the seismograms of the Darss Sill in the narrow sense. On the Falster-Rügen Plateau only the upper edge of the till was recorded, and a reliable chronological classification was not possible.

West of a line Darßer Ort–Møn its surface drops into the Arkona Basin. The thickness of the Weichselian till varies between 1.6 m and 16.9 m. It is grey to brownish grey, has a ductile to very firm consistency and is characterised by numerous chalk deposits. Its surface is covered on the seabed by unsorted, coarse residual sediments consisting of stones and boulders up to and above 1 m in diameter. Scouring around the stones and boulders indicates the intense effect of the strong currents.

Units 2 and 3 are sandy to silty sediments, which were deposited as glaciofluvial deposits in the till of the channels incised down to 50 m below sea level. They are up to 15 m thick. Plant remains prove the relatively old age of the fine sands, which occur under a 30 cm thick layer of sand and come from the Yoldia stage (about 10,200 - 9,300 years ago) of the Baltic Sea. The fine sands contain clays several metres thick in places, which accumulated in late glacial reservoirs. The distribution of unit 3 is mainly limited to the western edge of the Arkona Basin, the Grenztal Channel and Vierendehl Channel. These are mainly well- to moderately sorted olive-grey fine sands with a high lime content, which transition to the fine-grained facies of the late glacial clays in the Arkona Basin. The sediments of unit 4 are characterised by a great lithological diversity. On the Falster-Rügen Plateau they occur mainly bound in shallow channel and basin structures. In the area of the Darss Sill in the sense of the German word "Darßer Schwelle" they are represented by peat, peat and limestone gyttjas and intercalated fine sands. Unit 5 comprises the post-Ancylusian sediments (sea sands, after about 8,000 years ago), which rarely exceed 2 m thickness in the area of the Darss Sill. Greater thicknesses are found at Gedser Rev and east of Falster. On the Falster-Rügen Plateau they are sparsely distributed and only reach a thickness of 3 m locally in filled channels.

The Quaternary base is about 90 m below sea level and is formed by Jurassic sedimentary rocks (LEMKE, 1998). It rises from Fischland towards the north-east, where Cretaceous rocks form the bedrock. In the Prerow fault zone, the base of the Quaternary lies at 30 m below sea level and drops to about 70 m below sea level at the western edge of the Arkona Basin.

Arkona Basin

The Arkona Basin sub-area is delimited from the Falster-Rügen Plateau by the 40-m depth contour. In the west the elevation of the Krieger Flak juts into the basin. In the north-east, the Arkona Basin is connected to the Bornholm Basin via the Bornholm Gatt; in the east, it borders the shallows of Rönne Bank with the Adlergrund as its south-western extension. The Arkona Basin is characterised by a uniform basin structure. The maximum water depth is over 50 metres.

The sediment distribution on the seabed of the Arkona Basin (Figure 21) consists of clayey, fine and medium, poorly sorted silts (mud), usually of very soft to mushy consistency. The silt is greyish in colour and usually contains little in the way of shell remains; bioturbate structures are described in places. Towards the edges of the basin the silt sediments become sandier.

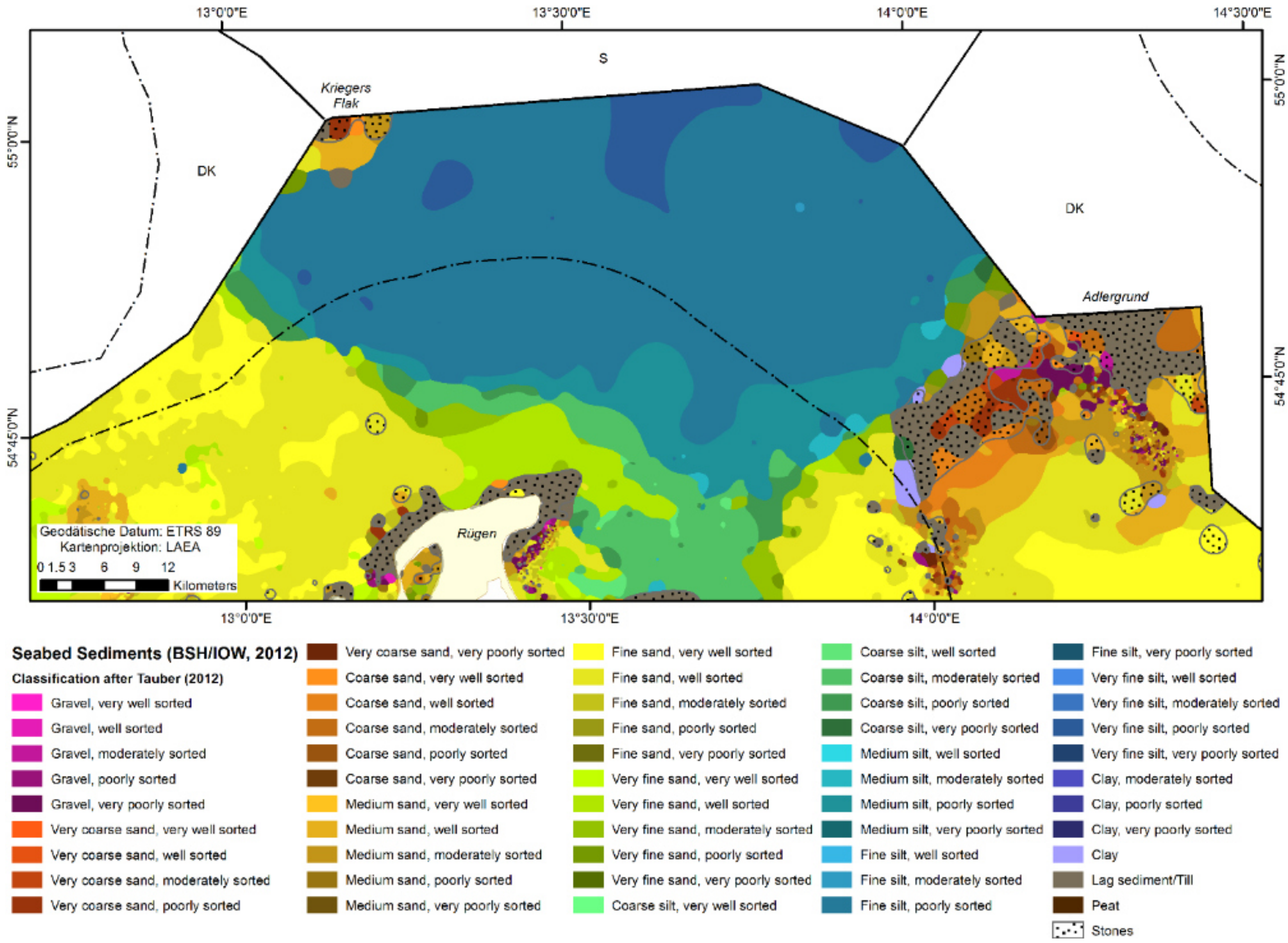


Figure 21: Sediment distribution on the seabed in the Arkona Basin (BSH/IOW, 2012.) The seabed consists mainly of clayey, fine to medium, poorly sorted silt of soft to mushy consistency.

About 25 km northeast of Cape Arkona, a small area with residual sediments in the Arkona Basin was mapped out as part of the "Sediment Mapping EEZ" project.

Due to the high gas content of the silt sediments, large areas of the Arkona basin cannot be mapped by seismic reflection, or only to a limited extent. Nevertheless, the geological structure of the subsurface can be reconstructed using results from seismic windows at specific locations.

In the Arkona Basin, the lowest unit can be divided into two till horizons (E1b and E1c), both presumably Weichselian. The upper limit of the lower till horizon can be traced over wide areas of the Arkona Basin. The greatest depth, 78 m below sea level, occurs north-northeast of Cape Arkona. The lower till is grey in colour and consists mostly of very firm clayey, partly fine sandy material. It carries numerous small boulders, the composition of which is dominated by chalk and flint. The lower till reaches a thickness of up to 35 m. The upper boulder clay (E1c) largely reproduces the topography of the lower boulder clay (E1b). It has thicknesses of barely more than 12 m, is sometimes patchily distributed and wedges out towards the edge of the basin.

This is followed by the late glacial pink clays of the units E2 and E3. They can only be distinguished in the seismograms in the area of the basin rim, e.g. in the sea area between Tromper Wiek and the Adlergrund. They can be found throughout the southern Arkona Basin and consist of layered reddish to reddish-brown varved clays (E2) and a homogeneous, strongly silty, reddish clay (E3), which can become up to 16 m thick in areas with deep till. They trace the surface of the till. Unit E4 consists of grey, post-glacial silty clays, silt and humus sediments of the Yoldia and Ancylus stages, which occur on the southern and western edges of the Arkona Basin. Characteristic features of the grey silts are the dark grey to black layers, lenses and pods. Their surface generally follows the topography of the reddish to reddish brown clays. They reach thicknesses of up to 5 m. The central part of unit E5 consists of silt, which transitions to sandy silts or silty sands towards the edge of the basin. The thickness is usually between 2 and 4 m, but depending on the topography it can be up to 10 m thick, which is mainly the case in the centre of the southern part of the basin. The sedimentation of silt has led to an extensive levelling of the topography. The silt has an olive to dark grey colour and soft plasticity. It often contains streaks, lenses and narrow lamellae, which consist of slightly lighter, coarse-silty to fine-sandy material and are due to bioturbation. The surface of the silt is covered by a brownish fluffy layer a few millimetres thick. Immediately below, there is usually a dark grey to black layer several decimetres thick, which is characterised by an intense hydrogen sulphide odour. With increasing sediment depth, this layer changes into the normal olive-grey silt, which becomes increasingly solid and often contains mollusc fragments and partially dissolved mollusc shells.

Kriegers Flak

To the west of the Arkona Basin, the spurs of the Kriegers Flak shoal extend into the German EEZ. Here the water depths range from 21 m in the shallow area to 40 m in the direction of the Arkona Basin. In contrast to the Arkona Basin, the Kriegers Flak shoal (see also Figure 21) has a strongly structured morphology and a very heterogeneous lithological composition of the surface sediments, which have the typical sill character and are closely associated with their geological formation and post-glacial alteration. In the higher areas of the Kriegers Flak shoal, the seabed surface consists mainly of residual sediments, till, gravel and medium to coarse sands. Especially in the northern part of Kriegers Flak, numerous stones and boulders can be found, some of which form embankment-like structures. Towards the Arkona Basin the coarse sands transition to medium and fine sands and with increasing depth to silt and clays.

In the north-western part of the shoal, the till is over 25 m thick. It is noticeably consolidated and inhomogeneous in its lithological composition. Characteristic features are the numerous stones and boulders that also occur below the seabed surface. These led to the premature termination of exploratory drilling for the location of the FINO 3 measuring platform. Towards the south, its surface is submerged under Late Glacial clays with a thickness of about 5 m. These can reach a thickness of more than 10 m in channel fillings where they can be formed as very soft varved clays. In addition, sand, gravel, silt and peat can be expected in these old channels. In the southern slope area, the Late Glacial clays are buried under a sand wedge of about 8 m thickness.

Adlergrund

The Adlergrund is the south-western spur of the Rönne Bank, a shallow area that stretches south-west from Bornholm. The seabed has a very uneven topography due to its glacial history and post-glacial development. The water depths range from 5 m at the Foule-Grund to 25 m.

Like the Kriegers Flak shoal, the Adlergrund also has a very inhomogeneous sedimentary composition (Figure 21), with residual sediments (coarse sand, fine gravel and stones) dominating the till. The stones are fist to head size and occur sporadically or widely in these areas. In addition, boulders several metres long are common, which are covered with shells (Mytilus) more or less densely. In the southeast, the till forms outright peaks. In the southern half of the area, a band of residual sediment with a thin sand cover runs parallel to the slope. The thin sea sands occur in patches between the residual sediments or as elongated bands 100 to 200 m wide and several kilometres long spaced 50 m apart. They often have ripple fields on their surface. At the north-western edge, the sands merge into the silt of the Arkona Basin. Towards the south, there is a continuous transition to the sandy areas of the Bay of Pomerania and Oder Bank (DIESING and SCHWARZER, 2003).

The Adlergrund owes its origin to the Weichselian glaciation. In the course of various glacial advances and retreats, significant accumulations of glaciofluvial deposits in the form of sands and gravels occurred, in connection with significant till settling. In the southern area, delta-like debris created sandur-like structures. The basis is Cretaceous chalk, which, due to glacial-tectonic stress, shows fault zones as well as intermediate layers of sands, gravel or stones. This is followed by a 6 to 10 m thick till, which is close to the surface in the central area of the Adlergrund. On its flanks it is overlaid by a sequence of coarse and gravel sands, medium to coarse sands and fine sands. Beneath it, Late Glacial clays and silts of the Bornholm and Arkona Basin wedge out. During the Littorina transgression (about 8000 years ago) the surface of the sand complexes were, reshaped forming complex deposits.

Oder Bank

This sub-area is bounded to the north by the southern spurs of the Adlergrund and merges into the Bornholm Basin to the east in Polish territory. The water depths are about 7 m in the shallowest parts of the Oder Bank and reach maximum values of 31 m. The Oder Bank itself is bounded by the 10 m depth contour (KRAMARSKA, 1998). Between the relatively steep southern slope of the Oder Bank and the coast, the seabed morphology is characterised by depressions and shallows of up to 3 m in height; the northern slope, on the other hand, slopes gently towards the northeast.

From a sedimentological point of view, the largely structureless seabed in the Oder Bank area is dominated by well to very well sorted fine sands (Figure 22). First results of the project "Sediment Mapping EEZ" show that coarser sediments such as medium and coarse sands can also be found in the Oder Bank area. Residual sediments in the form of isolated stone deposits predominate off the Greifswald bodden and off Usedom, and north to northeast of the Oder Bank in the Adlergrund Channel, but not at the same density as on the Adlergrund (BOBERTZ et al., 2004). In the north-western part of the Oder Bank, isolated residual sediment deposits (stones up to 1 m in diameter) are found, as well as mussel fields ranging from fist-size to several square metres, and smaller ripple fields of coarse sand (SCHULZ-OHLBERG et al., 2002).

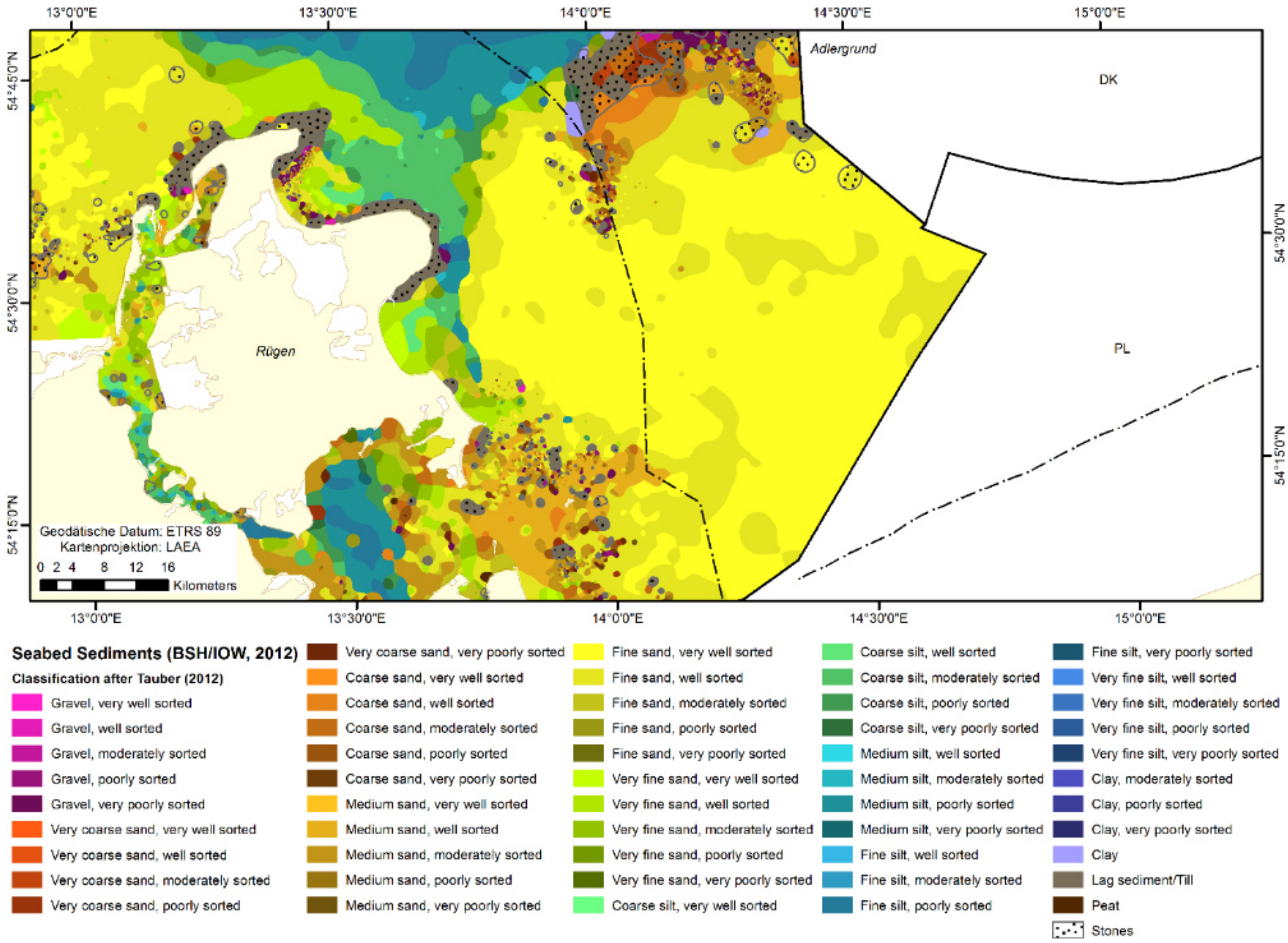


Figure 22: Sediment distribution on the sea floor in the Oder Bank area (BSH/IOW, 2012). The seabed in the area of the Oder Bank is dominated by well to very well sorted fine sands.

In addition, the sonograms (side scan sonar recordings) showed elongated to oval formations with a higher reflectivity than the surrounding sandy soil, up to 10 m wide and about 20 m long. Their distribution suggests a connection with fishing activities (LEMKE and TAUBER, 1997).

The geological structure of the Oder Bank shows glacial and fluvioglacial sediments in its core (Figure 23). The till forms two locally different units. The older one has so far only been recorded in seismograms and lies directly on the Cretaceous bedrock. The younger till is located just below the seabed and extends as a thin deposit from the coast to the Oder Bank, probably disappearing in the northern slope area and reappearing in the Bornholm Basin. The two tills are separated by a Pleistocene sand layer which is up to 30 m thick.

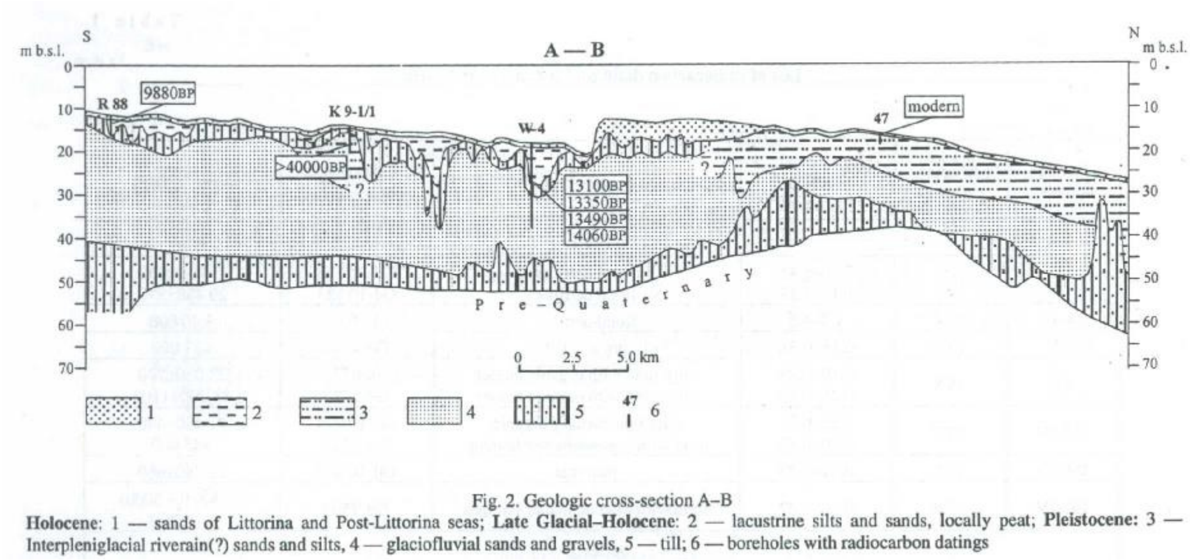


Figure 23: Geological profile section through the eastern extension of the Oder Bank on the Polish side (from: KRAMARSKA, 1998).

On the Polish side of the Oder Bank, the distinct paleotopography of the till was leveled by marsh and lake sediments during the late and post-glacial periods. On the Oder Bank, Littorina and Post-Littorina sand barrier sediments lie above the younger till. At their base, gravel and mollusc shells are present, and on their surface they are probably covered by former dune sands. The sands reach thicknesses of about 6 m to over 10 m. To the north, they dive to a depth of about 20 m under the wedging sea sands of the Baltic Sea, whose thickness hardly exceeds 1 m. The south-eastern extension in 12.5 m to 13 m water depth is interpreted as a pointed, "drowned" sandbank, which was formed by former sand transport parallel to the coast - similar to the present-day counterpart of Darßer Ort. South of the Oder Bank, the old river bed of the ancient Oder appears in the subsoil, which is filled with river sediments about 5 to 7 m thick (KRAMARSKA, 1998; USCINOWICZ et al., 1988; RUDOWSKI, 1979).

2.1.4 Distribution of pollutants in the sediment

2.1.4.1 Metals

Because of the short time-span of available series of measurements in the western Baltic Sea (Bay of Mecklenburg to Arkona Basin) no trend in the metal contents of surface sediments can be identified to date. The main areas of contamination are the Bay of Lübeck and the western Arkona Basin. Aside from historical pollution, metals are introduced into the Baltic Sea in particular via rivers and atmospheric depositions. In addition, there are possible entry routes from various forms of use, such as shipping and the offshore industry, which must be quantified more precisely in the future.

Covering of the legacy pollution in the Bay of Lübeck, and the associated containment of the resuspension of contaminated material, means that a normalization of the sediment quality in this area is expected in the long term. In the western Arkona Basin, elevated mercury and lead contents in particular have been measured for years. The causes of this anomaly are not yet known. Towards the coast, an increase in the element content of surface sediment is generally observed. This applies in particular to mercury and cadmium, but also to zinc and copper. In contrast, the lead contents measured in the EEZ are quite comparable with the values observed near the coast, and in some cases are even higher. In the MSRL Report 2018, concentrations of the HELCOM indicators lead, cadmium and mercury in sediment in the EEZ exceeded the threshold values (Status of German Baltic Sea waters 2018).

2.1.4.2 Organic substances

A summary overview of sediment pollution is hampered on the one hand by the lack of comprehensive data on the open sea and on the other hand by the heterogeneity of data from coastal areas. In addition, the published data usually lack a reference to TOC content (TOC = total organic carbon) or particle size normalization.

Pollutant discharges reach the Baltic Sea via direct discharges, rivers, and the atmosphere as well as indirect sources. Rivers and the atmosphere are the main routes of entry into the marine environment. In addition to input sources, input quantities and input routes (direct via rivers and offshore industry or diffuse via the atmosphere), the physical and chemical properties of the pollutants and the dynamic/thermodynamic state of the sea are relevant for dispersion, mixing and distribution processes. For these reasons, the various organic pollutants in the sea show an uneven and varying distribution and occur in very different concentrations. However, concentrations in the EEZ are consistently lower than in coastal areas, where local concentrations often occur.

More in-depth regional assessments require the consideration of sediment parameters (TOC, particle size distribution). In the EEZ, the sediments have a relatively homogeneous distribution with comparable TOC contents. Contamination levels at stations with a low fine particle content and low TOC values (sandy sediments) are always very low. Compared to the North Sea (German Bight), the concentrations in the Baltic Sea EEZ are on average significantly higher; this is most likely due to the higher TOC and silt contents of the Baltic sediments. In the MSRL Report 2018, the concentrations of the HELCOM indicator substances anthracene and TBT in the sediment of the EEZ exceed the threshold values (Status of German Baltic Sea waters 2018). However, the available data are insufficient, so that no statements can be made on trends over time.

Due to the increasing use of the Baltic Sea, direct discharges from e.g. shipping and the offshore industry will probably play a greater role in future in the assessment of the environmental status.

2.1.4.3 Radioactive substances (radionuclides)

In comparison with other marine areas, the surface sediments of the Baltic Sea show significantly higher specific activities than, for example, those of the North Sea. In most cases, this statement also applies to natural radionuclides. On the one hand, this effect is due to the smaller particle size of the siltier and thus finer-grained sediments of the Baltic Sea; on the other hand, it is also due to lower turbulence in the water of the Baltic Sea leading to sedimentation of the finer particles. Radioactive contamination of the Baltic Sea is determined by precipitation from the Chernobyl disaster in 1986, and the higher surface deposition of the Chernobyl input into the area of the western Baltic Sea compared to the North Sea is also reflected in the increased activities. It can be observed that the content in the sediments increased steadily in the first years after the Chernobyl disaster. Stagnation has been observed for about 10 years, which can be explained by a quasi-equilibrium between radioactive decay (half-life of Cs-137: 30 years) and further deposition. Although radioactive contamination of the Baltic Sea by artificial radionuclides is higher than in the North Sea, it does not pose any danger to man or nature according to currently available information.

2.1.4.4 Legacy contamination

Possible legacy contamination in the Baltic Sea includes ammunition. In 2011, a joint Federal/State working group published a basic report, updated annually, on the contamination of German maritime waters by ammunition. According to official estimates, the seabed of the North and Baltic Seas holds 1.6 million tonnes of old ammunition and explosive ordnance of various types. A significant proportion of these ammunition dumps are from the Second World War. Even after the end of the war, large quantities of ammunition were sunk in the North and Baltic Seas when Germany was disarmed. The explosive ordnance load in the German Baltic Sea, in particular in the coastal sea, is currently estimated at up to 0.3 million tonnes. It should be noted that the overall data are insufficient, and explosive ordnance should also be expected in the area of the German EEZ (e.g. remnants of mine barriers, combat operations and military exercises).

In general, the ammunition may be silted up or exposed on the seabed, depending on sediment properties. In addition, storms or strong currents can expose ammunition in the sediment. Thus, ammunition can constitute an artificial hard substrate.

Current research results indicate that corrosion of ammunition stored at sea may be at an advanced stage. Whether and to what extent this may have adverse effects on the marine environment, through the release of toxic ingredients (e.g. explosives such as TNT), is the subject of current research and part of the work to implement the resolutions of the 93rd Conference of Environment Ministers, TOP 27.

The location of known ammunition dumps can be found on official nautical charts and in the 2011 report (which also includes areas suspected of contamination by ammunition). The reports of the Federal/State working group are available at www.munition-im-meer.de.

2.1.5 Assessment of the state of the seabed

The assessment of the state of the seabed in terms of sedimentology and geomorphology is limited to the Baltic Sea EEZ.

2.1.5.1 Rarity and threat

The aspect rarity and threat takes into account the surface area of the sediments on the seabed and the distribution of the morphological inventory of forms in the south-western Baltic Sea as well as in the entire Baltic Sea.

The sediment types of the seabed surface found in the basin areas (such as the Bay of Mecklenburg or Arkona Basin), as well as the inventory of forms, essentially match basin sediments of identical or similar nature found in all basins of the Baltic Sea. Sediment types such as till and residual sediments, as well as stone and boulder deposits found on the sills and shoals (e.g. Kriegers Flak, Adlergrund or Darss Sill), are frequently found in the western and southwestern Baltic Sea.

The aspect rarity and threat is therefore rated as medium–low.

2.1.5.2 Diversity and uniqueness

The aspect diversity and uniqueness considers the heterogeneity of the described surface sediments and the uniqueness of the morphological inventory of forms.

Both the sills and shoals such as Kriegers Flak, Adlergrund and Darss Sill, as well as large areas of the Bay of Kiel and the Fehmarn Belt show a heterogeneous distribution of sediments and a rather distinct inventory of forms. This is particularly true for the pronounced, inflow-related bottom topography in the Fehmarn Belt and Darss Sill (in the narrow sense). The basin areas, such as the Bay of Mecklenburg or Arkona Basin, on the other hand, have a very homogeneous sediment distribution and a seabed devoid of structure.

The aspect diversity and uniqueness is therefore rated as medium–high, primarily due to the distinctive structures in the Fehmarn Belt and the Darss Sill (in the narrow sense of the term).

2.1.5.3 Legacy impacts

Natural factors

Climate change and sea level rise: The Baltic Sea region has experienced dramatic climate change over the past 11,800 years, with a profound change in land/sea distribution due to a global sea level rise of 130 m. Over the past 2,000 years or so, the sea level of the Baltic Sea has adjusted to its present level and is subject to short-term, meteorologically induced changes. Storms cause the most drastic changes to the seabed. All sediment dynamics can be traced back to meteorological and climatic processes which are essentially controlled by the weather in the North Atlantic.

Tectonic and isostatic movements, earthquakes: the tectonic and isostatic processes cover periods of several millennia. They have their causes in the tectonic movements of plates of the earth's crust and therefore occur over a large area. ANDREN and ANDREN (2001) found evidence in sediment cores that the tsunami wave from the submarine Storegga landslide in the Norwegian Sea could have spread to the Baltic Sea some 8,000 years ago. The trigger was probably a seaquake. The analysis of earthquake frequency and magnitude for the south-western Baltic Sea region shows that only relatively weak earthquakes occur in this sea area, which are relatively rare compared to the Baltic Sea as a whole. For this reason, the south-western Baltic Sea cannot be considered an earthquake-prone area.

Anthropogenic factors

Eutrophication: As a result of anthropogenic inputs of nitrogen and phosphorus via rivers, the atmosphere and diffuse sources, increased primary production leads to increased sedimentation of organic matter in the Baltic Sea basins.

Microbial degradation usually results in oxygen deficiency, leading to the formation of gyttja, which has a much softer consistency than silt deposits.

Fisheries: Since the end of World War I, commercial fisheries in the Baltic Sea have almost exclusively engaged in bottom trawling using otter boards. Beam trawling does not take place in this sea area (RUMOHR 2003). There are only isolated observations of seabed tracks caused by fishing in the area under consideration.

In general, the investigations in the Bay of Kiel have shown that the distribution density of the otter board tracks increases with water depth and the decreasing mechanical resistance of the sediments. The absence of trawl tracks on sandy soils is less due to reduced fishing activity than to the higher sediment redistribution potential of these sediments. For the remaining part of the south-western Baltic Sea, only isolated observations are available.

LEMKE (1998) describes numerous fishery tracks in the mudflats of the Arkona Basin. In the area of the Bay of Pomerania, otter board tracks are restricted to an area southwest of the Oder Bank (SCHULZ-OHLBERG et al. 2002). The penetration depths can reach up to 23 cm in silt (WERNER et al. 1990), up to 15 cm in silty fine sands (ARNTZ & WEBER 1970) and up to 5 cm in sands (KROST et al. 1990). Much shallower tracks are left by roller and ball gear, which according to observations by divers can be 2 to 5 cm deep (KROST et al. 1990).

Experimental investigations with a 3 m prawn trawl in the Baltic Sea showed penetration depths of max. 17 mm for the chains and over 40 mm for the runners (PASCHEN et al., 2000). The width of the otter tracks depends on the angle of attack, which in turn is influenced by the composition of the sediments. In the case of "hopping" otter boards, it lies between 1 and 2 m. This phenomenon occurs when the otter boards penetrate too deeply into the soft soil and jump over the compressed sediment. In most cases, however, the otter boards are pulled at an angle of attack of 35° to 40° and leave tracks less than 1 m wide (KROST et al., 1990). Banked up edges can only be clearly observed in the narrow otter board tracks. Often the banks are rounded at their edges, which indicates that the tracks have been levelled by natural sediment dynamics during heavy weather conditions. On muddy soils, jumping tracks consisting of sediment accumulations resembling a string of pearls are often observed. Roller and ball tracks are rare due to their low penetration depth, and are also easily overlaid by otter board tracks. In areas of mud, the otter board tracks can persist for at least 4 to 5 years (KROST et al., 1990). The formation of turbidity plumes also plays a role in this context. WERNER et al. (1990) were able to detect a 5-m-high turbidity plume in Eckernförde Bay 90 minutes after a towing operation using an otter trawl bottom net.

Historical stone removal: From around 1800 to the mid-1970s, large stones and boulders were taken from the shallow water areas off the German Baltic coast for the construction of piers, buildings and roads, among other things. In Schleswig-Holstein, stone removal was banned in 1976 in order not to further undermine coastal protection measures. Stone removal was restricted to water depths of up to a maximum of 20 m, with around 100 million tonnes of stones being removed from the entire Baltic Sea (ZANDER, 1991). For the Bay of Kiel, estimates by BREUER and SCHRAMM (1988) showed about 1.5 million tonnes of stones in the period from 1930 to 1970, which was corrected to 3.5 million tonnes (total quantity) by BOCK (2003) and BOCK et al. (2004), not taking illegal removal into account. KAREZ and SCHORIES (2005) estimate that a total of approx. 5.6 km² of settlement space for hard substrate inhabitants were lost to stone removal off the coast of Schleswig-Holstein. No such information is available for the coast of Mecklenburg-Western Pomerania.

However, it can be assumed that, as in Schleswig-Holstein, extraction activities were restricted to the coastal sea area for economic reasons. It can therefore be assumed that the stone deposits in the EEZ were not affected by stone removal.

Sand and gravel extraction: Since the 1960s, sand and gravel have been extracted in the southwestern Baltic Sea as raw materials for coastal protection and the construction industry. In the Bay of Kiel, sand was extracted between 1971 and 1981 on the Gabelsflach, the Stoller Grund and near Kiel Lighthouse, mainly for harbour construction; off the coast of Mecklenburg-Western Pomerania, sand and gravel extraction has been taking place since the 1960s. While no figures are available for the period before 1989, the extraction volume from 1990 to 2003 amounts to approximately 18 million m³. On the Danish continental shelf, sand and gravel have been extracted on Gedser Rev, Kriegers Flak and Rönne Bank. Two types of extraction with different ecological impact need to be considered: areal extraction is carried out by trailing suction hopper dredgers and leads to the formation of decimetre-deep furrows, whereas stationary extraction by anchor suction hopper dredgers can produce funnel-like structures up to several metres deep (ICES, 2001). Whether and how quickly these structures become refilled depends on water depth, sediment availability, exposure and extraction method. Where refilling does occur, finer-grained sediments usually provide the filler material. In gravel sand deposits in particular, a funnel or trough-shaped topography is retained because the recent hydrodynamic and sedimentary processes cannot completely refill or even regenerate the seabed, due to sediment availability (ZEILER et al., 2004).

Crude oil production: Between 1984 and 2000, a total of 3.4 million tonnes of crude oil were extracted from depths of between 1,400 and 1,600 m at the platforms Schwedeneck A and Schwedeneck B, which have since been dismantled, about 4 km off the coast of Schleswig-Holstein. There are no indications of subsidence phenomena in the vicinity of the production facilities as a result of oil production, as described for the North Sea (e.g. FLUIT and HULSCHER 2002; MES, 1990). Therefore, subsidence phenomena in the EEZ can also be ruled out.

Wind turbines and platforms: Wind turbines and platforms are currently installed almost exclusively on deep foundations. To protect against scouring, either mud mats or stone fill are distributed around the foundation elements, or the piles of deep foundations are inserted deeper into the ground. With regard to soil as factor, in addition to temporary sediment resuspension during installation, wind turbines and platforms lead to localized permanent sealing of the seabed. The area affected (sealed) by platforms, which almost exclusively use jacket foundations (without scour protection), is approx. 600 m² to 900 m² depending on size. Wind turbines are also almost exclusively built on deep foundations. By far the most common type of foundation for wind turbines is the monopile. A monopile with a diameter of 8.5 m, including scour protection, requires a surface area of around 1400 m².

Submarine cables (telecommunications and power transmission): Submarine cables are usually jetted in. Turbidity of the water column increases as a result of sediment resuspension caused by the jetting process. The extent of resuspension depends mainly on the laying process and the fine-grain content of the soil. In areas with a lower fine-grain content, most of the resuspended sediment will settle relatively quickly directly at the construction site or in its immediate vicinity. The suspension content will then decrease back to natural background values due to dilution effects and sedimentation of the resuspended particles. The expected negative impact due to increased turbidity remains localized. In areas with soft sediments and correspondingly high fine-grain content, the resuspended sediment will settle much more slowly.

However, as the near-seabed currents are relatively slow in these areas, it can be assumed that the turbidity plumes will remain localized and that the sediment will settle relatively close to the disturbance. A substantial change in sediment composition is unlikely.

Former ammunition dumps: After the end of World War II, 35,000 tonnes of chemical munitions were dumped east of Bornholm. The cargoes were transported along predefined routes from the loading ports of Wolgast and Peenemünde to the dumping area in the Bornholm Basin. According to eyewitness reports, part of the cargo was jettisoned during transport. From 1994 to 1996, the BSH surveyed these transport routes from the exit of Greifswald bodden to the edge of the EEZ by side scan sonar and magnetometer at 50 m intervals to locate possible ammunition remnants. As a result, about 100 suspicious objects were identified. In the course of the detailed inspection by the competent authority of the German Navy, the suspicion of corroded ammunition remnants could be substantiated for only four objects (SCHULZ-OHLBERG et al., 2002), which lie exclusively within the 12 nautical mile zone.

Military exercises at sea: During naval and air force firing exercises at sea, ammunition remnants (shells of grenades and the like) drop onto silty and sandy seabeds. Over time, they sink into the soft silt, or silt up, and can be re-exposed in the course of natural sediment displacement. In addition, submarines can compress sediment locally to varying degrees by their own weight when they are set down on the seabed.

Navigation: Wrecks can become silted and re-exposed, depending on water depth and the type and available amount of sediment. Depending on their size, wrecks influence the small-scale sediment dynamics by causing scouring in their vicinity or sedimentation of sands in their lee. In the case of anchoring, depending on the size of the anchor and the type of sediment, material is locally stirred up to a depth of about 1.5 to 2 m. In silty sediments a turbidity plume is formed which, due to the size and duration of the disturbance, is much smaller than that which results from bottom trawling.

Anthropogenic factors affect the seabed in the following ways:

- Erosion
- Mixing
- Sealing
- Resuspension
- Material sorting
- Displacement
- Compaction

In this way, the natural sediment dynamics (sedimentation/erosion) and substance exchange between sediment and water are influenced.

The extent of anthropogenic legacy impacts on sediments and the morphological inventory of forms are crucial for the assessment of the aspect legacy impacts. The seabed/area as a factor is assigned a medium impact, as legacy impacts do not cause a loss of ecological function.

2.2 Water

The Baltic Sea is an intracontinental sea. The Baltic Sea is connected to the Kattegat via the Little Belt, the Great Belt and the Øresund. The Kattegat is connected to the North Sea via the Skagerrak and thus to the Atlantic Ocean. Due to the shallow water depths of the straits, there is little water exchange with the North Sea. The Baltic Sea covers a total area of 415,000 km² with an average depth of 52 m (JENSEN & MÜLLER-NAVARRA 2008). Due to its low salinity, the Baltic Sea is brackish. Water circulation in the Baltic Sea is characterised by the inflow of fresh water via rivers on the one hand and the exchange of water with the North Sea on the other. As a result of the morphological conditions, the Baltic Sea can develop significant vertical salinity and temperature gradients , which cannot be broken up by the wind-driven currents and minimal tide (< 10 cm) (JENSEN & MÜLLER-NAVARRA 2008, FENNEL & SEIFERT 2008).

2.2.1 Currents

Circulation in the Baltic Sea is characterised by an exchange of water with the North Sea through the Belts and the Øresund . Near the surface, brackish Baltic Sea water flows into the North Sea, while at the bottom heavier, more saline North Sea water from the Kattegat advances into the Baltic Sea. This inflow of saline water is hindered by the Drogden Sill (sill depth 9 m) at the southern end of the Øresund and the Darss Sill (sill depth 19 m) east of the Belt Sea. Specific weather conditions cause saltwater intrusion to occur sporadically, as a result of which salt and oxygen-rich water at times flows into the deeper eastern basins of the Baltic Sea.

During these inflow events of saltwater from the Kattegat into the Baltic Sea, which contribute significantly to the aeration of the deeper Baltic Sea basins, two processes can be distinguished: On the one hand, there are the large saltwater inflows, which transport large quantities of saltwater into the Baltic Sea over a period of at least five days. During this process, large parts of the Arkona Basin are filled up with salt water. On the other hand, there are inflow events of medium intensity, which occur about 3 to 5 times per winter. After overflowing the Darss Sill and the Drogden Sill, the bottom water enters the Arkona Basin as a dense bottom current. The denser water entering over the Drogden Sill into the Arkona Basin flows as a relatively narrow band counterclockwise along the edge of the Arkona Basin. It flows around Kriegers Flak and continues towards the Darss Sill, where the saltwater flowing in over the Darss Sill overlaps this band. From there the band continues along the southern edge of the Arkona Basin eastwards towards the Bornholm Gatt, where it flows into the Bornholm Basin (BURCHARD & LASS 2004, LASS 2003).

Model studies (BURCHARD et al. 2005) with a simplified numerical model modify this picture: According to these studies, the majority of the water entering via the Drogden Sill flows clockwise around Kriegers Flak and influences the sector lying in the German EEZ less than the observations and model results published so far indicate. Measurements carried out using an acoustic Doppler current profiler set on the seabed east of Kriegers Flak could support these model results. As the new model studies are limited to the inflow from the Øresund only, no new findings are available concerning the inflow from the Belt Sea (Darss Sill). It can be assumed that this inflow spreads eastwards mainly along the southern edge of the Arkona Basin, and thus also affects the deeper parts of the Adlergrund.

Table 6: Characteristic current parameters for selected positions in the western Baltic Sea.

	Fehmarnbelt	**Bay of Mecklenburg**	**Arkona Basin**
Water depth [m]	28	26	31
Close to the surface:			
Average current [cm/s]	28,7	17,7	9,6
Maximum current [cm/s]	117,6	74,8	78,0
Residual current [cm/s]	7,6	1,4	2,3
Direction [°]	347	332	184
Near the seabed:			
Average current [cm/s]	16,4	12,9	6,0
maximum current [cm/s]	92,7	90,7	30,0
Residual current [cm/s]	6,6	2,3	0,4
Direction [°]	114	175	230
Source	LANGE et al. (1991)		BSH measurement (2005)

In the Baltic Sea, currents are primarily caused by the influence of wind (wind-driven current). Where a current meets the coast, stagnation also causes downward currents. A third factor is the freshwater discharge of the rivers, which is about 480 km³/year. With precipitation and evaporation taken into account, there is a freshwater surplus of 540 km³/year, which is about 2.5% of the water volume of the Baltic Sea. Tidal streams are negligible in the Baltic Sea. An annual average net outflow of 8 cm/s at the surface and average inflow of 7 cm/s at the seabed are observed in the Fehmarn Belt (LANGE et al. 1991). The average speeds here are on the order of 30 cm/s at the surface and 16 cm/s at the bottom. In the large basins east of the Belts, the near-surface velocities are in the range of 10-18 cm/s and 7-13 cm/s near the bottom.

Table 6 shows characteristic current parameters for the Fehmarn Belt, Bay of Mecklenburg and Arkona Basin.

2.2.2 Sea state and water level fluctuations

In a sea state, a distinction is made between waves generated by the local wind (the wind sea), and swell. Swell consists of waves that have left their area of origin. Due to the small size and irregular shape of the Baltic Sea, a fully developed swell rarely occurs. In the Arkona Sea the swell fraction is only about 4%. Swell has a longer wavelength and period than the wind sea.

The height of the wind sea depends on the wind speed and the length of time the wind acts on the surface of the water (duration of action), as well as on the fetch, i.e. the distance over which the wind acts. The significant wave height (Hs), i.e. the mean height of the upper third of the wave height distribution, is given as a measure of the sea state.

Seasonal variation of wind in the Arkona Sea (1961-1990) shows the highest speeds in December at about 19 kn, with a continuous drop to 13 kn in June. After that, the wind speed rises steadily again until the end of November. (BSH 1996). The annual average wind speed is 16.2 kn.

This annual cycle can be transferred to the average wave height of the sea state. It is just under 1.4 m in December, drops to about 1.15 m by the end of January and maintains this value until mid-March. Then the value drops steadily to 0.7 m until the end of May. From June onwards the wave height increases again continuously until December.

Water level fluctuations due to tides are negligible in the Baltic Sea. The tidal range of the semidiurnal tide at springs is less than 10 cm in the German EEZ. Due to its small size, the Baltic Sea reacts very quickly to meteorological influences (BAERENS & HUPFER 1999). Extremely high or low water levels are primarily caused by wind. Water levels of more than 100 cm above or below mean sea level are known as storm surges and reverse storm surges, respectively. On a long-term average, these extreme water levels are about 110 to 128 cm above and 115 to 130 cm below mean sea level. Individual events can lie significantly above these values. In addition to storm surges and reverse surges, natural oscillations of the Baltic Sea basins cause water level fluctuations on the order of up to one metre.

For the 20th century, the annual maximum water levels in the Baltic Sea and the annual variability show a statistically significant positive trend with a significant increase in the 1960s and 1970s. Sea level fluctuations with periods above one year also correlate with fluctuations in the North Atlantic Oscillation Index (NAO).

Long-term factors influencing mean sea level in the Baltic Sea are the isostatic land uplift in the Gulf of Bothnia (9 mm/a) and the eustatic sea-level rise of 1-2 mm/a (MEIER et al. 2004). Estimates for global sea-level rise range from 0.09 to 0.88 m by 2100, provided that the West Antarctic ice sheet remain stable. If it melted, this would raise global sea levels by up to 6 m.

2.2.3 Surface temperature and temperature stratification

Figure 24: Climatological monthly averages of surface temperature (1900–1996) according to JANSSEN et al. (1999). based on the data of JANSSEN et al. (1999), shows an area-wide distribution of monthly average surface temperatures. In the climatological mean, the lowest temperatures occur in February. The data set of JANSSEN et al. (1999) comprises all available temperature measurements from 1900 to 1996. Summer warming starts in April and reaches its maximum in August. The cooling phase begins in September.

Between May and June, a strong thermal stratification forms, which reaches its maximum in August with temperature differences between surface and seabed of up to 12 °C. In the course of September, the thermal stratification decomposes rapidly, and in October the western Baltic Sea is largely vertically homothermic. Depending on meteorological conditions, significant deviations from the long-term average may occur in individual years.

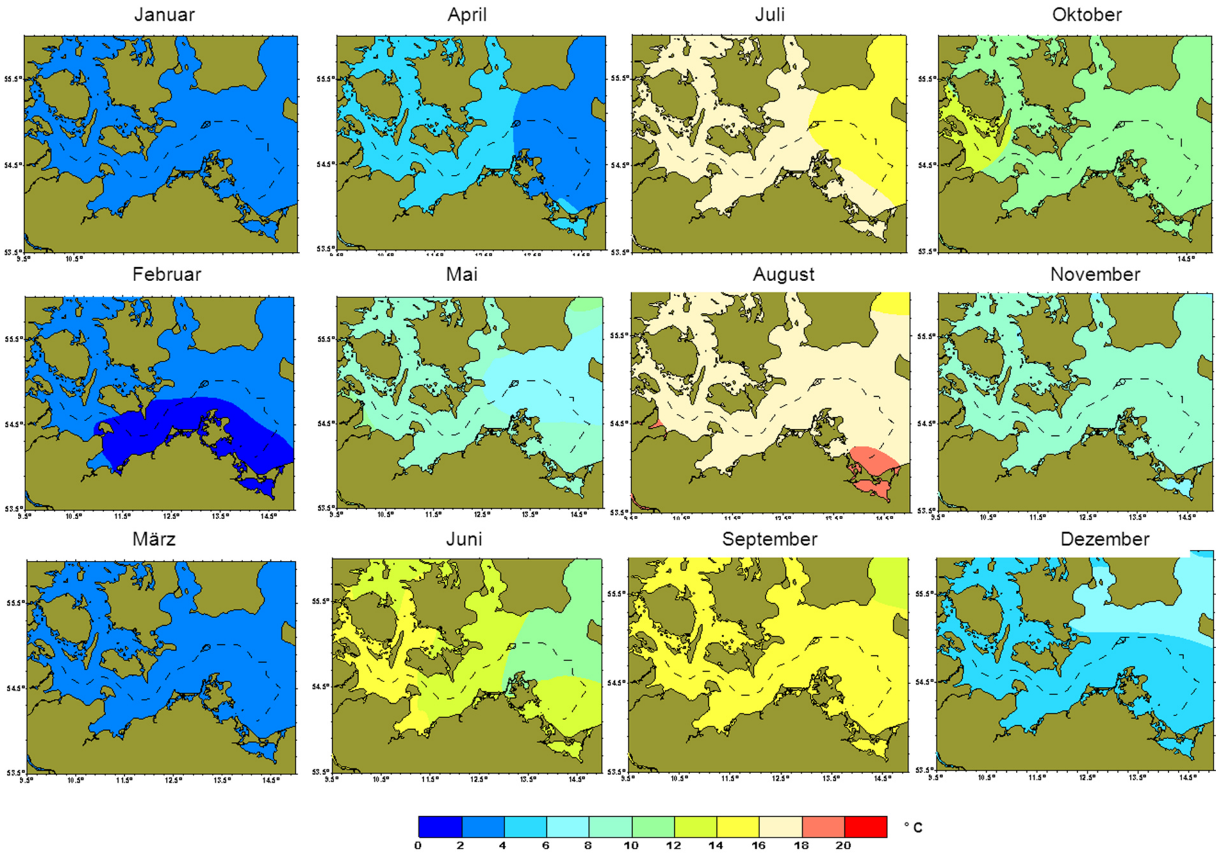


Figure 24: Climatological monthly averages of surface temperature (1900–1996) according to JANSSEN et al. (1999).

2.2.4 Surface salinity and salinity stratification

Salinity in the western Baltic Sea generally decreases from west to east, with horizontal gradients being particularly pronounced in the Belts and Øresund. Figure 25 shows the mean annual variation in salinity of the surface layer according to JANSSEN et al. (1999). The long-term average near-surface salinity in the Belt Sea can vary between 10 and 20 over the course of the year, while values between 6 and 8 are observed in the eastern Arkona Sea. The 10 isohaline is highlighted to illustrate the boundary between the low salinity brackish Baltic Sea water and the more saline water flowing into the western Baltic Sea from the Kattegat through the Belts and Øresund from the west. Due to the higher density of the saltier water, this inflow takes place primarily at the bottom and stratifies under the lighter surface water. The 10 isohaline reaches its westernmost position in the summer months and its easternmost position in December, when strong winter storms from the west push water from the Skagerrak and Kattegat into the western Baltic Sea.

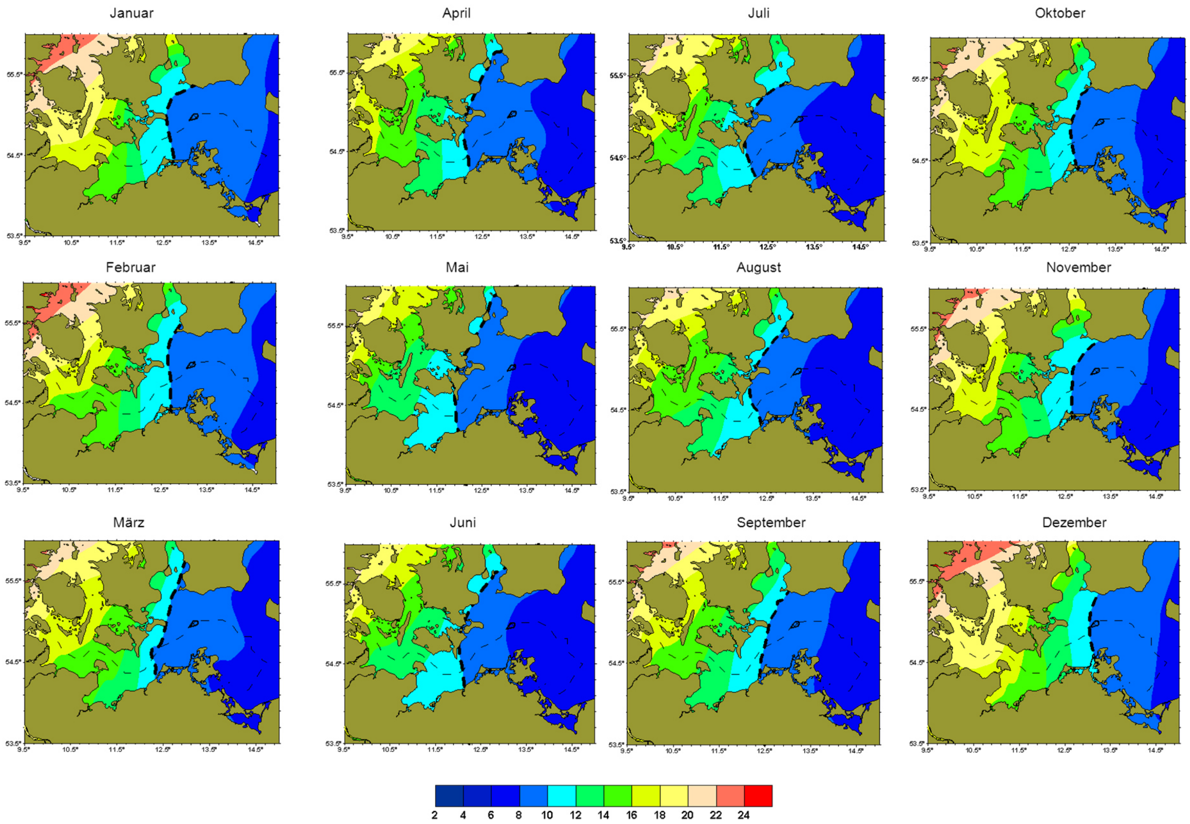


Figure 25: Monthly climatological averages of surface salinity (1900 - 1996) according to JANSSEN et al (1999).

The stratification of salinity is shown in Figure 26, based on the difference in salinity between bottom and surface. Large parts of the Belt Sea and the deep basins show year round haline stratification (water stratification caused by different levels of salinity) while shallow areas such as the Bay of Pomerania are vertically homohaline all year round, or show only very weak stratification. The haline stratification in the Belt Sea and deep basins intensifies in spring and reaches differences between surface and bottom salinity of more than 10 in summer.

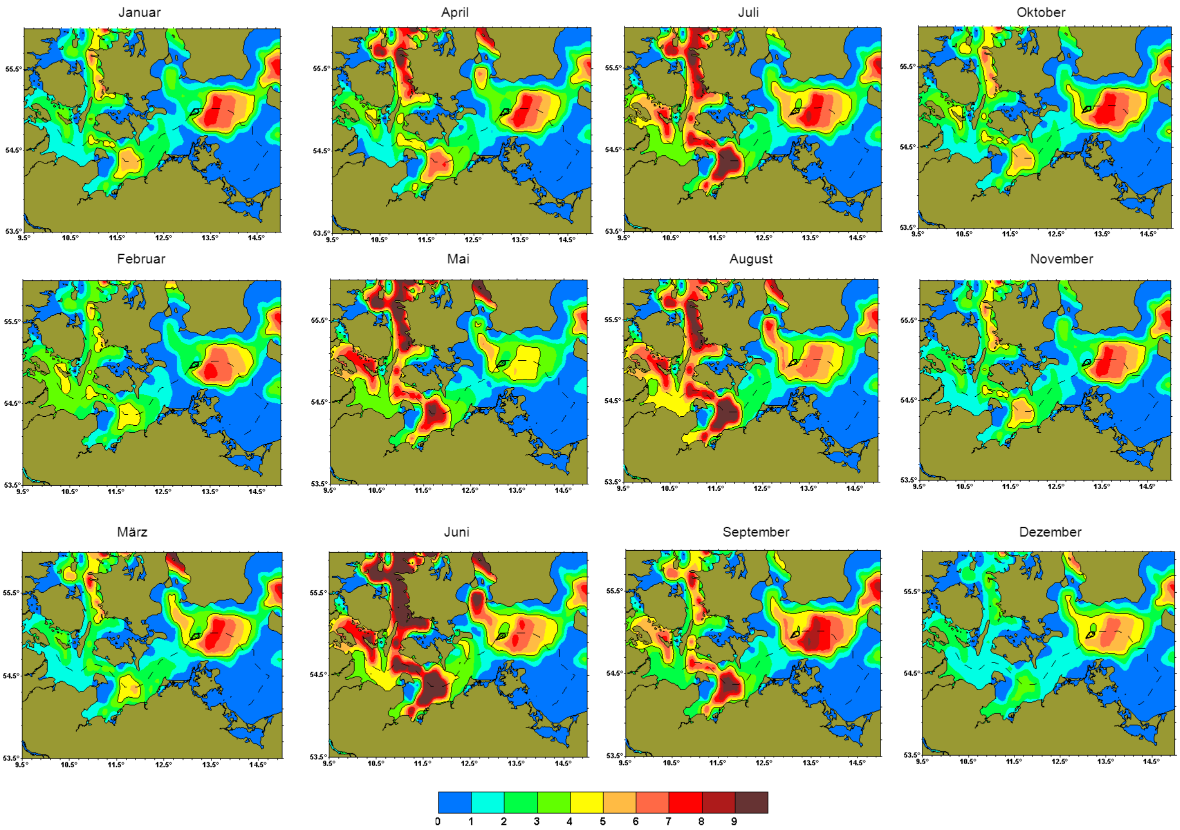


Figure 26: Stratification of salinity in the western Baltic Sea according to JANSSEN et al (1999).

2.2.5 Ice conditions

In the Baltic Sea south of 56° N, ice does not form regularly in winter. The large spatial and temporal variations in ice cover are a result of the nature and stability of the overall weather conditions prevailing over Europe. Ice formation can undergo four characteristic stages of development, which are determined by the severity of the winter, the regional oceanographic conditions and also by coastal morphology and sea depth. They are reflected in Figure 27 by the frequency distribution of ice occurrence.

In moderately icy winters, only shallow bays ice over completely. As they are relatively closed off from the sea, they have no significant water exchange with the warmer open sea. To a lesser extent, ice also forms on the outer coasts, especially off the eastern coast of Rügen and off Usedom.

In severely icy winters, the surface layer of the Bay of Kiel, Bay of Mecklenburg and Fehmarn Belt is cooled to such an extent that ice forms on the open sea. It grows into grey ice (ice thickness 10–15 cm). The degree of coverage is usually less than 60% of the water surface over a large area. East of the Darss Sill, ice occurs only in a narrow strip off the Baltic Sea coasts, and the degree of coverage is largely less than 60% of the water surface.

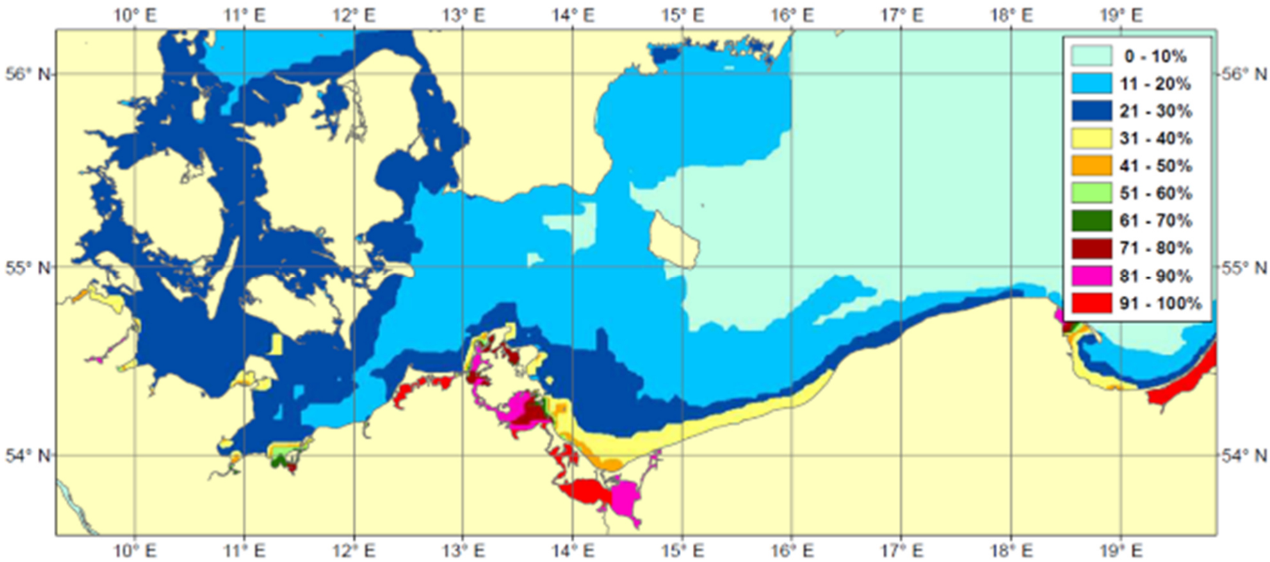


Figure 27: Frequency of ice occurrence in the Baltic Sea south of 56° N in the 50-year period 1961-2010 (BSH 2012).

During very rare extremely icy winters, the heat stored in the sea area between Bornholm and the Baltic coast – albeit significant due to the depth of water – is also depleted, so that continuous ice cover may form here. This rare state of icing occurred in the last century in the winters of 1939/40, 1941/42 and 1946/47.

In the 50-year period 1961–2010, ice in the Baltic Sea south of 56° N occurred with a frequency of 80 to 100% in shallow and sheltered bays, from 20 to 50% on the outer coasts and from 5 to 30% in the open sea area.

2.2.6 Suspended particulate matter and turbidity

The term suspended particulate matter (SPM) refers to all particles suspended in seawater with a diameter above 0.4 µm. Suspended particles consist of mineral and/or organic material. The organic part is strongly dependent on the season, with the highest values occurring during plankton blooms in early summer. During stormy weather conditions with a large swell, the suspended particle content in the entire water column increases sharply due to the resuspension of silty-sandy bottom sediments. The wind sea and, in deeper water especially, the swell have the greatest effect. In the shallow water areas of the Baltic Sea, the sandy sediment is often covered by a layer of fluff, which gets resuspended very easily and has a high proportion of organic material (EMEIS et al. 2000).

In the German EEZ of the Baltic Sea, available in-situ measurement data are highly inhomogeneous and insufficient for statistically reliable conclusions. As an initial estimate of the near-surface distribution of suspended particles, Figure 28 shows the monthly average for 2004 of the SPM content from the MERIS[3] data gathered by the European Space Agency's ENVISAT satellite.

[3] Medium Resolution Imaging Spectrometer remote sensing method

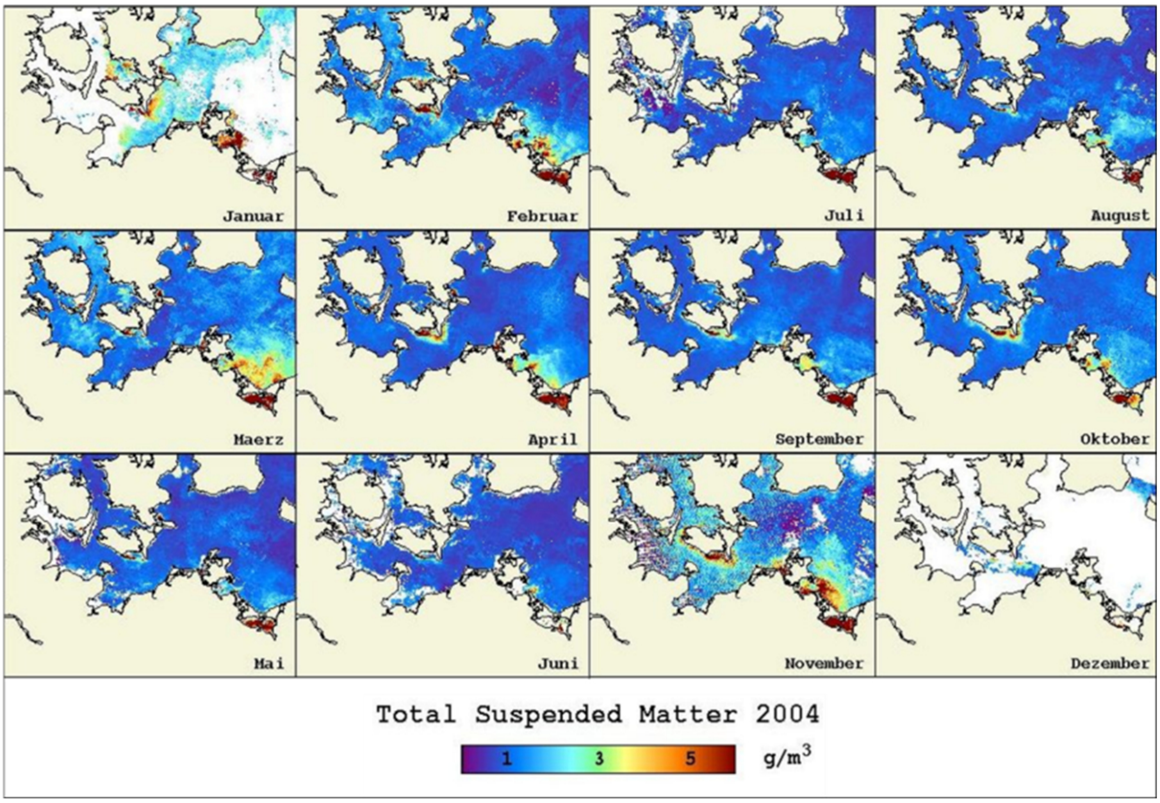


Figure 28: Monthly average of the total suspended particle content near the surface from the MERIS data gathered by the ENVISAT satellite for 2004.

The highest concentrations are observed in Stettin Lagoon and in the bodden. In spring, strong freshwater runoff (due to thaw) increases the amount of suspended particulate matter in the Bay of Pomerania. As easterly winds prevail in spring, suspended matter is transported mainly along the coast into the Arkona Sea (SIEGEL et al. 1999). The sedimentation rate in the Arkona Basin was estimated by EMEIS et al. (2000) to be about 600 g per m2 per year. An increased concentration of suspended matter is also visible year-round between the southern tip of Falster, the Gedser Odde, and the south-eastern coast of Lolland above Rødsand. This is primarily caused by current-induced cliff erosion.

2.2.7 Assessment of the state of nutrient and pollutant distribution

In general, the Baltic Sea area is a sensitive ecosystem with nutrients and pollutants remaining in the area for long periods of time, due to limited water exchange through the Belt Sea. Major problems continue to result from excessive nutrient loads and the resulting eutrophication phenomena. By nature, nutrient and pollutant loads are usually higher at river mouths and coasts and decrease towards the open sea.

2.2.7.1 Nutrients

Nutritive salts such as phosphate, inorganic nitrogen compounds (nitrate, nitrite, ammonium) and silicate are essential for marine life. They are vital substances for the formation of phytoplankton (microscopic unicellular algae floating in the sea), on whose biomass production the entire marine food chain is based. Since these trace substances promote growth, they are called nutrients. An excess of these nutrients, which occurred in the 1970s and 1980s due to extremely high nutrient inputs from industry, transport and agriculture, leads to a high accumulation of nutrients in seawater and thus to eutrophication. This continues in coastal regions even today. As a result, there may be an increased occurrence of algal blooms (in the Baltic Sea particularly cyanobacterial blooms), reduced visibility, changes in species composition, and oxygen deficiency near the seabed.

To monitor the nutrients and the oxygen content, the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) carries out several monitoring trips per year on behalf of the BSH. In the Baltic Sea as in the North Sea, a typical annual cycle of nutrients may be observed, with high nutrient concentrations in winter, followed by a sharp decrease in concentrations with the onset of biological activity in spring.

In spatial terms, nutrient concentrations in inshore waters are generally two to three times higher than in the open sea off the outer coast, and these differences are more pronounced for nitrate concentrations than for phosphate concentrations. Particularly in the shallow areas of the Baltic Sea, varying stratifications of temperature and salinity lead to highly variable nutrient distributions. Furthermore, in these shallower areas, exchange processes between water and sediment – in particular the dissolution of phosphorus – play a major role for concentrations in the water column.

The occurrence of oxygen-deficient areas is a natural phenomenon in the Baltic Sea due to the limited water exchange with the North Sea and the permanent stratification of bodies of water in some areas. However, eutrophication and the associated increased decomposition of organic material is leading to an increase in the frequency, intensity and spatial extent of oxygen deficiency. As the release of phosphorus from sediment occurs particularly in the presence of oxygen deficiency, this further increases eutrophication.

Although transport of phosphorus and nitrogen compounds by German tributaries to the Baltic Sea has been decreasing since the 1990s, the eutrophication problems of the Baltic Sea are only decreasing very slowly due to this internal fertilization. The follow-up assessment under the EU Marine Strategy Framework Directive (MSFD) therefore concludes that 100% of the German Baltic Sea continues to be eutrophicated (BMU 2018). The greatest exceedance of the concentrations of dissolved inorganic nitrogen (DIN) was found in the Bornholm Basin, due to the influence of the Oder plume. The same applies to the concentrations of total nitrogen (TN) and total phosphorus (TP). The evaluation (except for TN and TP as additional national indicators) is based on the HELCOM Eutrophication Assessment Tool HEAT 3.0, which classifies the entire Baltic Sea – with the exception of smaller areas in the northern Baltic Sea and Kattegat – as eutrophicated (HELCOM 2017).

2.2.7.2 Oxygen

The deeper areas of the western Baltic Sea are characterised by oxygen depletion in summer. The intensity of oxygen depletion depends on meteorological (temperature, wind) and hydrographic (stratification) factors, and the level of nutrient inputs from the drainage basin. The year 2002 represents an extreme situation with extreme oxygen depletion especially off the Danish and Schleswig-Holstein coasts. Hydrogen sulphide was widespread, with its negative consequences for seabed fauna. In the deep basins of the central Baltic Sea, the frequency and intensity of saltwater influx from the North Sea, which is necessary for water renewal and aeration, has decreased significantly since the mid-1970s. In the last 30 years, significant inflow events were only observed in 1983, 1993 and 2003. In between there have been long periods of stagnation with significant concentrations of hydrogen sulphide in deep water.

Due to limited water exchange with the North Sea, the bottom morphology, and the permanent haline stratification, periods of stagnation regularly occur in the deep waters of the central Baltic Sea. Salinity and oxygen concentrations are decreasing and considerable accumulations of hydrogen sulphide are being formed. Deep water can only be renewed by saltwater inflows, which transport salt and oxygen-rich water into the deep basins.

2.2.7.3 Metals

The metals cadmium, mercury, lead and zinc show a characteristic spatial distribution with a gradient decreasing from west to east in the surface waters of the EEZ (cf. BMU, 2012b). The elements lead, cadmium and mercury are below the reference values. On the basis of current knowledge, the above-mentioned metal pollution of seawater does not pose an immediate threat to the marine ecosystem.

2.2.7.4 Organic pollutants

The more polar compounds such as the HCH isomers and modern pesticides (triazines, phenylureas and phenoxyacetic acids) are present in the water at much higher concentrations than the more lipophilic, "classic" pollutants such as HCB, DDT, PCBs and PAHs. From 2012–2018, the herbicide diflufenican exceeded the threshold values along the coast of Mecklenburg-Western Pomerania (within 1 nautical mile) (MSRL Status Report 2018).

The HELCOM indicator for the new priority substance perfluorooctanesulphonic acid (PFOS) shows concentrations in water significantly exceed the threshold values, especially along the coasts. The lipophilic chlorinated hydrocarbons (HCB, DDT and PCB) are found in water only in very low concentrations (mostly < 10 pg/L). Pollution is generally higher near the coast than in the open Baltic Sea. No temporal trends can be observed due to the high variability and limited data available.

The Baltic Sea is polluted with organotin compounds, which were frequently used as ship paints in the past. Dibutyltin (DBT), for example, shows an exceedance in the Unterwarnow. The HELCOM indicator for TBT indicates an exceedance of the threshold value in the Baltic Sea (HELCOM 2018, MSRL Status Report 2018).

Pollution of Baltic Sea water with petroleum hydrocarbons is low. Identification of the individual components shows that the aliphatic hydrocarbons come mainly from biogenic sources. The concentrations of PAHs are also relatively low and do not show any particular spatial distribution. The content of more highly condensed PAHs (4-6-ring aromatics) increase near the coast, which is largely due to a higher suspended matter content. Due to the high variability, no time trends can be observed for any of the different hydrocarbon classes, but there are seasonal differences, with highest values in winter (PAH). Exposure to toxically relevant PAHs is two to three orders of magnitude below those concentrations at which the first signs of carcinogenic effects were observed in animal experiments (VARANASI 1989).

Most concentrations of pollutants in the Baltic Sea waters are at similar levels to the German Bight. Slightly higher concentrations of DDT have been observed in the Baltic Sea. The values are also slightly higher for γ-HCH. The concentrations of α-HCH are about three times and those of β-HCH at least ten times higher than in the North Sea. In contrast to the southern North Sea, the spatial distribution in the western and central Baltic Sea is characterised by the absence of major input sources. For this reason, gradients are small or non-existent. Long-term trends have only been found for the HCH isomers. Here, significant decreases in concentrations can be observed both in the short and long term.

Pollutants in the water of the Baltic Sea that exceed the threshold values are mainly pollutants that are already regulated or banned. However, due to the persistence of these substances, only a slow decrease in concentrations can be expected. The introduction of further pollutants would lead to increased pollution of the Baltic Sea.

2.2.7.5 Radioactive substances (radionuclides)

The Chernobyl accident and subsequent fallout have significantly altered the inventory of artificial radionuclides, in particular Cs-134 and Cs-137, with significant deposits in the Gulf of Bothnia and the Gulf of Finland. In the years following the accident, these high levels of contamination were also transported into the western Baltic Sea by the surface waters. The radioactive contamination of the Baltic Sea has decreased in recent years. Because the water exchange between the Baltic Sea and North Sea via the Danish straits averaged over many years is so low, the radioactivity introduced by Chernobyl remains in the water of the Baltic Sea for a long period of time. The concentrations of Cs-137 still increases slightly towards the east, the focal point of the fallout from Chernobyl. Concentrations of Cs-137 are still higher than the levels before the Chernobyl accident in April 1986, which coincides with the HELCOM threshold (15 Bq/m³) (HELCOM 2018). Concentrations are expected to be below this threshold in the next status report in 2024.

Among the artificial radionuclides, this nuclide contributes the most to a possible dose via the "seafood consumption" exposure route. However, a significant dose from this source or from time at sea or on the beach is not to be expected.

2.3 Plankton

Plankton includes all organisms that drift in the water. These mostly very small organisms form a fundamental component of the marine ecosystem. Plankton includes plant organisms (phytoplankton), small animals and developmental stages of the life cycle of marine animals, such as eggs and larvae of fish and benthic organisms (zooplankton), as well as bacteria (bacterioplankton) and fungi.

2.3.1 Data availability and monitoring programmes

In the Baltic Sea, regular surveys of phytoplankton and zooplankton have been carried out since 1979 under the Helsinki Convention (HELCOM). Within the framework of the COMBINE monitoring programme of HELCOM, investigations into both phytoplankton and zooplankton have been carried out by the countries bordering the Baltic Sea, using a large-scale station network in the Baltic Sea. This data is now freely available through the International Council for the Exploration of the Sea (ICES). In addition, coastal waters are sampled for plankton within the framework of the national marine surveillance for the Baltic Sea.

In the western Baltic Sea, the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), among others, examines plankton samples from stations in the coastal waters and in the German EEZ as part of the national monitoring programme. The German EEZ of the Baltic Sea has been covered by a total of 5 stations since 1979: one in the Bay of Mecklenburg, one at the Darss Sill, two in the Arkona Sea and one at the Oder Bank. The IOW takes two samples per year (on the outward and return journey) at each station on a total of five trips. In addition, the number of samples per station is adjusted based on the prevailing water stratifications (thermocline and halocline), so conclusions can be made on the vertical distribution of plankton. Vertical sampling is particularly relevant for the detection of zooplankton, as different communities occur at different depths within the water column. In 2015, a total of 65 samples were taken. The monitoring missions took place in February, March, April/May, July and October/November. However, there is no continuous sampling of plankton. This means that understanding of the occurrence of plankton communities is incomplete. In particular, long-term changes in plankton and the causes cannot be tracked precisely.

2.3.2 Spatial distribution and temporal variability of phytoplankton

Phytoplankton is the lowest living component of the marine food chains and comprises small organisms, mostly up to 200 µm in size, which are taxonomically classified as belonging to the plant kingdom. They are microalgae, either consisting of a single cell or being able to form chains or colonies of several cells. Phytoplankton organisms are predominantly autotrophic, i.e. through photosynthesis they can use the inorganic nutrients dissolved in water to synthesise organic molecules for growth. Phytoplankton also includes microorganisms that are heterotrophic, i.e. they can feed on other microorganisms. There are also mixotrophic organisms that can feed auto- or heterotrophically, depending on the situation. Many microalgae, for example, are capable of changing their diet during their life cycle. Bacteria and fungi form separate groups phylogenetically (in terms of evolutionary history). When examining phytoplankton, bacteria, fungi and those organisms that are closer to the animal kingdom due to their physiological properties, are also taken into account. In this report the term phytoplankton is used in this extended sense.

Around 800 different phytoplankton species occur in the Baltic Sea (WASMUND 2012). Phytoplankton of the western Baltic Sea include the following important taxonomic groups:

- diatoms (bacillariophyta*),*
- dinoflagellates (dinophyceae),
- microalgae or microflagellates of different taxonomic groups, and
- blue-green algae (cyanobacteria). These dominate fresh and brackish water areas. In waters with low salinity, such as the Baltic Sea, this group can be very abundant.

Phytoplankton serves as a food source for organisms that specialise in filtering the water for food. The primary consumers of phytoplankton include zooplanktonic organisms such as copepods and water fleas (Cladocera).

The special nature of the Baltic Sea as a semi-enclosed sea also leads to special ecological characteristics, and shapes the occurrence of biological communities. Overall, the Baltic Sea is characterised by limited species diversity (biodiversity). The brackish water of the Baltic Sea has salinity that decreases from 20 PSU in the west to 1 PSU in the eastern area. The water masses of the Baltic Sea also show strong stratification. As a result, the spectrum of species includes both marine and freshwater species. The special conditions in the Baltic Sea also mean that the marine food chains are highly sensitive to changes.

The occurrence of phytoplankton depends primarily on the physical processes in the water column. Hydrographic conditions, in particular temperature, salinity, light, currents, wind, turbidity, topography and exchange processes influence the occurrence and biodiversity of phytoplankton. The direct dependence of phytoplankton on light for photosynthesis restricts its occurrence to the euphotic zone of the pelagic. The depth of the euphotic zone depends on the clarity or turbidity of the water. The turbidity of the Baltic Sea varies greatly between different regions. Turbidity has increased dramatically over the past 25 years in many regions of the Baltic Sea. The increase in turbidity has favoured the growth of blue-green algae, and often leads to excessive blue-green algal blooms in summer. However, in 2015, blue-green algal bloom in the whole Baltic Sea remained below the extent observed in recent years. This was due to the lower sea surface temperature (SST) in the summer months compared to previous years.

Aside from the physical processes, the concentration of nutrients dissolved in the water determines the abundance and biomass development of phytoplankton. In addition, the distribution and abundance of plankton is affected by various other natural and anthropogenic factors. In the North Sea and Baltic Sea area, for example, the North-East Atlantic Oscillation (NAO) is vital for the natural succession of plankton. River discharge also influences the development of plankton – both through freshwater runoff and through nutrient and pollutant transport. Although some plankton species and developmental or dormant stages use sediment as a habitat, the water masses represent the real habit of plankton. Therefore, unlike the benthos, for example, spatial delimitation of habitat types is only possible to a very limited extent for plankton. The hydrographic properties of water masses are more decisive for associations of plankton species.

Seasonal phytoplankton growth in the Baltic Sea shows fixed patterns. Salinity, water depth, and how long the water remains at a certain location determine the occurrence and development of phytoplankton (THAMM et al. 2004). In spring, shallow coastal waters warm up more quickly and favour the growth of phytoplankton. In addition, nutrient inputs via rivers favour growth.

The spring bloom is usually dominated by diatom species. Spring algal blooms are triggered by the accumulation of nutrients in the preceding winter months, the increase in light intensity and the resulting warming of the water.

The spring bloom in the Bay of Mecklenburg in 2015 was not dominated by diatom species as is usually the case. Instead, dinoflagellates, dictyochophyceae and prymnesiophyceae dominated. However, the Bay of Mecklenburg is a very diverse system, so these shifts could also be due to measurement inaccuracies. In the Arkona Sea, the bloom started with *Mesodinium rubrum*. In mid-March, the bloom was dominated by diatoms (WASMUND et al. 2016a). The boundary between different bloom formations usually runs between the western and central Baltic Sea at the Darss Sill. In 2015, this boundary ran along the eastern Bay of Mecklenburg. The spring bloom grew until mid-March 2015 and disappeared in mid-April, with nitrate being the limiting nutrient factor this year (WASMUND et al. 2016a).

Each year, different species of diatoms such as *Thalassiosira levanderi, Skeletonema costatum, Thalassiosira baltica, Dictyocha speculum* and *Chaetoceros* sp. provide the spring algal bloom. In May the diatoms usually stop blooming abruptly. At the same time, dinoflagellates increase. In particular, dinoflagellates are then found in high concentrations even in deeper areas (15 m). It is likely that flagellates use nutrients from deeper water layers or low concentrations of regenerated nutrients. *Gymnodinium* sp. and *Peridiniella* sp. are among the most common taxa of dinoflagellates (WASMUND et al. 2005). In the summer months of July and August, blue-green algae occur in high concentrations and often cause extensive blooms. Blue-green algal blooms are favoured by salinity values between 3.8 and 11.5 PSU, temperatures around 16°C, insolation above 120 W/m2 (daily averages) and wind speeds of less than 6 m/s. The development of blue-green algal blooms comes to an end when weather conditions deteriorate (low insolation or strong winds) (WASMUND 1997). In autumn, diatom blooms develop again, but these are very weak compared to spring blooms (WASMUND et al. 2005). Over the past 30 years, the species composition of diatoms has been changing continuously in the summer and autumn bloom. The species of the diatom genera Skeletonema and Chaetoceros are successively being replaced by *Ceratulina pelagica*, *Dactyliosolen fragilissimus*, *Proboscia alata*, and *Pseudo-nitzschia* spp.

Eutrophication is a major threat to the Baltic Sea marine ecosystem. The concentration of chlorophyll$_a$ in the water, as a measure of phytoplankton biomass, provides information on the degree of eutrophication. In the Arkona Sea, the concentration of chlorophyll$_a$ in the water is much lower than in the Bay of Finland or the northern Baltic Sea (HELCOM 2004). Between 1993 and 1997, average primary production in the Arkona Sea varied between 37 mg C*m^{-2} per day in January to February and 941 mg C*m^{-2} per day in June to September (WASMUND et al. 2000).

Series of measurements by the IOW from 1979 to around 1995 show a significant increase in chlorophyll$_a$ concentration during this period. Since this time, measurements have been at a consistent high level, or have decreased slightly (WASMUND et al. 2016a). The high nutrient concentrations (mainly nitrate and phosphate) introduced in the 1970s affected the proliferation of spring blooms in particular, while summer and autumn blooms remained largely constant in character. The Bay of Mecklenburg is an exception, with a continuous decrease in spring bloom since measurements began in 1979 (WASMUND et al. 2016b).

2.3.3 Spatial distribution and temporal variability of zooplankton

Zooplankton includes all minute marine animals that drift or migrate in the water column. Zooplankton plays a central role in the marine ecosystem. On the one hand, as the lowest secondary producer within the marine food chain it is a food source for carnivorous zooplankton species, fish, marine mammals and seabirds. On the other hand, zooplankton has a special significance as a primary consumer (grazer) of phytoplankton. Grazing can stop algal bloom and regulate the decomposition processes of the microbial cycle by consuming the cells.

In the Baltic Sea, the succession of zooplankton shows a pronounced seasonal pattern. Maximum abundances are generally reached in the summer months. The succession of zooplankton is of critical importance for secondary consumers of the marine food chains. Predator-prey ratios and trophic relationships between groups or species regulate the marine ecosystem. Temporally or spatially staggered occurrence of succession and abundance of species leads to the interruption of food chains. In particular, temporal displacement, so-called trophic mismatch, results in food shortages at different developmental stages of organisms, with effects on the population level.

Zooplankton is divided into two large groups based on the survival strategies of the organisms:

- *Holozooplankton:* The entire life cycle of these organisms takes place exclusively in the water column. Among the best-known *holoplanktonic* groups of significance for the Baltic Sea are crustaceans such as *copepods* and *cladocera* (water fleas).
- *Merozooplankton:* Only certain stages of the life cycle of these organisms, mostly the early life stages such as eggs and larvae, are planktonic. The adult individuals then change over to benthic habitats or join the nekton. These include early life stages of bristle worms, bivalves, snails, crustaceans and fish. Pelagic fish eggs/fish larvae are abundant in meroplankton during the reproduction period.

In 2015, merozooplankton was particularly abundant in the Bay of Kiel, but reached below-average abundances in the Arkona Basin and the Bay of Mecklenburg. Among the main representatives were larvae of polychaetes and mussels (WASMUND et al. 2016a).

The genera *Acartia* and *Oithona,* belonging to the holozooplankton, were the main representatives among the copepods in 2015 with *Acartia bifilosa* as the most abundant species (WASMUND et al. 2016a).

As mentioned above, marine invertebrates have various stages of development that occur in plankton (e.g. larvae). The dispersal of larvae largely determines the occurrence and population development of both nektonic and benthic species. The transport, dispersal and successful settlement of larvae are of particular importance for the spatial distribution of the species and the development of their populations. The dispersal of larvae is determined both by the movements of the water masses themselves and by endogenous or species-specific characteristics of the zooplankton. Environmental factors that may influence larval dispersal, metamorphosis and settlement include sediment type and structure, meteorological conditions (particularly wind), light, temperature and salinity.

Two transport mechanisms influence the dispersal of the larvae and their settlement in the final habitat: horizontal advection of the larvae with the prevailing current direction, and diffusion through small-scale and mesoscale turbulence, i.e. mixing processes in the water body. Field studies have shown that larval settlement can take place both locally and far removed. The dispersal of larvae from coastal waters is mostly regulated by frontal zones between coastal waters and the open sea. However, the larvae have a limited ability to migrate vertically within the water column to reach areas that allow them to cross the boundary, such as areas of increased turbulence. Each species of organisms develops strategies that help the larvae to spread and settle successfully. Such strategies, which ultimately ensure the survival of the species, range from adjusting reproduction time, depth and area to vertical movements of the larvae and active crossing of boundary layers. Larval competence, or maintaining the ability to initiate metamorphosis until favourable conditions arise, regulates the success of individuals of each species in settling in the species-specific habitat (GRAHAM & SEBENS 1996).

Characterisation of habitat types based on the presence of zooplankton is difficult. As already explained for phytoplankton, the zooplankton habitat consists of water masses. A characterisation of water masses and associated zooplankton is therefore useful. When differentiating water masses, it is not the spectrum of zooplankton species populations that is important, but rather the proportion of the respective species, especially key species, in the composition of the associations.

In Baltic Sea biocoenoses, a shift in vertical distribution occurs due to the variability in salinity. This phenomenon was described by REMANE (1955) as submergence. Animals of the eulittoral and supralittoral zone tolerate greater fluctuations in salinity than animals of the sublittoral or the deep sea. They can therefore penetrate further into brackish water than deep sea species. Only a few species can also penetrate the depths, namely those that are carnivorous. However, the phenomenon of brackish water submergence is not unique to the Baltic Sea, but is typical of brackish waters (REMMERT 1968). In the Bay of Kiel, for example, the copepod *Oithona similis* occurs near the surface in concentrations of several thousand individuals per m^3. East of the faunistic boundary of the Darss Sill, on the other hand, this species is found in deep, salty water. Sampling at the Arkona Sea station after the saltwater inflow of 2003 showed that with increasing water depth, the abundance of this species increased from 2,400 females per m^3 in the upper 5 m to 31,500 females per m^3 between 18 and 22 m water depth (WASMUND et al. 2004).

On average, 22 zooplankton taxa occur in the Baltic Sea each year (WASMUND et al. 2005). However, only 12 taxa were encountered year-round in the period from 1999 to 2002 (POSTEL 2005). In general, spectrum of species, abundance and dominance conditions depend on the prevailing hydrographic and meteorological conditions and the development of the phytoplankton. Saltwater influxes from the North Sea supply the Baltic Sea ecosystem with marine species such as the copepod *Paracalanus parvus* and the anthomedusa *Euphysa aurata*. The arrow-worm *Sagitta elegans* occurs after the autumn and winter storms.

During long periods of stagnation, on the other hand, the brackish water copepod *Limnocalanus macrurus* occurs frequently in the southern Baltic Sea (POSTEL 2005). Mild winters and warm summers also influence the occurrence and abundance. For example, thermophilic species such as the copepods *Acartia tonsa* and *Eurytemora affinis* occur more frequently in particularly warm summer months. The occurrence of merozooplankton is controlled by the oxygen conditions on the seabed and the reproduction cycles of benthic organisms.

In 2015, significantly more zooplankton taxa were recorded at 9 IOW stations from the western Baltic Sea to the western Gotland Basin than in previous years. 61 taxa were registered in 2015, while 45 taxa were identified in 2014 and 52 taxa in 2013. This species increase is attributed to a strong saltwater influx from the North Sea in the previous year (WASMUND et al. 2016). The most recent comparably strong influx occurred in 1880 (Mohrholz et al., 2015, Nausch et al., 2016). Among the most numerous new species that occurred were *Acartia clausi*, *Calanus spp*., *Centropages typicus*, *Corycaeus spp*., *Longipedia spp*., *Oithona atlantica* and *Oncaea spp*.

High abundances of cladocera (water fleas) are usually found in the waters of the Bay of Mecklenburg and the Arkona Basin. In 2015, however, no occurrence of Cladocera could be detected (WASMUND et al. 2016a). Zooplankton development in the Bay of Mecklenburg and the Arkona Basin in 2015 was characterised by early growth compared to previous years. This led to an early population maximum in spring (March), usually reached in summer/autumn. Overall, zooplankton abundances have been declining since 2000. This trend continued in 2015. With 130 x 10^3 individuals per m^3, the total zooplankton abundance was at its lowest level since 1995 (WASMUND et al. 2016a).

2.3.4 Assessment of the state of the plankton

Based on the findings presented, only very limited conclusions can be drawn about the state of the plankton and the resulting effects on marine food chains. Firstly, there is a lack of consistently implemented monitoring programmes and long-term series of measurements to identify or differentiate between natural processes and anthropogenic changes in plankton development. Secondly, the influence of physical processes or hydrodynamics on plankton is profound. For example, phytoplankton data is of limited use in distinguishing between the effects of eutrophication and natural processes (ICES 2004).

The entire ecosystem of the Baltic Sea has undergone changes in recent years. Anthropogenic influences and climate change, in addition to natural variability, govern these changes. From the beginning of the 1980s onwards, slow changes and, in 1987/1988, abrupt changes have been observed throughout the Baltic Sea ecosystem. The changes in plankton are related to these observations.

Phytoplankton

The evaluation of phytoplankton data reveals changes in the spectrum of species, abundance and biomass. An increase in phytoplankton biomass can be observed. For years, the IOW has observed a decrease in diatoms in the spring bloom in favour of dinoflagellates (WASMUND et al. 2000). In recent years an increased occurrence of algal blooms, an aperiodic and unpredictable occurrence of toxic algal blooms and the introduction of non-native species have also been observed. However, it remains unclear to what extent eutrophication, climate change or simply natural variability contribute to the changes in phytoplankton (EDWARDS & Richardson 2004). The variability of hydrographic parameters governs and potentially restricts biological events.

Nutrient concentrations and the subsequent phytoplankton reaction to nutrient supply do, however, show pronounced seasonal effects. In the summer months in particular, nutrient supply is much more critical for phytoplankton growth than the accumulation of nutrients in winter, which only really stimulates spring growth. The spatial variability in nutrient uptake and utilisation between phytoplankton in coastal waters and offshore phytoplankton further complicates the evaluation of eutrophication effects on plankton development (PAINTING et al. 2005). Findings from large-scale investigations and research projects (HELCOM, IOW) have documented the high variability of phytoplankton occurrence in the Baltic Sea.

Phytoplankton growth developed in parallel with increasing nutrient inputs. Chlorophyll$_a$ concentrations increased significantly from the first chlorophyll measurements in 1979 until the mid-1990s, i.e. increased growth in the mass of microalgae was observed every year. Since then the values have stagnated or even decreased. Overall, however, phytoplankton abundance in the Baltic Sea is still at a very high level. An excessive supply of nutrients causes changes in the structure and functionality of the ecosystem.

In the case of phytoplankton, the following direct effects have been described with regard to eutrophication (HELCOM 2006): an increase in primary production and biomass, a change in the spectrum of species, an accumulation of algal blooms, an increase in turbidity and reduction in light penetration depth in the water, and an increase in sedimentation of organic material.

The IOW compiles comprehensive lists of diatoms and dinoflagellates for the Baltic Sea on an annual basis. For years it has been observed that the number of diatoms decreases in favour of dinoflagellates during the spring bloom (WASMUND et al. 2000). ALHEIT et al. (2005) have analysed the existing long-term data from the Heligoland Roads and the Baltic Sea station K2 Bornholm for changes. It was found that the ecosystems of the North Sea and Baltic Sea have undergone simultaneous changes with divergent consequences for the marine food chains since 1987. This is all the more significant when the completely different hydrographic conditions of the North and Baltic Seas are taken into account. These changes affect all levels of the food chains, from phytoplankton to upper secondary consumers. For both ecosystems, the changes correlated with changes in the NAO.

Under certain conditions, phytoplankton can pose a threat to the marine environment. In particular, toxic algal blooms (e.g. blue-green algal blooms) pose a major threat to secondary consumers of the marine ecosystem, and to humans. Toxic and potentially toxic species have been regularly identified in the Baltic Sea in recent years, occasionally in high abundance. The extreme proliferation or algal bloom of the toxic species *Chrysochromulina polylepis* from May to June 1988 led to mass mortality of fish and bottom-dwelling animals along the Norwegian coast in the Skagerrak (GJOSAETER et al. 2000). In 2015, the cyanobacterial bloom was smaller in terms of spread and density than in preceding years (ÖBERG 2016).

Avoidance reactions to toxic algal blooms in coastal waters have been documented in seabirds (KVITEK & Bretz 2005). Similar avoidance reactions are rarer in fish-eating offshore seabirds, and as a result they often fall victim to algal toxin accumulations in fish (SHUMWAY et al. 2003).

Zooplankton

Zooplankton is also affected by natural and anthropogenic changes. A creeping change may be demonstrated for the zooplankton of the western Baltic Sea in recent years. Species composition and dominance relationships within the zooplankton groups have changed. The number of non-native species has increased. Many non-native species have already established themselves. Many species typical for the area have declined, including those belonging to the natural food resources of the marine ecosystem. Evaluation of the data from the IOW monitoring trips has shown that the abundance of some zooplankton taxa has decreased in recent years, e.g. the maximum abundance of *Pseudocalanus spp.* an important food source for herring in the Baltic Sea (HELCOM 2004). In addition, there have been significant shifts in the spectrum of species (POSTEL 2005).

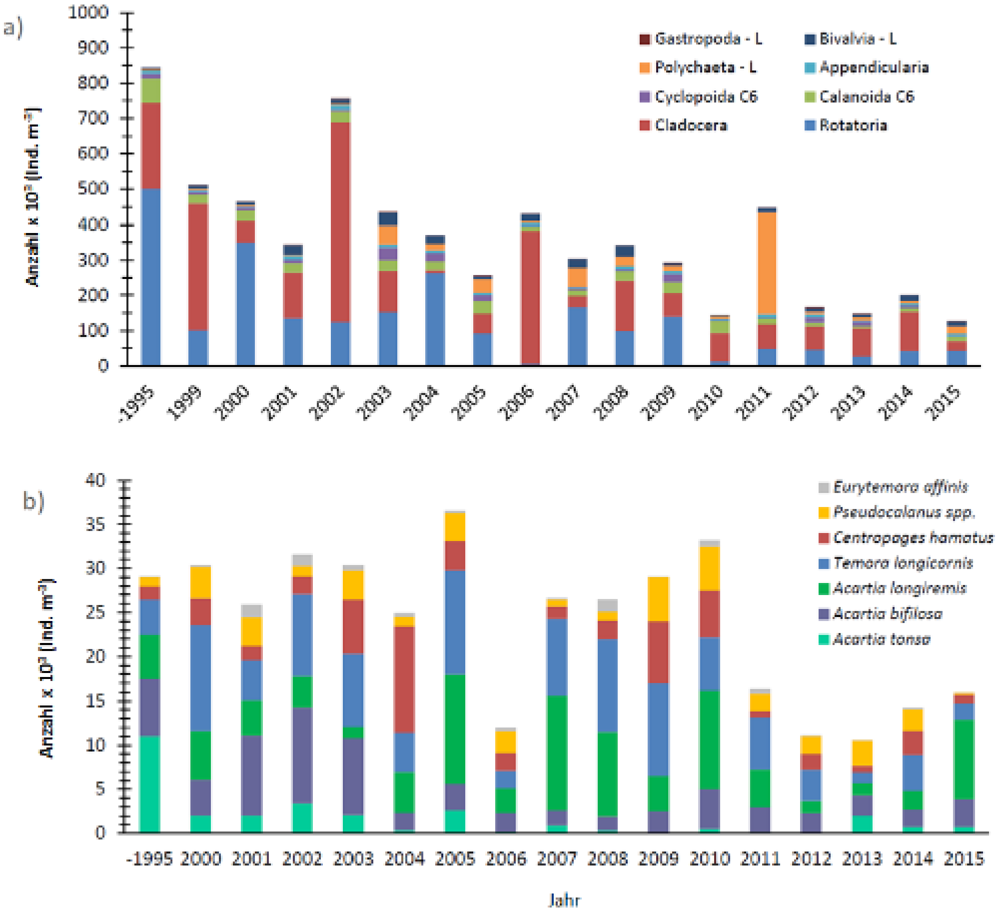


Figure 29: Development of abundance maxima of a) five holoplanktonic taxa (Rotatoria, Cladocera, Cyclopoida, Calanoida and Copelata) and three meroplanktonic taxa (Polychaeta, Bivalvia, Gastropoda) and b) seven calanoid copepods from 1995–2015 (WASMUND et al. 2016a).

The general trend in the IOW status report results shows a decrease in the overall abundance of the holozooplankton from 1995–2015 (Figure 29a). Apart from relatively high concentrations in 1995 and 2002, the sum of the maxima of all taxa under consideration reduced from 850 x 10^3 to 130 x 10^3 ind. per m³ between 1995 and 2015. In 2011, however, the sum of the respective maximum concentrations doubled compared to the previous year, due to a large increase in polychaete larvae and a moderate increase in rotatoria. The unusually high concentration of polychaete larvae is due to the synchronous release of the larvae, which must have coincided with the date of sampling in March. The low abundances in 2015 are due to a strong decrease in *Cladocera* and *Calanoida* compared to previous years (Figure 29a). Looking at individual calanoid copepods, it can be seen that the abundance of the species *Pseudocalanus spp*., *Temora longicornis* and *Centropages hamatus* tends to decrease. No clear trend can be seen for *Acartia spp.* (Figure 29b).

Changes were also observed in the zooplankton of the North Sea. Due to the exchange between the North Sea and Baltic Sea ecosystems, these changes are also relevant for the Baltic Sea. For example, the abundance of *scyphomedusae* (jellyfish) has decreased with rising water temperatures (LYNAM et al. 2004). Jellyfish feed primarily on fish larvae and may contribute to the depletion of fish stocks.

The authors therefore discuss the positive effects of climate change on the recovery of fish stocks – in this case caused by a reduction in predator abundance. Nevertheless, the simultaneous impact of other factors, such as eutrophication and fishing activity, cannot be ruled out.

Non-native species are increasingly influencing succession. These are mainly introduced by shipping (in ballast water) and mussel aquaculture. Changes in the species composition and possible species displacement due to the spread of non-native plankton cannot be ruled out. Indirect impacts of non-native species on the marine food chain cannot be ruled out either. Overall, it can be assumed that natural processes in plankton are endangered by the introduction of non-native species. Many non-native zooplankton species have already established themselves. The crustacean species *Acartia tonsa*, *Ameira divagans* and *Cercopagis pengoi* were introduced into the Baltic Sea by ballast water from ships. Recently, the introduction of the large comb jellyfish *Mnemiopsis leydei* has been the cause of increasing concern. If this comb jellyfish were to establish itself in the Baltic Sea and reproduce excessively as a result of warming, this would pose a threat to fish stocks. The large comb jellyfish feeds on larger zooplankton and in particular on fish larvae. However, there was no evidence of this in 2011 (WASMUND et al. 2012). Currently, no larger stocks of the comb jellyfish have been identified (WASMUND et al. 2016a).

As phytoplankton is transported and dispersed by currents, phytoplankton species also flow from the Atlantic into the Baltic Sea along with the water masses, and affect the natural succession (REID et al. 1990). In the phytoplankton, *Prorocentrum minimum* has been identified as the most important immigrant species. It probably entered the Baltic Sea naturally, has spread strongly from the west since 1981 and formed strong blooms, especially in the 1990s. *Prorocentrum minimum* (now called *Prorocentrum cordatum*) has now established itself in the Baltic Sea and occasionally develops dominant populations (WASMUND et al. 2016a).

Effects of climate change

In recent years, scientists have become increasingly concerned about climate change and its consequences for the marine ecosystem. BEAUGRAND (2004) analysed and summarised previous findings on the phenology, causes or mechanisms, and consequences of changes in the marine ecosystem of the northeast Atlantic and the North Sea. Considering the data from

1960 to 1999, statistical evaluations have shown a clear change or increase in the phytoplankton biomass after 1985. The increase in phytoplankton biomass was particularly pronounced in 1988. The increase in biomass coincides with the pronounced climatic and hydrographic changes of the years 1987 to 1988. BEAUGRAND (2004) suspects that changes in the marine ecosystem due to changes in hydrographic and meteorological conditions, especially after 1987, are strongly correlated with NAO development and that a shift in biogeographical boundaries has been taking place since the early 1980s as a result of the reorganisation of the biological structure of the ecosystem in the northeast Atlantic.

According to HAYS et al. (2005), changes in climate have particularly affected the distribution range of species and groups of the marine ecosystem. For example, zooplankton associations of warm-water species in the northeast Atlantic have extended their range by almost 1,000 km to the north. In contrast, the range of cold-water associations has shrunk. In addition, climate change has an impact on the seasonal occurrence of abundance maxima of various groups. A time-lagged shift in populations can have consequences for the entire marine food chain. EDWARDS and RICHARDSON (2004) even suspect that temperate marine ecosystems are particularly vulnerable to changes or temporal shifts in the development of different groups. The threat arises from the direct dependence of the reproductive success of secondary consumers on plankton (fish, marine mammals, and seabirds). Evaluation of long-term data for the period from 1958 to 2002 on 66 marine taxa have confirmed that marine planktonic associations react to climate change. However, the responses vary considerably in terms of association or group and seasonality.

BEAUGRAND & Reid (2003) have analysed long-term changes in three different trophic levels of the marine food chains (phytoplankton, zooplankton and fish) in connection with climate change. It was found that changes occurred with a time lag at all three pelagic levels. In 1982, a decrease in the number of Euphasiaceae (krill) was first observed. This was followed in 1984 by an increase in the abundance of small copepods. In 1986 there was an increase in phytoplankton biomass on the one hand and a decrease in the large copepod *Calanus finmarchicus* on the other. In 1988 there was a decrease in salmon stocks. In 1986, these changes initiated a new phase in the structure of the marine ecosystem in the northeast Atlantic and adjacent seas, which continues to this day. The increase in temperature seems to play a major role in this process.

Studies by SOMMER et al. (2007) also show that climate change can have an impact at several trophic levels. Higher mortality rates of Nauplius larvae, a developmental stage of copepods, were found at temperature increases of 2–6°C. Nauplius larvae are an important organism in the trophic network, as they are the main food of many fish larvae.

According to HELCOM, a surface water temperature increase of 2°C in the southern Baltic Sea and 4°C in the northern Baltic Sea can be expected by the end of the next century (HELCOM 2013a). In addition, a dramatic decrease in ice cover in winter is expected. Precipitation has increased already, and may increase more strongly on average, causing a reduction in salinity. The expected rise in temperature could lead to changes in the species composition of zooplankton (HELCOM 2013a).

A change in the size distribution of phytoplankton is another possible consequence of the rise in temperature. SOMMER et al. (2007), for example, found lower abundances of larger phytoplankton organisms at a temperature increase of only 2°C.

Changes in the seasonal pattern of growth in phytoplankton can also lead to trophic mismatch (the temporally staggered occurrence of groups that are dependent on each other for their food supply) within the marine food chains: Delayed diatom growth can affect the growth of primary consumers. Small copepods may suffer food shortages due to the absence of diatoms during the growth phase. In turn, copepods are an important part of the diet of fish larvae. Fish larvae would starve as a result of reduced copepod growth. Trophic mismatch has often been observed in various areas in recent years.

Plankton organisms react to adverse situations by means of species-specific survival and defence mechanisms. The best known of these mechanisms, which are important for survival, include diapause and spore formation (PANOV et al. 2004). Diatoms and dinoflagellates are able to develop resting cysts, which then winter in the sediment or wait for conditions favourable to growth.

2.4 Biotope types

According to VON NORDHEIM & MERCK (1995), a marine biotope type is a characteristic, typified marine habitat. Individual marine biotope types provide largely uniform conditions for marine biocoenoses, which differ from other types. Typification includes abiotic (e.g. moisture, nutrient content) and biotic features (occurrence of certain vegetation types and structures, plant communities, animal species).

The majority of the biotope types of Central Europe are also characterised in their specific features by the prevailing anthropogenic uses (agriculture, transport, etc.) and damage (pollutants, eutrophication, leisure use, etc.).

The current biotope type classification of the Baltic Sea was published by the Federal Agency for Nature Conservation (BfN) in the Red List of endangered biotope types in Germany (FINCK et al. 2017).

2.4.1 Data availability

As part of the BfN R&D project "Marine Landscape Types of the North and Baltic Seas", a spatial distribution pattern of most important sediment classes from an ecological point of view and, in some cases, higher-level biotope type classes, was developed (see Figure 30 Schuchardt ET al. 2010). It is, however, not possible to draw up sufficiently scientifically sound boundaries for the areas of marine biotope types on this basis. A modelled area-wide distribution of marine biotopes in the German Baltic Sea in accordance with the HELCOM "Underwater Biotope and Habitat Classification System" (HELCOM HUB) was developed by SCHIELE et al (2015). For this purpose, modelled distributions of less mobile macrozoobenthos species were combined with abiotic data (e.g. particle size, salinity, temperature, water depth etc.). Furthermore, the occurrences of reefs and sandbanks reported by the BfN can be used. Further important findings come from the data on biotope occurrence determined in the course of approval procedures for grid connections and wind farms. In the wind energy priority area EO1, the results of the biotope conservation assessment can be used, which were collected in the course of the two-year basic surveys from 2011 to 2013 (IFAÖ 2015, IFAÖ 2016).

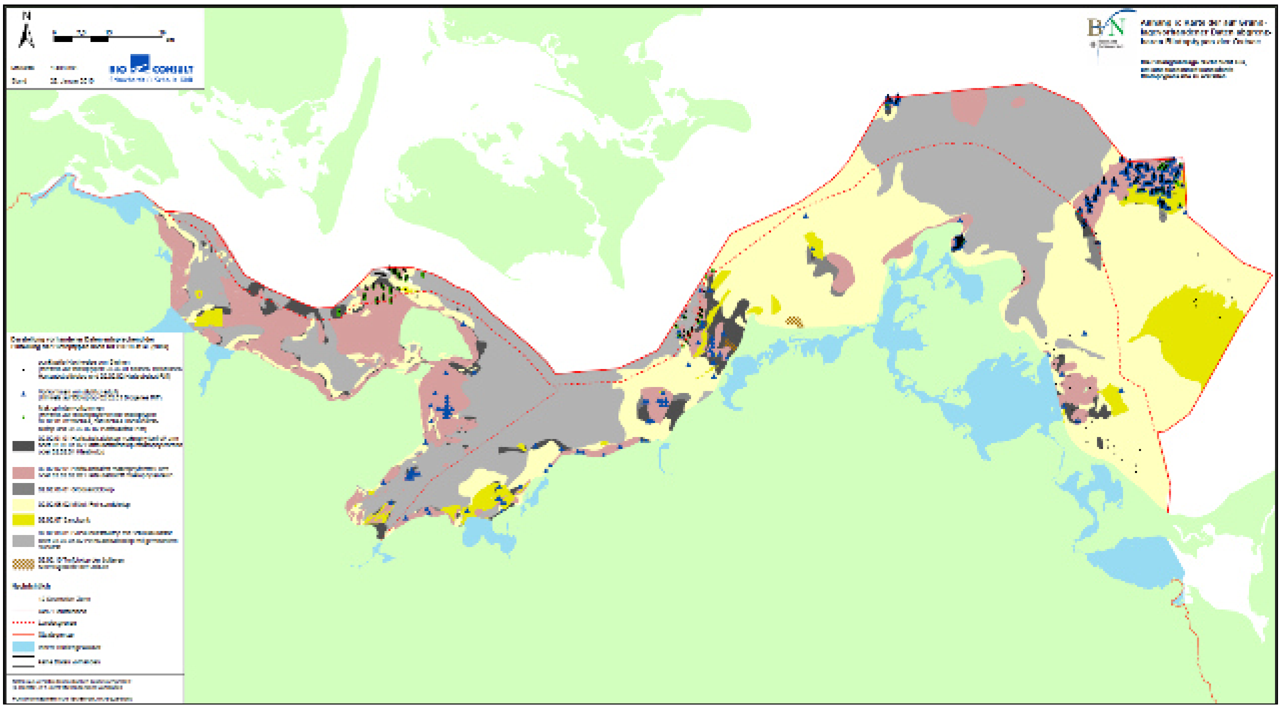


Figure 30: Map of the German Baltic Sea biotope types that can be defined on the basis of existing data (after SCHUCHARDT et al. 2010).

2.4.2 Biotope types in the German Baltic Sea

A current representation of the distribution of marine biotopes in the German Baltic Sea in accordance with the HELCOM "Underwater Biotope and Habitat Classification System" (HELCOM HUB) is shown in Figure 31. The analysis resulted the identification of a total of 68 HELCOM HUB biotopes for the German Baltic Sea area. According to SCHIELE et al. (2015), almost 60% of the German Baltic Sea area is covered by the following predominant HUB biotopes:

- Photic/aphotic sand with predominant colonisation by the bivalve species *Cerastoderma glaucum*, *Macoma balthica* and *Mya arenaria* (31.2%, code AA/AB.J3L9)
- Aphotic silty sediment dominated by the Baltic clam *Macoma balthica* (12.1%, code AB.H3L1)
- Photic/aphotic silty sediment dominated by *Arctica islandica* (9.6%, code AA/AB.H3L3)
- Photic/aphotic sand with *Arctica islandica* as the dominant species (6.3%, code AA/AB.J3L3)

Very few strong saltwater influx events have occurred in the Baltic Sea in recent decades. As a result, the deep water aphotic zone has seen prolonged periods of oxygen deficiency near the seabed. This has had a negative impact on the stocks of *Arctica islandica* in the deep basins of the Baltic Sea. For this reason, the two HUB biotopes characterised by *Arctica islandica* colonization are listed as endangered biotope types in the HELCOM Red List (HELCOM 2013a).

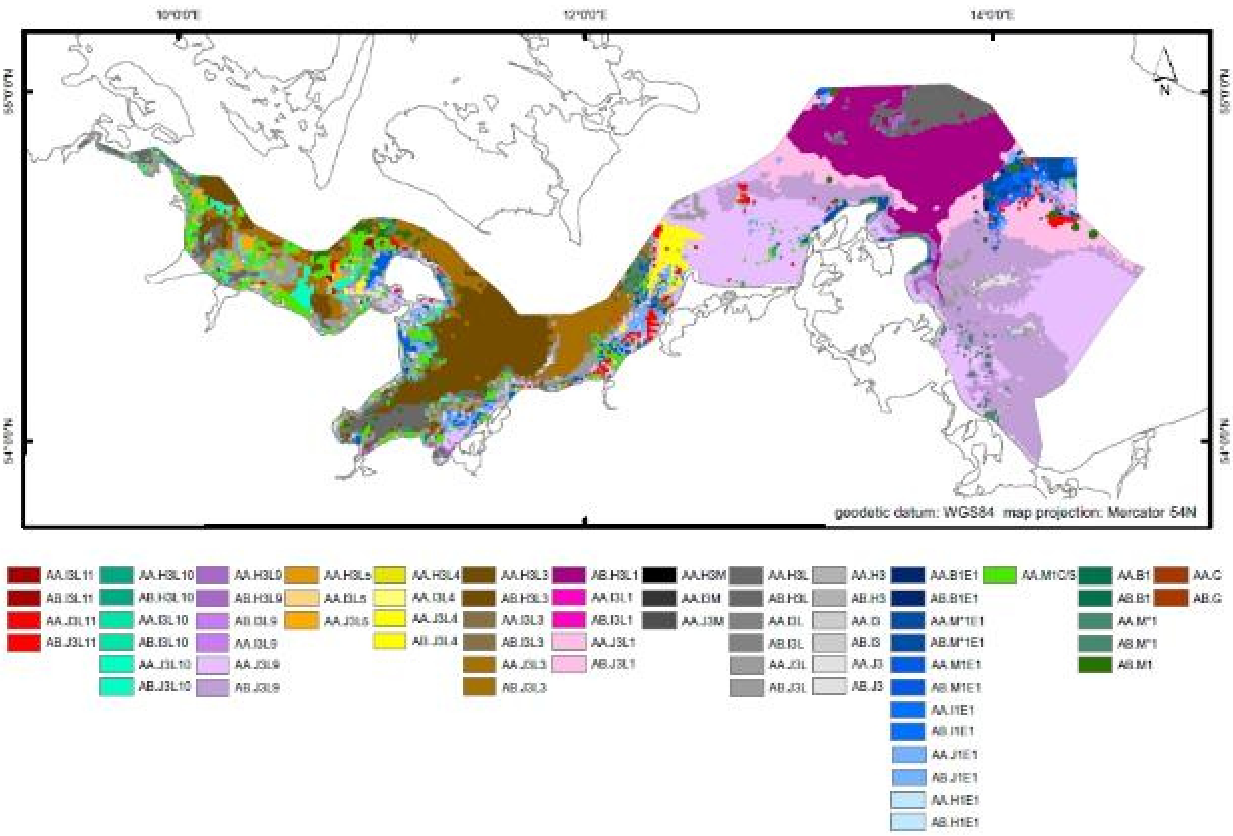


Figure 31: Biotope map of the German Baltic Sea according to SCHIELE et al. (2015). HELCOM HUB codes explained in HELCOM (2013a).

2.4.3 Legally protected marine biotopes in accordance with Section 30 of the Federal Nature Conservation Act and the Habitats Directive

Under Section 30 of the Federal Nature Conservation Act (BNatSchG), a number of marine biotopes are subject to direct federal protection. Section 30 Subsection 2 of the BNatSchG categorically prohibits actions that could cause destruction or other significant impairment of the listed biotopes. This does not require the designation of a protected area. This protection was extended to the EEZ with the 2010 amendment to the BNatSchG. In addition to the marine habitat types listed in Annex I of the EU Habitats Directive, reefs and sandbanks, the two biotopes "seagrass beds and other marine macrophyte populations" and "species-rich gravel, coarse sand and shell layers in marine and coastal areas" in the Baltic Sea EEZ area enjoy a statutory conservation status under Section 30 Subsection 2 sentence 1 no. 6 of the Federal Nature Conservation Act. The "seapen and burrowing megafauna communities" biotope type, which is also protected, does not occur in the German Baltic Sea.

2.4.3.1 Reefs

Habitat type 1170 (reefs) as per the Habitats Directive, and also a biotope type protected under Section 30 of the Federal Nature Conservation Act, is defined as follows: "Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and coralloggenic concretions". (DOC.HAB. 06-09/03). The "hard compact substrata" include rocks (including soft rocks such as chalk), as well as boulders and cobbles. The "BfN Mapping Instructions for "Reefs" in the German Exclusive Economic Zone (EEZ)" (https://www.bfn.de/fileadmin/BfN/meeresundkuestenschutz/Dokumente/BfN-Kartieranleitungen/BfN-Kartieranleitung-Riffe-in-der-deutschen-AWZ.pdf) was published on 09/07/2018, but has not yet seen use in projects.

In the Baltic Sea EEZ, reefs and reef-like structures occur predominantly as boulder fields on moraine ridges. They have been found mainly in the Adlergrund, Rönne Bank, Kadet Channel and Fehmarn Belt. Well-developed mussel banks with their accompanying species are found here, which have a comparatively high species count for the Baltic Sea. Plant cover consisting of large algae, especially laminaria (sugar kelp), red algae and sea lace is also of significance here. According to the BfN, reefs covering an area of approximately 460 km^2 have been identified in the German Baltic Sea EEZ. A large part of this area (270 km^2) has now been placed under protection by the regulation of 22/09/2017 on the designation of the Pommersche Bucht - Rönnebank nature conservation area, the regulation of 22/09/2017 on the designation of the Kadetrinne nature conservation area and the regulation of 22/09/2017 on the designation of the Fehmarnbelt nature conservation area. These regulations declared the existing nature conservation areas and Habitats Directive areas as nature conservation areas, and partly regrouped them. Within the scope of the approval procedure for the grid connection "Cables 1 to 6 / cross connection", suspected reef areas in addition to those reported by the BfN were designated in area EO1. The relevant mapping instructions issued by the BfN (BFN 2018) must be consulted when recording the "reefs" biotope type in the German EEZ.

2.4.3.2 Sandbanks

Habitat type 1110 (as per the Habitats Directive) designates "sandbanks which are slightly covered by seawater all the time" (DOC.HAB. 06-09/03) and is defined as follows: "Sandbanks are elevated, elongated, rounded or irregular topographic features, permanently submerged and predominantly surrounded by deeper water. They consist mainly of sandy sediments, but larger grain sizes, including boulders and cobbles, or smaller grain sizes including mud may also be present on a sandbank. Banks where sandy sediments occur in a layer over hard substrata are classed as sandbanks if the associated biota are dependent on the sand rather than on the underlying hard substrata." Sandbanks are also protected biotopes according to Section 30 of the Federal Nature Conservation Act.

Several sandbanks in the German Baltic Sea EEZ have now been identified as worthy of protection from a nature conservation perspective. Sandbanks as defined by the Habitats Directive occur in the German EEZ east of the Darss Sill on the edge of the Arkona Basin, and in the Bay of Pomerania. They are covered in residual sediments (cobbles, boulders, coarse sand, medium sand) and are accordingly colonised by sandy soil communities, or covered in large algae on hard soils in the euphotic zone. The total area is about 570 km^2, with the Oder Bank being a particularly large sandbank.

For these reasons, the identified sandbanks were placed under protection by the Habitats Directive designations Fehmarnbelt (DE 1332-301), Adlergrund (DE 1251-301) and Pommersche Bucht mit Oderbank (DE 1652-301) in the Baltic Sea EEZ.

The epifauna on the sandy soils is species-poor and consists mainly of mussels, which are covered in attached species on which substrate-bound species such as small crustaceans are found. Most of the species are found in the sand (infauna). Mollusc and polychaete species dominate. The number of species on the Adlergrund and Kriegers Flak is around 110, while only 21 species have been recorded on the Oder Bank. The decline in species richness compared to the Belt Sea is due to the low salinity.

The low number of species on the Oder Bank is due to the homogeneity of the habitat, which consists of level soils with little structure and fine sand cover. Under these extreme living conditions (exposed sandy soils, low salinity), adapted sandy soil species such as *Pygospio elegans*, the crabs *Bathyporeia pilosa* and *Crangon crangon* as well as the bivalves *Mya arenaria, Macoma balthica* and *Cerastoderma lamarcki* dominate. They often reach very high individual densities and are distributed quite homogeneously throughout the area. Three species, *Bathyporeia pilosa, Mya arenaria* and *Hydrobia ulvae,* together typically make up over 70% of the total number of individuals.

There are currently no mapping instructions for the biotope type "sandbanks which are slightly covered by seawater all the time ".

2.4.3.3 Seagrass beds and other marine macrophyte populations

The biotope "Seagrass beds and other marine macrophyte populations" describes a habitat characterised by submerged flowering plants and/or large algae under the influence of light. Currently it is only known to occur in association with reefs in the Baltic Sea EEZ. In coastal areas, however, extensive "marine macrophyte populations" also occur beyond reefs. Various biotope types characterised by marine macrophyte populations are recorded in the OSPAR and HELCOM lists of declining and/or endangered biotope types (BFN 2012a). There are currently no mapping instructions for the biotope "Seagrass beds and other marine macrophyte populations". Based on current knowledge, no specific areas can be identified for this biotope type.

2.4.3.4 Species-rich gravel, coarse sand and shell layers in marine and coastal areas

This legally protected biotope includes species-rich pure or mixed sublittoral occurrences of gravel, coarse sand or shell sediments of the seabed, which are colonised by a specific endofauna (e.g. interstitial fauna) and macrozoobenthos community, irrespective of their general location.

In the North Sea and Baltic Sea, this biotope may be associated with the occurrence of stones or mixed substrates and the occurrence of mussel beds or may occur in close proximity to the sandbank and reef habitat types. Reefs and species-rich gravel, coarse sand and shell beds regularly occur together. In the sublittoral of the Baltic Sea, this biotope is characterised by the polychaete genera *Ophelia* spp. and *Travisia forbesii. Branchiostoma lanceolatum is* also found in the western Baltic Sea shell layers. The richness of species or high proportion of specialised species in these sediment types results from the occurrence of relatively stable interstitial spaces between sediment particles with a large pore water content and relatively high oxygen content.

The colonisation of species-rich gravel, coarse sand and shell layers is very heterogeneous. Gravel and coarse sand biotopes occur in the outer coastal waters of the Baltic Sea, mainly at a depth of 5–15 m, in submarine sills and together with reefs, among others. An example is the Adlergrund, whose sediment contains coarse sand and gravel in certain areas. Pure shell gravel biotopes are generally rare.

On the basis of the comprehensive mapping of HELCOM HUB biotope types in the German Baltic Sea presented by SCHIELE et al. (2015), certain conclusions can be drawn about the possible occurrence of "species-rich gravel, coarse sand and shell layers". However, as the distributions of the relevant characteristic species *Ophe-*

lia spp. and *Travisia forbesii,* which form the basis of the study, stem from presence/absence modelling, the mapping instructions "Species-rich gravel, coarse sand and shell layers in marine and coastal areas" (BFN, 2012b) must also be consulted when recording this biotope.

2.4.4 Assessment of the state of the biotopes

The assessment of biotope types occurring in the German marine area is based on the national conservation status and the threat to these biotope types according to the Red List of Endangered Biotope Types in Germany (FINCK et al. 2017). The legally protected biotopes mentioned above are generally of great importance in this context. In the Baltic Sea, these biotopes are endangered mainly by current or past nutrient and pollutant inputs (including wastewater discharge, oil pollution, and dumping of waste and debris), by bottom fishing, and possibly also by the effects of construction activities. As bottom fishing activity is largely precluded within the wind farms, a certain degree of recovery of the biotopes occurring in these areas can be expected.

2.4.4.1 Importance of wind energy areas for biotope types

Wind energy priority area EO1

The biotope "reefs" is known to occur in area EO1. Particularly in the south-east of the area there are boulder fields with well-developed mussel beds, which extend from the Adlergrund into the area. Mainly mussel banks, gravel and stone banks and the presence of till have been identified. Stone cover in the southeastern area is above 10% in many areas. In the southwestern part of area EO1, stone cover is lower (<10 %). This section of the reef designated area no. 33 by the BfN, has a reef share of 26 % according to BfN estimates.

Area reserved for wind energy EO2

Area EO2 has a low overall structural richness. According to the Red List (FINCK et al. 2017), there is currently no identifiable threat to the biotope type "Sublittoral mudflats of the Baltic Sea" (Code 05.02.11), which occurs throughout area EO2. No legally protected biotopes are expected to occur in this area.

Wind energy priority area EO3

The northern flat part of area EO3 has stone and cobble areas with well-developed mussel beds. The embankment-like erratic boulder accumulations occurring there could possibly be classified as biotope type "reef". Verification using the mapping instructions of the BfN is still pending.

2.5 Benthos

Benthos is the term used to describe all biological communities bound to substrate surfaces or living in soft substrates at the bottom of water bodies. Benthic organisms are an important component of the Baltic Sea ecosystem. They are the main food source for many fish species and play a crucial role in the conversion and remineralisation of sedimented organic material (KRÖNCKE 1995). According to RACHOR (1990), benthos includes micro-organisms such as bacteria and fungi, unicellular animals (protozoa) and plants, as well as multicellular organisms, large algae and organisms including bottom-dwelling fish. Zoobenthos refers to those animals that live predominantly in or on the seabed. These creatures largely restrict their activities to the boundary layer between the free water and the uppermost layer of the seabed, which is usually only a few decimetres in depth.

In the case of holobenthic species, all phases of life take place within this community close to the seabed. However, the majority of animals are merobenthic, i.e. only certain phases of their life cycle are linked to this ecosystem (TARDENT 1993).

These animals usually spread via planktonic larvae. In more mature stages of their life cycle, however, their ability to relocate is more limited. Overall, most of the benthos is characterised by a lack of or limited mobility compared to plankton and necton. As a result of this relative lack of mobility, the seabed fauna is generally unable to avoid natural or anthropogenically induced changes and pressures, and is therefore in many cases an indicator of changed environmental conditions (RACHOR 1990).

The German part of the Baltic Sea is characterised by a textured seabed and a very heterogeneous surface structure. Although the seabed of the Baltic contains coarse sand, cobbles and boulders, it consists largely of sandy or silty sediments, and therefore animals can also penetrate the bottom. In addition to the epifauna living on the surface of the seabed, a typical infauna living in the soil has also developed. Micro-animals of less than 1 mm body size (micro- and meiofauna) make up the majority of these soil dwellers. However, the larger animals (macrofauna) are better known, especially the more sedentary forms such as annelids, shells and snails, echinoderms and various crustaceans (RACHOR 1990). For practical reasons, therefore, the macrozoobenthos (animals > 1 mm) are studied internationally as representatives of the entire zoobenthos (Armonies & ASMUS 2002).

2.5.1 Data availability

The flora and fauna living on the bottom of the Baltic Sea aroused the interest of naturalists as early as the middle of the 19th century, when they started collecting and cataloguing them (MÖBIUS, 1873). In the 20th century, the macrozoobenthos of the Bay of Kiel and Bay of Mecklenburg were studied in detail (HAGMEIER 1925; KÜHLMORGEN-HILLE 1963, 1965, SCHULZ 1968, 1969a, 1969b, ARNTZ 1970, 1971, 1978, ARNTZ et al. 1976; GOSSELCK & GEORGI 1984, Weigelt 1985, Arntz & RUMOHR 1986, GOSSELCK ET AL. 1987, Brey 1984, Rumohr 1995, GOSSELCK 1992, ZETTLER ET AL. 2000). More recent data are available from long-term biological monitoring by the IOW, and from benthos investigations carried out since 2002 within the scope of approval procedures for offshore wind farm projects. Research projects such as the benthological work on the ecological assessment of areas suitable for wind energy by ZETTLER et al. (2003) or BeoFINO, as well as the monitoring of benthic communities in nature conservation areas, also provide important information.

2.5.2 Spatial distribution and temporal variability

The spatial and temporal variability of zoobenthos is largely controlled by oceanographic and climatic factors as well as by anthropogenic influences. Important climatic factors include winter temperatures, which cause high mortality rates for some species (BEUKEMA 1992, ARMONIES et al. 2001), and wind-driven currents. The currents are responsible for the dispersal of planktonic larvae and for a redistribution of the bottom-dwelling stages via current-induced sediment redistribution (ARMONIES 1999, 2000). Among the anthropogenic impacts, disturbance of the seabed surface by fisheries is of particular importance, in addition to nutrient and pollutant inputs (RACHOR et al. 1998).

Salinity is the determining factor for the occurrence and distribution of benthic species in the Baltic Sea. Aperiodic saltwater influxes temporarily raise the salinity in deeper areas (> 40 m) to over 15 PSU, while surface water rarely exceeds a salinity of 10 PSU. The zoobenthos of the Baltic Sea is composed of a variety of systematic groups and shows a wide range of different behaviours. In general, this fauna has been quite well studied, allowing comparison with conditions several decades ago.

Natural area division of the German Baltic Sea EEZ: benthos

The following proposal for a division of natural areas in the German Baltic Sea EEZ from a benthological point of view differs from the division based on sedimentological criteria. The main structuring factor for the composition of macrozoobenthos is salinity. Furthermore, the occurrence of macrozoobenthos species in the Baltic Sea depends on hydrographic conditions and water depth. The natural areas are classified in accordance with the BfN's nature conservation planning contribution to the spatial plan (BFN 2006). According to this contribution, five natural units of area may be distinguished (from west to east): Bay of Kiel (A) and Bay of Mecklenburg (B), which are still quite marine in character, the transitional area of the Darss Sill (C), followed by the Arkona Basin (D) and Bay of Pomerania (E) (Figure 32).

The German part of the Baltic Sea lies in the transition area between the marine Belt Sea and the brackish water dominated central Baltic Sea. The Darss Sill forms a prominent ecological boundary between the two different water bodies.

Table 7: Natural area division of the German Baltic Sea EEZ (according to BFN 2006).

Designation	**Abbreviation** Figure 32	**Hydrography**	**Water depth**	**Sediment**	**Benthos**
Belt Sea EEZ and Bay of Kiel	**A**	thermohaline stratification with avg. salinity > 20, frequent oxygen depletion in the water layers near the bottom; rare icing	from 15 m to 30 m	Fine sand, occasionally also silt and clay, stones, residual sediment, heterogeneous sediment distribution	Marine species dominate, partly species-rich endofauna communities and very species-rich phytal communities
Bay of Mecklenburg EEZ	**B**	relatively low flow velocities; thermohaline stratification with regular oxygen depletion, avg. salinity > 7 < 20; occasional icing	from 20 m to 30 m	silt, clay in the central area, residual sediment areas in the peripheral areas	Marine species dominate, partly species-rich endofauna communities and very species-rich phytal communities
Darss Sill	**C**	Water exchange between central and western Baltic Sea through the Kadet Channel	from 18 m to 25 m; threshold between Belt Sea/Bay of Mecklenburg and Arkona Basin; the up to 25 m deep Kadet Channel is embedded	Medium and coarse sand, gravel, residual sediment areas and boulder fields (reef)	Transitional area, decrease of marine species (*Macoma balthica*; in depths below 20 m also *Abra alba*, Arctica islandica communities as well as phytal communities in the Kadet Channel)
Arkona Basin EEZ	**D**	relatively low flow velocities; thermohaline stratification with frequent oxygen depletion; icing possible in winter, salinity > 7	from 20 m to 47 m	silt, clay	Species-poor brackish water community of the central Baltic Sea with stenothermal cold-water relicts in unique combination with freshwater species
Bay of Pomerania (with Adlergrund and Oder Bank)	**E**	relatively low flow velocities; icing possible in winter: (Adlergrund: rare icing; Oder Bank: frequent winter icing), salinity > 7	Flat seabed from 6 m to 30 m	Medium and coarse sand, gravel, boulders, in the central areas large areas of homogeneous sand	Species-poor brackish water communities in unique combination with freshwater species (*Macoma balthica*; *Mya arenaria, Theodoxus fluviatilis*)

The Kadet Channel acts as a link between the two. More than 70% of the water exchange of the entire Baltic Sea runs through the Fehmarn Belt and Kadet Channel.

Water exchange of the bottom water in the Belt Sea takes place several times a year, while saltwater influxes into the Baltic Sea occur rarely. The salinity is subject to strong horizontal and vertical fluctuations. The stratification in the Belt Sea is unstable (stagnation phases), whereas in the central Baltic Sea there is a stably stratified water body.

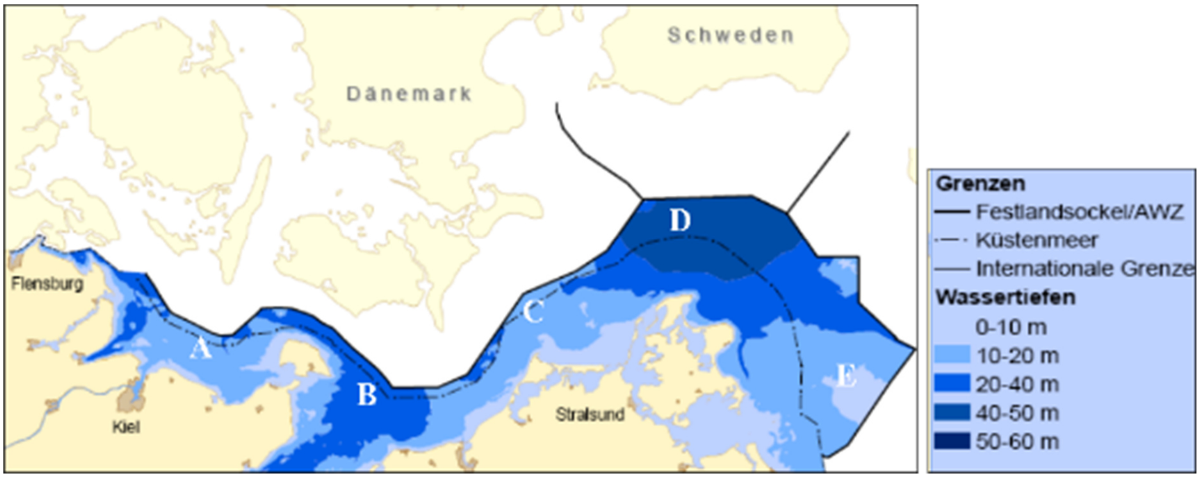


Figure 32: Natural area classification of the German Baltic Sea EEZ (according to BFN 2006).

2.5.2.1 The macrozoobenthos of the German Baltic Sea

Overall, the Baltic Sea is species-poor compared to the North Sea. The bottom-dwelling invertebrates of the Baltic Sea are primarily composed of marine immigrants from the North Sea, brackish water species and ice age relics (GOSSELCK et al. 1996). The majority of species are marine euryhaline species, which penetrate into the Baltic Sea to varying degrees depending on their tolerance to decreasing salinity. Many marine species do not penetrate into the areas east of the Darss Sill, or only following extreme events. As such, marine species decrease from the Belt Sea towards the central and eastern Baltic Sea in favour of brackish and limnic species, and reach their eastern limit of distribution in the area of the Arkona Basin. As the marine euryhaline species are not replaced by a similar number of limnic species, overall species richness tends to decrease.

The decline in species as a result of decreasing salinity from west to east is illustrated in Figure 33, an evaluation of data from long-term monitoring at 8 monitoring stations in the western Baltic Sea (WASMUND et al. 2017). The results show a clear decrease in species numbers from the Bay of Kiel (83 species) to the central Bay of Mecklenburg (12-16 species) both in 2016 and in the long-term trend. In the Fehmarn Belt area, significantly lower species numbers were recorded in 2016 compared to the long-term trend. An increased species diversity of up to 62 species can be seen in the area of the southern Bay Mecklenburg and the Darss Sill. East of the Darss Sill into the Bay of Pomerania, species numbers are again lower (18-28 species) and the lowest in the long-term trend (WASMUND et al. 2017).

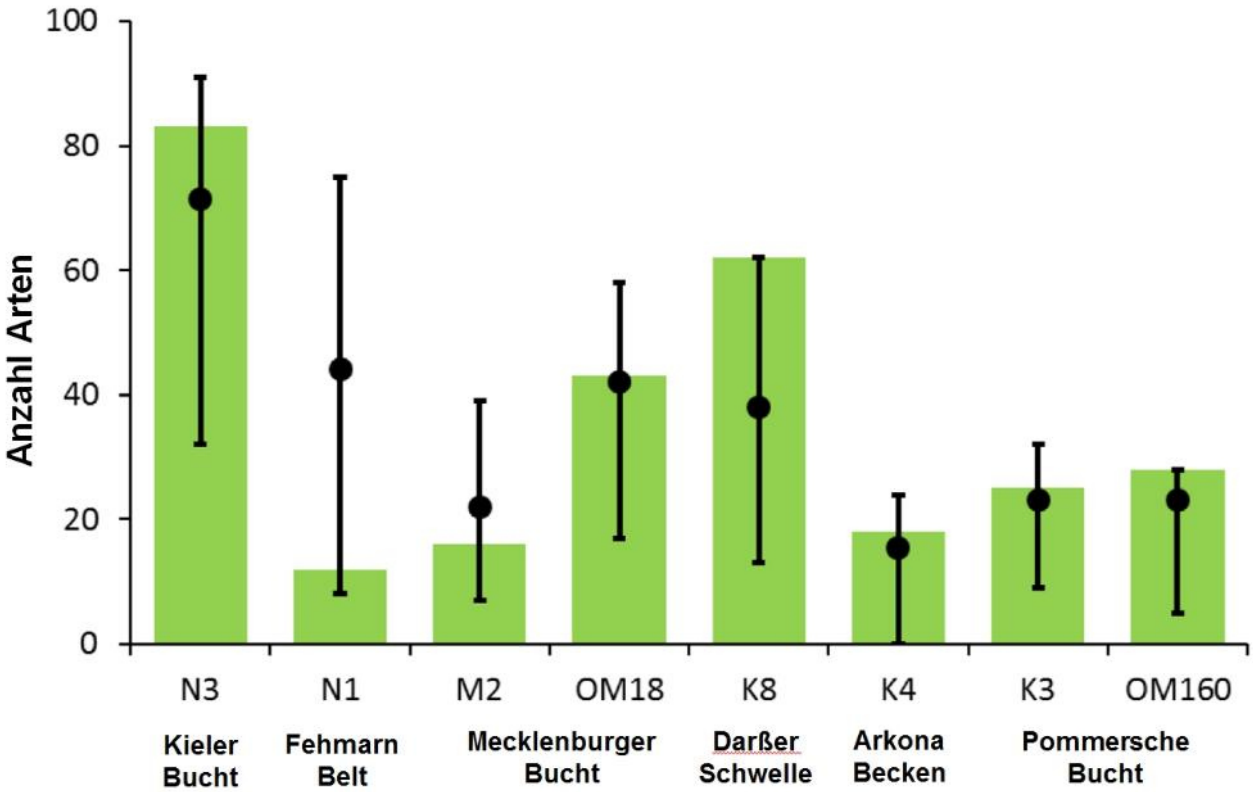


Figure 33: Number of macrozoobenthic species at 8 monitoring stations in November 2016 (green bars). Black dots and error bars show median, minimum, and maximum species numbers between 1991 and 2016 (modified according to WASMUND et al. 2017).

The number of macrozoobenthos species correlates closely with both salinity and sedimentary conditions (REMANE 1934; ZETTLER et al. 2014). Higher mean salinity levels and hard or fine substrate habitats (including silty areas) have proven to be particularly rich in macrozoobenthos species.

When looking at the detailed results for the Fehmarn Belt Station, it becomes clear that the benthic communities are subject to strong fluctuations from year to year, both in terms of individual densities and species composition (Figure 34). The highest abundances are found in molluscs, which are not very species-rich, with *Macoma baltica* (Baltic clam) and *Mytilus edulis* (blue mussel) being the most common. Less consistent in their densities are the crustaceans and polychaetes.

Polychaetes have the highest number of species over the years. This is due to their high adaptability to changing environmental conditions (e.g. lower salinity or low oxygenation).

Fluctuations in abundance of other species can be explained by strong annual fluctuations in saltwater inflow from the North Sea. A strong saltwater influx can lead to a significant increase in the number of individuals among macrozoobenthos species within a few weeks. Frequent oxygen deficiency events have reduced species diversity and colonisation density in recent decades. However, following a saltwater influx in 2014, euhaline species such as the bivalves *Abra alba* and *Corbula gibba*, the polychaetes *Nephtys ciliata* and *Nephtys hombergii* and the brittle star *Ophiura albida* were detected in the central Arkona Basin the following year after a long absence (WASMUND et al. 2016a).

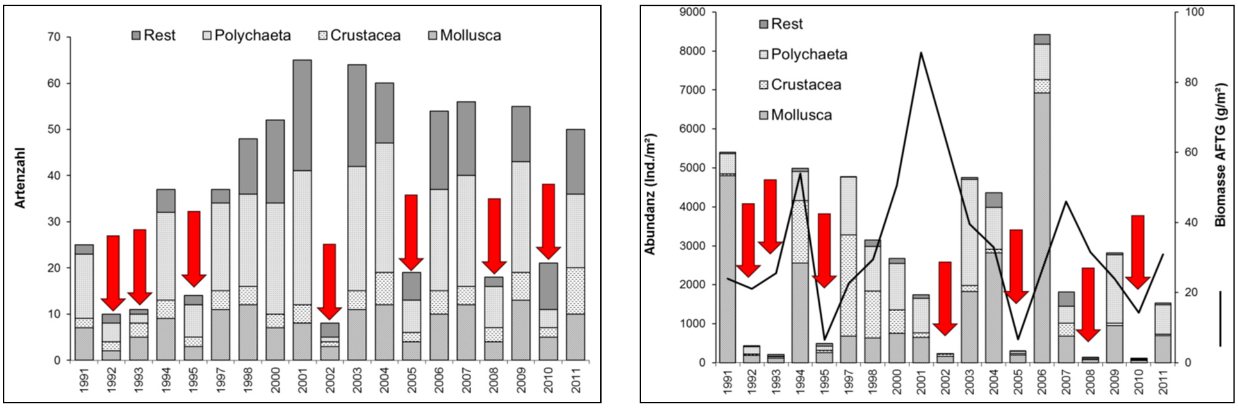


Figure 34: Development of species numbers, abundance and biomass of macrozoobenthos at the Fehmarn Belt station from 1991 to 2011. The arrows mark summer oxygen deficiency events in the bottom-level water body (from WASMUND et al. 2012).

A total of 383 benthic species are listed for the German marine and coastal area of the Baltic Sea by GOSSELCK et al (1996). In comparison, a total of 2,035 macrozoobenthos species can be found throughout the Baltic Sea, distributed among 1,423 marine species and 612 freshwater and brackish water species (ZETTLER et al. 2014). A total of 51 of these species are classified as neozoans.

WASMUND et al (2017) state that between 1991 and 2016 a total of 260 taxa were detected at eight stations in the Baltic Sea (Bay of Kiel to Bay of Pomerania). Of these, however, around a third only occur occasionally. 150 regularly occurring macrozoobenthos species were recorded in the Bay of Kiel in the 1980s (BREY 1984; WEIGELT 1985). In the course of the long-term monitoring of the outer coasts of Mecklenburg-Western Pomerania (IFAÖ 2005b), around 140 taxa were identified in the Bay of Mecklenburg. The high proportion of marine "guest species" introduced into the Bay of Mecklenburg during saltwater inflows is striking. ZETTLER et al (2000) identified a total of over 240 macrozoobenthos species in the Bay of Mecklenburg. The dominant systematic main groups were Polychaeta (71 taxa), Crustacea (57 taxa) and Mollusca (50 taxa). This high species diversity can be attributed to the fact that all benthic habitats were recorded, and also to the fact that, due to favourable hydrographic conditions, a large number of marine immigrants were resident in the benthic zone of the Bay of Mecklenburg at the time of the study in 1999.

According to literature research in the context of an R&D project (Zettler ET al. 2003), 126 taxa have been identified in the Arkona Sea so far. It should be noted that more than 80 species are rare or isolated finds. The bivalves *Macoma balthica* and *Mytilus edulis as* well as the polychaetes *Pygospio elegans* and *Scoloplos armos* are the dominant species.

The occurrence of macrozoobenthos species in the Baltic Sea depends not only on salinity but also on hydrographic conditions and water depth. In particular, deeper zones (40 m) below the halocline with silt seabeds are considered to be very species-poor. For example, ZETTLER et al (2000) found the greatest species diversity (140 taxa) in the Bay of Mecklenburg in water depths between 10 and 20 m. The lowest species diversity (around 70 taxa) was found at depths of 25–30 m, which represented the deepest zone studied.

Stratified waters have a special status. Increased salinity and temporary oxygen deficiency in the body of water near the bottom lead to different benthos settlement patterns. Larvae of marine invertebrates penetrate into the Baltic Sea with the saline water from the North Sea/Kattegat area, so that marine faunal elements at least temporarily settle in the mixohaline waters. On the other hand, the resulting oxygen deficiency can lead to the collapse of benthic communities (KÖLMEL 1979, WEIGELT 1987, GOSSELCK et al. 1987).

A special feature of this region is the brackish water submergence of some species. Saline water is deposited in the basins and depressions, providing a habitat for species that can be found at shallower depths in a fully marine environment. They may also move to substrates that do not correspond to their preferred habitat in a fully marine environment. Due to the constant exchange processes between the North Sea and the Baltic Sea, submergence areas can shift and need not remain constant. Among the species of macrozoobenthos which, according to TISCHLER (1993), can serve as examples of "brackish water submergence" in the Baltic Sea are *Mytilus edulis* (blue mussel), *Macoma baltica* (Baltic clam), *Hydrobia ulvae* (mudsnail) and the worms *Pygospio elegans* and *Scoloplos armiger*.

2.5.2.2 Benthic communities

According to RUMOHR (1996), the zoobenthos community in the shallow waters of the western Baltic Sea is mostly dominated by the *Macoma balthica* (Baltic clam) community. The lower limit of the community's distribution in the North Sea is at 10–15 m. However, as a result of increasing salinity in deeper water, it extends to depths between 75 and 100 m in central, low salinity regions of the Baltic Sea (TISCHLER 1993). In the western Baltic Sea, the species of the *Macoma balthica* community can also be found in shallower parts of the coastal waters. The "true" deep-water communities of the western Baltic Sea, on the other hand, are dominated by the *Abra alba* or *Arctica islandica* communities. GLOCKZIN & ZETTLER (2008) also point to a clear distinction between shallow and deep-water benthic communities.

According to KOCK (2001), the fauna of the deeper Fehmarn Belt (19–28 m) can be considered a depauperate *Abra alba* community in the sense of PETERSEN (1918) and THORSON (1957). This community occurs on mixed to silty soils with organic matter at depths of 5 to 30 metres. The expected characteristic species are the bivalves *Abra alba, Phaxas pellucidus, Aloides gibba* and *Nucula* sp., the polychaetes *Pectinaria koreni* and *Nephtys* sp. and the sea urchin *Echinocardium* sp.

In the Bay of Mecklenburg, according to ZETTLER et al. (2000), the delimitation of biocoenoses is directly linked to depth zoning (salinity, temperature, and sediments). Three main communities can be distinguished: The first group can be described as the *Mya arenaria-Pygospio elegans* biocoenosis of shallow sandy areas in water depths of less than 15 m. Here, aside from the softshell clam and the spionid *pygospio elegans*, *Hydrobia ulvae, Mytilus edulis, Macoma balthica* and *Scoloplos armiger* are significantly represented. The second group is the biocoenosis of sandy silt and silt in water depths of over 15 m. The main species are *Arctica islandica* and *Abra* *alba*. Other important taxa are *Diastylis rathkei, Euchone papillosa* and *Terebellides stroemi*. This *Abra alba-Arctica icelandica* biocoenosis is found in the Bay of Mecklenburg at depths between 15 and 29.6 m. After prolonged oxygen deprivation, this biocoenosis can be reduced to *A. islandica* and *Halicryptus spinulosus* (PRENA et al. 1997). The third group are species of silty sand at water depths between 12 and 22 m. This transition area from sands to silt has also produced a definable biocoenosis. This biocoenosis can be referred to as the *Mysella bidentata-Astarte borealis* biocoenosis. This area is mainly dominated by five species of bivalves. Besides *Mysella bidentata* and *Astarte borealis, Corbula gibba, Parvicardium ovale* and *A. elliptica* are regularly represented. This zone is also the main area of occurrence of *Asterias rubens*.

The exposed crests with their moving coarser sands represent a special habitat. Various specialists such as the bristle worms and *Bathyporeia sarsi* settle here. Fine sands with low silt content predominate. They are colonised by a characteristic species-poor community with high stability. Dominant species in these areas are the Baltic clam, softshell clam, lagoon cockle, mussel and the laver spire shell from the mollusc phylum as well as the ragworm, *Pygospio elegans*, *Marenzelleria neglecta* and *Heterochaeta costata* from the annelid phylum (Polychaeta and Oligochaeta). Special communities can also be found on the boulder and cobble slopes. The epifauna community of hard soils is dominated by the mussel (*Mytilus edulis*) and barnacles (*B. improvisus*). This community, like the phytocoenosis, is accompanied mainly by sessile colony formers (bryozoans, cnidarians) and vagile woodlice and amphipods (SORDYL et al. 2010).

An up-to-date and comprehensive description of benthic communities for the entire Baltic Sea is provided by GOGINA et al. (2016). This study identified 10 benthic communities based on abundance and 17 communities based on biomass. In the area of the Bay of Mecklenburg and in shallow sandy sediments, a biocoenosis is found which is characterised by high abundances of snails of the genus *Hydrobiidae*, the polychaete *Pygospio elegans* and the lagoon cockle *Cerastoderma glaucum.* Furthermore, in deeper areas of the Bay of Mecklenburg, a biocoenosis occurs which is characterised by the occurrence of the cumacean *Diastylis rathkei*, the bivalve molluscs *Corbula gibba, Arctica islandica, Abra alba* as well as the polychaetes *Dipolydora quadrilobata and Aricidea suecica.* In the Arkona basin, the amphipod *Pontoporeia femorata* and the polychaete *Bylgides sarsi* are common. This community is closely linked to the level of oxygenation in the deep basins. When oxygen concentrations increase after prolonged periods of oxygen deficiency, *Bylgides sarsi* is often one of the first species to recolonize the sediment GOGINA et al. (2016).

Wind energy priority area EO1

Three communities (A, B and C) have been identified in area EO1. Community A is mainly distributed above the halocline, but is locally present below the halocline in areas with hard bottoms. The community is dominated by the mussel and elements of its typical accompanying fauna (e.g. *Gammarus spp.*, *Microdeutopus gryllotalpa*, *Jaera albifrons*), but also by *Saduria entomon*. Community B remains restricted in its distribution to the sandy areas above the halocline. It is dominated by Oligochaeta, *Pygospio elegans* and *Hydrobia ulvae*, locally also by *Marenzelleria neglecta* and *Travisia forbesii.* Community C is the biocoenosis of the silt-rich soft soils below the halocline. Characteristic species include *Scoloplos armiger, Halicryptus spinulosus, Pontoporeia femorata, Diastylis rathkei, Ampharete* spp. and *Terebellides stroemi*.

Area reserved for wind energy EO2

The *Macoma balthica* community, which is spread over large parts of the Baltic Sea, has developed throughout area EO2. The three main species, measured in terms of total individual numbers, are the Baltic clam, *Scoloplos armiger* and the cumacean *Diastylis rathkei.* The predominant benthic species are mainly composed of species that regenerate quickly after disturbances.

Wind energy priority area EO3

In the Arkona Sea, two biocoenoses can be designated in area EO3. The first community lives in shallow areas (up to 30 m water depth). Here, the polychaete *Travisia forbesii*, the bivalve *Mya arenaria*, the snail *Hydrobia ulvae* and the amphipod *Bathyporeia pilosa* are typical representatives of the community. Due to their diet, all four are typical for coastal waters with slight to average exposure, and are rarely found below 20 m water depth. The areas in the central and northern part of area EO3 can be assigned to this biocoenosis. The second biocoenosis is found in the deeper areas (30 to 40 m) and includes cold-water species such as the bivalve mollusc *Astarte borealis*, the glacial relict amphipods *Monoporeia affinis* and *Pontoporeia femorata*, the relict isopod *Saduria entomon* and the polychaete *Terebellides stroemi*.

2.5.2.3 Red List species

Current estimates suggest a possible occurrence of at least 30 Red List species according to RACHOR et al. (2013) and HELCOM (2013b) in the area of the German EEZ (Table 8). The main threats are habitat destruction due to direct anthropogenic influences and effects of eutrophication such as oxygen depletion and increasing siltation of sandy soils. Climate-induced warming of the Baltic Sea represents a significant threat for the future of stenothermic species adapted to cold water (SORDYL et al. 2010).

The macrozoobenthos surveys carried out as part of HELCOM monitoring at eight stations in the western Baltic Sea (WASMUND et al. 2017) revealed a total of 23 Red List species for the North Sea and Baltic Sea (RACHOR et al. 2013) in November 2016. Two of these species are listed as critically endangered (category 1), including the clam *Macoma calcarea*, which, as in previous years, was recorded in low abundance in the area of the Bay of Kiel. The anthozoan *Halcampa duodecimcirrata,* also classified as critically endangered, was found in small numbers in the southern Bay of Mecklenburg, but outside of the German EEZ. Among the species classified as endangered (category 2) according to RACHOR et al. (2013), the common whelk (*Buccinum undatum*) was found in the area of the Bay of Kiel. The polychaete *Euchone papillosa,* also categorised as endangered, was found in the Bay of Mecklenburg. Among the species categorised as vulnerable (category 3), the bivalve *Astarte montagui* was found exclusively in the area of the Bay of Kiel, while the black clam (*Arctica islandica*) was found at several stations in the western Baltic Sea as well as in the Arkona Basin.

As a result of different assessment criteria, fewer species are listed as endangered in the HELCOM Red List of the entire Baltic Sea (HELCOM 2013b), which was developed in accordance with global criteria of the International Union for Conservation of Nature (IUCN), than in the national Red List according to RACHOR et al (2013) (Table 8). Due to the different assessment criteria of the two Red Lists, the risk categories also differ.

Most of the species listed as endangered (category EN) or vulnerable (category VU) on the HELCOM list occur outside of the German EEZ in the Kattegat area or are restricted to shallow coastal waters or beaches. Of the species potentially occurring in the area of the German EEZ, HELCOM (2013b) lists the three shellfish species *Macoma calcarea*, *Modiolus modiolus* and *Nucula nucleus* as vulnerable (category VU). Three species occurring in the EEZ are listed as near threatened (category NT), including the truncate softshell (*Mya truncata*), the Icelandic moonsnail (*Amauropsis islandica*) and the bobtail trophon (*Boreotrophon truncatus*).

As part of investigations for the wind farm projects Wikinger, Wikinger Süd, Wikinger Nord, Arkonabecken Südost, Baltic Eagle and EnBW Baltic 2 as well as the grid connection "Cables 1 to 6 / cross connection", a further 6 species on the Red List were identified. These include the endangered bryozoan species *Alcyonidium gelatinosum* and the amphipod *Monoporeia affinis*. A further four species are endangered to an indeterminate extent. In the investigations of area EO1 to date, 10 endangered species have been identified (Table 8).

Arctica islandica is found in the Baltic Sea from the Bay of Kiel via the Bay of Mecklenburg to the northern Arkona Basin. It colonises silt and silty sand and requires a high salinity of at least 14 PSU and low temperatures. A decline in the Baltic Sea population has been seen since 1960, caused by a long-term lack of oxygen in the deep water (SCHULZ 1968). At depths from 20 to 15 m, where oxygen deficiency is rare, *Arctica islandica* continues to occur and is again found in high densities in the Bay Mecklenburg (ZETTLER et al. 2001). It has a high potential for recolonisation and, following oxygen deficiency situations, is almost always one of the first colonisers of the deserted soils in the deep zones of the Bays of Lübeck and Mecklenburg (GOSSELCK et al. 1987). Older individuals are tolerant of temporary oxygen deficiency. The occurrences in the Baltic Sea are the only currently known reproducing populations of this species, which in principle is widely distributed throughout German waters.

Table 8: Endangered benthic invertebrate species in the German Baltic Sea EEZ and detection (X) in areas EO1 to EO3. (RACHOR et al. 2013: 1=critically endangered, 2=endangered, 3=vulnerable, G=threatened to indeterminate extent HELCOM, 2013b: VU=vulnerable, NT=near threatened).

Species	Status as per Rachor et al., 2013	Status as per HELCOM, 2013	Area EO1	Area EO2	Area EO3
Anthozoa					
Halcampa duodecimcirrata	1	-			
Bivalvia					
Arctica islandica	3	-	X	X	X
Astarte borealis	G	-	X		X
Astarte elliptica	G	-	X		X
Astarte montagui	3	-			X

Species	Status as per Rachor et al., 2013	Status as per HELCOM, 2013	Area EO1	Area EO2	Area EO3
Macoma calcarea	1	VU			
Modiolus modiolus	2	VU			
Musculus discors	G	-			
Musculus niger	G	-			
Musculus subpictus	G	-			
Mya truncata	2	NT	X		
Gastropods (snails)					
Amauropsis islandica	2	NT			
Aporrhais pespelicani	G	-			
Boreotrophon truncatus	2	NT			
Buccinum undatum	2	-			
Nassarius reticulatus	G	-			
Neptunea antiqua	G	-			
Crustacea					
Monoporeia affinis	3	-	X		X
Saduria entomon	G	-	X		X
Oligochaeta					
Clitellio arenarius	G	-			X
Tubificoides pseudogaster	G	-			X
Polychaeta					
Euchone papillosa	2	-			
Fabriciola baltica	G	-	X		X
Nereimyra punctata	G	-			
Scalibregma inflatum	G	-			
Travisia forbesii	G	-	X		X
Echinodermata					
Echinocyamus pusillus	G	-			
Hydrozoa					
Sertularia cupressina	G	-			
Halitholus yoldiaearcticae	3	-	X		
Bryozoa					
Alcyonidium gelatinosum	3	-	X		

There are three species of Astartidae in the EEZ. In area EO1, *Astarte borealis* and *Astarte elliptica* have been documented. As marine species, they colonise the sublittoral sandy-silty to silty-sandy zone between about 12 m to 20 m water depth. *Astarte montagui* has never been frequently recorded. It is one of the marine species that temporarily colonise the area of the Belt Sea after saltwater influxes.

The population of *Mya truncate,* presumably always small, was further decimated by oxygen deficiency. The occurrence of *Mya truncata* is further influenced by eutrophication and bottom fishing, as the species does not dig particularly deep into the sediment (HELCOM 2013b). Since 1994, and more frequently since 1997, *M. truncata* has again been detected at the deep stations (15 to 20 m) of the coastal monitoring programme for Mecklenburg-Western Pomerania.

The species has so far been identified in small numbers in the Bay of Kiel and in the course of investigations in area EO1.

Macoma calcarea, the larger relative of the Baltic clam, was found along the saltwater zone between 15 and 20 m water depth in the Belt Sea, the Northern Arkona Basin and the Bornholm Basin until the 1970s. Oxygen deprivation led to a decline in the population in the Baltic Sea and the Bay of Mecklenburg. Currently, occurrence of this species is limited to the western part of the German EEZ (HELCOM 2013b).

The sea snails *Amauropsis islandica* and *Boreotrophon truncatus* are marine species that require cold water and high salinity. Their occurrence is currently restricted to the western part of the German EEZ and their stocks are threatened above all by bottom fishing and eutrophication (HELCOM 2013b).

The amphipod *Monoporea affinis* lives in the cold-water zone of the Baltic Sea proper. Under favourable hydrographic conditions it is one of the dominant species (ANDERSIN et al. 1978). The species colonises sandy and muddy soils and is linked to cold water temperatures. It lives in the upper 5 cm of the sediment and is an active bioturbator that influences sediment structure, nutrient fluxes and oxygen availability in the sediment. Sedimented phytoplankton and organic detritus are considered to be the main food source. In the German EEZ, *M. affinis* was detected in area EO3.

2.5.2.4 Benthic algae

The biotopes of the Baltic Sea EEZ are primarily populated by benthic invertebrates. The submerged vegetation is represented by large algae (red and brown algae) on hard bottoms (cobbles, boulders) in the area of the shoals (Adlergrund, Kriegers Flak) and Channels (Kadet Channel). There are no observations of eelgrass (*Zostera marina*) from the EEZ area, although it could well occur at this water depth.

Macrophyte populations have not yet been detected in area EO1.

2.5.3 Assessment of the state of the factor benthos

The benthos of the Baltic Sea EEZ is subject to changes due to both natural and anthropogenic influences. In addition to natural and weather-related variability (severe winters), the main influencing factors are demersal fishing, sand and gravel extraction, the introduction of non-native species and eutrophication of the water body, and climate change.

2.5.3.1 Importance of sites for benthic communities

Criteria which have already proven their worth in the environmental impact assessments for offshore wind farm projects in the EEZ are used for the assessment of benthic communities.

Criterion: Rarity and threat

The criterion rarity and threat of the population takes into account the number of rare or endangered species. This can be assessed on the basis of the Red List species that have been identified.

According to current studies, the macrozoobenthos of the Baltic Sea EEZ is considered average on the basis of the number of Red List species detected. A species list for the entire EEZ is currently not available. However, information on species diversity is provided by KOCK (2001), who found over 110 different macrozoobenthos species in the deep-water area of the Fehmarn Belt. According to ZETTLER et al (2003), over 126 species have been identified in the Arkona Sea to date.

GOSSELCK et al (1996) list a total of 383 benthic species for the German marine and coastal area of the Baltic Sea. WASMUND et al. (2016) state that between 1991 and 2015, a total of 251 macrozoobenthos taxa were detected at eight stations in the Baltic Sea (Bays of Kiel and Mecklenburg, Arkona Sea). The 29 Red List species detected in the German EEZ thus represent approximately 8-12% of the total population. Species on the near-threatened list and data deficient species are not included here.

Criterion: Diversity and uniqueness

This criterion refers to the number of species and the composition of the species communities. It assesses the extent to which species or biotic communities characteristic of the habitat occur and how regularly they occur.

The species inventory of the Baltic Sea EEZ, with its approximately 200 macrozoobenthos species, can be regarded as average. The benthic communities are also largely nonexceptional. At higher salinities, such as those found in the deeper zones of the German Belt Sea (from approx. 20 m), conditions are right for a relatively species-rich *Abra alba* biocoenosis. The eponymous white furrow shell (*Abra alba*) is joined by the basket shell (*Corbula gibba*), the black clam (*Arctica islandica*), the trumpet worm (*Lagis koreni*), the catworm *Nephtys sp.*, the cumacean *Diastylis rathkei* or the common brittle star (*Ophiura albida*). In addition, there are a number of other marine/euryhaline polychaetes, crustaceans and bivalves. In the Baltic Sea proper, the *Macoma Balthica* biocoenosis predominates in the shallower areas, with salinity-related species decline.

Criterion: Legacy impacts

For this criterion, the intensity of fishing exploitation, which is the most effective disturbance variable, will be used as a benchmark. Eutrophication can also affect benthic communities. Other disturbance variables, such as vessel traffic, pollutants, etc. cannot be included in the assessment as there is currently a lack of suitable measurement and detection methods.

The benthos of the Baltic Sea has legacy impacts from various anthropogenic disturbance factors and deviates from its natural state. As a result, neither the species composition nor the biomass of zoobenthos today corresponds to the state that would be expected without human activity. Particularly noteworthy is the disturbance of the seabed surface by intensive fishing activity, which poses a high risk to epibenthos and causes a shift from long-lived species (bivalve molluscs) to short-lived, rapidly reproducing species. Other major factors are eutrophication and shipping. The main effects of eutrophication on the Baltic Sea ecosystem have been the increase in planktonic primary production, the increase in benthic biomass (CEDERWALL and ELMGREN, 1980) and the increase in oxygen depletion events. Increasing oxygen consumption due to eutrophication processes and reduced water exchange due to climate fluctuations or changes are considered to be the causes of the frequent and extreme oxygen deficiency conditions in the Baltic Sea (HELCOM 2009). Munitions dumped in the Baltic Sea can also pose a threat to the benthos.

In addition to the evaluation criteria mentioned above, the Baltic Sea succession model of RUMOHR (1996) can be used to describe the situation of benthic communities in the Baltic Sea. Application of this model shows that the benthological status of the Baltic Sea deteriorated by at least one stage between 1932 and 1989. The particular hydrographic and morphological characteristics of the Baltic Sea, natural events (saltwater intrusion, oxygen depletion) and anthropogenic influences (eutrophication, pollutant inputs) indicate a succession of typical benthic states. RUMOHR (1996) distinguishes a sequence of typical states and defines a total of five different stages. These begin with a stable (climax) community dominated by long-lived bivalves or echinoderms (stage 1, hardly ever found today) and, as eutrophication increases, change into a community with increased biomass (stage 2), which is dominated by bivalves and long-lived polychaetes and is subject to strong fluctuations. If conditions continue to deteriorate, a short-lived community of small polychaetes with low biomass follows, with strong fluctuations in population parameters and occasional extinctions due to oxygen deficiency (stage 3). If the oxygen content decreases even further, the entire fauna living in the soil (infauna) dies and only occasionally a mobile epifauna can be found. In the long term, stage 5 consists of animal-free (azoic) finely laminated sediment.

Since the end of the 1980s, the western Arkona Basin, like the eastern basins, has been one of the areas of the Baltic Sea acutely endangered due to temporary oxygen deficiency events. This is shown by a comparison of the state of the marine environment between data by HAGMEIER from 1932 (stages 1–2) and data from 1989 (stages 3–4) (RUMOHR, 1996). However, following previous oxygen deficiency situations, it also became apparent that the benthos has enormous regeneration potential (cf. WASMUND et al. 2012). Thus the current state of the benthos, as derived from data from environmental impact studies (EIS) and R&D projects, can be placed in stage 2–3 of the Baltic Sea succession model according to Rumohr (1996). However, the individual steps in this succession model can be reversed if conditions change as a result of environmental improvements.

Wind energy priority area EO1

In preparatory studies by ZETTLER et al (2003) for the designation of the special suitability area "West of Adlergrund" (area EO1), a total of 69 macrozoobenthos species were identified. Total densities of between 750 and 31,250 individuals per square metre were found, with abundances mainly influenced by the presence of mussels (*Mytilus edulis*). Accordingly, the biomass correlates mainly with their occurrence. A total of six species were identified by ZETTLER et al. (2003) as being glacial relics (*Halitholus yoldiaearcticae*, *Astarte borealis, A. elliptica, Monoporeia affinis, Pontoporeia femorata* and *Saduria entomon*). Like *Arctica islandica,* these species depend on cold and relatively salty water and are therefore largely restricted in their occurrence to the deeper parts of the area. From a macrozoobenthic point of view, the areas with *Astarte borealis* are particularly valuable for the region. Strong aperiodic saltwater influxes can transport marine species into the eastern Arkona Basin and thus contribute to biodiversity. In the southern half of the area, bivalve coenoses of *Mytilus edulis* and *Macoma baltica* have been recorded.

The investigations of the benthos in area 1 (MARILIM 2016) carried out as part of the baseline survey were only partially able to confirm the results of ZETTLER et al (2003). The species found were assigned to the *Macoma balthica* community, which is widely distributed in the western and central Baltic Sea. Accordingly, in area EO1 the species *Macoma balthica, Scoloplos armiger* and *Pygospio elegans* were the most common, with the biomass dominated by the Baltic clam (*Macoma balthica*). In the southern part of area EO1, on the other hand, the three main species *Mytilus edulis*, *Pygospio elegans* and *Macoma balthica* were most abundant.

The biomass in this area was constantly dominated by bivalves (*Mytilus edulis* and *Macoma balthica*).

The benthic community in area EO1 should be considered of high quality due to the richness of species, rare relict species and Red List species. The area has a comparatively high proportion of endangered species. From a macrozoobenthic point of view, the boulder fields with their distinct mussel beds are particularly valuable. In the southeast, the high numbers of benthic species from the Adlergrund reach into area EO1. Mainly mussel beds, gravel and stone banks and the presence of till have been identified.

Area reserved for wind energy EO2

The results of the environmental assessments for the proposed offshore wind farms Baltic Eagle and Ostseeschatz will be used for the assessment of the benthos in area EO2. The *Macoma balthica* community, which extends over large parts of the Baltic Sea, is established throughout the area. Apart from the eponymous Baltic clam, the benthic community is dominated by various other bivalves, polychaetes, crustaceans and gastropods. The three main species, measured in terms of the total number of individuals, are the Baltic clam, *Scoloplos armiger* and the cumacean *Diastylis rathkei*. Apart from the bivalve molluscs, they are mainly fast-growing, short-lived "opportunists", characterised by rapid attainment of sexual maturity, high numbers of offspring and short life cycles. These are crucial characteristics for survival in the highly variable environmental factors of this habitat.

A total of 42 macrozoobenthos species were identified in the Baltic Eagle and Ostseeschatz project areas. The average density of individuals in the project area Baltic Eagle was 643 individuals per m². Individual species often dominate. The epifauna is dominated by species that can live as scavengers or predators on muddy substrates, such as the polychaetes *Nephtys ciliata* and *Bylgides sarsi*. Of the species identified, only the Iceland mussel (*Arctica islandica*) is classified as endangered in accordance with the Red List (Rachor et al., 2013) (cf.

Table 8).

Overall, area EO2 has a low structural richness. The benthos is mainly composed of species that regenerate quickly. The pronounced ability to recover quickly after disturbances is a characteristic feature of the benthic fauna (RUMOHR 1995). The area is therefore of minor importance both for the infauna and the epifauna.

Wind energy priority area EO3

The results of the preparatory investigations for the designation of the special suitability area Kriegers Flak, the results of the benthos investigations within the scope of the EIA, and monitoring performed during construction of wind farm EnBW Baltic 2 will be used for the description of the area EO3.

In the investigations of ZETTLER et al. (2003) a total of 77 macrozoobenthos species were detected. Total densities between 386 and 8875 individuals/m² were found, where the abundances were significantly influenced by the presence or absence of the Baltic clam (*Macoma balthica*) and the polychaete *Pygospio elegans.* The biomass was mainly dependent on the larger bivalve species (*Macoma balthica*, *Mya arenaria* and *Mytilus edulis*). At the silt stations in water depths of more than 35 m, the polychaete *Terebellides stroemi* was regularly recorded in relatively high abundances. Of the species recorded, seven species should be regarded as glacial relics (including *Astarte borealis*, *Monoporeia affinis* and *Pontoporeia femorata)*. These species, as well as *Arctica islandica,* depend on cold and relatively salty water and are therefore largely restricted in their occurrence to the deeper zones of the area. These zones are particularly valuable for the Kriegers Flak region from a macrozoobenthic point of view.

With the exception of a few reports of rare species, the results of the investigations within the scope of the EIA on the current population of benthic communities are in agreement with the results of the investigations within the scope of the R&D project commissioned by the BfN (Zettler ET al. 2003). A total of 83 macrozoobenthos taxa were identified in the EIA of the study area for the wind farm EnBW Baltic 2. Investigations carried out as part of construction monitoring (IFAÖ 2015a) identified a total of 60 species and 20 supraspecific taxa. Most frequently present were the Baltic clam (*Macoma balthica*) and the mussel, the laver spire shell (*Hydrobia ulvae*), the polychaetes *Pygospio elegans* and *Scoloplos armiger* and the cumaceae species *Diastylis rathkei*.

Between 2002 and 2014, a total of 10 endangered Red List species as per RACHOR et al. (2013) were identified in area EO3 (cf. Table 8).

The benthic community in area EO3 is considered to be of high quality due to its species richness, rare relict species and the number of Red List species. This follows from the fact that a total of 83 species were identified in the study area of the EnBW Baltic 2 wind farm, 10 of which are Red List species. The southern and to some extent the northeastern area of the site is of particular importance, as it is home to cold-water species that are rare in the Baltic Sea (e.g. *Astarte borealis, Monoporeia affinis*). According to ZETTLER et al. (2003), the cobble and stone bottoms in the northern shallow area with its pronounced mussel beds are also particularly valuable from a macrozoobenthic point of view.

Area reserved for cables LO6

Within the scope of the benthos investigations for the grid connection of the offshore wind farm Arkona-Becken Südost, a total of 36 macrozoobenthos species were detected by means of grab sampling. Polychaetes and crustaceans represented the most species-rich groups. The average density of individuals was 3,396 individuals per m². A total of 61 species were detected within the scope of the route investigations for the planned grid connections for area EO1 carried out in 2012.

The soft soil zone found along the route outside area EO1 is relatively species-poor. The individual species densities and total biomass found are also comparatively low. Soft soil-dwelling species such as *Halicryptus spinulosus, Macoma balthica, Terrebellides stroemi, Diastylis rathkei* and *Pontoporeia femorata* predominate. Especially in summer, aperiodic oxygen deficiency events can occur in the muddy soils and lead to large-scale die-off of benthic fauna. Overall, the importance of the route for macrozoobenthos can be classified as low to medium, at most. The transect studies within area EO1 show a clearly species-rich benthic fauna with higher individual densities. Here the mussel dominates the hard seabed biocoenosis.

More recent investigations of benthic communities were carried out as part of the approval procedure "Cables 1 to 6 / cross connection" for the grid connection in areas 1 and 2 (50 HERTZ 2014), the route of which largely corresponds to the routes of the connections. A total of 42 taxa were identified along the planned cable routes, with polychaetes (14 species), crustaceans (12 species) and molluscs (5 species) being the taxonomic groups with the greatest number of species. Two of the identified species are on the Red List as per RACHOR et al. (2013) with a degree of threat of indeterminate extent due to their current population or population development (directive category G). These are the bivalve mollusc *Astarte borealis* and the isopod *Saduria entomon*. The endangered, long-lived bivalve mollusc *Arctica islandica* (directive category 3) may also occur locally, even if it was not detected in the above investigations. Within the boulder fields occurring in the area, the occurrence of typical reef species or reef communities can be expected. The benthic community should therefore be classified as regionally significant, especially in area EO1.

2.6 Fish

As the most species-rich of all vertebrate groups living today, fish are equally important in marine ecosystems as predators and prey. Bottom-dwelling fish feed predominantly on invertebrates living in and on the bottom, while pelagic fish species feed almost exclusively on zooplankton or other fish. In this way, biomass produced in and on the seabed and in open water, and the energy it binds, is also made available to seabirds and marine mammals.

The way of life of adult fish in the water body lends itself as a first subdivision of the fish fauna, according to which bottom-dwelling species (demersal) can be distinguished from those living in open water (pelagic). Mixed forms (benthopelagic) are also widely distributed. However, this separation is not strict: demersal fish do ascend into the water column, just as pelagic fish may temporarily stay near the bottom. At 53%, demersal fish account for the largest proportion, ahead of benthopelagic (27%) and pelagic (17%) species. Only around 3% of fish cannot be assigned to any of the three habitats due to close habitat affinity (FROESE & PAULY 2000). The individual life stages of each species often differ more in form and behaviour than the same stages of different species: the pelagic herring *Clupea harengus* lays its eggs in thick mats on sandy and gravelly ground, or sticks them to suitable substrates such as algae or stones (DICKEY-COLLAS et al. 2015); all flatfish have pelagic larvae, which later take on their characteristic shape and become bottom-dwelling (VELASCO et al. 2015), and benthopelagic fish such as cod have pelagic eggs and larvae (HISLOP et al. 2015). The most important influences on fish populations are fishing and climate change (HOLLOWED et al. 2013, HEESSEN et al. 2015). These factors interact, and their relative impact on fish population dynamics is difficult to distinguish (DAAN et al. 1990, VAN BEUSEKOM et al. 2018). Added to this are the hydrographic conditions and the influences of a wide range of human activities. For example, although the dominance relationships within a fish species community may follow long-term, periodic climate fluctuations (PERRY et al. 2005, BEAUGRAND 2009, GRÖGER et al. 2010, HISLOP et al. 2015), they cannot be explained without taking fisheries into account (FAUCHALD 2010).

A weakening of the synchronicity between temperature-controlled zooplankton development and day-length-controlled phytoplankton development represents another mechanism by which elevated temperatures due to climatic change can influence fish population dynamics. As a result of this temporal mismatch (CUSHING 1990), fish larvae may find a reduced density of zooplankton once they have consumed their yolk sac and become dependent on an external food supply. Across species, the survival rates of early life stages have a disproportionately high impact on population dynamics (HOUDE 1987, 2008). This variability can extend to predators at the top of the food web (DURANT et al. 2007, DÄNHARDT & BECKER 2011), which includes fisheries. Indirectly, climate change could affect marine fish communities due to the installation of offshore wind farms in response to climate change (EEA 2015). On the one hand, this would create large areas from which fishing is excluded, and on the other hand it would introduce artificial hard substrates on a large scale, thereby creating habitats for species that would not otherwise occur in the areas concerned (EHRICH et al. 2007). In principle, these mechanisms are also effective in the Baltic Sea, whose hydrographic dependence on wind-driven inflow of saline and oxygen-rich North Sea water is the determining factor for fish populations (MÖLLMANN et al. 2009). Oxygen deficiency repeatedly occurs in the deep basins. Stable stratification of the water body, with oxygen depletion below the thermocline can massively impair the reproductive success of fish whose eggs float in these layers (e.g.

Baltic cod; NISSLING et al. 1994). However, climate change and fisheries are not the only factors that can control fish populations. For example, ÖSTERBLOM et al. (2007) explain the development of fish stocks in the Baltic Sea between 1900 and 1980 largely based on the decline in the seal population and severe eutrophication.

2.6.1 Data availability

As data is almost exclusively available from bottom fisheries, not from pelagic sampling, the following assessment can only be made for demersal fish. For pelagic fish, no reliable estimates can be made. The bases for the status assessment of the protected (bottom-dwelling) fish are

- the results of environmental impact studies and cluster investigations for the preparation of current species lists (Area 1: Cluster west of Adlergrund spring 2014; Area 2: Baltic Eagle autumn 2012; Area 3: EnBW Baltic 2 autumn 2014), and
- the International Council for the Exploration of the Sea (ICES) trawl survey database (DATRAS) (accessed 12th of March 2018). Only the standard areas and grid squares covering the German Baltic Sea EEZ were considered. These are standard roundfish areas 22 and 24, with wind farm areas EO1, EO2 and EO3 all located in standard roundfish area 24. The catch data from the 4th quarter of 2017 and the 1st quarter of 2018 were combined.

EHRICH et al (2006) and KLOPPMANN et al (2003) were considered as a historical reference. HEESSEN et al. (2015) was used to classify the project in the wider context of the entire Baltic Sea. The Internet portal "Fischbestände Online" (BARZ & ZIMMERMANN 2018), which summarises the scientific assessment of stocks by ICES, was used for the current assessment (2017/2018) of exploited stocks.

2.6.2 Spatial distribution and temporal variability

The spatial and temporal distribution of fish is determined first and foremost by their life cycle and the associated migrations of the various developmental stages (HARDEN-JONES 1968, WOOTTON 2012, KING 2013). The framework for this is set by many different factors affecting different spatial and temporal scales. On a large scale, hydrographic and climatic factors (in the broad sense) such as swell, and above all wind-driven currents – which control the influx of cold, oxygen-rich saltwater from the North Sea – have a major impact on living conditions for fish in the Baltic Sea. On a medium (regional) to small (local) space-time scale, the effects of water temperature and other hydrophysical and hydrochemical parameters, as well as food availability, intra- and inter-species competition and predation, including fisheries, may be seen. Another decisive factor for the distribution of fish in time and space is habitat. In a broader sense this refers not only to physical structures, but also to hydrographic phenomena such as fronts (MUNK et al. 2009) and upwelling areas (GUTIERREZ et al. 2007), where prey aggregates and can thereby set in motion and maintain entire trophic cascades. Various human activities and influences are further factors that structure the fish distribution. These include nutrient and pollutant discharges, the obstruction of migration routes for migratory species, fisheries, and marine structures used by fish as a spawning substrate (sheet piling for herring spawn), food source (fouling/growth on artificial structures), and even as a refuge (wind farms) (EEA 2015).

2.6.2.1 Fish fauna in the German EEZ

The special hydrography and decrease in salinity from west to east are also reflected in the fish fauna of the Baltic Sea. Where marine species predominate in the North Sea, freshwater fish make up a large part of the Baltic Sea fish species community. As of November 2015, the fish database Fishbase (FROESE & PAULY 2000) lists 160 species recorded throughout the Baltic Sea to date. THIEL et al (1996) put the number of

Baltic fish species at 144, comprising 97 marine fish species, 7 migratory and 40 freshwater fish species. In their comprehensive overview, WINKLER & SCHRÖDER (2003) list 151 species for the entire German Baltic Sea coast. The reference area covers the Baltic coasts of Schleswig-Holstein and Mecklenburg-Western Pomerania, externally bounded by the central EEZ dividing line established with neighbouring countries (as defined by FRICKE et al. 1996). The documentation includes all species for which there is scientifically proven evidence from the German Baltic Sea region. Taking into account all individual species ever recorded in the Baltic Sea, the list of Baltic fish consists of 176 species (WINKLER et al. 2000). According to MÖBIUS & HEINCKE (1883), the species are divided into four categories depending on how the area is used as a habitat:

- Marine sedentary fish which, although they do migrate, are continuously encountered and reproduce in the area
- Marine migratory and erratic migratory species which regularly, sporadically or extremely rarely migrate from the North Sea, but do not reproduce in the Baltic Sea
- Diadromous migratory fish that reproduce in fresh water and grow to maturity in the sea, or vice versa
- Freshwater fish that are stationary or migratory, reproducing in brackish or pure fresh water

According to MOYLE & CECH (2000), diadromous migratory species can be divided into

- anadromous species such as salmon, twaite shad (*Alosa fallax*) and river lamprey (*Lampetra fluviatilis*), which spawn in freshwater and grow to maturity in estuaries or the sea,
- semi-anadromous species such as vimba bream (*vimba vimba*), ziege (*Pelecus cultratus*), Baltic whitefish (*Coregonus maraena*) and smelt *Osmerus eperlanus*, which spawn in the upper estuary/low salinity brackish or fresh water, and
- catadromous species such as eel or flounder, which spawn in the sea and grow to maturity in brackish or fresh water.

While migratory species generally occur regularly in the area during their food migrations, erratic migratory species appear in the area with little predictability and mostly as a result of unusual hydrographic and meteorological phenomena. In the Baltic Sea, almost half of all species are resident, 18% can be classified as regular visitors, 29% as migrants and 8% have been introduced into the Baltic Sea, mostly temporarily, through deliberate or accidental stocking.

The total number of species has almost doubled since the 16th century, mainly due to the appearance of marine species. However, the ratio between marine species, and diadromous and freshwater species has remained at 2:1. According to WINKLER & SCHRÖDER (2003), 2/3 of the fish community are marine species, 12% are diadromous migratory species and 21% are freshwater fish. Of the 151 species found in the Baltic Sea, 44 are considered very rare, 36 rare, 33 regular, 24 common and 13 species are very common in the German Baltic Sea. This means that around 46% of the fish species (70 of 151) occur regularly to very frequently and around 54% rarely to very rarely in the German Baltic Sea (WINKLER & SCHRÖDER 2003).

2.6.2.2 Habitat-typical fish communities

The habitat-typical fish communities of the Baltic Sea are represented by pelagic, benthic (demersal) and littoral species (NELLEN & THIEL 1995). The boundaries are fluid and there is interchange, e.g. when pelagic fish such as herring visit their spawning grounds on the coast. In addition to spawning grounds, there are also feeding grounds for many fish species along the coast. The pelagic fish community is dominated by herring, which is found throughout the Baltic

Sea. Sprat, salmon and sea trout are other typical representatives. The economically most important representatives of the benthic fish community are cod, flounder and plaice. In addition to the above-mentioned commercially exploited species, various small fish species (e.g. gobies) are important members within the fish communities of the Baltic Sea.
The littoral fish community consists almost exclusively of juvenile individuals of pelagic species. The littoral of the Baltic Sea, consisting of bodden and lagoons, is characterised by dense growth of algae and sea grass as well as a richness of food, which explains its function as a nursery area for economically important species and as a habitat for small fish.

2.6.2.3 Biocoenoses typical of the region

The distribution of Baltic fish is largely determined by their tolerance or preference for abiotic factors such as salinity, temperature and oxygen content. In particular, the more sensitive developmental stages are decisive in this respect. Freshwater fish reach their physiological limits in the brackish Baltic Sea in the same way as marine fish from the North Sea, and the distribution of fish species reflects the salinity gradient, which decreases toward the east and north (RHEINHEIMER 1996). Along the same gradient, both the number of species and the species-specific abundance decreases, which can be explained to a large extent by the fact that marine fish avoid areas that are too low in salinity. In the Kattegat and the western Baltic Sea, marine fish are predominantly found (NELLEN & THIEL 1995), while freshwater fish are found in the coastal waters of the central Baltic Sea, where they are the most abundant species. REMANE (1958) reports 120 species of marine fish in the North Sea, only 70 in the Bays of Kiel and Mecklenburg, 40 to 50 in the southern and central Baltic Sea, and only 20 species in the Sea of Åland, the Gulf of Finland and the Bothnian Sea. In addition to salinity, water temperature also appears to be a factor that structures the fish community. The fish fauna of the North Sea is composed of species whose distribution centres on the north (Norway and Iceland) or the south (the Channel and the Bay of Biscay). In the western Baltic Sea, with few exceptions, all common marine fish are predominantly adapted to cold, e.g. cod, whiting, plaice and dab. In contrast, fish species with a more southerly distribution, including mackerel (*Scomber scombrus)*, horse mackerel (*Trachurus trachurus*), haddock (*Melanogrammus aeglefinus*), tub gurnard (*Chelidonichthys lucernus*), anchovy (*Engraulis encrasicolus*) and grey mullet (*Chelon labrosus*) rarely enter the western Baltic Sea. Nevertheless, the resident turbot, garfish, sprat, black goby (*Gobius niger*) and sand goby are all representatives of the "southern type" (NELLEN & THIEL 1995). The occurrence of freshwater fish in the Baltic Sea is limited to the river estuaries, bodden and lagoon waters (THIEL et al. 1996).

2.6.2.4 Red List species in the German EEZ

As part of the Red List, the threat to the 89 established fish and lamprey species in the Baltic Sea was assessed, based on current stocks as well as long-term and short-term stock trends (THIEL et al. 2013). According to this assessment, 9% (8 species) of the established marine fish and lamprey species in the Baltic Sea are classified as extinct or endangered under the Red List status. Taking extremely rare species into account, the proportion of Red List species increases to 16.9% (15 species). In the eastern EEZ, a total of 4 species having Red List status in the Baltic Sea were identified (FREYHOF 2009; THIEL ET AL. 2013). The river lamprey is critically endangered (1) (FREYHOF 2009). The European eel is endangered in the Baltic Sea (2), twaite shad and salmon are vulnerable (3) (THIEL et al. 2013).
Three of the Red List species are listed in Annex II of the Habitats Directive, namely the twaite shad, river lamprey and salmon (which however only has this status in freshwater). The sturgeon

Acipenser oxyrhinchus is considered extinct in the Baltic Sea (FREYHOF 2009). According to genetic and morphometric studies, the "Baltic sturgeon" is not the Atlantic sturgeon *Acipenser sturio,* as previously assumed, but the descendant of *A. oxyrhinchus,* now widespread in North America (LUDWIG et al. 2002). *A. sturio* was last caught off Rügen in 1952. As part of the project to reintroduce the Baltic sturgeon *Acipenser oxyrinchus,* several thousand juveniles, some of which were tagged, have been released in the Oder River since 2007/2008. To date, no natural reproduction has taken place and all reported sturgeon catches are the result of these stocking measures (GESSNER et al. 2000).

2.6.3 Assessment of the state of the factor fish

The status assessment of the demersal fish community in the German Baltic Sea EEZ is based on i) rarity and threat, ii) diversity and uniqueness, and iii) naturalness. These three criteria are defined below and applied separately for areas 1, 2 and 3.

Rarity and threat

The rarity and threat of the fish community are assessed on the basis of the proportion of species that are considered vulnerable according to the current Red List of marine fish (THIEL et al. 2013) or Red List of freshwater fish for diadromous species (FREYHOF 2009) and have been assigned to one of the following Red List categories: Extinct in the wild (0), critically endangered (1), endangered (2), vulnerable (3), threatened to an indeterminate extent (G), extremely rare (R), early warning (V), data deficient (D) or not threatened (*) (THIEL et al. 2013) Particular attention is paid to the threat level for species listed in Annex II of the Habitats Directive. They are the focus of Europe-wide conservation efforts and require special conservation measures, e.g. for their habitats.

In the Baltic Sea areas where **areas EO1, EO2** and **EO3** are located, a total of 45 fish species were identified as part of the environmental impact assessment and fish stock monitoring assessment in the above period (2.8.1). Of these, according to THIEL et al. (2013) and FREYHOF (2009), no species is considered extinct in the wild (0) or critically endangered (1). Three endangered species (2), eel, haddock and sea stickleback, were identified (6.7%). *Trachinus draco* and *Trisopterus minutus are* considered vulnerable (3) (2 species, 4.4%). None of the occurring species were found to be threatened to an indeterminate extent (G). Pollack is considered extremely rare (R, 1 species, 2.2%). Turbot, mackerel and sole (*Solea solea*) are on the early warning list (V; 3 species, 6.7%). The data availability for the sand eels *Ammodytes tobianus*, *Hyperoplus immaculatus* and *H. lanceolatus,* as well as hake and longspined bullhead (5 species, 11.1%), is considered insufficient for an assessment (D). The vast majority of species (31, 68.9%) are considered not threatened (*).

In the sea areas in which **area EO1** is located, a total of 38 species were identified during the environmental impact assessments and fish stock monitoring assessment. According to FREYHOF (2009) and THIEL et al. (2013), none of these species are considered extinct in the wild (0), critically endangered, or threatened to an indeterminate extent (G). Eel, haddock and sea stickleback, are the three endangered species (category 2, 7.9%), while the greater weever is vulnerable (3, 1 species, 2.6%). Pollack is considered extremely rare (R, 1 species, 2.6%), turbot, mackerel and sole are on the early warning list (V; 3 species, 7.9%). For the greater sandeel and Corbyn's sandeel, the available data do not allow an assessment (D, 3 species, 7.9%). The remaining 27 species (71.1%) are considered not threatened (*) (Table 9).

Table 9: Relative proportions of the Red List categories in the fish species detected in areas 1, 2 and 3. Extinct in the wild (0), critically endangered (1), endangered (2), vulnerable (3), threatened to an indeterminate extent (G), extremely rare (R), early warning list (V), data deficient (D) or not threatened (*) (THIEL et al. 2013). (EIA data for areas 1, 2, and 3 and 2017/2018 data from ICES DATRAS database, see 2.8.1). For comparison, the relative proportions of the assessment categories of the Baltic Sea Red List (THIEL et al. (2013) are shown.

	Red List Category								
TERRITORY	**0**	**1**	**2**	**3**	**G**	**R**	**V**	**D**	*****
1	0,0	0,0	7,9	2,6	0,0	2,6	7,9	7,9	71,1
2	0,0	0,0	7,1	2,4	0,0	2,4	7,1	9,5	71,4
3	0,0	0,0	7,5	5,0	0,0	2,5	7,5	5,0	72,5
Red List	**1,1**	**2,1**	**1,1**	**3,2**	**1,1**	**7,4**	**1,1**	**19,1**	**63,8**

In the sea areas in which the **area EO2** is located, a total of 42 species were identified during the environmental impact assessments and fish stock monitoring assessment. According to FREYHOF (2009) and THIEL et al. (2013), none of these species are considered extinct in the wild (0), critically endangered, or threatened to an indeterminate extent (G). Eel, haddock and sea stickleback are the three endangered species (category 2, 7.1%), while the greater weever is vulnerable (3, 1 species, 2.4%). Pollack is considered extremely rare (R, 1 species, 2.4%), turbot, mackerel and sole are on the early warning list (V; 3 species, 7.1%). For sandeel and hake, the available data do not allow an assessment (D, 4 species, 9.5%). The remaining 30 species (71.4%) are considered not threatened (*) (Table 9).

In the sea areas in which the **area EO3** is located, a total of 40 species were identified during the environmental impact assessments and fish stock monitoring assessment. According to FREYHOF (2009) and THIEL et al. (2013), none of these species are considered extinct in the wild (0), critically endangered, or threatened to an indeterminate extent (G).

Three endangered species (2) were identified (7.5%): eel, haddock and sea stickleback. The greater weever and poor cod are considered to be vulnerable (3) (2 species, 5.0%). Pollock is considered extremely rare (R, 1 species, 2.5%), turbot, mackerel and sole are on the early warning list (V; 3 species, 7.5%).

For the greater sandeel and Corbyn's sandeel the available data do not allow an assessment (D, 2 species 5.0%). The remaining 29 species

(72.5%) are considered not threatened (*) (Table 9).

In the Baltic Sea Red Lists of marine fish (THIEL et al. 2013) and freshwater fish (FREYHOF 2009), a total of 16.0% of the species assessed were assigned to a risk category (0, 1, 2, 3, G or R); 1.1% are on the early warning list, and for 19.1% no assessment is possible due to a lack of data. A total of 63.8% of species are considered not threatened (FREYHOF 2009, THIEL et al. 2013) (Table 9). By comparison, fewer species with a threatened status were recorded in all three Baltic Sea areas (1: 13.1%, 2: 11.9%, 3: 15.0%), while in each case there were more non-threatened species than on the Red Lists (1: 71.1%, 2: 71.4%, 3: 72.5%).

As expected, no extinct species (category 0) were found in any of the areas. The significance of the areas is below average for critically endangered species (1), while endangered species (2) were relatively more common in all areas than in the Red Lists. This also applied to vulnerable species (3) in Area 3. For these species, the areas are of above average significance. Vulnerable species accounted for a smaller proportion in areas 1 and 2 (Table 9). Species in category G (threatened to an indeterminate extent) and extremely rare species were found in lower proportions than in the Red Lists in all three areas, while the proportion of species on the early warning list was higher. The proportion of species that could not be assessed due to lack of data (D) was half (area 2) to almost three quarters (area 3) below the proportion in the Red Lists. Relatively more non-threatened species (*) were found in all areas, which means that they are of above-average importance for species in this category (Table 9).

Habitats Directive species were identified neither during the environmental impact assessments nor in the fisheries management surveys. Against this background, the fish fauna of the areas under consideration is considered to be average in terms of the criteria of rarity and threat.

Diversity and uniqueness

The diversity of a fish community can be described by the number of species (α-Diversity, species richness). The species composition can be used to assess the uniqueness of a fish community, i.e. how regularly habitat-typical species occur. Diversity and uniqueness are compared and assessed below, between the Baltic Sea as a whole and the German EEZ, and between the EEZ and the individual areas.

Taking all documented species into account, there are 176 species in the Baltic Sea (WINKLER et al. 2000). According to the fish database Fishbase, as of November 2015, 160 fish species have been recorded in the entire Baltic Sea, and WINKLER & SCHRÖDER (2003) list 151 species for which there is scientifically proven evidence from the German Baltic Sea region. THIEL ET AL (1996) put the number of Baltic fish species at 144, including 97 marine fish species, 7 migratory fish species and 40 freshwater fish species. The vast majority of these are rare and only just over half of them reproduce regularly in the German Exclusive Economic Zone (EEZ) or are found as larvae, juveniles or adults. In accordance with these criteria, only 89 species are considered established in the Baltic Sea (THIEL et al. 2013). In the Baltic International Trawl Surveys (BITS), 69 fish species were recorded throughout the North Sea between 2014 and 2018. In the German EEZ, represented here by the cluster-related fish data from environmental impact studies (see 2.8.1) and the DATRAS database of ICES (BITS data 2017 & 2018), a total of 45 species were identified (Table 10). The number of species in the individual areas was tightly grouped between 38 and 42 (cf. "Rarity and threat"). Most of the species were caught during the fisheries management surveys, but some species that did not appear in the BITS survey were detected in the EIAs. These were the sand lance, anchovy, three-spined stickleback, common seasnail *Liparis liparis*, hake, sand goby, longspined bullhead and pouting. Most species were found in Area 2, followed by Areas 3 and 1 (Table 10).

All demersal flat and roundfish species typical for the Baltic Sea were detected across all areas. All flatfish species (long rough dab (*Hippoglossoides platessoides*), common dab, flounder, plaice, turbot, brill and sole) were present in all of the areas considered (Table 10).

Although the bottom trawls used were not suitable for capturing pelagic fish, the typical pelagic species of this fish community were found in all clusters, namely sand lance, herring, greater sand eel, Corbyn´s sandeel, smelt, mackerel, sprat and horse mackerel (Table 10).

Of the 45 species recorded in the German EEZ during the period in question, 37 species were found in all areas, one species (sand goby) was found in two areas and seven species were recorded in one area each (Table 10). No spatial structure of the occurrence of different species, e.g. according to their preferred habitat or salinity preference, could be identified. Freshwater fish such as perch and zander and inshore species such as flounder and smelt were found in all three areas, while marine species such as anchovy and hake were caught in only one area (Table 10). It is possible that the environmental gradients in the area under consideration are not sufficiently pronounced to give a measurable structure to the occurrence of species. The composition of fish species differs between the areas only in terms of individual rare species, while there are large similarities in the more common, characteristic species (Table 10).

Between 1977 and 2005, EHRICH et al. (2006) identified 58 fish species in the Baltic Sea. Compared to these reports and to data from the Baltic Sea as a whole, the diversity in all areas can be considered average. In all areas, the typical and characteristic species of both the pelagic and demersal components of the fish communities considered were represented (see above). The uniqueness of the fish communities found is therefore also considered to be average.

Table 10: List of all fish species in the German Baltic Sea EEZ and species records in clusters 1, 2 and 3 (EIS data from 2014 and data from 2017/2018 from the ICES DATRAS database, see 2.8.1)

Artname	Deutscher Trivialname	OS1	OS2	OS3
Agonus cataphractus	Steinpicker	■	■	■
Ammodytes tobianus	Tobiasfisch		■	
Anguilla anguilla	Europäischer Aal	■	■	■
Aphia minuta	Glasgrundel	■	■	■
Clupea harengus	Hering	■	■	■
Cyclopterus lumpus	Seehase	■	■	■
Enchelyopus cimbrius	Vierbärtelige Seequappe	■	■	■
Engraulis encrasicolus	Sardelle		■	
Eutrigla gurnardus	Grauer Knurrhahn	■	■	■
Gadus morhua	Kabeljau	■	■	■
Gasterosteus aculeatus	Dreistachliger Stichling			■
Gobius niger	Schwarzgrundel	■	■	■
Hippoglossoides platessoides	Doggerscharbe	■	■	■
Hyperoplus immaculatus	Ungefleckter großer Sandaal	■	■	■
Hyperoplus lanceolatus	Gefleckter großer Sandaal	■	■	■
Limanda limanda	Kliesche	■	■	■
Liparis liparis	Großer Scheibenbauch		■	
Melanogrammus aeglefinus	Schellfisch	■	■	■
Merlangius merlangus	Wittling	■	■	■
Merluccius merluccius	Seehecht		■	
Mullus surmuletus	Streifenbarbe	■	■	■
Myoxocephalus scorpius	Seeskorpion	■	■	■
Neogobius melanostomus	Schwarzmundgrundel	■	■	■
Osmerus eperlanus	Stint	■	■	■
Perca fluviatilis	Flussbarsch	■	■	■
Platichthys flesus	Flunder	■	■	■
Pleuronectes platessa	Scholle	■	■	■
Pollachius pollachius	Pollack	■	■	■
Pollachius virens	Seelachs	■	■	■
Pomatoschistus minutus	Sandgrundel		■	■
Sander lucioperca	Zander	■	■	■
Scomber scombrus	Makrele	■	■	■
Scophthalmus maximus	Steinbutt	■	■	■
Scophthalmus rhombus	Glattbutt	■	■	■
Solea solea	Seezunge	■	■	■
Spinachia spinachia	Seestichling	■	■	■
Sprattus sprattus	Sprotte	■	■	■
Syngnathus rostellatus	Kleine Seenadel	■	■	■
Syngnathus typhle	Grasnadel	■	■	■
Taurulus bubalis	Seebull	■		
Trachinus draco	Großes Petermännchen	■	■	■
Trachurus trachurus	Holzmakrele (=Stöcker)	■	■	■
Trisopterus esmarkii	Stintdorsch	■	■	■
Trisopterus minutus	Franzosendorsch			■
Zoarces viviparus	Aalmutter	■	■	■
	Anzahl Arten	38	42	40

Legacy impacts

The legacy impacts on a community are defined as the presence of anthropogenic influences, of which fishing is the most important. It is true that fish are also subject to other direct and indirect human influences, such as eutrophication, shipping traffic, pollutants, and sand and gravel extraction. However, these effects cannot yet be measured reliably. In principle, the relative effects of individual anthropogenic factors on the fish community and their interactions with natural biotic (predators, prey, competitors, reproduction) and abiotic (hydrography, meteorology, sediment dynamics) parameters of the German EEZ cannot be clearly separated. However, by taking target species and by-catch, and by disturbing the seabed in the case of bottom fishing methods, fisheries are the most effective disturbance to fish communities and can therefore serve as a measure of the legacy impact on fish communities in the Baltic Sea. An assessment of stocks on a smaller spatial scale, such as the German EEZ, is not carried out as part of fisheries management, so the following assessment of this criterion cannot be carried out at cluster level either, but only for the Baltic Sea as a whole. Of the 89 species considered established in the Baltic Sea (Thiel et al. 2013), 17 stocks of 9 species are fished commercially (ICES 2017a). The assessment of the existing stocks is based on the "Fisheries Overview - Baltic Sea Ecoregion" of the International Council for the Exploration of the Sea (ICES 2017a).

Fisheries have two main effects on the ecosystem: the disturbance or destruction of benthic habitats by nets in contact with the seabed, and the taking of target species and by-catch species. The latter often include protected, threatened or endangered species, including not only fish but also reptiles, birds and mammals (ICES 2017b). More than 5300 fishing vessels from nine nations operate in the Baltic Sea with an annual catch of almost 700,000 tonnes across species and stocks (ICES 2017a). In total there are 4100 small-scale coastal fishing vessels, and only 1200 vessels fishing in the open Baltic Sea. However, there are major differences between the countries involved.

Bottom fishing is concentrated in the southern Baltic Sea. However, outside of coastal waters the fleet mainly uses pelagic trawls in the entire Baltic Sea. In coastal fisheries, bottom-set gillnets predominate (ICES 2017a).

The German fleet consists of more than 700 vessels, of which only 60 operate in offshore areas. In coastal waters, 650 smaller vessels operate exclusively in bottom-set gillnet fisheries. On the German Baltic Sea coast alone, the number of recreational anglers targeting cod, herring, sea trout, whiting and flatfish from shore or boats is estimated at 161,000.

Commercial fisheries and the size of spawning stocks will be assessed against Maximum Sustainable Yield (MSY), taking into account the precautionary approach. A total of 17 stocks have been considered in terms of fishing intensity, with scientific stock assessments for 14, neglecting just 3 stocks. Of the 17 stocks assessed, 7 are sustainably managed and 7 are over-exploited (Figure 2.8.5; ICES 2017a). Of the 17 stocks, 10 were assessed in terms of their reproductive capacity (spawning biomass). Of these, 6 have full reproductive capacity (Figure 22; ICES 2017a). The biomass share of the total Baltic catch (687,000 tonnes in 2017) of over-exploited stocks outweighs by a large margin (>90%) the share of stocks caught sustainably and not assessed. Nevertheless, fish from stocks whose reproductive capacity is above the defined reference value accounts for the majority of the biomass share in the catch (>90%). Biomass from assessed stocks and those with a reproductive potential below the reference value accounts for less than 10% overall.

Overall fishing yields were at their peak in the mid-1970s and 1990s, which can be explained by the stocks of cod *Gadus morhua* and herring

Clupea harengus. Half of the fish stocks in the Baltic Sea monitored against reference values are managed at or below sustainable yield (FMSY), while the other half are overfished. This is reflected in the fact that the vast majority of the biomass in the catch comes from these stocks (Figure 35). While pelagic trawls and passive fishing gear are the predominant fishing methods in the Baltic Sea, bottom trawling with its resultant disturbance of the seabed is concentrated in the southern Baltic Sea. The bottom trawling fisheries sometimes have high by-catch rates of diving seabirds (auks and seaducks) and, more rarely, harbour porpoises.

In the overview of the fishery indicators (ICES 2017a), the ecosystem effects of bottom fishing (WATLING & Norse 1998, Hiddink ET al. 2006) and set gillnetting, the impact on fish fauna is considered to be average.

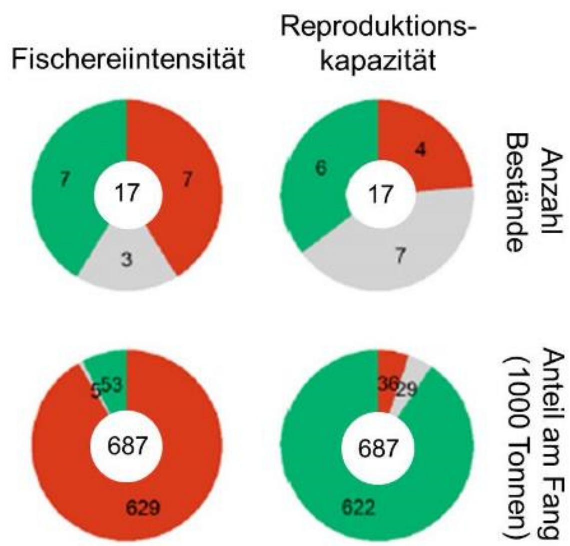


Figure 35: Summary of the status of fish stocks in the Baltic Sea in 2017. Left: Fishing intensity indicates the number of stocks (top) and the biomass share of the catch (bottom, in 1000 tonnes) that is below (green) or above (red) the reference level (fishing mortality at maximum sustainable yield, FMSY). Right: Reproductive capacity indicates the number of stocks (top) and the biomass share of the catch (bottom) that is above (green) or below (red) the reference level (spawning biomass, MSY Btrigger). Grey indicates the number or biomass share of the catch of stocks for which no reference points have been defined and for which no stock assessment is therefore possible. A total of 17 stocks were considered, which together accounted for a catch of 687,000. Amended in accordance with ICES (2017a).

2.6.3.1 Importance of the areas for fish

The overriding criterion for the importance of the areas for fish is the relation to the life cycle, within which different stations are linked to stage-specific habitat requirements by more or less extensive migrations between them. No information on reproductive status was collected for the data sets used, so the importance of the areas for fish can only be described in general terms. A further obstacle to a high-resolution areal assessment is the fact that the catch data were collected using methods that do not allow for an assessment with respect to habitat. The overview of species records by area did not show any particular significance of a specific area for the regular, common characteristic species. There is no apparent tendency for species with specific habitats to favour certain areas (Table 10), but this may be due to the fact that the area under consideration is too small and too homogeneous for environmental gradients to be reflected in the species composition. Fish also pass through wind farm areas on the regular migrations between the spawning and nursery grounds near the coast and the deeper areas that characterise the life cycle of most species. They are therefore important as transit areas, at least for marine species. Freshwater species are concentrated along the coast and near the estuaries, as evidenced by the absence of many freshwater species that are quite typical and characteristic in the Baltic Sea (THIEL et al. 2013) in the data evaluated here. The importance of wind farm areas is low for these species. However, the relatively higher proportion of endangered fish species in all three areas indicates that these areas are more important for these species (eel, haddock and sea stickleback).

2.7 Marine mammals

Three species of marine mammals regularly occur in the German Baltic Sea EEZ: Harbour porpoises (*Phocoena phocoena*), grey seals (*Halichoerus grypus*) and harbour seals (*Phoca vitulina*). All three species are characterised by high mobility. Migration, especially in search of food, is not limited to the EEZ. It includes coastal waters and large areas of the Baltic Sea beyond the German EEZ. The two seal species have their resting and whelping grounds on islands and sandbanks in coastal waters. They forage extensively in the open sea from their resting sites. Due to their high mobility and use of very extensive areas, it is necessary to consider the occurrence not only in the German EEZ, but in the entire western Baltic Sea.

Marine mammals are among the top consumers in the marine food chain. They are therefore dependent on the lower components of the marine food chain: on the one hand on their direct food organisms (fish and zooplankton) and on the other hand indirectly on phytoplankton. As consumers at the top of the marine food chain, marine mammals also influence the occurrence of food organisms.

2.7.1 Data availability

As a result of a large number of investigation programmes, particularly in German waters, data availability has improved significantly in recent years, and can now be considered good. However, there is no continuous investigation or monitoring programme for marine mammals in the EEZ and coastal waters.

Data are available at different spatial levels from the following sources:

- Surveys of the entire area of northern European waters carried out under SCANS I, II and III[4] in 1994, 2005 and 2016, and the mini-SCANS of 2012 (however, SCANS only covers the western Baltic Sea up to the German part of the Bay of Pomerania)
- Research projects in the German EEZ and in coastal seas, such as the MINOS[5] and MINOSplus surveys in the years 2002 to 2006
- Investigations in the context of authorisation and planning approval procedures for offshore wind farms, and planning approval procedures for pipelines
- Monitoring of Natura 2000 sites / acoustic monitoring by the German Oceanographic Museum
- The EU research project SAMBAH[6]

SAMBAH (Static Acoustic Monitoring of the Baltic Sea Harbour porpoise) is an international monitoring project aimed at providing scientific data to support the conservation of the Baltic porpoise. Between May 2011 and May 2013, 300 click detectors were deployed in the Central Baltic Sea to determine the density, frequency and distribution of the harbour porpoise population.

2.7.2 Spatial distribution and temporal variability

The high mobility of marine mammals depending on specific conditions of the marine environment leads to a high spatial and temporal variability in occurrence. Both the distribution and abundance of the animals vary over the course of the seasons. A good database is necessary in order to draw conclusions about seasonal distribution patterns and the use of different sub-areas. Large-scale long-term studies in particular are necessary in order to identify the effects of intra-annual and interannual variability.

Harbour porpoises occur all year round in the German Baltic Sea EEZ, but their abundance and spatial distribution varies with the seasons (GILLES et al. 2008, 2009). However, the seasonal distribution patterns are less pronounced than in the North Sea.

2.7.2.1 Harbour porpoises

The harbour porpoise is a common cetacean species in the temperate waters of the North Atlantic and North Pacific, and in some marginal seas like the Baltic Sea. Due to its hunting and diving behaviour, the distribution of harbour porpoises is limited to continental shelf seas (READ 1999). The harbour porpoise is the only species of cetacean that occurs regularly in the Baltic Sea.

Studies indicate that there are three separate porpoise populations in the waters between the North Sea and the Baltic Sea: a) the population of the North Sea and the Skagerrak, b) the Belt Sea population (Kattegat, Belt Sea, Øresund and Western Baltic Sea) and c) the separate population of the Central Baltic Sea (TEILMANN et al. 2011). The existence of a separate population

[4] Small Cetacean Abundance in the North Sea and Adjacent Waters

[5] Marine warm-blooded animals in the North and Baltic Seas: Principles for the assessment of wind turbines in the offshore area (project funded by BMU)

[6] Static Acoustic Monitoring of the Baltic Sea Harbour Porpoise

in the eastern Baltic Sea with a stock of a few hundred individuals is indicated by the results of morphometric and genetic investigations and the results of the SAMBAH research project (GALATIUS et al. 2012).

Harbour porpoises migrate in search of rich food sources and temporarily concentrate in areas of high quality and/or high quantity food supplies (REIJNDERS 1992, EVANS 1990). Fish, mainly herring and cod species, are part of the harbour porpoise's preferred food spectrum. Harbour porpoises mainly hunt schools of fish (READ 1999). Pelagic and semi-pelagic fish species dominate the porpoise's diet. Breeding grounds are mainly reported as coastal areas with water depths below 20 m, e.g. in the Belt Sea and on the coasts of Mecklenburg-Western Pomerania (KINZE 1990, SCHULZE 1996).

Occurrence of harbour porpoise in the German Baltic Sea

There was a significant decrease in population numbers between 1994 and 2005 for the whole Kattegat, Belt Sea, Øresund and Western Baltic Sea area. Whereas in 1994, 27,800 porpoises (95% confidence interval = 11,946–64,549) were recorded in this area within the scope of SCANS I, in 2005 only 10,900 individuals (CI = 5,840–20,214) were recorded for the area (TEILMANN et al. 2011). However, the difference is not significant, due to the wide range of the 95% confidence intervals (ASCOBANS 2012). The area east of the Darss Sill is not covered by the SCANS survey.

SCHEIDAT et al. (2008) showed that population density in the southwestern Baltic Sea is subject to both seasonal and spatial fluctuations. The highest densities occur in the area of the Bay of Kiel. The abundance of harbour porpoise recorded varied between 457 individuals in March 2003 (CI: 0–1,632) and the highest estimates in May 2005 with 4,610 individuals (CI: 2,259–9,098). The most recent population estimates for the Bay of Kiel (including Danish waters to the island of Funen) in 2010 and 2011 show low densities of less than 0.4 individuals per km² (GILLES et al. 2011).

For the area east of the Darss and Limhamn sill to Øland and the outer Gdansk Bay, only 599 individuals were recorded in 1995 (HIBY & LOVELL 1995). These values reflect a significant decrease in population density along a gradient from the Kattegat to Polish waters (KOSCHINSKI 2002).

An analysis of data from airborne censuses, random sightings and strandings has shown that the density of harbour porpoises in the Baltic Sea decreases from west to east (SIEBERT et al. 2006). This is confirmed by a gradient in the echolocation activity of harbour porpoises (GILLESPIE et al. 2003, VERFUSS et al. 2004). By using stationary click detectors (PODs), harbour porpoises were detected almost every day at Fehmarn. In the period from 2008 to 2010, 90% to 100% porpoise-positive days (PPDs) were recorded around Fehmarn and in the Bay of Mecklenburg. The results from Adlergrund and the Oder Bank showed significantly lower harbour porpoise registration rates overall than in the western study areas, with a maximum of 21% porpoise-positive days in February 2010 (see Fig. 14; GALLUS et al. 2010).

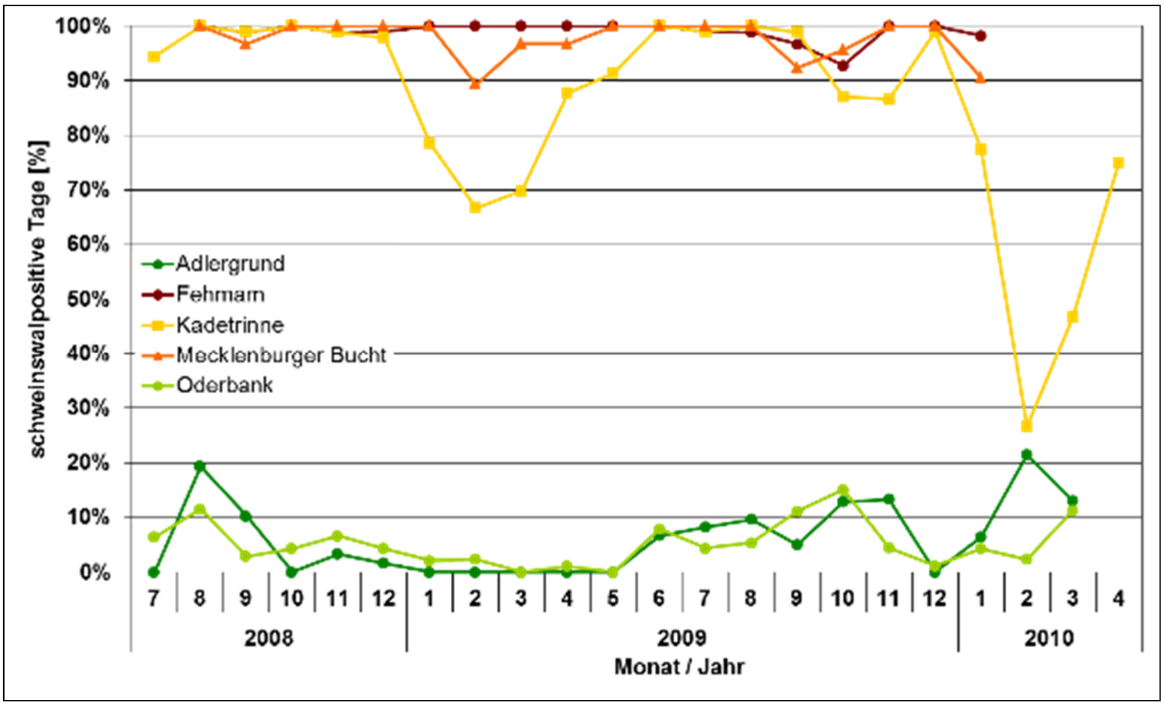


Figure 36: Harbour porpoise positive days as a percentage of the total number of recording days for the study areas Fehmarn (3 stations), Bay of Mecklenburg (1 station), Kadet Channel (3 stations), Adlergrund (2 stations) and Oder Bank (3 stations). Fehmarn, Kadet Channel and the Bay of Mecklenburg were automatically evaluated using *Cet All*, while Oder Bank and Adlergrund were visually verified. The values for 2010 on Adlergrund should be taken as a trend only, as at this time only one station provided usable data, and in March observations were made on just 6 days (source: GALLUS et al. 2010).

For the large-scale investigations in the MINOS and MINOSplus projects, the German EEZ of the Baltic Sea was divided into three sub-areas (SCHEIDAT et al. 2004, GILLES et al. 2007, GILLES et al. 2008). Area E (Bay of Kiel) comprises the western part of the EEZ and coastal waters, area F (Bay of Mecklenburg) the area up to the Darss Sill and area G (Rügen) comprises the eastern part of the German EEZ and coastal waters. In the entire period under study, the mapping effort reached 24,360 km. However, in total just 335 harbour porpoises were sighted. During the period under review from 2002 to 2006, the density of harbour porpoises in the areas varied between 0.06 individuals/km² in spring 2005, 0.08 individuals/km² in June 2003 and 0.13 individuals/km² in June 2005. The population was estimated at 1,300 (200 to 3,800) individuals in spring, 1,700 (700 to 3,700) individuals in summer and 2,800 (1,200 to 5,900) individuals in autumn.

Due to weather conditions in the winter months from December to February, the mapping effort remained low, so that no calculations are possible. In spring, most porpoises were seen around the island of Fehmarn and on the Oder Bank. In summer, the highest densities were found in the Bay of Kiel. Although an unexpectedly high number were sighted on the Oder Bank in July 2002 (84), none were found in the following years. It cannot therefore be excluded that this was a temporary immigration of porpoises from the western Baltic Sea in search of food. In autumn, many individuals were sighted in the western part of the Baltic Sea, although fewer than in summer. With the exception of a single sighting on the Adlergrund, no porpoises were sighted east of the Darß peninsula. The density gradient running from west to east remained throughout the entire period and was particularly pronounced in autumn (GILLES et al. 2007).

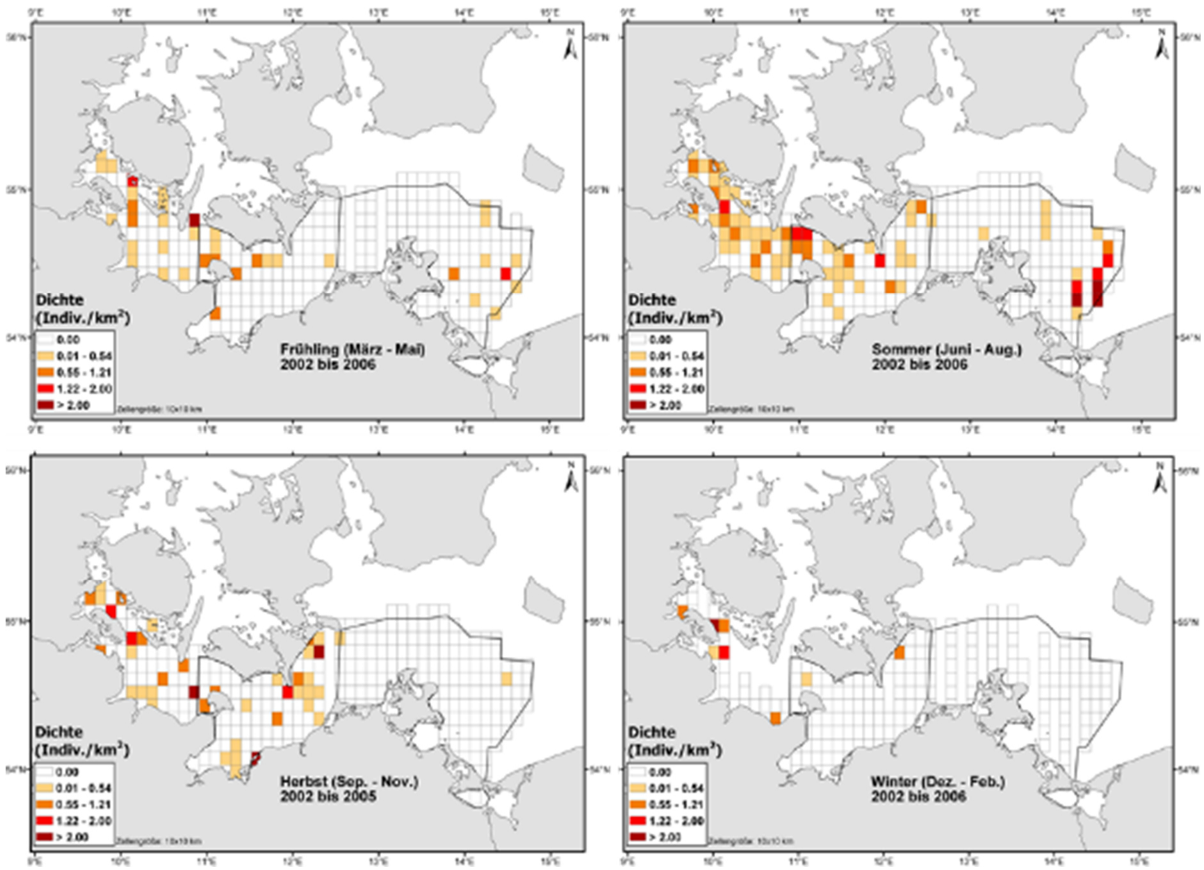


Figure 37: Seasonal distribution patterns of harbour porpoises in the southwestern Baltic Sea (2002-2006). The grid maps are corrected for effort expenditure. They show the average density of harbour porpoises per grid cell (10x10km) in a) spring (March-May), b) summer (June-August), c) autumn (September-November) and d) winter (December-February, source: GILLES et al. 2007, p.126f.).

Occurrence in nature conservation areas

Based on the results of the MINOS and EMSON[7] surveys, five areas of particular importance for harbour porpoises have been defined in the German Baltic Sea EEZ. These are the Habitats Directive areas Fehmarnbelt, Kadetrinne (Kadet Channel), Adlergrund, Westliche Rönnebank (western Rönne Bank) and Pommersche Bucht mit Oderbank (Bay of Pomerania with Oder Bank). Systematic aerial surveys of harbour porpoises in the Adlergrund and Bay of Pomerania were only carried out in May 2002 (GILLES et al. 2004). The abundance extrapolated on the basis of sightings for the Adlergrund comes to 33 individuals.

[7] Survey of marine mammals and seabirds in the German EEZ of the North Sea and Baltic Sea

For the Bay of Pomerania, an abundance calculation is only possible with a very large error. The method used leads to excessive values. The observation of 84 individuals on the Oder Bank in July 2002 remained unique. Despite a high mapping effort, no more animals were sighted here in the following years. Echolocation clicks were regularly recorded around the island of Fehmarn and in the Kadet Channel (VERFUSS et al. 2004). The Kadet Channel is regularly frequented by harbour porpoises, especially during migration. Furthermore, the significance of the area for the animals is still unclear. Between 1996 and 2002, calves represented 36% of all stranded porpoises in the area of the Bay of Kiel to Fehmarn. This indicates that the area is of great importance for reproduction (SCHEIDAT et al. 2004).

High incidences of echolocation clicks in winter at some stations near Fehmarn (VERFUSS et al. 2004) suggest use as a wintering area. Overall, the evaluated data indicate a strongly seasonal occurrence with abundance maxima in summer.

As a result of the 2017 regulations, the Habitats Directive areas in the German Baltic Sea EEZ have been granted the status of nature conservation areas:

- Regulation on the designation of the nature conservation area Fehmarnbelt (NSGFmbV), Federal Law Gazette I, I p. 3405 of 22/09/2017,
- Regulation on the designation of the nature conservation area Kadetrinne (NSGKdrV), Federal Law Gazette I, I p. 3410 of 22/09/2017,
- Ordinance on the designation of the nature conservation area Pommersche Bucht - Oderbank (NSGPBRV), Federal Law Gazette I, I p. 3415 of 22/09/2017.

Occurrence in the wind energy areas EO1 and EO2

The areas for wind energy EO1 and EO2 are designated as porpoise habitats based on sightings in the general vicinity during MINOS and EIS investigations, monitoring of the projects Wikinger and Arkona-Becken Südost, and acoustic surveys of porpoise activity.

The results obtained so far from investigations in the two areas as well as from the general vicinity can be summarised as follows:

- The areas are irregularly used by harbour porpoises to transit, rest and feed.
- The incidence of harbour porpoises in these areas is low compared to the area east of the Darss Sill, and in particular around the island of Fehmarn, in the Bay of Kiel, the Belt Sea and the Kattegat.
- Temporary use, as identified in July 2002, is possible for areas such as the Oder Bank - possibly as a result of increased food supply.
- There is no clear evidence that the areas are used as nursery grounds.
- For harbour porpoises, these areas are generally of medium importance, and seasonally high importance.
- The high importance of the areas results from the possible use by individuals of the separate and highly endangered Baltic Sea population of harbour porpoises during the winter months.
- These areas have a low to medium importance for grey seals and harbour seals.

If no prevention or mitigation measures are taken, the construction of the wind turbines and transformer platforms in areas EO1 and EO2, in particular noise emissions during the installation of the foundations, poses risks to harbour porpoises.

Occurrence in wind energy priority area EO3

Wind energy priority area EO3 is designated a harbour porpoise habitat based on the sightings in the general vicinity during the MINOS and EIS investigations, monitoring of the offshore project EnBW Baltic 2 and on the results of the acoustic recording of harbour porpoise activity within the scope of research projects and monitoring by the Federal Office for Nature Conservation (BfN).

All of the results obtained so far from investigations in area EO3 as well as from the general vicinity can be summarised as follows:

- The area is irregularly used by harbour porpoises for transit.
- The presence of harbour porpoises in this area is low compared to the presence east of the Darss Sill and, in particular, around the island of Fehmarn, in the Bay of Kiel, the Belt Sea and the Kattegat.
- Based on current information, use of the area as a nursery ground has not been proven.
- For harbour porpoises, this area is of medium importance.
- For grey seals and harbour seals, this area is of little importance.

Hazards for harbour porpoises in area EO3 may result from the construction of the transformer platforms, in particular noise emissions during the installation of the foundations, if no prevention or mitigation measures are taken.

2.7.2.2 Harbour seals and grey seals

The harbour seal is the most widespread seal species in the North Atlantic and is found throughout the North Sea and Kattegat. In the Baltic Sea, its regular range is limited to the Øresund and areas around the Danish islands of Falster, Lolland and Møn. The southeastern limit is in Skåne (Sweden) (HARDER 1996, TEILMANN & HEIDE-JØRGENSEN 2001, SCHWARZ et al. 2003). There are currently no seal colonies on the German coasts (HELCOM 2005). Every year about 5 to 10 seals are recorded in Mecklenburg-Western Pomerania. The records are distributed over the entire coastal region, with the main focus in the bodden west of Rügen and Wismar Bay (HARDER & SCHULZE 2001). Occasional whelping occurs here, too.

Suitable undisturbed resting sites are crucial for the presence of harbour seals. The significantly shallower diving depth observed in telemetric surveys and the significantly shorter distances covered in comparison to grey seals (DIETZ et al. 2003), indicate that harbour seals in the southern Baltic Sea probably mainly hunt in shallow coastal waters. Potential food habitats in German waters can therefore be found along the bodden coast of Mecklenburg-Western Pomerania, especially within a radius of up to 60 km from the resting sites. Telemetric studies show that adult harbour seals in particular rarely move more than 50 km from their original resting sites (TOLLIT et al. 1998).

On the basis of regular airborne censuses of the closest resting sites to the German EEZ off the Danish and Swedish coasts in 2002 and 2003, and applying a correction factor for harbour seals in the water, the authors calculate a total population of 655 individuals in the southern Baltic Sea area (TEILMANN et al. 2004).

Suitable, undisturbed whelping and resting sites are also crucial for the occurrence of grey seals. Potential resting sites include sandbanks and unused beach sections (e.g. in the core zone of the Vorpommersche Boddenlandschaft National Park). There are currently no grey seal colonies on the German Baltic Sea coast. The closest resting sites to the German EEZ are at Rødsand off the Danish island of Falster, in the Øresund, and at Måkläppen near Falsterbo in southern Sweden (TEILMANN & HEIDE-JØRGENSEN 2001, SCHWARZ et al. 2003). In the German EEZ, habitats east of the Darß are mainly used for foraging, while areas further west probably only play a minor role (SCHWARZ et al. 2003).

Grey seal counts at the time of moulting, between May and June in the Baltic Sea, resulted in a total of 17,640 individuals for the Baltic Sea in 2004 (KARLSSON & HELANDER 2005). A total population of approximately 21,000 is extrapolated from this data.

The distribution of Baltic grey seals is probably dependent on ice cover, among other factors. Grey seals hunt in shallow water areas near and far from the coast, as well as on underwater slopes and reefs (SCHWARZ et al. 2003). Potential hunting grounds can therefore be found in the EEZ, for example in the Kadet Channel, the Adlergrund or the Oder Bank. However, current findings do not allow for predictions regarding the use of these potential habitats, as both the food composition and the preferences in the selection of food habitats can vary greatly seasonally and in the longer term (SCHWARZ et al. 2003).

In addition to relatively small-scale movements of less than 10 km leading back to the same resting site, hunting excursions to grounds more than 100 km away, and occasional extensive migrations to other colonies were described. DIETZ et al. (2003) determined the "95% Kernel Home Range" from the positions of grey seals fitted with transmitters at Rødsand. This indicates the area where an animal can be sighted with a probability of 95% at any time. For four of the six individuals, the "Kernel Home Range" includes parts of the German EEZ.

No harbour seals or grey seals were sighted during the Baltic Sea porpoise survey flights (GILLES et al. 2004), so no conclusions can be made about the use of the areas. The telemetric surveys from the southern Baltic Sea (DIETZ et al. 2003) and observations in the area of Wismar Bay (HARDER & SCHULZE 1997) suggest that the Fehmarn Belt is occasionally used as a feeding ground by harbour seals. The telemetric study from the southern Baltic Sea (DIETZ et al. 2003), and individual observations as well as strandings (HARDER et al. 1995) suggest that the Kadet Channel, the Adlergrund and the Oder Bank may be used as a migration corridor or feeding habitat for grey seals. According to a current BfN survey, there are about 50 to 60 grey seals living in the waters around Rügen – 30 of which in the Greifswald bodden alone.

2.7.3 Assessment of the state of marine mammals

The population of harbour porpoises in the Baltic Sea has decreased over the past centuries. The situation of the harbour porpoise in the Baltic Sea worsened due to commercial hunting in earlier times, but also due to extreme ice winters. More recently it has worsened due to by-catch, pollution, noise and food limitation (ASCOBANS 2003). The separate population of the eastern Baltic Sea is at particular risk due to the the small number of individuals, geographical restrictions and lack of gene exchange and is therefore considered critically endangered (ASCOBANS 2010).

2.7.3.1 Importance of the areas for marine mammals

Reliable estimates of the occurrence of harbour porpoise in the German waters of the North Sea and Baltic Sea were made on the basis of large-scale aerial surveys and acoustic recordings using click detectors, especially within the scope of research projects such as MINOS and MINOSplus, and within the scope of the monitoring of Natura 2000 sites by the German Oceanographic Museum on behalf of the Federal Agency for Nature Conservation (BfN). A density gradient from west to east was determined in the Baltic Sea. This gradient is already present in summer and increases in autumn. Current information suggests that the western area is most frequently used by harbour porpoises. The eastern part of the German Baltic Sea is used less by harbour porpoises. The single sighting of a larger group of animals on the Oder Bank indicates temporary immigration rather than regular use of the area (BENKE et al. 2014). It is conceivable, however, that the population could be increased through appropriate measures (ASCOBANS 2003/ 2010) and that the eastern area could once again see more frequent use by harbour porpoises. Overall, the evaluated data indicate a strongly seasonal occurrence with abundance maxima in summer.

Recent results of the SAMBAH research project involving the Baltic Sea countries have shown that three populations of harbour porpoise are found in the Baltic Sea: a) the North Sea population in Skagerrak, b) the Belt Sea population in the western Baltic Sea (Kattegat, Belt Sea, Øresund) up to the area north of Rügen, and c) the Baltic Sea population from the area north of Rügen and in the central Baltic Sea. The abundance of the Baltic Sea population was estimated based on acoustic data to number 447 individuals (95% confidence interval, 90–97) (SAMBAH 2014 and 2016).

The Baltic Sea population has been classified as endangered by IUCN and HELCOM (HELCOM - Red List Species, 2013), among other things because of the very small number of individuals and the spatially limited gene exchange.

Importance of areas for wind energy EO1 and EO2

Areas EO1 and EO2 are part of the harbour porpoise habitat, as is the entire western Baltic Sea.

The BSH has solid data sources for the assessment of the importance of the areas in the German EEZ.

Based on current information, areas EO1 and EO2 are predominantly assigned to the harbour porpoise habitat of the highly endangered Baltic Sea population. However, the area is irregularly used by harbour porpoises for transit, resting and feeding. Harbour porpoise numbers in these areas are low compared to those west of the Darss Sill and in particular around the island of Fehmarn, the Bay of Kiel, the Belt Sea and the Kattegat. Temporary use, as noted in July 2002, is possible for areas such as the Oder Bank – possibly through enrichment of the food supply. There is no clear evidence that the areas are used as breeding grounds. For harbour porpoises, these areas have a medium importance, rising to high importance during the winter months. The importance of areas EO1 and EO2 results from possible use by individuals of the separate and endangered Baltic Sea population of harbour porpoise. Research results have shown that individuals of the endangered harbour porpoise population of the central Baltic Sea migrate to German waters in the winter months in particular and also use the planning area. For grey seals and harbour seals, these areas are of little importance. Harbour seals and grey seals cross the areas sporadically during their migrations.

Since 2003, data for the vicinity of areas EO1 and EO2 have been collected in the context of various research projects, such as MINOS, and from acoustic monitoring of harbour porpoises in the German Baltic Sea by the German Oceanographic Museum on behalf of the Federal Agency for Nature Conservation. The data from long-term monitoring by the German Oceanographic Museum show that the German waters of the Baltic Sea are home mainly to harbour porpoises of the Belt Sea population. The rates of presence of harbour porpoise west of the Darss Sill are significantly higher than east of it (Gallus A., K. Krügel and H. Benke, 2015; Acoustic Monitoring of Harbour Porpoises in the Baltic Sea, Part B in Monitoring of Marine Mammals 2014 in the German North Sea and Baltic Sea commissioned by the BfN).

Taking into account the results of acoustic, morphological, genetic and satellite-based surveys, the limit of the population of harbour porpoise in the central Baltic Sea at the latitude of Rügen classified as endangered is 13°30' East (SVEEGARD et al. 2015).

The results of the multi-year SAMBAH project have also shown that during the winter months up to April, the members of the central Baltic Sea population are distributed over a large area and close to the coast. In summer, however, a clearly defined border exists east of Bornholm (SAMBAH 2015).

Additional findings for areas EO1 and EO2 are provided by the investigations carried out as part of monitoring for the existing Nord Stream pipeline. The occurrence of marine mammals was investigated from June 2010 until the end of 2013. Within the scope of the environmental impact study for the Nord Stream 2 pipeline, further investigations were carried out from September 2015 up to and including August 2016 (Nord Stream 2, 2017. Environmental Impact Study (EIS) for the area from the seaward boundary of the German Exclusive Economic Zone (EEZ) up to the landing site). Here, too, the focus of the investigations was on the acoustic recording of the harbour porpoise using C-PODs.

Due to the low frequency of occurrence, visual surveying by means of observers or digital technology is not a suitable method of recording in this area of the western Baltic Sea. No marine mammals were observed during the ship-based survey for the Nord Stream pipeline in the period from June 2010 to the end of 2013. One harbour porpoise was sighted from the ship in the period 2015 to 2016. No marine mammals were detected in a total of four airborne surveys using digital recording.

Further current information on the occurrence of marine mammals in areas EO1 and EO2 is provided by the ongoing monitoring of the cluster "West of Adlergrund" for the offshore wind farms Wikinger and Arkona-Becken Südost.

From March 2015 up to and including February 2016, ten video-based airborne surveys identified a total of eight harbour porpoises, two harbour seals and one unidentified species of seal in the 2,620 km^2 study area. A single grey seal was sighted as part of 12 vessel-based surveys carried out over the same period, one each month. In order to confirm the continuous use of the area by harbour porpoises, data from the acoustic survey using C-PODs at two measuring stations located far north of the planned pipeline were evaluated.

The data from the acoustic survey using C-PODs show that the area of the German EEZ north of the planned pipeline is used by harbour porpoises to a small extent in the period from June to October. At the nearest measuring station, at a distance of approximately 18 km, in Area I of the Pommersche Bucht - Rönnebank nature conservation area, a total of 17.8% of detection-positive days were recorded, i.e. harbour porpoises were present in the area on 65 out of 365 days (MIELKE L., A. SCHUBERT, C. HÖSCHLE AND M. BRANDT, 2017. Environmental monitoring in the "West of Austerngrund" cluster, expert report on marine mammals, 2nd year of investigation, March 2015 to February 2016).

The use of the area by harbour porpoises is low compared to the use west of the Darss Sill. For this reason, the assessment of habitat use is based on the proportion of days with porpoise clicks recorded per month (PPD/month).

The use of the area by harbour porpoises shows a strong interannual variability. The rate of presence was highest in 2013, with 40% porpoise-positive days per month (PPD/month). The use of the area by harbour porpoises was lower in 2011, on the other hand, with a maximum presence rate of up to 25% PPD/month.

There are also distinct seasonal patterns in the use of the area by harbour porpoises east of Sassnitz and the Oderbank.

Harbour porpoise abundance rates begin to rise slowly from June onwards. The highest presence rates were always observed in late summer and autumn. The area is only sporadically used by harbour porpoises in winter and spring.

The highest presence rates were always found in the northern part of the area along the slopes of the Arkona basin.

In contrast, very low presence rates were found in the southern part of the area in shallower zones of the Bay of Pomerania. A seasonal pattern was not observed in this area.

Based on all of the information available to date, the area surrounding the cable route can be assigned to the harbour porpoise habitat.

- Areas EO1 and EO2 are regularly used by harbour porpoises, but to a very limited extent.
- The presence of harbour porpoise in the vicinity of areas EO1 and EO2 is low compared to the presence west of the Darss Sill.
- Use of the area as a nursery ground has not been proven based on current information.
- For harbour porpoises, these areas are of low to medium importance.
- For grey seals and harbour seals these areas are of minor importance.

Predicted impacts on harbour porpoises in the vicinity of the above areas include by-catch in gillnets, fishing and reduction of food supply, pollution, eutrophication and climate change.

No impact on marine mammals is expected from the laying of the pipeline in the German Baltic Sea EEZ or from the operation of the pipeline.

According to currently available information, the three areas are used by harbour porpoises as transit areas. There is currently no evidence that these areas have any particular function as feeding grounds or breeding grounds for harbour porpoises. Harbour seals and grey seals only use the areas sporadically as transit areas. On the basis of the findings from the monitoring of Natura 2000 sites and from research results, it is currently possible to deduce that areas EO1 and EO2 are of medium to seasonal importance for harbour porpoises. The seasonally high importance of the area results from the possible use by individuals of the separate and endangered Baltic Sea population of harbour porpoise during the winter months. For harbour seals and grey seals these areas have a low to medium importance, at most.

Importance of the wind energy priority area EO3

Area EO3 is of medium importance for marine mammals. The use of the area by harbour porpoises varies by season. Harbour porpoise numbers in the area are average to very low compared to the Bay of Kiel, the Belt Sea and the Kattegat. The area has no particular function as a breeding ground for harbour porpoises. For grey seals and harbour seals it is of little importance due to the distance to the nearest resting sites.

Current data are available from the investigations for the wind farm project EnBW Baltic 2 (BioConsultSH, 2018. Expert report 2nd year of operation monitoring).

- The area is used by harbour porpoises irregularly and on a very small scale.

- The occurrence of harbour porpoise in area EO3 is low compared to the occurrence in the Kadet Channel.
- Use of the area as a nursery ground has not been proven by current information.
- This area is of minor importance for harbour porpoises.
- For grey seals and harbour seals, this area lies on the edge of the distribution area of the respective species and is of little importance.

2.7.3.2 Conservation status

Harbour porpoises are protected under several international conservation agreements. Harbour porpoises fall under the conservation mandate of the European Habitats Directive, under which special areas are designated to protect the species. Harbour porpoises are listed in both Annex II and Annex IV to the Habitats Directive. As a species listed in Annex IV, it enjoys strict general species protection in accordance with Articles 12 and 16 of the Habitats Directive.

The porpoise is also listed in Appendix II to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, CMS). The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) was also adopted under the auspices of CMS. In 2002, a specific conservation plan for Baltic harbour porpoises, the Jastarnia Plan, was adopted under ASCOBANS, following the identification of the Baltic Sea harbour porpoise populations as self-sustaining and particularly threatened. The objective of the Jastarnia Plan, revised in 2009, is to restore the population size to 80% of the biotope capacity of the Baltic Sea ecosystem (ASCOBANS 2010).

In addition, the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), in Annex II of which the harbour porpoise is also listed, should be mentioned.

In the IUCN List of Threatened Species, the harbour porpoise population of the central Baltic Sea is considered to be endangered (Cetacean update of the 2008 IUCN Red List of Threatened Species). In Germany the harbour porpoise is also included in the Red List of Threatened Species (HAUPT et al. 2009), where it has been classified in threat category 2 (endangered).

Grey seal and harbour seal are also listed in Annex II of the Habitats Directive. In the Red List, the grey seal has also been classified in threat category 2, while the common seal has been classified as not threatened.

2.7.3.3 Legacy impacts

Legacy impacts on marine mammals results from fishing, underwater noise emissions and pollution. The main threat to harbour porpoise stocks in the Baltic Sea comes from fishing through unwanted by-catch in bottom-set gillnets (ASCOBANS 2010). The by-catch in the Baltic Sea is much higher than in the North Sea. In particular, the separate Baltic population is under serious threat even at low by-catch levels. The Baltic harbour porpoise population is also threatened by a variety of anthropogenic activities, changes in the marine ecosystem and climate change.

The International Whaling Commission (IWC) has agreed that by-catch mortality should not exceed 1% of the estimated stock (IWC, 2000). If by-catch rates are higher, the conservation objective of population recovery to 80% of the carrying capacity of the habitat is at risk (ASCOBANS 2010).

From individual reports on by-catches in the Baltic Sea (KASCHNER 2001), it may be assumed that bottom-set gillnet fisheries for turbot, cod, plaice and lumpfish and the driftnet fisheries for salmon are responsible for the majority of by-catch. However, it is not possible to calculate by-catch rates for the Baltic Sea due to the limited information available (KASCHNER 2001, 2003). Poland reports about 5 by-catches per year, Sweden also reported 5 in the early 1990s (SGFEN 2001). A questionnaire-based projection for German fisheries in the western Baltic Sea assumes an annual by-catch of 57 (21 by-catches in part-time fisheries, 36 in commercial fisheries) (RUBSCH & KOCK 2004).

For the area east of the Darss Sill, 25 by-catches (1 part-time, 24 commercial) are reported. This is much higher than the official figures reported by fisheries and exceeds the tolerable by-catch rates under IWC and ASCOBANS (IWC 2000).

In extreme cases, underwater noise from anthropogenic sources can cause physical damage, but it can also disrupt communication or lead to behavioural changes, e.g. interrupt social behaviour and the catching of prey, or trigger flight behaviour. Current anthropogenic activity in the EEZ causing high noise pollution includes seismic exploration, sand and gravel extraction, military activities, and shipping traffic. Hazards for marine mammals may arise during the construction of wind turbines and transformer platforms, in particular by noise emissions during the installation of the foundations, if no mitigation measures are taken. As of yet there is no experience with the possible effects of water stratification under particular hydrographic conditions on the propagation of impact noise in the Baltic Sea, and related effects on marine mammals. In general, sound propagation in the Baltic Sea is considered particularly difficult to describe, and therefore also difficult to predict (THIELE 2005).

In addition to pressures from the discharge of organic and inorganic pollutants, threats to the stock may also arise from diseases (of bacterial or viral origin), eutrophication, and climate change (impact on marine food chains). At present, porpoises are also migrating to the southern North Sea, presumably due to climate change (CAMPHUYSEN 2005, ABT 2005). To what extent this has an indirect impact on the harbour porpoise population in the Baltic Sea is still unknown.

2.8 Seabirds and resting birds

According to the "Quality standards for the use of ornithological data in spatially significant planning" (Deutsche Ornithologen-Gesellschaft 1995), resting birds are defined as "birds which stay in an area outside their breeding territory, usually for a longer period of time, e.g. for moulting, feeding, resting, wintering". Feeding birds are defined as birds "which regularly seek food in the investigated area, do not breed there, but breed or might breed in the wider region".

Seabirds are species of birds that are mainly bound to the sea by their way of life and come ashore only for breeding for a short time. These include, for example, fulmars, gannets and auks (guillemots, razorbills). Terns and gulls, on the other hand, are usually more common near the coast than other seabirds.

2.8.1 Data availability

A good database is necessary in order to draw conclusions about seasonal distribution patterns and the use of different sub-areas. Large-scale long-term studies in particular are necessary in order to identify the effects of intra-annual and interannual variability.

Findings on the spatial and temporal variability of seabird abundance in the western Baltic Sea are based on a number of research and monitoring activities. However, the majority of these data describe the occurrence of waterbirds, in particular sea ducks, in the inshore area and in the Bay of Pomerania.

For the EEZ area, sources of information have improved in recent years, in particular through data from environmental impact studies (EIS) for planning approval procedures for offshore wind farms, and the subsequent mandatory investigations during the construction and operation phase. Furthermore, findings from various research projects contribute to a better understanding of seabird populations. In the period 2001–2004, studies were carried out within the scope of the R&D projects ERASNO and EMSON to define bird conservation areas in the EEZ. Ship-based and airborne censuses were carried out throughout the German Baltic Sea between 2002 and 2006 as part of the MINOS and MINOSplus projects (DIEDERICHS et al. 2002, GARTHE et al. 2004). In a study based on the results of various research projects and literature sources, GARTHE et al. (2003) summarise the findings on winter occurrence, threats and conservation of seabirds and waterbirds in the German Baltic Sea. On the basis of systematic ship-based censuses in the period from 2000 to 2005, SONNTAG et al. (2006) performed the first analysis of distribution and abundance of seabirds and waterbirds during the course of the year, focusing on the offshore area. The seabird monitoring of Natura 2000 sites commissioned by the Federal Agency for Nature Conservation in recent years contributes further essential information on resting populations and wintering of regularly occurring and highly abundant bird species in the Baltic Sea (MARKONES & Garthe 2011, Markones ET al. 2013, Markones ET AL. 2014, Markones ET AL. 2015, Borkenhagen ET al. 2017, Borkenhagen ET al. 2018, Borkenhagen ET AL. 2019).

Data availability can therefore be regarded as very good.

2.8.2 Spatial distribution and temporal variability

Seabirds have the highest mobility among the upper consumers of the marine food chains. They are able to scan large areas in their search for food or, depending on the species, to track prey such as fish over long distances. High mobility, depending on specific conditions in the marine environment, leads to a high spatial and temporal variability in the occurrence of seabirds. The distribution and abundance of birds vary seasonally and interannually.

The distribution of seabirds in the Baltic Sea is determined in particular by the food supply, hydrographic conditions, water depth and sediment conditions. It is also influenced by distinct natural events (e.g. icy winters) and anthropogenic factors such as nutrient and pollutant inputs, shipping and fisheries. In general, open, largely shallow areas with water depths of up to 20 m and a rich food supply offer ideal conditions for seabirds to rest and winter. In addition, the importance of resting areas increases when, due to ice formation or ice cover in the eastern Baltic Sea, stocks move further west in winter (Vaitkus 1999).

Several million birds winter in the Baltic Sea every year. It is one of the most important areas for sea and waterbirds in the Palearctic. A number of studies also show the great importance of the German Baltic Sea for seabirds and waterbirds, not just nationally but also internationally (DURINCK et al. 1994, Garthe et al. 2003, SONNTAG et al. 2006, SKOV et al. 2011). Particular mention should be made here of the Pommersche Bucht - Rönnebank nature conservation area, which has been part of the Natura 2000 European network of protected areas since 2007 and was established by regulation on 22 September 2017, with the main resting and feeding grounds Adlergrund and Oder Bank.

2.8.2.1 Abundance of seabirds and resting birds in German waters of the Baltic Sea

The western Baltic Sea is of great importance as a resting and wintering habitat for many seabirds and waterbirds. 38 species of seabirds and resting birds regularly occur in the German Baltic Sea (SONNTAG et al. 2006). T

Table 11 below contains winter population estimates for the most important seabird species in the EEZ and in the entire German Baltic Sea.

Table 11: Midwinter populations of the main resting bird species in the German Baltic Sea and EEZ according to MENDEL et al. (2008).

Common name (*binomial*)	**Baltic Sea stock**	**German EEZ stock**
Long-tailed duck *(Clangula hyemalis)*	315,000	150,000
Common scoter *(Melanitta nigra)*	230,000	57,000
Velvet scoter *(Melanitta fusca)*	38,000	37,000
Eider duck *(Somateria mollisima)*	190,000	9,000
Red-breasted Merganser *(Mergus serrator)*	10,500	0
Great crested grebe (*Podiceps cristatus*)	8,500	< 50
Red-necked grebe *(Podiceps grisegena)*	750	210
Horned grebe (thin-beaked) (*Podiceps auritus*)	1,000	700
Red-throated diver (*Gavia stellata*)	3,200	550
Black-throated diver (*Gavia arctica*)	2,400	550
Great cormorant (*Phalacrocorax carbo*)	10,500	< 50
Razorbill *(Alca torda)*	3,600	310
Common guillemot (*Uria aalge*)	1,500	950
Black guillemot (*Cepphus grylle*)	700	310
Little gull *(Hydrocoloeus minutus*)	220	90
Black-headed gull *(Larus ridibundus)*	15,000	0
Common gull (*Larus canus*)	11,500	1,100

Common name (*binomial*)	Baltic Sea stock	German EEZ stock
Great black-backed gull (*Larus marinus*)	7,000	800
Herring gull (*Larus argentatus*)	70,000	4,200

2.8.2.2 Common species and species of special importance for the nature conservation area Pommersche Bucht - Rönnebank

Long-term observations and systematic censuses provide information on recurring seasonal distribution patterns of the most common species in German waters of the Baltic Sea. Overall, the evaluation by MENDEL et al (2008) and SONNTAG et al (2006) confirms and underlines the high species-specific spatial and temporal variability of the occurrence of seabirds and resting birds in German waters of the Baltic Sea. Numerous recent studies can be used to underscore that these descriptions are up to date.

Sea ducks prefer coastal areas with shallow water depths as well as shallow offshore areas such as the Adlergrund and the Oder Bank. Great crested grebes and red-breasted mergansers are found almost exclusively in coastal waters, while horned grebes prefer shallow water areas further offshore. Guillemots and razorbills are mainly found in areas far from the coast with greater water depths. Terns only occur sporadically in offshore areas during migration periods. They almost exclusively use bodden waters and inland lakes for foraging (SONNTAG et al. 2006, MENDEL et al. 2008).

<u>Red-throated diver (*Gavia stellata*) and black-throated diver (*Gavia arctica*)</u>

Divers are found in the Baltic Sea as winter visitors and migrants (MENDEL et al. 2008). Red-throated divers use the coastal sea and the German EEZ in spring and winter, while black-throated divers are found more frequently in autumn and winter, with only small numbers in spring and sporadically in summer. Both species prefer an area east of the island of Rügen or the Bay of Pomerania to the Oder Bank (seeFigure 38: Distribution of divers (*Gavia stellata/G. arctica*) in the entire German Baltic Sea in January/February 2009 (airborne survey; MARKONES & GARTHE 2009). Figure 38 and Figure 39; **Fehler! Verweisquelle konnte nicht gefunden werden.**SONNTAG et al. 2006).

Red-throated divers rest in the Baltic Sea primarily in waters less than 20 m deep (DURINCK et al. 1994). The most important resting sites are in the sea area around Rügen, in the area of the Oder Bank and in the Bay of Mecklenburg. In spring, the main distribution area is the Bay of Pomerania, especially in the coastal waters off Rügen. Black-throated divers are concentrated in the eastern part of the German Baltic Sea. In winter they are widely distributed in the Bay of Pomerania. Here, the highest densities can usually be observed in the coastal area of Rügen, on the Adlergrund and on the Oder Bank (MENDEL et al. 2008). Towards spring, they occur mainly in areas of the Bay of Pomerania far from the coast. Investigations within the scope of BfN seabird monitoring in the German Baltic Sea confirm this distribution (MARKONES et al. 2014).

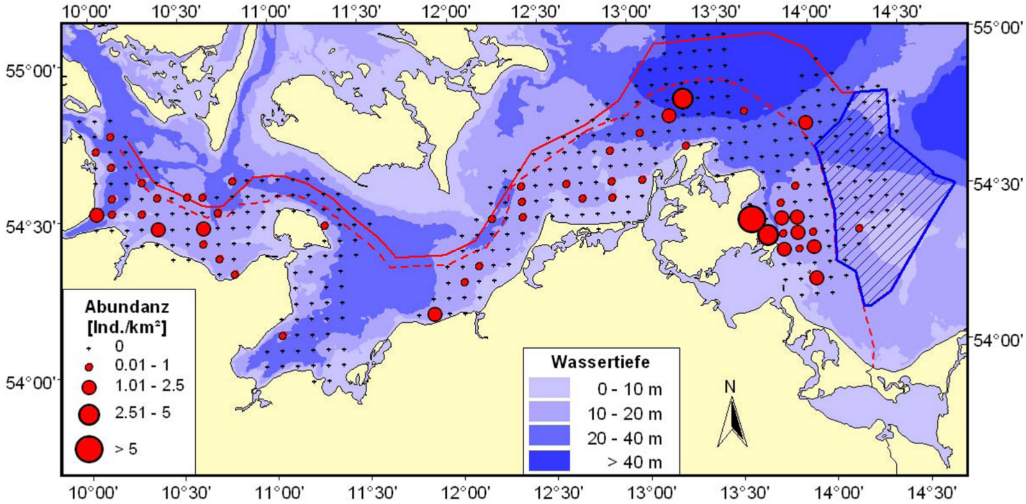


Figure 38: Distribution of divers (*Gavia stellata/G. arctica*) in the entire German Baltic Sea in January/February 2009 (airborne survey; MARKONES & GARTHE 2009).

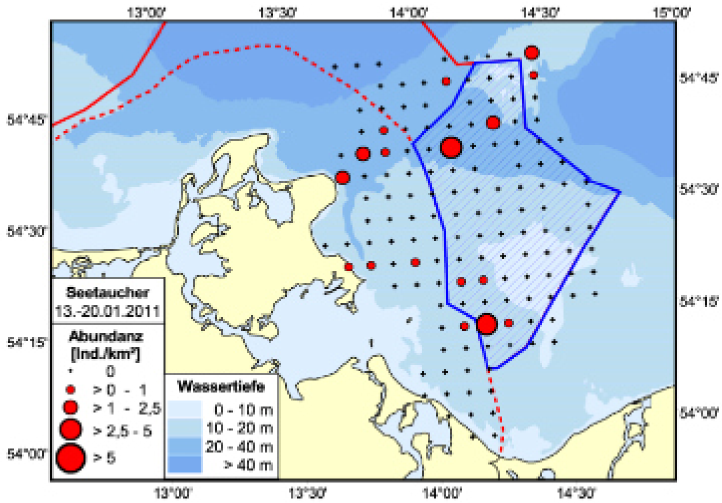


Figure 39: Occurrence of divers (*Gavia stellata/ G. arctica)* in the German Baltic Sea during a ship-based survey from 13 to 20 January 2011 (MARKONES & GARTHE 2011).

<u>Horned Grebe (*Podiceps auritus*)</u>

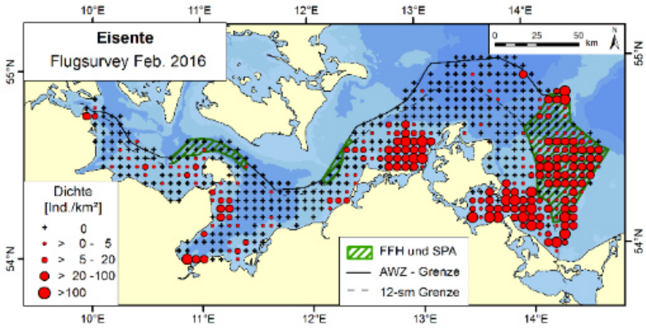
The main area of occurrence of the Horned Grebe in the German Baltic Sea lies in the Bay of Pomerania. This is the most important wintering area in NW European waters (DURINCK et al. 1994). The main distribution area of the approximately 1,000 horned grebes (German winter population) is on the Oder Bank. In particular, waters with less than 10 m depth are used. In autumn, horned grebes migrate to the shallow waters and spend the winter there (SONNTAG et al. 2006). Horned divers are also increasingly present on the Oder Bank in spring, but also spend time in the coastal area off Usedom. Investigations on wind farm projects in the EEZ have revealed only very sporadic sightings of horned grebes (BIOCONSULT SH GmbH & Co.KG 2016, Oecos GMBH 2015).

<u>Little Gull (*Larus minutus*)</u>

In spring and summer, little gulls are only found in small numbers in offshore areas. The main focus of occurrence is in inshore waters. Little gulls mainly migrate along the coastline. During the autumn migration they appear in large numbers in the Bay of Pomerania. Little gulls then prefer areas close to the coast for foraging and rest (SONNTAG et al. 2006).

<u>Long-tailed Duck (*Clangula hyemalis*)</u>

The long-tailed duck is the most common duck species in the Baltic Sea. However, according to a study by SKOV et al. (2011), its winter resting population in the Baltic Sea decreased by 65.3% between 1992 and 2009. One of the most important winter resting areas is the Bay of Pomerania in the southern Baltic Sea. As in the Baltic Sea as a whole, a decline in the occurrence of long-tailed ducks of 82% by 2010 was also recorded here (BELLEBAUM et al. 2014). Consideration of other resting habitats suggests a shift to the north (SKOV et al. 2011). However, it is generally assumed that the Bay of Pomerania will continue to be able to accommodate larger numbers (BELLEBAUM et al. 2014). In winter and spring, the long-tailed duck uses further extensive resting habitats east of Rügen and north of Usedom (



) (Garthe et al. 2003, Garthe et al. 2004). From the end of October, a large migration to the German Baltic Sea areas takes place. In summer, on the other hand, only very few long-tailed ducks are present in the German Baltic Sea. The absence of the species in the offshore EEZ area north and northeast of Rügen is conspicuous at all times of the year. Like other duck species in the Baltic Sea, the long-tailed duck prefers shallow water areas near the coast and shallow offshore grounds down to 20 m water depth (SONNTAG et al. 2006, MARKONES & GARTHE 2009). Recent studies confirm the widespread winter occurrence of long-tailed duck, with a focus on the Adlergrund and the Oder Bank (MARKONES et al. 2014, BIOCONSULT SH & Co.KG 2016).

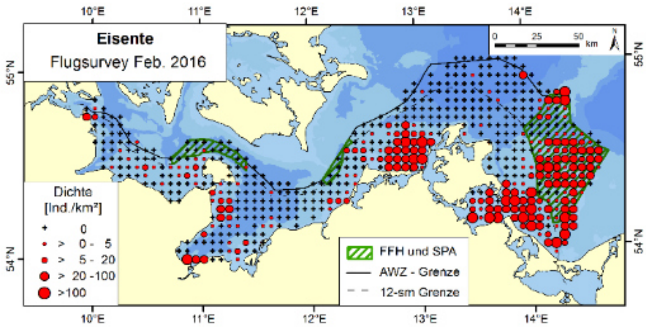


Figure 40: Occurrence of long-tailed ducks (*Clangula hyemalis*) in the German Baltic Sea in February 2016 (aerial surveys, BORKENHAGEN et al. 2017).

<u>Velvet scoter (*Melanitta fusca*)</u>

In addition to the northern Kattegat and Riga Bay, velvet scoters use the northern Bay of Pomerania as their wintering grounds. In the Bay of Pomerania, velvet scoter distributions in winter and spring are concentrated in the area between the Oder Bank and Adlergrund (Garthe et al. 2003, GARTHE et al. 2004). During ice-free winter months, the velvet scoter mainly uses central areas of the Oder Bank. When ice cover occurs, its occurrence appears to be limited to directly adjacent ice-free areas in the northern part of the Oder Bank (MARKONES et al. 2013, MARKONES et al. 2014, BORKENHAGEN et al. 2018, BORKENHAGEN et al. 2019).

Common scoter (*Melanitta nigra*)

On the Oder Bank in the Bay of Pomerania lies one of the most important common scoter resting areas in the entire Baltic Sea (DURINCK et al. 1994, Garthe et al. 2003). Other resting areas include the shallow waters of the Bay of Kiel and north of the Darß-Zingst peninsula (Figure 41**Fehler! Verweisquelle konnte nicht gefunden werden.**). According to Garthe et al. (2003, 2004) and SONNTAG et al. (2006) common scoters can be found all year round in the German Baltic Sea. The Bay of Pomerania plays a key role as a resting and moulting habitat for the common scoter. In the summer of 2012, around 2,000 common scoters were sighted during moulting in the north-west of the Oder Bank on a single day of investigation (MARKONES et al. 2013).

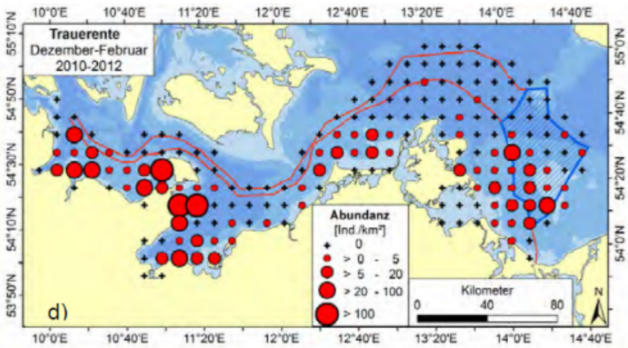


Figure 41: Mean winter occurrence of common scoter (*Melanitta nigra*) in the German Baltic Sea in the years 2010 - 2012 (airborne and ship-based surveys, MARKONES et al. 2015).

Eider duck (*Somateria mollissima*)

Eider ducks are very common during the winter months and are found in high densities west of the Darss Sill. East of the Darss Sill, eider ducks are found only sporadically. Only in winter do they occur in small numbers in the Greifswald bodden and in the coastal waters off the Bay of Pomerania. In summer, only a few eider ducks are found in the western Baltic Sea (SONNTAG et al. 2006).

Common Guillemot (*Uria aalge*)

DURINCK et al. (1994) estimate the winter resting population of Common Guillemots in the Baltic Sea at about 85,000 individuals. In spring, summer and autumn it occurs only sporadically. Guillemots reach their highest numbers in winter. It is assumed that common guillemots are less sensitive to severe winter conditions.

Common guillemots spend the winter in the Baltic Sea near their breeding colonies. Their main area of distribution is in the offshore areas of the Bay of Pomerania, particularly in the deeper waters between the Oder Bank and Adlergrund, and north-west of the Adlergrund (see Figure 42**Fehler! Verweisquelle konnte nicht gefunden werden.**) (MENDEL et al. 2006). According to GARTHE et al. (2003, 2004), common guillemots occur north-east of Rügen at low to medium densities.

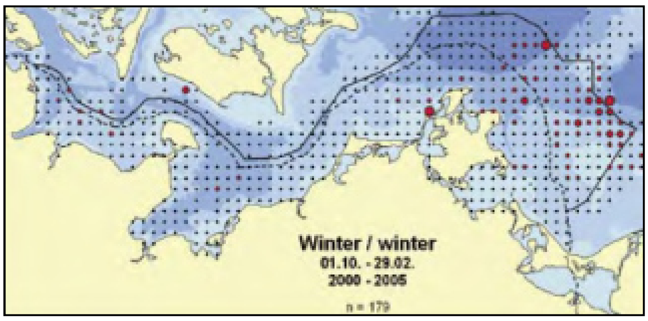


Figure 42: Distribution of the common guillemot in the German Baltic Sea (winter 2000-2005; SONNTAG et al. 2006).

Razorbill (*Alca torda*)

The winter resting area of the razorbills lies above the deeper parts of the central Baltic Sea. Razorbills occur mainly in winter on the German Baltic Sea. They occur at low to medium densities in large parts of the coastal and offshore area of the Bay of Pomerania (MENDEL et al. 2008).

Black Guillemot (*Cepphus grylle*)

DURINCK et al (1994) estimate the winter resting population of black guillemots in the Baltic Sea at 28,560 individuals. Among the preferred winter resting grounds of black guillemots are shallower areas and rocky seabeds. In the German Baltic Sea, Black Guillemots spend most of their time from autumn to spring in the area of the Adlergrund (see Figure 43). Despite relatively low densities, Garthe et al. (2003) classify this occurrence as internationally significant (MENDEL et al. 2008).

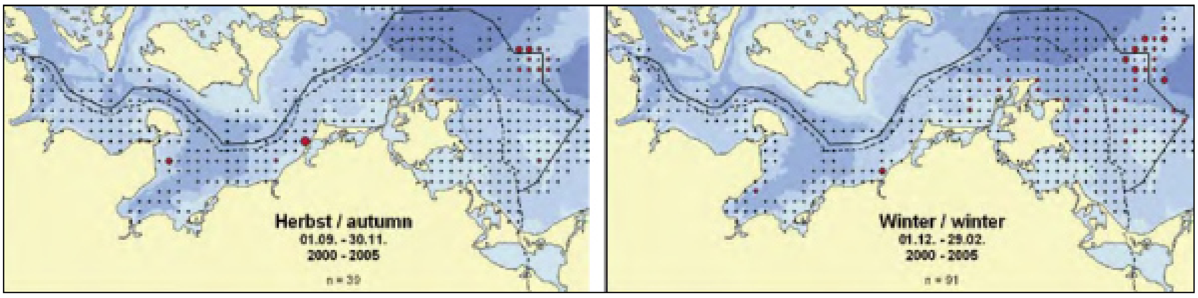


Figure 43: Distribution of black guillemot in the western Baltic Sea in autumn (left) and winter 2000 to 2005 (right) from SONNTAG et al. (2006).

Red-necked grebe (*Podiceps grisegena*)

The main occurrence of red-necked grebes in the German Baltic Sea is in the Bay of Pomerania (see Figure 44**Fehler! Verweisquelle konnte nicht gefunden werden.**). As is the case for divers, they are mainly winter visitors and migrating species. The largest resting populations occur in winter, decreasing in spring (MENDEL et al. 2008).

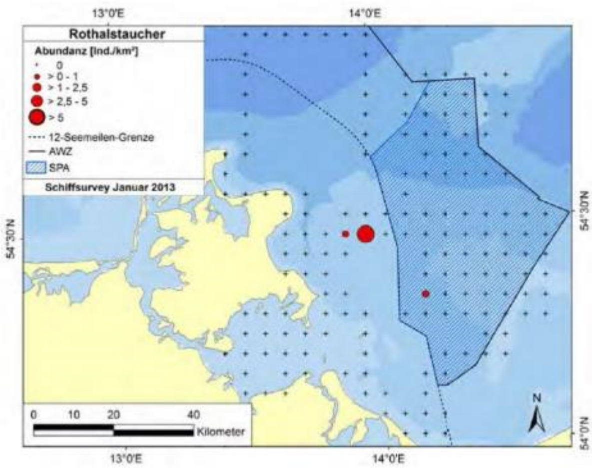


Figure 44: Distribution of red-necked grebes (*Podiceps grisegena)* in the Bay of Pomerania, Baltic Sea, in January 2013 (MARKONES et al. 2014).

Yellow-billed diver (*Gavia adamsii*)

Yellow-billed divers are found in the Baltic Sea as migrants during migration periods, and for winter rest in the western Baltic Sea. Their winter occurrence is low, and limited to the more offshore areas of the Bay of Pomerania (BELLEBAUM et al. 2010).

Common gull (*Larus canus*)

Gulls occur in the Baltic Sea at much lower densities than in the North Sea. This is also due to the fact that their food is of terrestrial origin throughout the breeding season (KUBETZKI et al. 1999). In summer, gulls therefore only occur sporadically in the German Baltic Sea. The largest numbers occur in winter and spring. The common gull then occurs mainly in the inshore and offshore areas of the Bay of Pomerania (SONNTAG et al. 2006).

Other Larus gulls

The most common gull species in the Baltic Sea is the herring gull (*Larus argentatus*), which occurs all year round. In winter and spring, herring gulls are found in high concentrations both in coastal waters and in the EEZ. In particular, they are represented in the areas of the Bays of Kiel and Mecklenburg, around Fehmarn and northwest of Rügen. Particularly high concentrations occur in connection with fishing activities (SONNTAG et al. 2006). The herring gull is probably not a naturally occurring breeding bird in the western Baltic Sea.

It was only the establishment of motorised trawling that led to immigration and stock growth since the 1930s (VAUK & Prüter 1987).

Great black-backed gulls *(Larus marinus)* are present in the western Baltic Sea all year round. However, during the breeding season from April to July the population is small. The winter population may depend on ice conditions in the Baltic Sea. However, the great black-backed gull is more common during migration and in the winter months. Like the herring gull, this species is often concentrated near fishing boats (SONNTAG et al. 2006).

Herring gulls *(Larus fuscus)* are sometimes found in the Baltic Sea in the summer months, occasionally in connection with fishing activity (MENDEL et al. 2008).

2.8.2.3 Occurrence of seabirds in the nature conservation area Pommersche Bucht - Rönnebank

By the regulation of 22/09/2017, the nature conservation area Pommersche Bucht - Rönnebank was placed under protection as a complex area under national law. The conservation area is home to significant populations of important resting bird species, especially sea ducks (long-tailed duck, common scoter, velvet scoter).

It covers a total area of 2,092 km^2. Sub-area IV of the nature conservation area corresponds to the Pommersche Bucht bird sanctuary, which was designated as a nature conservation area with effect from 15 September 2005, and was included in the list of specially protected areas (SPA) as a bird sanctuary (DE 1552-401). Sub-area II covers an area of 2,004 km^2. Sub-area II includes a total of three species listed in Annex I of the European Birds Directive, namely the red-throated diver, black-throated diver and red-throated grebe. Regularly occurring migratory bird species include red-necked grebes, yellow-billed divers, long-tailed ducks, common scoters, velvet scoters, common gulls, guillemots, razorbills and black guillemots (Section 7 Subsection 1 nos. 1 and 2 of the Regulation on the Establishment of Nature Conservation Area Pommersche Bucht - Rönnebank).

As part of the description and status assessment of the Pommersche Bucht - Rönnebank nature conservation area (BfN 2020), species-specific population figures were determined for the entire complex area and not separately for sub-area IV. However, sub-area I, which does not form part of the actual bird sanctuary, is only 86 km^2 in size (BfN 2020).

Table 12 below lists the populations determined in BfN (2020) for the species protected in accordance with the protective purpose of sub-area IV in the season of highest occurrence.

Table 12 Stocks of bird species protected in the Pommersche Bucht - Rönnebank nature conservation area in the season of highest occurrence according to BfN (2020).

Common name (*scientific name*)	**Season**	**Stock NCA Pommersche Bucht - Rönnebank**
Red-throated diver (*Gavia stella*)	Spring	1,600
Black-throated diver (*Gavia arctica*)	Winter	850
Horned Grebe (*Podiceps auritus*)	Winter	1,500
Red-necked grebe (*Podiceps grisegena*)	Winter	430
Yellow-billed diver (*Gavia admasii)*)	Autumn	6-10
Long-tailed Duck (*Clangula hyemalis*)	Winter	145,000
Common scoter (*Melanitta nigra)*	Spring	230,000
Velvet Scoter (*Melanitta fusca*)	Spring	73,000
Common gull (*Larus canus*)	Spring	310
Common guillemot (*Uria aalge*)	Autumn	1,400
Razorbill (*Alca torda*)	Summer	550
Black guillemot (*Cepphus grylle*)	Spring	90

2.8.2.4 Occurrence of seabirds and resting birds in the areas

Priority area wind energy EO1

The investigations carried out so far on the wind farm projects in area EO1 show a medium occurrence of seabirds.

The extensive resting habitats of the Bay of Pomerania and the Adlergrund (including their northern and north-western peripheries, respectively) only extend to the southern and south-eastern parts of area EO1. According to GARTHE et al. (2003), the sub-area is not considered a valuable resting habitat or preferred habitat in the Baltic Sea for the seabird species listed in Annex I of the Birds Directive. Current investigations in area EO1 show only a small occurrence of divers south of area EO1 (BIOCONSULT SH & CO.KG 2017A, BioConsult SH & CO.KG 2018, BIOCONSULT SH & CO.KG 2019). So fa,r only very few horned divers have been sighted in this area. Little gulls are sporadically seen as migrants in spring (BIOCONSULT SH & CO.KG 2016, BioConsult SH & CO.KG 2018, BIOCONSULT SH & CO.KG 2019).

Even during pronounced ice formation in coastal waters and on the Oder Bank in winter 2010, the ice-free part of area EO1 was not used as a fallback area by seabirds and resting birds (SONNTAG et al. 2010). Similar observations were made when the Bay of Pomerania froze over in winter 2011 (MARKONES et al. 2013). This is due to the special location of the area in the transition zone between the deeper waters of the Arkona Basin and the shallower areas of the Bay of Pomerania and Adlergrund. For example, the occurrence of diving sea ducks in the area EO1 is only average. In current studies, long-tailed ducks have been sighted east and south of area EO1 in high to very high densities, whereas in the area itself, only a few individuals have been sighted. Velvet scoter and common scoter were mainly observed during migration periods in the southern part of area EO1 (BIOCONSULT SH & CO.KG 2016, BIOCONSULT SH & CO.KG 2017A, BIOCONSULT SH & CO.KG 2018, BIOCONSULT SH & CO.KG 2019).

Common guillemots and razorbills occur widely in area EO1, with a southerly focus. For the two species of auk, this area is one of the southern spurs of their main wintering grounds in the Baltic Sea. Black guillemots are observed only very sporadically east of the area. Herring gulls are among the most common species in area EO1 during migration periods, and are also widely distributed in winter. Great black-backed gulls and common gulls, on the other hand, only occur in low densities during these periods, but in some cases over a large area (BIOCONSULT SH & CO.KG 2016, BIOCONSULT SH & CO.KG 2017A, BIOCONSULT SH & CO.KG 2018, BIOCONSULT SH & CO.KG 2019).

Area reserved for wind energy EO2

Area EO2 is home to a seabird community consisting mainly of migrant pelagic species such as common guillemots and gulls. The main occurrence of divers in the German Baltic Sea is far south of area EO2, south-east of Rügen. All findings to date indicate that the entire vicinity of area EO2 is used by sea and resting bird species for which this area of the German Baltic Sea is more of a transit area than a resting or feeding area (OECOS GMBH 2015, BIOCONSULT SH & CO.KG 2016, BIOCONSULT SH & CO.KG 2017A, BIOCONSULT SH & CO.KG 2018, BIOCONSULT SH & CO.KG 2019).

Wind energy priority area EO3

A comparison of the data for area EO3 with data from the Bay of Pomerania shows that seabird occurrence in the area is below average (GARTHE et al. 2003). A seabird community generally consisting of species that use the area mainly for transit has been identified in area EO3. According to GARTHE et al. 2003, area EO3 is not one of the preferred habitats in the Baltic Sea for the divers (red-throated diver, black-throated diver) and horned grebe listed in Annex I of the Birds Directive. The same applies to little gulls. Even more recent investigations have revealed only isolated sightings of these species in this area (IFAÖ 2016). Sea ducks diving for food, such as long-tailed duck, velvet scoter and common scoter, mainly occur as migrants in spring, but also to a lesser extent during winter rest in this area of the EEZ. However, their distribution area then extends to the Kriegers Flak shoal in the north-west of area EO3 (IFAÖ 2016, IFAÖ 2017a). Great black-backed gulls and herring gulls are among the most common species in area EO3 and its surroundings. Common gulls occur in winter in areas with greater water depths. In recent studies, razorbills have been observed in more abundant numbers than common guillemots in the vicinity of area EO3. For both species, however, this area has no special significance as a resting habitat. Black guillemots are only very sporadically sighted (IFAÖ 2016, IFAÖ 2017a).

2.8.3 Assessment of the state of seabirds and resting birds

A high mapping effort in recent years and the current state of knowledge allow for a good assessment of the importance and state of the areas under consideration here as habitats for seabirds. This importance results from the assessments of the occurrence and spatial units or functions. In addition, the criteria of protected status and legacy impacts are also considered at a higher level.

2.8.3.1 Conservation status

The German Baltic Sea EEZ is home to significant populations of long-tailed duck, common scoter, velvet scoter and black guillemot. Black-throated and red-throated divers, horned grebes and little gulls are subject to special protection. The other species are migratory bird species whose protection must also be ensured under Article 4 (2) of the Birds Directive.

Table 13 below summarises the current allocation to threat categories of the European Red List (Europe and EU27) and the HELCOM Red List. Differences in allocation result from different geographical frames of reference.

Table 13: Allocation of the most important resting bird species of the German EEZ in the Baltic Sea to the threat categories of the European Red List and according to HELCOM. Definition in accordance with IUCN (also applies to HELCOM): **LC** = Least Concern, **NT** = Near Threatened, **VU** = Vulnerable, **EN** = Endangered, **CR** = Critically Endangered

	Annex I Birds Di-rective	**IUCN Red List Europe[a)]**	**IUCN Red List EU 27 [a)]**	**HELCOM winter resting population [b)]**
Red-throated diver	X	LC	LC	CR
Black-throated diver	X	LC	LC	CR
Horned grebe	X	NT	VU	NT
Red-necked grebe		LC	LC	EN
Great crested grebe		LC	LC	LC
Little gull	X	NT	LC	NT
Herring gull		NT	VU	
Great black-backed gull		LC	LC	
Common gull		LC	LC	
Long-tailed duck		VU	VU	EN
Velvet scoter		VU	VU	EN
Black scoter		LC	LC	EN
Eider duck		VU	EN	EN
Black guillemot		LC	VU	NT
Common guil-lemot		NT	LC	
Razorbill		NT	LC	

[a] BIRDLIFE INTERNATIONAL (2015) European Red List of Birds

[b] HELCOM (2013c)

According to the European Red List, the long-tailed duck, velvet scoter and eider duck are considered vulnerable due to negative population trends in recent years. The drastic decline in the winter resting population of the long-tailed duck in the Baltic Sea (SKOV et al. 2011) is also reflected in the HELCOM Red List, where the long-tailed duck is classified as endangered, along with other species of sea duck. The winter resting populations of red-throated and black-throated divers in the Baltic Sea are even considered critically endangered, even though their European populations are classified as being of least concern. The populations of little gull and horned grebe are classified as near threatened in Europe as a whole and in the Baltic Sea (winter resting population). Great black-backed gulls and common gulls are generally considered to be of least concern. The herring gull, common guillemot and razorbill are listed as near threatened in the pan-European Red List, but their winter resting population in the Baltic Sea has not been given a threat status. The situation is reversed for the black guillemot.

2.8.3.2 Legacy impacts

As part of the marine ecosystem, seabirds are exposed to many legacy impacts that may pose a potential threat, but also affect their occurrence and distribution. Changes in the ecosystem may be associated with threats to seabird populations. The following factors can cause changes in the marine ecosystem and thus also in seabirds:

- ***Fisheries***: Fisheries can be expected to have a strong influence on the composition of the seabird community in the EEZ. Fisheries can lead to a reduction in the food supply and even to food limitation. Selective fishing of fish species or fish sizes may lead to changes in the food supply for seabirds. Bottom-set gillnet fishing causes high annual losses of seabirds in the Baltic Sea through entanglement and drowning in the nets (ERDMANN et al. 2005). In particular divers, grebes and diving ducks are among the victims of bottom-set gillnets (SCHIRMEISTER 2003, DAGYS & Zydelis 2002). According to ZYDELIS et al. (2009), the annual by-catch of seabirds is around 73,000 in the entire Baltic, with 20,000 in the southern Baltic Sea. Fishery discards provide additional food sources for some seabird species (CAMPHUYSEN & Garthe 2000). In particular, many species of seabird such as the herring gull and the great black-backed gull benefit from discards.
- ***Shipping***: Shipping can have a deterrent effect on disturbance-sensitive species such as divers (MENDEL et al. 2019, FLIESSBACH et al. 2019, BURGER et al. 2019) and also includes the risk of oil spills.
- ***Technical structures (e.g. offshore wind turbines)***: Technical structures can have similar effects on disturbance-sensitive species as shipping traffic. In addition, there is an increase in the volume of shipping traffic, due, for example, to maintenance trips.

There is also a risk of collision with such structures.

- ***Hunting***: Almost all migrating ducks in the Baltic Sea area are affected by hunting. Between 1996 and 2001, 122,500 eider ducks were shot annually in Scandinavia, of which 92,820 were shot in Denmark alone (ASFERG 2002). This represents 16% of the winter population of 760,000 individuals (DESHOLM et al. 2002).
- ***Climate change***: Changes in water temperature are accompanied by changes in water circulation, plankton distribution and the composition of the fish fauna. Plankton and fish fauna serve as a food source for seabirds. However, due to the uncertainty regarding the effects of climate change on the individual ecosystem components, it is near impossible to predict the effects of climate change on seabirds.
- ***Other legacy impacts:*** In addition, eutrophication, accumulation of pollutants in the marine food chain and water-borne debris, e.g. parts of fishing nets and plastic debris, can affect seabirds in their occurrence and distribution. Epidemics of viral or bacterial origin may pose a threat to populations of seabirds and resting birds.

In summary, it may be concluded that the seabird community in the German Baltic Sea EEZ is clearly subject to anthropogenic influence. The seabird community in the EEZ cannot be regarded as natural for the reasons given here.

2.8.3.3 Significance of sub-area IV of the Pommersche Bucht - Rönnebank nature conservation area

In the German Baltic Sea, sub-area IV of the Pommersche Bucht - Rönnebank nature conservation area has an exceptional function as a feeding, wintering, moulting, transit and resting area for species listed in Annex I of the Baltic Sea Birds Directive (in particular red-throated diver, black-throated Diver, and horned grebe) and regularly occurring migratory bird species (especially red-necked grebe, yellow-billed diver, long-tailed duck, common scoter, velvet scoter, common gull, common guillemot, razorbill and black guillemot). It is also one of the ten most important wintering areas for seabirds in the Baltic Sea (Durinck et al. 1994; Skov et al. 2000; Skov et al. 2011).

The importance of individual parts of the nature conservation area for resting and migratory birds varies from year to year due to hydrographic conditions and weather patterns. Within the bird sanctuary, numerous migratory and resting birds use the high biomass available.

2.8.3.4 Importance of the areas for seabirds and resting birds

Wind energy priority area EO1

All findings to date indicate that area EO1 is of medium importance for seabirds. It only touches the southern and south-eastern edges of the extensive resting habitats of the Bay of Pomerania and the Adlergrund. Overall, the area has a medium seabird occurrence and medium occurrence of endangered species and species worthy of special protection. It is not one of the main resting, feeding and wintering habitats of species listed in Annex I of the Directive or of species worthy of protection in the Pommersche Bucht - Rönnebank nature conservation area.

Area EO1 is of medium importance as a feeding and resting habitat for seabirds and ship-followers. It is insignificant for breeding birds due to its distance from the coast. Due to the depth of the water (more than 20 m) and the seabed conditions, it is not an important feeding ground for diving sea ducks. They use the area as a transit area in spring and autumn. Herring gulls are common in the area, great black-backed gulls and common gulls are found in comparatively lower densities. Grebes and divers use the subarea exclusively as a transit area. Area EO1 touches the outermost edges of the winter resting habitats of razorbill and guillemot. Black guillemots are only rarely sighted. The legacy impacts from fishing and shipping are of at least medium intensity for seabirds.

Area reserved for wind energy EO2

All findings to date indicate that area EO2 is of minor importance for seabirds. The area has a low occurrence of endangered species and species worthy of special protection. It does not belong to the main resting, feeding and wintering habitats of species listed in Annex I of the Directive or of species worthy of protection in the nature conservation area Pommersche Bucht - Rönnebank. The legacy impacts of fishing and shipping are of at least medium intensity for seabirds.

Wind energy priority area EO3

According to currently available information, area EO3 is of minor importance as a feeding and resting habitat for seabirds. Overall, the area has a low seabird population. It is not one of the main resting, feeding and wintering habitats of species listed in Annex I of the Directive or species of the Pommersche Bucht - Rönnebank nature conservation area which are worthy of special protection. The occurrence of these species is very low. The area is insignificant for breeding birds due to the distance from the coast. Due to the depth of the water and the composition of the bottom, the area is also of no importance as a feeding ground for diving sea ducks. The legacy impacts of fishing and shipping are at least of medium intensity for seabirds.

2.8.3.5 Conclusion

The EEZ in the Baltic Sea, in particular the priority and reservation areas for offshore wind energy considered in more detail here, have or had a seabird occurrence to be expected based on the respective prevailing hydrographic conditions, the distances to the coast and legacy impacts.

2.9 Migratory birds

Bird migration usually refers to periodic migrations between the breeding area and a separate non-breeding area, which for birds at higher latitudes normally contains the wintering grounds. Often, in addition to a resting destination, one or more stopovers are made, e.g. for moulting or to seek out favourable feeding areas. A distinction is made between long-distance and short-distance migrants, depending on distance covered and on physiological criteria.

2.9.1 Data availability

Systematic surveys of bird migration have a long tradition in the Baltic Sea region. The first surveys were carried out in 1901 at the former Rossitten Ornithological Station on the Curonian Spit. In Falsterbo at the southern tip of Sweden, observation and ringing of migrating birds has been carried out since 1972. In addition, numerous experiments were carried out here, which provided detailed information on various aspects of migratory behaviour (e.g. choice of migration direction). Also on the Swedish side, the Ottenby ringing station, in operation since 1948, is located at the southern tip of the island of Öland. Another ringing station is located on the Danish island Christiansø near Bornholm (LAUSTEN & Lyngs, 2004). Since 1995, the Jordsand Association has been conducting a registered catch of migrating songbirds on the island of Greifswalder Oie southeast of Rügen (VON RÖNN 2001).

As a result of many years of research activities, more than 1,000 publications have been produced on bird migration in the western Baltic Sea. Detailed long-term data are available from ringing stations, some of which allow an assessment of population trends. The majority of these data relate to songbird and raptor migration, but in some cases there are also visual observations of waterbirds and waders. These numbers describe migration in the coastal area.

There is hardly any long-term data on migration on the open sea. The records from the lightship in the Fehmarn Belt, from which bird migration over the sea was systematically observed between 1955 and 1957, represent one exception. Migratory behaviour at sea has also been studied by military radar for a number of species since the 1970s (Lund University, Sweden). Since 2002, the Institute for Applied Ecology (IfAÖ) has been investigating visible bird migration in the German part of the Baltic Sea at various locations along the western Baltic coast, and at offshore sites within the scope of approval procedures for offshore wind farms, and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) research projects (see Figure 45). In parallel, bird migration up to 1,000 m altitude is quantified using vertical radar. Further investigations within the scope of offshore wind farm projects have been or are being carried out by other planning offices (e.g. OECOS 2015, BIOCONSULT SH 2017).

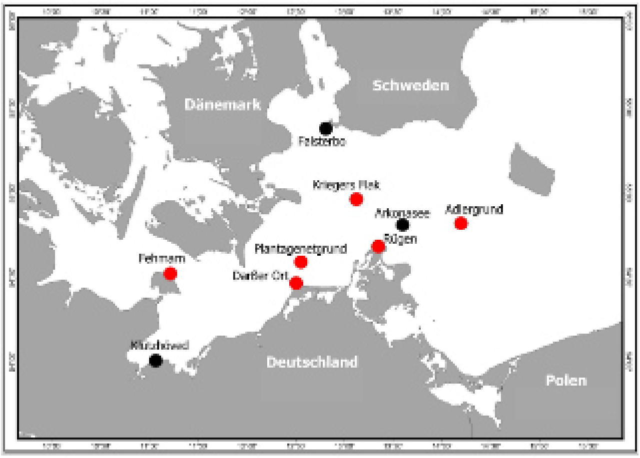


Figure 45: Bird migration monitoring stations and points of the IfAÖ's radar survey of bird migration in the western Baltic Sea (Falsterbo: no own observations; from BELLEBAUM et al. 2008).

In addition to data from ringing stations, various other sources must also be consulted for population estimates of migratory bird populations (national breeding bird monitoring programmes in Scandinavia, BIRDLIFE INTERNATIONAL, 2004a). The breeding populations in Sweden and Finland are relevant for migratory songbirds and birds of prey. For divers and sea ducks, on the other hand, the population sizes of birds crossing the Baltic Sea on their migration from breeding grounds in Western Siberia to their wintering grounds in Western Europe are of interest. Population estimates of waders at the resting places along the East Atlantic Flyway can be used to estimate the extent of the migration of this bird group in the Baltic Sea area. Despite many years of observations, the available findings are not yet sufficient for specific issues in the German Baltic Sea EEZ area.

2.9.2 Spatial distribution and temporal variability of migratory birds

According to current findings, migratory bird activity can be roughly divided into two phenomena: broad-front migration and migration along migratory corridors. It is known that most migratory bird species fly over large parts of their transit areas in a broad front. According to KNUST et al. (2003), this also applies to the North Sea and Baltic Sea, according to the current state of knowledge. In particular, species that migrate at night, which cannot be guided by geographical structures due to darkness, migrate across the sea in a broad front. However, many species migrate in narrow corridors without any direct guiding mechanism. This is the case with cranes, for example. The crane migrates from its huge range, which extends across most of northern Eurasia, via relatively few established narrow migration corridors to just ten fixed wintering grounds spread from Spain to North and East Africa and China. This represents a case of narrow-front migration.

It is well known, particularly from birds diurnal migrants, that geographical barriers or guides, such as estuaries and large water areas, influence the migratory routes. In the western Baltic Sea, three main migration routes can be distinguished, according to PFEIFER (1974):

- Southern Sweden–Danish islands (Zealand, Møn, Falster, Lolland)–Fehmarn (known as the "Vogelfluglinie" or "Bird flight route"). This route is mainly preferred by songbirds migrating in daylight and thermal soarers such as birds of prey. Distances over water surfaces are short.

- Southern Sweden–Rügen. Besides cranes and birds of prey, this route is probably also used in spring by songbirds who cross the Baltic Sea from the Darß and Rügen in a northerly direction.
- Coming from the Baltic states/Finland/Siberia, following the narrowing funnel of the western Baltic Sea towards south-west/west. A distinction is made here between two main coastal routes 1) along the coast of Mecklenburg and 2) along the south coast of Sweden and the Danish islands to Fehmarn.

Seasonal migration intensity is closely linked to species- or population-specific life cycles (see, for example, BERTHOLD 2000). In addition to these largely endogenously controlled annual rhythms in migratory activity, the actual course of migratory events is mainly determined by weather conditions. Weather factors also influence the height and speed at which the birds migrate.

In general, birds wait for favourable weather conditions (e.g. good visibility, tailwinds, no precipitation) for their migration, in order to optimise it in terms of energy use. As a result, bird migration is concentrated on individual days or nights in autumn and spring. According to the results of an R & D project (Knust ET al. 2003), half of all birds migrate on only 5 to 10% of all days. Furthermore, migration intensity is also subject to fluctuations depending on time of day. Around two thirds of all bird species migrate mainly or exclusively at night (HÜPPOP et al. 2009).

2.9.2.1 Bird migration over the western Baltic Sea

Bird migration over the western Baltic Sea is documented throughout the year by various methods (radar and visual observations, acoustic recordings, ring analyses). The Baltic Sea is along the migration route of numerous bird species. Every year in autumn, around 500 million birds (see

Table 14) migrate across the western Baltic Sea from their Nordic breeding areas to their wintering grounds further south (BERTHOLD 2000). In spring, there are considerably fewer (200-300 million). This is due to the high mortality of young birds in their first winter. More than 95% of these birds are small land birds.

In order to analyse migratory rates and migratory routes, it is useful to differentiate migratory birds by type of migration. Water and land birds as well as diurnal and nocturnal migrations should be distinguished on the basis of the different migration conditions. Among land birds migrating in daylight, some are optional thermal soarers (cranes, large birds of prey), which use thermals over land to gain height, but migrate over water in active flight (BELLEBAUM et al. 2008).

Table 14: Population estimates for migratory birds of different flight types in the southern Baltic Sea region (data only for the autumn season; source: BELLEBAUM et al. 2008; calculated according to HEATH et al. 2000 and SKOV et al. 1998).

Type of migration	Species groups	Autumn numbers
Waterbirds	Divers, grebes, pelecaniformes, ducks, geese, mergansers, waders, gulls, terns, auks	10-20 million
Land birds: optional thermal soarers	Birds of prey	< 0.5 million
	Cranes	60,000
Land birds: active fliers	Nocturnal migrants	200-250 million
	Diurnal/nocturnal migrants, pure diurnal migrants	150-200 million

About 200 species of bird are involved in bird migration in the Western Baltic Sea every year. In addition, there are another 100 rare species and vagrants. Figure 46 shows a schematic diagram of the general migration systems in the western Baltic Sea, with the arrows representing migration areas whose specific course cannot be narrowly defined. The significant migratory populations of waterbirds (sea ducks, divers, geese and swans) originate mainly from Siberia, so their migratory path is generally longitudinal. Sea ducks and divers fly at low height above the water, usually below 10 m, and often close to the coast (see, for example, KRÜGER & GARTHE 2001). Waders flying at high altitudes, at least in spring (on average 2,000 m, GREEN 2005) have been observed relatively rarely in the Baltic Sea. Birds of prey migrate both along the "Vogelfluglinie" and across the open Baltic Sea. Their flight behaviour varies by species and season. Active fliers tend to take the route over the sea, while thermal soarers such as buzzards generally use the "Vogelfluglinie".

Crane migration across the Baltic Sea takes place mainly between the Rügen-Bock region in the Vorpommersche Boddenlandschaft national park and the Swedish south coast, in a north-south direction (Alerstam 1990).

For songbirds migrating in daylight, especially short- and medium-distance migrants such as finches and wagtails (BERTHOLD 2000), the "Vogelfluglinie" is important, as guidelines play a role for this species group (at least for the orientation of individuals flying at low altidude). However, a large proportion of migration also takes place latitudinally across the open Baltic Sea when there is a tail wind at high altitude (ALERSTAM & ULFSTRAND 1972). Due to the limited scope for visual navigation, broad-fronted migration is assumed for small birds migrating at night, especially middle-distance migrants such as thrushes and robins or long-distance migrants such as reed warblers (BERTHOLD 2000, ZEHNDER et al. 2001, BRUDERER & LIECHTI 2005). KNUST et al. (2003) identified the main migration direction for the autumn migration in the German Baltic Sea region at the locations Fehmarn and Rügen as being SW to SSW.

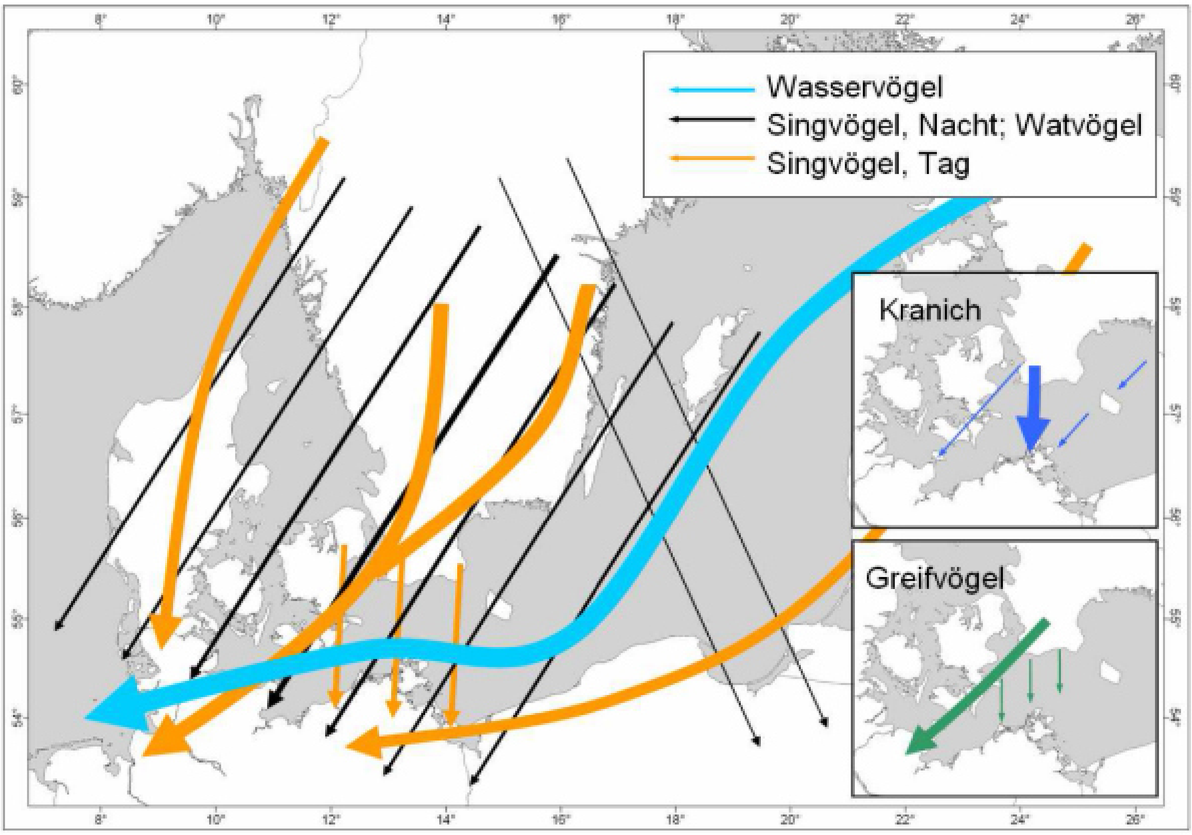


Figure 46: Diagram of the most important routes in the Baltic Sea region for the autumn migration (BELLEBAUM et al. 2008).

Above open water, the migration altitude seems to rise in general (BEZZEL & PRINZINGER 1990). Ultimately, flight altitudes during the migration depend on various factors (e.g. time of year and day, wind and weather conditions). Nocturnal migrants generally fly higher than diurnal migrants. The wind conditions also have a major influence on migration height. KRÜGER & GARTHE (2001), for example, found that divers and sea ducks (eider duck, common scoter) often fly very low over the water when there is a headwind (less than 1.5 m high), whereas flight altitudes increase when there is a tailwind. This is probably due to the fact that wind speed generally increases with height. By adapting altitude to the wind conditions, flight speed can be greatly increased and energy consumption can be significantly reduced (LIECHTI et al. 2000, LIECHTI & BRUDERER 1998).

2.9.2.2 Species composition

Waterbirds (active fliers, diurnal/nocturnal migrants)

The exact migration route is known for just one third of the 70 or so waterbird species that regularly migrate through the western Baltic Sea (only diurnal migrants with flight altitudes < 200 m, divers, geese, sea ducks, terns). Many species migrate at night and/or at high altitude (diving ducks, waders, see for example GREEN 2005). The flight paths of most species/populations cross the area in an east-west direction to reach their wintering grounds in western Europe from their Arctic breeding grounds in western Siberia (e.g. geese, sea ducks, sandpipers, divers; see Figure 46 and Figure 47). These birds often orient themselves along the coastlines. Other species/populations which breed in Scandinavian wetlands and use freshwater biotopes as their habitat migrate in a north-south direction (ansers, dabbling ducks, mergansers, sandpipers). These species often follow established, population-specific migration routes. Species migrating at night probably also fly in a broad front (e.g. snipes).

In terms of diurnal migrants, there are three known main routes for waterbirds through the western Baltic Sea:

- Along the Swedish coast (main route of most eider ducks, brent geese and barnacle geese)
- Along the German coast (main route of most common scoters and many divers and terns)
- In a north-south direction (swans, ansers, dabbling ducks, mergansers)

Geese

During the autumn migration, the Russian and Baltic populations of the barnacle goose (*Branta leucopsis*) and the brent goose (*Branta bernicla bernicla*) cross the Baltic Sea to reach their wintering grounds on the coasts of western Europe. In the western Baltic Sea, most of these geese migrate along the southern Swedish coast. Only a few thousand birds cross the Arkona Sea and follow the German coast.

There are gradual differences between the two species during the spring migration in the western Baltic Sea. Barnacle geese fly more over the open sea or the southernmost tip of southern Sweden, while brent geese tend to fly further inland (GREEN & ALERSTAM 2000). The general direction of migration of the barnacle goose is north-east, while brent geese fly in a more easterly direction. The spring migration of barnacle geese tends to occur in April, while brent geese migrate mostly in late May. The main migration days fall in periods with tailwinds, which are selectively favoured. Both species fly over the German EEZ mainly in the Bay of Kiel/Fehmarn Belt area. Brent geese show higher flight speeds in spring than in autumn, and they migrate in larger groups and at higher altitudes (average in spring: 341 m, autumn: 215 m).

Other species of geese probably migrate mainly at higher altitudes across the Baltic Sea or prefer to follow the coasts. In 25 years, only great white-fronted geese (*Anser albifrons*) have been observed in larger numbers on the Danish island of Christiansø (LAUSTEN & LYNGS 2004). In the previous migratory observations of the IfAÖ, great white-fronted geese were predominantly seen crossing the Baltic Sea. In May 2003 a conspicuous, low-altitude (< 100 m) moulting migration from Darßer Ort to the Danish Islands was recorded for the greylag goose *Anser anser* (and for the mute swan *Cygnus olor*) (IfAÖ 2005).

Sea Ducks

The southern and western Baltic Sea represents an important transit area to the wintering grounds in the North Sea and the northern Kattegat for sea ducks. Although most migration tends to take place close to the coast (many sea ducks maintain visual contact with land structures during flight), sea duck migration also takes place over the open sea (IfAÖ 2005).

During spring, the **eider duck** migrates back along the southern Swedish coast in a relatively narrow corridor very close to the coast. Their path shows a strong relation to topographical structures (coastline): coming from the Kattegat or the Belt Sea, they first migrate eastwards (partly overland) and then remain concentrated along the coastline in a north-easterly direction (ALERSTAM 1990). In the autumn the migration runs roughly along the same route. Although eider ducks migrate both during the day and at night, the main focus of migration is clearly during the day. Radar surveys of the eider duck migration off the coast of southern Sweden showed that less than 10% of the total migration occurred at night (ALERSTAM et al. 1974). Depending mainly on weather conditions, most of the eider duck migration can take place over just a few days (ELLESTRÖM 2002).

The spring migration of the **common scoter** runs mainly along the German coast. It appears that most of the common scoters wintering in the North Sea fly so far south during their inbound migration that they meet the western beach of the Darß and then fly relatively closely around Darßer Ort and Cape Arkona. In spring 2003, about 9% of the biogeographic population (1.6 million individuals, Wetlands International, 2006) were recorded at Darßer Ort alone (WENDELN & KUBE 2005). However, with a 35% share of simultaneous observations (to the observations at Darßer Ort itself) from a ship at sea 20 km north of Darßer Ort in spring (24% in autumn), larger numbers of common scoters can also be expected in the offshore area. An unknown proportion of these birds migrate at night.

While the moulting and autumn migration of the common scoter north of Cape Arkona on Rügen is highly concentrated (50,000 to 100,000 in July/August alone, NEHLS & ZÖLLICK 1990), the total numbers at Darßer Ort are low at this time of year (Wendeln & Kube, 2005). It appears that the autumn migration in the area between Darßer Ort and Falsterbo does not run close to the coast. Presumably, the birds head for the Danish island of Møn from Cape Arkona. In the Fehmarn Belt, hardly any common scoters were observed along the German coast in spring and autumn 2005 (IfAÖ 2005). Either the migration is concentrated along the Danish coast, or the birds are already at high altitudes in this area in order to fly over Schleswig-Holstein (cf. Berndt and Busche, 1991).

Velvet scoter migration is almost never observed in the German Baltic Sea (GARTHE et al. 2003, WENDELN & KUBE 2005). There appear to be very few exchange movements between the main wintering areas in the northern Kattegat and the Bay of Pomerania. The same applies to the **long-tailed duck**. Only a few thousand individuals of this species winter west of the Darss Sill. However, there are very intensive exchange relationships between the important wintering areas west and east of Rügen.

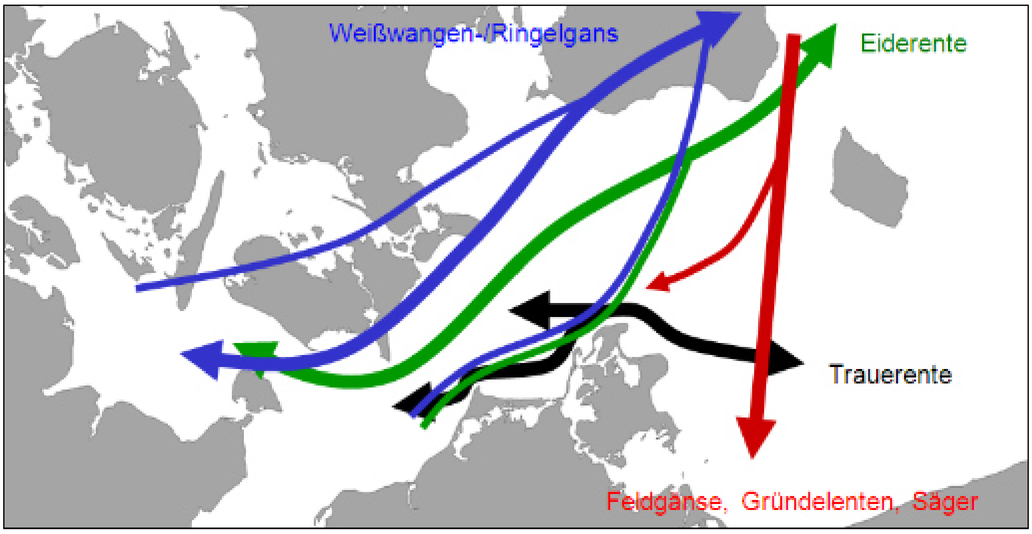


Figure 47: Diagram of selected migratory routes of waterbirds in the western Baltic Sea (compiled by IfAÖ according to literature sources and own observations in the Arkona Sea; from BSH 2009).

Ansers, swans, dabbling ducks and sandpipers

According to the observations of the IfAÖ, limnic waterbird species with a Scandinavian breeding habitat (swans, dabbling ducks and diving ducks, sandpipers) migrate in a north-south direction across the Arkona Sea, presumably heading mainly towards the Oder Estuary (incl. Greifswald bodden). Birds that meet the north coast of Rügen then turn west and follow the coastline. Observations from southern Sweden suggest that these birds initially migrated along the Swedish Baltic coast (FLYCKT et al. 2003, 2004). However, there is currently insufficient data to describe the existing north-south migration in detail. It is noticeable that for many of these species, generally only a few individuals are seen per season (exceptions: Eurasian Wigeon and red-breasted merganser, see also LAUSTEN & LYNGS 2004). This suggests that many duck species probably migrate mainly at night at high altitude.

Waders from the Siberian Arctic

Adult waders from arctic breeding areas (sandpipers, plovers, etc.) migrate across the Baltic Sea, mostly at high altitudes, into the Wadden Sea, frequently crossing southern Sweden. The juveniles, on the other hand, migrate in small steps along the coasts and rest several times in the mudflats (KUBE & STRUWE 1994). In spring, almost all limicolae migrate at high altitude from the Wadden Sea to western Siberia. Their average flight altitude is about 2,000 m (GREEN 2005). Limicolae generally prefer tailwinds for migration (GREEN 2005). In the event of strong headwinds or precipitation in the western Baltic Sea, birds may need to rest or fly at low altitude over the sea along the Swedish (in autumn with SW wind) or German coast (in autumn with NW wind). On the open sea, on the other hand, limicolae are very rarely registered. Call records during the night hours predominate (IFAÖ 2005).

Cranes/birds of prey (thermal soarers / active fliers / diurnal migrants)

Cranes

The cranes (*Grus grus*) of northern Europe use a variety of migration routes. While eastern populations (Finland, Baltic states) migrate in a south-south-easterly direction (towards Israel, north-west Africa and eastern Africa), birds of the sub-population that follow the western European migratory route from Norway, Sweden, Poland and Germany to their wintering grounds in France, Spain and north-west Africa fly south-west. This population is currently estimated at approximately 150,000 individuals (G. NOWALD pers. comm.).

Of particular interest for the western Baltic Sea are the Scandinavian birds that cross the Baltic Sea during their migration. For these cranes, the Rügen-Bock region is the most important resting place on the southern Baltic Sea coast (up to 40,000 resting cranes at one time).

Scandinavian cranes reach their resting areas in the area of the bodden waters of Western Pomerania via two migration routes: From Finland partially along the southern Baltic coast and from Sweden by a non-stop flight of 1–2 hours over the Arkona Basin. It is estimated that 50,000–60,000 individuals use the latter route. The return migration from the resting areas in Western Pomerania to Sweden runs in the opposite direction (northwards) (ALERSTAM 1990, Figure 48).

Cranes cross the Baltic Sea almost directly in a north-south direction. The flight directions of the cranes covered by the IfAÖ deviated by a good 10° from north-south, both outbound and inbound. This could be related to only partial compensation for wind drift over the sea. Over land, on the other hand, wind drift is fully compensated (ALERSTAM 1975). Neither the autumn nor the spring migration was uniform; both were characterised by mass migration on relatively few days. The cranes used tailwind conditions to cross the Baltic Sea. The wind also had a decisive influence on the flight altitude of the cranes. In headwinds, the flight altitude was significantly lower than in tailwinds or neutral winds (BELLEBAUM et al. 2008).

Cranes belong to the group of birds that are classified as thermal soarers due to their large wing area in relation to weight. Phases of increasing flight altitudes in thermal columns alternate with gliding phases. This behaviour enables a very energy-conservative flight style. A Baltic Sea crossing in gliding flight, however, is not possible due to the distance to be covered, of about 80 km. With an initial altitude of 1,000 m, cranes can glide for a maximum distance of 16 km (ALERSTAM 1990).

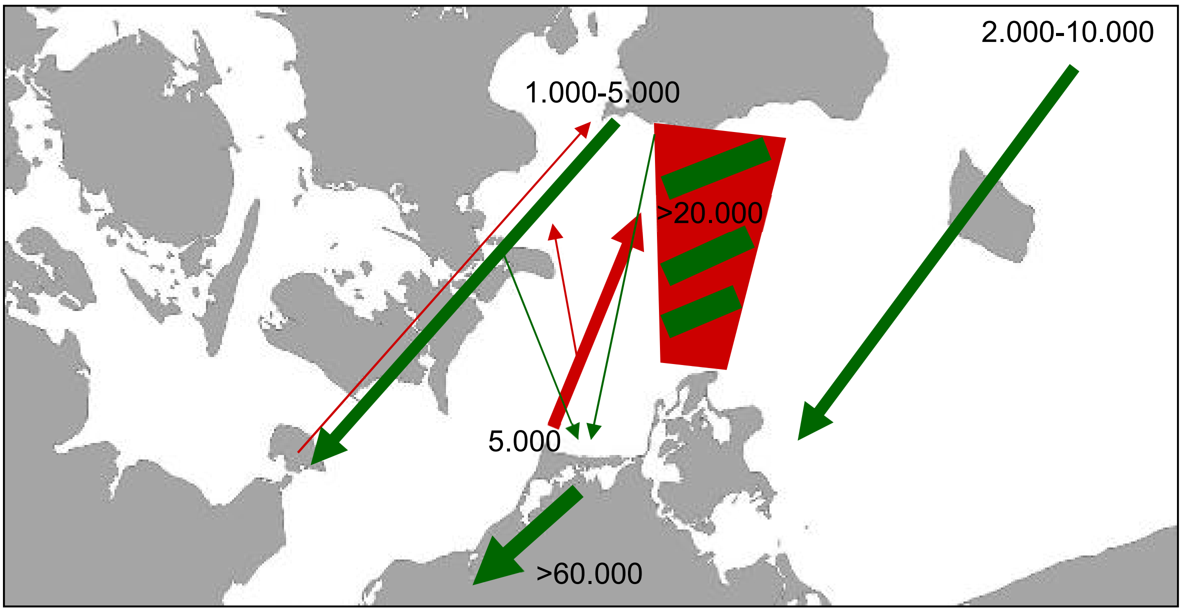
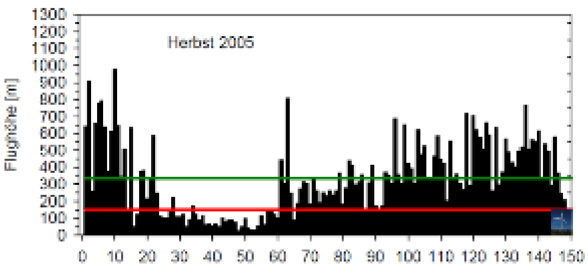
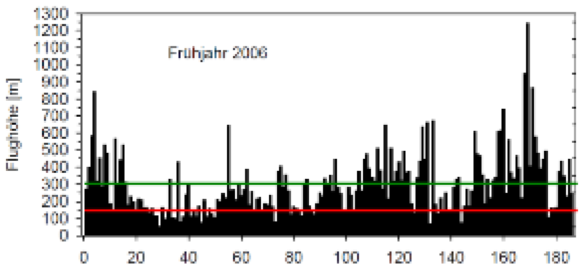


Figure 48: Diagram of the migration routes of cranes in the western Baltic Sea (red=vernal migration, green=autumnal migration. Compiled by IfAÖ based on observation data from Falsterbo, Bornholm and own observations in the Arkona Sea; from: BSH 2009).

As there are no updraughts over sea surfaces, most of the distance requires active flight (probably alternating with gliding phases at the beginning). Cranes usually wait for weather conditions with tailwinds (ALERSTAM & BAUER 1973). The speed of the migration also depends strongly on the wind, averaging about 70 km/h (ALERSTAM 1975). Flight altitudes of 200–700 m were measured above the southern tip of Sweden after crossing the Baltic Sea in spring (KARLSSON & ALERSTAM 1974). Particularly over land, sedges of crane recorded by IfAÖ showed circling flight movements to gain altitude. However, cranes circling over water with significant height gains could also be observed regularly near land at distances of up to 15 km from the coast (Wendeln et al., 2008). The proportion of nocturnal migration was estimated at around 10% based on the available data (BELLEBAUM et al., 2008).





Fortlaufende Nummerierung der Kranichtracks über See

Figure 49: Flight altitudes of crane sedges over the sea during autumn and spring migration (green line: mean flight altitude over the entire season; red line: max. altitude of wind turbines; BELLEBAUM et al. 2008).

The results of target-tracking radar observations on the coast of Rügen show that the altitude above sea level can vary considerably. Around a third of the cranes recorded (32% in autumn 2005, 33% in spring 2006) migrated at altitudes below 200 m (Figure 49). This means that a considerable proportion of crane migration over the Baltic Sea takes place at the height of wind turbines.

Birds of prey

Birds of prey are often considered thermal soarers. Thermal soaring birds of prey circle over land to a height of several 100 metres and then start their migration. However, there are also species that migrate in active flight (e.g. sparrowhawks, ospreys, falcons). While the majority of Swedish populations of diurnal birds of prey follow the "Vogelfluglinie" over Falsterbo in the autumn, a proportion crosses the Baltic Sea in a north-south direction (partly species-specific, e.g. rough-legged buzzard). For example, the migration patterns of sparrow hawks ringed in Falsterbo and Ottenby show a parallel offset in breeding and wintering areas: Birds that breed further east probably migrate along a route further east, and must therefore fly over larger water areas when crossing the Baltic Sea. Birds of prey that mainly follow the "Vogelfluglinie" follow a south-southwestly direction of migration in autumn. Birds of prey that mainly cross the open sea between the southern Swedish coast and the Mecklenburg coast migrate in more of a southerly direction.

Every year in autumn, up to 50,000 Scandinavian birds of prey migrate south via Falsterbo. These birds then cross the Fehmarn Belt. Depending on the prevailing wind direction, the crossing of this sea area takes place in a somewhat wider front (KOOP 2005). The altitude of migration of these birds of prey is mostly over 50 m (IFAÖ 2005).

During the spring migration, the Fehmarn Belt is less important for migrating birds of prey. It is likely that many birds pass over Schleswig-Holstein and the Danish islands north of the Fehmarn Belt at this time of year. However, a significant number also follow the southern Baltic coast and cross the western Baltic Sea from Darßer Ort and Rügen. The population shares of some species are considerable at Darßer Ort (Table 15). In spring there was a clear concentration of migration at Darßer Ort. The proportion of individuals observed in almost all species exceeded 10% in relation to the autumn migration in Falsterbo (red kite: approx. 30%, osprey/buzzard: approx. 20%). Bird of prey migration was also observed on Rügen in spring. However, the proportion of birds of prey in relation to autumn migration in Falsterbo rarely exceeds 10% and is thus significantly lower than the values recorded at the Darß site (BELLEBAUM et al., 2008).

Table 15: Comparison of autumn migration of birds of prey in Falsterbo 2002 and 2003 with spring migration in 2003 at Darßer Ort (Mecklenburg-Western Pomerania) and autumn migration in Falsterbo 2007 with spring migration in Rügen 2007 and 2008 (numbers of observed individuals; source: BELLEBAUM et al. 2008).

	Falsterbo autumn 2002	**Falsterbo autumn 2003**	**Darßer Ort spring 2003**	**Falsterbo autumn 2007**	**Rügen spring 2007**	**Rügen spring 2008**
Honey Buzzard	3,232	3,076	574	2,745	0	30
Red Kite	1,148	1,441	390	2,381	308	255

	Falsterbo autumn 2002	Falsterbo autumn 2003	Darßer Ort spring 2003	Falsterbo autumn 2007	Rügen spring 2007	Rügen spring 2008
Marsh Harrier	801	969	142	569	44	90
Sparrowhawks	13,478	24,648	1,446	27,193	1,258	1,462
Buzzard	8,607	14,203	1,820	18,872	743	970
Rough-legged	374	153	442	1,165	95	372
Osprey	234	303	57	232	19	33
Kestrel	385	943	41	725	0	0
Merlin	182	405	17	367	12	25
Hobby	47	61	24	39	6	12

Only a few migrating birds of prey can be detected above the Arkona Sea by visual observation (IFAÖ own observations). It is possible that birds of prey migrate mainly above the 200 m visibility range. Above other sea areas, thermal soaring birds of prey fly mainly at higher altitudes, e.g. rarely below 400 m when crossing the Straits of Gibraltar (MEYER et al. 2000). In autumn, however, with frequent headwinds, the migration heights in the area of the "Vogelflugline" are often lower (Falsterbo/Fehmarn Belt).

Land birds (active flight)

Land birds (diurnal migrants)

Many land bird species migrate during the day. In addition to the birds of prey already described, these include pigeons and songbirds (Table 16). Among the songbirds, short-distance migrants are the main diurnal migrants (mainly finches and buntings; but also pipits, wagtails, tits and crows). Among the long-distance migrants, swallows are an exception as purely diurnal. Some of the most common breeding bird species in Scandinavia are diurnal migrant land birds. As regards the western Baltic Sea, Swedish and to some extent Finnish breeding birds are of particular relevance (see ringing results in LAUSTEN & LYNGS 2004).

Table 16: Observable part of the autumn migration of frequent Scandinavian diurnal migrants. Migration rates for different locations and breeding populations of Swedish populations, and estimation of the proportion of non-observable diurnal bird migration (from BELLEBAUM et al. 2008).

	Chaffinch and mountain finch	**Eurasian skylark**	**Meadow Pipit**	**Barn swallow**	**House martin**
Average migration rate [Ind. per h]					
Falsterbo	1,002.0	4.7	16.5	25.3	12.9
Kriegers Flak	1.1	0.2	0.5	0.7	0.05
Adlergrund	3.8	0.5	1.9	1.6	0.2
Darßer Ort	22.3	4.0	4.1	5.4	0.6
Total number of birds observed					
Falsterbo (average 1973-2001)[1]	760,758	1,571	8,324	23,279	5,283
Offshore[2]	664,160	136,320	292,800	618,240	29,280
Breeding population Sweden/migration volume					
Breeding pairs[3]	12,500,000	750,000	750,000	225,000	150,000
Total individuals (autumn)[4]	50,000,000	3,000,000	3,000,000	900,000	600,000
Observable proportion (%)					
Falsterbo	1.52	0.05	0.28	2.59	0.88
Offshore (Møn to Bornholm)	1.29	4.54	9.76	68.69	4.88
Observable proportion, total (%)	2.81	4.60	10.04	71.28	5.76
Non-observable proportion (%) Migration over the Danish islands/ high migration / nocturnal migration / wintering in Scandinavia	**97.19**	**95.40**	**89.96**	**28.72**	**94.24**

1 http://www.skov.se/fbo/index_e.html
2 Assumption: Broad-front migration of Swedish breeding birds, migration rates at Kriegers Flak as a base for the sea area between Møn and Bornholm (150 km), max. detection distance at the ship
3 Number of breeding pairs according to HEATH et al. (2001)
4 Conservative estimate of the reproduction rate (= 2 fledglings juvenile per pair): Autumn migration volume = (2 adults + 2 juveniles)*number of breeding pairs

The migration of diurnal migrant land birds in the western Baltic Sea follows two basic rules:

- Many diurnal migrants prefer to cross the Baltic Sea in the area of the Danish islands. They fly partially in the observable range (below 50-100 m). Wood pigeons, for example, migrate in a broad front over the Swedish interior, but in the area of the southern tip of Sweden near Falsterbo there is a clear concentration of migration. Wood pigeons are observed in large numbers at Falsterbo and on Fehmarn (KOOP 2005).
- Diurnal migrants avoid crossing the Arkona Sea during the day at low altitude (below 100 m). They either migrate at very high altitudes (e.g. chaffinch > 1,000 m, IfAÖ's own observations) or sometimes at night (e.g. skylark, starling, mountain finch).

In view of the methodological difficulties involved in recording diurnal migrant land birds at sea (only possible with target-tracking radar), little is known about the migratory behaviour of these species. Only a few species are known to cross the Baltic Sea in a broad front (e.g. swallows, wagtails and pipits).

Land birds (nocturnal migrants)

Nocturnal migrants account for more than half of all migratory birds in the western Baltic Sea (long- and short-distance migrants). Among the most common nocturnal migrants are small insectivorous birds such as typical warblers, leaf warblers, flycatchers, wheatears (*Oenanthe oenanthe*) and robins (*Erithacus rubecula*), but also thrushes (Table 17 (Alerstam et al., 1974).

Table 17Table 17). A number of bird species can be observed migrating at night and during the day (ducks, geese, swans, waders and gulls). Often, however, the main migration of these species occurs during the day. Radar surveys of the eider duck migration off the coast of southern Sweden, for example, showed that a maximum of 10–20% of the total migration occurred in darkness (Alerstam et al., 1974).

Table 17: Population sizes (number of breeding pairs; status 2000) for the most common nocturnal migrant songbird species in Sweden (D = partially diurnal migrants; according to BIRDLIFE INTERNATIONAL, 2004a).

Species	Number of breeding pairs	Species	Number of breeding pairs
Cuckoo	30,000 – 70,000	Lesser whitethroat	150,000 – 400,000
Wren	100,000 – 500,000	Whitethroat	500,000 – 1,000,000
Robin	2,500,000 – 5,000,000	Garden warbler (D)	1,000,000 – 3,000,000
Thrushes	20,000 – 50,000	Blackcap (D)	400,000 – 1,000,000
Common redstart	100,000 – 300,000	Wood warbler	200,000 – 250,000
Wheatear	100,000 – 500,000	Common chiffchaff	100,000 – 400,000
Whinchat	200,000 – 400,000	Willow warbler	10,000,000 – 16,000,000
Song thrush	1,500,000 – 3,000,000	Goldcrest	2,000,000 – 4,000,000
Redwing (D)	750,000 – 1.500,000	Spotted flycatcher (D)	500,000 – 1,200,000
Reed warbler	50,000 – 200,000	Pied Flycatcher	1,000,000 – 2,000,000
Marsh warbler	15,000 – 20,000	Red-backed shrike	26,000 – 34,000
Icterine warbler	40,000 – 100,000		

Most nocturnal bird migration takes place in a broad front across the Baltic Sea. The birds of individual sub-populations fly, based on their (mainly endogenous) determined migratory direction, in parallel adjacent sectors, so that area-wide migratory patterns develop (e.g. BERTHOLD 2000). An indication of broad-fronted migration is provided, for example, by comparisons of catch figures from the Falsterbo and Ottenby ringing stations, which are about 240 km apart. Goldcrests were caught there in almost identical numbers every year for a period of over 20 years. Anomalies such as the almost complete lack of Goldcrest migration in 2002 are also reflected at both catching stations. This can only be explained by the fact that birds migrating at night move southwards across a broad front (GRENMYR 2003).

Vertical radar surveys of species composition during the autumn migration in 2005 on the island of Rügen showed that songbirds accounted for the largest proportion of nocturnal bird migration at around 90%, while waders only accounted for around 5%. Large songbirds, especially thrushes, were more common than small songbirds (see Figure 50). The relative proportion of small songbirds compared to large songbirds increased with height.

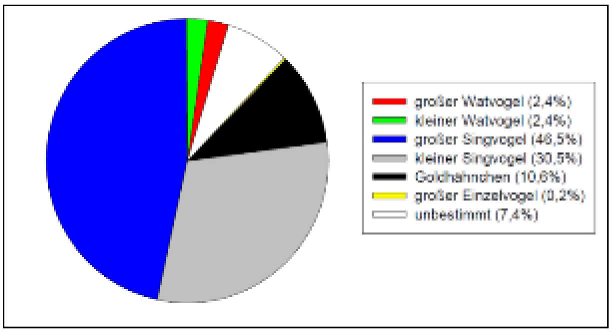


Figure 50: Species composition of nocturnal bird migration on Rügen in autumn 2005 (n= 26,612 echoes; from BELLEBAUM et al. 2008).

The main nocturnal migration direction is the same for many species. In autumn it runs approximately south-southwest and in spring north-northwest (see Figure 51). In autumn 2005, the recording of migratory directions of nocturnal migrants using the Rügen tracking radar (mean over 9 nights; n = 712 measurements) revealed a median flight course of 213°, while bird heading was oriented slightly more to the south (median: 207°). In addition, there are species whose wintering grounds lie in a south-easterly direction (e.g. barred warbler, marsh warbler, lesser white-throat, red-backed shrike, etc.). However, even nocturnal migratory birds with a main south-west direction of migration regularly make strong south-easterly migrations, especially in conjunction with north-westerly winds. The active selection of a migration direction depending on wind direction is also known as "pseudo-drift".

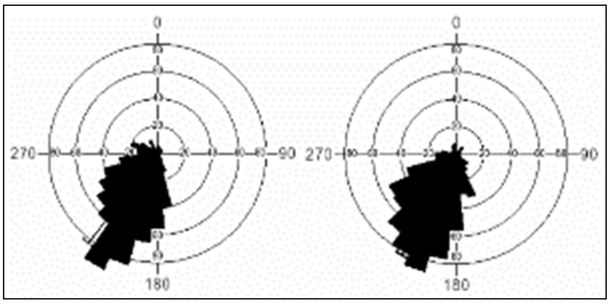


Figure 51: Frequency of night-time bird migration (left: course, right: heading) based on measurements with the "Superfledermaus" tracking radar in autumn 2005 on the island of Rügen (from BELLEBAUM et al. 2008).

Land birds cross the Baltic Sea throughout the year. However, there are seasonal differences with high migration intensities from March to May (vernal migration) and in September/October (autumnal migration). Within the main migration periods, the migration intensity varies greatly from day to day. These variations are caused by differences in weather conditions, with wind conditions often the deciding factor (see LIECHTI & BRUDERER 1998; Erni ET al. 2002). There are fundamental differences in the seasonal phenologies of nocturnal migrant songbirds between long distance and short to medium-distance migratory birds. Short and medium-distance migratory birds (e.g. golden grouse, wren, thrushes, robins) enter the breeding area earlier (often as early as March/April) and leave later (September to November), while the breeding season of long-distance birds (e.g. warblers, reed warblers, flycatchers and icterine warblers *Hippolais icterina*) is shorter, i.e. they often arrive in the breeding area in May/June and leave again at the end July/beginning of August (see for example KARLSSON 1992).

Between 2002 and 2006, vertical radars at coastal locations and on ships in the Baltic Sea were used to determine migration rates in order to obtain an idea of the spatial distribution of nocturnal migratory activity.

The highest nocturnal migration traffic rates were recorded at the coastal locations Darßer Ort and Fehmarn (approx. 1,000 echoes/(h*km) on average in spring and approx. 500–600 in autumn). The rates recorded on the island of Rügen were about half of these values. Here, the migration traffic rates recorded in Fehmarn and Darßer Ort were not reached on any night. Significantly lower migration traffic rates were measured at the offshore locations. On a few nights, however, higher rates were recorded (e.g. Kriegers Flak on 7/10/2003: average migration rate 1,802 / max. hourly value: 3,513 echoes/(h*km)).

The maximum nocturnal migration rates reached their highest values in spring on Fehmarn with 5,228 echoes per hour and km in one night (max. hourly value: 15,278 echoes/(h*km)).

A comparison of the different locations and years of investigation illustrates the pronounced fluctuations in nocturnal migration traffic rates at the coastal locations where continuous measurements could be taken (see Figure 52). However, the data suggest that higher migration rates also occur at night along the "Vogelfluglinie" and that these rates decrease in the easterly direction. The low migratory rates at sea are presumably related to the incomplete coverage and insufficient constancy of the recording conditions (BELLEBAUM et al. 2008).

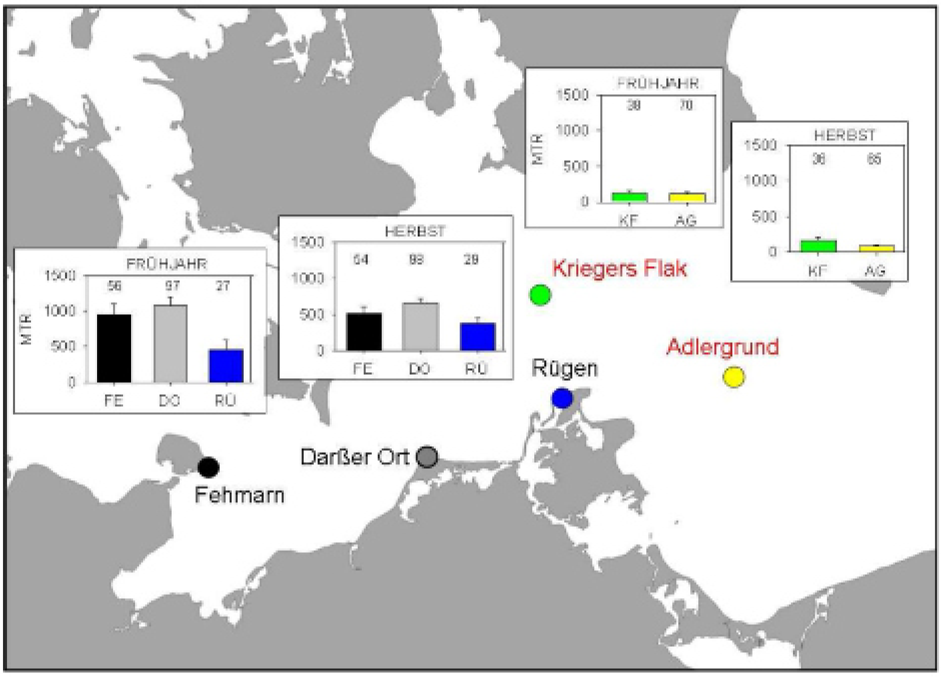


Figure 52: Mean migration traffic rates (MTR = birds per kilometre and hour) at different monitoring sites in spring and autumn (from BELLEBAUM et al. 2008).

2.9.3 Assessment of the state of the factor migratory birds

The assessment of the state of migratory birds in the German Baltic Sea EEZ is based on the following assessment criteria:

- Large-scale importance of bird migration
- Evaluation of occurrence
- Rarity and threat
- Legacy impacts

In the following section, the assessment for the EEZ is carried out separately for the main groups of waterbirds, cranes, birds of prey, and land birds. For the species requiring special protection under Annex I of the Birds Directive and the bird species subject to special protection under Article 4 (2) of the Birds Directive, an additional individual assessment is also made.

According to currently available information, several million birds migrate across the western Baltic Sea every year. In particular, the nocturnal migration of land birds takes place on a wide scale between Central Europe and Scandinavia. Due to the broad frontal migration of these birds, there is no land-sea gradient. In the western Baltic Sea, land-sea gradients are restricted to the immediate coastal area, where the guiding effect of the beach line means that migration is concentrated locally even at night (in autumn in southern Sweden, in spring in Mecklenburg-Western Pomerania).

Concentration zones and guidelines for bird migration are found in the western Baltic Sea for diurnal migrants. Thermal soarers and other diurnal migrant land birds, such as wood pigeons, prefer to migrate along the "Vogelfluglinie" (islands of Fehmarn, Falster, Møn and Zealand, Falsterbo). East of this main route these birds migrate at a much lower density (e.g. FRANSSON & PETTERSSON 2001).

Waterbirds

The western Baltic Sea is an important transit area for sea ducks and geese breeding in northern Europe and Russia (as far as western Siberia) to wintering grounds in the North Sea and northern Kattegat. As the sea ducks are mainly diurnal migrants, which prefer to navigate using landmarks, a large part of the migration takes place near the coast. Scoters, for example, usually fly within sight of land structures. Radar measurements in the area of Cape Arkona and Hiddensee within the scope of an R & D project (Knust ET al. 2003) have revealed migration to run largely parallel to the coast. In addition, in the area of the western Baltic Sea, a broad-front migration across the open sea also occurs (RAUTENBERG 1956; KNUST et al. 2003). According to observations of the IfAÖ, gulls and auks migrate across the open sea without being tied to specific routes.

Divers

The red-throated and black-throated diver, which are grouped together under the term diver, are also listed in Annex I of the Birds Directive. One main route takes most divers along the German coast. Results from the EIS monitoring reports indicate that the migration of divers in the EEZ is of minor importance (for more details see chapter 2.9.3.2).

Sea Ducks

Eider ducks, long-tailed ducks, common scoters and velvet scoters are among the regularly occurring migratory bird species not listed in Annex I of the Directive, for which special conservation measures must be taken in accordance with Article 4 (2) of the Directive. According to BIRDLIFE INTERNATIONAL (2004b), the populations of sea ducks (with the exception of velvet scoter) are showing a predominantly positive trend. According to more recent estimates by WETLANDS INTERNATIONAL (2012), however, this only applies to the eider duck, where the biogeographical population of the eider duck is currently estimated at 976,000 individuals. The numbers of the biogeographical populations of the three other duck species have declined by more than 50 percent in recent years. Values of 1.6 million individuals are currently given for the long-tailed duck, 550,000 for the common scoter and 450,000 for the velvet scoter (WETLANDS INTERNATIONAL 2012).

The four duck species are mainly diurnal migrants and are strongly affected by topographical structures. However, investigations carried out as part of an R&D project (Knust ET al. 2003) have shown that the ducks also migrate across the Baltic Sea in a broad frontal migration.

According to currently available information, eider duck migration occurs on a large scale along the Swedish coast. During daily observations between autumn 2013 and autumn 2015 in area EO3, sighting rates of eider ducks fluctuated very strongly. Most eider ducks were sighted in autumn 2013 with 10,832 individuals, and fewest in spring 2015 with 1,823 individuals (IFAÖ 2016a and b). In area EO1 the number of sighted eider ducks in 2014 was 457 (BIOCONSULT 2016). This means that a maximum of 1.1% of the biogeographical population was sighted in a small area of the EEZ during a migration period. Despite this high sighting rate, the eider duck migration along the Swedish coast is about 40 times higher than in area EO3. Based on these results and the observation that eider ducks have a strong relation to topographic structures (coastline), the German EEZ has an average importance for the eider duck migration.

The migration of the common scoter, on the other hand, is increasingly taking place along the German coast. In spring, about 9% of the biogeographical population was recorded at Darßer Ort (WENDELN & KUBE 2005), although a not inconsiderable proportion was also sighted at sea 20 km north of Darßer Ort, indicating that larger numbers of common scoters also migrate in the EEZ. In area EO1 approx. 0.33% of the biogeographical population was sighted in 2014 (BIOCONSULT 2016) and in area EO3 approx. 0.5% (2014) and 0.12% (2015) (IfAÖ 2016a and b) respectively. Velvet scoter migration is almost never observed in the German Baltic Sea (GARTHE et al. 2003, WENDELN & KUBE 2005). This is also confirmed by recent observations in the two priority areas. Only 105 velvet scoters were sighted in priority area EO3 and 217 in priority area EO1. The same applies to the long-tailed duck in priority area EO3. Although 6,728 long-tailed ducks (0.4% of the biogeographic population) were sighted in area EO1 in 2014, the EEZ is of little importance for the migration of these two duck species.

Overall, the German EEZ of the Baltic Sea is of average to above-average importance for migratory waterbirds. This is due to the fact that there are two main routes in the western Baltic Sea for diurnal migrant waterbirds along the Swedish and German coasts, and that the German EEZ at least borders the near-coastal concentration of migration along the Mecklenburg coast (KNUST et al. 2003). There are also concentration areas in the north-south direction along the known migration routes of the open Baltic Sea (e.g. "Vogelfluglinie", southern Sweden–Rügen). In addition, the western Baltic Sea is crossed by several species requiring special protection (e.g. barnacle goose, whooper swan, eider, common scoter and velvet scoter), in some cases at high intensities.

Barnacle goose (Branta leucopsis)

The Russian-Baltic breeding population of the barnacle goose is significant for the western Baltic Sea, because this population crosses the Baltic Sea on its way to its main wintering grounds (including the German and Dutch coasts). The biogeographical population of the barnacle goose is estimated at 770,000 individuals (WETLANDS INTERNATIONAL 2012). The population has shown a large increase in the number of individuals in recent decades. According to the literature, the main migration area in the western Baltic Sea lies along the Swedish coast. During the spring migration, however, there is also an increased migration over the open sea (GREEN & ALERSTAM 2000).

The main flight zone in the EEZ is in the Bay of Kiel/Fehmarn Belt area. However, monitoring of the offshore wind farm project EnBW Baltic 2 in priority area EO3 identified 8,190 migrating barnacle geese in 2014 and 2,622 in 2015 (IfAÖ, 2016a and b). This represents approximately 1.06% and 0.34% of the biogeographical population respectively. This means that the area around Kriegers Flak is of high importance for barnacle goose migration. Area EO1, on the other hand, is of minor importance, as a maximum of 42 migrating barnacle geese were identified (BioConsult, 2016), i.e. about 0.01% of the biogeographical population. In area EO2, a total of 3,340 barnacle geese were recorded in the period from 2008 to 2012 as part of the bird migration observations for the offshore wind farm Baltic Eagle (OECOS 2015). This corresponds to an average annual sighting rate of about 850 individuals (= 0.11% of the biogeographic population). According to currently available information, the EEZ is of average to high importance for the migration of the barnacle goose. The average importance can be explained by the fact that the main migration focus is generally outside the EEZ. A high importance is found in some areas, e.g. in the area of Kriegers Flak, where barnacle geese migrate with significant intensity (> 1% of the biogeographical population).

Whooper Swan (Cygnus cygnus)

According to BAUER & BERTHOLD (1997), in all European countries with breeding populations, the population of the Whooper Swan has been increasing continuously for several decades. The biogeographic population crossing the Baltic Sea on its migration route is estimated at 59,000 individuals (WETLANDS INTERNATIONAL 2012). Approximately 0.3% of the biogeographic population was recorded in priority area EO1 in one year and approximately 0.03% in priority area EO3. In area EO2 the sighting rate is about 0.01%. The three areas are therefore of minor importance for the migration of whooper swans. Overall, the importance of the EEZ for whooper swan migration may be estimated as average at most, as it cannot be excluded that the whooper swans, being mainly diurnal, may use the known migratory routes ("Vogelfluglinie") with higher intensity.

Cranes

As a bird species listed in Annex I of the Directive, the crane enjoys a special conservation status. While the European population experienced a sharp decline between 1970 and 1990, it has now been increasing significantly for many years (Birdlife International, 2004; Prange, 2005). According to WETLANDS INTERNATIONAL (2012), the biogeographic population comprises 90,000 individuals. Cranes from the various breeding grounds in northern Europe use different migratory routes to their wintering grounds. Of particular interest for the western Baltic Sea are the Scandinavian birds that cross the Baltic Sea on migration.

The western Baltic Sea as a whole (and thus the German EEZ) is of above-average importance for crane migration, as the majority of the biogeographic population inevitably has to cross the Baltic Sea on their way south. However, as the crane is a narrow-fronted migratory bird, the migration path across the EEZ is concentrated in individual areas. It is assumed that about 50,000 to 60,000 cranes coming from southern Sweden cross the Arkona Basin. This means that about 55% of the biogeographical population uses this migration route alone. However, increased crane migration can also be observed in neighbouring areas as a result of stronger winds.

For example, in autumn 2014 and autumn 2015 very high numbers (5,028 and 3,517 cranes respectively) were recorded in area EO3 (IFAÖ 2016a and b). This meant that about 5.6% and 3.9% of the biogeographical population passed through area EO3. This was likely caused by stronger easterly winds, causing the cranes to drift into the area of the offshore wind farm project area EnBW Baltic 2. This is supported by the fact that in autumn 2015, the cranes were recorded at EnBW Baltic 2 exclusively at force 2–5 Beaufort from northeast or east. In area EO2, annual sighting rates were between 500 and 700 individuals, with 550 cranes being sighted on two days alone in autumn 2008 in westerly breezes of force 4 to 5 (OECOS 2015). In priority area EO1, a total of 546 migrating cranes were registered during the autumn migration of 2014 (BIOCONSULT SH, 2016), which corresponds to about 1.4% of the Western Pomeranian resting population (resting numbers: over 40,000 individuals at a time) or 0.6% of the biogeographic population. Here, too, the majority of these birds may have experienced drift in north-westerly winds, deviating from a flight path south of Sweden-Rügen to the south-east. However, cranes from Finnish (and Baltic) populations are more likely to appear in the area of Adlergrund. On Christiansø and Bornholm, for example, 5,490 and 6,300 cranes, respectively, (flight direction W to SW) were recorded on 12/10/2003, so it can be assumed that larger numbers of cranes may also appear in the Adlergrund area at times.

On the basis of this migratory behaviour, a nuanced consideration is necessary. The known main migratory routes are undoubtedly of above-average importance. The areas adjacent to these main migration routes are probably of average to above-average importance, depending on wind force and direction. Outside these areas, the importance is probably low. Based on the flight altitudes and flight directions determined, it can be assumed that some of the cranes migrating across the Baltic Sea will encounter the planned wind farms. Since cranes usually migrate with tailwinds and good visibility under favourable weather conditions, evasive movements similar to those at land-based sites can be assumed. However, there is still a lack of relevant studies for the open sea. Ultimately, it is necessary to carry out crane migration studies at project level for individual projects in order to assess the condition of the affected migration route.

Birds of prey

In the majority of cases, diurnal migrants from Swedish populations use the "Vogelfluglinie" via Fehmarn coming from Falsterbo. However, some also cross the Baltic Sea in a north-south direction in autumn. In total, up to 50,000 Scandinavian birds of prey migrate south via Falsterbo. These include Appendix I species (of the Birds Directive), which migrate across the Baltic Sea to a significant extent. These are the honey buzzard (*Pernis apivorus*), red kite (*Milvus milvus*), marsh harrier (*Circus aeruginosus*), osprey (*Pandion haliaetus*) and merlin (*Falco columbarius*).

Overall, the German EEZ of the Baltic Sea is of above-average importance for birds of prey, especially the Scandinavian populations. However, there are also considerable local differences due to their migratory behaviour, so that a nuanced approach is necessary. For example, the known main migratory routes are undoubtedly of above-average importance. The areas adjacent to these main migration routes are probably of average to above-average importance, depending on wind force and direction. Outside these areas, the importance is probably low. Ultimately, it is necessary for individual projects to carry out investigations of bird of prey migration at project level, which will allow an assessment of the condition of the affected area.

Land birds

For land birds, a distinction must be made between diurnal and nocturnal migratory birds.

Diurnal migrants

The diurnal migrants consist mainly of pigeons and songbirds. Geographic guidelines play an important role for these species. This is why they mainly use the Danish islands when crossing the Baltic Sea. A further grouping of migratory birds takes place via the "Vogelfluglinie". These areas are therefore of above-average importance. Outside these main migratory routes, the intensity of diurnal migrants in areas far from the coast is comparatively low and therefore of low to average importance.

However, it should be noted that little is known about the migration across the open Baltic Sea. It is known that only a few species (e.g. swallows, wagtails, pipits) migrate across the Baltic Sea in a broad front.

Nocturnal migrants

Nocturnal migratory birds account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place across the Baltic Sea in a broad front. Due to the very high numbers of individuals and the significant proportion of endangered species, the EEZ is of above-average importance for nocturnal migrants.

2.9.3.1 Legacy impacts

Migratory birds are subject to a variety of anthropogenic impacts. Anthropogenic factors contribute to the mortality of migratory birds in a variety of ways, and their complex interaction can affect population size and determine current migratory patterns. On the one hand, these include losses of breeding, resting and wintering areas due to a wide range of human activities, and, in the long term, climate change. In addition, a large number of birds die directly as a result of human activity every year. In Scandinavia and the Baltic Sea region alone, more than 100 million birds die every year as a result of active hunting, collisions with man-made structures, fishing, and oil and chemical pollution. The various factors are cumulative, making it difficult to determine their separate significance.

Analyses of birds ringed on Heligoland show that, over the last century, anthropogenic causes of death have increased in all species groups, with collisions with buildings and vehicles being the most prominent ("passive causes of death", 14% of all deaths in the last two decades, 49% in birds of prey and owls; HÜPPOP & HÜPPOP 2002).

Many migratory bird species of Scandinavia are listed in Annex II/1 and II/2 of the Birds Directive and are subject to hunting in at least part of their annual habitat. Almost all migratory anatidae (ducks, swans, geese) in the Baltic Sea area are affected by hunting. From 1996 to 2001, 122,500 eider ducks were hunted annually in Scandinavia, of which 92,820 in Denmark alone (ASFERG 2002). This represents 16% of the winter population of 760,000 individuals (DESHOLM et al. 2002), to which must be added shootings in the successor states of the former Soviet Union, for which no data are available. Particularly in the western Mediterranean region, an important wintering ground for Scandinavian middle-distance birds of prey, there is still an insufficient statistical record of hunting (HÜPPOP & HÜPPOP 2002).

In the western Baltic Sea itself, apart from hunting, there is currently little legacy impact on Scandinavian migratory birds. These generally consist of collision risks for nocturnal birds with ships, bridges, offshore wind turbines and lighthouses.

The results of the investigations on lightships and platforms suggest that the risk of collision of migrating land birds with offshore wind turbines is high. The collision risk at lighthouses in the western Baltic Sea has been investigated several times (see for example HANSEN 1954, BANZHAF 1936). HANSEN (1954) analysed the collision mortalities reported at 50 lighthouses in Denmark over a period of 54 years (1887-1939), a total of 96,500 birds. About 50% of all reported collision mortalities came from the 12 Danish lightships, although it is likely that only some collision mortalities were found on board and a much larger number fell into the sea. It appears that the risk of collision was generally higher for birds at sea than on land. For lightships, the annual collision rate was at least 100–200 birds. The risk of collision varies greatly from species to species. In HANSEN'S studies (1954), five species accounted for approximately 75% of all victims, namely skylark, song thrush, redwing, starling and robin. The collision mortalities were almost without exception nocturnal migrants. Only in exceptional cases did diurnal migrants suffer collisions, and thermal soarers had almost no accidents at all (three individuals).

Similar findings are available for the research platform FINO1 (HÜPPOP et al. 2009) and the research platform Nordsee (MÜLLER 1981). The affected species are characterised by nocturnal migration and relatively large populations. It is striking that almost 50% of the collisions registered on FINO1 occurred on just two nights. During both nights, south-easterly winds, which may have promoted the migration over the sea, and poor visibility conditions prevailed, which may have led to a reduction in flight altitude and increased attraction by the illuminated platform (HÜPPOP et al. 2009). Illuminated bridges over large areas of water may also pose a danger to nocturnal migrants. After the completion of the Øresund Bridge in autumn 2000, mass collisions occurred at the strongly illuminated bridge in limited visibility, resulting in several thousand casualties in a few days. Investigations initiated by this event resulted in 295 dead birds the following year (with a significant reduction in illumination), with robins, song thrushes and goldcrests most at risk (BENGTSSON mdl. comm.). The studies also show the risk to songbirds migrating at night across the sea.

Quantitative data on the collision risk for birds with offshore wind turbines are not yet available (DESHOLM et al. 2005). At the offshore wind farms Tunø Knob (Denmark, GUILLEMETTE et al. 1999), Utgrunden (Sweden, PETTERSSON 2005) and Nysted (Denmark, DESHOLM & Kahlert 2005), only the collision risk for eider ducks and geese has been investigated so far. For methodological reasons, the investigations using infrared cameras in the offshore wind farm Nysted (DESHOLM 2005) do not yet allow any conclusions to be drawn about the collision risk for small birds.

Global warming and climate change also have measurable impacts on bird migration, for example through changes in phenology or modified arrival and departure times, but these impacts vary from species to species and region to region (see BAIRLEIN & Hüppop 2004; Crick, 2004, Bairlein & WINKEL 2001).

For example, clear relationships between large-scale climate cycles such as the North Atlantic Oscillation (NAO) and the condition of songbirds on their spring migration have been demonstrated (HÜPPOP & HÜPPOP 2003). Climate change can also influence conditions in breeding, resting and wintering areas, and the availability of these sub-habitats.

2.9.3.2 Significance of individual parts of the EEZ for bird migration

The criteria listed in Chapter 2.11.3 are used to assess the significance of individual sub-areas of the EEZ for bird migration, taking into account the main groups of waterbirds, cranes, birds of prey, and land birds. For the species requiring special protection under Annex I of the Birds Directive and the bird species subject to special protection under Art. 4 (2) of the Birds Directive, an additional individual assessment is made. The sub-areas considered include the reserved and priority areas for offshore wind energy defined in the spatial plan, and the Fehmarn Belt Lolland bird migration corridor (the "Vogelfluglinie"), which is designated as an area reserved for nature conservation area.

Wind energy priority area EO1

Waterbirds

Overall, area EO1 is of average importance for migratory waterbirds. This is due to the fact that the area is transited by several species requiring special protection (e.g. barnacle goose, whooper swan, eider, common scoter and velvet scoter), but is located outside the main route along the German coast. However, the results of environmental monitoring in area EO1 "West of Adlergrund" indicate that the migration of protected waterbird species is of little significance (BIOCONSULT SH 2016, 2017). For example, only 26 divers were sighted in 2014 and only 105 in 2015. The number of sighted eider ducks was 457 in 2014 and 2786 in 2015, which means that in 2015 approximately 0.3% of the biogeographical population was sighted in area EO1. In both years (2014 and 2015), the sighting rates of common scoter, velvet scoter and long-tailed duck were also below 0.5 % of the respective biogeographical population (common scoter 0.33 %, velvet scoter 0.05 % and long-tailed duck 0.4 %). The sighting of 42 migrating barnacle geese (BIOCONSULT 2016) corresponds to a share of about 0.01 % of the biogeographical population. As for the whooper swan, it can also be noted that the area is not of great importance for migration, as only about 0.3% of the biogeographical population was registered in one year.

Cranes

In area EO1, a total of 546 migrating cranes were registered during the autumn migration of 2014 and 110 in the autumn migration of 2015 (BIOCONSULT SH 2016, 2017). The 546 cranes represent about 1.4% of the Western Pomeranian resting population (resting numbers: over 40,000 individuals at a time) or 0.6% of the biogeographic population. The majority of these birds may have drifted from a flight path from southern Sweden to Rügen toward the south-east due to north-westerly winds. However, cranes from Finnish (and Baltic) populations are more likely to appear in the area of the Adlergrund. For example, on Christiansø and Bornholm, 5,490 and 6,300 cranes (flight direction W to SW), respectively, were recorded on 12/10/2003, so it may be assumed that larger numbers of cranes may also appear in the Adlergrund area at times.

A nuanced consideration is necessary as a result of this migratory behaviour. The known main migration routes are undoubtedly of above-average importance. The areas adjacent to these main migration routes are probably of average to above-average importance, depending on wind force and direction. This also applies to area EO1.

Birds of prey

According to current research results, area EO1 is of little importance for the migration of birds of prey, as only very small numbers of individuals have been recorded. For example, 2 individuals of the Appendix I (Birds Directive) species honey buzzard, 4 marsh harriers and 1 merlin have been sighted.

Land birds

For land birds, a distinction must be made between diurnal and nocturnal migratory birds.

Diurnal migrants

The diurnal migrants are mainly pigeons and songbirds. Guidelines play an important role for these species. This is why they mainly use the Danish islands when crossing the Baltic Sea. A further grouping of migratory birds takes place via the "Vogelfluglinie". These areas are therefore of above-average importance. Outside these main migratory routes, the intensity of diurnal migration in areas far from the coast is comparatively low and therefore of low to average importance.

Nocturnal migrants

Nocturnal migratory birds account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place across the Baltic Sea in a broad front. Due to the very high numbers of expected individuals and the significant proportion of endangered species, area EO1 has an average to above-average importance for nocturnal migratory birds.

Area reserved for wind energy EO2

Waterbirds

Overall, area EO2 is of average to above-average importance for migratory waterbirds. This is due to the fact that the area is transited by several species requiring special protection (e.g. barnacle goose, whooper swan, eider, common scoter and velvet scoter), but is located outside the main route along the German coast. However, the results of the baseline survey for the planned offshore wind farm Baltic Eagle indicate that the migration of some protected waterbird species is only of minor importance (OECOS 2012a). For example, only 347 divers were sighted in 2011. The number of eider ducks sighted in 2011 was 140, which means that around 0.01% of the biogeographic population in area of EO2 was registered. The sighting rates of velvet scoter and long-tailed duck were also very low in 2011, at 0.04 % and 0.06 % of the respective biogeographical population. In contrast, the common scoter was recorded in high numbers: 8174 animals were counted in 2011. This means that about 1.5% of the biogeographical population passed through area EO2. The area is therefore of above-average importance for common scoter migration. The sighting of 2619 migrating barnacle geese (OECOS 2012a) represents about 0.34% of the biogeographical population, so the area is of average importance. With regard to the whooper swan, the area is not of great importance for migration, as only 30 individuals were registered in one year.

Cranes

A total of 1231 migrating cranes were registered in area EO2 during the autumn migration in 2008 (OECOS 2012a). The 1231 cranes represent about 3.1% of the Western Pomeranian resting population (resting numbers: over 40,000 individuals at a time) or 1.37% of the biogeographic population. The majority of these birds may have been diverted by north-westerly wind drift from a flight route from southern Sweden to Rügen toward the south-east. However, cranes from Finnish (and Baltic) populations are more likely to appear in the area of the Adlergrund. On Christiansø and Bornholm, for example, 5,490 and 6,300 cranes, respectively, (flight direction W to SW) were recorded on 12/10/2003, so it may be assumed that larger numbers of cranes may occasionally appear in area EO2.

A nuanced consideration is necessary as a result of this migratory behaviour. The known main migration routes are undoubtedly of above-average importance. The areas adjacent to these main migration routes are probably of average to above-average importance, depending on wind force and direction. This also applies to area EO2.

Birds of prey

According to current research results, area EO2 is of little importance for the migration of birds of prey, as only very small numbers of individuals have been recorded. For example, of the Annex I species (Birds Directive), 1 honey buzzard, 4 marsh harriers, 2 sea eagles and 4 merlins were sighted (OECOS 2012a).

Land birds

For land birds, a distinction must be made between diurnal and nocturnal migratory birds.

Diurnal migrants

The diurnal migrants are mainly pigeons and songbirds. Guidelines play an important role for these species. This is why they mainly use the Danish islands when crossing the Baltic Sea. A further grouping of migratory birds takes place via the "Vogelfluglinie". These areas are therefore of above-average importance. Outside these main migratory routes, the migration intensity of diurnal migrants in areas far from the coast is comparatively low and therefore of low to average importance.

Nocturnal migrants

Nocturnal migrants account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place across the Baltic Sea in a broad front. Due to the very high numbers of individuals expected, and the significant proportion of endangered species, area EO2 has an average to above-average importance for nocturnal migratory birds.

Wind energy priority area EO3

Waterbirds

Overall, area EO3 is of average to above-average importance for migratory waterbirds. This is due to the fact that the area is transited by several species requiring special protection (e.g. barnacle goose, whooper swan, eider, common scoter and velvet scoter), but is located outside the main route along the German coast. However, the results of the construction monitoring for the offshore wind farm EnBW Baltic 2 indicate that the migration of some protected waterbird species is only of minor importance (IFAÖ 2016b). For example, only 91 divers were sighted in 2014 and only 18 in 2015. With regard to the common scoter, approximately 0.5% (2014) and 0.12% (2015) (IFAÖ 2016b) of the biogeographical population were sighted in area EO3. The sighting rate of velvet scoter was 105 individuals, and similar rates apply for the long-tailed duck. During daily observations between autumn 2013 and autumn 2015 in area EO3, the sighting rates of eider ducks fluctuated very strongly. The most eider ducks were sighted with in autumn 2013 with 10,832 individuals, and the fewest in spring 2015 with 1,823 individuals (IFAÖ 2016b). This means that a maximum of 1.1% of the biogeographic population was sighted in a small area of the EEZ during a migration period, which implies that area EO3 is of above-average importance for eider duck migration. Area EO3 is of comparable importance for the migration of the barnacle goose. Monitoring of the offshore wind farm project EnBW Baltic 2 identified 8,190 migrating barnacle geese in 2014 and 2,622 in 2015 (IfAÖ 2016a and b). These number represent about 1.06% and 0.34% of the biogeographic population, respectively. With regard to the whooper swan, the area is not very important for migration, as only about 0.03% of the biogeographical population was recorded in one year.

Cranes

A very high number of 5,028 and 3,517 cranes were recorded in area EO3 in autumn 2014 and autumn 2015 respectively (IfAÖ 2016a and b). This means that about 5.6% and 3.9% of the biogeographical population passed through area EO3. This was probably caused by stronger easterly winds causing the cranes to drift into the area of the offshore wind farm project EnBW Baltic 2. This is supported by the fact that, in autumn

2015, the cranes at EnBW Baltic 2 were found exclusively at wind forces of 2 - 5 Beaufort from the north-east or east. A nuanced consideration is necessary as a result of this migratory behaviour. The known main migration routes are undoubtedly of above-average importance. The areas adjacent to these main migration routes are probably of average to above-average importance depending on wind force and direction. This also applies to area EO3.

Birds of prey

According to current research results, area EO3 is of little importance for the migration of birds of prey, as only very small numbers of individuals have been recorded.

Land Birds

For land birds, a distinction must be made between diurnal and nocturnal migratory birds.

Diurnal migrants

The diurnal migrants are mainly pigeons and songbirds. Guidelines play an important role for these species. This is why they mainly use the Danish islands when crossing the Baltic Sea. A further grouping of migratory birds takes place via the "Vogelfluglinie". These areas are therefore of above-average importance. Outside these main migratory routes, the diurnal migration intensity in areas far from the coast is comparatively low and therefore of low to average importance.

Nocturnal migrants

Nocturnal migratory birds account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place across the Baltic Sea in a broad front. Due to the very high numbers expected and the significant proportion of endangered species, area EO3 has an average to above-average importance for nocturnal migratory birds.

Fehmarn Belt ("Vogelfluglinie")

In its official contribution to the planning process (BfN 2020), the BfN describes the bird migration corridor in the Fehmarn Belt area as follows:

The Fehmarn Belt is one of the most important concentration points for bird migration in Europe (Koop 2004). The area between the islands of Fehmarn and Lolland, also known as part of the "Vogelfluglinie", is used twice a year by migrating land birds and waterbirds in considerable concentrations. It is estimated that 100 million birds, mainly songbirds, pass through the Fehmarn Belt every year in autumn alone (Koop 2004). It thus occupies a prominent position in the Eurasian bird migration system.

For land birds, the Fehmarn Belt, as the shortest link between Germany, eastern Denmark and Sweden, is an important stepping stone on the migration route from Scandinavia to central Europe. Thermal soarers in particular, such as large birds of prey, but also diurnal migratory songbirds avoid long flights over the water and concentrate at geographical bottlenecks such as the Fehmarn Belt to minimize distance over the water (Hüppop et al. 2018). With orders of magnitude of approx. 10,000 to 25,000 birds of prey per migratory period, internationally significant migratory bird concentrations are achieved that fulfil the IBA criterion category A 4 iv (globally important congregations, bottleneck site).

The Fehmarn Belt is also of outstanding importance for waterbird migration. Various migratory routes are bundled in the area, which previously ran parallel to the coast or across the open Baltic Sea from the east. At least 300,000 eider ducks, 50,000–80,000 barnacle geese, 50,000–80,000 brent geese, as well as more than 500,000 laro-limicolae and > 1,000 divers cross the area on their way from their Scandinavian to West Siberian breeding grounds into the Wadden Sea. No alternative routes to the Fehmarn Belt exist that could be used by significant numbers.

For songbirds migrating at night, larger migratory patterns appear due to limited possibilities for visual navigation. However, measurements of migratory activity using radar equipment on the Baltic Sea and at various coastal locations suggest that higher migratory rates also occur at night along the "Vogelfluglinie" over the Danish islands and Fehmarn, with decreasing rates in an easterly direction (Bellebaum et al. 2008).

The Fehmarnbelt is therefore a hub for bird migration. While the prevailing migration direction for land birds during the autumnal migration period is from north-east to south-west, waterbirds cross the area from east to west during this period. The vernal migration runs in the opposite direction. The area is of special nature conservation importance for bird migration across the Baltic Sea and must therefore be secured as a priority area for bird migration.

2.10 Bats and bat migration

Bats are characterised by very high mobility. While bats can travel up to 60 km per day in search of food, roosting or summer resting places and wintering areas lie several hundred kilometres apart. Movements of bats in search of abundant food sources and suitable resting places are very often observed on land, but predominantly aperiodically.

In contrast to irregular movements, migrations take place periodically or seasonally. Both the movements and the migratory behaviour of bats are highly variable depending on species and sex. Differences in migratory behaviour also occur within a population of a species. Based on their migratory behaviour, bats are divided into short-distance, medium-distance and long-distance migratory species.

In their search for roosting, feeding and resting grounds, bats move over short and medium-distances. Corridors for movement along rivers, around lakes and bodden waters are known to exist for medium distances (BACH & MEYER-CORDS 2005). However, long-distance movements are still largely unexplored. In contrast to bird migration, which has been confirmed by extensive studies, very little is known about bat migration due to the lack of suitable methods or large-scale special monitoring programmes.

Long-distance migratory species include the common noctule (*Nyctalus noctula*), Nathusius' pipistrelle (*Pipistrellus nathusii*), the parti-coloured bat (*Vespertilio murinus*) and the lesser noctule (*Nyctalus leislerii*). For these four species, regular migrations over a distance of 1,500 to 2,000 km have been recorded (TRESS et al. 2004, HUTTERER et al. 2005). Long-distance migratory movements are also suspected for the species *Pipistrellus pygmaeus* and *Pipistrellus pipistrellus* (BACH & MEYER-CORDS 2005). Some long-distance migratory species occur in Germany and countries bordering the Baltic Sea and have occasionally been encountered on ships and in coastal regions of the Baltic Sea.

Common noctule (*Nyctalus noctula*): In coastal regions of southern Sweden, individuals have been observed leaving land headed for sea during the usual bird migration period. Winter finds of individuals ringed in Sweden have also been recorded in Germany (AHLEN 1997, AHLEN et al. 2009).

Nathusius' pipistrelle (*Pipistrellus nathusii):* In spring and autumn migrants are often observed. There is increasing evidence that these bats also winter in northern Germany. In coastal regions of southern Sweden, individuals flying towards the sea have been observed, as with the common noctule. There are also winter finds in Germany of individuals that were ringed in Sweden (AHLEN 1997, AHLEN et al. 2009).

According to BOYE et al (1999), *Pipistrellus pipistrellus* is the most frequently recorded bat species in Germany. It occurs throughout the year and is widely distributed. There is some evidence that these species also migrate over long distances, possibly over the sea.

The northern bat (*Eptesicus nilssoni*) is a Nordic species with its centre of distribution north of 60°N, reaching its southernmost limit in Germany. Accumulations of northern bats have been observed in coastal regions of southern Sweden (AHLEN 1997). Observations to date indicate that the northern bat may undertake long-distance migrations across the sea.

2.10.1 Data availability

Migration movements of bats over the Baltic Sea are documented by ringing finds. To date, however, migration directions, migration times and above all possible migration corridors in the Baltic Sea are largely unknown for bats. Data availability is therefore insufficient for a detailed description of the occurrence and intensity of bat migration in the offshore area and the areas recorded in the spatial plan for wind energy. In the following, therefore, reference is made to the general literature and publications on bats or bat migration over the Baltic Sea in order to reproduce the current state of knowledge.

2.10.2 Movement and migration of bats over the Baltic Sea

Migratory movements of bats over the Baltic Sea have been little researched to date. This is mainly due to the lack of suitable recording methods that would be able to provide reliable data on bat migration in the marine environment. Although visual observations, e.g. on the coast or on ships, do provide clues, they are hardly suitable for a full understanding of the migratory behaviour of nocturnal bats. In addition, due to the height of the flight movements (e.g. 1,200 m for the common noctule), visual observations are of low or very limited suitability for recording migratory behaviour. WALTER et al. (2005) have summarised all previous sightings of bats from ships and platforms.

A number of observations lead to the assumption that bats regularly cross the Baltic Sea during seasonal migration. The few systematic scientific studies on bat migration across the Baltic Sea have been conducted in Scandinavia. Based on observations of bat concentrations at various coastal locations in southern Sweden (e.g. Falsterbo, Ottenby) by AHLEN (1997) and AHLEN et al. (2009), at least four of the 18 bat species found in Sweden migrate south. Observations of individuals that have left land headed for sea are available for Nathusius' pipistrelle, the common noctule and the parti-coloured bat. However, winter finds in Germany of animals that have been ringed in Sweden are only documented for Nathusius' pipistrelle and the common noctule.

Further information based on ringing finds is provided by studies on the migratory behaviour of Nathusius' pipistrelle from Latvia (PETERSONS 2004). It was found that bats roosting in Latvia during the summer months visit wintering grounds in western, central and southern Europe. The ringed bats were recorded at a distance of up to 1,905 km. The average distance for all finds was 1,365.5 km for males and 1,216.5 km for females. The calculated average migration speed of the ringed bats was around 47.8 km per night. Among other things, ringed bats were found in resting habitats in the north and north-east of Germany. Ringing finds were also reported from the Netherlands and France – with a possible migration route via Germany. Little is known about the flight and migration altitudes of the bats. In search of food (insects), the common noctule usually flies at an altitude of 500 m. Observations from Falsterbo indicate that the common noctule flies at altitudes of up to 1,200 m (AHLEN 1997). The common noctule is also known as a diurnal migrant species (EKÖLF 2003). It is assumed that migratory movements during daylight occur preferentially above 500 m in order to avoid hunting by birds of prey.

Ringing recovery can be used to prove individual positions of ringed bats, but not the migration routes in between. No suitable method currently exists for the exact recording of the flight routes of individual bats over longer distances (HOLLAND & WIKELSKI 2009). As a result, it is not possible to draw conclusions about the number of bats regularly migrating.

Ultrasonic detectors, known as bat detectors, provide reliable information on the occurrence of bats on land (SKIBA 2003). However, their use in offshore areas is difficult. Records do show the presence of bats in offshore areas, within the limited detection range of the system. However, stronger winds, which are more common at sea, cause background noise that makes it difficult to reliably detect bat signals. There is a continuing need for research in this area.

A good summary of the current state of knowledge is provided by the expert report "Bat migration in the area of the German Baltic Sea coast" commissioned by the BSH (SEEBENS et al. 2013). It summarises and discusses the results of different bat surveys off the coast of Mecklenburg-Western Pomerania. Among others, surveys on Greifswalder Oie, the survey from the Riff Rosenort platform and the survey from a ferry are taken into account. On the work platform Riff Rosenort about 2 km off the coast, a total of 23 Nathusius' pipistrelles and 7 common noctules were recorded from mid-May to mid-June 2012 using real-time/time-expansion detectors. The evidence suggests migratory activities. However, due to their proximity to the coast, hunting flights of both species on the Baltic Sea cannot be excluded (SEEBENS et al. 2013).

On the island of Greifswalder Oie, which lies around 12 km north of Usedom and 10 km east of Rügen, investigations into bat occurrence were carried out in 2011 and 2012 using automatic detectors, nets, and checking of buildings suited for roosting. Nine species were identified during these investigations, some in remarkable numbers, including the common noctule, lesser noctule, common pipistrelle and Nathusius' pipistrelle. High levels of activity were recorded, particularly in May, on only a few days. Evaluation of the automatically recorded bat calls shows a total of 4,788 counts for Nathusius' pipistrelle in 2012 (2011: 3,644 counts), 2,178 counts for the common pipistrelle (2011: 1,750 counts) and 817 counts for the common noctule (2011: 1,056 counts). On 6 May 2011, 48 Nathusius' pipistrelles and one common noctule were recorded via net catches at force 2–3 Beaufort (SEEBENS et al. 2013). Based on the high levels of activity of Nathusius' pipistrelle and the common noctule during just a few days in spring, the authors conclude that there are clear indications of migration in the area of Greifswalder Oie.

Information on the occurrence of bats in the offshore area was obtained with the help of a bioacoustic recording system installed on a ferry. The ferry sails between Rostock and Trelleborg in Sweden. In May 2012, 11 bat echolocation calls were recorded offshore over 180 of a total of 540 migration-relevant night hours. Seven of these contacts were within 20 km of the coast of Mecklenburg-Western Pomerania, two others within 20 km of the Swedish and Danish coasts, and two were recorded at a distance of more than 20 km from the nearest coast. The recorded calls could be assigned to the common noctule and Nathusius pipistrelle (SEEBENS et al. 2013).

Despite this evidence, there is a lack of concrete information at this stage to quantify bat migration across the Baltic Sea. This applies to migratory species, migration corridors, migration height, migration direction and concentrations. So far, evidence only indicates that bats, especially long-distance migratory species, migrate across the Baltic Sea.

Based on the results of the above-mentioned expert report, the recording of bat migration was included in the current Standards for Environmental Impact Assessments (Standarduntersuchungskonzept StUK4) in order to obtain more concrete evidence of the importance of the Baltic Sea EEZ as a transit area for bats. The investigations are to be carried out using bat detectors to record call activity, in parallel with nightly call recording of migratory birds. Within the scope of this mandatory bat monitoring of wind farm projects in area EO1, only four bats (two of which are Nathusius' pipistrelles) were detected in nine nights in spring 2014 (May). In autumn (August–October) of the same year, three Nathusius' pipistrelles were detected over 20 nights. A special significance of the area EO1 cannot be deduced from the available data (BIOCONSULT SH 2015).

In the course of baseline surveys for offshore wind farm projects in the German Baltic Sea EEZ, individual sightings of bats were recorded as part of the night-time bird migration survey. During the investigations for the offshore wind farm project Arkona-Becken Südost, one bat was sighted from a ship in autumn 2003 and one in 2004. Another bat was sighted during the investigations for the offshore wind farm project Wikinger in autumn 2003. During further ship voyages, individual specimens were twice sighted area EO1. In area EO2, three bat calls were registered on 21/5/2012 using bioacoustic handheld devices. In spring 2011, two additional bats were sighted from the ship used for bird surveys. In area EO3, one specimen each of an undetermined species was observed as part of the baseline surveys in July and September 2003. Some of the sightings took place during the day.

In summary, it can be concluded that the populations and distribution of migratory species in the bat populations of species relevant to the Baltic Sea have not been conclusively recorded, mainly due to high migration dynamics. There is a lack of adequate methods and monitoring programmes to record and quantify population trends, migration and movements across the open sea.

On the basis of the findings to date, the following statements can be made regarding bat migration across the Baltic Sea: Observations and ringing finds indicate that some species, such as the common noctule, Nathusius' pipistrelle, parti-coloured Bat, common pipistrelle and northern bat migrate across the Baltic Sea.

It is assumed that a broad frontal movement takes place along prominent topographical features, such as coastlines. However, migration directions, migration heights, migration times and, above all, possible migration corridors in the Baltic Sea are still largely unknown for bats.

2.10.3 Conservation status of potentially migratory bat species in countries bordering the Baltic Sea

Some species, such as Nathusius' pipistrelle and the common noctule, are listed in Appendix II to the 1979 Convention on the Conservation of Migratory Species of Wild Animals (CMS) (Bonn Convention). Within the CMS Convention, the framework for a conservation and management plan for the conservation of bats in Europe was established with the adoption of the Agreement on the Conservation of Bats in Europe (EUROBATS) in 1991 and its ratification in 1994.

As part of the reporting obligations for EUROBATS, reports on regional abundance, population trends and the status of bats are compiled by all contracting states. Data from the EUROBATS reports of some of the Baltic Sea countries, including the Baltic states and Scandinavia, provide information on the species spectrum and abundance of bats and on their possible movement or migration across the Baltic Sea.

In Denmark, 17 bat species have been identified, 14 of which roost in Denmark. Although the populations of the three long-distance migratory species, Nathusius' pipistrelle, common noctule and parti-coloured bat, have not been quantified, there is significant evidence of roosts. The presumed long-distance migrants, the common pipistrelle and the northern bat, are also among the species that roost in Denmark. The five species mentioned above are considered not threatened in Denmark (THE DANISH NATURE AGENCY 2015).

Bat occurrence in Sweden was last described in a national report from 2006 in the context of EUROBATS (SWEDISH ENVIRONMENTAL PROTECTION AGENCY 2006). There are 18 bat species in Sweden. Stocks have increased in recent decades for five species, including the Nathusius' pipistrelle and the northern bat. Three other species are thought to be in decline, including the migratory parti-coloured bat. Among the migratory species, only Nathusius' pipistrelle is red listed as near threatened in Sweden. The common noctule was removed from the Red List in 2000. Overall, Swedish research has shown that the populations of Nathusius' pipistrelle have increased over the past two decades, extending its geographical range up to 60° N. In contrast, the common noctule is only relatively common in southern Sweden and in coastal areas. In contrast to the above-mentioned species, the parti-coloured bat is very unevenly distributed. This species has occasionally been observed on the south coast during migration periods.

There are 13 bat species in Finland (MINISTRY OF THE ENVIRONMENT FINLAND, 2014). The most common is the northern bat. The three migratory species, Nathusius' pipistrelle, common noctule and parti-coloured bat, occur only in the summer months in Southern Finland. However, their populations and trends are largely unknown. Nathusius' pipistrelle is classified as threatened.

There are 15 bat species in Latvia (MINISTRY OF ENVIRONMENTAL PROTECTION AND REGIONAL DEVELOPMENT OF THE REPUBLIC OF LATVIA 2014). A comparison of the occurrence of bats in Latvia with those in Estonia and north-west Russia has shown that at least four species in reach their northernmost limit of distribution in Latvia. Nathusius' pipistrelle, the common noctule and the parti-coloured bat are common during the summer months. Two other species, the common pipistrelle and the lesser noctule, have been classified as migratory in Latvia based on ring recovery. This brings the total number of migratory species in Latvia to five. Nathusius' pipistrelle and the common noctule are not classified as endangered in Latvia. The parti-coloured bat, common pipistrelle and lesser noctule are considered rare.

In Lithuania, 15 species of bats have been recorded, including the long-distance Nathusius' pipistrelle, common and lesser noctules, the common pipistrelle and the parti-coloured bat. Population trends are largely unknown and most are considered not threatened (THE PROTECTED AREAS AND LANDSCAPE DEPARTMENT OF THE MINISTRY OF ENVIRONMENT OF THE REPUBLIC OF LITHUANIA 2014).

Poland has a total of 21 bat species (MINISTRY OF THE ENVIRONMENT POLAND 2014). Among the migratory species in Poland, the common pipistrelle is classified as threatened. In contrast, the parti-coloured bat is considered to be of low concern.

A total of 25 species of bat are native to Germany. In the current Red List of Mammals (MEINIG et al. 2008), two of these species are classified as threatened to an indeterminate extent, four as endangered and three as critically endangered. Schreiber's bat (*Miniopterus schreibersii) is* considered extinct in the wild. Of the species that have been recorded more frequently in Germany to date in marine or coastal areas, the common noctule is on the early warning list, while the common pipistrelle and Nathusius' pipistrelle are considered not threatened. There is insufficient data to assess the risk status of the lesser noctule.

2.10.4 Threat of bats

Anthropogenic threats to migratory bats include the loss of summer roosts due to deforestation of old-growth woodlands, the loss of winter roosts due to renovation of old buildings and use of wood preservatives, intensification of agriculture and use of pesticides. According to the BTO (British Trust for Ornithology) report on the impact of climate change on migratory species, some effects of climate change can be predicted on the basis of existing knowledge on the abundance, distribution and habitat preferences of bats. For example, the loss of resting places along migratory routes, decimation of breeding habitats and changes in the food supply are to be expected (ROBINSON ET AL. 2005). All species will be indirectly affected by possible impacts of climate change on their food organisms, in this case insects. The observed insect die-off will have an increasingly negative impact on bats. In particular, temporal mismatch in the development of bat larvae and their food may have consequences for the breeding success of bats. In addition, tall structures such as buildings, bridges or wind turbines can pose a threat to bats through barrier effects and possible collisions (e.g. AHLEN 2002).

2.11 Biological diversity

Biological diversity (or biodiversity for short) includes diversity within species, between species, and of ecosystems (Art. 2 Convention on Biological Diversity 1992). The public focus is on species diversity. Species diversity is the result of an evolutionary process that has been going on for over 3.5 billion years, a dynamic process of extinction and species formation. Of the approximately 1.7 million species described by science to date, around 250,000 occur in the sea, and although considerably more species have been described on land, phylogenetically the sea is more comprehensively and highly than the land. Of 33 known animal phyla, 32 are found in the sea, of which 15 are exclusively marine (VON WESTERNHAGEN & Dethlefsen 2003). More recent projections by MORA et al (2011) show that there are about 8.7 million species worldwide, 2.2 million of which occur in the sea.

Marine diversity cannot be directly observed and is therefore difficult to assess. Aids such as nets, traps, grab samplers, and optical registration methods are always needed. However, the use of such equipment can only ever provide a partial picture of the actual species spectrum, and only that part which is specific to the equipment in question. It may therefore be deduced that there must still be a large number of species that are not yet known in areas that cannot be reached with existing equipment (e.g. the deep sea). The situation in the Baltic Sea is different. It is a relatively shallow inland sea and therefore more easily accessible, as a result of which intensive marine research was already taking place in the middle of the 19th century, leading to an increase in knowledge about its flora and fauna. As part of HELCOM monitoring, over 800 phytoplankton taxa have been recorded in the Baltic Sea (WASMUND et al. 2016a). About 61 zooplankton taxa were recorded (WASMUND et al. 2016a). More than 700 species of macrozoobenthos are known in the Bay of Kiel alone (GERLACH 2000). According to WINKLER et al. (2000), the fish fauna of the Baltic Sea currently comprises 176 species of fish and lamprey. Only four species of marine mammals are known. In the German Baltic Sea, 38 species of seabirds and resting birds occur regularly.

With regard to the current state of biodiversity in the Baltic Sea, it should be noted that there are countless indications of changes in biodiversity and species structure at all systematic and trophic levels in the Baltic Sea. The changes in biodiversity are mainly due to human activities, such as fishing and marine pollution, or due to climate change.

Red lists of endangered animal and plant species fulfil an important monitoring and warning function in this context, as they show the status of the populations of species and biotopes in a region. The Red Lists show that over 17% of the macrozoobenthos species (GOSSELCK et al. 1996) and around 16.9% of the cyclostomes and marine fish permanently present in the Baltic Sea (THIEL et al. 2013) are at risk. Marine mammals form a group of species in which all representatives are currently threatened (VON NORDHEIM et al. 2003). Of the 38 regularly occurring seabirds and resting birds, four species are listed in Annex I of the Birds Directive. In general, the Birds Directive stipulates that all native wild bird species must be preserved and thus protected.

2.12 Air

Shipping causes emissions of nitrogen oxides, sulphur dioxides, carbon dioxide and soot particles. These can have a negative impact on air quality and can largely get discharged into the sea as atmospheric deposition. As the Baltic Sea has been a Sulphur Emission Control Area (SECA) under Annex VI of the MARPOL Convention since 2006, stricter rules apply to emissions from shipping. Since 1 January 2015, ships may only use heavy fuel oil with a maximum sulphur content of 0.10% here. According to HELCOM, this has led to an 88% reduction in sulphur emissions compared to 2014. The global limit is currently at 3.50%. However, in accordance with a decision by the International Maritime Organisation (IMO) in 2016, this is to be reduced to 0.50% worldwide from 2020.

Emissions of nitrogen oxides are particularly relevant for the Baltic Sea as an additional nutrient load. Shipping is one of the largest sources of nitrogen oxide inputs from the air (HELCOM). To this end, the IMO decided in 2017 that the Baltic Sea will be declared a Nitrogen Emission Control Area (NECA) from 2021. The reduction of nitrogen oxide discharges into the Baltic Sea region through the North Sea and Baltic Sea ECA measure is estimated at 22,000 tonnes in total (European Monitoring and Evaluation Programme (EMEP, 2016)).

2.13 Climate

The German Baltic Sea lies in the temperate climate zone. As an inland sea, it is decoupled from the influence of the Gulf Stream. It does not develop a maritime climate of its own because it is quite small, and the salinity of the water is relatively low. As a result, it freezes over partially every winter, sometimes even completely. There is broad agreement among climate researchers that the global climate system is being noticeably affected by the increasing release of greenhouse gases and pollutants, and that the first effects are already being felt. According to the latest report of the Intergovernmental Panel on Climate Change (IPCC, 2019), the large-scale consequences of climate change on the oceans are expected to include a rise in sea surface temperature, further acidification and a decrease in oxygenation. Sea levels continue to rise at an increasing rate. Many marine ecosystems are sensitive to climate change. Global warming is also expected to have a significant impact on the Baltic Sea.

2.14 Landscape

The marine landscape above the surface

The current marine landscape above the water column is characterised by open spaces largely unaffected by disturbances. To date, only a few buildings have been constructed in the German Baltic Sea EEZ. These are the offshore wind farm Baltic 2, located around 33 km north-west of Rügen, and the wind farm Wikinger, located around 34 km north-east of Rügen. Additional structures include two masts for measurement and research purposes: the Arkona Basin measuring mast, around 35 km north-east of Rügen, and the FINO 2 research platform in the Kriegers Flak area, around 39 km north-west of Rügen. However, these are beyond sight from land. The construction of more wind farms will further change the landscape in the future. The necessary lighting can also lead to a visual impact on the landscape. The extent to which the landscape is impaired by vertical structures depends strongly on visibility conditions. The space in which a building is visible in the landscape is known as its viewshed. It is defined by the visual relationship between the building and its surroundings, where the intensity of impact decreases with increasing distance (Gassner et al. 2005). For measuring masts, platforms and offshore wind farms planned at a distance of at least 30 km from the coastline, the impact on the landscape as perceived from land is minimal. At such a distance, the platforms and wind farms will be barely perceptible even in good visibility conditions. This also applies to night-time lighting.

2.15 Cultural and other material assets (underwater cultural heritage)

2.15.1 Recording of protected assets and availability of data on the underwater cultural heritage in the EEZ

The known underwater cultural heritage in coastal waters, and to some extent in the EEZ, is recorded in the register of sites and monuments of the North German coastal states. However, it is important to note that this only applies to a small part of the underwater cultural heritage. The cultural authorities of the federal states are exclusively responsible for state waters. Therefore, systematic processing of information on the underwater cultural heritage in the EEZ has largely been omitted. The quality of the data also varies, from identified historical wrecks to inaccurate information from records, and may need to be improved in order to make a concrete planning statement. The registers of sites and monuments therefore reflect the current state of knowledge, but not the actual stock of underwater cultural heritage.

The only active survey of underwater obstacles, including shipwrecks, in the North German coastal sea is carried out by the Federal Maritime and Hydrographic Agency (BSH). However, this search for wrecks is not focused on underwater cultural heritage, but rather serves to locate and assess obstacles to shipping. It concentrates on objects rising from the seabed that could pose a threat to shipping or fishing. Although the findings of the BSH are regularly included in the registers of sites and monuments of coastal federal states, underwater cultural heritage sites that are covered by sediment or barely visible on the seabed are not normally recorded in wreck surveys.

An impression of the actual density of seabed monuments in the coastal sea is provided by maritime construction projects such as submarine cable connections and pipelines, in the course of which a large number of previously unknown monuments regularly come to light during preliminary investigations.

The risk of unexpected discovery of seabed features in the course of a construction project can only be minimised by a definitive survey as part of the environmental impact assessment.

2.15.2 Potential for prehistoric settlement remains in the German EEZ

Some parts of the German EEZ in the Baltic Sea consisted of dry land in the early Holocene. These areas were settled by humans between 10,000 and 6,000 years ago (Schmölcke et al. 2006; Behre 2003). To date, preserved paleolandscape remains in the form of peat and tree remains have been found at water depths of up to 20 m (Tauber 2014). The archaeological cultural heritage in the form of settlement sites has been investigated at water depths of up to 10 m (Hartz et al. 2014). This indicates that preserved prehistoric settlement traces in paleolandscapes should only be expected in water depths of between 10 m and 40 m (50 m in exceptional cases) in the German Baltic Sea EEZ. Landscape reconstructions may be used to identify areas of particular potential for archaeological sites. Areas with no longer preserved traces of occupation can be identified by evaluating erosion zones.

Due to reshaping of the Baltic Sea basin during the Weichselian glaciation, sites from the Paleolithic and older phases of human history have not been preserved in this region.

The landscape of the south-western Baltic Sea area, however, which became available with the melting of the glaciers 10,000 years ago, was immediately settled by humans of the Mesolithic period. Their subsistence was provided by hunting, fishing and gathering plant-based food. The Stone Age inhabitants of this landscape left traces in their habitation spaces and hunting grounds. These include, for example, fireplaces, pits, simple buildings, tools and related debitage, hunting weapons, food leftovers, watercraft, religious remains, jewellery and signs of artistic activity. Due to favourable conditions for locomotion and transport, and the diverse marine food sources, a particular focus of settlement was in the respective coastal zones. However, wetlands with lakes, rivers and bogs offered rich food sources, too. As particular topographic locations were favoured, reconstruction of the prehistoric landscape is essential for an understanding of the way of life, and at the same time represents the key to finding settlement sites.

The deposition and preservation conditions for habitation waste in the wet to humid shore area also characterise the sediments and cultural layers and give them significance as archaeological sources. Due to the rise in sea level since the end of the last ice age, these sites and their relation to the landscape have flooded. As a result, the traces of settlement, mostly covered by newer sediments, lie at the bottom of the Baltic Sea.

In the course of the SINCOS research project from 2002 to 2009, diving excavations at coastal sites in Schleswig-Holstein and Mecklenburg-Western Pomerania at water depths of up to 10 m provided important insights into the history of settlement and regional development of the economy (Hartz et al. 2014). Furthermore, side scan sonar surveys identified paleolandscapes with a potential for older sites in areas further from the coast (Tauber et al. 2014), while sampling of tree remains down to a water depth of around 20 m enabled dating of these former landmarks (Westphal et al. 2014).

Peat layers on the seabed are an important indicator of preserved remnants of paleolandscapes, as they represent flooded, formerly freshwater-influenced parts of the landscape. They are also paleoecological archives that can be used to reconstruct vegetation and landscape development as well as human use and anthropogenic influence (Anton et al. 2019, 35f.).

2.15.3 Wrecks of vessels and wreckage

This type of underwater cultural heritage includes not only wrecks of watercraft but also wreckage and associated equipment, cargo and inventories. The majority of known wreck sites are made up of boats and vessels of various periods. The spectrum ranges from Stone Age dugouts to wooden trading vessels from the Middle Ages and warships from the World Wars.

Maritime navigation in the Baltic Sea is documented from the iron age onwards by the Hjortspring boat (350 BC) and the Nydam boat (320 AD) from Denmark. Earlier references to watercraft are found on Bronze Age rock carvings with depictions of boats from Sweden. A boat burial (7th/8th century AD) in Salme, Estonia, for example, is documented from the Vendel period. Ship finds from the Viking age (8^{th}-11^{th} century AD) such as those from the Haddebyer Noor, the Schlei and Roskilde Fjord prove the widespread use of the sea route across the Baltic Sea (Crumlin-Pedersen 1997; Crumlin-Pedersen & Olsen 2002). In Viking times, navigational skills had advanced to the point where long sea voyages could be made at a considerable distance from the coast and often without sight out land, as documented in the report of a contemporary navigator on Wulfstan's voyage from Hedeby to Truso (cf. Englert & Trakadas 2009).

One of the few examples of offshore prehistoric sites is the recovery of Iron Age pottery vessels by fishermen in 1927 and 1931 from a depth of around 25 m in the Fehmarn Belt. This location was investigated using side scan sonar and sediment echosounder recordings, which revealed anomalies in the form of slight elevations (Tauber 2018). It can be assumed that this anomaly is the wreck of a ship on which the pottery was transported.

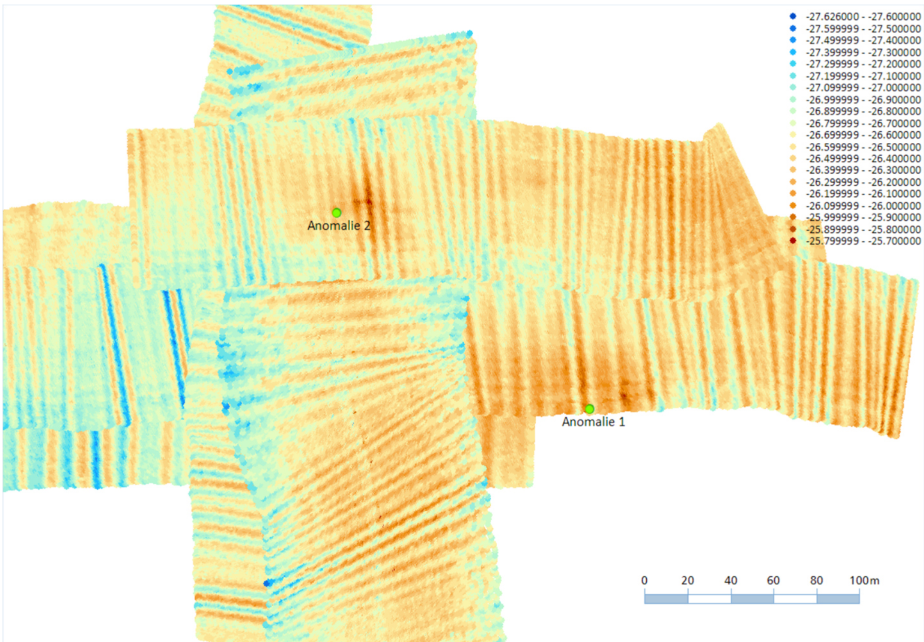


Figure 53: Iron Age anomalies in the Fehmarn Belt. Seabed topography calculated by multibeam echosounder. The stripes transverse to the direction of travel are caused by strong swell. The highest points (reddish brown) are near the anomalies (Tauber 2018) .

From the Middle Ages onwards, the long-distance trading routes ran across the open sea, as the 12th chapter of the Hanseatic Rutter in the "home sea" of the Hanseatic League shows. Although shipwrecks from this period have so far been found mainly in the immediate coastal area and in silted up former harbours, new finds in the open sea are increasing. Examples from the Baltic Sea are the wreck of an almost completely preserved Dutch fluyt from around 1650, discovered a few years ago at a depth of 130 m (Erikson & Rönnby 2012), and the *Mars*, a Swedish warship from 1561, discovered in 2011 at a depth of 75 m.

Shipping in the North and Baltic Seas in the 16th-18th centuries was mainly influenced by the rise of the United Netherlands as a trading power and the naval wars of the Scandinavian kingdoms for supremacy over the Baltic Sea. Examples include the Swedish flagship *Prinsessan Hedvig Sophia*, which sank in 1715, the frigate *Mynden*, which sank off the coast of Rügen in 1718, and the Danish man-of-war *Lindormen* from 1644 (Auer 2004; Auer 2010; Segschneider 2014).

In the course of the 18th and 19th centuries, the volume of trade across the North and Baltic Seas increased enormously. Examples include coal exports from the British Isles and timber exports from the Baltic States. These goods were transported on wooden sailing ships and later on iron steamships. Lively maritime trade also led to an increase in shipping accidents during this period. Archaeologically investigated ship finds from this period include the wreck of the British merchant ship *General Carleton* from 1785 (Ossowski, 2008), and the wreck of a 19th century coal transporter off Rotterdam (Adams et al., 1990).

With the emergence of industrial composite, iron and steel shipbuilding from the middle of the 19th century onwards, written and pictorial accounts become the main sources of information. As they are often in a better state of preservation, wrecks from the 19th and 20th centuries are currently far more common as archaeological evidence than wooden wrecks (Oppelt 2019). In the longer term, however, this is likely to change due to the ongoing corrosion of steel wrecks.

Due to their historical significance and the lack of written sources on certain military aspects of the course of the war, wrecks from the two world wars, up to and including 1945, are listed as archaeological cultural monuments. They also have an important function as memorial sites (Ickerodt 2014). Particularly in the course of the First World War, naval battles sometimes resulted in the loss of several vessels within a limited space. In August 1914, for example, three small cruisers and a torpedo boat were sunk in a naval battle between the Imperial German Navy and the Royal Navy west of Heligoland. The wrecks of these ships are all located in the German EEZ (Huber & Witt 2018).

Equipment and remains of cargo can provide evidence of past maritime activities. Among the most common objects are anchors, which for various reasons could not be recovered after an anchor manoeuvre and remained on the seabed.

Ballast piles are accumulations of stone ballast on the seabed. These usually resulted when loading ships in a natural harbour, but can also be an indication of lightering of a vehicle that has run aground. However, it is not uncommon for ballast material to conceal a shipwreck.

2.15.4 Aircraft wrecks and rockets

Most of the known finds of aircraft wrecks in the North and Baltic Seas are related to World War II. The fates of countless aircraft crews, both on the Allied and the German side, are unknown. Aircraft crashes can rarely be precisely located, making it difficult to classify the wrecks. While emergency ditching can lead to relatively well-preserved aircraft wrecks, crash sites are often marked by extensive debris fields at the seabed.

In addition to providing insights into technical aspects of construction and deployment, the aircraft wrecks of the Second World War also bear testimony to the events of the war.

Another aspect is the possible presence of human remains. In particular, wrecks from the two world wars are often not only buried archaeological monuments, but also war graves.

The remains of missiles and rockets form a special group of finds. These are frequently found on the Baltic coast of Mecklenburg-Western Pomerania, among other places, where gliding bombs and rockets were developed and tested in Peenemünde between 1936 and 1938. The ammunition-free parts of these structures offer detailed insights into the development of rocket technology and, like the aircraft wrecks mentioned above, represent archaeological monuments.

2.15.5 Potential for wrecks in the German EEZ

Although prehistoric and early historical wreck finds were mostly discovered in coastal waters or came from burial sites, under favourable conditions such wrecks may also be found in the German EEZ. At the latest, medieval shipwrecks are known from the open Baltic Sea at depths of over 50 m. These wooden wrecks are particularly well preserved, thanks to the low temperatures and low levels of infestation by wood-decomposing organisms.

In general, wooden ships and their remains may have survived undetected under sediment layers. Even if parts of a wreck are barely visible above the seabed, considerable remains of a ship's hull together with the ship's inventory can be hidden under the sediment. Cargo remains and parts of the equipment or armament are therefore in a closed find context, representing time capsules that allow unique insights into the past.

2.15.6 Assessment of the state of cultural and other material assets

Central factors for the definition of an archaeological monument (buried or under water) are its historico-cultural significance (suitability for preservation) and the public interest in its study and preservation (worthiness of preservation).

The significance of the protected asset and its value as a monument are assessed according to the following criteria (see also the monument protection laws of the federal states; see also Ickerodt 2014):

- Value as historical evidence
- Scientific or technical value, research value
- Social significance (memorial site, e.g. sea grave)
- Rarity
- Integrity (conservation status, condition, threats)

The value as historical evidence varies depending on state of preservation and type of site. For example, the value as historical evidence of underwater sites is generally very high due to favourable conservation conditions for organic materials. On land, Mesolithic sites are mostly limited to scattered flint objects. The way of life, settlement structure and social organisation of the people of that time can only be further researched through bones, antlers, wood and other plant remains preserved in boggy and underwater sites. The same applies to finds of organic materials from well-preserved shipwrecks, which may be personal belongings, cargo or armament. Well preserved wrecks with preserved inventory and structural elements have a high value as evidence.

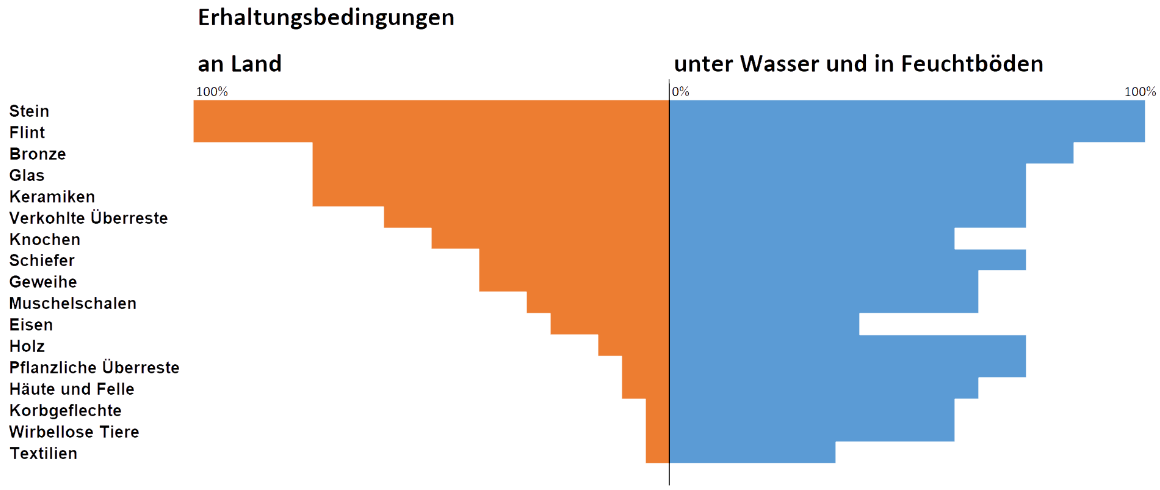


Figure 54: Comparison of the state of preservation of archaeological finds on land and under water (after Coles 1988).

Technical value can be illustrated using watercraft as an example. These were among the most advanced means of transport of their time and reflect the technological know-how of a society. Merchant ships were built to transport cargo safely over long distances. Warships were not only intended to serve as effective battle platforms, but also had to meet high standards in terms of seaworthiness, manoeuvrability and speed. They also had a representative function. Therefore, the scientific and technical value, and value as evidence of shipwrecks with well-preserved structural elements is high.

Since the loss of a vehicle with cargo and inventory records a certain moment in the past, wrecks are often referred to as time capsules. If properly preserved, an analysis of the wreckage provides detailed insights into everyday life on board. In addition to technological progress, ship finds can therefore often also be used to draw conclusions about political, economic and environmental factors, as well as the social structure of a society. This illustrates the extraordinary research value of underwater sites, and also their high integrity compared to sites on land.

The commemorative value of the wrecks of ships and aircraft from the First and Second World War is particularly high.

The rarity value varies depending on the type and dating of the site. Prehistoric wrecks have a very high rarity value. The same applies to medieval and early modern wreck finds in good condition. Modern wreck finds can also have a high rarity value if they are characterised by special technical or construction features.

The integrity or conservation status of an underwater site must be determined and assessed individually in each case. Both the sedimentation conditions during the formation of a site (or during the sinking and silting of a wreck) as well as subsequent impairment, for example by abiotic factors such as erosion by currents or organic decomposition, influence the integrity and preservation of a site or parts of a site. As already mentioned, preservation conditions for organic materials under exclusion of oxygen in the underwater environment are particularly good. While exposed wrecks are subject to erosion and can be damaged by various uses of the seabed, fully covered sites offer excellent conservation conditions.

The location of a large number of wrecks is known, based on the evaluation of existing hydro-acoustic recordings and the wreck database of the BSH, and is recorded in the nautical charts published by the BSH. No further information is available for the EEZ on buried monuments such as settlement remains.

2.16 Human beings, including health

Overall, the area covered by the spatial development plan is of minor importance for the protection of human beings. In a broader sense, the maritime space represents the working environment for people employed on ships. Exact numbers of people regularly present in the area are not available. Its importance as a working environment can be regarded as low. Direct use for recreation and leisure is occasionally made by pleasure craft and tourist vessels. The legacy impact can be considered as low. A special significance of the planning area for human health and well-being cannot be deduced.

2.17 Interactions between the factors

The components of the marine ecosystem, from bacteria and plankton to marine mammals and birds, influence each other through complex processes. The biological factors plankton, benthos, fish, marine mammals and birds, which are described in detail in Chapter 2, are interdependent within the marine food chains.

The phytoplankton serves as a food source for organisms that specialise in filtering the water for food. The primary consumers of phytoplankton include zooplanktonic organisms such as copepods and water fleas. Zooplankton plays a central role in the marine ecosystem as a primary consumer of phytoplankton on the one hand and as the lowest secondary producer within the marine food chains on the other. Zooplankton serves as food for the secondary consumers of the marine food chains, from carnivorous zooplankton species to benthos, fish, marine mammals and seabirds. Among the uppermost components of the marine food chains are the predators. The upper predators within the marine food chains include waterbirds, seabirds and marine mammals. In the food chains, producers and consumers are interdependent and influence each other in many ways. In general, food availability regulates the growth and distribution of species. Depletion of the producer results in the decline of the consumer. Consumers in turn control the growth of producers by feeding on them. Food restriction acts at the individual level by affecting the condition of the individual. At the population level, food restriction leads to changes in the abundance and distribution of species. Food competition within a species or between species has similar effects.

The timing of among different components of the marine food chains is of critical importance. For example, the growth of fish larvae is directly dependent on the available biomass of plankton. In seabirds, breeding success is also directly related to the availability of suitable food, mostly fish (species, length, biomass, energy value). Temporally or spatially staggered occurrence of succession and abundance of species from different trophic levels leads to the interruption of food chains. Temporal shifts, known as trophic mismatch, mean that early developmental stages of organisms in particular become undernourished or even starve. Disruptions in marine food chains can have an effect not only on individuals but also on populations. Predator-prey relationships or trophic relationships between size or age groups of a species or between species also regulate the balance of the marine ecosystem. For example, the decline of cod stocks in the Baltic Sea has had a positive effect on the development of sprat stocks. However, the exceptional increase in sprat stocks was limited by the food resources available (zooplankton). As a result, the abundant sprat stocks ultimately remained undernourished and therefore had a low energy content. The poor nutritional status of sprat was reflected in the nutritional status of their consumers, the guillemots. The growth and survival rate of the young Guillemots was temporarily reduced due to reduced food quality (Österblom et al. 2008).

Trophic relationships and interactions between plankton, benthos, fish, marine mammals and seabirds are controlled by a variety of mechanisms. These mechanisms operate from the lower part of the food chains, starting with nutrient, oxygen or light availability and moving upwards to the upper predators. These bottom-up control mechanisms can act by increasing or decreasing primary production. Effects starting from the upper predators downwards, known as top-down mechanisms, can also control food availability.

The interactions within the components of the marine food chains are influenced by abiotic and biotic factors. For example, dynamic hydrographic structures, water stratification and currents play a decisive role in food availability (increase in primary production) and use by upper predators. Exceptional events, such as storms and icy winters, also influence trophic relationships within marine food chains. Biotic factors, such as toxic algal blooms, parasite infestation and epidemics, also affect the entire food chain.

Anthropogenic activities also have a decisive influence on the interactions within the components of the marine ecosystem. Humans affect the marine food chain both directly through the capture of marine animals and indirectly through activities that can influence components of the food chain. For example, overfishing of fish stocks confronts upper predators, seabirds and marine mammals with food limitation or forces them to find new food resources. Overfishing can also bring about changes at the lower end of food chains. For example, jellyfish can multiply to extreme numbers when their fish predators have been removed. Shipping and mariculture represent an additional factor, which can lead to positive or negative changes in marine food chains through the introduction of non-native species. Discharge of nutrients and pollutants via rivers and the atmosphere also affect marine organisms and can lead to changes in trophic conditions. Natural or anthropogenic impacts on one of the components of the marine food chains, e.g. the species spectrum or the biomass of the plankton, can affect the entire food chain, shifting the balance of the marine ecosystem and possibly endangering it. Examples of the highly complex interactions and control mechanisms within the marine food chains were presented in detail in the descriptions of the individual factors.

Finally, the complex interactions between the various components result in changes in the entire marine ecosystem of the Baltic Sea, as already illustrated by the trophic interactions between guillemots, cod, sprat and zooplankton. The changes already described in Chapter 2 in terms of protected species can be summarised for the Baltic Sea marine ecosystem as follows:

- There are slow changes in the biotic marine environment.
- Since 1987/88, sudden changes have been observed in the biotic marine environment.

The following aspects or changes can influence the interactions between the various components of the biotic marine environment: Changes in species composition (phytoplankton, zooplankton, benthos, and fish), introduction and partial establishment of non-native species (phytoplankton, zooplankton, benthos, and fish), changes in abundance and dominance ratios (phytoplankton and zooplankton), changes in available biomass (phytoplankton), decline in many area-typical species (plankton, benthos, fish), decline in the food base for upper predators (seabirds).

3 Anticipated development if the plan is not implemented

According to Annex 1 No. 2b) to Article 8 ROG, a forecast of the development of the state of the environment must be included in the environmental report even if planning is not carried out.

3.1 Shipping

Shipping is one of the traditional maritime uses, alongside fishing. Several shipping routes run through the coastal sea and the EEZ and are of great importance for German foreign trade and international transit traffic due to their central location in the North and Baltic Seas.

Prior to the adoption of the Spatial Plan in 2009 and the associated definition of priority and reservation areas for shipping, only traffic separation areas (VTG) had been established in the North Sea by the International Maritime Organisation (IMO) to ensure ship safety and minimise the risk of collision.

In particular, with the emergence of the first offshore wind turbines and the increasing number of applications from the wind energy industry, the need to secure unobstructed shipping routes and thus the added value of the provisions in maritime spatial planning became clear.

The legal situation of shipping is strongly influenced by international regulations. In particular, the law on the United Nations Convention on the Law of the Sea of 10 December 1982 (Treaty Law Convention on the Law of the Sea), in which the freedom of navigation is guaranteed under Article 58. In addition, internationally applicable rules and standards are laid down by the IMO. The definition of traffic separation areas is of particular importance for spatial planning. These lay down mandatory lane routing in one-way traffic with separate lanes at potential danger points.

The Act on the Tasks of the Federal Government in the Field of Maritime Navigation (Seeaufgabengesetz – SeeAufgG) and, in particular, the various ordinances issued on the basis of this Act form the legal basis for measures to avert dangers to the safety and ease of transport and to prevent dangers arising from maritime navigation, including harmful effects on the environment.

Important international conventions on environmental protection in maritime transport are the Convention for the Prevention of Pollution from Ships, as amended by the 1978 Protocol (MARPOL 73/78), which contains regulations on the discharge of waste water and ship's waste and on the gradual reduction of air pollutant emissions.

As the North and Baltic Seas are SOx emission control areas (SECA), the sulphur emission limits are particularly low. From 2021, the North and Baltic Seas will also become NOx emission control areas (NECA).

The International Convention for the Control and Management of Ships' Ballast Water and Sediments is an international agreement adopted in 2004 within the International Maritime Organisation. The aim of the Convention is to mitigate damage to the marine environment caused by ballast water, in particular to prevent the introduction of non-native species.

One measure against anthropogenic eutrophication is the "definition" of the Baltic Sea as a "special area" under MARPOL Annex IV. Here, additional limit values or discharge criteria for total nitrogen and total phosphorus levels are laid down for passenger ships.

The HELCOM Baltic Sea Action Plan, adopted by all coastal states and the EU in 2007, sets out measures to restore the good environmental status of the marine environment in the Baltic Sea. For shipping, the plan includes enforcement of international rules, in particular on illegal discharges, ensuring safe maritime transport to prevent accidental pollution, measures to prevent the introduction of non-native species and measures to minimise waste generation and air pollution from ships.

The average traffic density reflected in the analysis of AIS data shows an increasing demand for space, driven not least by construction, maintenance and supply trips for the growing offshore wind industry, the increasing number of cruise ships and a higher demand for anchorage and shipping space.

With its maritime traffic forecast for 2030, the BMVI published a forecast of the development of the transhipment volume for German seaports (BMVI, 2014). For the period from 2010 to 2030, the volume of cargo handled is forecast to increase from 438 million tonnes to 712 million tonnes. This refers to the transhipment of cargo from German and foreign ports and their hinterland traffic using German transport infrastructure. The main drivers for the predicted increase in the volume of cargo handled are the overall continuing trend towards globalisation and the strong export orientation of the German economy. However, this assumed increase in transhipment and shipping traffic as a whole is subject to uncertainty and may be significantly lower due to a changed economic situation and crises.

With regard to the technical development of ships, regulations by the IMO, in particular, are strong drivers. For example, various purification plants or alternative fuels are used to comply with the emission limits of NOx and SOx. The IMO strategy to reduce CO_2 emissions, adopted in April 2018, will also require alternative fuels and higher energy efficiency (DNV GL 2019).

Shipping has a range of impacts on the marine environment. These include illegal discharges of oil at sea, propulsion emissions, waste disposal, noise emissions, consequences of shipwrecks, discharges of toxic substances such as TBT and the introduction of exotic species. The effects can be of supra-regional, temporary or permanent character. These can be summarised as follows:

- a supra-regional, temporary effect due to oil input, emissions and introduction of toxic substances;
- a supra-regional, permanent effect due to the introduction of exotic species.

The following table gives an overview of the effects caused by shipping and their potential impact on the protected goods. The impacts are mainly to be classified as prior impacts (Chapter 2) and as impacts that will occur even if the plan is not implemented.

Table 18: Effects and potential impacts of shipping (t=temporary).

Nutzung	Wirkung	Potenzielle Auswirkung	Schutzgüter																
			Benthos	Fische	See- und Rastvögel	Zugvögel	Meeressäuger	Fledermäuse	Plankton	Biotoptypen	Biologische Vielfalt	Boden	Fläche	Wasser	Luft	Klima	Mensch/ Gesundheit	Kultur- und Sachgüter	Landschaftsbild
Schifffahrt	Unterwasserschall	Beeinträchtigung / Scheucheffekt		x			x												
	Emissionen und Einbringen gefährlicher Substanzen (Unfälle)	Beeinträchtigung/ Schädigung	x	x	x		x		x	x	x	x		x			x		
	Physische Störung beim Ankern	Beeinträchtigung des Meeresbodens	x t							x t		x t	x t					x	
	Emission von Luftschadstoffen	Beeinträchtigung der Luftqualität			x	x		x							x	x	x		
	Einbringen und Verbreitung invasiver Arten	Veränderung der Artenzusammensetzung	x	x	x				x		x								
	Einbringen von Müll	Beeinträchtigung/ Schädigung	x	x	x		x		x					x			x		
	Kollisionsrisiko	Kollision			x	x	x												
	Visuelle Unruhe	Beeinträchtigung/ Scheucheffekt		x	x														

3.1.1 Seabed/Site

Shipping emits pollutants that contribute to the pollution of water and sediments.

The input of oil causes water and sediment to be contaminated to varying degrees with sometimes highly toxic pollutants. Depending on the quantity, type and composition, oil slicks or oil slicks can form which, under appropriate weather conditions, can spread over large areas and sink to the sea floor.

The effects mentioned above are independent of the implementation or non-implementation of the plan.

3.1.2 Water

Shipping emits pollutants that contribute to the pollution of water and sediments.

The input of oil causes water and sediment to be contaminated to varying degrees with sometimes highly toxic pollutants. Depending on the quantity, type and composition, oil slicks or oil slicks can form which, under appropriate weather conditions, can spread over large areas and sink to the seabed.

The effects mentioned above are independent of the implementation or non-implementation of the plan.

3.1.3 Benthos and biotopes

The following comments are limited to the effects of the uses on benthic communities. Since biotopes are the habitats of a regularly recurring community of species, impairments to biotopes have direct impacts on the biotic communities. Shipping impacts on benthos are caused by the following factors:

<u>Oil entry.</u> Even the smallest level of oil pollution poses a risk to living organisms. The effects of chronic oil pollution on birds are well documented. In contrast, there are few studies that examine the effects of chronic oil pollution on other organisms. The few studies show, among other things, a reduced species diversity and number of individuals in molluscs. BERNEM (2003) looks primarily at the effects on coastal areas and identifies salt marshes in particular as endangered habitats. Studies of the effects on the benthos of deeper marine areas such as the EEZs are not known, although oil can drift below the water surface and sink to the bottom.

Entry of toxic substances. Since the beginning of the 1970s, the effects of TBT on aquatic organisms, primarily in coastal waters, have become known of, which should not actually be affected by the biocidal action of the chemical. TBT has been shown to have an endocrine effect, i.e. it interferes with the endocrine system of organisms. TBT is capable of causing a pathomorphosis known as imposex, not only in bivalve molluscs but also in segregated gastropods. Imposex describes a masculinisation of female animals in snail populations. In the female whelk (*Buccinum undatum*) there is an additional development of male reproductive organs. In the final stage of the development of imposex, proliferating male genitals lead to sterilisation in most species and often to the death of the affected females (WATERMANN et al., 2003). Eventually, entire populations can become extinct (WEIGEL, 2003).

This ultimately led to an extensive international ban on organotin anti-fouling agents in 2008.

Physical disturbances during anchorage

Anchorage of ships causes local and temporary damage to the seabed and thus impairs benthic communities on a small scale.

Introduction of non-native species. Since 1970 an increasing trend of first-time introductions of non-native species has been observed. In addition to aquaculture, which in some cases makes targeted use of alien species, the main contributors to this trend have been shipping traffic via ballast water, via the sediments of ballast tanks and via the outer walls of ships (GOLLASCH, 2003). The spectrum of introduced species ranges from macro-algae to invertebrates. If the alien species find optimal living conditions, mass reproduction can occur, which in turn can cause considerable ecological and economic damage. However, none of the newly introduced species has led to drastic negative impacts in recent years. The species that lead to the greatest negative economic impacts, such as the Chinese mitten crab (*Eriocheir sinensis*) and the shipworm (*Teredo navalis*), which has now caused considerable damage since it has become firmly established, or various species of phytoplankton, have been resident here for a long time (GOLLASCH, 2003).

The Ballast Water Convention has been in force since 2017 and regulates the introduction and spread of organisms with the ballast water of seagoing ships. The current ballast water exchange is only possible under certain conditions and is only possible in the North Sea. Species are released with bio-accumulation, but these are sedentary species that require suitable environmental conditions (hard substrates) to settle and establish themselves when released.

The introduction of alien species through the fouling of ships, including smaller recreational craft, is also increasingly becoming a focus of attention.

In summary, the main impacts of shipping on marine benthos are as follows:

- supra-regional, temporary effects due to oil input, emissions and input of toxic substances, anchoring
- supraregional, permanent effect due to the introduction of non-native species.

The above impacts on benthic communities and biotope types arise independently of the non-implementation or implementation of the plan.

3.1.4 Fish

The effects of shipping on fish fauna include underwater noise, the introduction of hazardous substances, the dumping of waste and the introduction and spread of invasive species.

Most ships, especially larger vessels, emit mostly low-frequency **underwater sound**, which depends, among other things, on the type of ship,
the ship's propeller and the hull design (POPPER & HAWKINS 2019). The sound emitted by ships could have an impact on fish fauna. The

hearing of fish varies greatly. Some species, such as herring species, have very good hearing, because their inner ear is connected to the swim bladder. When sound hits the swim bladder, the vibrations generated are mechanically transmitted to the ear. Herring species are therefore probably more sensitive to underwater sound than fish species without a swim bladder, such as flatfish or sand eels. For example, hearing allows fish to locate prey, escape predators or find a reproductive partner (POPPER & HAWKINS 2019). The noise could particularly affect fish that communicate using self-produced sounds (LADICH 2013, POPPER & HAWKINS 2019). Continuous underwater noise could mask communication, especially during spawning (DE JONG et al. 2020). Some fish species, such as herring or cod, also showed typical avoidance reactions to shipping traffic, such as changing swimming direction, increased diving or horizontal movements (MITSON 1995, SIMMONDS & MACLENNAN 2005). In general, the responses of fish to the direct and indirect effects of shipping are inconsistent (POPPER AND HASTINGS 2009) and may vary between species. Even a single species' response to shipping noise can vary depending on the life stage (DE ROBERTIS & HANDEGARD 2013). The literature contains references to possible behavioural changes caused by ship noise, but their findings are not conclusive when drawing conclusions about their significance. Scientific reviews of the existing literature on the possible effects of ship noise on fish clearly indicate the lack of comparability, transferability and reproducibility of the results (POPPER & HAWKINS 2019). Moreover, long-term studies on the effects of continuous noise emissions on fish in their natural habitat are needed to draw conclusions at a population level (WEILGART 2018, DE JONG et al. 2020).

In addition to acoustic stimuli, the input of pollutants as an effect of shipping traffic is particularly noteworthy. Shipping can have a strong impact on the marine environment as a result of accidents and the potential escape of pollutants, especially **heavy oil.** Several factors such as the type, condition and quantity of oil determine the degree of damage (VAN BERNEM 2003).

Pelagic species may be able to avoid oil-contaminated areas, as observed in laboratory studies on salmon (VAN BERNEM 2003). Bottom-dwelling fish species may be damaged by prolonged contact with oily sediments. Possible consequences include the uptake of hydrocarbons from sediment, the occurrence of certain diseases (including fin rot) and stock decline. There is no known scientific evidence on the natural habitat that could be used to assess the significance of these effects.

In general, fish eggs and juveniles are more vulnerable than adults because their sensory skills are not yet or not fully developed and they are less mobile.

Another impact of shipping is the **introduction of non-native species**. Since 1970, an increasing trend of initial introductions of alien species has been observed. Traffic by vessels via ballast water and via the outer hulls of ships has also contributed to this (GOLLASCH 2003). In principle, non-native fish species can be introduced into the Baltic Sea and potentially become established. If the non-native species find suitable living conditions, mass reproduction can occur, which in turn can lead to the displacement of native species due to competition for food and habitats. Studies on alien species focus primarily on benthic invertebrates (see BMU 2018). Fish could primarily be spread via the transport of eggs and larvae in ballast water (LLUR 2014). Originating from the Black Sea, the black-mouth goby has spread westwards in the Baltic Sea since 1990 from Gdansk Bay (SAPOTA & SKORA 2005) and as far as Estonian and Latvian coastal waters (Ojaveer 2006). In Germany, the first record dates from 1998 (WINKLER 2006). It is suspected that bottom-dwelling eggs or larvae entered the Baltic Sea via the ballast water of ships (SAPOTA 2004). In the meantime, gobies up to 20 cm in length have become established in the food web all the way through to the birds (KARLSON et al. 2007, ALMQVIST et al. 2010). Competition with native species may arise due to aggressive territorial behaviour, limited spawning grounds or available food resources (LLUR 2014). However, serious competition with other small fish, such as sticklebacks, has not yet been demonstrated on the German Baltic Sea coast (LLUR 2014).

Marine pollution is a global threat to the marine ecosystem and can also have negative effects in the Baltic Sea. Accounting for 68%, plastic is the dominant category of waste at the floor of the Baltic Sea (THÜNEN 2020). Shipping also contributes to this. Fish can ingest plastic with their food and spread it through the food web. There are currently no systematic studies on the effects of plastic on fish fauna that would allow a differentiated assessment. The Thuenen Institute of Fishery Ecology is expected to be working on the risk posed by plastic in the marine environment until 2021 in the PlasM project. Results have not yet been obtained.

3.1.5 Marine mammals

The effects of shipping on marine mammals can be caused by, among other things, noise emissions, pollution during normal operation or accidents involving ships. In normal operation, shipping poses a potential hazard to marine mammals. The effects are area-specific and of low, medium or even high intensity. The effects are also area-specific, being temporary or recurrent, such as along busy shipping routes.

Direct disturbance of marine mammals by sound emissions is more likely to occur, especially along busy traffic separation areas, e.g. north of the East Frisian Islands. Unlike other cetacean species, harbour porpoises are not known to be attracted by ships. In general, harbour porpoises tend to have shy behaviour. Collisions with ships are also not known for harbour porpoises and seals. It is assumed that interference may occur by masking communication, especially for bearded whales, which use echolocation and communicate in low frequency ranges, overlapping with ship sounds. Evidence can be found in numerous studies, but the results are often not comparable, transferable and reproducible (Erbe et al., 2019). Moreover, the possible effects of disturbance from ship noise are difficult to quantify and differentiate from other sources of disturbance. Furthermore, marine mammals have developed adaptation mechanisms to maintain communication in noisy areas. Among the known adaptations of cetaceans to the acoustic environment in the oceans is the so-called Lombard effect. The Lombard effect is described as the ability to maintain communication between conspecifics by changing the volume, vocalisation rate and frequency of sounds in noisy environments and has been demonstrated in various groups of animals. Whales, such as the harbour porpoise, are also able to increase the volume and frequency of vocalisation and change the frequency spectrum. This adaptation is a vital strategy for survival, enabling them to search for food effectively and efficiently, escape predators, maintain contact between mother and calf, but also to seek out conspecifics (Erbe et al., 2019).

Shipwrecks can result in the release of environmentally hazardous substances, such as oil and chemicals. Direct mortality as a result of oil pollution is only to be expected in major oil disasters (GERACI and ST AUBIN 1990; FROST and LOWRY, 1993). Oil spills can cause lung and brain damage in marine mammals. The observed long-term effects of oil spills have included increased juvenile mortality in seals.

The loss of cargo can also lead to contamination by toxic substances. Even during normal ship operation, oil and oil residues, lipophilic cleaning agents from tank cleaning, ballast water containing non-indigenous organisms and solid waste are released into the marine environment (OSPAR, 2000). Pollutants discharged into the sea by ships can accumulate in the food chains and thus contribute to pollution and contamination. Effects on marine mammals through the accumulation of pollutants in the food chains are also possible.

According to the current state of knowledge, effects at population level are very difficult to assess. It is, therefore, recommended to always act in accordance with the precautionary principle for all uses (Evans, 2020).

The non-implementation of the plan would not affect the existing or described impacts of shipping on harbour porpoise, seals and grey seals.

3.1.6 Seabirds and resting birds

The effects of shipping on seabirds and resting birds include visual disturbance, attraction and collisions, pollution and the introduction of invasive species.

Visual agitation can cause fright or avoidance reactions in species sensitive to disturbance. According to a recent study by FLIEßBACH et al (2019), the red-throated diver, black guillemot, black-throated diver, velvet scoter and red-breasted merganser are among the species most sensitive to shipping traffic. The most common reaction is flight. Flight distances vary according to species and individual and may be related to various individual and ecological factors (FLIEßBACH et al. 2019). The sensitivity of loons to ships is also known from other studies (GARTHE & HÜPPOP 2004, Schwemmer ET al. 2011, Mendel ET al. 2019, Burger ET al. 2019).

Direct effects on seabirds through visual disturbance are to be expected, especially along busy traffic routes or traffic separation areas. The effects of visual disturbance caused by shipping on seabirds and resting birds depend on the regional and temporal occurrence of shipping. Findings on the reactions of loons to ships indicate that the duration and intensity of the frightening reaction may be related to the type of ship and related factors, such as ship speed (BURGER et al. 2019).

Shipping can release oil and oil residues, lipophilic detergents from tank cleaning, ballast water containing non-native organisms and solid waste into the marine environment (OSPAR 2000). WIESE AND RYAN (2003) found signs of chronic oil pollution in seabirds. Almost 62% of all seabird deaths in the south-eastern coasts of Newfoundland in the years 1984-1999 were contaminated with oil from ship operations. Auks were those most frequently contaminated with oil.

The loss of cargo can also lead to contamination with toxic substances. Pollutants discharged into the sea from ships can accumulate in the food chain and thus contribute to pollution and contamination. Shipwrecks can also cause massive discharges of environmentally hazardous substances such as oil and chemicals.

Various effects are known to be caused by oil spills. After the accident of the "Prestige" in 2003, for example, up to 50% reduced breeding success of the cormorant was observed on breeding colonies affected by the oil pollution compared to undisturbed breeding colonies (VELANDO et al. 2005a). Indirect effects from the accident of the "Prestige" on the breeding success of the cormorant were also observed: a high level of contamination in sediment, plankton and benthos reduced the sand eel population. The reduction of sand eels has in turn influenced the breeding success of the cormorant. For example, in 2003, fewer breeding pairs than expected on the basis of long-term data hatched successfully. The condition of the chicks was also exceptionally poor due to lack of food or reduced food quality (VELANDO et al. 2005b).

The above-mentioned effects on seabirds and resting birds are independent of the non-implementation or implementation of the plan.

3.1.7 Migratory birds

For migratory birds, the effects of shipping may be caused by visual stimuli and the input of pollutants. Migratory birds can be attracted at night by ship lighting. This is particularly true for nights with poor visibility conditions caused by clouds, fog and rain, among other things. The possible consequence is collisions.

Migratory birds are not very likely to be endangered by oil or pollutants. Only those migratory birds, such as seabirds, that interrupt their migration by landing on the water, either to feed or to wait out bad weather conditions (such as headwinds and poor visibility) would be affected. The result would be that the birds would die from oily plumage and the absorption of oil into the gastrointestinal tract due to their cleaning behaviour or the consumption of oily food.

The above effects on migratory birds are independent of the non-implementation or implementation of the plan.

3.1.8 Bats and bat migration

The effects of shipping on bats are largely unknown. There are only isolated reports of bats found on ships. WALTER et al (2005) have summarised such observations/findings on ships in the context of investigations for offshore wind energy projects. It is then assumed that attracting effects from ships can occur.

Insects can be attracted to ships by lighting and heat generation. Bats in search of food can be attracted by the insects as a result. It is also assumed that migrating bats also visit ships to rest. However, this does not necessarily imply a risk of collision.

No other direct or indirect effects of shipping on bats are known. The attraction effects described above can at most be regional and temporary.

The above-mentioned effects on bats are independent of the non-implementation or implementation of the plan.

3.1.9 Climate

The pollutant emissions from shipping described in chapter 3.1.10contribute to climate change. The global share of maritime transport in global greenhouse gas emissions is 2.2%. (BMU, 2020).

However, this is independent of the non-implementation or implementation of the ROP.

3.1.10 Air

Shipping generates pollutant emissions, in particular nitrogen oxides, sulphur dioxides, carbon dioxide and soot particles. These can have a negative impact on air quality. These effects are independent of the implementation or non-implementation of the plan.

3.1.12 Cultural and other material goods

In the context of navigation, measures to deepen, relocate or widen fairways, for example through dredging, can lead to the destruction of the neighbouring underwater cultural heritage. Furthermore, underwater cultural heritage sites are threatened, especially in shallow waters, as ship propellers can cause turbulence in the sediment, which has an erosive effect on the layers of finds. Destruction can also be caused by anchoring, especially in the case of structural measures involving anchored service vessels.

Indirectly, the increasing trend since 1970 of introducing non-native species via the ballast water and on the hull of the ship itself (Gollasch 2003) poses the greatest threat to the underwater cultural heritage. Three species of teredinids are active in native waters, including the best-known representative Teredo navalis, which was detected in the Baltic Sea as early as 1872 and has since caused major damage to wooden harbour structures, ship hulls and piles. Its spread is bound to its tolerance ranges with regard to salinity, water temperature and oxygen (cf. Björdal et al. 2012, 208; Lippert et al. 2013, 47). However, shipping can cause the immigration of further destructive organisms that are adapted to a different tolerance range and can penetrate previously undisturbed areas.

Recreational diving in the EEZ can also be mentioned as an indirect consequence of recreational boating. In the past, objects from historical wrecks were removed or even deliberately mined, as the example of the wreck of the SMS Mainz, which was looted by Dutch divers in 2011 (Huber & Knepel 2015) shows.

Blasting of wrecks from the period of the world wars was carried out in the past by the Explosive Ordnance Disposal Service on the suspicion that ammunition might still be on board. In this case, a balance must be struck between safety aspects and the protection of cultural heritage.

3.2 Offshore wind energy

The increasing demand for space due to offshore wind energy and the German government's ambitious targets for offshore wind energy use were the main reasons for drawing up the 2009 spatial plans for the German North Sea and Baltic Sea EEZ. The preparation of the spatial plans was an explicitly stated measure to promote the expansion of renewable energies.

When the 2009 regional development plans were adopted, an initial offshore wind farm, the alpha ventus test field, with 12 individual turbines, was nearing completion. In the meantime, 21 wind farms with a total of 1,399 turbines and an installed capacity of around 7.2 GW are in (trial) operation in the North Sea EEZ.

The first offshore wind turbines had a rated output of 2.3 to 5 MW. Larger rotors and more load-bearing substructures have led to a significant increase in rated output over time.

<u>Specialist planning</u>:

With the FEP 2019 (currently being updated and amended), there is a current sectoral plan to control the planning of the expansion of offshore wind energy and the electricity grid connections.

The current draft FEP defines areas O-1 to O-3 in the Baltic Sea EEZ for offshore wind energy in order to achieve the 20 GW expansion target by 2030. The increased expansion path for offshore wind energy results from the draft law amending the Wind Energy at Sea Act and other provisions adopted by the Federal Cabinet on 3 June 2020.

The construction and operation of wind turbines can have a number of impacts on the marine environment, including local habitat loss due to permanent seabed sealing, chilling and barrier effects and a resulting loss of habitat for avifauna. Potential impacts from maintenance and service traffic must also be considered.

For the assessment of the requirements for offshore wind energy, the following possible impacts will be considered:

Table 19: Effects and potential impacts of offshore wind energy (t = temporary).

Nutzung	Wirkung	Potenzielle Auswirkung	Schutzgüter: Benthos	Fische	See- und Rastvögel	Zugvögel	Meeressäuger	Fledermäuse	Plankton	Biotoptypen	Biologische Vielfalt	Boden	Fläche	Wasser	Luft	Klima	Mensch/ Gesundheit	Kultur- und Sachgüter	Landschaftsbild
Gebiete für Windenergie auf See	Einbringen von Hartsubstrat (Fundamente)	Veränderung von Habitaten	x	x			x		x	x	x	x							
		Lebensraum- und Flächenverlust	x	x			x			x	x	x	x					x	
		Anlockeffekte, Erhöhung der Artenvielfalt, Veränderung der Artenzusammensetzung	x	x	x		x		x		x								
		Veränderung der hydrographischen Bedingungen	x	x			x		x					x					
	Auskolkung/Sediment-umlagerung	Veränderung von Habitaten	x	x					x	x		x	x						
	Sediment-aufwirbelungen und Trübungsfahnen (Bauphase)	Beeinträchtigung	x t	x t	x t				x t					x t					
		Physiologische Effekte und Scheucheffekte		x t			x												
	Resuspension von Sediment und Sedimentation (Bauphase)	Beeinträchtigung	x t	x t					x t					x t					
	Schallemissionen während der Rammung (Bauphase)	Beeinträchtigung/ Scheucheffekt		x t			x												
		potenzielle Störung/ Schädigung		x t			x												
	Visuelle Unruhe durch Baubetrieb	Lokale Scheuch- und Barriereeffekte		x t	x t														
	Hindernis im Luftraum	Scheucheffekte, Habitatverlust			x														
		Barrierewirkung, Kollision			x	x		x											x
	Lichtemissionen (Bau und Betrieb)	Anlockeffekte, Kollision			x	x		x											x
	windparkbezogener Schiffsverkehr (Wartungs-, Bauverkehr)	siehe Schifffahrt	x	x	x	x	x	x	x	x	x	x	x t	x	x	x	x	x	

3.2.1 Seabed/site

The use of offshore wind energy has the following effects on the seabed:

The wind turbines have a locally limited environmental impact with regard to the seabed as a factor. The sediment is only permanently affected in the immediate vicinity by the insertion of foundation elements (including scour protection, if applicable) and the resulting land use.

During the foundation of the wind turbines and platforms and the injection of cables within the park, sediments are temporarily stirred up and turbidity plumes are formed. The extent of resuspension depends mainly on the fine-grain content (clays and silt) in the sediment. In areas with a lower fine-grain content, most of the released sediment will settle relatively quickly directly in the area of the intervention or in its immediate vicinity. The suspension content will quickly return to its natural background values due to dilution effects and sedimentation of the stirred-up sediment particles. The impairments to be expected in areas with a higher fine-grain content and the associated increased turbidity remain limited on a small scale due to the low flow near the ground.

In areas with soft sediments and correspondingly high fine-grain contents (e.g. the Arkona Basin or Mecklenburg Bay), the sediment released will settle much more slowly. However, since the near-bottom currents are low (in the Arkona Basin the average is about 0.06 m/s; near the surface 0.1 m/s), it can be assumed that here, too, the turbidity plumes that occur will have a rather local character and the sediment will settle again relatively close to the site. A simulation on the effects from the offshore wind farm "Beta Baltic" in the Mecklenburg Bight, which has a comparable sediment composition to the Arkona Basin, showed that at current velocities of 0.3 m/s the maximum sediment dispersion is about 2 to 3 km (MEYERLE & WINTER 2002). The material released remains in the water column long enough to be distributed over a large area, so that, due to the comparatively small volumes, hardly any detectable thickness of the deposited material can be expected. At the most 12 hours after release, the concentration drops to below 0.001 kg/m³. In the environmental impact assessment for the "Nord Stream Pipeline", the monitoring results during the construction phase also showed only small to medium-scale, temporary effects due to sediment drifting (turbidity plumes) and confirmed the forecasts of the environmental expert (IFAÖ 2009), who classified the effects overall as minor structural and functional impairment. On the basis of these results, it can be assumed that turbidity plumes released during the foundation of wind energy plants and platforms or the laying of submarine cables in areas with soft sediments will not exceed the natural suspended matter maxima at a distance of up to 500 m.

Studies by ANDRULEWICZ et al. (2003) also show that the seabed of the Baltic Sea is undergoing levelling due to natural sediment dynamics along the affected routes. However, various model calculations carried out as part of the procedures and the experience gained from the procedures show that levelling is more likely to occur in the long term.

In the short term, pollutants and nutrients can be released from the sediment into the seabed water. The possible release of pollutants from sandy sediments is negligible if the proportion of fine grains and heavy metal concentrations is relatively low. In areas with a high proportion of fine grains (e.g. basins), a significant release of pollutants from the sediment into the soil water can occur. The pollutants generally adhere to sinking particles which, due to the low current velocities in the Baltic Sea basins, rarely drift over long distances and remain in their original environment.

In the medium term, this remobilised material is deposited again in the silty basins.

Impacts in the form of mechanical stress on the seabed due to displacement, compaction and vibrations, which are to be expected during the construction phase, are estimated to be low due to their small size.

Due to the operational conditions, the interaction between the foundation and hydrodynamics in the immediate vicinity of the installations and platforms may lead to a permanent agitation and rearrangement of sediments. According to previous experience in the North Sea, current-related permanent sediment shifting can only be expected in the immediate vicinity of the platforms. Such experience is not yet available for the Baltic Sea. However, due to the low near-seabed flow velocities, only local scouring is to be expected in the area of the foundation structures, even in the Baltic Sea. Due to the predicted spatially limited extent of scouring, no significant changes in the substrate are to be expected.

In the case of in-park cabling, the surrounding sediment is heated radially around the cables due to operational conditions. The heat emission results from thermal losses from the cable systems during energy transmission. The depth at which the cable systems are laid is also decisive for the temperature development in the sediment layer near the surface. According to the current state of knowledge, no significant effects from cable-induced sediment heating are to be expected if a sufficient installation depth is maintained and if state-of-the-art cable configurations are used.

The effects described for wind energy at sea are spatially limited and, with the exception of seabed sealing through the insertion of foundation structures, temporary. The effects occur independently of the implementation or non-implementation of the plan.

The ROP provides for three priority areas and no reservation areas in the Baltic Sea EEZ. If the plan is not implemented, a less co-ordinated development of offshore wind energy can be expected. This could lead to a comparatively high land consumption, increased sediment relocation and thus to increased negative impacts on the factors of seabed and site compared to a spatially and temporally coordinated relocation. In addition, an uncoordinated expansion could lead to an increased number of crossing structures, which would make the insertion of hard substrate necessary. For example, rock fills could also become necessary in areas with predominantly homogeneous sandy seabed, which could otherwise be avoided.

3.2.2 Benthos and biotopes

Benthic communities and biotopes would be partially affected by the impacts from a range of uses, such as raw materials extraction and fisheries, even if the plan were not implemented. In addition, it is to be expected that the warming of water already triggered by climate change will continue in the future. This also has an impact on benthic communities. This may lead to the colonisation of new species or to a shift in the species spectrum as a whole. However, this development is independent of the non-implementation or implementation of the plan.

If the plan is not implemented, less spatially coordinated planning of the wind farms would be expected. As a result of non-implementation of the plan, comparatively higher seabed use could be expected and thus a greater potential impact on the benthos and biotopes compared with implementation of the plan. Possible impacts result from the installation of the foundations for the wind turbines and platforms. During the construction phase, impacts on benthic communities could occur through direct disturbance of near-surface sediments, through pollutant inputs, sediment resuspension, the formation of turbidity plumes and increased sedimentation.

In the vicinity of the foundations of the installations and platforms, changes in the existing species composition may occur due to the artificial hard substrate introduced.

Since the provisions of the plan are aimed at minimising the use of the seabed, it would probably be more difficult to ensure the protection of benthos and biotopes if the plan were not implemented than if it were.

3.2.3 Fish

The impact of OWPs on the fish fauna due to construction, installation and operation is spatially and sometimes temporally limited and is mainly concentrated on the area of the planned project. In the following, the effects of the various wind farm phases are described in detail.

<u>Construction-related effects</u>

- Noise emissions due to the ramming of the foundations
- Sedimentation and turbidity plumes

In the area of the project, construction-related **noise emissions are expected to be caused** both by the use of ships, cranes and construction platforms and by the installation of the foundations and, if necessary, scour protection. It is known from the literature that underwater ramming strikes produce high sound pressures in the low-frequency range. All fish species investigated so far at all of their life stages can perceive sound as particle movement and pressure changes (KNUST et al. 2003, KUNC et al. 2016, WEILGART 2018, POPPER & HAWKINS 2019). Depending on the intensity, frequency and duration of the sound events, sound could have a direct negative impact on the development, growth and behaviour of fish or superimpose environmental acoustic signals, which are sometimes crucial for fish survival (KUNC et al. 2016, WEILGART 2018, DE JONG et al. 2020). However, most of the evidence to date on the effects of sound on fish comes from laboratory studies (WEILGART 2018). The range of perception and possible species-specific behavioural reactions in marine habitats have been studied little to date. The construction-related effects of wind farms on fish fauna are limited in terms of space and time. It is likely that short, intensive sound events during the construction phase – especially during the installation of the foundations – will cause fish to be frightened away. In the Belgian EEZ, DE BACKER et al (2017) showed that the sound pressure generated during pile driving was sufficient to cause internal bleeding and barotrauma in the swim bladder in cod *Gadus morhua.* This effect was observed at a distance of 1,400 m or closer to a pile-driving source without any sound insulation (DE BACKER et al. 2017). Such investigations indicate that significant disturbances or even the killing of individual fish in the vicinity of the ramming points are possible. Hydroacoustic measurements showed that construction measures (pile driving and other construction activities) in the test field "alpha ventus" resulted in a strongly reduced population of pelagic fish relative to the surrounding area (KRÄGEFSKY 2014). After temporary displacement, however, it is likely that the fish will return once the noise-intensive construction measures are completed. Studies on sound effects on fish by NEO et al. (2016) showed that the animals largely returned to their normal behaviour 30 min after the auditory stimuli.

The construction work on the foundations of wind turbines, the transformer platform and the internal cabling of the wind farm causes **sediment turbulence and turbidity plumes**, which – although temporary and species-specific – can cause physiological disturbances to the fish fauna, especially fish spawn. However, significant effects on the fish fauna from sediment upheavals, turbidity plumes and sedimentation are not expected. Detailed information on this topic can be found in Section 3.4.3

System-related effects

- Site use
- Inserting hard substrate
- Fishing ban
- Operating noise

The construction of the foundations of the WTGs and technical platforms, as well as scour protection, means that habitats are being built over and are no longer available for fish. This results in permanent **habitat loss** for demersal fish species and their food source, macrozoobenthos, due to local overbuilding. However, this habitat loss is limited to the immediate, small-scale location of the individual WTGs and platforms.

The erection of wind farms changes the structure of the often uniformly sandy seabed of the Baltic Sea through newly introduced hard substrate (foundations, scour protection). An **attraction effect of artificial reefs** on fish has been observed in most cases (METHRATTA & DARDICK 2019). However, it has not yet been conclusively clarified whether this is the result of a concentration effect on fish that would otherwise be found elsewhere, or the consequence of increased productivity (GLAROU et al. 2020). Catches of cod and saithe near Norwegian oil platforms have been higher than before they were built (VALDEMARSEN 1979, SOLDAL et al. 2002). In the Baltic Sea, large adult predators such as cod *Gadus morhua* and saithe *Pollachius virens* are increasingly observed above wrecks and stone fields (EHRICH 2003). Increased densities of flatfish have been found near artificial reefs (POLOVINA & SAKI 1989). According to expert reports and video recordings of the accompanying monitoring, a large number of fish species using the artificial hard substrate are found at the monopiles of the existing "Horns Rev I" wind farm (LEONHARD et al. 2011). In addition to this positive effect, changes in the dominance relationships and size structure within the fish community as a result of the increase in large predatory fish could lead to increased feeding pressure on one or more prey fish species.

The attractiveness of artificial substrates for fish depends on the size of the hard substrate introduced (OGAWA et al. 1977). The radius of action is assumed to be 200 to 300 m for pelagic and up to 100 m for benthic fish (GROVE et al. 1989). STANLEY & WILSON (1997) found increased fish densities in a 16 m radius around an oil rig in the Gulf of Mexico. Transferred to the foundations of the wind turbines, it can be assumed that, due to the distance between the individual turbines, each individual foundation, regardless of the foundation type, acts as a separate, relatively unstructured substrate and the effect does not cover the entire wind farm area.

COUPERUS et al. (2010) found up to 37 times higher concentrations of pelagic fish in the vicinity (0-20 m) of wind turbine foundations using hydroacoustic methods compared to the areas between the individual wind turbines. REUBENS et al. (2014) found significantly higher concentrations of whiting-pout *Trisopterus luscus* at the foundations than above the surrounding soft substrate, which mainly fed on the vegetation on the foundations. GLAROU et al (2020) evaluated 89 scientific studies on artificial reefs, 94% of which demonstrated positive or no effects of artificial reefs on the abundance and biodiversity of the fish fauna. In 49% of the studies, locally increased fish abundance was recorded after the construction of artificial reefs. Reasons for increased fish abundance on artificial reefs and in OWPs could be the locally more extensive food availability and protection from currents and predators (GLAROU et al. 2020).

The **elimination of fishing** due to the expected traffic ban in the wind farms could have a further positive effect on the fish community. This would eliminate the negative effects of fishing, such as disturbance or destruction of the seabed and the capture and by-catch of many species. Due to the lack of fishing pressure, the age structure of the fish fauna within the project area could again develop towards a more natural distribution, so that the number of older individuals increases. In addition to the absence of fishing, an improved food base for fish species with a wide variety of diets would also be conceivable. The growth of sessile invertebrates on wind turbines could favour benthos-eating species and provide the fish with a larger and more diverse food source (GLAROU et al. 2020). This could improve the condition of the fish, which in turn would have a positive effect on their health. There is currently a need for research to transfer such cumulative effects to the fish population level. To date, the effects on the fish fauna that could result from the discontinuation of fishing in the area of offshore wind farms have not been directly investigated or results are still pending for some fish species (GIMPEL et al. 2020).

For the operational phase of the OWPs, it can be assumed that, due to the prevailing meteorological conditions in the Baltic Sea, almost permanent operation of the WTGs will be possible in principle. The noise emitted by the WTGs is, therefore, expected to be permanent. Studies by MATUSCHEK et al (2018) on the **operational noise** of wind farms showed that low-frequency noise can be measured at a distance of 100 m from the respective turbine. With increasing distance from the turbine, the noise levels towards the centre of the wind farm decreased in all wind farms. However, outside the wind farms, at a distance of 1 km, higher levels were measured than in the centre of the wind farm. In general, the investigations revealed that the underwater sound emitted by the turbines cannot be clearly separated from other sound sources, such as waves or ship noise (MATUSCHEK et al. 2018). Previous studies on the effects of continuous noise emissions on fish have not been able to provide clear evidence of negative effects such as persistent stress reactions (WEILGART 2018).

3.2.4 Marine mammals

Construction-related: Hazards can be caused for harbour porpoises, grey seals and seals by noise emissions during the construction of offshore wind turbines and the transformer station if no avoidance and reduction measures are taken. Depending on the foundation method, impulse sound or continuous sound can be input. The input of impulse noise, which is generated, for example, when piles are driven with hydraulic hammers, has been well investigated. The current state of knowledge about impulse noise contributes significantly to the development of technical noise reduction systems. On the other hand, the current state of knowledge on the input of continuous sound resulting from the driving of foundation piles by means of alternative methods is very low.

The Federal Environment Agency (UBA) recommends compliance with noise protection values when installing foundations for offshore wind turbines. The sound event level (SEL) outside a circle with a radius of 750 m around the pile-driving or insertion point should not exceed 160 dB (re 1 µPa). The maximum peak sound pressure level shall not exceed 190 dB if possible. The UBA recommendation does not include any further concretisation of the SEL noise protection value (http://www.umweltdaten.de/publikationen/fpdf-l/4118.pdf, as of May 2011).

The noise protection value recommended by UBA has already been developed through preliminary work in a number of projects (UNIVERSITY OF HANNOVER, ITAP, FTZ 2003). For precautionary reasons, "safety margins" have been taken into account, e.g. for the inter-individual scattering of hearing sensitivity documented to date and, above all, because of the problem of repeated exposure to loud sound impulses, as will occur when foundations are rammed (ELMER et al., 2007). At present, only very limited reliable data is available to evaluate the duration of exposure to pile-driving sounds. However, pile-driving operations, which can last several hours, have a much higher damage potential than a single pile-driving operation. It remains unclear at present what reduction to the above-mentioned limit value should be applied to a series of individual events. An allowance of 3 dB to 5 dB for each tenfold increase in the number of pile-driving impulses is being discussed in expert circles. Due to the uncertainties shown here in the evaluation of the exposure duration, the limit value used in licensing practice is below the limit value proposed by SOUTHALL et al (2007).

As part of the development of a measurement specification for recording and evaluating underwater noise from offshore wind farms, the BSH has specified the requirements of the UBA recommendation (UBA 2011) and the findings of the research projects with regard to noise protection values and standardised them as far as possible. In the BSH's measurement regulations for underwater sound measurements, the SEL5 value is defined as the assessment level, i.e. 95% of the measured individual sound event levels must be below the statistically determined SEL5 value (BSH 2011). The extensive measurements carried out as part of the efficiency check show that SEL5 is up to 3 dB higher than SEL50. Thus, by defining the SEL5 value as an assessment level, a further tightening of the noise protection value was made in order to take the precautionary principle into account.

Thus, in its overall assessment of the available expert information, the BSH assumes that the sound event level (SEL5) outside a circle with a radius of 750 m around the pile-driving or placement site must not exceed 160 dB (re 1 µPa) in order to be able to rule out adverse effects on harbour porpoises with the necessary certainty.

Results on the acoustic resilience of harbour porpoises were obtained within the MINOSplus project. After sonication with a maximum reception level of 200 pk-pk dB re 1 µPa and an energy flux density of 164 dB re 1 µPa2/Hz, a temporary hearing threshold shift (so-called TTS) was detected for the first time in a captive animal at 4 kHz. It was also shown that the hearing threshold shift lasted for more than 24 hours. Behavioural changes were already registered in the animal from a reception level of 174 pk-pk dB re 1 µPa (LUCKE et al. 2009). In addition to the absolute volume, however, the duration of the signal also determines the effects on the exposure limit. The exposure limit decreases as the duration of the signal increases, i.e. if exposure is prolonged, damage to the animals' hearing can occur even at lower volumes. Based on these latest findings, it is clear that harbour porpoises suffer a shift in hearing thresholds above 200 decibels (dB) at the latest, which may also lead to damage to vital sensory organs.

The scientific evidence that has led to the recommendation or setting of so-called noise limits is based mainly on observations of other cetacean species (SOUTHALL et al. 2007) or on experiments on harbour porpoises in captivity using so-called airguns or air pulse generators (LUCKE et al. 2009).

Without the use of noise-reducing measures, considerable disturbance to marine mammals during the pile driving of the foundations cannot be ruled out. In the specific approval procedure, therefore, pile driving of the wind turbines and the transformer station will only be permitted if effective noise reduction measures are used. Principles will be included for this purpose. These principles state that pile driving work when installing the foundations of offshore wind energy plants and platforms may only be carried out under compliance with strict noise reduction measures. In the specific approval procedure, extensive noise reduction measures and monitoring measures will be ordered to ensure compliance with applicable noise protection values (noise event level (SEL) of 160 dB re 1µPa and maximum peak level of 190 dB re 1µPa at a distance of 750 m around the pile driving or insertion point). Suitable measures must be taken to ensure that no marine mammals are present in the vicinity of the pile-driving site.

Current technical developments in the field of reducing underwater noise show that the use of suitable systems can significantly reduce or even completely prevent the effects of noise input on marine mammals (Bellmann, 2020).

Taking into account the current state of knowledge, conditions will be imposed in the licensing procedure as part of the specification of the types of foundations to be constructed, with the aim of avoiding effects on harbour porpoises caused by noise as far as possible. The extent of the necessary conditions will be determined at the approval level for each site and project by examining the structural design of the respective project on the basis of the requirements of species protection law and area protection law.

The approval notices of the BSH include two orders for the protection of the marine environment from noise emissions from pile driving:

a) reduction of noise input at source: Mandatory use of low-noise work methods in accordance with the state of the art for driving foundation piles and mandatory limitation of noise emissions during pile driving. The primary purpose of the ordinance is to protect marine species from impulse noise input by avoiding death and injury.

b) avoidance of significant cumulative effects: The spread of noise emissions must not exceed defined proportions of the German EEZ and nature conservation areas. This ensures that sufficient high-quality habitats are available to the animals at all times for their avoidance. The primary purpose of the order is to protect marine habitats by avoiding and minimising disturbances caused by impulsive noise input.

The order under a) specifies the noise protection values to be complied with and the maximum duration of the impulsive sound input, the use of technical noise reduction systems and averting as well as the extent of monitoring of the protective measures.

Under order b), provisions are made, among other things, to avoid and reduce significant cumulative effects or disturbances to the population of harbour porpoise which may be caused by impulsive sound impacts.

In general, the considerations made for harbour porpoises regarding noise pollution from the construction and operation of wind turbines and platforms also apply to all other marine mammals present in the immediate vicinity of the structures.

Particularly during pile driving, direct disturbances on marine mammals at the individual level are to be expected locally around the pile driving site and for a limited time, whereby – as explained above – the duration of the work also has an impact on the exposure limit. In order to prevent any resulting hazard to the marine environment, the specific approval procedure must include an order to limit the effective pile driving time (including aversive measures) to a minimum. The effective pile-driving time (including aversive measures) to be observed in each case will be specified later in the licensing procedure on a site and system-specific basis. Within the framework of the enforcement procedure, a coordination of noise-intensive work with other construction projects is also reserved in order to prevent or reduce cumulative effects.

On the basis of the function-dependent importance of the areas for harbour porpoises and taking into account the noise abatement measures to avoid disturbances and cumulative effects, the provisions made in the area development plan (FEP, 2019), the requirements within the framework of the suitability test and the conditions imposed within the framework of individual approval procedures to reduce noise emissions, the potential impacts of noise-intensive construction work on harbour porpoises are not considered to be significant. The establishment of priority areas for wind energy production outside of nature conservation areas will ensure that important feeding and rearing grounds for harbour porpoises are not adversely affected.

According to current knowledge, operational noise from the wind turbines and the transformer platform has no effect on highly mobile animals such as marine mammals. Investigations within the framework of the operational monitoring for offshore wind farms have so far not provided any indications that wind farm-related shipping traffic could be avoided. Avoidance could so far only be detected during the installation of the foundations, which may possibly be related to the large number and different operating conditions of vehicles on the construction site.

The standardised measurements of the continuous sound input from the operation of the wind farms, including the wind farm related shipping traffic, have shown that low frequency noise can be measured at a distance of 100 m from the respective wind turbine. However, with increasing distance from the wind turbine, the noise of the turbine only differs slightly from the ambient noise. Even at a distance of 1 km from the wind farm, noise levels are always higher than those measured in the middle of the wind farm. The investigations have clearly shown that the underwater sound emitted by the turbines cannot be clearly identified from other sound sources, such as waves or ship noise, even at short distances. It was also very diccult to differentiate the wind farm related shipping traffic from the general ambient noise, which is introduced by various sound sources such as other shipping traffic, wind and waves, rain and other uses (MATUSCHEK et al. 2018).

All of the measurements showed that it is not only the offshore wind turbines that emit sound into the water, but various natural sound sources, such as wind and waves (permanent background sound) can also be detected in the water in a broadband manner and contribute to the broadband permanent background noise.

In the measurement regulation for recording and evaluating underwater noise (BSH, 2011), a level difference of at least 10 dB between impulse and background noise is required for a technically unambiguous calculation of impulse noise during pile driving. For the calculation or evaluation of continuous sound measurements, however, there is no minimum requirement in this respect due to a lack of experience and data. In the airborne sound range, a level difference between system and background noise of at least 6 dB is required for the unambiguous assessment of system and operating noise. If this level difference is not achieved, a technically unambiguous assessment of the system noise is not possible or the system noise is not clearly distinguishable from the background noise level.

The results available from the measurements of underwater sound show that such a 6 dB criterion based on airborne sound can at most only be met in the immediate vicinity of one of the installations. However, this criterion is no longer fulfilled even at a short distance from the edge of the wind farm. As a result, from an acoustic point of view, the sound emitted by the operation of the wind turbines outside the project areas does not clearly differ from the existing ambient noise.

The biological relevance of continuous sound to marine species, and in particular to harbour porpoises, has not yet been conclusively clarified. Continuous noise is the result of emissions from a range of anthropogenic uses but also from natural sources. The reactions of animals in the immediate vicinity of a source, such as a moving ship, are to be expected and can occasionally be observed. Such reactions are even essential for survival, for example to avoid collisions. In contrast, reactions that have not been observed in the immediate vicinity of sound sources can no longer be assigned to a specific source.

The vast majority of behavioural changes are the result of a variety of impacts. Noise can certainly be a possible cause of behavioural changes. However, behavioural changes are primarily controlled by the survival strategy of the animals, to prey on food, to escape predators and predators and to communicate with conspecifics. For this reason, behavioural changes always occur in different situations and in varying degrees.

In the literature there are references to possible behavioural changes caused by ship noise, but the results are not conclusive for drawing conclusions about the significance of behavioural changes or even for developing and implementing suitable mitigation measures.

However, scientific reviews of the existing literature on the possible effects of ship noise on cetaceans, as well as on fish, clearly point to the lack of comparability, transferability and reproducibility of the results (Popper & Hawkins, 2019, Erbe et la. 2019).

It is known from oil and gas platforms that the the attraction of different fish species leads to an enrichment of the food supply (Fabi et al., 2004; Lokkeborg et al., 2002). The recording of harbour porpoise activity in the immediate vicinity of platforms has also shown an increase in harbour porpoise activity associated with foraging during the night (TODD et al., 2009). It can, therefore, be assumed that the possibly increased food supply in the vicinity of wind turbines and the transformer platform is very likely to have an attractive effect on marine mammals.

As a result of the SEA, it can be concluded that, according to the current state of knowledge, no significant impacts on the protected marine mammal species are to be expected from the installation and operation of wind turbines and the transformer platform.

The non-implementation of the plan would have had an impact on the existing or described effects of wind energy production on harbour porpoise, harbour seal and grey seal, in that it would not have been possible to plan the expansion in an orderly manner, taking into account specific objectives and principles.

3.2.5 Seabirds and resting birds

Constructional: During the construction of offshore wind energy plants, effects on seabirds and resting birds should be assumed, although the type and extent of these effects are limited in time and space.

In the case of species sensitive to disturbance, avoidance of the construction site is to be expected, the intensity of which varies according to species and can very probably be attributed to the construction-related shipping traffic.

Construction-related turbidity plumes occur locally and for a limited time. Attracting effects caused by the lighting of the construction site and of the construction site vehicles cannot be ruled out.

Operational and system-related: erected wind energy plants may constitute an obstacle in the airspace and may also cause collisions with the vertical structures by sea birds and resting birds (GARTHE 2000) It is difficult to estimate the extent of such incidents to date, since it is assumed that a large proportion of the colliding birds do not collide with a fixed structure (HÜPPOP et al. 2006). However, the risk of collision is estimated to be very low for species sensitive to disturbance, such as loons and black-throated divers, as they do not fly directly into or near the wind farms due to their avoidance behaviour. Furthermore, factors such as manoeuvrability, flight altitude and the proportion of time spent flying determine the collision risk for a species (GARTHE & HÜPPOP 2004). The collision risk for seabirds and resting birds must, therefore, be assessed differently for each species.

For the assessment of a possible collision risk for sea birds and resting birds with wind turbines at sea, the corresponding height parameters of the turbines are an important key figure. In the ROP, the bandwidths for the height parameters of currently installed or potential turbine types were included in line with the current technical developments of wind energy plants (cf. Chapter 1.5). This takes into account wind farm projects which are already in operation, as well as those which will go into operation in zones 1 and 2 within the framework of the transitional system and the first years of operation of the central system. For wind farm projects already implemented or planned for the future in zones 1 and 2, data or assumptions are available for 5 to 12 MW turbines with a hub height of 100 to 160 m and, based on rotor diameters of 140 m to 220 m, a total height of 170 m to 270 m. This means that the lower rotor-free area from the water surface to the lower rotor blade tip would be between 30 m to 50 m for wind farm projects in zones 1 and 2. The wind farm projects in the Baltic Sea EEZ are in zone 1.

Within the framework of StUKplus, the "TESTBIRD" project used a range finder to determine the flight altitude distribution of, among others, the three large gull varieties, the silver gull, the herring gull and the great black-backed gull as well as the smaller species little gull and common gull. The great black-backed bull flew in the majority of the recorded flights at altitudes of 30 - 150 m, whereas the common gull and little gull were mainly observed at lower altitudes up to 30 m (MENDEL et al. 2015). A current study at the English wind farm Thanet Offshore Wind Farm also used a rangefinder to investigate the flight altitude distribution of the three great black-backed gull, Caspian gull and lesser black-backed gull, among others (SKOV et al. 2018). The flight level measurements of the great black-backed gulls revealed altitudes comparable to those determined by Mendel et al. (2015).

In general, large and small gulls have a high level of manoeuvrability and can react to wind turbines with appropriate evasive manoeuvres (GARTHE & HÜPPOP 2004). This was also shown in the study by SKOV et al. (2018), in which not only the flight altitude but also the immediate, small-scale and large-scale avoidance behaviour of the species under consideration was examined. Furthermore, the investigations using radar and thermal imaging cameras revealed low nocturnal activity. The risk of collisions at night due to attracting effects caused by the lighting of the wind turbines can, therefore, also be rated as low.

Garthe & Hüppop (2004) attested the low manoeuvrability of diving sea ducks, great crested grebes and red-necked grebes, but these species generally fly at altitudes of no more than 5-10 m and thus outside the rotor range.

For species susceptible to disturbance, it can be assumed that species-specific avoidance of wind farm areas is to be assumed during the operating phase of the wind farms.
Red-throated divers and black-throated divers (hereinafter referred to collectively as divers) are considered to be particularly sensitive to disturbance from wind farms and also from moving ships. A scare reaction to the latter is known in the form of flying up at a distance of 2 km from the ship (GARTHE et al. 2002, SCHWEMMER et al. 2011).

Ongoing investigations as part of the operational monitoring of the wind farm projects in the North Sea have now revealed significant avoidance distances of up to 15 km, depending on the area. It should be noted that these distances are not total avoidance, but partial avoidance with increasing loon densities up to the corresponding distances (BIOCONSULT SH & Co.KG 2017b, BioConsult SH & Co.KG 2018, IfAÖ ET AL. 2017b, IfAÖ 2018B, IBL UMWELTPLANUNG GMBH ET AL. 2017, IBL UMWELTPLANUNG GMBH ET AL. 2018).

Such large-scale avoidance reactions by loons are not known from the Baltic Sea (IfAÖ 2018a). This may be due to the fact that the areas designated in the ROP and the Baltic Sea EEZs in general are of no particular significance for this group of species and that loons are only occasionally encountered as migrants and in winter. The same applies to other species such as the guillemot, razorbill and little gull, for which small-scale avoidance behaviour is known to date (IFAÖ et al. 2017b, IBL UMWELTPLANUNG GMBH et al. 2017, IBL UMWELTPLANUNG GMBH et al. 2018).

It is also expected that fish stocks will recover during the operational phase through a regular ban on fishing within the wind farms accompanied by a ban on vessels. In addition to the introduction of hard substrate, this could thus increase the range of fish species present and provide an attractive food supply for foraging seabirds.

If the ROP is not carried out, there would be less spatially coordinated planning of wind farm projects. This would probably increase land use, which in turn could have an impact on species sensitive to disturbance. Furthermore, the ROP is based on planning principles which provide for the spatial and temporal coordination of construction projects in order to be able to reduce temporary factors affecting seabirds and resting birds, such as construction-related additional shipping traffic.

Even if similar factors would, in fact, have an effect on the protection of seabirds and resting birds both when the ROP is carried out and when it is not carried out, the protection of seabirds and resting birds would be more difficult to ensure in the absence of planning principles and their coordinating requirements.

3.2.6 Migratory birds

Constructional: The main effects during the construction phase are light emissions and visual disturbance. These can have different, species-specific chasing and barrier effects on migrating birds. However, lighting for construction equipment can also have the effect of attracting migrating birds and increase the risk of collision.

Installation and operational: The potential impact of offshore wind farms in the operational phase may be that they constitute a barrier to migrating birds or a risk of collision. Flying around or otherwise disturbing flight behaviour can lead to higher energy consumption, which can affect the birds' fitness and consequently their survival rate or breeding success. Bird strike events may occur on vertical structures (such as rotors and supporting structures of wind turbines, substations and converter platforms). Poor weather conditions – especially at night and in strong winds – and high levels of migration increase the risk of bird strikes. Added to this are possible glare or attracting effects caused by the safety lighting on the installations, which can lead to birds becoming disoriented. Furthermore, birds caught in wake currents and air turbulence at the rotors could have their manoeuvrability impaired. For the factors mentioned above, however, as with the chasing and barrier effects, it must be assumed that sensitivities and risks vary from species to species.

In general, a threat to bird migration does not already exist if there is an abstract danger that individual birds may be harmed when passing through an offshore wind farm. A threat to bird migration only exists if there is sufficient evidence to justify the prediction that the number of potentially affected birds is such that, taking into account their respective population sizes, it can be assumed with sufficient probability that individual or several different populations will be significantly impaired. The biogeographic population of the migratory bird species in question is the reference point for the quantitative assessment.

There is agreement that under the existing legal situation, individual losses of individuals during bird migration must be accepted. In particular, it must be taken into account that bird migration in itself involves many dangers and subjects populations to harsh selection processes. The mortality rate can be around 60-80% for small birds, while the natural mortality rate is lower for larger species. Also, different species have different rates of reproduction, so the loss of individuals may be of different magnitude for each species.

Due to a lack of sufficient knowledge, it has not yet been possible to determine a generally accepted acceptance threshold.

For the assessment of a possible collision risk for sea birds and resting birds with wind turbines at sea, the corresponding height parameters of the turbines are an important key figure. In the ROP, the bandwidths for the height parameters of currently installed or potential turbine types were included in line with the current technical developments of wind energy plants (cf. Chapter 1.5). This takes into account wind farm projects already in operation, as well as those which will go into operation in zones 1 and 2 within the framework of the transitional system and the first years of operation of the central system. For wind farm projects already implemented or planned for the future in zones 1 and 2, data or assumptions are available for 5 to 12 MW turbines with a hub height of 100 to 160 m and, based on rotor diameters of 140 m to 220 m, a total height of 170 m to 270 m. This means that the lower rotor-free area from the water surface to the lower rotor blade tip would be between 30 m to 50 m for wind farm projects in zones 1 and 2. The wind farm projects in the Baltic Sea EEZ are in zone 1.

Elevation profiles obtained from migration route observations by a visual observer in areas EO1, EO2 and EO3 (OECOS 2015, IFAÖ 2016A AND BIOCONSULT SH 2017) show a strong concentration on elevation ranges up to 20 m. In area EO3 about 90 % of the train movements took place at altitudes up to 20 m (*BIOCONSULT SH 2017)*.

Previous investigations of bird migration using vertical radar in the Baltic Sea EEZ showed that there was a diurnal dependence in the height distribution. In the EO3 area, bird migration took place mainly in the lower 500 metres of altitude. The preference for low flight altitudes also leads to a high proportion of flight movements in the potential risk area of the rotors. For example, in the altitude range up to 200 m, between 65.2% (spring) and 66.7% (autumn) of flight movements were recorded during the day, while at night the figure was between 28.8% (spring) and 26.8% (autumn). Furthermore, there was a correlation between migration altitude and migration intensity. At night, in particular, bird detection was more frequent in the lower altitudes during periods of low migration. This could reflect worse migratory conditions (weather), which reduce the number of migrating birds and allow them to move to lower migratory heights.

Long-term investigations of bird migration in the North Sea EEZ in the area "North of Borkum" *revealed a bimodal distribution pattern to the recorded bird movements during darkness in spring 2016. On the one hand, the lowest altitude ranges up to 100 m (35,018 flight movements; 13.2 %) and, on the other hand, the highest ranges between 900-1,000 m (30,295 flight movements; 11.4 %) were most heavily flown at night. About one third of the echoes were recorded at altitudes of up to 300 m, above 300 m to 700 m and above 700 m to 1,000 m (AVITEC RESEARCH 2017). Corresponding to the conditions in spring, however, bird migration nights were also recorded in autumn, the height profiles of which deviated from the basic pattern. During the strong bird migration night of 25/26 October 2016, the altitude range above 900 m to 1,000 m was the most heavily flown, which suggests that bird migration was underestimated during this night and a high (but unknown) proportion of migrating birds flew over the area covered by radar measurements. Even during the very strong bird migration night of 09./10.11., bird migration shifted relatively strongly upwards.*

Avitec Research therefore assumes that its vertical radar system with its considered data basis up to 1,000 m altitude registers on average at least 2/3 of the entire bird migration. In individual cases, depending on the vertical wind profile, the recorded proportion can be significantly higher during heavy bird migration. Conversely, more than half of all migratory birds will also be missed at nights with a distribution of altitude that only slowly decreases or even increases with altitude. However, this is usually the case only in a small number of nights.

There is evidence that the height range between 20 and 200 m is preferred for cranes. In the case of the crane, 91% of visible migration was observed at heights between 20 and 200 metres (BIOCONSULT SH 2017). Intensive radar surveys of migrating cranes on the island of Rügen between 2005 and 2008 revealed a high variability of flight altitudes (20 m - 1,300 m) on the migration between the northern tip of Rügen and the southern coast of Sweden (IFAÖ 2010). On average, groups of cranes travelled at an altitude of around 300 metres. Two different flight patterns were recorded: the 'simple' straight flight without loss of altitude and straight flight interrupted by regular circling. While circling, height was gained and the straight flight routes were associated with a loss of height. The circling flight movements were mainly observed close to land and probably exploited updrafts in this area. A study with 3D GPS devices on eight cranes crossing the Baltic Sea between the southern coast of Sweden and the German Baltic coast showed similar flight behaviour (SKOV et al. 2015). Four cranes travelled the entire distance across the open sea at a constant altitude of less than 200 m. Two individuals, on the other hand, climbed to altitudes of about 1,000 m before reaching the Swedish coast, lost height continuously during the crossing and reached land at a flight altitude of about 200 m.

Extensive measurements with a "laser rangefinder" from the FINO2 platform near the "Baltic 2" OWP also showed a clear dominance of flight altitudes below 200 m in both spring and autumn, as well as a dependence of the flight altitude distribution on wind conditions (SKOV et al. 2015). In contrast to radar observations, visual observations, even with the support of rangefinders, are subject to methodological limitations with regard to the detection probability of higher-flying individuals. In the opinion of the experts, this probably leads to systematic underestimation of the proportion of cranes in the height range above 200 m (cf. IFAÖ 2010).

The results of the investigations on area O.1-3 by means of visual observations and rangefinder measurements confirm the flight altitude distributions of cranes in the lower altitude range up to

200 m already known from these methods (IFAÖ et al. 2020).

Migrating birds generally fly higher in good weather than in poor weather. In addition, most birds usually start their migration in good weather and are able to choose their departure conditions so that they are likely to reach their destination in the best possible weather. In the clear weather conditions preferred by birds for their migration, the probability of collision with WTGs is, therefore, low, as most birds will fly above the range of the rotor blades and the turbines will be clearly visible. On the other hand, unexpected fog and rain, which lead to poor visibility and low flight altitudes, represent a potential risk situation. The coincidence of poor weather conditions and so-called mass migration events is particularly problematic. According to information from various environmental impact studies, mass migration events in which birds of different species fly over the North Sea simultaneously occur about 5 to 10 imes a year. An analysis of all existing bird migration studies from the mandatory monitoring of offshore wind farms in the North Sea and Baltic Sea EEZ (observation period 2008 - 2016) confirms that particularly intensive bird migration coincides with extremely bad weather conditions for less than 1% of the migration periods (WELCKER 2019b).

In addition to the risk of bird strikes, another risk for migrating birds may be that the presence of wind turbines could divert the migration route and thus extend it. However, this does not affect bird migration in its entirety, since much of the migration takes place at altitudes that are beyond the influence of wind turbines. Many songbirds migrate at altitudes between 1,000 and 2,000 m. Waders are also known to migrate at very high altitudes (JELLMANN 1989). However, significant numbers migrate at altitudes of < 200 m and thus within the sphere of influence of wind turbines. Many of the low migrating species belong to the group of waterfowl and seabirds, which are able to land on the water to rest and possibly eat. For species such as these, any detours will, therefore, have little impact. Problems could arise for migrating land birds that are not capable of landing on water. It should be borne in mind that migratory birds are capable of impressive non-stop flights, especially when non-waterborne species migrate across seas. For example, the non-stop flight performance of many species, including small birds, is over 1,000 km (TULP et al. 1994). It is, therefore, unlikely that the additional energy demand that may be required would endanger bird migration by a diversion necessary in the Baltic Sea EEZ.

If the ROP is not carried out, there would be less spatially coordinated planning of wind farm projects. This would probably increase land consumption. Furthermore, the ROP is based on planning principles which provide for spatial and temporal coordination of construction projects.

Although similar factors would, in fact, affect migratory birds, both if the ROP is carried out and if it is not, the protection of migratory birds would be more difficult to ensure in the absence of planning principles and their coordinating requirements.

3.2.7 Bats and bat migration

At present, there is no reliable information available on possible migration corridors and migration behaviour of bats over the Baltic Sea. In general, the following effects of the use of offshore wind energy can affect bats:

Construction-related: Construction activities during the construction of WTGs are associated with an increased volume of shipping. The lighting of the ships and the construction site can have an attracting effect on bats migrating across the sea. There would then be a risk of collision with the ships and the construction site.

Installation and operational: During the operating phase, the lighting of the installations may cause attracting effects that could lead to collisions.

Failure to implement the plan may have the same effects on bats as if the plan had been implemented.

3.2.8 Climate

Negative effects on the climate from offshore wind farms are not expected, as there are no measurable climate-relevant emissions during construction or operation. Rather, the coordinated expansion of the grid infrastructure in the offshore sector will create greater planning security for the expansion of offshore wind energy. The CO_2 savings associated with the expansion of offshore wind energy (cf. Chapter 1.8) can be expected to have positive effects on the climate in the long term.

3.2.9 Air

The construction and operation of wind energy plants and platforms and the laying of submarine cable systems will increase shipping traffic. However, there are no measurable effects on air quality. Therefore, the air to be protected develops in the same way if the plan is implemented as if the plan were not implemented.

3.2.10 Landscape

The realisation of offshore wind farms has an impact on the landscape, as it is changed by the erection of vertical structures. The installations also need to be lit up at night or in poor visibility for safety reasons. This can also lead to visual impairments of the landscape. The erection of platforms can also lead to visual changes in the landscape. The extent to which the landscape is impaired by offshore installations depends strongly on the respective visibility conditions, but also on subjective perceptions and the basic attitude of the observer towards offshore wind energy. The vertical structures, which are untypical for the usual picture of a marine landscape, can be perceived as partly disturbing, but also as technically interesting. In any case they cause a change in the landscape and the character of the area is modified. The actual visibility is determined by the distance of the offshore wind farms from the coast or islands, the size of the wind farm in terms of area, the height of the wind turbines, the visibility range based on the specific weather conditions, the height of the observer's location (e.g. beach, viewing platform, lighthouse) and the performance of the human eye. Due to the considerable distance (more than 30 km) between the planned and already installed wind energy plants and platforms and the coast, the plants will only be visible from land to a very limited extent and only under good visibility conditions. This also applies to night-time safety lighting.

Overall, the impairment of the landscape by offshore installations from the coast can be classified as quite low.

The development of the landscape when the ROP is not carried out is not expected to differ significantly from the development when the ROP is carried out. However, it should be noted that the required area requirement can be minimised by the provisions of the ROP (and the area development plan). The potential impacts on the landscape as a factor can thus be reduced by means of spatially coordinated, forward-looking and harmonised overall planning. Inadequate spatial coordination in the event of non-implementation of the plan could lead to more fragmented wind farm areas and a larger area claim and slightly increased visibility from the coast.

For the submarine cable systems, negative impacts on the landscape during the operating phase are to be ruled out due to their installation as underwater cables.

3.2.11 Cultural and other material goods

Deep foundations of wind turbines cause disturbances on the seabed due to construction, which can affect both discovered and undiscovered cultural heritage. The cultural heritage is completely or partially destroyed during excavation or pile driving, or its context is affected. In addition, during construction work, extensive secondary impacts on the factor, the underwater cultural heritage, are to be expected from the construction vehicles.

Due to the foundation as a flow obstacle, the long-term formation of scour funnels is to be expected, especially on fine sandy seabeds, which means that cultural traces that remained undiscovered during the construction work can be freely eroded.

3.3 Cables

Cables within the meaning of the spatial plan include pipelines and submarine cables. Submarine cables include cross-border cables and connecting lines for offshore wind farms as well as data cables. So-called submarine cables within the park are not covered by this definition. Reference is made in this respect to specifications within the framework of sectoral planning (FEP).

The two Nord Stream 1 pipelines, which land on the German coast, run through the Baltic Sea EEZ. The two Nord Stream 2 pipelines are currently under construction. The pipelines transport natural gas from Russia to Germany. They will land on the coast of Mecklenburg-Western Pomerania.

The reserved area pipelines serves to secure routes for existing and future pipelines and submarine cables. Current-carrying cables are the subject of specialist planning.

Five submarine cable systems are currently in operation in the Baltic Sea EEZ to connect three offshore wind farms.

Furthermore, three transnational power cables are currently in operation in the Baltic Sea EEZ: Baltic Cable, Kontek and the Kriegers Flak Combined Grid Solution. Transnational data cables – usually fibre optic cables for telecommunications – cross the German Baltic Sea in large numbers. There are also a number of cables in the seabed which have been taken out of service and which have not been removed after being abandoned.

Pipelines have different impacts on the marine environment. Pipelines primarily affect the protected resources of soil, benthos and fish, where the potential effects of introducing hard substrate, turbidity plumes and, for live cables, operational heat emissions and possibly magnetic fields are assessed.

For the evaluation of the specifications for pipelines, the following possible impacts are examined:

Table 20: Effects and potential impacts of pipelines (t = temporary).

Nutzung	Wirkung	Potenzielle Auswirkung	Schutzgüter																
			Benthos	Fische	See- und Rastvögel	Zugvögel	Meeressäuger	Fledermäuse	Plankton	Biotoptypen	Biologische Vielfalt	Boden	Fläche	Wasser	Luft	Klima	Mensch/ Gesundheit	Kultur- und Sachgüter	Landschaftsbild
Leitungen Trassen für Seekabelsysteme und Rohrleitungen	Einbringen von Hartsubstrat (Steinschüttung)	Veränderung von Habitaten	x	x					x	x		x						x	
		Lebensraum- und Flächenverlust	x	x						x		x	x					x	
	Wärmeemissionen (stromführende Kabel)	Beeinträchtigung/ Verdrängung kaltwasserliebender Art	x								x	x							
	Magnetfelder (stromführende Kabel)	Beeinträchtigung	x																
		Beeinträchtigung des Orientierungsverhaltens einzelner wandernder Arten		x															
	Trübungsfahnen (Bauphase)	Beeinträchtigung	x t	x t	x t				x t					x t					
		Physiologische Effekte und Scheucheffekte		x t															

3.3.1 Seabed/site

Pipelines

During installation in the seabed, the formation of a near-bottom turbidity plume and the small-scale change in morphology and sediment composition is likely. The resuspended sediments are transported and deposited in the vicinity of the pipeline at different distances depending on the grain size: the distances are significantly less than those determined for the sedimentation of turbidity plumes in the course of sand and gravel extraction. The concentrations of resuspended particulate material are of a comparable order of magnitude to those found in natural resuspensions of sediments caused by storms.

The formation of undercuts ("freespans") can lead to a change in the sedimentary composition or grain composition, which is, however, spatially limited. Depending on the sand supply and geological structure of the substrate, these undercuts can stabilise or only occur temporarily. In the case of sand deficits, the substrate may change, e.g. by the temporary presence of bed load marl, clay or similar on the seabed.

To protect the pipeline against external corrosion, sacrificial anodes made of zinc and aluminium are applied at regular intervals. Only small amounts of these are dissolved and released into the water column. Due to the very high dilution, they are only present in trace concentrations; in the water they are adsorbed on sinking or resuspended sediment particles and sediment on the sea floor.

Submarine cables

When submarine cables are laid, the seabed morphology and the original sediment structure in the route area generally change as a result of the cable laying and a turbidity plume is formed near the ground. The ROP-E defines the reservation areas for cables LO1 to LO8. Pipelines within the meaning of ROP-E include pipelines and submarine cables. Under submarine cables, cross-border power lines and connecting lines for wind farms as well as data cables are summarised. So-called in-farm submarine cables are not covered by this definition. In addition, the ROP-E defines the objective of routing cables at the transition to the territorial sea through gates GO1 to GO5.

Overall, the effects correspond to those of the cabling within the wind farm as described in Chapter 3.2.1 on offshore wind energy.

Due to the construction of the submarine cables, sediments are stirred up and turbidity plumes are formed. The extent of the resuspension depends mainly on the fine-grain content of the sediment. In areas with a lower fine grain content, the majority of the released sediment will settle relatively quickly directly in the area of the intervention or in its immediate vicinity. The suspension content will quickly return to its natural background values due to dilution effects and sedimentation of the sediment particles stirred up. The impairments to be expected in areas with a higher fine-grain content and the associated increased turbidity remain limited on a small scale due to the low flow near the seabed.

In areas with soft sediments and correspondingly high fine-grain contents (e.g. Arkona Basin or Mecklenburg Bay), the sediment released will settle much more slowly. However, since the currents near the seabed are very low, it can be assumed that the turbidity plumes occurring here will also have a rather local character and that the sediment will settle again relatively close to the construction site.

Within the framework of the environmental impact assessment for the "Nord Stream Pipeline", the monitoring results during the construction phase showed only small to medium-scale, temporary effects due to sediment drifting (turbidity plumes) and confirmed the forecasts of the environmental expert (IFAÖ 2009), who classified the effects as minor structural and functional impairment. On the basis of these results, it can be assumed that turbidity plumes released during the laying of submarine cables in areas with soft sediments will not exceed the natural suspended matter maxima up to a distance of 500 m.

Studies by ANDRULEWICZ et al. (2003) also show that the seabed of the Baltic Sea is undergoing levelling due to natural sediment dynamics along the affected routes. However, various model calculations carried out as part of procedures and the experience gained from the procedures show that re-levelling is more likely to occur in the long term.

Due to operational conditions, energy is transmitted radially around the cables in submarine cables, which leads to a heating of the surrounding sediment. The heat emission results from the thermal losses of the submarine cable systems during energy transmission. The depth at which the cable systems are laid is also decisive for the temperature development in the sediment layer near the surface. According to the current state of knowledge, no significant effects from cable-induced sediment heating are to be expected if a sufficient installation depth is maintained and if state-of-the-art cable configurations are used.

The potential impacts of the construction and operation of pipelines and submarine cables on the factors, i.e. the seabed or site, are locally limited and occur independently of the implementation of the plan.

Failure to implement the plan would lead to less co-ordinated laying of cables and, if necessary, to a greater number or longer cables, particularly for submarine cables. This could lead to an increase in land use and thus to an increase in the potential impact on the factors of seabed and site compared to the implementation of the plan. In addition, if the plan is not implemented, an increased number of crossing structures would have to be expected, which would lead to an increase in the introduction of rock debris even in areas with sandy sediments or soft sediments, which could otherwise be avoided.

3.3.2 Benthos and biotopes

With regard to benthos and biotopes, the comments in Chapter 3.2.2apply analogously. If the plan is not implemented, less spatially coordinated planning of the pipeline systems would be expected. In addition, an increased number of pipeline intersections or intersection structures would have to be expected, which would also require the introduction of hard substrate. Here, too, the habitat structures would change on a small scale, which in turn could lead to a shift or change in the species spectrum of the benthos.

As the plan's provisions aim at minimising the use of the seabed by reducing the number of pipeline routes and minimising the number of crossings, it would probably be more difficult to ensure the protection of benthos and biotopes if the plan were not implemented than if it were.

3.3.3 Fish

Pipelines

During the construction phase of pipelines, the fish fauna can be temporarily disturbed by **noise and vibrations** both through the use of ships and cranes and through the installation of the pipeline systems (see also Chapter 3.1.4). In addition, construction-related **turbidity plumes** may occur near the seabed and local sediment shifts may take place which may damage fish, especially spawn and larvae. The ecological effects of the turbidity plumes on the fish are described in detail in Chapter 3.4.3 The effects on fish in areas with sediment redistribution are short-term and spatially limited.

Submarine cable

Construction-related impairments of the fish fauna by submarine cables, as well as by pipelines, are to be expected through **noise emissions and turbidity plumes.** Detailed information is provided in Chapters 3.1.4and 3.4.3.

The rock fills in the area of the planned pipeline crossings are expected to cause a **local change in the fish community.** A change in the fish community can lead to a change in the dominance conditions and the food web. However, these effects are to be regarded as minor due to the small-scale nature of the planned cable crossings.

With regard to the possible operational impacts of submarine cable systems of OWPs, such as **sediment heating and electromagnetic fields,** no significant effects on fish fauna are expected either. Experience shows that sediment heating in the immediate vicinity of the cables will not exceed the precautionary value of 2K at a sediment depth of 20 cm. Direct electric fields do not occur with the intended cable type due to the shielding. Induced magnetic fields of the individual conductors largely cancel each other out in the planned bundled installation with one outgoing and one return conductor each and are significantly below the strength of the natural earth magnetic field. According to the TdV, the magnetic field generated during operation of the Ostwind 2 cable system amounts to a maximum of 20 µT at the sea floor surface. In comparison, the natural geomagnetic field of the earth is 30 to 60 µT depending on the location. The field strength decreases rapidly with increasing distance from the cable. Diadromous species in particular, such as salmon and European eel, could react sensitively to electromagnetic fields. However, various studies on the effects of electromagnetic fields on the European eel did not show clear results. In the Danish wind farm "Nysted" no behavioural changes of the eel could be recorded (BIO/CONSULT AS 2004). However, both WESTERBERG AND LAGENFELT (2008) and GILL AND BARTLETT (2010) recorded short-term changes in their swimming activity. Overall, the expected moderate and small-scale changes in the magnetic field in the area of the cable make it unlikely that the migration of marine fish will be blocked. However, magnetosensitive fish species could avoid the immediate vicinity of the cable.

In the case of the three-wire three-current cables and bipolar direct current cables provided for in the German EEZ, magnetic effects during operation can be neglected or excluded, as the magnetic fields almost cancel each other out. No significant effects on sensitive fish species are therefore to be expected.

3.3.4 Marine mammals

Pipelines

The laying, operation, maintenance and dismantling of pipelines in the sea can have an impact on marine mammals. The following should be mentioned: shipping traffic, noise emissions, sediment plumes and pollution. In normal operation, effects on marine mammals can be ruled out with reasonable certainty. During maintenance work, increased shipping traffic with noise emissions and pollution is possible.

Constructional: During the laying of pipelines, temporary sound loads and turbid sediment plumes occur. The intensity and duration of the sound emissions depend mainly on the laying method. Overall, however, disturbances caused by pipe-laying operations for marine mammals are small-scale, local and short-lived.

Effects due to changes in sediment structure and damage to benthos during installation are negligible for marine mammals, in any case. These changes take place on a small scale along the pipeline. The effects of long-term changes in - sediment structure and benthos are insignificant for marine mammals, as they search for their prey organisms mainly in the water column over extensive areas.

Direct disturbance of marine mammals at the individual level can occur during the laying and dismantling of pipelines. Effects from shipping traffic and in particular noise emissions during laying work are only expected to be regional and temporary. The formation of sediment plumes is largely expected to be local and temporary. Habitat loss for marine mammals at the individual level could therefore only occur locally and for a limited period of time.

Operational: The pipelines laid on the seabed can have attracting effects on marine mammals, caused by increased fish populations in the vicinity of the pipelines (these can in turn be attracted by the colonisation of benthic organisms on the pipelines).

In normal operation, pipelines do not have a significant impact on marine mammals. In the event of damage to the pipeline or inspection and maintenance work being carried out, regional and temporary disruptions due to shipping traffic with noise emissions and pollutant leakage are possible.

The effects of sediment and benthic changes are insignificant for marine mammals, as they search for their prey organisms mainly in the water column in extensive areas. If the benthic species spectrum were to change along pipelines laid on the sea floor, the change would possibly attract fish more strongly. Increased fish occurrence could in turn attract marine mammals.

During normal operation, the effects on the population level are not known. Due to the narrow, linear shape of pipelines, negative effects on the population level can be excluded with certainty.

The non-implementation of the plan would not affect the existing or described effects of pipelines on harbour porpoise and on harbour seal and grey seal.

Submarine cables

Potential impacts during the laying and, in some cases, the dismantling of submarine cables for marine mammals shipping traffic, noise emissions and opacity plumes. Potential operational effects on marine mammals from the generation of electric and magnetic fields in the immediate vicinity of submarine cables depend on the type of cable.

Constructional: The laying of cables causes temporary noise emissions that may cause disturbance to marine mammals. The duration and intensity of the sound emissions vary depending on the installation method. However, the effects of noise emissions during installation are local and temporary. The intensity of the effects may vary between medium and high, depending on the method of installation. This also applies to effects due to the formation of turbidity plumes. Changes in sediment structure and associated temporary changes in benthos have no effect on marine mammals. Marine mammals seek their prey in extensive areas in the water column.

Operational: During operation, power cables can lead to heating of the surrounding sediments. However, this has no direct effect on highly mobile animals such as marine mammals.

Overall, no significant effects are expected from cables used to dissipate energy or by bundling cables in a common pathway on marine mammals, either at individual or population level.

The non-implementation of the plan would not affect the existing or described effects of submarine cables on harbour porpoise, seals and grey seals.

3.3.5 Seabirds and resting birds

Pipelines

Constructional*:* When pipelines are laid, sediment cloudiness plumes and local sediment and benthic changes occur temporarily. During the laying work, construction-related shipping traffic can lead to visual disturbance and, in the case of species sensitive to disturbance, can trigger flight or avoidance reactions.

Potential construction-related effects are only temporary and local for the duration and immediate area of the relocation.

Operational: The effects of sediment and benthic changes are of little importance for seabirds and resting birds, as they search for their prey organisms mainly in the water column in extensive areas. If the benthic species spectrum changes along pipelines laid on the seabed, the change would possibly attract fish more strongly. Increased fish occurrence could in turn also attract seabirds. During the operating phase, maintenance-related shipping traffic can lead to visual disturbance and trigger temporary flight or avoidance reactions in the case of species sensitive to disturbance.

Submarine cables

Constructional*:* During the laying of submarine cables, sediment cloudiness plumes and local sediment and benthic changes occur temporarily. During the laying work, construction-related shipping traffic can lead to visual disturbance and trigger flight or avoidance reactions in the case of species sensitive to disturbance.

Potential construction-related effects are only temporary and local for the duration and immediate area of the relocation.

Operational: The effects due to sediment and benthic changes are of little importance for seabirds and resting birds, as they search for their prey organisms predominantly in the water column over wide areas. During the operational phase, maintenance-related shipping traffic can cause visual disturbance and trigger temporary frightening or avoidance reactions in the case of species sensitive to disturbance.

Failure to implement the plan would result in less spatially coordinated planning of lines and gates. The ROP is based on planning principles which provide for the spatial and temporal coordination of construction projects in order to minimise impacts on, among other things, the marine environment and thus also sea birds and resting birds.

Even if similar factors would, in fact, have an effect on the protection of sea birds and resting birds both during the implementation and the non-implementation of the ROP, the protection of the marine environment and thus of sea birds and resting birds would be more difficult to ensure in the absence of planning principles and their coordinating requirements.

3.3.6 Migratory birds

Pipelines

Potential effects of pipelines on migratory birds are mainly limited to the construction phase. Illuminated construction vehicles can cause attracting effects, which can lead to collisions.

Submarine cable

The potential effects of pipelines on migratory birds are mainly limited to the construction phase. Illuminated construction vehicles can cause attracting effects, which can lead to collisions.

The potential impact on bats is independent of the non-implementation or implementation of the plan.

3.3.7 Bats and bat migration

Potential effects of pipelines on bats are mainly limited to the construction phase. Illuminated construction vehicles can cause attracting effects, which can lead to collisions.

The potential impact on bats is independent of the non-implementation or implementation of the plan.

3.3.8 Air

Pipelines

The laying, maintenance and dismantling of pipelines involves shipping traffic. This in turn leads to emissions of pollutants that can affect air quality. Significant adverse effects on air quality are not expected.

Submarine cable

The laying, maintenance and dismantling of submarine cables involves shipping traffic. This in turn leads to emissions of pollutants that can affect air quality. Significant adverse effects on air quality are not expected.

3.3.9 Cultural and other material goods

The construction-related effects of pipelines and submarine cables on the underwater cultural heritage depend on the installation methods used. Both flushing and dredging operations can lead to the destruction of underwater cultural heritage at the seabed. In addition to the direct effects of the installation methods used, indirect effects, e.g. through anchorage work or screw water, must also be considered.

In the case of pipelines that are laid directly on the seabed and sink into the sediment over time, the direct impact can be considered low. Installation and operational impacts are not to be expected.

3.4 Raw material extraction

Raw materials are extracted from the sea for both commercial purposes and, in particular, stone, gravel and sand extraction for coastal protection. In addition, large areas, especially in the North Sea, have already been covered by hydrocarbon exploration licences. In the German EEZ, these are primarily natural gas deposits. Their importance is particularly evident in the Baltic Sea, which borders on Schleswig-Holstein, where production at sea clearly exceeds that on land.

The Federal Mining Act (BBergG) is the federal law regulating mining law issues and includes, among other things, the exploration and extraction of raw materials. The purpose of the raw materials safeguarding clause in Section 48 (1) sentence 2 BBergG is to apply extra-mining regulations of other competent authorities in such a way that the exploration and extraction of raw materials is impaired as little as possible. Furthermore, the BBergG states in Sections 48 et seq. of the BBergG also contains provisions for the benefit of shipping, fisheries, the laying and operation of cables and pipelines and the marine environment which must be observed when exploring for or approving operating plans for an operation in the area of the continental shelf.

According to Section 7 BBergG, permits grant the authorised permit holder the exclusive right to search for mineral resources in a specific field. Pursuant to Section 8 BBergG, permits grant in particular the exclusive right to extract a raw material. The refusal of a permit or authorisation is based on the existence of the reasons stated in Section 11 or Section 12 BBergG.

During implementation, the extraction of raw materials is regularly divided into different phases - exploration, development, operation and aftercare phase.

The exploration serves the purpose of exploring raw material deposits in accordance with Section 4 para. 1 BBergG. In the marine area it is regularly carried out by geophysical surveys, including seismic surveys and exploration drilling. In the EEZ, the extraction of raw materials includes the extraction (loosening, release), processing, storage and transport of raw materials.

According to the Federal Mining Act, mining permits (permission, licence) must be obtained for exploration in the area of the continental shelf. These grant the right to explore for and/or extract mineral resources in a defined field for a specified period of time. Additional permits in the form of operating plans are required for development (extraction and exploration activities) (cf. Section 51 BBergG). For the establishment and management of an operation, main operating plans must be drawn up for a period not normally exceeding 2 years, which must be continuously updated as required (Section 52 (1) sentence 1 BBergG).

In the case of mining projects requiring an EIA Act, the preparation of a general operating plan is mandatory, and a planning approval procedure must be carried out for its approval (Section 52 (2a) BBergG). Framework operation plans are generally valid for a period of 10 to 30 years. Marine sand and gravel extraction on extraction sites of more than 25 ha or in a designated nature reserve or Natura 2000 area require an EIA under Section 57c BBergG in conjunction with the Ordinance on the Environmental Impact Assessment of Mining Projects (UVP-V Bergbau).

In the Baltic Sea, in addition to the coastal sea of Mecklenburg-Vorpommern, the fields Adlergrund North, Adlergrund North East and Adlergrund South West were approved for sand and gravel extraction in the EEZ during the planning period 2004 to 2009. These permits were partly based on mining rights from the period before German reunification. Even at the beginning of the planning process, the main operating plan approvals for these areas had expired, so that no further extraction took place. The permit for Adlergrund Nordost runs until 2020, while the permits for the two fields Adlergrund Nord and Südwest expired in 1991.

In the period from 2009 to 2019, no new permit or authorisation fields for sand and gravel extraction or hydrocarbons have been authorised in the German Baltic Sea EEZ.

As part of the procedure for the construction of the Fehmarn Belt tunnel, a permit (fixed Fehmarn Belt crossing) for the extraction of sand and gravel was granted in the territorial sea of Schleswig-Holstein and in the adjacent EEZ (source: LBEG).

In Adlergrund, only the Adlergrund Nordost permit (for which the Stralsund mining authority is responsible), which is valid until 31.12.2040, is still available. Three licence fields have been approved for the exploration of hydrocarbons: Oderbank, Plantagenet KW and Ribnitz. Each of these extends from the territorial sea into the EEZ.

The following table shows the effects of raw material extraction and potential impacts on the factors.

Table 21: Effects and potential impacts of raw material extraction (t= temporary).

Nutzung	Wirkung	Potenzielle Auswirkung	Schutzgüter																
			Benthos	Fische	See- und Rastvögel	Zugvögel	Meeressäuger	Fledermäuse	Plankton	Biotoptypen	Biologische Vielfalt	Boden	Fläche	Wasser	Luft	Klima	Mensch/ Gesundheit	Kultur- und Sachgüter	Landschaftsbild
Rohstoffe Sand- und Kiesabbau / Seismische Untersuchungen	Entnahme von Substraten	Veränderung von Habitaten	x	x			x		x	x	x	x						x	
		Lebensraum- und Flächenverlust	x	x			x		x	x	x	x	x					x	
	Trübungsfahnen	Beeinträchtigung	x t	x t	x t				x t					x t					
		Physiologische Effekte und Scheucheffekte		x t															
	Physische Störung	Beeinträchtigung des Meeresbodens	x							x		x	x					x	
	Unterwasserschall bei seismischen Untersuchungen	Beeinträchtigung / Scheucheffekt		x t			x												
	Visuelle Unruhe	Beeinträchtigung/ Scheucheeffekt			x														

Potential temporary effects result from underwater noise during seismic investigations and from turbidity plumes during raw material extraction and can lead to impairments and chilling effects. Potential permanent effects due to substrate extraction and physical disturbance result in habitat and area loss, habitat alteration and seabed degradation.

3.4.1 Floor/ Area

Sand and gravel extraction

In general, gravel and sand is extracted over a large area with a suction trailer hopper dredging. For technical and navigational reasons, a suction trailer hopper dredger with a towing head usually 2 m wide passes over the extraction field several times until the maximum permissible extraction depth is reached. Usually about 2 to 4 m wide furrows are created between which unused seabed remains. A residual thickness of the sediment worthy of extraction must be maintained in order to preserve the original substrate for repopulation. In the case of selective sediment extraction, the gravel sands are screened on board and the unused fraction (sand or gravel) is returned to the site.

Due to the mining technique described, a relief of multiple crossing furrows and the original seabed is created on the seabed. This topographical and morphological change is accompanied by an influence on the bottom-near flow pattern.

The expansion of the turbidity plumes which arise when material is returned depends on the grain size and the quantity of the returned material as well as the flow and its directional stability. Due to the low flow velocities in the Baltic Sea, a locally limited expansion of the turbidity plumes is to be expected. In the case of selective extraction, either the gravel or the sand fraction is returned to the water column.

Depending on grain size and water depth, the returned grain mixture is sorted: the coarse particles are deposited first, which are largely covered by the finer particles. In the further course of the process, a progressive sorting takes place as the finer sands are redistributed by the natural sediment dynamics; the coarser sand portion remains in the area of the return flow and undergoes less redistribution (ZEILER et al. 2004, DIESING, 2003).

In principle, the original substrate is to be preserved by means of area-based mining, provided that the thickness of the sands, gravel sands and gravel that can be mined is sufficient. Selective extraction leads to a change in the substrate; depending on the returned fraction, a refinement or coarsening of the original type of sediment takes place. While the gravel fraction is locally stable and does not undergo any significant rearrangement, the returned sand is more or less mobilised by the natural sediment dynamics. Due to the changed topography, this results in a trap effect of the furrows in which relocated, generally finer-grained sand accumulates and permanently alters the substrate (BOYD et al., 2004; ZEILER et al., 2004). Some of the physicochemical parameters can change due to the substrate change. A change in the grain composition results in different penetration depths for oxygen. This oxygen is consumed during the aerobic decomposition of organic matter, whereby the sediments that are degradable generally only contain a very small amount of organic matter. Due to the low level of pollution and the low impact on physicochemical parameters, which play a decisive role in the mobilisation of pollutants, no significant release of pollutants from the sediment can be assumed.

Extraction of hydrocarbons

There is currently no coal production in the Baltic Sea EEZ. Three licence fields have been authorised for the exploration of hydrocarbons in the territorial sea: Oderbank, Plantagenet KW and Ribnitz. These extend from the territorial sea into the EEZ.

In general, the following effects on the factor seabed or site can be expected (planning approval decision of the Clausthal-Zellerfeld Upper Mining Authority; now LBEG – State Office for Mining, Energy and Geology):

Constructional: The discharge of drill cuttings/drilling mud may be affected by load-induced compaction and material changes in the sediments. During the discharge of cuttings/drilling fluid, temporary turbidity can occur.

System-related: Effects may occur in the form of foundation-related compaction of the seabed, pollution caused by coatings and changes in the current conditions caused by the platform.

Operating conditions: Corrosion coatings, coating materials, sacrificial anodes used for corrosion protection may release harmful substances. The discharge of production water and waste water from the sewage treatment plant may have effects on the water and sediment.

In addition, as a result of the extraction of natural gas deposits, long-term seabed subsidence in the order of several metres is to be expected, which has been described or forecast for Norwegian and Dutch oil and gas fields (FLUIT UND HULSCHER, 2002; MES, 1990; SULAK UND DANIELSEN, 1989).

The effects described would exist both if the plan were implemented and if it were not implemented. However, by defining priority or reservation areas, the use of raw material extraction will be assigned more importance in spatial planning considerations in future. It is, therefore, more probable that the seabed in the priority and reservation areas will be affected when the plan is implemented than if it is not implemented.

3.4.2 Benthos and biotopes

The following comments are limited to the effects of the uses on benthic communities. Since biotopes are the habitats of a regularly recurring community of species, impairments to biotopes have direct impacts on the biotic communities.

Sand and gravel extraction

A number of physical and chemical effects of sediment dredging (HERMANN and KRAUSE, 2000) are possible, which are also relevant for marine benthos:

<u>Substrate removal and change of soil topography.</u> The most serious ecological effect of sand and gravel extraction is the reduction of the in or epifauna. This usually affects aspects of settlement density and biomass of benthic organisms more than species numbers. In Dutch studies by MOORSEL AND WAARDENBURG (1990, 1991, at ICES WGEXT 1998), immediately after extraction, settlement density was reduced by 70% and biomass by 80%, while species numbers were reduced by only 30%. Depending on the intensity and duration of the change in environmental conditions and sediment character, and the spatial distance for immigrant species, the regeneration of benthic fauna can take periods of between one month and 15 years or more (HERRMANN and KRAUSE, 2000). Repopulation depends not only on physical factors such as water depth, currents and swell, as well as sedimentological parameters, but also on the species composition. It is particularly important that the sediment character has not been changed by dredging. In general, the repopulation process can be divided into three phases (HERRMANN and KRAUSE, 2000):

- *Phase I*: Rapid re-colonisation by species that were dominant even before degradation (predominantly opportunistic species); species and individual numbers increase rapidly and may sometimes reach the initial level after a short time; biomass remains low, however.
- *Phase II*: The biomass remains significantly reduced over a longer period (several months to years). This may be due to the loss of older vintages of long-lived species (e.g. bivalve molluscs such as *Mya arenaria, Cerastoderma* spp. and *Macoma balthica*) or to the fact that repopulation is hindered by the continued relocation of sediments disturbed by degradation.
- *Phase III*: The biomass increases significantly, the cenoses regenerate completely.

  Very long-lasting changes in benthic communities are observed in mining areas where another sediment remains after dredging. The result is a permanent change in seabed fauna, often towards soft seabed communities (HYGUM, 1993, currently in HERRMANN and KRAUSE, 2000). In certain cases, there may also be a permanent change from soft to hard seabeds with a corresponding change in fauna (HERRMANN and KRAUSE, 2000). According to ICES (2016), the repopulation process is supported if the substrate after sampling has comparable properties to the substrate before sampling.

There is no concrete information on the SKO1 area. However, for the comparable gravel sand storage area "OAM III" in the North Sea EEZ, which is also located in a nature conservation area, environmental monitoring has shown that the mining activities carried out to date have not led to any fundamental change in the sediment structure or composition in the mining area. There were no statistically significant differences in the structure and species composition of macrozobenthos in the extraction and reference areas. Only the total biomass was, as expected, statistically significantly lower in the extraction area than in the reference area (IFAÖ 2019). Overall, the investigations show that the original substrate was preserved in the area and that there is a regeneration capacity, especially for species-rich gravel, coarse sand and shell seabeds.

Change in hydrographic conditions. Changes in soil topography can cause changes in hydrographic conditions and thus also in water exchange and sediment transport. As a consequence of changes in bathymetry, a local decrease in flow velocity may occur, leading to the deposition of fine sediments and local oxygen deficiency phaenomena (NORDEN ANDERSEN et al., 1992). This may have consequences for the bottom fauna. According to GOSSELCK et al. (1996), no effects on large-scale flow conditions are to be expected from sand and gravel mining, but small and mesoscale changes must be taken into account.

Turbidity plumes*. Turbidity* plumes can essentially occur at three points in the degradation process (HERRMANN and KRAUSE, 2000):

- Due to the mechanical disturbance of the sediment in the seabed by the dredger head
- The overflow water flowing back into the sea from the dredger
- The dumping of unwanted sediment fractions (screening).

Although increased turbidity can be observed up to a few hundred metres away from the excavator, and in some cases even several kilometres away, the concentration of suspended material normally decreases very quickly with distance (HERRMANN AND KRAUSE, 2000). A short-term occurrence of elevated concentrations of suspended material does not appear to be harmful to adult bivalve molluscs. The growth of filtering bivalve molluscs can even be promoted. However, eggs and larvae of one species are generally more sensitive than those of adults.

Although the concentration of suspended particles can reach levels that are harmful to certain organisms, the impact on marine organisms must be regarded as relatively low, since such concentrations occur only for a limited period of time and space and are rapidly reduced again by dilution and distribution effects (HERRMANN and KRAUSE, 2000).

Remobilisation of chemical substances. The resuspension of sediment particles can lead to the release of chemical compounds, such as nutrients and heavy metals. The oxygen content may decrease when organic substances are brought into solution (HERRMANN and KRAUSE, 2000).

According to measurements during dredging in the Belt Sea, the concentration of inorganic nitrogen and phosphorus in the overflow water can be 3 to 100 times higher (HYGUM, 1993). As regards nutrient levels, increases have been measured up to a distance of 180 m behind the dredger, with the highest concentrations recorded within the first 50 m (HERRMANN and KRAUSE, 2000). An increase in heavy metal concentrations (manganese and copper) was detected up to a distance of 12 m.

The chemical effects are generally considered to be relatively low, as the commercially used sands and gravels generally have a low content of organic and clay components and thus show little chemical interaction with the water column. Furthermore, the mining activities are limited in time and space. In addition, waves and currents cause rapid dilution of any increases in the concentration of nutrients and pollutants that may occur (ICES, 1992; ICES WGEXT, 1998)

Sedimentation and sanding: the dispersion of sediment particles depends to a large extent on the content of fine particles and the hydrographic situation (especially sea state, currents) (Herrmann and Krause, 2000). Drifting by suspended particles has been demonstrated in some cases up to 1,000 m from the dredging site. Most of the material, however, sediments at the extraction site or in its immediate vicinity. Furthermore, studies by Kenny and Rees (1996) showed that sediments that were disturbed by dredging can remain more mobile for longer periods of time due to tides and waves. Such a degradation-induced increase in sediment mobility can also lead to sedimentation phaenomena and impair the development of benthic organisms.

The practice of "screening" (dumping of unwanted sediment fractions) can also lead to a change in the soil substrate towards mobile sandy areas. The effects of sediment fallout from the overflow of ships on the benthic communities of areas not directly affected by dredging can vary greatly. The following possibilities have been observed in previous studies (ICES 1992):

- Initially, as in the dredging area, an almost complete death of the benthic fauna, but the subsequent re-colonisation is faster.
- The benthic fauna is damaged, but less severely than in the mining area, and subsequent repopulation is faster.
- Biodiversity and abundance are enhanced in the sedimentation area.
- The impact is insignificant.

The main risk of sedimentation is for sessile benthic organisms, such as bivalves and polychaetes. In addition, crustaceans such as lobsters can lose their habitat if the caves and crevices they inhabit are buried. Edible crabs, which are immobile during reproduction, are also at risk of sediment spillage and suffocation (ICES, 1992).

In summary, the main effects of sand and gravel extraction on marine benthos are as follows:

<u>Direct effects:</u>

- Temporary (short-term for opportunistic species; medium-term for long-lived species), regional (small-scale) loss of individuals of the benthic in and epifauna due to substrate removal.
- Temporary (short-term), regional (small-scale) damage to individuals, eggs and larvae of benthic organisms due to turbidity plumes
- Temporary (short-term) and regional (small-scale) impairment of benthic organisms due to the remobilisation of chemical substances
- Temporary (short-term) and regional (small-scale) impairments of development, possibly also loss of individuals of benthic organisms due to sedimentation and overlying sand.

<u>Indirect effects:</u>

- Temporary (short-term) and regional (small-scale) loss of settlement space for benthic organisms due to substrate removal if the sediment character is not changed by dredging.
- Permanent and regional (local) loss of settlement space due to possible changes in hydrographic conditions.
- Temporary (short-term) and regional (small-scale) impact on the food supply for benthic organisms by impairing primary production (phyto and zooplankton) due to the remobilisation of chemical substances.

3.4.3 Fish

Sand and gravel extraction

The extraction of sand and gravel in the Baltic Sea can change habitats and result in a loss of habitat for fish fauna. In addition, substrate extraction leads to turbidity plumes with associated sedimentation and resuspension of sediment particles, which can affect the fish fauna.

During the removal of substrates, fish are usually averted from their habitat. A **loss of area** depends on the geological condition of the material removed. A change in the sediment type after removal can make it difficult for some species to recolonise. Fish are significantly affected by the effects of sand and gravel extraction, especially when the extraction areas overlap with the spawning grounds, which is only the case for a few species in the Baltic Sea EEZ, such as the sand eel (HERRMANN & Krause 2000). Sand eels burrow into sediments and lay their eggs there. As a main food source for harbour porpoises, grey seals and various species of sea birds, habitat loss for sand eels through the food web could also affect other protected species. Connections between the abundance of sand eels and the breeding success of birds have been demonstrated for kittiwakes, for example (MACDONALD et al. 2019). Fish themselves are also indirectly affected by the loss of food resources, as the extraction of sand and gravel is accompanied by a reduction in the invertebrate infauna and epifauna in the area.

Sand and gravel extraction also causes **sediment upheavals and turbidity plumes**, which – although temporary and species-specific – can cause physiological impairments and aggravation. Predators such as mackerel and wood mackerel hunting in open water avoid areas with high sediment loads and thus avoid the danger of sediment sticking to the gill apparatus (Ehrich & Stransky 1999). A threat to these species as a result of sediment upheavals does not appear likely due to their high level of mobility. Neither is any impairment of bottom-dwelling fish to be expected due to their good swimming properties and the associated evasion possibilities. In the case of plaice and sole, increased foraging activity has even been observed following storm-induced sediment upheavals (EHRICH et al. 1998). In principle, however, fish are able to avoid disturbances due to their pronounced sensory abilities (lateral line organ) and their high level of mobility, so that impairments are unlikely for adult fish. Eggs and larvae, in which the reception, processing and implementation of sensory stimuli are not yet or only slightly pronounced, are generally more sensitive than adult conspecifics. After fertilisation, fish eggs form a dermis which makes them robust against mechanical stimuli, e.g. sediments that have been stirred up. Although the concentration of suspended particles can reach levels that are harmful to certain organisms, the effects on fish must be regarded as relatively low, since such concentrations occur only for a limited period of time and space and are quickly reduced again by dilution and distribution effects (HERRMANN & KRAUSE 2000).

This also applies to possible increases in the concentration of nutrients and pollutants due to the **resuspension** of sediment particles (ICES 1992;
ICES WGEXT 1998). The resuspension of sediment particles can lead to the release of chemical compounds such as nutrients and heavy metals. The oxygen content may decrease when organic substances are brought into solution (HERRMANN & Krause 2000). The chemical effects are generally considered to be relatively low for the Baltic Sea, as the commercially used sands and gravels generally have a low content of organic and clay components and thus show little chemical interaction with the water column.

In the **sedimentation of** the substrate released, the main risk is the covering of fish spawn deposited on the seabed. This can result in an undersupply of oxygen to the eggs and, depending on the efficiency and duration of the sedimentation process, can lead to damage or even death of the spawn. For most fish species present in the EEZ, no damage to the spawning stock is expected, as they either have pelagic eggs and/or their spawning grounds are in shallow water outside the EEZ. The early life stages may also be adapted to turbulence, which regularly recurs in the Baltic Sea due to natural phenomena such as storms or currents.

3.4.4 Marine mammals

Sand and gravel extraction

Sand and gravel extraction can cause sediment plumes as well as sedimentary changes and the associated damage to or alteration of benthic communities. Temporary effects on marine mammals due to noise emissions from vehicles involved in extraction would also be expected. In particular, turbidity plumes and changes in sediment structure and benthos can affect the quality of the habitat for marine mammals. However, these are local and temporary and any disturbance would therefore be negligible.

The non-implementation of the plan would not affect the existing or described effects of sand and gravel extraction on harbour porpoise, seals and grey seals.

Extraction of hydrocarbons

Possible impacts on marine mammals from the construction and operation of offshore platforms for the production of natural gas can be caused by shipping traffic, noise emissions, pollution through leakage and sediment plumes. In normal operation, platforms are expected to cause sediment and benthic changes. Attraction effects for fish caused by changes in the composition of benthos can in turn lead to attraction effects for marine mammals (consumers). Collisions of harbour porpoises with platforms are not known. In the event of accidents, pollutants can enter the marine environment, which can lead to contamination of marine mammals.

Direct disturbance to marine mammals at the individual level can only occur during the construction phase of gas production platforms. However, effects from shipping traffic and, above all, noise emissions during the construction phase are only expected to be regional and temporary. The formation of sediment plumes can largely only be expected locally and also for a limited period of time. A loss of habitat for marine mammals could thus occur locally and for a limited period of time.

Indirect effects due to pollutant discharges during normal operation and accumulation in the food chains should be prevented by appropriate measures according to the state of the art. Effects due to the release of pollutants in the event of an incident or accident cannot be excluded. These would mainly occur at specific locations.

The non-implementation of the plan would not affect the existing or described effects of hydrocarbon extraction on harbour porpoises, harbour seals and grey seals.

3.4.5 Seabirds and resting birds

Sand and gravel extraction

For seabirds, the extraction of sand and gravel may be affected mainly by turbidity plumes and visual disturbance caused by shipping traffic. Indirectly, sedimentary changes and associated changes in benthic communities may affect seabirds and resting birds via the food chain. These effects are generally weak for seabirds and resting birds, as the birds search for their prey organisms mainly in the water column over extensive areas.

The direct effects of turbidity plumes vary for seabirds, depending on their feeding strategy. Moreover, the turbidity plumes only cause turbidity locally.

Shipping traffic during excavation work can lead to avoidance behaviour for species sensitive to disturbance and thus to a temporary loss of habitat.

Overall, the impact on seabirds and resting birds from shipping traffic and the formation of turbidity plumes as a result of dredging is limited regionally and to the duration of the extraction work.

The above-mentioned effects on seabirds and resting birds are independent of the non-implementation or implementation of the plan.

Extraction of hydrocarbons

For seabirds and resting birds, the construction and operation of hydrocarbon extraction installations can cause potential impacts from the use-related shipping traffic in the form of visual disturbance and sediment plumes. In addition, sediment and benthic changes may occur. Attraction effects on fish due to changes in the composition of the benthos can, in turn, lead to attraction effects for their consumers, in this case seabirds (LOKKEBORG et al. 2002, FABI et al. 2004). Accidents can release pollutants and oil into the marine environment, which can also result in contamination of seabirds. Depending on the technical implementation of hydrocarbon extraction, the effects may be comparable to those of offshore wind energy (see Chapter 3.2.5).

The effects of usage-associated shipping traffic are to be expected above all for species sensitive to disturbance, such as divers, but are only regional and temporary.

The formation of sediment plumes can largely be expected to be local and also temporary.

Effects of sediment and benthic changes are generally not very pronounced for seabirds, as they search for their prey organisms mainly in the water column over extensive areas.

According to current knowledge, the effects of hydrocarbon extraction on seabirds and resting birds are mainly temporary and spatially limited. For further potential impacts comparable to the impacts of wind energy, please refer to Chapter 3.2.5

The above-mentioned effects on seabirds and resting birds are independent of the non-implementation or implementation of the plan.

3.4.6 Migratory birds

Sand and gravel extraction

The impact of sand and gravel extraction on migratory birds may be mainly due to the attracting effect of illuminated mining vehicles. These effects can occur especially at night in poor visibility and weather conditions, which can lead to collisions.

The above effects on migratory birds are independent of the non-implementation or implementation of the plan.

Extraction of hydrocarbons

In the extraction of hydrocarbons, illuminated structures can have an attracting effect. Depending on the technical implementation of hydrocarbon extraction, system-related effects comparable to those of offshore wind energy may occur (see section 3.2.7).

The above effects on migratory birds are independent of the non-implementation or implementation of the plan.

3.4.7 Air

Sand and gravel extraction

The shipping traffic associated with sand and gravel extraction will result in emissions of pollutants that may affect air quality. Significant adverse effects on air quality are not expected.

Extraction of hydrocarbons

The extraction of hydrocarbons is associated with emissions that can affect air quality. The emissions come in particular from shipping traffic (e.g. supply vessels) associated with offshore activities, drilling activities, construction activities (e.g. driving foundation piles) and from the operation of production platforms. The operation of the platforms emits e.g. carbon dioxide, nitrogen oxides and volatile organic compounds including methane. Significant adverse effects on air quality are not expected.

3.4.8 Cultural and other material goods

In principle, large-scale interventions in the seabed, such as dredging for sand and gravel extraction, increase the probability of finding archaeological traces. The primary risks relate to fully covered, previously unknown wrecks and prehistoric sites. In addition, dredging can influence current conditions and thus lead to local erosion, which successively covers and finally destroys new archaeological sites (cf. Gosselck et al. 1996).

The same applies to the extraction of stone material, which was already practised as near-shore stone fishing in the years 1840-1930 and in the years 1930-1976 down to depths of 6-12 m (Bock et al. 2003). In addition to changes in current and erosion conditions, wrecks can also be directly affected when the ballast stones above a wreck find are removed.

3.5 Fisheries

Traditionally, the entire North Sea and Baltic Sea EEZ has been used for fishing. In the Baltic Sea, coastal and cutter fisheries are the main activities. The larger cutters (18 - 24 m) are mainly used for trawling for herring and cod, while in the much larger small-scale cutter fishery, it is mainly gill nets, pots and rods that are used. In addition to German fishermen, Danish fishermen are also active in German waters, mostly with larger vessels.

The number of operations is declining sharply; in 2019, around 300 cutters were still being operated in Schleswig-Holstein and Mecklenburg-Western Pomerania as their main occupation, and around 500 as a side-line. This development is being promoted by greatly reduced quotas for the most important target species, cod and herring, whose stocks are threatened partly by overfishing, as well as by climatic influences.

Table 22: Effects and potential impacts of fishing (t= temporary).

Nutzung	Wirkung	Potenzielle Auswirkung	Schutzgüter																
			Benthos	Fische	See- und Rastvögel	Zugvögel	Meeressäuger	Fledermäuse	Plankton	Biotoptypen	Biologische Vielfalt	Boden	Fläche	Wasser	Luft	Klima	Mensch/ Gesundheit	Kultur- und Sachgüter	Landschaftsbild
Fischerei	Entnahme ausgewählter Arten	Reduzierung der Bestände	x	x							x								
		Verschlechterung der Nahrungsgrundlage			x														
	Beifang	Reduzierung der Bestände	x	x	x		x				x								
	Physische Störung durch Schleppnetze	Beeinträchtigung/ Schädigung	x	x			x			x		x						x	

3.5.1 Seabed/site

Trawls and static nets are used for fishing purposes in the Baltic Sea EEZ. The otter boards of bottom trawls generally penetrate the sandy to silty seabed of the Baltic Sea to a depth of a few millimetres to centimetres. This intervention, which varies over time and space, is subject to relatively rapid regeneration in the course of the natural sediment dynamics on the sandy seabed, so that the drag marks usually disappear within a few days or weeks. At greater water depths, especially in the Baltic Sea basins, the relatively deep drag marks are retained over long periods of time due to the low sediment dynamics.

The formation of turbidity plumes near the bottom and possible release of pollutants from the sandy sediments is negligible in areas with a relatively low proportion of fine grain (silt and clay) and low concentrations of heavy metals. In the area of silty seabeds, a significant release of pollutants from the sediment into the bottom water may occur. The pollutants generally adhere to sinking particles which, due to the low currents in the Baltic Sea basins, drift only very rarely over long distances and remain in their original environment. An exception to this are individual events, such as saltwater intrusion over the Danish Belts and Sounds, which under certain conditions and for a limited period of time can transport turbidity laterally near the seabed. In the long term, this remobilised material is deposited back into the muddy basins.

The effects on the seabed as a factor arise independently of the non-implementation or implementation of the plan.

3.5.2 Benthos and biotopes

Fishing for demersal fish species is important for benthos. Changes to the seabed caused by fishing gear in the Baltic Sea are almost exclusively caused by otter trawling, which leaves visible traces. While on a sandy seabed the observed penetration depth of the boards is less than 5 cm, the traces on a seabed bottom have depths of up to 23 cm (WEBER AND BAGGE, 1996). The impact of bottom trawling on the seabed and its living inhabitants has been little studied overall. Ultimately, fishing activities can kill epibenthos and endobenthos organisms through mechanical stress, or they can be removed from the system and returned overboard, usually damaged. For the Baltic Sea, the fragmentation of the *Arctica islandica* by the otter boards has been discussed by several authors. According to RUMOHR & Krost (1991), thin-shelled and large mussels are most affected. The most common damage is found on the fragile white pepper clam *Syndosmya alba*, but also about 50% of the large specimens of the Iceland clam are destroyed by the otter boards.

The extent of the damage depends not only on the sediment type and the penetration depth of the fishing gear but also on the frequency with which an area is fished. Furthermore, the degree of damage also depends on the species composition of the benthos, which can react differently to disturbances (SCHOMERUS et al., 2006).

The effects of fishing gear on benthic communities can be divided into short-term and long-term effects (WEBER et al., 1990):

- Short-term consequences: The animals freed from the fishing gear are partially injured or killed. The larger and hard-shelled representatives, such as sea urchins and swimming crabs, are particularly susceptible to this. The exposed and damaged animals are food for fish from the immediate vicinity. MARGETTS AND BRIDGER (1971) observed that dabs are more numerous and feed more actively in the towing track than in the surrounding area.
- Long-term consequences: Fishing activities increase the mortality of sensitive species until only opportunists can exist. Diversity decreases at the same time. The abundance increases for those species that are not damaged by fishing activities to the extent that sensitive species disappear from the biotope. Organic matter production could increase first, as the older, slow-growing specimens are replaced by fast-growing, young ones. As trawling activity increases, the younger animals will then also die, so that production will decline.

In summary, the main impacts of fishing on marine macrozoobenthos are as follows:

- loss of individuals, especially long-lived and vulnerable species, through fishing gear
- reduction of sedentary epifauna
- decline in biodiversity
- shift in the size spectrum of the soil fauna
- habitat levelling by removing stones when fishing.

3.5.3 Fish

Fisheries

Fisheries throughout the Baltic Sea involve some 5300 vessels and are concentrated on 17 fish stocks of 9 different species (ICES 2019). The main target species are cod, herring and sprat. Flatfish fisheries in the German EEZ target, among others, plaice, flounder, turbot or brill. When fishing, it is not only heavy bottom gear that is often towed, but relatively small meshes are also used, as a result of which by-catch rates of small fish and other marine animals can be very high.

The environmental impacts resulting from fishing are manifold and, in some cases, considerable. The basic problem is excessive fishing effort and overfishing of some stocks (see also Chapter 2.6.3Pre-pollution). Negative to critical inventory developments are a major problem in the Baltic Sea, as is the by-catch of young stocks, as this deprives the stocks of their future reproductive potential. As a result, the full reproductive potential of commercial fish stocks in the Baltic Sea is often not available. In addition to the direct mortality of target species, non-target by-catch species are potentially threatened by fishing. In particular, sharks and rays are very sensitive to fishing pressure, due to their very slow growth, late maturity and low fertility, with the possible consequence of stock decline in the Baltic Sea (ZIDOWITZ et al. 2017). In addition, demersal fishing has a negative impact on invertebrates, which are an important food source for many bony and cartilaginous fish.

A further effect of intensive fishing is the change in the age and length structure of the fish due to size-selective fishing methods. It is mainly larger older individuals that are taken, so that the proportion of smaller younger individuals in the fish community is increasingly predominant. This change in the fish community will probably have consequences above all for the reproduction of fish stocks. In general, small fish produce fewer and smaller eggs than their larger conspecifics.

Their fry is also more sensitive to a variable environment and may, therefore, be subject to increased mortality (TRIPPEL et al. 1997). This impact of fishing can lead to stock decline and changes within the community (such as dominance relationships).

In addition to the direct effects of fishing, the discharge of marine waste can lead to indirect negative impacts on fish fauna. In the Baltic Sea, around 10,000 bottom-set gill nets are lost every year, which continue fishing for years (German government 2020). Mortality caused by fishing ghost nets could contribute to stock decline and pose a problem especially for endangered fish species.

Aquaculture

Marine aquaculture, in particular fish rearing in net cages, can be associated with conflicts with the marine environment, which, with its effects, can also affect fishing communities. Inappropriate feeding methods can lead to feed losses, which pollute the seabed with organic material. This results in local oxygen shortages due to the oxygen-depleting microbial degradation of organic substrates. During disease outbreaks, an increased density of parasites and pathogens can also lead to an increased risk of transmission to natural stocks in the surrounding water near the plant. The escape of cultivated organisms is also problematic if they mingle with natural conspecifics and participate in reproduction. This can endanger genetic diversity (WALTER et al. 2003). If alien fish species escape and are able to establish themselves, native fish species may be displaced.

3.5.4 Marine mammals

Fisheries

In the Baltic Sea, bottom-set gill nets are used by the fishing industry due to the nature of the bottom. The main threat to harbour porpoises in the Baltic Sea is unwanted by-catch in nets (ASCOBANS, 2003, Evans 2020).

The non-implementation of the plan would not affect the existing or described impacts of fishing on harbour porpoise, seals and grey seals.

3.5.5 Seabirds and resting birds

Fisheries

Fisheries influence the occurrence of seabirds. Discards of by-catch from fishing activities provide additional food sources for some seabird species. This creates concentrations around fishing vessels. In particular, fulmar, skua, lesser black-backed gull, herring gull, little black-backed gull and great black-backed gull benefit from discards. In one study, a trend towards an increased number of birds (lesser black-backed gull, herring gull, little black-backed kittiwake and black-backed gull) with a correspondingly increased number of fishing vessels was clearly identified (GARTHE et al. 2006). In addition, seabirds and resting birds can, themselves, perish as by-catch in fishing nets.

The overfishing of important stocks that provide the food base for various species of seabird also limits food supply. Indirect effects of food limitation or the switch to other fish species as a food source are a reduction in the reproductive success and impairment of the survival chances of many bird species. In particular, the effects of overfishing and the decline in sand eel stocks from the North Sea are well known (FREDERIKSEN et al. 2006). For example, there are observations of reduced reproductive success in kittiwakes and guillemots from British breeding colonies, which are linked to the decline of sand eels as the main food for chicks. The spread of the sand eel-like straightnose pipefish in the North

Sea, which is often used by parent birds instead of the sand eel to feed the chicks, is not scientifically proven to provide an equivalent diet. Because of the hard consistency of the straightnose pipefish, the young birds are not able to use them as food. As a result, they remain undernourished or starve to death (WANLESS et al. 2006).

In summary, the main impacts of fishing on seabirds are as follows:

The effects of fishing can thus be limited in time and space by the actual fishing process, but can also be long-lasting and long-range through changes in food availability and prey spectrum.

Aquaculture

Sea birds and resting birds would be indirectly affected by the establishment of aquaculture through potential deterioration of water quality and through the food chains: pollutants, in particular growth hormone preparations and antibiotics, could also affect upper predators such as seabirds through accumulation in the food chain. Direct effects could also be caused by seabirds being trapped in cages or aquaculture farms.

The above-mentioned effects of fisheries and aquaculture on sea birds and resting birds are independent of the non-implementation or implementation of the plan.

3.5.6 Migratory birds

Fisheries

For migratory birds, fisheries cause visual and acoustic disturbance and flight effects that depend on the frequentation of marine areas. Migratory water birds that stop their migration to feed also run the risk of getting caught in fishing nets and drowning.

Aquaculture

The management of aquaculture facilities involves the transport of vessels and various offshore activities in the facilities, which cause visual and acoustic disturbance and flight over small areas.

The above-mentioned effects of fisheries and aquaculture on migratory birds are independent of the non-implementation or implementation of the plan.

3.5.7 Cultural and other material goods

Fishing with trawls can contribute to the destruction of archaeological layers and wreck finds. The trawls and their trawl boards penetrate the sediment of the seabed and can leave furrows up to 50 cm deep and 100 cm wide on a fine sandy bottom, which can even be seen in the side scan sonar image (Firth et al. 2013, 17). In individual cases, a targeted search is made for proximity to wrecks which, as hard substrate, form natural habitats and in whose vicinity larger fish populations can be expected. There are already many documented examples worldwide of the destruction of underwater cultural heritage caused by trawling (Atkinson 2012, 101). On the other hand, information on net hangers, when reported by fishermen, can also contribute to the discovery of underwater cultural heritage.

3.6 Marine Research

Extensive research and environmental monitoring activities take place in the German EEZ of the North and Baltic Seas. According to Art. 56 para. 1 UNCLOS, the coastal State has sovereign rights for the purpose of exploring and exploiting, conserving and managing the living and non-living natural resources of the waters above the seabed.

The BSH itself has been operating the MARNET monitoring network since 1989 - with the majority of monitoring stations in the German EEZ and a few more in the coastal seas of the North and Baltic Seas. The systematic measurements are used for long-term marine environmental monitoring. Unmarked ground frames with measuring instruments are installed around the stations at a distance of about 500 – 1000 m.

In the Baltic Sea EEZ, these include the FINO 2 station in the area of the Baltic 2 wind farm on the border with Denmark and Sweden, the Grosstonne Fehmarn Belt and the main diving buoy in the Arkona Basin.

The Thuenen Institute, the Institute for Baltic Sea Research (IOW) and other research institutions operate measuring stations in the Baltic Sea, conduct surveys on various research and monitoring questions and tasks. This is associated with different requirements regarding accessibility or avoidance of disturbances.

Within the framework of the German Small-scale Bottom Trawl Survey (GSBTS), several standard investigation areas ("boxes") in the North Sea and the Baltic Sea have been sampled since 1987 by the Thuenen Institute of Sea Fisheries (with the vehicles SOLEA, Walter Herwig III).

The TI is investigating abundances and distribution patterns of bottom-dwelling fish in the North Sea on a small scale. To this end, annual fishing with a standardised bottom trawl net is carried out in 12 standard study areas ("boxes"), each measuring 10 x 10 nautical miles. The present data set forms an important basis for assessing long-term changes in the North Sea bottom fish fauna caused by natural (e.g. climatic) influences or anthropogenic factors (e.g. fisheries).

The GSBTS uses a standardised bottom trawl with a high-density otter trawl of the GOV type to sample small-scale bottom fish communities. In parallel, epibenthos (by means of a 2 m beam trawl), infauna (by van Veen grab) and sediments will be studied, and hydrographic and marine chemical parameters of habitats typical for the region will be recorded.

The following impacts on the marine environment are possible through the use of marine scientific research.

Table 23: Effects and potential impacts of marine research (t= temporary).

Nutzung	Wirkung	Potenzielle Auswirkung	Schutzgüter																
			Benthos	Fische	See- und Rastvögel	Zugvögel	Meeressäuger	Fledermäuse	Plankton	Biotoptypen	Biologische Vielfalt	Boden	Fläche	Wasser	Luft	Klima	Mensch/ Gesundheit	Kultur- und Sachgüter	Landschaftsbild
Meeres-forschung	Entnahme ausgewählter Arten	Reduzierung der Bestände		x															
	Physische Störung durch Schleppnetze	Beeinträchtigung/ Schädigung Beifang	x	x						x		x						x	

3.6.1 Seabed/site

The various marine research activities are associated with a range of environmental impacts, depending on the type of methods and equipment used. Of particular importance for the seabed as a factor are fisheries research activities which involve physical disturbance of the seabed surface by trawls. Bottom trawls generally penetrate the seabed to a depth of several millimetres to centimetres on sandy soils.

It cannot be ruled out that, as a consequence of regular fishing, sediment grain sorting may take place on the seabed as a result of the accumulation of previously stirred up fine sandy sediment on the seabed surface. The fact that the natural sediment dynamics, especially during intensive sand redistributions during storms, cause the upper tens of centimetres to be mixed completely, thus restoring a largely natural sediment composition, speaks against this.

The formation of turbidity plumes near the bottom and the possible release of pollutants from the sediment is negligible in areas with a relatively low proportion of fine sediment grain and low heavy metal concentrations. In areas with a high fine grain content (e.g. the basins), a significant release of pollutants from the sediment into the bottom water can occur. The pollutants generally adhere to sinking particles which, due to the low velocity bottom currents in the Baltic Sea basins, hardly drift at all over long distances and remain in their original environment. In the medium term, this remobilised material is deposited again in the silty basins.

The effects on the seabed as a factor arise independently of the non-implementation or implementation of the plan.

3.6.2 Benthos and biotopes

The various marine research activities are associated with a range of environmental impacts, depending on the type of methods and equipment used. For example, sampling can lead to damage of varying degrees and even to the death of individual benthic organisms. Similarly, the use of specific methods and equipment can result in a wide range of material emissions to a small extent. In principle, it can be assumed that intensive research activities, especially on sensitive species or in sensitive habitats, can lead to considerable environmental impacts. Overall, however, it can be assumed that marine research is aimed at minimising environmental impacts and is adapted to the requirements for the protection of endangered species.

In summary, the main impacts of research activities on marine macrozoobenthos are as follows:

- local, temporary damage or loss of individuals due to the sampling
- local, temporary effect due to the increase in pollutant inputs.

The impacts on benthic communities and biotopes listed above arise independently of the non-implementation or implementation of the plan.

3.6.3 Fish

The various marine research activities have different impacts on the fish fauna depending on the methods and equipment used. For example, sampling can lead to damage of varying degrees and even death of fish. Sampling of fish could contribute to the decline of some species. Intensive research activities, especially on sensitive species or in sensitive habitats, could have significant environmental impacts. In general, however, marine research in the Baltic Sea identifies negative developments in the ecosystem at an early stage and makes targeted recommendations. In the long term, various marine research projects can thus make an important contribution to preserving the marine environment.

3.6.4 Marine mammals

The following potential impacts of research on marine mammals are possible: small-scale and temporary impacts from by-catch in fisheries research, localised, temporary impacts from fishing vessels and sub-regional, temporary impacts from seismic and other noise-intensive research activities.

The non-implementation of the plan would not affect the existing or described impacts of marine research on harbour porpoises and on harbour seals and grey seals.

3.6.5 Seabirds and resting birds

Marine research can have a range of impacts on seabirds and resting birds, depending on its objectives and design. Fisheries research focuses on by-catch and discard impacts. The use of vessels can lead to visual disturbance effects on species sensitive to disturbance, triggering avoidance behaviour. Indirectly, fisheries research can have an impact on the marine food chain and influence the food supply for seabirds and resting birds.

Overall, the impacts of marine research can be described as small-scale and limited to the duration of the research activity.

Due to the small-scale, time-limited activities involved in scientific research, significant impacts on seabirds can be safely ruled out.

The above-mentioned effects on seabirds and resting birds are independent of the non-implementation or implementation of the plan.

3.6.6 Migratory birds

The various marine research activities are associated with a range of environmental impacts, depending on the methods and equipment used. For migratory birds, short-term and small-scale visual and acoustic disturbance effects may be relevant. However, these effects are small-scale and limited in duration.

In addition, research activities may be linked to the installation of structures. These could have an impact at night in bad weather conditions, when migratory birds are attracted by illuminated structures and could potentially collide with them.

The above-mentioned effects on seabirds and resting birds are independent of the non-implementation or implementation of the plan.

3.6.7 Cultural and other material goods

When assessing the impact of marine research or even archaeological research, a distinction must be made between intrusive and non-intrusive research methods. Non-intrusive research methods, such as geophysical or acoustic mapping of the seabed, are generally not expected to have negative effects. On the contrary, the results could also be used for research into the underwater cultural heritage.

During the taking of seabed samples by drill cores, archaeologically relevant layers could be punctured, but the disturbance of these layers is insignificant due to the small area involved. Sampling by excavator grabs can have a greater impact on potential cultural property, but an information gain in the recording and reporting of archaeological finds is usually of greater value than any potential destruction.

3.7 Nature conservation

The German EEZ represents a special natural area with a great diversity of species, biotic communities and habitat-typical processes.

In contrast to Nachholbedarfeother types of use, marine nature conservation is not a use in the narrower sense, but rather an existing basic area-wide spatial functional claim, which must be taken into account when other uses take advantage of it. The transboundary character of marine nature should also be emphasised. Marine nature and all related processes are part of a large-scale, dynamic system without being bound by political boundaries.

In accordance with Article 57 of the Federal Nature Conservation Act (BNatSchG), the ordinances of 22 September 2017 included the existing bird protection areas and FFH areas in the German EEZ in the national area categories and declared them nature conservation areas. Within this framework, they were partially regrouped. For example, the Regulation on the designation of the "Fehmarnbelt" nature reserve (NSGFmbV), the Regulation on the designation of the "Kadetrinne" nature reserve (NSGKdrV) and the Regulation on the designation of the "Pomeranian Bay - Rönnebank" nature reserve (NSGPBRV) now establish the "Fehmarnbelt", "Kadetrinne" and "Pomeranian Bay - Rönnebank" nature reserves.

Article I 6 (1) of the Habitats Directive provides that Member States shall establish the necessary conservation measures and, where appropriate, draw up management plans (also known as management plans). BfN began the participation procedure for the management plans for the nature conservation areas in the German EEZ in the Baltic Sea in August 2020.

3.7.1 Seabed/site

One of the aims of establishing national marine protected areas is to achieve or maintain the favourable conservation status of habitat types such as "reefs" and "sandbanks" and biotopes, such as the "KGS beds". Protection of these habitat or biotopes is also accompanied by protection of sediment deposits, such as coarse sand, gravel, residual sediment areas and boulders, in the protected areas. The protective measures taken in the management plans are associated with a positive effect on the seabed as a factor. Furthermore, the marine protected areas represent exclusion zones for wind energy.

As the spatial plan supports nature conservation by identifying priority areas, the protection of the seabed in national marine protected areas would probably be less well ensured if the plan were not implemented.

3.7.2 Benthos and biotopes

The aim of designated nature reserves and protected area measures is to safeguard the ecological functions of protected species and habitats. Among other things, this means that the desired target statuses for the Habitats Directive habitat types "reefs" and "sandbanks" with the corresponding benthic biotic communities are to be achieved through appropriate measures. If the plan were not implemented, the positive effects on benthic habitats of designating nature conservation areas as priority areas would probably be less likely to be achieved.

3.7.3 Fish

Marine protected areas of sufficient size could have a positive impact on the fish community and help to prevent overexploitation of fish stocks.

The FFH species Baltic sturgeon and twait shad are both protected under the Protected Areas Ordinance in the "Pomeranian Bay - Rönnebank" nature reserve (BfN 2020). Both species are anadromous migratory fish and use the marine protected area as a feeding habitat. Overall, various fish species, whether FFH, Red List (THIEL et al. 2013) or commercially exploited species, can occur in all three marine protected areas and benefit from them. Previous studies have shown an increase in abundance, biomass and species diversity within marine protected areas of sufficient size and protection status ("no-take areas"/"no-trawl areas") compared to unprotected areas (CARSTENSEN et al. 2014, MCCOOK et al. 2010, STOBART et al. 2009). In addition, the age-length structure could shift towards older, larger individuals with increased reproduction (CARSTENSEN et al. 2014). The result would be improved recruitment and, thus, increased productivity of fish stocks. However, there is a need for research on the impact of nature conservation areas on the fish community in the Baltic Sea. A direct transfer of the available international findings is only possible to a limited extent, as important influencing variables, such as other uses in the protected area or climatic changes are largely ignored. In general, according to scientific findings, the benefits for the fish fauna are higher in nature reserves without any uses whatsoever compared to partially protected areas (LESTER & HALPERN 2008, Sciberas ET al. 2013). In German marine protected areas, other uses, such as fishing, are permitted in some cases. There are currently no uses in the most relevant protected area of the fish fauna "Pomeranian Bay - Rönnebank". Accordingly, the fish community has a refuge at its disposal, from which they could benefit considerably. The extent to which the fish community in the Baltic Sea has so far recovered as a result of marine protected areas cannot be conclusively assessed due to a lack of studies. Overall, according to the current state of knowledge, all marine protected areas in the Baltic Sea can have a significant positive impact on the fish community.

3.7.4 Marine mammals

The protection of endangered and characteristic species and habitats is of great importance in order to maintain healthy marine ecosystems and marine biodiversity. The development of the Natura 2000 network and the establishment of the nature reserves "Pomeranian Bay - Rönnebank", "Kadetrinne" and "Fehmarnbelt" will contribute to the conservation or restoration of stocks of protected and characteristic species and their habitats.

3.7.5 Seabirds and resting birds

The protection of nature and habitats contributes to the maintenance or restoration of stocks and habitats. In this context, nature reserves and other areas of particular importance have an important function in maintaining ecological links between the different levels of the food web. Adequate protection of habitats also serves, in particular, to protect endangered species and conserve species.

3.7.6 Migratory birds

Many bird species migrating across the German North Sea rest on their migration to their wintering or breeding grounds in the EEZ. The general impacts of nature conservation on seabirds and resting birds described in Chapter 3.7.4therefore also apply accordingly to many migratory bird species.

3.8 Other uses without spatial specifications

For other uses, the ROP-E does not specify any spatial specifications, but only general textual specifications.

3.8.1 National and alliance defence

3.8.1.1 Fish

The impact of military uses on fish fauna is difficult to assess due to military secrecy. The fish fauna could be affected in particular by underwater noise and the introduction of dangerous substances. Depending on the level, underwater sound can lead to flight effects (shipping traffic) or even the death of individual fish (e.g. detonation). For detailed effects of underwater sound on fish fauna, see Chapters 3.1.4and 3.2.3 In general, military activities, such as firing exercises or submarine manoeuvres, are limited in space and duration.

Other adverse effects of military events could be caused by the release of toxins from munitions dumps and wrecks located on the seabed of the Baltic Sea. Chemical warfare munitions have been sunk mainly in deep areas of the Baltic Sea (LANG et al. 2017). Little is known about the extent to which the progressive corrosion promotes the release of toxic substances and how this affects the health status of fish. Initial results from the Thuenen Institute for Fishery Ecology showed no difference in the health status of cod from the main area for chemical warfare agent munitions east of Bornholm compared to an uncontaminated reference area (LANG et al. 2017). Nevertheless, an increased accumulation of pollutants in fish cannot be ruled out. There is a need for research on effects on different species and life stages, the reproductive capacity or the spread of toxic substances via the food web.

3.8.1.2 Avifauna

General effects of national defence on birds may include, in particular, visual disturbance from shipping or low-flying air traffic. In general, military activities, such as firing exercises or submarine manoeuvres, are limited in space and duration. In addition, direct and indirect effects, e.g. via the food chain, are possible through the introduction of dangerous substances, such as the release of toxic substances.

The general impact of national defence on birds does not distinguish between non-implementation or implementation of the plan.

3.8.2 Leisure

3.8.2.1 Fish

Leisure activities can affect the fish fauna of the Baltic Sea in a number of ways. Landings from recreational fisheries do not generally have to be reported to state institutions from the marine area, so there are no scientifically usable catch statistics for the Baltic Sea (BFAFi 2007). According to HYDER et al (2018), recreational fisheries in the Baltic Sea focus on the species cod, European eel, salmon and sea trout. The removal of individual fish by anglers and hobby fishermen could contribute to the decline in the populations of these species, with particularly negative effects on the populations of endangered species.

Further impairments due to leisure activities are caused by underwater noise (for details, see Chapter 3.1.4) and rubbish discharges (see Chapter 3.5.3).

3.8.2.2 Avifauna

The general effects of recreational activities on birds can be caused, in particular, by visual disturbance from recreational traffic. There may also be direct and indirect effects via the food chain through the disposal and introduction of waste into the marine environment.

There is no difference in the general impact of recreational use on birds in the absence or implementation of the plan.

3.9 Interactions

It is assumed that the interactions between the factors will develop in the same way if the plan is not implemented as if the plan were implemented. Reference is made here to Chapter 2.17

4 Description and assessment of the likely significant impacts on the marine environment of implementing the Spatial Plan

In the following, the description and assessment of the environmental impacts of the plan focus on those protected assets for which significant impacts on the marine environment as a result of implementing the Spatial Plan cannot be ruled out right from the start.

According to Section 8 of Germany's Federal Regional Planning Act (ROG), the probable significant impacts of the Spatial Plan on the protected assets must be described and evaluated. The Spatial Plan sets a framework for downstream planning levels.

Not taken into account are the protected assets for which significant impairments could already be ruled out in Section 2 above. This applies to plankton, air, cultural heritage and other material assets as well as to human beings, including human health.

Possible impacts on biodiversity as a protected asset are addressed for each individual biological asset. Overall, the protected assets listed in Section 8 subsection (1) of the ROG are examined before then presenting the reviews of the laws and regulations governing species protection and conservation of natural habitats.

4.1 Shipping

In the Baltic Sea Exclusive Economic Zone (EEZ), priority areas SO1 to SO4 are defined.

When assessing the environmental impacts of shipping, a distinction must be made between the impacts caused by the use of shipping (see table) and the impacts specifically attributable to the provisions of the draft Spatial Plan.

The priority areas identified must be kept free of any use for erected structures. This control measure in the Spatial Plan will reduce collisions and accidents. Based on the provisions of the Spatial Plan, the frequency of traffic in the priority areas is expected to increase, in particular due to the increase of offshore wind farms along the shipping routes. Ship movements on the shipping routes SO1 to SO4 vary considerably, with about 1 to 6 ships per day operating on the routes (BfN, 2017).

As a precautionary measure, the designation of exclusively priority areas for shipping serves to minimise risk. In addition, it must be taken into account that the freedom of navigation must be ensured in accordance with United Nations Convention on the Law of the Sea (UNCLOS) and that the possibility of regulation by the International Maritime Organization (IMO) is much stronger in international conventions than in the Spatial Plan.

The general impacts due to shipping are presented in Section 2 as a legacy impacts, especially for birds and marine mammals. The impacts of service traffic to the wind farms are addressed in the Section on wind energy.

4.1.1 Soil / Area

As the impacts of shipping on the seabed occur independently of whether or not the plan is implemented, the Spatial Plan does not have any other impacts than those described in Section 3.1.1. The principle in the Spatial Plan of reducing pressures on the marine environment through best environmental practice in accordance with international conventions can contribute to a reduction or prevention of pollutant inputs.

Any significant negative impacts on the seabed caused by the Spatial Plans provisions governing shipping can be ruled out.

4.1.2 Water

The effects of shipping on the protected resource water arise independently of whether or not the Spatial Plan is carried out. Considerable impacts on this protected resource as a result of the Spatial Plan provisions governing shipping can be ruled out.

4.1.3 Benthos and biotope types

With regard to use for shipping, there are no further concrete impacts arising from the provisions of the Spatial Plan compared to the general impacts from use described in Section 3.1.3 Significant impacts on benthic communities and biotopes as a result of the Spatial Plan's provisions governing shipping can thus be ruled out.

4.1.4 Fish

No significant impact of fish populations is expected to occur from the provisions governing shipping.

4.1.5 Marine mammals

The priority areas for navigation are based in particular on existing shipping routes identified in the procedure for updating the Spatial Plan. The purpose of these definitions is to help reduce risks by identifying important shipping routes of incompatible uses. The definition of priority areas for shipping does not have a direct concentration and steering effect on shipping traffic. Shipping can continue to use the entire maritime space in the future. In this respect, the establishment of shipping priority areas has no additional impact on marine mammals as a whole compared to the current situation and the zero option.

The Spatial Plan also makes further statements regarding reducing the burden on the marine environment by complying with IMO regulations and taking into account best environmental practice in accordance with the OSPAR and HELCOM Conventions and the current state of the art in shipping. This serves to prevent negative impacts on the protected assets.

On the basis of the above statements and the information presented in Section 3, the SEA concludes that no significant impacts on marine mammals are to be expected as a result of the provisions for shipping in the Spatial Plan, but rather that, compared with non-implementation of the plan, adverse impacts will be prevented, in particular by reducing conflicts of use.

4.1.6 Seabirds and resting birds

The general effects of shipping on seabirds and resting birds are described in Section 3.1.6.

The spatial planning definitions of priority areas for shipping reflect the main traffic flows in the EEZ where shipping is given priority over other uses of spatial importance. This objective of spatial planning serves in particular to prevent conflicts (collisions) with offshore wind farms and, as a consequence, potential disasters affecting the marine environment and thus also seabirds and resting birds. The provisions for shipping do not automatically lead to an increase in traffic in the priority areas, as shipping already enjoys special freedoms under Article 58 of the Convention on the Law of the Sea, and is therefore not bound to specific routes.

Additional or significant impacts on seabirds and resting birds due to the plan’s provisions for navigation can thus be ruled out with the necessary certainty.

4.1.7 Migratory birds

With regard to the use of shipping, there are no additional concrete impacts arising from the provisions of the Spatial Plan compared to the general impacts described in Section 3.1.7. Significant impacts on migratory birds due to the provisions of the Spatial Plan governing shipping can be ruled out with the necessary degree of certainty.

4.1.8 Bats

With regard to the use of shipping, there are no additional concrete impacts arising from the provisions of the Spatial Plan compared to the general impacts described in Section 3.1.8. Significant impacts on bats based on the provisions of the ROP governing shipping can be ruled out with the necessary degree of certainty.

4.1.9 Air

Shipping generates pollutant emissions. These can have a negative impact on air quality. However, this is independent of the implementation of the Spatial Plan.

4.1.10 Climate

The provisions governing shipping are not expected to have any significant impact on climate.

4.2 Offshore wind energy

In the Baltic Sea EEZ, areas EO1 and EO3 are designated as priority areas for wind energy, while area EO2 is designated as the wind energy reserve.

4.2.1 Soil / Area

The erection and operation of offshore wind energy installations causes impacts more of a local nature on the seabed (soil) as a protected asset (see Section 3.2.1) which arise irrespectively of whether the Spatial Plan is implemented or not. However, the definition of priority and reservation areas for the use of offshore wind energy reduces negative impacts on the seabed by ensuring that the priority and reservation areas defined for offshore wind energy allow for coordinated expansion, and thus also reduce land use. The nature conservation priority areas contribute to safeguarding open space, as uses incompatible with nature conservation are excluded from these areas.

The priority areas in the Baltic Sea shown in the Spatial Report correspond to the priority areas defined in the current Site Development Plan (SDP) which are necessary to achieve the expansion target of 20 GW. The aim of the SDP is the spatially and temporally coordinated expansion of offshore wind power generating capacity so that the impacts on the protected assets of soil and area resulting from this use can be mitigated or even prevented altogether.

Overall, the provisions of the Spatial Plan are not expected to have any significant impacts on the protected assets soil or area.

4.2.2 Benthos

The use of wind energy can have an impact on macrozoobenthos. These effects apply equally to all defined areas for wind energy use.

The inventory of species in the Baltic Sea EEZ, with its approximately 260 macrozoobenthos species, can be regarded as average.

<u>Construction-related impacts:</u> Construction of the deep foundations of offshore wind energy installations cause disturbances of the seabed, sediment turbulence and the formation of turbidity plumes. This can lead to the impairment or damage of benthic organisms or communities in the immediate vicinity of the installations for the duration of construction activities.

During the erection of these installations, it is mainly the resuspension of sediment that leads to direct impairments of the benthic community. During the foundation work for the installations, turbidity plumes are to be expected. However, the concentration of suspended material usually decreases very quickly with removal. Benthic organisms can also be affected in the short term and on a small scale by the release of nutrients and pollutants associated with the resuspension of sediment particles.

The construction-related impacts caused by the turbidity plumes and sedimentation are to be classified as short-term and small-scale.

<u>Depending on the installation,</u> changes in the benthic community may occur due to local land sealing, the introduction of hard substrate and

changes in the flow conditions around the installations. In addition to local habitat losses or habitat changes, new non-situational hard substrate habitats are created.

According to current knowledge, no operational impacts of wind turbines on macrozoobenthos are expected to occur.

On the basis of the above statements and representations, the result of the SEA is that, according to the current state of knowledge, no significant impacts on the protected resource benthos are to be expected from the use of wind energy. Overall, the impacts on the protected asset benthos are estimated to be short-term and small-scale. Only small-scale areas outside protected areas are taken up and, due to the usually rapid regeneration capacity of the existing populations of benthic organisms with short generation cycles and their widespread distribution in the German Baltic Sea, rapid repopulation is very likely.

4.2.3 Biotope types

Possible impacts of wind energy use on the protected asset biotope types can arise from the direct use of protected biotopes by the foundations of wind turbines, possible cover by sedimentation of material released during construction, and potential habitat changes. These impacts apply equally to all defined areas for wind energy use.

No significant construction-related use of protected biotopes by the installations is to be expected, as protected biotopes under Article 30 of the Federal Nature Conservation Act are to be prevented to the greatest extent possible within the framework of the specific approval procedure. Owing to the predominant sediment composition in areas where the occurrence of protected biotopes is to be expected, impairments due to sedimentation are likely to be small-scale, since the sediment released will settle quickly.

Due to the nature of the installations, permanent habitat changes occur, but these are limited to the immediate vicinity of the installations. The artificial hard substrate provides new habitats for benthic organisms and can lead to changes in species composition (SCHOMERUS et al. 2006). These small-scale areas are not expected to have any significant impacts on biotope types as a protected asset. In addition, it is highly probable that species will be recruited from natural hard substrate habitats, such as superficial boulder clay and stones. This means that the risk of negative impacts on the benthic soft soil community by non-native species is low.

According to current knowledge, operational impacts of wind energy use on biotopes are not to be expected.

4.2.4 Fish

In the priority areas for wind energy use, the typical and characteristic species of both the pelagic and demersal components of the Baltic Sea fish communities considered were found to be consistent. For all priority areas it is equally true that no significant impacts at population level are to be expected from the construction, foundations and operation of the wind turbines.

On the basis of the current state of knowledge, the SEA concludes that the provisions for wind energy in the Spatial Plan are expected not only to have no significant impacts on fish as a protected resource, but rather also to prevent negative impacts that could arise if the plan is not implemented.

4.2.5 Marine mammals

The overall impact of wind turbine generators (WTG) on marine mammals arising from the designation of priority areas for wind energy is expected to be negligible. This is also true when considered cumulatively.

The function and importance of the priority areas in the German Baltic Sea EEZ for harbour porpoises were assessed in Section 2 based on the current state of knowledge.

By establishing priority areas for offshore wind energy in ecologically suitable locations outside nature conservation areas, negative impacts on marine mammals are prevented and mitigated. In addition, to protect the marine environment, provisions have been made to take account of best environmental practice under the OSPAR and Helsinki Conventions and the state of the art. In this context, rules must be laid down governing the prevention and reduction of negative impacts on marine mammals caused by the construction and operation of WTGs, in particular in the form of noise reduction measures, which may also provide for the co-ordination of construction work on projects constructed at the same time. This corresponds to current licensing practice. Significant impacts on harbour porpoises, harbour seals and grey seals can be ruled out on the basis of the function-dependent importance of the priority areas for wind energy and the principles adopted in the Spatial Plan as well as the measures ordered in the downstream licensing procedures and taking into account the current state of the art in science and technology in reducing impact noise loads. Direct disturbances of marine mammals at the individual level due to noise emissions during the construction phase, in particular during pile driving, are to be expected on a regional and temporal scale. However, due to the high mobility of the animals and the above-mentioned measures to be taken to prevent and reduce intensive noise emissions, significant effects can be ruled out with a high degree of certainty. This also applies from the standpoint that shipping could have an impact on disturbance-sensitive marine mammals, as these impacts are only very brief and local. Sediment plumes can be expected to occur largely at local and temporal scales. Habitat loss for marine mammals could therefore be local and temporary. Effects of sediment and benthic changes are insignificant for marine mammals, as they seek their prey organisms mainly in the water column in broadly expansive areas. Effects at the population level are not known and are rather unlikely due to predominantly short-term and local effects in the construction phase.

Significant impacts on marine mammals in the priority areas arising from WTGs in their operational phase can also be ruled out with certainty on the basis of the current state of knowledge. Investigations carried out to date as part of the operational monitoring of offshore wind farms have so far not yielded any indication of detectable avoidance effects among harbour porpoises due to wind farm related shipping traffic. Avoidance could so far only be detected during the installation of the foundations, which may possibly be related to the large number and the different operating conditions of vessels/vehicles at the construction site.

In summary, the establishment of priority areas outside the main feeding and rearing areas for harbour porpoises indirectly serves to protect the species. At the same time, priority areas for nature conservation help to safeguard open spaces, as uses incompatible with nature conservation are prohibited there. This reduces threats to harbour porpoises with important feeding and rearing grounds. On the basis of the above statements and the descriptions provided in Section 3, the SEA concludes that not only will the designation of priority areas for wind energy in the Spatial Plan for the German Baltic Sea EEZ have no significant impacts on marine mammals, even from a transboundary perspective, but rather that, compared with not implementing the plan, it will serve to prevent adverse impacts.

4.2.6 Seabirds and resting birds

The general effects of offshore wind series on seabirds and resting birds are described in Section 3.2.5

The draft Spatial Plan identifies areas EO1 and EO3 as priority areas for offshore wind energy in the Baltic Sea EEZ. Area EO2 is designated a reserved area.

Priority areas will be identified in areas where offshore wind farm projects have already been implemented. The designation of the EO2 area as a reserve area for offshore wind energy takes into account the review of the area, including consideration of bird migration in the 2019 SDP (BSH 2019). The nature conservation priority areas contribute to securing open space, as uses incompatible with nature conservation are prohibited there. This reduces negative impacts on seabirds and contributes to the protection of these important habitats.

The provisions for offshore wind energy may lead to a spatial concentration of shipping traffic in some parts of the EEZ due to the existing navigation regulations. However, it can be assumed that this congestion will take place in traffic areas which already have a high level of shipping activity.

According to the current state of knowledge, the provisions of draft Spatial Plan for offshore wind energy will not have any additional or significant impacts on the protected assets seabirds and resting birds.

4.2.7 Migratory birds

The general effects of offshore wind energy on migratory birds are described in Section 3.2.6

By defining priority and reservation areas in a mutual spatial context, barrier effects and collision risks in important food and resting habitats are reduced. The designation of the EO2 area as a reserved area for offshore wind energy takes account of the area's status as a priority area in the 2019 SDP (BSH 2019).

On the basis of the current state of knowledge, significant impacts arising from the plan’s provisions on migratory birds can be ruled out with the necessary certainty, in particular in comparison with non-implementation of the Spatial Plan.

4.2.8 Bats and bat migration

The general, the effects of offshore wind energy on bats and the current state of knowledge of bat migration over the Baltic Sea are described in Section 3.2.7

There is currently no evidence that the spatial planning regulations have a significant impact on bats. By defining priority and reservation areas in a spatial context, barrier effects are reduced and important habitats are protected. The nature conservation priority areas contribute to safeguarding open spaces, since uses incompatible with nature conservation are prohibited in these areas.

4.2.9 Climate

The provisions on offshore wind energy are not expected to have any significant negative impact on climate.

The reduction in CO2 emissions associated with the expansion of offshore wind energy (cf. Section 1.8) can be expected to have positive effects on the climate in the long term.

4.2.10 Landscape

The construction of offshore wind farms in the priority and reservation areas for wind energy will have an impact on the landscape as a protected asset, as it will be altered by the erection of vertical structures and safety lighting. The extent of these visual impairments to the landscape caused by the planned offshore installations will depend to a large extent on the respective visibility conditions. Due to the distance of the priority areas to the Baltic Sea coast of more than 25 km, the installations will be very limited in visibility from land (HASLØV & KJÆRSGAARD 2000) and only under good visibility conditions. This also applies to night-time safety lighting. Due to subjective perceptions as well as the basic attitude of the observer towards offshore wind energy, the vertical structures – untypical for a marine and coastal landscape – can be perceived partly as disturbing, but partly also as technically interesting. In any case they cause a change in the landscape, and the character of the area is modified.

Beyond the coast, the visual impairment of the landscape changes with greater spatial proximity to the priority areas. The type of use is decisive here. For example, the value of the landscape in terms of industrial or transport use plays a subordinate role. For recreational uses, such as water sports and tourism, the landscape is of great importance. However, direct use for recreation and leisure by pleasure boats and tourist vessels is only sporadic in the planned priority areas for wind energy. These are mainly located in areas used by shipping and the offshore industry, which means that the impact on recreational use by water sports enthusiasts can be regarded as minimal.

As a result, the impairment of the landscape by the planned wind energy installations along the coast can be classified as low. For the submarine cable systems, negative impacts on the landscape can be ruled out due to their installation as undersea cables.

4.3 Pipelines and cables

The draft Spatial Plan designates the reservation areas LO1 to LO8 for pipelines and cables. “Lines” as defined in the draft Spatial Plan include pipelines and submarine cables. Submarine cables are understood to include cross-border power lines and connecting lines for wind farms as well as data cables. So-called in-farm submarine cables are not covered by this definition. In addition, the draft Spatial Plan defines the objective of routing cables at the transition to the territorial water through the border corridors GO1 to GO5.

4.3.1 Soil / Area

The impacts on the seabed described in Section 3.3.1 that arise from construction and operation of pipelines and submarine cables occur independently of the provisions of the draft Spatial Plan.

The draft Spatial Plan makes statements regarding the desired reduction of ecological stressing of the marine environment by taking into account best environmental practice in accordance with international conventions and the state of the art in science and technology. In this way, adverse impacts on the marine environment can be reduced. For example, when laying and operating pipelines and cables, damage to or destruction of biotopes must be prevented in accordance with Article 30 of the Federal Nature Conservation Act (BNatSchG).

In addition, the designation of areas in the Spatial Plan reserved for pipelines and cables means that interactions between uses and cumulative effects on protected assets can be better assessed and forecast for existing and, above all, future planning.

Thus, with regard to the protected assets soil and area, no significant impacts are to be expected from the provisions for pipelines and cables in the draft Spatial Plan. On the contrary, adverse effects are prevented in comparison with non-implementation of the plan, as the provisions of the plan aim to minimise the use of the seabed by bundling and reducing the number of pipeline/cable routes.

4.3.2 Benthos

Pipelines and cables can have an impact on macrozoobenthos. These effects apply equally to all the areas reserved for pipelines and cables.

Construction-related impacts: Possible effects on benthos depend on the installation methods used. By carefully laying the submarine cable systems and pipelines by means of flushing procedures or laying lines on the seabed surface, only small-scale, short-term and thus minor disturbances of the benthos are to be expected.

Based on current knowledge, impairments during the construction phase remain small-scale and usually short-term.

In the event of stock decline due to a natural or anthropogenic disturbance (e.g. from cable laying), sufficient potential of organisms for repopulation remains in the overall system (KNUST et al., 2003). The linear character of submarine cable systems favours repopulation from undisturbed peripheral areas. Monitoring for the Nord Stream pipeline (2011-2013) revealed recolonisation of the stressed areas in the Greifswald Bodden and the Pomeranian Bay by all species native to these areas.

Benthic organisms can also be affected in the short term and on a small scale by the release of nutrients and pollutants associated with the resuspension of sediment particles. In the medium term, this remobilised material will be re-suspended in the silty basins.

Installation-related impacts: Surface-mounted pipelines or locally required stone fills represent a permanent hard substrate that is foreign to the location. This provides new habitat for benthos, enabling species and biotic communities to settle even in areas where they have not previously been present, so that their distribution areas can expand (SCHOMERUS et al. 2006).

Operation-related conditions may cause a warming of the upper sediment layer of the seabed directly above current-carrying cables, which may reduce the winter mortality of the infauna and lead to a change in species communities in the area of the submarine cable routes. This can lead to the displacement of cold-water-loving species (e.g. *Arctica islandica*) from the area of the submarine cable routes, particularly in deeper areas. According to the current state of knowledge, no significant effects from cable-induced sediment heat-up are to be expected if a sufficient laying depth is maintained and if state-of-the-art cable configurations are used.

Likewise, electric and electromagnetic fields are not expected to cause and significant impacts on macro-zoobenthos.

On the basis of the above statements, the findings of the SEA are that, according to the current state of knowledge and taking into account damage-reducing measures, no significant impacts on the protected asset benthos are to be expected from the laying and operation of pipelines and cables.

In the case of pipelines, the chemicals resulting from hydrostatic pressure testing can be introduced into the water body in high dilution. To protect the pipeline from external corrosion, sacrificial anodes made of zinc and aluminium are placed at regular intervals. Due to the very high dilution, they are only present in trace concentrations; in the water they are adsorbed on sinking or resuspended sediment particles and settle on the sea floor.

4.3.3 Biotope types

Pipelines and submarine cables can have an impact on biotopes. These effects apply equally to all defined areas reserved for pipelines and cables.

Construction-related impacts: Possible impacts of pipelines and cables on the protected asset biotope types can arise through direct use of protected biotopes, possible covering by sedimentation of released material and potential habitat changes. Direct use of protected biotopes is prevented to the greatest extent possible by planning the pipeline and cable systems. In addition, biotope structures protected under Article 30 of the BNatSchG must be given special consideration in the specific approval procedure, and prevented to the greatest extent possible within the scope of detailed routing.

Owing to the predominant sediment composition in areas where occurrences of protected biotopes are to be expected, impairments due to overburdening are likely to be small-scale, since the released sediment will settle quickly.

Installation-related impacts: Permanent habitat changes are restricted to the immediate vicinity of rock fills used for pipeline or cable crossings or in case pipelines or submarine cable sections are laid on top of the seabed. Stone rubble represents a hard permanent substrate that is not native to the site. This provides new habitats for benthic organisms and can lead to a change in species composition (SCHOMERUS et al. 2006). These small-scale areas are not expected to have any significant impacts on the protected biotope types.

4.3.4 Fish

The specifications in the draft Spatial Plan governing pipelines and submarine cables do not have any significant impact on the protected asset fish.

4.3.5 Marine mammals

The draft Spatial Plan makes statements regarding the desirable reduction in burdens stressing the marine environment by taking into account the best environmental practice in accordance with the OSPAR and HELCOM Conventions as well as the respective state of the art in laying, operating, maintaining and dismantling submarine pipelines and cables. This can reduce adverse impacts on the marine environment.

The designation of areas for pipelines and cables in the draft Spatial Plan means that interactions between uses and cumulative impacts on biological assets can be better assessed and forecast for existing and, above all, future planning.

4.3.6 Avifauna

The general effects of pipelines and cables on seabirds, resting birds and migratory birds are described in Sections 3.3.5and 3.3.6 Such effects are only temporary and local.

Any significant impacts arising from the provisions of the Spatial Plan can be ruled out with the necessary certainty.

4.3.7 Bats and bat migration

The general effects of pipelines and cables on bats are described in Section 3.3.7 Such effects are only temporary and local.

Any significant impacts arising from the provisions of the Spatial Plan can be ruled out with the necessary certainty.

4.3.8 Cultural and material goods

The regulations governing the planning, construction and operation of wind energy installations, pipelines and submarine cables aim to prevent or reduce construction-related disturbances of the seabed that could impact discovered and undiscovered cultural heritage sites by involving the sectoral authorities at an early stage. Synergy effects are to be promoted through cooperation in the assessment of results yielded by seabed substrate investigations and soil samples, which will be carried out as part of the large-scale development of marine areas for wind energy, and which may provide new insights into cultural traces such as submerged/lost landscapes.

4.4 Raw materials extraction

As a principle of land use planning, the SKO1 area is designated as the reserved area for sand and gravel extraction.

The effects of raw material extraction on the marine environment must be assigned to the provisions of regional planning, since these mean long-term land security with possible use. This can be longer than the duration of the currently valid operational plans.

4.4.1 Soil / Area

The draft Spatial Plan provides for only one reserved area for sand and gravel extraction in the EEZ of the Baltic Sea in the area of the Adler Ground.

By establishing the principle of the most complete possible extraction of the existing extraction fields, the aim is to achieve the most space-saving and concentrated extraction of raw material deposits possible – as far as compatible with the interests of the marine environment, while also preserving a residual sediment layer necessary for the regeneration of biotic communities. In the case of sand and gravel extraction, this will in particular preserve the naturalness of the unimpaired coarse sand and gravel areas in the EEZ, which are important as spawning and feeding grounds. This has corresponding positive consequences for other protected species such as benthic communities, plankton and fish.

The draft Spatial Plan makes further statements with regard to reducing the ecological stressing of the marine environment by taking into account best environmental practice in accordance with the OSPAR and Helsinki Conventions and the respective state of the art in the exploration for and extraction of raw materials. In order to ensure that the extraction of raw materials is done in as environmentally sound a manner as possible, the effects of raw material extraction on the marine environment are to be investigated and presented within the framework of project-related monitoring. Dispersion processes and wide-ranging ecological interrelationships between species and their habitats are to be taken into account in the selection of sites. Damage to or destruction of sandbanks, reefs and submarine structures caused by gas leaks, as well as delimited areas with the occurrence of benthic communities worthy of protection as particularly sensitive habitats, should also be prevent during raw materials extraction. The interests of cultural assets are also to be taken into account. These regulations serve to mitigate or even prevent negative impacts with regard to the protected assets soil and area, and the marine environment as a whole.

Not only are no significant impacts on the protected assets of soil and area are to be expected as a result of the provisions made in the Spatial Plan for the extraction of raw materials, but rather negative impacts can be reduced or prevented altogether in comparison with non-implementation of the plan.

4.4.2 Benthos and biotope types

The general impacts of raw materials extraction are described in Section 3.4.2**Fehler! Verweisquelle konnte nicht gefunden werden.**.

With regard to the designation of the SKO1 area as a reserved area for sand and gravel extraction, its location within the Pomeranian Bay – Rönne Bank Nature Conservation Area must be taken into account.

Under similar conditions as for the "OAM III" gravel sand storage area in the Baltic Sea EEZ (cf. Chapter 3.4.2), it can be assumed that, based on the current state of knowledge, significant impacts on benthic habitats and their communities can be rule out by designating the SKO1 area for this purpose.

4.4.3 Fish

The designation of the areas for the extraction of raw materials does not have any significant impact on the protected asset fish.

4.4.4 Marine mammals

The general impacts of raw materials extraction are described in Section 3.4.4.

The plan designates the SKO1 area as the reserved area for gravel and sand extraction. The SKO1 reserve is located in sub-area II of the Pomeranian Bay – Rönne Bank Nature Conservation Area. While the permit for the fields "Adlergrund Nordost" and "Adlergrund Nord" is valid until 2040, no sand and gravel mining has taken place since 2004.

This specification in the update of the plan has no implications for marine mammals.

4.4.5 Avifauna

The general impacts of raw materials extraction (here: sand and gravel extraction and hydrocarbons extraction) on seabirds, resting birds and migratory birds are described in sections 3.4.5and 3.4.6

The draft Spatial Plan establishes the SKO1 area as the reserved area for sand and gravel extraction. It consists of the permit areas "Adlergrund Nordost" and "Adlergrund Nord". The permit for "Adlergrund Nordost" is valid until 2040, but mining took place only in the period from 1993 to 2004. In the "Adlergrund Nord" permit area, no mining has been carried out since 2004 (BfN 2020).

The SKO1 reserve is located in sub-area II of the Pomeranian Bay – Rönne Bank Nature Conservation Area. As previously noted, no sand or gravel has been extracted from the Adler Ground permit fields since 2004. According to the information available to date, it cannot be assumed that the designation of the SKO1 reserve will be accompanied by an increase in activity.

Any significant impacts on avifauna from the designation of this area can be excluded with the necessary certainty.

4.5 Marine research

In the Baltic Sea EEZ, the areas FoO1 to FoO4 are designated as research reserve areas.

This area has been designated in order to safeguard existing long-term fisheries research programmes. The aim is to keep these areas free of uses which could devalue the long-term research series.

The results of marine scientific research are to be continuously recorded in order to explain ecosystem interrelationships as comprehensively as possible and thus create an important basis for sustainable development in the EEZ.

Since the aim here is to safeguard the stock, the area designations have no further impact on the protected species and the marine environment as a whole compared with the current status and the zero variant.

4.5.1 Soil / Area

The area designations of the Spatial Plan do not result in any additional concrete impacts on the seabed than those described in Section 3.6.1. Significant impacts on the soil as a protected resource as a result of the provisions of the Spatial Plan for marine research use can thus be ruled out.

4.5.2 Benthos and biotope types

With regard to the use of marine research, there are no additional concrete impacts arising from Spatial Plan provisions other than the general effects of use described in Section 3.6.2 Significant impacts on benthic biotic communities and biotopes based on the Spatial Plan's provisions on marine research can thus be ruled out.

4.5.3 Fish

The designation of the reservation areas for marine research does not have any further significant impact on the protected asset fish.

4.5.4 Marine mammals

The designation of the reservation areas for scientific research in the draft Spatial Plan for the German Baltic Sea EEZ means that interactions among uses and cumulative impacts on biological assets can be better assessed in existing and, above all, future planning.

On the basis of the above statements and the presentations in Sections 3, the SEA concludes that the provisions for scientific research in the draft Spatial Plan are expected not only to have no significant impact on marine mammals, but rather also to prevent adverse effects in comparison with non-implementation of the plan.

4.5.5 Avifauna

With regard to marine research, there are no further concrete effects arising from the Spatial Plan provisions beyond the general effects of use described in Sections 3.6.5and 3.6.6Significant impacts on seabirds and resting and migratory birds arising from the provisions of the Spatial Plan on marine research can be ruled out with the necessary degree of certainty.

4.6 Nature conservation

National marine nature conservation areas Fehmarn Belt, Kadet Trench and Pomeranian Bay – Rönne Bank in the Baltic Sea EEZ will be designated as priority areas for nature conservation in accordance with their conservation objectives.

The bird migration corridor "Fehmarn-Lolland" is designated as a bird migration reserve.

The provisions contribute to the long-term preservation and development of the marine environment in the EEZ as an ecologically intact open space over a large area.

The reserved area set aside for the "Fehmarn-Lolland" bird migration corridor serves to protect this migration corridor.

The draft Spatial Plan thus contributes to achieving the objectives of the Marine Strategy Framework Directive (MSFD). However, the influence of regional planning is limited in this respect and cannot affect all objectives.

4.6.1 Soil / Area

The draft Spatial Plan strengthens nature conservation in the German EEZ by designating priority areas. Due to the expected positive effects on the soil as a protected resource, any negative impact of the draft Spatial Plan in this respect can be ruled out.

4.6.2 Benthos and biotope types

The definition of the designated nature conservation areas of the Baltic Sea EEZ as nature conservation priority areas supports the positive effects on benthic communities and biotopes that can be expected on the basis of appropriate management measures for the nature conservation areas.

The spatial planning designation as a priority area supports the maintenance or restoration of a favourable conservation status for the habitat types characteristic of the nature conservation areas as defined in Annex I to Directive 92/43/EEC (sandbanks with only weak permanent cover by seawater (EU code 1110) and reefs (EU code 1170), as well as a natural or semi-natural character of species-rich gravel, coarse sand and shell/sediment beds, and the function of these habitats as regeneration areas for benthic biotic communities.

4.6.3 Fish

In general, the establishment of marine protected areas in the EEZ could, in particular, increase the biodiversity and improve the condition of the fish zone, and counteract the overexploitation of fish stocks. The Pomeranian Bay – Rönne Bank Nature Conservation Area is of particular importance for fish, as the FFH species Baltic sturgeon and twaite shad are both protected under the Nature Conservation Area Regulation. Overall, according to the current state of knowledge, all of the marine protected areas in the Baltic Sea can have a significant positive impact on the fish community.

4.6.4 Marine mammals

The draft Spatial Plan designates the Pomeranian Bay – Rönne Bank, Kadet Trench and Fehmarn Belt Nature Conservation Areas as priority areas. The harbour porpoise is one of the protected species in all three of these priority areas. The establishment of priority areas for wind energy production outside the nature conservation areas will prevent and reduce negative impacts on the harbour porpoise population in the German Baltic Sea EEZ.

As a result, the nature conservation provisions have a positive impact on the conservation status of the harbour porpoise population**.**

4.6.5 Seabirds and resting birds

Among its provisions, the draft Spatial Plan designates, among other things, the nature reserve Pomeranian Bay – Rönne Bank Nature Conservation Area, with its bird sanctuary in sub-area IV of the complex, to be a priority area for nature conservation. This provides special protection for the habitat of specially protected species and regularly occurring migratory bird species. In addition, a principle of regional planning stipulates that the expansion of offshore wind energy is not permitted in any of the three aforementioned nature conservation areas in the EEZ. These nature conservation priority areas contribute to safeguarding open space, as uses incompatible with nature conservation are prohibited there. This reduces the impacts of offshore wind energy – such as habitat loss and collision risks – on protected birds and other bird species and their habitats.

All in all, the spatial planning provisions governing nature conservation in the EEZ have exclusively positive impacts of a significant scope on seabird and resting bird species.

4.6.6 Migratory birds

The draft Spatial Plan designates the bird migration corridor between Fehrman and Lolland (the so-called "bird flight line") as a reserve for nature conservation. As a result, nature conservation, in particular bird migration, is accorded special importance in this area.

In addition, many birds migrating across the German Baltic Sea rest within the EEZ on their migration to their wintering or breeding areas. The considerably positive impacts of the spatial planning provisions on nature conservation described in Section 4.6.4therefore also apply to migratory birds accordingly.

4.7 Other uses without spatial specifications

4.7.1 National and alliance defence

No spatial specifications are made for the defence of the country and/or the NATO alliance, and the military exercise grounds/areas are merely presented for information purposes.

As the draft Spatial Plan merely reflects the current given status, there are no effects beyond those of non-implementation of the plan.

4.7.2 Aviation

Air traffic in the skies above the EEZ takes place in the context of commercial flights at higher altitudes. No direct impact on the marine environment is expected from the provisions of the draft Spatial Plan.

4.7.3 Recreation

Recreational activities in the EEZ are mainly carried out in private small motor and sailing boats. In contrast to areas near the coast, relatively low frequencies and environmental pollution are assumed. No direct pollution of the marine environment is to be expected as a result of the provisions of the draft Spatial Plan.

4.8 Interactions

In general, impacts on any one protected asset lead to various consequences and interactions between the protected assets. Hence, impacts on the soil or the water body usually also have consequences for the biotic assets in these habitats. For example, pollutant discharges may impair water and/or sediment quality and be absorbed by benthic and pelagic organisms from the surrounding medium. The protected biotic assets are essentially interlinked via the food chains. These interrelationships between the various protected assets and possible impacts on biological diversity are described in detail for the respective protected assets.

Sediment shifting and turbidity plumes

During the construction phase of wind farms and platforms or the laying of a submarine cable systems, sediment shifting and turbidity plumes occur. Fish are temporarily scared away. The macrozoobenthos is locally covered. As a result, the feeding conditions for benthos-eating fish and for fish-eating seabirds and harbour porpoises also change temporarily and locally (decrease in the supply of available food). However, any significant impairments to the biotic assets to be protected, and thus to the existing interactions with each other, can be ruled out with the necessary degree of certainty due to the mobility of species and the temporal and spatial limitation of sediment rearrangements and turbidity plumes.

Noise emissions

Work to construct and install the systems can lead to temporary escape reactions and avoidance of the area by marine mammals, some fish species and seabird species. However, the use of sound-attenuation measures during pile driving of the foundations of platforms and wind turbines is mandatory. This can prevent significant impacts on the interaction of the protected assets with the necessary level of certainty.

Land use

The laying of foundations results in a local deprivation of settlement area for the benthic zone, which can lead to a potential deterioration of the food base for fish, birds and marine mammals following within the food pyramid. However, any significant impairment of food availability can be ruled out with the necessary level of certainty.

Placement of artificial hard substrate

The introduction of artificial or non-indigenous hard substrate (foundations, necessary stone fills for cable crossing structures or local cable laying on the seabed floor) leads to local changes in soil and sediment conditions. As a consequence, the composition of macrozoobenthos can change. According to KNUST et al (2003), the introduction of artificial hard substrate into soft soils leads to the colonisation of additional species. These species will most likely be recruited from natural hard substrate habitats, such as superficial boulder clay and stones. The risk of negative impacts on benthic soft soil communities by non-native species is therefore low. However, settlement areas of the soft soil fauna are lost at these sites. By changing the species composition of the macrozoobenthos community, the food base of the fish community at the site can be influenced (bottom-up regulation).

However, this could attract certain fish species, which in turn could increase the feeding pressure on the benthos by predation and thus shape the dominance relationships by selecting certain species (top-down regulation). Furthermore, the growth on the hard substrate could serve as a new food source for benthos-eating sea ducks.

Prohibition of use and entry

There is a ban on fishing within and around wind farms. The resulting loss of fishing activity can lead to an increase in the stock of both target and unused fish species. A shift in the length spectrum of these fish species is also conceivable. If fish stocks increase, an enrichment of the food supply for harbour porpoises can be expected. It is also expected that a macrozoobenthos community undisturbed by fishing activity will develop. This could mean that the diversity of the community of species will increase, giving sensitive and long-lived species of the current epifauna and infauna better chances of survival and developing stable stocks.

Due to the variability of the habitat, interactions can only be described in a very imprecise manner overall. In principle, it can be stated that, at present, no effects on existing interactions that could result in a threat to the marine environment are discernible as a result of the Spatial Plan. Therefore, it must be concluded for the SEA that, according to the current state of knowledge, not only are no significant impacts due to interactions on the marine environment to be expected from the provisions of the draft Spatial Plan, but rather, compared with non-implementation of the plan, adverse impacts can be prevented.

4.9 Cumulative effects

4.9.1 Soil/area, benthos and biotope types

A substantial share of the environmental impacts on land, benthos and biotopes caused by offshore areas devoted to wind energy production and areas reserved for pipelines and submarine cables will only occur during the construction period (formation of turbidity plumes, sediment shifting, etc.), and within a spatially limited area. Due to the gradual implementation of the construction projects, cumulative environmental impacts caused by construction are unlikely. Possible cumulative effects on the seabed, which could also have a direct impact on the benthic material to be protected and on specially protected biotopes, result from the permanent direct land use of the installations' foundations and from the pipelines and cables laid. The individual impacts are generally small-scale and local.

In the area of trenches where piping and cables are laid, the impact on sediment and benthic organisms will be essentially temporary. Where such lines cross particularly sensitive biotope types such as reefs or species-rich gravel, coarse sand and shell beds, permanent impairment would have to be assumed.

For a balancing analysis of soil/land use, please refer to the environmental report for the 2019 SDP or draft 2020 SDP in which an estimation of the direct land use by wind energy and power cables is made using model assumptions.

No statement can be made on the use of specially protected biotopes under Article 30 of the BNatSchG due to the lack of a reliable scientific basis. An area-wide sediment and biotope mapping of the EEZ currently being carried out will provide a more reliable basis for evaluation in future.

In addition to the direct use of the sea floor and thus the habitat of the organisms that have settled there, installation foundations, pipeline and cable structures lying on top of the seabed, and required crossing structures lead to an additional volume of hard substrate. As a result, species that take to non-indigenous hard substrate can colonise and alter the species composition. This effect can lead to cumulative effects due to the construction of several offshore structures, pipelines and cable lines or rock fills were lines cros. The benthic fauna adapted to soft soils is lost to the habitat due to the hard substrate introduced. However, since the land use of both the grid infrastructure and the wind farms will be in the ‰ range, no significant impairments are to be expected in the cumulative effects that could endanger the marine environment with regard to the seabed and benthos.

4.9.2 Fish

The impact on the fish fauna caused by the regulations is probably most strongly influenced by the installation of an initial 20 GW of wind power generating capacity in the reservation areas of the North and Baltic Seas. The impacts of the offshore wind farms are concentrated on the one hand on the regularly ordered closure of the area for fishing, and on the other hand on habitat changes and their interaction.

The expected fishery-free zones within the wind farm areas could have a positive impact on the fish zone by eliminating the negative effects of fishing, such as disturbance or destruction of the seabed, and the catch and by-catch of many species. The lack of fishing pressure could lead to a more natural age distribution of the fish fauna, leading to an increase in the number of older individuals. The offsure wind farms could develop into an aggregation site for fish, although it is not yet clear whether wind farms attract fish.

In addition to the absence of fishing, an improved food base for fish species with a wide range of diets could be envisaged. The growth of sessile invertebrates on wind turbines could favour benthos-eating species and provide fish with a larger and more diverse food source (GLAROU et al. 2020). This could improve the condition of the fish, which in turn would have a positive effect on their fitness. There is currently a need for research to transfer such cumulative effects to the fish population level.

Species composition could also change directly, as species with habitat preferences different from those of established species, e.g. reef dwellers, find more favourable living conditions and are more abundant. At the Danish wind farm Horns Rev, seven years after its construction, a horizontal gradient in the occurrence of hard subsrtate-affected species was found between the surrounding sand areas and near the turbine foundations: goldsinny wrase, viviparous eelpout and lumpfish were found much more frequently near the wind turbine foundations than on the surrounding sand areas (LEONHARD et al. 2011). Cumulative effects resulting from a major expansion of offshore wind energy could include

- an increase in the number of older individuals,
- better conditions for fish due to a larger and more diverse food base,
- further establishment and distribution of fish species adapted to reef structures,
- recolonisation of previously heavily fished areas,
- better living conditions for territorial species such as cod-like fish.

The natural mechanism for limiting populations is, besides predation, intra- and inter-species competition, also called density limitation. It cannot be excluded that within individual wind farms local density limitation sets in before the favourable effects of the wind farms are spatially reproduced, e.g. through the migration of "surplus" individuals. In this case the effects would be local and not cumulative. What effects any changes in the fish fauna could have on other elements of the food web, both below and above their trophic level, cannot be predicted at this stage of knowledge.

Together with the designation of nature conservation areas, wind farms could contribute to positive stock development and thus to the recovery of fish stocks in the Baltic Sea.

4.9.3 Marine mammals

Cumulative effects on marine mammals, in particular harbour porpoises, may occur mainly due to noise exposure during the installation of deep foundations. For example, marine mammals can be significantly affected by the fact that, if pile driving is carried out simultaneously at different sites within the EEZ, there is not enough equivalent habitat available for evasion and retreat.

The implementation of offshore wind farms and platforms so far has been relatively slow and gradual. To date, pile driving work has been carried out for three wind farms in the German Baltic Sea EEZ. Since 2011, all pile driving work has been performed using technical noise reduction measures. Since 2014, the noise protection limits have been reliably observed, and noise levels even kept below these limits by successfully using noise reduction systems. The three construction sites did not overlap in time, so that there was no overlapping of noise-intensive pile-driving work which could have led to cumulative effects. Only in the case of the construction of the wind farm "EnBW Baltic 2" was it necessary to coordinate the pile driving work, including deterrent measures, due to the installation work using two installation ships.

The evaluation of the sound analysis results with regard to sound propagation and the possible resulting cumulation has shown that the propagation of impact sound is greatly restricted when effective noise control measures are applied (BRANDT et al. 2018, DÄHNE et al., 2017).

In order to avoid and reduce cumulative effects on the population of harbour porpoise in the German EEZ, the directives of the downstream authorisation procedure stipulate a restriction of noise exposures of habitats to maximum permitted areas of the EEZ and nature reserves. According to these rules, the spread of noise emissions must not exceed defined spatial volumes of the German EEZ and nature conservation areas. This ensures that animals have sufficient suitable habitats at all times to avoid them. The primary purpose of these requirements is to protect marine habitats by preventing and minimising disturbances caused by impact noise emissions. The prevention and mitigation measures in the EO1 and EO2 areas will focus in particular on the protection of animals of the highly endangered population of the central Baltic Sea.

The conclusion is that the implementation of the plan will lead to the prevention and reduction of cumulative effects. This assessment also applies to the cumulative impacts of the various uses on marine mammals.

4.9.4 Seabirds and resting birds

Among the uses considered in the draft Spatial Plan, the use of wind energy by vertical structures such as platforms and wind turbines in particular can have various impacts on seabirds and resting birds, such as habitat loss, an increased risk of collision or a scaring and disturbance effect. These effects are considered site- and project-specifically in the environmental impact assessment, and are monitored in the subsequent monitoring of the construction and operation phase of offshore wind farm projects. For seabirds and resting birds in particular, the loss of habitat due to cumulative effects of multiple structures or wind farms can be significant. The nature conservation priority areas contribute to safeguarding open spaces, as they exclude uses that are incompatible with nature conservation. This reduces the impacts on seabirds and resting birds (see Section 3.2.5) in these important habitats, which are associated with offshore wind farms, for example. Although the draft Spatial Plan also lays down provisions for other uses within the nature conservation areas, no increases in intensity are expected as a result of the spatial planning provisions. Rather, they are rather a record of already existing uses or intensities of use.

As a result of the SEA, any significant cumulative impacts from the spatial planning provisions on the protected asset seabirds and resting birds are not to be expected based on current knowledge.

4.9.5 Migratory birds

Among the uses taken into account in the Spatial Plan, the use of offshore wind energy by the vertical structures of offshore wind farms in particular can have various impacts on migratory birds, such as barrier effects and risk of collision. These effects are considered site-specifically within the scope of the environmental impact assessment, and are monitored within the subsequent monitoring of the construction and operation phase of offshore wind farm projects.

By defining priority and reservation areas for offshore wind energy in a spatial context to one another and by securing open space, barrier effects and collision risks in important feeding and resting habitats are reduced. The designation of area EO2 as a reserved area for offshore wind energy also takes into account the importance of this area for bird migration. The effects of the other uses and their definition are comparatively less extensive with regard to the verticality in the airspace.

Based on current knowledge, any significant cumulative impacts on migratory birds caused by the spatial planning definitions of all uses taken into account can be ruled out with the necessary certainty.

4.10 Transboundary impacts

The present SEA concludes that, based on current knowledge and conditions, the provisions of the Spatial Plan do not pose any significant impacts on the areas of the neighbouring countries bordering the German Baltic Sea EEZ.

For the protected assets soil and water, plankton, benthos, biotope types, landscape, cultural heritage and other material goods and human beings, including human health, significant transboundary impacts can essentially be rule out. Possible significant transboundary impacts could at best arise from a cumulative view in the area of the German Baltic Sea for the highly mobile biological assets fish, marine mammals, seabirds and resting birds, as well as migratory birds and bats.

With regard to fish as a protected resource, the SEA comes to the conclusion that, according to the current state of knowledge, no significant transboundary impacts on the protected resource are to be expected as a result of implementing the Spatial Plan, since the recognisable and predictable impacts are of a small-scale and temporary nature.

This also applies to the protected species marine mammals, and seabirds and resting birds, which use these spaces mainly as transit areas. There is unlikely to be any significant loss of habitat for strictly protected seabird and resting bird species. Based on current knowledge and taking into account impact-reducing and damage-limiting measures, significant transboundary impacts can be ruled out. For example, the installation of the foundations of wind turbines and platforms is only permitted in the specific approval procedure if effective noise reduction measures are applied. Against the background of the particular threat of the separate Baltic Sea population of harbour porpoise, intensive monitoring measures must be carried out as part of enforcement and, if necessary, the noise reduction measures must be adapted or the construction work coordinated in order to exclude any cumulative effects.

For migratory birds, erected wind turbines in particular can pose barriers or collision risks. Priority areas for nature conservation help to safeguard open spaces by excluding uses that are incompatible with nature conservation. This reduces these impacts, such as those caused by wind energy in important resting areas of some migratory bird species. Furthermore, particularly due to the conflict with bird migration, the EO2 area is only designated as a reserved area for offshore wind energy. The other uses taken into account in the draft Spatial Plan do not have comparable spatial impacts. Based on current knowledge, no significant transboundary impacts on migratory birds are to arise from the provisions of the draft Spatial Plan.

5 Review of wildlife conservation laws and regulations

5.1 General part

As explained above, various European wild bird species within the meaning of Article 1 of the Birds Directive and marine mammal species listed in Annexes II and IV of the Habitats Directive can be found in the German Exclusive Economic Zone (EEZ) in the Baltic Sea.

The scope of this review of the laws and regulations governing wildlife conservation is aimed at determining whether the plan meets the requirements of Article 44 subsection (1) numbers 1 and 2 of Germany's Federal Nature Conservation Act (BNatSchG) for specially and strictly protected animal species. In particular, it will be examined whether the plan violates any prohibitions related to species protection.

Under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act, the killing or injury of wild animals of specially protected species, i.e. including animals listed in Annex IV to the Habitats Directive and Annex I to the Habitats Directive, is prohibited. The review of wildlife conservation laws and regulations under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act always relates to the killing and injury of individuals.

Under Article 44 subsection 1 number 2 of the Federal Nature Conservation Act, it is also prohibited to cause significant disturbance to wild animals of strictly protected species during their reproduction, rearing, moulting, wintering and migration periods.

It is immaterial in this context whether a relevant injury or disturbance is based on reasonable grounds, nor do inducements, motives or subjective trends play a role in committing the elements of the prohibited action (Landmann/Rohmer, 2018).

According to the legal definition in Section 44 subsection (1) number 2, second half-sentence of the BNatSchG, a significant disturbance occurs when the conservation status of the local population of a species deteriorates. According to the guidelines on the system of strict protection for animal species of Community interest under the Habitats Directive (margin number 39), a disturbance within the meaning of Article 12 of the Habitats Directive exists if the survival chances, reproductive success or ability of a protected species to reproduce is reduced by the act in question or if this act leads to a reduction in its range. On the other hand, occasional disturbances which are not likely to have a negative impact on the species concerned are not to be regarded as disturbance within the meaning of Article 12 of the Habitats Directive.

Among the uses specified in the plan, wind energy generation is the most intensive use. In recent years, the state of knowledge in connection with impacts relevant to species conservation law has been expanded through the use of prevention and mitigation measures and their monitoring.

In the following, species protection issues are examined with regard to wind energy production. Subsequently, possible cumulative impacts with other uses are presented.

5.2 Marine mammals

In the German Baltic Sea EEZ, the harbour porpoise, harbour seal and grey seal are species listed in Annex II (animal and plant species of Community interest whose conservation requires the designation of special areas of conservation under the Habitats Directive) and Annex IV (animal and plant species of Community interest requiring strict protection) of the Habitats Directive, which must be protected under Article 12 of the Habitats Directive. Harbour porpoises occur throughout the year in varying densities, depending on the area. This also applies to harbour seals and grey seals. In general, it can be assumed that the entire German Baltic Sea EEZ is part of the harbour porpoise habitat. The German EEZ is used for crossing but also for resting as well as for feeding and rearing.

The occurrence of the animals differs greatly from one area to another, both in terms of space and time. For marine mammals, and in particular for the strictly protected species of harbour porpoise, the effects of implementing the plan must be assessed in terms of species protection.

According to current knowledge, there are two separate populations of harbour porpoise in German waters of the Baltic Sea: the Belt Sea population in the western Baltic Sea - Kattegat, Beltsee, Sund - up to the area north of Rügen, and the population of the central Baltic Sea from the area north of Rügen.

Taking into account the results of acoustic, morphological, genetic and satellite-based surveys at the level of Rügen, the boundary of the population of harbour porpoise in the central Baltic Sea classified as endangered is 13°30' East (SVEEGARD et al. 2015).

The abundance of the separate population of the central Baltic Sea was estimated to be 447 individuals (95% confidence interval, 90 - 997) (SAMBAH 2014 and 2016).

The separate population of the central Baltic Sea has been classified as highly endangered by IUCN and HELCOM (HELCOM - Red List Species, 2013), among other reasons due to the very small number of individuals and the spatially limited genetic exchange.

In the Baltic Sea EEZ, the three nature conservation areas "Pomeranian Bay – Rönne Bank" (NSGPBRV), "Fehmarn Belt" (NSGFmbV), and "Kadet Trench" (NSGKdrV) were established in 2017 with the aim of conserving and, where necessary, restoring to a favourable conservation status the species listed in Annex II to Directive 92/43/EEC, i.e. porpoise, harbour seal and grey seal. The Pomeranian Bay – Rönne Bank Nature Conservation Area is of great importance for harbour porpoises in winter. During this period, the nature conservation area and its surroundings up to Rügen are also used by animals of the highly endangered population of harbour porpoise of the central Baltic Sea. No animals of the population of the central Baltic Sea occur west of a longitude of 13° 30'. The Kadet Trench Nature Conservation Area marks the borderline of the population of harbour porpoise from Skagerrak, Kattegat and Beltsee with higher harbour porpoise densities west of the nature conservation area and strongly decreasing densities in the eastern direction. The Fehmarn Belt Nature Conservation Area and its surroundings have the highest density of harbour porpoise in German waters in the Baltic Sea.

Areas EO1 and EO2 are regularly used by harbour porpoises, but to a very limited extent. The presence of harbour porpoise in both areas is low compared to the presence west of the Darss threshold. There is no evidence that either area is used as a breeding ground according to current knowledge. For harbour porpoises, areas EO1 and EO2 are of low to medium importance. During the winter months, however, the areas are expected to be of high importance due to their potential use by animals of the highly endangered population of the central Baltic Sea. For grey seals and harbour seals these areas are of low importance.

Area EO3 is used by harbour porpoises on an irregular and very small scale. Overall, the abundance of harbour porpoise in area EO3 is low compared to the abundance in the Kadet Trench and further west. According to the current state of knowledge, the area is not used as a rearing area. For harbour porpoises, area EO3 is of minor importance. For grey seals and harbour seals, this area lies on the edge of the distribution area.

5.2.1 Article 44(1)1 of BNatSchG (prohibition of killing and injury)

Under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act, the killing or injuring of wild animals of specially protected species, i.e. including animals listed in Annex IV to the Habitats Directive, such as the harbour porpoise, is prohibited.

The main threats with fatal consequences for harbour porpoise in the ASCOBANS agreement area, which includes the German EEZ in the North Sea, include by-catch in bottom-set gillnets but also in trawls, attacks by dolphins, depletion of food resources, physiological effects on reproductive capacity and infectious diseases, possibly as a result of contamination with pollutants. A survey of 1692 deaths along the UK coast between 1991 and 2010 showed that 23% of deaths were related to infectious diseases, 19% to dolphin attacks and 17% to by-catch. A further 15% had died of starvation and 4% were stranded alive (Evans, 2020).

Evidence of collisions with ships exists for at least 21 species of whale (Evans, 2003, cited in Evans 2020). However, collision risks are highest for large cetacean species, such as the fin whale or the humpback whale (Evans, 2020). A study on the causes of deaths on the coasts of the British Isles has shown that about 15% to 20% of baleen whales (fin whale, minke whale) have had injuries that could have resulted from collisions with ships. In contrast, only 4% to 6% of small cetaceans, such as harbour porpoise and dolphin, had similar injuries (Evans, Baines & Anderwald, 2011, cited in Evans, 2020).

According to the current state of knowledge, killing or injury of individual animals as a consequence of the uses specified in the plan is possible by the input of impact noise during pile driving for the foundations of offshore wind energy installations.

Marine mammals, and in particular the highly protected harbour porpoise species, could likely be injured or even killed by pile-driving for the foundations of offshore wind turbines, substations or other platforms if no prevention and mitigation measures are taken.

BfN regularly assumes in its statements that, according to current knowledge, injuries to harbour porpoises occur in the form of temporary hearing loss when animals are exposed to a single event sound exposure level (SEL) of 164 dB re 1 μPa2/Hz, or a peak sound pressure level (SPL) of 200 dB re 1 μPa.

According to the BfN, it is sufficiently certain that, if the specified limits of 160 dB for the event sound exposure level (SEL05) and 190 dB for the peak sound pressure level at a distance of 750 m from the emission point are complied with, no killing or injury pursuant to Article 44 subsection (1) number 1 of the Federal Nature Conservation Act can occur.

BfN assumes that suitable means such as deterrent conditioning and soft-start procedures will be used to ensure that no harbour porpoises are present within a 750-m radius of the pile-driving site.

The BSH agrees with this assessment in the update of the Spatial Plan on the basis of existing knowledge, in particular from the enforcement procedures at the existing installations already in operation. The plan lists objectives and principles that provide a framework for downstream planning levels and individual licensing procedures. In the downstream procedures, specifications, orders and requirements are made with regard to the necessary noise abatement measures and other prevention and reduction measures by means of which violation of the prohibition can be ruled out or the intensity of any adverse effects reduced. These measures are strictly monitored by the prescribed monitoring system in order to ensure with the necessary certainty that the killing and injury pursuant to Article 44 subsection (1) number 1 of the Federal Nature Conservation Act will not occur.

The updating of the plan contains principles according to which the discharge of noise into the marine environment should be prevented when constructing installations in accordance with the state of the art in science and technology, and there should be overall coordination of the construction work of installations located in close proximity to each other. Noise abatement measures are to be applied. On this basis, the BSH may, within the framework of the subordinate procedures, the site development plan, the suitability test of sites and, in particular, within the framework of the respective individual licensing procedures and within the framework of enforcement, order suitable detailed specifications with regard to individual work steps, such as deterrent measures and a slow increase in pile driving energy, by means of so-called "soft-start" procedures. Deterrent/aversive measures and soft-starts can ensure that no harbour porpoises or other marine mammals are present in an adequate area around the pile-driving site, keeping them a minimum distance of 750 m or more from the construction site.

In accordance with the precautionary principle, the above-mentioned prevention and reduction measures may preclude any occurrence of killing in violation of the prohibition. The use of appropriate deterrent measures will ensure that the animals are outside the 750-metre radius of the point of emission. In addition, the degree of noise reduction required and specified in the draft suitability assessment must be such that it can be assumed that no lethal or long-term adverse effects will occur outside the area where no harbour porpoises are expected to be present as a result of the deterrent measures to be implemented.

In the light of the above, it can be concluded with sufficient certainty that no killing or injury as prohibited under species protection law in Article 44 subsection (1) number 1 of the Federal Nature Conservation Act will occur.

According to the current state of knowledge, neither the operation of the installations nor the laying and operation of the wind farm's internal submarine cabling will have any significant negative impacts on marine mammals that meet the killing and injury criteria under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act.

Since 2017, the Fauna Guard system has been ordered as a deterrent measure in all construction projects in the German Baltic Sea EEZ. The use of the Fauna Guard system is accompanied by strict monitoring measures with good results so far. Within the framework of a research project, the effects of the Fauna Guard system are currently being systematically analysed, and the application of the system for future construction projects will be optimised as needed (Fauna Guard Study, 2020, in preparation).

To prevent cumulative effects, prohibitions are imposed in the context of downstream planning approval procedures and enforcement to ensure that no animals are injured or killed by multiple sources of impact noise inputs acting at the same time. For example, no pile driving is allowed while detonating non-transportable unexploded ordinance found at site.

As a result, the principles and objectives laid down in the update of the plan and the measures ordered in the context of subordinate procedures, in particular the approval procedures for individual projects, prevent with sufficient certainty any occurrence of actions prohibited under the species protection provisions of Article 44 subsection (1) number 1 of the Federal Nature Conservation Act.

According to the current state of knowledge, neither the operation of the installations nor the laying and operation of the wind farm's internal power cabling, nor the laying and operation of the power transmission to grid connection will have any significant negative impacts on marine mammals that meet the killing and injury criteria under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act.

5.2.2 Article 44(1)2 BNatSchG (prohibition of disturbance)

Under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act, it is also prohibited to cause significant disturbance to wild animals of strictly protected species during the reproduction, rearing, moulting, wintering and migration periods. A local population comprises those (sub-) habitats and activity areas of individuals of a species which are spatially and functionally connected in a way that is sufficient for the habitat requirements of the species. A deterioration of the conservation status is to be assumed in particular if the survival chances, breeding success or reproductive capacity is reduced, whereby this must be examined and assessed on a species-specific basis for each individual case (cf. explanatory memorandum to the BNatSchG Amendment 2007, BT-Drs. 11).

The harbour porpoise is a strictly protected species in accordance with Annex IV of the Habitats Directive and thus within the meaning of Article 44 subsection (1) number 2 in conjunction with Article 7 subsection (1) number 14 of the Federal Nature Conservation Act, so that a species protection assessment must also be carried out in this respect.

The species protection assessment under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act relates to population-relevant disturbances of the local population, the occurrence of which varies in the German Baltic Sea EEZ.

In its statements in the context of planning approval and enforcement procedures, BfN regularly examines the existence of disturbances under species protection law within the meaning of Article 44 subsection (1) number 2 of the BNatSchG. It comes to the conclusion that the occurrence of a significant disturbance due to construction-related underwater noise in relation to the protected species harbour porpoise can be prevented provided that the sound exposure (event) level (SEL) of 160 dB or the peak sound pressure level of 190 dB is not exceeded at a distance of 750 m from the point of emission and sufficient alternative areas are available in the German North Sea. BfN demands that compliance with the latter requirement be ensured by coordinating the timing of noise-intensive activities of multiple project participants with the aim of ensuring that no more than 10 % of the area of the German North Sea EEZ is affected by noise (BMU 2013).

Construction-related effects of wind energy generation

The temporary pile driving work is not expected to cause any significant disturbance to harbour porpoises within the meaning of Article 44 subsection (1) number 2 of the Federal Nature Conservation Act.

According to the current state of knowledge, it cannot be assumed that disturbances which may occur due to noise-intensive construction measures would worsen the conservation status of the local population provided that appropriate prevention and reduction measures are implemented. .

No negative impacts of the pile driving on harbour porpoises are to be expected if effective noise abatement management is implemented, in particular by applying suitable noise abatement systems in accordance with the principles and objectives in the update of the plan and subsequent arrangements in the dedicated approval procedure of the BSH, and taking into account the requirements of the noise abatement concept of the BMU (2013).

The planning approval decisions of the BSH will contain detailed rules to ensure effective noise abatement management by means of suitable measures. The protection of the highly endangered population of harbour porpoise in the central Baltic Sea is always given top priority.

In accordance with the precautionary principle, measures to prevent and reduce the effects of noise during construction are specified according to the state of the art in science and technology. The specifications in the subordinate procedures and, in particular, the measures ordered in the planning approval decisions to ensure the requirements of species protection are coordinated with the BfN over the course of implementation and adapted as needed. The following noise-reducing and environmental protection measures are regularly ordered within the framework of the planning approval procedures:

- Preparation of a sound prognosis giving consideration to the site- and installation-specific characteristics (basic design) before the start of construction,
- Selection of the construction method that generates the lowest noise level based on the state of the art and currently existing conditions,
- Preparation of a concrete noise control plan specifically adapted to the selected foundation structures and erection processes for carrying out the pile driving work, in principle two years before the start of construction, and in any case before the conclusion of contracts concerning the components affected by noise,
- Use of noise-reducing accompanying measures, individually or in combination, pile-remote (bubble curtain system) and, if necessary, pile-related noise-reducing systems in accordance with the state of the art in science and technology,
- Consideration of the characteristics of the hammer and the possibilities of controlling the pile driving process in the noise control plan,
- Plan for averting the animals from the endangered area (at minimum within a radius of 750 m around the pile-driving site),
- An approach to verifying the effectiveness of the deterring and noise-reducing measures,
- State-of-the-art installation design to reduce operational noise.

As outlined above, deterrent measures and a "soft-start" procedure must be applied to ensure that animals in the vicinity of the pile-driving operations have the opportunity to move away or to take evasive action in time.

Even measures ordered to prevent the risk of killing pursuant to Article 44 subsection 1 number 1 of the Federal Nature Conservation Act, such as averting a species, can in principle fulfil the definition of a disturbance under the prohibition of disturbance if said measures are implemented during the protected periods, and are significant (BVerwG, judgement of 27 November 2018 - 9 A 8/17, cited in juris).

Until 2016, a combination of pingers was used as an early warning system in construction projects in the German Baltic Sea, followed by the use of what are termed “seal scarers” as a warning system. All the results of the monitoring by means of acoustic detection of harbour porpoises in the vicinity of offshore construction sites with pile driving have confirmed that the use of deterrence has always been effective. The animals have left the danger zone of the respective construction site. However, deterrence using seal scarers is accompanied by a large loss of habitat, caused by the animals' flight reactions and therefore constitutes a disturbance (BRANDT et al., 2013, DÄHNE et al., 2017, DIEDERICHS et al., 2019).

In order to prevent this, a new system for deterring animals from the danger zone of the construction sites, the Fauna Guard system, has been used in construction projects in the German Baltic Sea EEZ since 2017 and in the North Sea EEZ since 2018. The development of new deterrent systems, such as Fauna Guard, opens up the possibility for the first time of adapting deterrent measures for harbour porpoise and seals in such a way that the killing and injury as defined in Article 44 subsection (1) number 1 of the Federal Nature Conservation Act can be ruled out with certainty without the simultaneous violation of the requirements stipulated under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act.

The use of the Fauna Guard system is accompanied by monitoring measures. The effects of Fauna Guard are being systematically analysed as part of a research project. If necessary, adjustments in the application of the system will have to be implemented in future construction projects (the Fauna Guard study is currently in preparation).

The selection of noise abatement measures by the subsequent sponsors of the individual projects must be based on the state of the art in science and technology and on experience gained from previous offshore projects. Findings from practical experience in the application of technical sound-reducing systems as well as from experience with the control of pile driving processes in connection with the characteristics of the impact hammer were particularly important for the foundation work of the projects in the German North Sea and Baltic Sea EEZ, such as "Butendiek", "Borkum Riffgrund I", "Sandbank", Gode Wind 01/02", "NordseeOne", "Veja Mate", "Merkur Offshore", "EnBWHoheSee" and in particular "Arkona Basin South East". A current study commissioned by BMU (BELLMANN, 2020) provides a cross-project evaluation and presentation of the results from all technical noise abatement measures used in German projects to date.

The results of the very extensive monitoring of the construction phase of 20 wind farms have confirmed that the measures to prevent and mitigate disturbances to harbour porpoise by impact noise have been effectively implemented, and that the requirements of BMU's noise abatement concept (2013) are reliably met. The current state of knowledge takes into account construction sites at water depths ranging from 22 m to 41 m, in seabed soils ranging from homogeneous sandy to heterogeneous and difficult to penetrate profiles, and piles with diameters of up to 8.1 m. It has been shown that the industry has found solutions in the various procedures to effectively harmonise installation processes and noise protection.

According to the current state of knowledge and on the basis of the development of technical noise protection to date, it can be assumed that significant disturbance to harbour porpoises from foundation work can be ruled out within the areas covered by the plan, even assuming the use of piles with a diameter of more than 10 m.

In addition, in the downstream approval procedures of the BSH, concrete monitoring measures and noise measurements will be ordered in order to detect a possible hazard potential on site on the basis of the concrete project parameters and, if necessary, to initiate optimisation measures.

New findings confirm that the reduction of noise input through the use of technical noise reduction systems clearly reduces disturbance effects on harbour porpoises. The minimisation of effects concerns both the spatial and temporal extent of disturbances (DÄHNE et al., 2017, BRANDT et al. 2016, DIEDERICHS et al., 2019).

In order to avoid cumulative effects due to parallel pile driving for different projects, the timing of pile driving shall be coordinated in the context of downstream planning approval procedures and implementation. In line with the BMU's noise abatement concept (2013) for the North Sea, the area approach is also being pursued with the aim of always keeping sufficiently high-quality alternative habitats for the harbour porpoise population in the German Baltic Sea EEZ free of disturbance-inducing noise inputs.

Cumulative effects on marine mammals, in particular harbour porpoises, may occur mainly due to noise exposure during the installation of foundations using impact pile driving. For example, marine mammals may be significantly affected if pile driving is performed simultaneously at multiple sites within the EEZ without equivalent alternative habitats being available.

So far, the implementation of offshore wind farms and platforms has been relatively slow and gradual. In the period from early 2013 to the end of 2017, pile driving work was carried out at three wind farms in the German Baltic Sea EEZ. Since 2013, all pile driving work has been performed using technical noise reduction measures. Since 2014, the noise control limits have been reliably observed, and noise even kept to below limit values by successfully applying noise reduction systems (Bellmann, 2020 in preparation).

Due to the small number of construction projects in the Baltic Sea, there was no overlapping of noise-intensive work activities.

The evaluation of the sound results with regard to sound propagation and the possible resulting cumulation has shown that the propagation of impulsive sound is greatly restricted when effective sound-reducing measures are applied (Dähne et al., 2017).

Two studies from 2016 and 2019 commissioned by the German Offshore Wind Energy Association (BWO) provide current findings on possible cumulative effects of noise impacts on the occurrence of harbour porpoise in the German North Sea EEZ. Within the framework of the two studies, the extensive data from monitoring the construction phases of offshore wind farms by means of acoustic and visual/digital recording of harbour porpoises were evaluated and assessed across the projects (Brandt et al., 2016, Brandt et al., 2018, Diederichs et al., 2019). In both studies, the effects were assessed on the basis of the range and duration of the deterrence of harbour porpoises from the vicinity of pile-driving sites before, during and after pile-driving.

The study of 2019, which deals with the evaluation of the data from the period from early 2014 to the end of 2018, comes to the conclusion that optimised use of technical noise reduction measures since 2014 and the resulting reliable compliance with the limit value has not led to any further reduction of the displacement effects on harbour porpoises compared to the phase from 2011 to 2013 during which noise reduction systems that had not yet been optimised were used. The displacement radius determined in both studies is approximately 7.5 km, thus confirming the assumptions made in BMU's noise abatement concept (2013) for the North Sea. However, the latest study has also shown that no reduction of the displacement effects could be detected from a sound pressure level of 165 dB (SEL05 re 1µPa2 s at a distance of 750 m) (Diederichs et al., 2019). The authors of the study put forward various hypotheses for the interpretation of the results, which take into account, among other things, psychoacoustic reactions of the animals, differences in food availability, effects of deterrence behaviour using seal scarers and the activity of the respective construction site, but also differences in data quality. The study also evaluated data from the construction of a wind farm in the EEZ of a neighbouring country where no noise reduction measures were implemented. It was shown that the displacement and thus the disturbance at construction sites using noise reduction systems is significantly lower than at construction sites without noise reduction (Diederichs et la. 2019).

According to the current state of knowledge, prevention and mitigation measures, as described above, are required during pile driving operations in order to rule out with certainty any significant disturbance of the local harbour porpoise population.

As a result, by applying the above-mentioned strict noise protection and noise reduction measures in accordance with the principles and objectives of the plan and the instructions in the planning approval decisions and in compliance with the limit value of 160 dB SEL5, no significant disturbances within the meaning of Article 44 subsection (1) number 2 of the BNatSchG are to be expected within a radial distance of 750 m from the noise source. Furthermore, the BfN's call to coordinate the timing of noise-intensive construction phases of multiple project developers in the German North Sea EEZ in accordance with the BfN's demand has been ordered.

Operational effects of wind energy production

According to the current state of knowledge, the operation of offshore wind turbines cannot be assumed to constitute a disturbance pursuant to Article 44 subsection 1 number 2 of the BNatSchG. Based on the current state of knowledge, no negative long-term impacts on harbour porpoises are to be expected from the noise emissions of standardised, properly designed and erected wind turbines. Any effects are limited to the immediate vicinity of the installations and depend on sound propagation in the specific area and, not least, on the presence of other sound sources and background noise, such as shipping traffic (MADSEN et al. 2006). This is confirmed by findings from experimental work on the perception of low-frequency acoustic signals by harbour porpoises using simulated operating noise from offshore wind turbines (LUCKE et al. 2007b): Masking effects were recorded at simulated operating noises of 128 dB re 1 µPa at frequencies of 0.7, 1.0 and 2.0 kHz. In contrast, no significant masking effects were detected at operating noises of 115 dB re 1 µPa. The first results thus indicate that masking effects due to operating noises can only be expected in the immediate vicinity of the given installation, with the intensity again depending on the type of installation.

Standardised measurements during the operating phase of offshore wind farms in the German North Sea EEZ have confirmed that, from an acoustic standpoint, the underwater noise emitted by the wind turbines outside the wind farm areas is not clearly distinguishable from the background noise that is permanently present. Only low-frequency sounds can be measured at a distance of 100 m from the respective wind turbine. However, with increasing distance from the wind turbine, the noise of the turbine differs only slightly from the ambient noise. Even at a distance of 1 km from the wind farm, noise levels are always higher than those measured in the middle of the wind farm. The investigations have clearly shown that the underwater sound emitted by the turbines cannot be clearly distinguished from other sound sources, such as waves or ship noise, even at short distances. It was also hardly possible to differentiate the wind farm-related shipping traffic from the general ambient noise, which is introduced by various sound sources such as other shipping traffic, wind and waves, rain and other uses (MATUSCHEK et al. 2018). Results from current investigations of underwater noise in the operating phase of offshore wind farms are presented in detail in Section 3.2.3.

Results of a study on the habitat use of operating offshore wind farm areas by harbour porpoises based on the Dutch offshore wind farm "Egmont aan Zee" confirm this assumption. The acoustic survey was used to assess the use of the area of this wind farm, i.e. two reference sites, by harbour porpoises prior to erection of the wind turbines (baseline survey), and then again over two consecutive years of the constructed wind farm’s operation. The results of the study confirm a pronounced and statistically significant increase in acoustic activity in the inner area of the wind farm during the operating phase compared to the activity or use during the baseline survey (SCHEIDAT et al. 2011). The increase in harbour porpoise activity within the wind farm during operation significantly exceeded the increase in activity in both reference areas. The increase in use of the wind farm area was significantly independent of seasonality and interannual variability. The authors of the study see a direct correlation between the presence of the turbines and the increased use by harbour porpoises. They suspect the causes lie in factors such as an enrichment of the food supply by a so-called "reef effect" or a calming of the area due to the absence of fishing and shipping, or possibly a positive combination of these factors.

The results of the investigations during the operational phase of the "alpha ventus" project in the North Sea EEZ also indicate a return to distribution patterns and abundances of harbour porpoise that are comparable - and in some cases higher - to those from the baseline survey of 2008.

The results from monitoring the operational phase of offshore wind farms in the EEZ have so far not provided clear results. The investigation in accordance with Standard StUK4 by means of aircraft-based recording has so far revealed fewer sightings of harbour porpoises inside the wind farm areas than outside. However, acoustic recording of habitat use by means of special underwater passive acoustic measuring devices called C-POD hydrophones shows that harbour porpoises use the wind farm areas (Butendiek 2017, North Helgoland, 2019, Krumpel et al., 2017, 2018, 2019). The two methods – visual/digital detection from aircraft and underwater acoustic detection – are complementary, i.e. the results from both methods should be used together to identify and assess possible effects. This joint evaluation of the data, the development of suitable evaluation criteria and the description of the biological relevance is to be the subject of a research programme.

Against this backdrop, in order to ensure with sufficient certainty that incidents pursuant to Section 44 subsection (1) number 2 of the Federal Nature Conservation Act do not occur, an operational noise-reducing installation design in accordance with the state of the art will be used in the sense of meeting the corresponding requirements of the subordinate suitability assessment and the instructions in individual plan approval decisions.

Appropriate monitoring will also be arranged for the operational phase of the individual projects in the areas covered by the plan in order to identify and assess any site- and project-specific impacts.

As a result, the protective measures ordered are sufficient to ensure that, with regard to harbour porpoises, the operation of the installations in the areas covered by the plan will also comply with the requirements governing the prohibition under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act.

Cumulative consideration

In Section 4.10.3, cumulative effects of offshore wind energy generation on harbour porpoises were presented, and related prevention and mitigation measures were described. However, harbour porpoises are exposed to the impacts of various anthropogenic uses as well as natural and climate-related changes. A differentiation or even weighting of the proportion of the impacts of a single use on the state of the population is hardly possible from a scientific standpoint.

Spatial planning and the specifications stipulated in the Spatial Pan, including the principles and objectives, constitute one of the key instruments for reducing or even preventing cumulative impacts on the harbour porpoise population by rectifying spatial conflicts between various uses and defining priority and reservation areas for nature conservation.

The designation of priority areas for wind energy exclusively outside of nature conservation areas serves as one measure for ensuring the protection of harbour porpoises in the German EEZ. In addition, regional planning paves the way for downstream planning levels and procedures. Finally, the principles of the plan form the backbone for the specifications in the downstream procedures and for the directives governing the protection of harbour porpoise within the framework of individual licensing procedures.

In addition, the planning approval decisions of the BSH include a number of requirements, due to the habitat approach pursued, which ensure effective prevention and reduction of cumulative effects caused by impact noise, in particular on the highly endangered population of harbour porpoise in the central Baltic Sea and on the populations in the nature conservation areas. During the period from 1 November through 31 March every year, no noise-intensive work is permitted at any construction projects in areas EO1 and EO2 without full noise protection, including such measures as reference and test measurements for further development and optimisation of technical noise reduction systems.

In conclusion, with regard to harbour porpoises, it must be stated that implementation of the plan will not produce any violations of the prohibitions laid down in Article 44 subsection (1) numbers 1 and 2 of the Federal Nature Conservation Act, even with regard to cumulative effects.

Other marine mammals

In addition to the harbour porpoise, animal species declared to be specially protected in a statutory instrument pursuant to Article 54 subsection (1) of the Federal Nature Conservation Act (BNatSchG) are considered specially protected under Article 7 subsection (2) number 13 letter c of the BNatSchG). The German Federal Ordinance on the Conservation of Species (BArtSchV), which was issued on the basis of Article 54 subsection number 1 of the Federal Nature Conservation Act (BNatSchG), lists indigenous mammals as being specially protected, which thus also fall under the species protection provisions of Article 44 subsection (1) number 1 of the BNatSchG. In principle, the considerations listed in detail for harbour porpoises regarding noise pollution from the construction and operation of offshore wind turbines apply to marine mammals occurring in areas EO1 to EO3 and their surroundings. However, hearing thresholds, sensitivity and behavioural responses vary considerably among marine mammals, depending on the species. The differences in the perception and evaluation of sound events among marine mammals are based on two components: On the one hand, the sensory systems are morphoanatomically and functionally species-specific. As a result, different marine mammal species hear and react differently to sound. On the other hand, both perception and reaction behaviour depend on the respective habitat (KETTEN 2004).

The areas covered by the plan have a low to medium importance for harbour seals and grey seals.

Seals are generally considered tolerant of sonic activity, especially when they are fed abundantly. However, telemetric studies have shown escape reactions during seismic activity (RICHARDSON 2004). According to all findings to date, seals can still hear pile-driving sounds at a distance of more than 100 km. Operating noises from 1.5 - 2 MW wind turbines can be heard by harbour seals even at a distance of 5 to 10 km (LUCKE K., J. SUNDERMEYER & U. SIEBERT, 2006, MINOSplus Status Seminar, Stralsund, Sept. 2006, presentation).

All in all, it can be assumed that the species protection requirements can be met due to the long distances to casting grounds and moorings and the protective measures provided.

With regard to the harbour seal and grey seal, the prevention and reduction measures already note for harbour porpoise shall apply.

In conclusion, with regard to harbour seals and grey seals, the implementation of the plan will not produce any violations of the requirements governing the prohibitions under Article 44 subsection (1) numbers 1 and 2 of the Federal Nature Conservation Act, including with regard to other marine mammals.

5.3 Avifauna (seabirds, resting and migratory birds)

The plan is to be evaluated on the basis of species conservation requirements pursuant to Article 44 subsection 1 of the BNatSchG for avifauna (resting and migratory birds).

The areas covered by the plan contain varying densities of protected bird species listed in Annex I to the Birds Directive (in particular red-throated diver, black-throated diver, little gull and horned grebe) and regularly occurring migratory bird species (long-tailed duck, common scoter, velvet scoter, guillemot and razorbill) which also occur as resting species. Against this background, the compatibility of the plans with Article 44 subsection (1) number 1 of the BNatSchG (prohibition of killing and injury) and Article 44 subsection (1) number 2 of the BNatSchG (prohibition of disturbance) must be examined and ensured.

The individual areas for offshore wind energy in the Baltic Sea EEZ are of varying importance for seabirds and resting birds. Overall, area EO1 is expected to be of medium importance for seabirds. The area touches the southern and south-eastern edges of the extensive resting habitats of the Pomeranian Bay and the Adler Ground. Overall, the area has a medium seabird occurrence and a medium occurrence of endangered species and species requiring special protection. According to current knowledge, areas EO2 and EO3 are of minor importance as feeding and resting habitats for seabirds. Both areas have a low incidence of endangered species and species requiring special protection. They do not belong to the main resting, feeding and wintering habitats of species listed in Annex I of the Birds Directive.

Furthermore, the EEZ has an average to above-average importance for bird migration. Up to one billion birds migrate across the Baltic Sea every year. The Baltic Sea is an important transit area for sea ducks and geese from Northern Europe and Russia (as far as Western Siberia), with much of the migration in autumn taking place in an east-west direction close to the coast. Thermal gliders (and other tagging land birds such as wood pigeons) migrate preferably along the "bird flight line" (islands of Fehmarn, Falster, Møn and Seeland, Falsterbo). East of this main route, these birds migrate at a much lower density. The western Baltic Sea is of above-average importance for crane migration, as the majority of the biographical population inevitably has to cross the Baltic Sea on their way south. In addition, the western Baltic Sea is flown over by several species requiring special protection (e.g.

white-cheeked goose, whooper swan, common eider, common scoter and velvet scoter) at sometimes high intensities.

Among the uses specified in the plan, wind energy production is the most intensive use, also with regard to possible impacts on seabirds. At the same time, wind energy production is the only use that is controlled by the BSH within the framework of subordinate processes. In recent years, the monitoring of the operating phase of offshore wind farms in the German EEZ has increased the level of knowledge in connection with impacts relevant to species conservation law.

5.3.1 Article 44(1)1 of the BNatSchG (prohibition of killing and injury)

Under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act, it is prohibited to hunt, capture, injure or kill wild animals of specially protected species. The specially protected species include European bird species, so that species listed in Annex I of the Birds Directive, species whose habitats and haunts in nature conservation areas are protected, as well as characteristic species and regularly occurring migratory bird species. Accordingly, the possibility of birds being injured or killed as a result of collisions with wind turbines must, in principle, be ruled out. The risk of collision depends on the behaviour of the individual animals and is directly related to the species affected and the environmental conditions they encounter. For example, any collision of divers with wind turbines is not to be expected to occur due to their pronounced avoidance behaviour towards vertical obstacles (GARTHE et al. 2018, Mendel et al. 2019, BIOCONSULT SH et al. 2020).

As already explained, according to Article 44 subsection (5) second sentence number 1 of the BNatSchG, a violation of the prohibition of killing and injury does not exist "if the impairment caused by the intervention or the project does not significantly increase the risk of killing and injury to specimens of the species concerned, and this impairment cannot be avoided by applying the necessary, professionally recognised protective measures". This exception was included in the BNatSchG on the basis of pertinent Supreme Court decisions, since in the planning and approval of public infrastructure and private construction projects, it must regularly be assumed that unavoidable operational killings or injuries of single individuals (e.g. due to collision of birds with wind turbines) may occur, which, however, as the realisation of socially adequate risks, should not fall under the scope of the ban (BT-Drs. 16/5100, p. 11 and 16/12274, p. 70 f.). An attribution is only made if the risk of success of the project is significantly increased due to special circumstances, such as the construction of the installations, the topographical conditions or the biology of the species. In this context, risk prevention and mitigation measures must be included in the assessment (cf. LÜTKES/EWER/HEUGEL, SECTION 44 BNATSCHG, MARGIN NO. 8, 2011; BVERWG, RULING OF 12 MARCH 2008; REF. 9 A3.06; BVERWG, RULING OF 9 July 2008, ref. 9 A14.07; FRENZ/MÜGGENBORG/LAU, Section 44 BNATSCHG, MARGIN NO. 14, 2011).

In its statements, BfN regularly states that the changes in technical variable/size parameters of the wind turbines in current offshore wind farm projects, compared to the projects implemented from 2011 to 2014, generally lead to an increase in vertical obstacles in the airspace. However, according to the current state of knowledge, an increased risk of bird strikes could not be quantified due to the simultaneous reduction of the number of turbines. It is true that individual collision-related losses caused by the erection of a fixed installation in previously obstacle-free areas cannot be completely ruled out. However, the ordered measures, such as minimisation of light emissions, ensure that a collision with the offshore wind turbines is prevented to the greatest extent possible, or at least this risk is minimised. In addition, effects monitoring is carried out during the operating phase in order to verify the current nature conservation assessment of the actual risk of bird strike posed by the installations and, if necessary, to be able to adjust it.

According to current knowledge, there is an increased risk potential for cranes to collide with wind turbines on the basis of flight behaviour and flight altitude distribution. Over the course of past bird migration observations in the vicinity of area O-1.3, a higher number of cranes were observed, especially under crosswind conditions from the west (BioConsult SH 2019, IfAÖ et al. 2020). For the suitability test of area O-1.3, a requirement was included in Section 43 of the draft suitability assessment for the protection of cranes, taking into account the available findings, in order to comprehensively observe migratory events and thus recognise situations with increased migratory events in good time, so that effective measures can be taken to reduce the collision risk of cranes in these situations. On the basis of the strict species protection standards, it was also considered necessary to include other species or groups of species in the specifications for area O-1.3 in order to be able to exclude a significantly increased risk of killing and injury with the necessary certainty. The EO2 area is designated as a reserved area because of its central location in the bird migration corridor between Rügen and Skåne. Comparable measures as for O-1.3 cannot be excluded for areas or projects in the area.

Against this background, there is no reason to fear a significant increase in the risk of killing or injury to avifauna. Hence, the realisation of offshore wind energy installations together with ancillary facilities, such as a transformer station and submarine power cabling within the wind farm does not violate the prohibition of killing and injury pursuant to Article 44 subsection 1 number 1 of the BNatSchG.

If the requirements of the suitability test are implemented as defined, it can be assumed that no violation of the prohibition of injury and killing under Article 44 subsection 1 number 1 of the Federal Nature Conservation Act (BNatSchG) within the framework of offshore wind energy use in the areas covered by the plan will occur.

5.3.2 Article 44(1)2 BNatSchG (prohibition of disturbance)

Under Article 44 subsection 1 number 2 of the Federal Nature Conservation Act, it is prohibited to cause significant disturbance to wild animals of strictly protected species during their breeding, rearing, moulting, wintering and migration periods. For this reason, it is necessary to consider possible disturbances to local populations in German waters, in particular in the German EEZ, by wind energy use in the areas covered by the plan.

A cross-area and area-wide species protection assessment with regard to the ban on disturbance in the sense of a deterioration in the conservation status of local populations of protected species was carried out as part of the SEA for the Site Development Plan (SDP, Environmental Report 2019). The results of the assessment carried out within the framework of preparing the SDP (BSH 2019) can be confirmed on the basis of the available data and information.

As noted above, protected species are present in areas EO1 to EO3. These include species listed in Annex I to the Birds Directive, species whose habitats and haunts are protected in the nature conservation areas, as well as characteristic species and regularly occurring migratory bird species.

The area of areas EO1 to EO3 is mainly used by divers as a transit area during migration periods and in winter. According to current knowledge, this area and its surroundings lie outside the main occurrence areas in the Pomeranian Bay. On the basis of the available findings, the BSH comes to the conclusion that areas EO1 to EO3 are not of high importance for the diver population in the German Baltic Sea. In this respect, no disturbance of the local population can be assumed.

Due to the relatively low observed densities of little gulls in the areas EO1 to EO3 and the temporary coupling to the species-specific main migration periods, the areas EO1 to EO3 can only be assumed to be of minor importance for little gulls. With regard to little gulls, the current state of knowledge is that an implemented wind farm project in areas EO1 to EO3 does not fulfil the disturbance criteria under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act.

Horned grebes prefer shallow water with depths up to 10 m. Due to the water depths of areas EO1 to EO3, this part of the EEZ is not particularly important for horned grebes. This is confirmed by only sporadic sightings from the seabird surveys in the cluster "Westlich Adlergrund", which also cover area EO1. Therefore, no disturbance of the local population of horned grebes can be assumed.

Diving sea ducks, such as long-tailed duck, velvet scoter and common scoter, also prefer the food-rich shallow waters of the Baltic Sea. They are therefore unlikely to be particularly interested in areas EO1 to EO3 and their surroundings. As far as diving sea ducks are concerned, a wind farm project in areas EO1 to EO3 is not expected to meet the disturbance criteria under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act (BNatSchG).

Common guillemots (murres) and razorbills are widely distributed in winter in the areas covered by the plan. On the basis of existing studies and knowledge of the distribution throughout the Baltic Sea, no focal points for occurrence can be identified for the areas EO1 to EO3. The area EO1 only borders on the southern foothills of the distribution area of the auks. On the basis of current knowledge, it is not expected that a wind farm project in the areas covered by the plan will have a significant impact on a number of auks, in particular common guillemots (murres) and razorbills. On the basis of the information currently available, the BSH therefore does not assume that the disturbance criteria defined under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act will be met.

The gull species found in the areas covered by the plan are known to be prominent ship followers. In addition, findings from research projects and wind farm monitoring indicate that offshore wind farms have an attraction effect. According to current knowledge, an offshore wind farm in the areas earmarked for wind energy production is not expected to have any significant disturbance impacts on the populations of the gull species.

In conclusion, based on current knowledge, the construction and operation of offshore wind turbines and ancillary installations (transformer station, submarine power cabling within the wind farm) in the areas covered by the plan are not considered to meet the criteria for a disturbance under Article 44 subsection 1 number 2 of the Federal Nature Conservation Act (BNatSchG).

Within the scope of the individual approval procedures, however, an update of the investigation for compliance with the disturbance ban in accordance with Article 44 subsection 1 number 2 of the BNatSchG is required, if necessary taking into account further prevention and mitigation measures, but in any case taking into account the specific technical specifications.

5.4 Bats

The areas covered by the plan for offshore wind energy production are to be defined on the basis of species protection regulations in accordance with Article 44 of BNatSchG in conjunction with Article 12 of the Habitats Directive for bats.

5.4.1 Article 44(1)1 and 2 BNatSchG

In terms of species protection law, the same considerations apply in principle as those already set out in the assessment of avifauna. Under Article 12 subsection (1) letter (a) of the Habitats Directive, all deliberate forms of capture or killing of individuals taken from the wild of the species listed in Annex IV to the Habitats Directive, and thus of all bat species, are prohibited. With regard to collisions with offshore structures, reference can be made to the guide to the strict system of protection for animal species of Community interest under the Habitats Directive, which assumes in II.3.6 margin number 83 that the killing of bats through collisions with wind turbines is an unintentional killing which must be continuously monitored in accordance with Article 12 subsection 4 of the Habitats Directive. There are no indications for the examination of further facts according to Article 12 subsection 1 of the Habitats Directive.

Migration movements of bats over the Baltic Sea have been documented in various ways, but concrete information on migratory species, migration corridors, migration heights and migration concentrations is still missing. Previous findings merely confirm that bats, especially long-distance migratory species, migrate across the Baltic Sea. At present, there is no reliable data available that would indicate significant impacts on bats and question the suitability of the areas for wind energy generation.

It can also be expected that any adverse effects of wind turbines on bats will be avoided by the same prevention and mitigation measures that are in place to protect bird migration.

Experiences and results from research projects or from wind farms already in operation will also be adequately considered in further procedures.

The BfN regularly assumes in its statements that, according to the current state of knowledge, the killing or injury (as per Article 44 subsection 1 number 1 of the BNatSchG) of other specially protected species, such as bats, by offshore wind farms can be ruled out. According to the BfN, based on current knowledge, any violation of the prohibition criteria for a significant disturbance (as per Article 44 subsection. 1 number 2 of the BNatSchG) of other strictly protected species is also not to be expected. The BSH agrees with the opinion of the BfN.

6 Review for Compatibility with the legal framework governing the conservation of natural habits

6.1 Legal basis

Insofar as a site of Community importance or a European bird sanctuary may be significantly impaired in its elements relevant to the conservation objectives or the purpose of protection, Section 7 subsection (6) in conjunction with subsection (7) of Germany's Federal Regional Planning Act (ROG), the provisions of the Federal Nature Conservation Act (BNatSchG) on the permissibility and implementation of such interventions, including obtaining the opinion of the European Commission, must be applied when amending and supplementing Spatial Plans.

The Natura2000 network comprises the sites of Community importance (Habitats Directive) under the Habitats Directive and the special protection areas (SPA) under the Birds Directive, which have now been designated as protected areas in Germany (as per e.g. the Federal Administrative Court (BVerwG) Decision of 13 March 2008 - 9 VR 9/07). It therefore does not replace the assessment at the level of the specific project in terms of knowledge of the specific project parameters, which is carried out within the framework of approval procedures. To this extent, further prevention and mitigation measures are to be expected as deemed necessary by the impact assessment within the framework of approval procedures in order to exclude any impairment of the conservation objectives of the Natura 2000 sites or the protection purposes of the protected areas by the use inside or outside a nature conservation area. At the same time, it must be taken into account that for some uses - especially for wind energy production – the Spatial Plan (ROP) traces the projects already in operation and the provisions of the sectoral planning in the site development plan (SDP), for which compatibility assessments have already been carried out.

The German Baltic Sea Exclusive Economic Zone (EEZ) contains the Pomeranian Bay – Rönne Bank Nature Conservation Area, created by Regulation on the Establishment of the Pomeranian Bay – Rönne Bank of 22 September 2017 (NSGPBRV, Federal Law Gazette I, p. 3415) Fehmarn Belt Nature Conservation Area created by the Regulation on the Establishment of the Fehmarn Belt Nature Conservation Area of 22 September 2017 (NSGFmbV, Federal Law Gazette I p. 3405) and Kadet Trench Nature Conservation Area created by the Regulation on the Establishment of the Kadet Trench Nature Conservation Area of 22 September 2017 (NSGKdrV, Federal Law Gazette I, p. 3410).

The total area of these three nature conservation areas amounts to 2,472 km², with Pomeranian Bay – Rönne Bank Nature Conservation Area covering an area of 2,092 km², Fehmarn Belt Nature Conservation Area an area of 280 km²km2, and Kadet Trench Nature Conservation Area 100 km².

The protected habitats are the habitat types "reefs" and "sandbanks" as defined in Annex I of the Habitats Directive, certain fish species (sturgeon, twaite shad) and marine mammals listed in Annex II of the Habitats Directive (harbour porpoise, grey seal, seal) as well as various species of seabirds listed in Annex I to the Birds Directive (red-throated diver, black-throated diver, horned grebe) and regularly occurring migratory bird species (red-necked grebe, yellow-billed diver, long-tailed duck, common scoter, velvet scoter, petrel, guillemot, razorbill and black guillemot).

The impact assessment carried out here takes place at a higher level of regional planning and sets a framework for subordinate planning levels, where these exist. It therefore does not replace the assessment at the level of the specific project. Depending on the provisions of the Spatial Plan for the respective use, the assessment is stratified. In the case of wind energy, there is a staged planning and approval process. This means that the reviews of the downstream planning levels are taken into account within the scope of this Spatial Plan. If no review has yet been carried out at subordinate planning levels, the review within the framework of this SEA for the Spatial Plan is carried out on the basis of the available data and knowledge.

There is also a staged planning and approval process for the extraction of raw materials. Insofar as data and knowledge are available, an impact assessment is carried out within the scope of this SEA, otherwise the assessments are reserved for the downstream planning levels.

The draft Spatial Plan contains provisions relevant to the impact assessment concerning priority and reservation areas for wind energy, reservation areas for pipelines and power cables, and reservation areas for hydrocarbons and sand and gravel extraction.

Scientific determinations can only be reviewed where information is available.

For the impact assessment, a distinction must be made between the following:

Wind Energy

Since the technical legislation under Section 5 subsection (3) sentence 5 point a) of Germany's Offshore Wind Energy Act (WindSeeG) prohibits areas and sites chosen for wind energy installations in the Spatial Plan from being within a protected area designated under Article 57 of the Federal Nature Conservation Act (BNatSchG), the Spatial Plan does not contain any area definitions for the use of wind energy within the protected areas designated by such regulation.

In the following, therefore, the impact assessment relates exclusively to site definitions at or near protected areas designated by regulation.

For the areas EO1, EO2 and EO3, reference is made to the impact assessment of the 2019 SDP and 2020 draft SDP.

6.2 Assessment of the compatibility of the Spatial Plan with habitat types

The conservation or, where necessary, the restoration of a favourable conservation status of the habitat type "reef" (EU Code 1170) is the conservation objective in the Kadet Trench Nature Conservation Area (Section 3 subsection (3) number 1 of NSGKdrV) and the Pomeranian Bay – Rönne Bank Nature Conservation Area (Section 4 subsection (1) number 1 of NSGPBRV). The habitat type "sandbank" is a protected site in the "Pomeranian Bay – Rönne Bank Nature Conservation Area (Section 5 subsection (1) number 1 of NSGPBRV) and in the Fehmarn Belt Nature Conservation Area (Section 3 subsection (3) number 1 of NSGFmbV).

Based on the shortest distance between areas EO1 to EO3 and the aforementioned nature conservation areas, any impacts of construction, installation and operation on the Flora Fauna Habitat (FFH) types "reef" and "sandbank" and their unique and endangered communities and species, can be ruled out. The areas lie far beyond the drift distances discussed in the reference literature, such that no release of turbidity, nutrients and pollutants is to be expected which could impair the nature conservation and FFH areas in their components relevant to the conservation objectives or the protection purpose.

6.3 Assessment of the compatibility of the Spatial Plan with protected species

6.3.1 Impact assessment under the Regulation on the Establishment of the Pomeranian Bay – Rönne Bank Nature Conservation Area

Any impairment of the conservation objectives or protection purposes of the nature conservation areas arising from implementation of the plan must be examined In accordance with Section 9 subsection (1) number 3 of NSGPBRV.

Such assessment of the impact of the plan is based on the define protection purpose of the Pomeranian Bay – Rönne Bank Nature Conservation Area. Section 3 subsection (1) of NSGPBRV states that the overarching protection objective is to achieve the conservation objectives of the Natura 2000 areas by permanently preserving the marine area, the diversity of its habitats, biotic communities and species relevant to these areas and the special character of this part of the Baltic Sea, which is characterised by the Oderbank, Adler Ground, Rönne Bank and the slopes of the Arkona Basin.

According to Section 3 subsection (2) number 3 of NSGPBRV, this includes the conservation or, where necessary, the restoration of the specific ecological values and functions of the area, in particular the populations of harbour porpoises, grey seals and seabird species, as well as their habitats and natural population dynamics.

<u>Protected marine mammal species</u>

Finally, the Regulation of 22 September 2017 sets out under Section 4 subsection 6 of NSGPBRV specific objectives for ensuring the survival and reproduction of the marine mammal species noted in Section 3 subsection 2 of NSGPbrV that are listed in Annex II to the Habitats Directive - harbour porpoise and grey seal - as well as for conserving and restoring their habitats.

According to Section 4 subsection (3), the protection of harbour porpoise in Area I requires in particular the conservation or, where necessary, restoration of

- the natural population densities of this species with the aim of achieving a favourable conservation status, their natural spatial and temporal distribution, health status and reproductive fitness, taking into account natural population dynamics, natural genetic diversity within the stock in the area and genetic exchanges with stocks outside the area,
- the area as a harbour porpoise habitat largely free of disturbance and unaffected by local pollution,
- undissected habitats and the possibility of harbour porpoise migration within the Central Baltic Sea and to the Western Baltic and Belt Sea, and
- the essential nutritional requirements of harbour porpoises, in particular the natural densities, age-group distributions and distribution patterns of the organisms that provide a food source for harbour porpoises.

The same is regulated in Section 6 subsection (3) of NSGPBRV for the harbour porpoise in Area III of the nature conservation area, as well as in Section 5 subsection (3) of the NSGPBRV.

Section 5 subsection (1) of the NSGPBRV states that the purpose of protection in Area II is to maintain or restore a favourable conservation status of the harbour porpoise and, additionally, to maintain or restore a favourable conservation status of the grey seal.

Reference is made to the results of the impact assessment for the 2019 SDP and 2020 draft SDP.

Possible impairments of the protective purposes of the Pomeranian Bay – Rönne Bank Nature Conservation Area caused by implementing projects in the areas EO1, EO2 and EO3 of the present plan can be rule out with certainty if the instructions in the subordinate individual approval procedures are complied with.

<u>Protected seabird species</u>

Pursuant to Section 34 subsection (1) of the Federal Nature Conservation Act and Section 9 subsection (1) number 3 of NSGPBRV, any impairment of the conservation objectives of subarea IV of the nature conservation area arising from implementation of the plan must be examined.

The compatibility assessment test is performed on the basis of the protective purpose of subarea IV in accordance with Section 7 of the NSGPBRV.

According to Section 7 subsection (1) of the NSGPBRV, the protective purposes pursued in subarea IV include the maintenance or, where necessary, the restoration of a favourable conservation status

- under number 1, of the species listed in Annex I to Directive 2009/147/EC occurring in that area: red-throated diver (*Gavia stellata*), black-throated diver (*Gavia arctica*), horned grebe (*Podiceps auritus*),
- under number 2, of the migratory species regularly occurring in this area: red-necked grebe (*Podiceps grisegena*), yellow-billed grebe (*Gavia adamsii*), long-tailed duck (*Clangula hyemalis*), common scoter (*Melanitta nigra*), velvet Scoter (*Melanitta fusca*), common gull (*Larus canus*), common guillemot (*Uria algae*), razorbill (*Alca torda*) and black guillemot (*Cepphus grylle*), and
- under number 3, of the function of this area as a feeding, wintering, moulting, transit and resting area for the above species.

Under Section 7 subsection (2) of the NSGPBRV, in order to protect habitats and to ensure the survival and reproduction of the bird species listed in subsection (1) and of the area in its functions listed in subsection (1), it is in particular necessary to maintain or, where necessary, restore

- under number 1, the qualitative and quantitative populations of bird species with the aim of achieving a favourable conservation status, taking into account the natural population dynamics and population trends of their biogeographical population,
- under number 2, the essential nutritional requirements of bird species, in particular population densities, age-group distributions and distribution patterns of the organisms serving as food for bird species,
- under number 3, the characteristics of the area, in particular salinity, freedom from ice even in severe winters, and the geo- and hydromorphological characteristics with their species-specific ecological functions and effects, and
- under number 4, the natural quality of habitats with their respective species-specific ecological functions, their fragmentation and spatial interrelationships, and unimpeded access to adjacent and neighbouring marine areas.

Reference is made to the results of the impact assessment for the 2019 SDP and 2020 draft SDP.

Possible impairments of the protective purposes of the Pomeranian Bay– Rönne Bank Nature Conservation Area arising from the implementation of projects in the areas EO1, EO2 and EO3 of the present plan can be ruled out with certainty if the instructions in the subordinate individual approval procedures are complied with.

6.3.2 Impact assessment under the Regulation on the Establishment of the Fehmarn Belt Nature Conservation Area

The compatibility of implementation of the plan with the protection purposes of the nature conservation area must be examined in accordance with in accordance with Section 3 of NSGFmbV.

According to Section 3 subsection (1) of Regulation on the Establishment of the Fehmarn Belt Nature Conservation Area (NSGFmbV), the overarching conservation objective of the Fehmarn Belt Nature Conservation Area is to achieve the conservation objectives of the Natura 2000 site by permanently preserving the marine area, the diversity of its habitats, biotic communities and species relevant to the area, and the special features of the sandbank in the form of megaripples.

According to subsection (2), this protection shall include

the conservation or, where necessary, the restoration of

- the specific ecological values and functions of the area, in particular, its characteristic morphodynamics and hydrodynamics shaped by the water exchange between the North Sea and the Baltic Sea, a natural or semi-natural expression of marine macrophyte stocks and the species-rich gravel, coarse-sand and shell beds,

- the populations of harbour porpoises, harbour seals, including their habitats and natural population dynamics, and

- its connecting and stepping stone function for the ecosystems of the western and central Baltic Sea.

In accordance with Section 3 subsection (3) number 2 of NSGFmbV, the protection objectives pursued include in particular the conservation or, where necessary, the restoration of a favourable conservation status of the harbour porpoise and seal species.

To protect harbour porpoises and common seals, Section 3 subsection (5) of NSGFmbV stipulates in particular the conservation or restoration of

- the natural population densities of these species with the aim of achieving a favourable conservation status, their natural spatial and temporal distribution, health status and reproductive fitness, taking into account natural population dynamics, natural genetic diversity within the stock and genetic exchanges with stocks outside the area,
- the area as a feeding and migration habitat for harbour porpoises and seals that is as undisturbed as possible and largely unaffected by local pollution, and as a reproduction and breeding habitat for harbour porpoises,
- undissected habitats and the possibility of migration of harbour porpoises and seals within the Baltic Sea, in particular to the adjacent and neighbouring nature conservation areas of Schleswig-Holstein and Mecklenburg-Western Pomerania, and to the moorings along the Danish (in particular Rødsand) and German coasts, and
- the essential nutritional requirements of harbour porpoises and harbour seals, in particular the natural densities, age-group distributions and distribution patterns of the organisms that provide a food source for harbour porpoises and seals.

Reference is made to the results of the impact assessment for the 2019 SDP and 2020 draft SDP.

Possible impairments of the protective purposes of the Fehmarn Belt Nature Conservation Area arising from the implementation of projects in areas EO1, EO2 and EO3 of the present plan can be ruled out with certainty if the instructions in the subordinate individual approval procedures are complied with.

6.3.3 Impact assessment in accordance with the Regulation on the Establishment of the Kadet Trench Nature Conservation Area

The compatibility of the plan's implementation with the conservation purposes of the nature conservation area must be examined in accordance with Section 3 of NSGKdrV.

According to Section 3 subsection (1) of NSGKdrV, the overriding conservation objective of the Kadet Trench Nature Conservation Area is to achieve the conservation objectives of the

Natura 2000 site by permanently preserving the marine area, the diversity of its habitats, biotic communities and species relevant to this area, and the special importance of the channel system existing here for the exchange of water between the North Sea and the Baltic Sea. The protection includes

- the maintenance or, where necessary, restoration of the specific ecological values and functions of the area, in particular its characteristic morphodynamics and the hydrodynamics shaped by the water exchange between the North Sea and the Baltic Sea
- porpoise populations, including their habitat and natural population dynamics, and
- its connecting and stepping stone function for the ecosystems of the western and central Baltic Sea.

According to Section 3 subsection (3) number 2 of NSGKdrV, the protection objectives pursued include the maintenance or restoration of a favourable conservation status of harbour porpoises, including

- the natural population densities of the species with the aim of achieving a favourable conservation status, their natural spatial and temporal distribution, health status and reproductive fitness, taking into account natural population dynamics, natural genetic diversity within the stock and genetic exchanges with stocks outside the area,
- the area as a feeding, migration, reproduction and rearing habitat for harbour porpoises that is as undisturbed as possible and largely unaffected by local pollution,
- undissected habitats and the possibility of migration of marine mammals within the Central Baltic Sea and into the Western Baltic Sea, and
- the main organisms serving as food sources for harbour porpoises, in particular natural population densities, age class distributions and distribution patterns.

Reference is made to the results of the impact assessment for the 2019 SDP and 2020 draft SDP.

Possible impairments of the protective purposes of the Fehmarn Belt Nature Conservation Area arising from the implementation of projects in areas EO1, EO2 and EO3 of the present plan can be ruled out with certainty if the instructions in the subordinate individual approval procedures are complied with**.**

6.3.4 Natura2000 sites outside the German EEZ

The impact assessment will also take into account the long-range effects of the plan on the protected areas in the adjacent 12-mile zone and in the adjacent waters of neighbouring countries. This also applies to the assessment and consideration of functional relationships between the individual protected areas and the coherence of the network of protected areas pursuant to Article 56 subsection (2) of the Federal Nature Conservation Act, since the habitat of some target species (e.g. avifauna and marine mammals) may extend across several protected areas due to their large home range.

Specifically, the bird protection area "Western Pomeranian Bay", the FFH and bird protection area "Plantagenetgrund", the FFH area "Darßer Schwelle", the bird protection area "Vorpommersche Boddenlandschaft und nördlicher Strelasund" and the FFH area "Greifswalder Boddenrandschwelle und Teile der Pommerschen Bucht" in the coastal sea of Mecklenburg – Western Pomerania are taken into account. In the adjacent areas of the neighbouring states, the FFH areas "Adler Grund og Rønne Banke" and "Klinteskov kalkgrund" in Danish waters, the Swedish FFH area "Sydvästskånes utsjövatte", the Polish bird sanctuary "Zatoka Pomorska" and the Polish FFH area "Ostoja na Zatoce Pomorskiej" have been taken into account.

The protection and conservation objectives for the Natura 2000 sites outside the EEZ were taken from the following documents:

- Bird sanctuary "Western Pomeranian Bay" (territorial sea M-V, DE1649 401): EUNIS factsheet (https://eunis.eea.europa.eu/sites/DE1649401)
- FFH and bird protection area "Plantagenetgrund" (coastal sea M-V, DE 1343 301/ DE 1343 401): FFH area https://www.lung.mv-regierung.de/dateien/de_1343_301.pdf, bird protection area https://eunis.eea.europa.eu/sites/DE1343401
- FFH area "Darßer Schwelle" (coastal sea M-V, DE 1540 302): https://www.lung.mv-regierung.de/dateien/de_1540_302.pdf
- Bird protection area "Vorpommersche Boddenlandschaft und nördlicher Strelasund" (coastal sea M-V, DE 1542 401): EUNIS factsheet (https://eunis.eea.europa.eu/sites/DE1542401)
- FFH area "Greifswalder Boddenrandschwelle and parts of the Pomeranian Bay" (coastal sea M-V, DE 1749-302): EUNIS factsheet (http://eunis.eea.europa.eu/sites/DE1749302)
- Danish FFH site "Adler Grund og Rønne Banke" (DK 00VA 261): EUNIS Factsheet (http://eunis.eea.europa.eu/sites/DK00VA261)
- Danish FFH site "Klinteskov kalkgrund" (DK 00VA 306): EUNIS factsheet (http://eunis.eea.europa.eu/sites/DK00VA306)
- Swedish FFH site "Sydvästskånes utsjövatte" (SE 0430187): EUNIS Factsheet (https://eunis.eea.europa.eu/sites/SE0430187)
- Polish bird sanctuary "Zatoka Pomorska" (PLB 990003): EUNIS factsheet (http://eunis.eea.europa.eu/sites/PLB990003)
- Polish FFH site "Ostoja na Zatoce Pomorskiej" (PLH 990002): EUNIS Factsheet (https://eunis.eea.europa.eu/sites/PLH990002).

Reference is made to the results of the impact assessment for the 2019 SDP and 2020 draft SDP.

Possible impairments of the protective purposes of the Natura 2000 areas arising from the implementation of projects in the areas EO1, EO2 and EO3 of the present plan can be ruled out with certainty if the instructions in the subordinate individual approval procedures are complied with.

6.4 Outcome of the impact assessment

The impact assessment has revealed that any significant impairment of the protection purposes of the Pomeranian Bay – Rönne Bank, Fehmarn Belt, and Kadet Trench Nature Conservation Areas by the continuation of the plan, taking into account prevention and mitigation measures for the FHH habitat types, marine mammals, avifauna and other protected animal groups, can be ruled out with the necessary certainty.

It should be noted that the FFH impact assessment carried out for this purpose was not able to examine project-specific properties which are determined and defined in detail by project developers over the course of planning approval procedures.

The impact assessment is therefore carried out in the context of planning approval procedures for the respective project, with the aim of deriving and defining the necessary prevention and mitigation measures at project level.

Based on current knowledge, any significant impairment of the FFH habitat types "reefs" and "sandbanks with only weak permanent seawater intrusion" can be ruled out even if the plan and existing projects for the Pomeranian Bay – Rönne Bank, Fehmarn Belt and Kadet Trench Nature Conservation Areas as well as for Natura 2000 sites in the territorial waters are considered cumulatively, due to the small-scale effects on the one hand and the distances to the sites on the other.

7 Evaluation of the overall plan

In summary, the provisions of draft Spatial Plan (ROP-E) are designed to minimise the impacts on the marine environment as far as possible through orderly, coordinated overall planning. The protection of the nature conservation areas defined by regulation as priority areas for nature conservation serves to safeguard the protection purposes and secure open spaces. By strictly adhering to prevention and mitigation measures, in particular to reduce noise during the construction phase, significant impacts can be prevented, in particular when implementing the provisions for offshore wind energy production and pipelines. No priority or reservation areas for wind energy production are defined within the priority areas for nature conservation. Most of the reservation areas for pipelines also run outside ecologically significant areas.

On the basis of the above descriptions and review of the legal framework governing the protection of species and areas, the Strategic Environmental Assessment (SEA) concludes, also with regard to possible interactions between the protected assets (factors), that according to the current state of knowledge and at the comparatively abstract level of regional planning, the planned specifications are not expected to cause any significant impacts on the marine environment within the area under investigation.

Many environmental impacts, such as those from shipping or fisheries, are independent of the implementation of the plan and can only be controlled to a very limited extent by spatial planning.

Most of the environmental impacts of the individual uses for which specifications are made would also occur – based on the same medium-term time horizon – if the plan were not implemented, as it is not apparent that the uses would not take place or would take place to a significantly lesser extent if the plan were not implemented. In this regard, the provisions of the plan appear in principle "neutral" in terms of their environmental impact. Although it is in principle possible due to the concentration/bundling of individual uses within certain areas or sites that some of the plan's specifications for this specific area may well have negative environmental impacts, an overall balance of the environmental impacts due to the bundling effects would tend to be positive, since the stressing of the remaining areas and sites is lessened, and hazards to the marine environment (e.g. the risk of collision) are reduced.

For wind energy use, the potential impacts are often minor in scale and mostly short-term, as they are limited to the construction phase. For the cumulative assessment of impacts on individual protected species such as bats, there is a lack of sufficient scientific knowledge and uniform assessment methods to make such determinations. For this reason, the potential impacts either cannot be conclusively assessed within the scope of the present SEA, or are subject to uncertainties and require more detailed examination in the context of downstream planning stages.

8 Measures to prevent, reduce and offset significant negative impacts of the Spatial Plan on the marine environment

8.1 Introduction

Pursuant to Annex 1 number 2 point c) to Section 8 subsection 1 of Germany's Federal Regional Planning Act (ROG), the environmental report contains a description of the measures planned to prevent, reduce and, as far as possible, compensate for significant adverse environmental impacts resulting from the implementation of the plan.

The basic principle is that the Spatial Plan (ROP) takes better account of the concerns of the marine environment. The provisions of the ROP prevent negative impacts on the marine environment. This is due in particular to the fact that it is not apparent that the uses would not take place or would take place to a lesser extent if the plan were not implemented. The need to expand offshore wind energy production and the associated connecting pipelines and power lines exists in any case, and the corresponding infrastructure would have to be created even without the Spatial Plan (cf. Section 3.2). If the plan is not implemented, however, the uses would develop without the space-saving and resource-conserving steering and coordination effect of the Spatial Plan.

In addition, the provisions of the Spatial Plan are subject to a continuous optimisation process, as the findings gained on a continual basis over the course of the Strategic Environmental Assessment (SEA) and the consultation process are taken into account in the preparation of the plan.

While individual prevention, mitigation and offsetting measures can be initiated at the planning level, others only come into effect during the concrete implementation phase and are regulated there in the individual approval procedure on a project- and site-specific basis.

8.2 Measures at the planning level

With regard to the planning of prevention and mitigation measures, the Spatial Plan lays down spatial and textual provisions which, in accordance with the environmental protection objectives set out in Section **Fehler! Verweisquelle konnte nicht gefunden werden.**1.4serve to prevent or reduce significant negative impacts on the marine environment arising from implementation of the Spatial Plan. This essentially includes the following:

- the designation of all nature conservation areas within the Exclusive Economic Zone (EEZ) identified by regulation as priority areas for nature conservation,
- the definition of the reserved protected area for the Fehmarn-Lolland bird migration corridor,
- the waiving of the designation of priority or reservation areas for wind energy production in priority nature conservation areas,
- the establishment of reservation areas for pipelines mainly outside of priority nature conservation areas,
- the principle that existing nature conservation areas should be taken into account in the planning, laying and operation of pipelines
- the principle of noise reduction in the construction of wind turbines,
- the principle of overall coordination of the construction of power generation installations and the laying of submarine power cables,

- the principle of choosing the most environmentally compatible method for laying submarine power cables,
- the principle of preventing as much as possible the heat-up of seabed sediments by submarine power cables,
- the principle of taking into account best environmental practice as defined in the OSPAR Convention and the current state of science and technology, and
- use of the least possible amount of land, ensured by the following principles:
  - Economic uses should be as space-saving as possible.
  - Fixed installations are to be dismantled at the end of their use.
  - When laying submarine power cables, the aim should be to achieve the greatest possible bundling in the sense of parallel routing. In addition, the route should be as parallel as possible to existing structures and buildings.

8.3 Measures at the concrete implementation level

In addition to the measures at the planning level noted in Section 8.2measures for certain specifications or associated uses – such as offshore wind energy production, pipelines, power lines, and sand and gravel extraction – to prevent and reduce insignificant and significant negative impacts from the concrete implementation of the Spatial Plan. These prevention and mitigation measures are specified and ordered by the respective competent licensing authority at project level for the planning, construction and operation phases.

With regard to the concrete prevention and reduction measures for offshore wind energy production, pipelines and power cables, reference is made to the comments in the Baltic Sea Environmental Report on the 2019 Site Development Plan (SDP) and 2020 draft SDP. Such measures, e.g. for noise abatement for offshore wind energy installations, are defined in detail in Section 8 of the SDP.

Specific prevention and mitigation measures for pipelines include, for example, construction time restrictions for laying pipe within protected areas, a reduction in light emissions during construction work, extensive avoidance of stone rubble, and measures to protect cultural and material assets.

For sand and gravel extraction, the specific prevention and mitigation measures are derived from the main operating plans. Such measures include, for example, restricting extraction activities during times that are sensitive for certain species, restricting the use of ships to vessels with a certain noise spectrum, requiring exclusion of certain rock fields or reef types from extraction and from impairments through screening, and strict monitoring by means of appropriate monitoring systems and regimes (cf. Section 10**Fehler! Verweisquelle konnte nicht gefunden werden.**).

9 Review of alternative options

9.1 Principles behind assessment of alternatives

9.1.1 General

For the draft Spatial Plan, a staged review of alternative options is carried out. Depending on the increasingly more specific planning, the alternative options to be examined are reduced during the course of the planning process and become increasingly (spatially).more specific

In general, the environmental report pursuant to Article 5 subsection (1) first sentence 1 of the SEA Directive in conjunction with the criteria defined in Annex I to the SEA Directive and Section 40 subsection (2) number 8 of Germany's Environmental Impact Assessment Act (UVPG) contains a brief description of the reasons for the choice of the reasonable alternatives to be examined.

In describing and assessing the environmental impacts identified under Section 8 subsection (1) of the Federal Regional Planning Act (ROG), the report shall contain information on the other planning options under Annex 1 number 2 point c) to Section 8 subsection 1 of the ROG, taking into account the objectives and the spatial scope of the Spatial Plan. The prerequisite is always that they take the objectives and the spatial scope of the Spatial Plan into account.

At the same time, the identification and examination of the planning possibilities or planning alternatives under consideration must also be based on what can reasonably be required in terms of the content and level of detail of the Spatial Plan. The following applies here: The greater the expected environmental impacts and thus the need for planning conflict resolution, the more extensive or detailed investigations are required.

Annex 4 number 2 to the UVPG gives examples of the examination of alternatives with regard to the design, technology, location, size and scope of the project, but explicitly refers only to projects. Hence, the conceptual and strategic design and spatial alternatives play a major role at the planning level.

In principle, it should be noted that a preliminary examination of possible and conceivable planning options is already inherent in all specifications in the form of objectives and principles. As can be seen from the justification of the individual objectives and principles, in particular those relating to the environment, the respective definition is already based on a weighing up of possible public interests and legal positions affected, so that a "preliminary investigation" of planning possibilities or alternatives has already been carried out. A large number of different uses and legally protected interests already exist in the EEZ.

In addition to the zero alternative, the environmental report examines in particular spatial planning possibilities and alternatives, where relevant for the individual uses.

The SEA and thus also the alternative assessment for the draft Spatial Plan are characterised by a larger scope of investigation and a lower level of detail compared to environmental assessments at subsequent planning and licensing levels.

9.1.2 Process of reviewing spatial plan alternatives

The framework for selecting and evaluating alternative options is first provided by the general guidelines, which serve as starting point at an early stage of the planning process with three planning options each, as overall spatial planning solutions. Then, various selected sectoral and sub-regional planning options are examined as planning becomes more concrete, in parallel with preparation of the first draft plan (cf. Figure 55 below).

In the final planning phases - for the revised draft plan as well as the final version - the planning options selected, weighed and defined from the various alternatives are justified in the environmental reports.

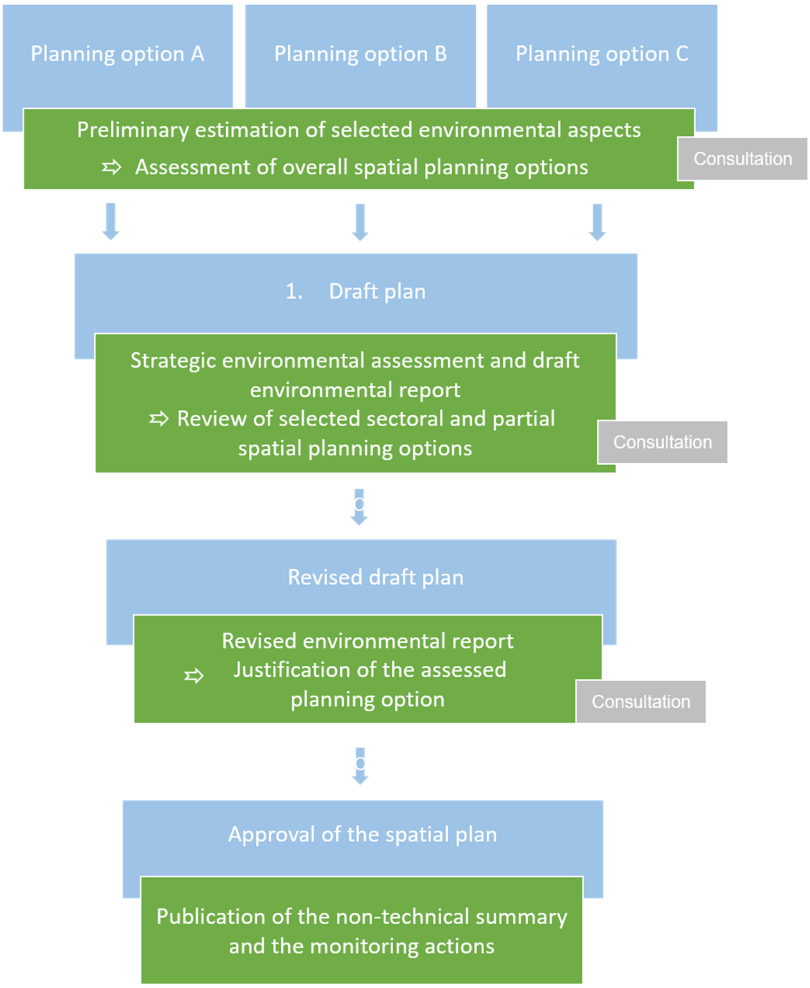


Figure 55. Staged approach to reviewing alternative options.

Section 1 of the draft plan formulates the mission statement and, below it, guidelines for the draft Spatial Plan. The following overall objectives can be derived from this, against which the planning alternatives considered below are measured.

<u>The draft Spatial Plan shall:</u>

- support coherent international maritime spatial planning and territorial cooperation with other countries and at the regional seas level,
- take into account land-sea relations and planning in territorial waters,

- lay the foundations for a sustainable maritime economy in the spirit of Blue Growth, and
- contribute to the protection and improvement of the status of the marine environment and to the prevention and reduction of disturbance and pollution.

These objectives are to be achieved through:

- the coordination of current and future spatial requirements, with
- the identification of suitable areas, in particular for economic and scientific uses, but also for the marine environment and other concerns,
- a prioritisation of sea-specific uses and functions,
- the balancing of environmental, economic and social concerns,
- the conserving and optimised use of the areas allocated to the uses, in particular the areas for fixed infrastructure, which also includes the reversibility of fixed installations
- the holistic view of the various activities in the sea,
- with their interactions and cumulative effects,
- and by applying the ecosystem approach and the precautionary principle.

9.2 Assessment of alternatives within the planning concept (January 2020)

The planning concept was prepared as a first informal planning step. In the early stages of the process of updating the Spatial Plans in the German North Sea and Baltic Sea EEZ, the concept for updating the Spatial Plans comprised three planning options (A-C) as overall spatial plan variants. The early and comprehensive consideration of several planning options represents an important planning and review step in the updating of the Spatial Plans.

The concept for the plan revision represents the claims on utilisation of different sectors from three different perspectives - in terms of overall plan alternatives, which are all taking into account the general framework conditions described above and the basic assumptions listed below, and are thus to be understood as "reasonable" alternatives. In this way, spatial and content-related dependencies and interactions as well as corresponding planning principles were taken into account, and it has been shown how maximum demands of individual sectorshave been limited in this respect.

A preliminary assessment of selected environmental aspects for this revision concept was already carried out before this environmental report was prepared. The preliminary assessment of selected environmental aspects in the sense of an early examination of variants and alternatives should support the comparison of the three planning options from an environmental standpoint.

The three planning options at a glance:

(A) The focus of planning option A is on traditional uses of the sea, with particular attention to the interests of shipping, raw materials extraction and fisheries.
(B) Planning option B shows a climate protection perspective in which a lot of space is given to future use of offshore wind energy.
(C) Planning option C focuses in particular on broadly securing extensive areas for marine nature conservation. In addition to the initial, mainly spatial definitions, there are some supplementary textual definitions.

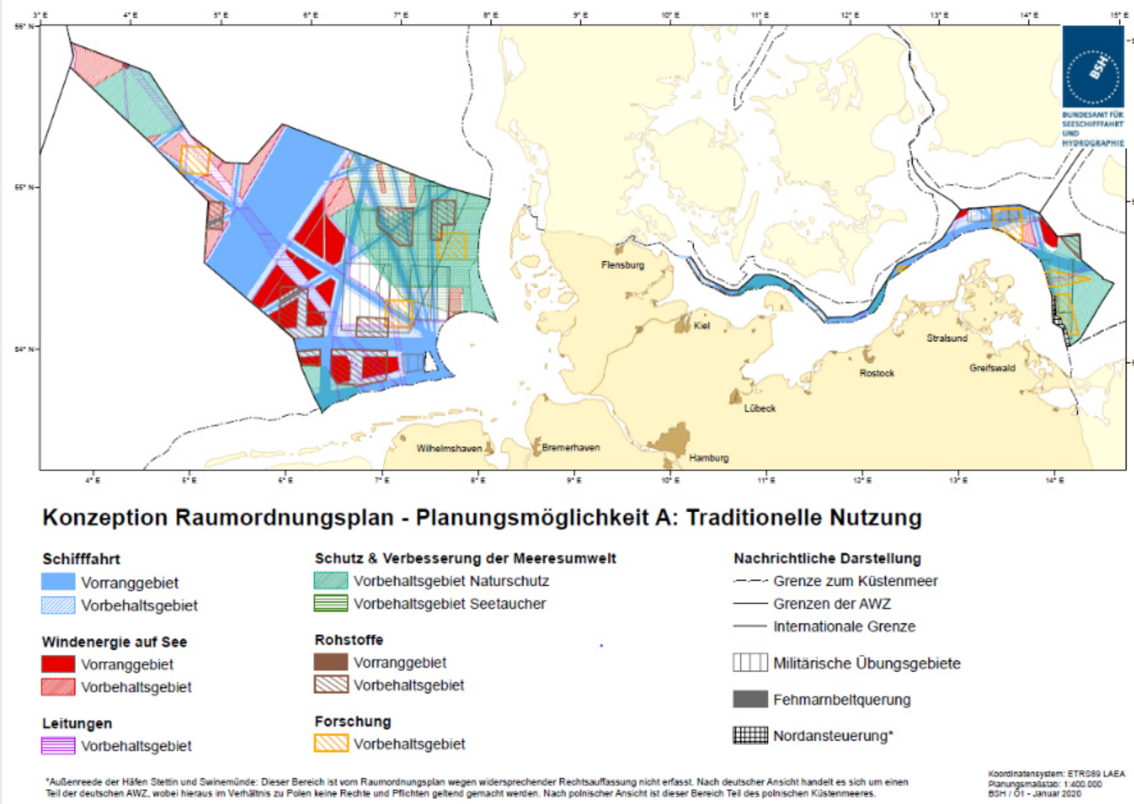


Figure 56: Concept of the Spatial Plan - planning option A for "traditional use"

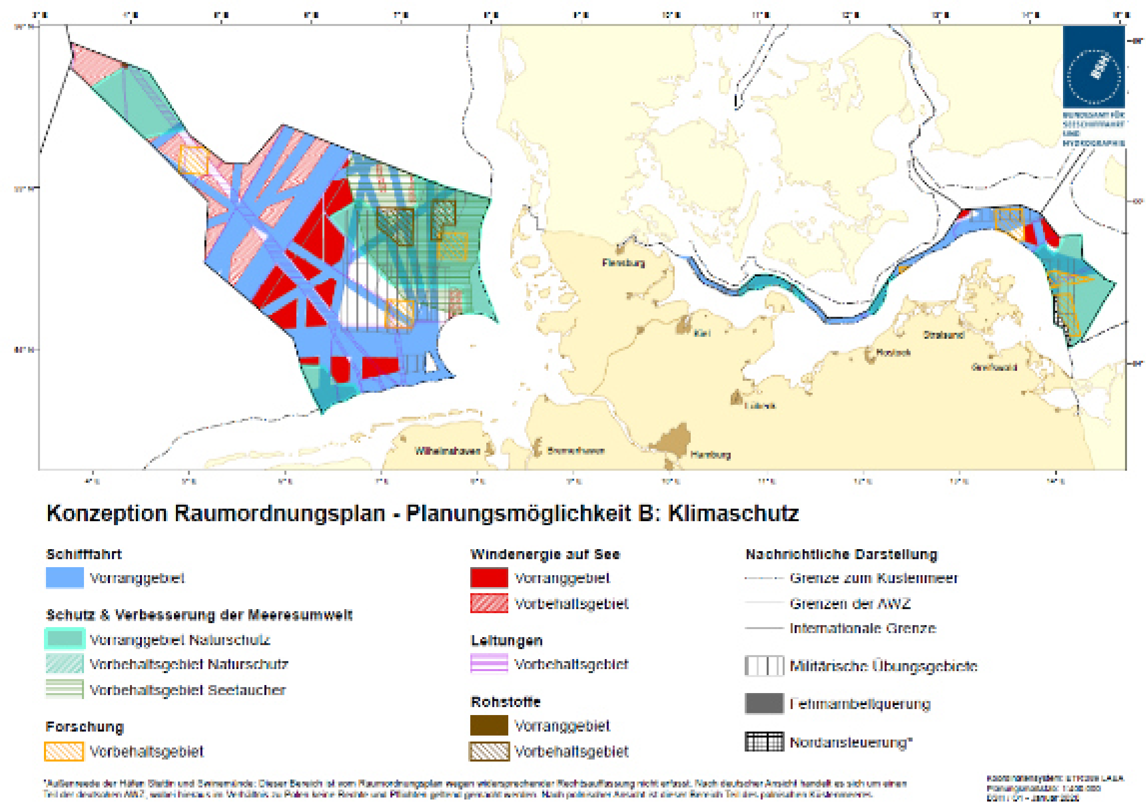


Figure 57: Concept of the Spatial Plan - planning option B for "Climate protection"

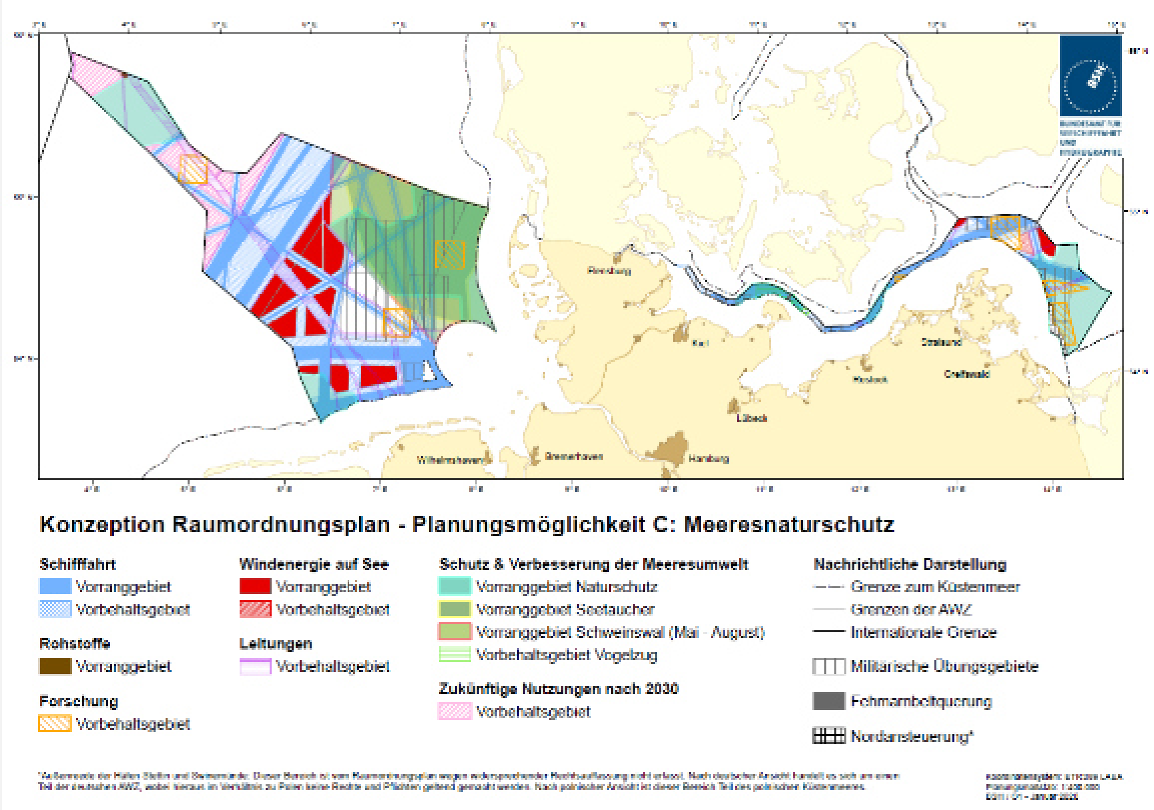


Figure 58: Concept of the Spatial Plan - planning option C for "Marine nature conservation"

In addition to general basic assumptions and overall objectives that applied to all three planning options (cf. conception), the individual planning options were based on the following additional objectives.

Planning option A

Shipping

- Barrier effects must be prevented, especially with regard to the possible establishment of future maritime traffic separation schemes (TSS), and sufficient space must be secured for this in the long term, especially along Route SN10.

Raw material extraction

- The extraction of raw materials should also be made possible in combination with other uses and in nature conservation areas, and should be given special weight in the overall balance. Permit areas in accordance with the Federal Mining Act (BBergG) are defined as reservation areas.

Fisheries

- For fisheries, opportunities are to be created to limit the restrictive effects of uses, in particular through further expansion of offshore wind energy, and to generate income opportunities through joint use in wind farm areas; this is explained in the text.

Planning option B

Offshore wind energy

- Areas for further development of offshore wind power production beyond 2030 that maximises installed electrical generating capacity must be comprehensively secured. To this end, areas for shipping along Route 10 in the North Sea will be designated only for the areas of the main traffic flows.

- The future extraction of hydrocarbons, which, depending on the location of production facilities, could hamper the expansion of wind energy, is not supported by the designation of reservation areas, but permit areas for sand and gravel extraction are taken into account.

Planning option C

<u>Protection and improvement of the marine environment</u>

- Economic uses not compatible with the purpose of protection in areas earmarked for protection and improvement of the marine environment should be excluded as far as possible.
- Raw materials extraction of sand and gravel, but also of hydrocarbons, should not be privileged by dispensing with spatial definitions for all raw materials.
- For bird migration in the Baltic Sea, a reserved area is established in the area of the Fehmarn-Lolland route.

9.2.1 Environmental assessment of the alternative specifications in the planning concept

The table below lists only those planning topics for which alternative planning solutions have been presented in the planning options. In assessing the environmental aspects, impacts are primarily named which relate to the spatial definitions, and here in particular to the differences between the three planning options.

In general, it can be stated from an environmental standpoint that no clear preference for a planning option can be identified. For shipping, differences between the three planning options in terms of environmental impacts cannot really be determined at such a general level. This is because the same basic assumptions such as traffic volume, ship types and ship classes were used as a basis in all plan variants. For example, the fact that in planning option B broader priority areas are defined within nature conservation areas does not de facto lead to an increase in shipping traffic in these areas. For offshore wind energy there are different spatial definitions between the planning options. Here, the extent of the area definitions varies greatly. From a climate protection perspective, this leads to different levels of CO_2 savings potential. In a relative comparison, planning option B offers significantly greater CO_2 savings potential than A and C based on the assumed installed capacity. On the other hand, the three planning options lead to different sea use, ranging between 9 and 20% of the total North Sea and Baltic Sea EEZ area. This refers to the total area of the defined priority and reservation areas for offshore wind energy. In general, however, less than 1% of the designated areas are actually sealed. The nature conservation areas account for a large part of the EEZ area. Over a third of the North Sea EEZ and more than 50% of the Baltic Sea EEZ are protected. These are relatively large areas, but this does not necessarily mean zero use in these areas. The nature conservation priority areas help to safeguard open spaces, as uses incompatible with nature conservation are excluded in these areas. The quantitative differences in terms of area definitions for the protection and improvement of the marine environment are rather small between the three planning options. In this case, the qualitative criterion is the protection purpose of the areas defined; for example, in some options the main distribution area of divers (loons) and harbour porpoises is defined as a priority area. In this respect, planning option C is to be preferred from the pure perspective of nature conservation and the precautionary principle. However, the climate protection aspect must be taken into account here, which is given much less consideration in planning option C.

The differences in the area definitions are described in detail below.

	Area definitions	Selected environmental aspects
Shipping		
A	Navigation routes as priority areas with accompanying reservation areas	• Some crowding out and bundling effects are to be expected.
B	All shipping routes across the whole width of the area Priority areas; SN10 is divided into three main traffic routes, leaving gaps which are presented as reservation areas for offshore wind energy	• Possibly increased risk of collision with corresponding environmental risks compared to planning options A and C due to reservation areas of wind energy within route SN10, and the concentration of traffic in the remaining corridors, without additional navigation areas.
C	Navigation routes as priority areas with accompanying reservation areas; SN10 along the main traffic flows as priority area Navigation, with remaining gaps as temporary priority area until 2035	• Due to the temporary priority area, there are no additional environmental impacts in the medium term compared to planning option A.

<table>
<tr><th colspan="3">Offshore wind energy / Future uses</th></tr>
<tr><td>A</td><td>Designation of areas as priority and reservation areas for offshore wind energy production for approx. 35 to 40 GW of installed electrical generating capacity;

Definition of areas EN1 to EN3, and EN6 to EN12, and EO1 and EO3 as priority areas for offshore wind energy.</td><td>• Sea area use approx. 5,000 km², approx. 15% share of the North Sea and Baltic Sea EEZs.</td></tr>
<tr><td>B</td><td>Sea area allocations with more extensive priority and reservation areas for wind energy, also within SN10 for approx. 40 - 50 GW;

Definition of areas EN1 to EN3, and EN6 to EN13 and EO1 to EO3 as priority areas for offshore wind energy.</td><td>• Sea area u approx. 6,400 km², approx. 20% share of the North Sea and Baltic Sea EEZs, considerably larger than in planning option A.
• CO_2 savings potential under climate protection aspects: In relation to planning options A and C, the CO_2 savings potential is significantly greater when taking into account the capacities for the installed electric power.
• It is possible that a higher risk of collision could result from the location of wind energy areas within the main shipping route 10.</td></tr>
<tr><td>C</td><td>Designation of areas with less extensive priority and reservation areas wind energy production for approx. 25 to 28 GW of installed electrical generating capacity;

Definition of areas EN1 to EN3, and EN6 to EN12, and EO1 and EO3 as priority areas for offshore wind energy.

In the Entenschnabel (“Duck's Bill”), i.e. the German EEZ in the North Sea, reservation areas are planned for future use, with wind energy as just one possible use;

No designation of areas for wind energy in the reservation areas for divers (loons) and porpoises.</td><td>• Compared to planning options A and B, the CO_2 savings potential already secured for wind energy by the specifications is significantly lower.
• At approx. 3,000 km², approx. 9% of the area used for wind energy, the North Sea and Baltic Sea EEZs account for about 9%, which is significantly lower than in planning options A and B.
• In an area of around 1,600 km² or about 6% of the North Sea EEZ, future use will be kept open, but no prioritisation will be given to offshore wind energy, for example, thus maintaining the option for uses with less environmental impact in the long term.
• Subsequent use of wind energy at the sites of the wind farms in the main distribution areas of divers (loons) and harbour porpoises is ruled out, so that a positive long-term environmental impact can be expected compared with the status quo.
• Overall, compared with planning options A and B, a significantly higher weighting of marine nature conservation concerns is to be expected, with a potentially lower impact on the marine environment as a result.</td></tr>
<tr><th colspan="3">Raw materials</th></tr>
</table>

A	Reservation areas for all permits, for hydrocarbons and areas for sand and gravel extraction	• A possible adverse impact can be caused by avoidance effects and potential physical disturbance / injury by underwater sound during seismic surveys. In addition, there would be possible effects from the construction and operation of production platforms • Mining in the sand and gravel reserves, all of which are located in nature conservation areas, can have the following effects: damage to the seabed through physical disturbance, impairment and avoidance effects through turbidity plumes, habitat change through removal of substrates and habitat and area loss.
B	Reservation areas for sand and gravel extraction only	• Fewer impairments than in planning option A are to be expected, because only specifications for sand and gravel extraction are provided for and there is no prioritisation of hydrocarbon extraction by regional planning.
C	No specifications for raw materials extraction	• By dispensing with specifications for the extraction of raw materials as a whole, including protected areas, a lower burden can arise compared with planning options A and B, since regional planning does not set any priorities here compared with other uses. In this case, the use is carried out solely on the basis of the operational plans following approval under mining law. These may include measures that must be taken to reduce and limit the environmental impacts of the projects as far as possible.
Nature conservation		
A	For nature conservation, reservation areas are shown in the extension of existing nature conservation areas. In addition, the main concentration area of divers (loons) in the North Sea is designated as a reserved area.	• Restrictions in nature conservation areas generally exclude offshore wind energy and thus support the conservation purpose of these areas. In the context of further land development for offshore wind energy and a subsequent update of sectoral planning, regional planning would only give nature conservation the weight of a reservation when weighing up the interests here. • The restrictions governing the area of the divers (loons) dictate that subsequent use or expansion of wind energy is subject to reservations.
B	Priority areas for nature conservation are defined in the extent of existing nature conservation areas, with the exception of areas overlapping with the reservation areas for sand and gravel extraction.	• The designation of priority areas for nature conservation supports the conservation purposes of the nature conservation areas. However, where specifications for sand and gravel extraction overlap with a nature conservation area, nature conservation is only assigned a reservation.

	The main concentration area for divers (loons) in the North Sea is defined as a reservation area, as in planning option A.	• The use of wind energy in the priority area and in the nature conservation area is excluded. • The restrictions governing the area of the divers (loons) dictate that subsequent use is subject to reservation. • Compared to planning option A, nature conservation is given greater weight in the overall picture.
C	Priority areas for nature conservation are defined in the extension of all nature reserves, as well as for the main concentration area of divers (loons) and the main distribution area of harbour porpoises (these are limited to the months of May to August). In the area between Fehmarn and Lolland, a bird migration reserve is defined.	• The designation of the nature reserves as well as the main concentration areas of great cetaceans and harbour porpoises as nature conservation priority areas supports the protection purposes of the nature conservation areas and other areas of outstanding nature conservation importance. As a result, nature conservation is given greater weight when weighing up against other uses within these areas. • The priority of the main concentration area of divers (loons) also leads here to the exclusion of a subsequent use of the existing wind farm areas within the area, as well as the exclusion of wind energy development in the priority area of harbour porpoises. In the long term, this could mitigate or compensate for the observed avoidance effects and habitat losses of the divers (loons). • The Fehmarn-Lolland bird migration reserve in the Baltic Sea will serve as an additional definition in support of the MSFD measure to protect migratory species.

9.3 Review of alternative options within the framework of preparing the first draft plan

The first draft plan was prepared on the basis of the planning concept, the comments received on it and further findings and requirements from subsequent informal technical and departmental discussions.

On the one hand, the selection was made on the basis of the assessments of comparative environmental impacts presented in Section 1.2 (cf. also Section 5 of the Conceptual Design), with adoption as implemented in the respective planning option, but also partly spatially adapted due to other considerations, or as further development of a combination of different aspects of individual planning solutions.

The overall context of the plan is to be considered and, in the choice of plan solutions, in addition to taking account of nature conservation concerns and avoiding or reducing possible negative environmental impacts, the aim is to achieve the greatest possible balance in the overall picture with other economic, scientific and safety concerns. The decisive factor is that, based on current knowledge, at the level of this SEA no significant impacts on the marine environment are to be expected from the provisions set out in the draft Spatial Plan.

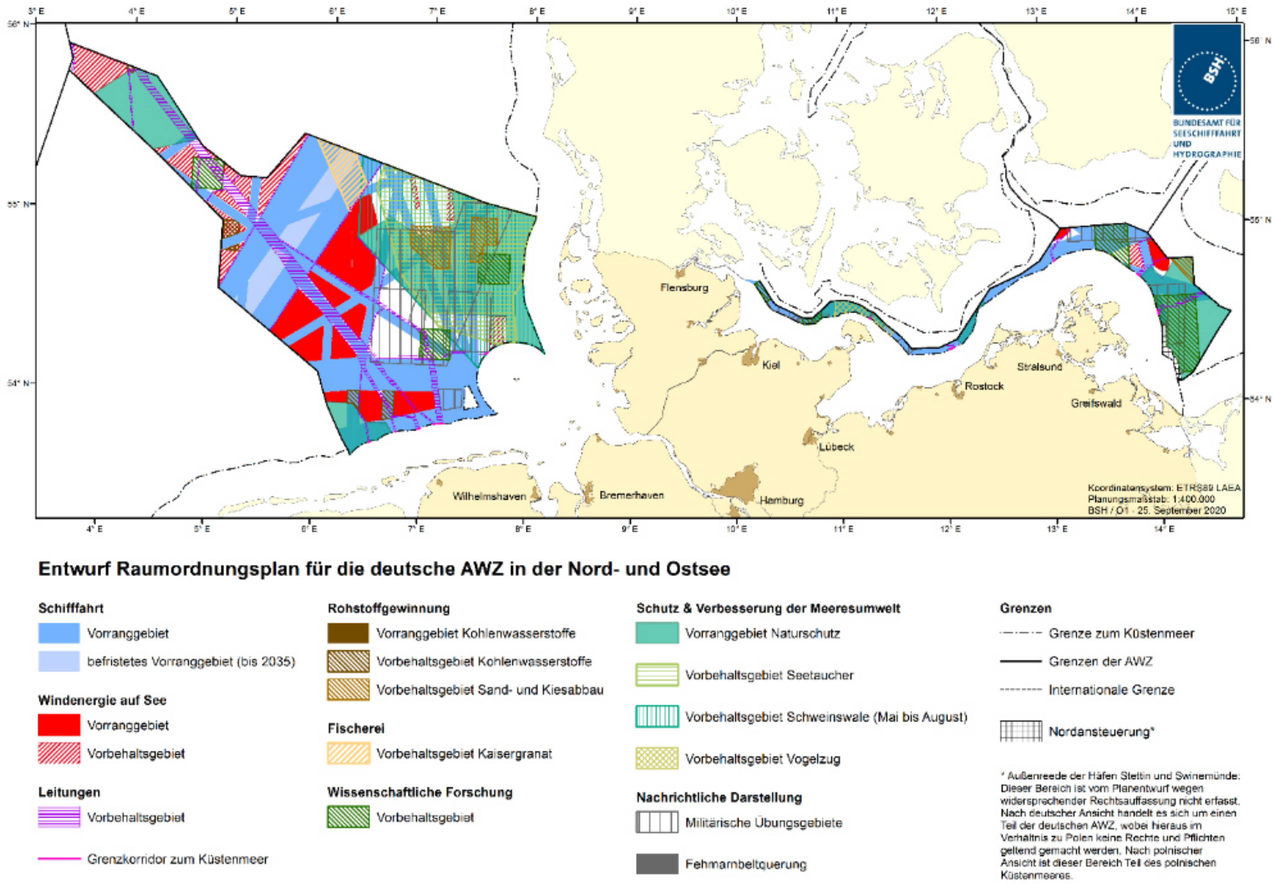


Figure 59: Draft Spatial Plan for the German North Sea and Baltic Sea EEZ

9.3.1 Zero alternative

The zero option, i.e. not updating the Spatial Plan, is not considered a reasonable option.

Overall, overarching and forward-looking planning and coordination taking into account a large number of spatial requirements is likely to lead to comparatively lower spatial utilisation and thus to lower environmental impacts (cf. Section 3).

Compared to the 2009 Spatial Plan and the 2019 Site Development Plan, the draft plan includes a designation of reservation areas for wind energy for the long-term expansion of offshore wind energy and thus fulfils a precautionary management of the expansion of offshore wind energy. The inclusion of these areas enables spatially ordered and space-saving planning, taking into account environmental concerns and the interests of other uses. This also applies to the definition of reservation areas for cables andpipelines. While the 2009 Spatial Plan only designates reservation areas for existing pipelines, the current reservation areas for cables and pipelines also include routes for future connecting power lines and interconnectors. These reservation areas are predominantly located outside protected areas and thus have a steering effect on the routing of cables and pipelines outside sensitive areas.

9.3.2 Spatial alternatives

When drawing up the draft plan, the following alternatives (for the entire area / for sub-areas) were considered:

9.3.2.1 Shipping

For shipping, the approach of planning option B is adopted:

All shipping routes will be designated as priority areas. In contrast to planning option C, the general designation of reservation areas for shipping along all shipping routes has been dispensed with (cf. further justifications in the draft Spatial Plan).

The renunciation of the differentiation between priority and reservation areas shipping has no influence on potential environmental impacts. The designation of priority areas for shipping within nature conservation area reflects the existing traffic flows and serves to keep the routes ope. The priority areas do not de facto change maritime traffic. Shipping also enjoys priority in the priority areas for nature conservation, i.e. in the Pomeranian Bay – Rönne Bank, Kadet Trench and Fehmarn Belt Nature Conservation Areas. It should be noted that the shipping routes in the north of the Pomeranian Bay – Rönne Bank Nature Conservation Area (SO3, in the course of the Adler Grund traffic separation scheme (TSS)), as well as in the area of the Kadet Trench and Fehmarn Belt Nature Conservation Areas (SO1) are important and very busy routes. The number of ship movements in the southern part of the Pomeranian Bay – Rönne Bank Nature Conservation Area is much lower – despite the fact that the northern approach to the ports of Swinemünde and Szczecin (SO2) is located here.

Alternative: Shipping	
Brief description	• The areas for navigation are designated as reservation areas in the nature conservation areas across the whole width of the area.
Presentation of the alternative option in comparison to the draft plan	• In the draft plan all routes are designated as priority areas, including in nature conservation areas.
Points of conflict with other uses	• According to the provisions of the UNCLOS to be applied under Section 1 subsection (4) of the Federal Regional Planning Act (ROG), restriction of shipping within the EEZ is only possible under the conditions laid down there, so that there can be no legal conflict of interests. Furthermore, Article 57 subsection (3) number 1 of the Federal Nature Conservation Act (BNatSchG) stipulates that restrictions on shipping are not permitted in nature conservation areas. • In particular in the Pomeranian Bay – Rönne Bank Nature Conservation Area and the international shipping route in the Adler Ground TSS would not be adequately secured by regional planning.
Environmental assessment	• There would probably be no change in the environmental impact of shipping, because the freedom of navigation and, in the traffic separation schemes, for large vessels calling at seaports, the obligation to use them, would continue to exist. • . • It is not possible to make provisions through spatial planning to avoid certain areas, or to change routes in nature conservation areas. However, the number of ship movements outside the TSS is rather low. • The priority areas for shipping are mainly intended to keep the important shipping routes clear of fixed installations and are therefore complementary to the priority areas for nature conservation in their regulatory purpose of preventing accidents.

9.3.2.2 Offshore wind energy

For offshore wind energy in the Baltic Sea the spatial specifications from planning options A and C are used. Beyond areas for 20 gigawatts of offshore wind energy production required by law as the basis for designating priority areas, all areas likely to be required for the expansion of offshore wind energy by 2035 (approx. 30 GW) - as the medium-term planning horizon of the Spatial Plan - are designated as priority areas for wind energy. For the Baltic Sea, these are areas EO1 and EO3. In addition, area EO2 is designated as reservation area for wind energy.

9.3.2.3 Cables and pipelines

The reservation areas for cables and pipelines correspond to those which have already been presented in all three planning options in the planning concept. Only those corridors have been designated in which at least two lines exist or are planned, or which are reserved for future lines.

These provisions

- are required for the submarine cable systems to transport the electricity from the offshore wind farms to the grid connection onshore based on the provisions of the site development plan,
- secure the routing of existing interconnectors and pipelines, and
- secure routes for future cables and pipelines.

Nature conservation areas are excluded as far as possible from designations. The only exception is the corridor along the (existing) Nord Stream 1 and 2 pipelines, which cross the Pomeranian Bay – Rönne Bank Nature Conservation Areas. Due to the distance that remains between the pipelines, further cable systems (especially interconnectors) may be planned here in the future.

Compared to the planning concept, border corridors at the transition of the pipeline routes into the territorial waters are supplemented similarly to the provisions of the 2009 Spatial Plan and in line with the provisions of the site development plan.

The reservation areas for cables and pipelines can be an instrument, for example in approval procedures for transit pipelines and cross-border submarine cables, for requiring lines be routed, wherever possible, within these spatially suitable corridors, and thus avoiding routing through nature conservation areas and associated adverse effects. Where individual cables or other linear infrastructure currently pass through nature conservation areas, no reference can be made to a reservation from regional planning in the event of changes or new projects, but where appropriate, more ecologically compatible routing can be demanded, and where possible, the use of the designated corridors can be worked towards.

9.3.2.4 Raw materials extraction

For the specifications for raw materials extraction in the Baltic Sea EEZ, the draft includes the approach of planning option A in addition to the assumptions on which all planning options are based:

Sand and gravel extraction

The permit area for sand and gravel extraction within the Pomeranian Bay – Rönne Bank Nature Conservation Area is designated as a reservation area in the same way as planning option A.

The alternative of not defining areas, as provided for in planning options B and C, would probably not result in a de facto reduction of environmental impacts, since sand and gravel extraction is in principle permitted as a privileged use in the nature conservation area, and if a permit is granted, corresponding conditions are imposed to reduce or prevent impairments of the protected assets and objectives.

9.3.2.5 Protection and improvement of the marine environment

The spatial designations for protection and improvement of the marine environment in the Baltic Sea EEZ will also safeguard the Pomeranian Bay – Rönne Bank, Kadet Trench and Fehmarn Belt Nature Conservation Areas (which were established by regulation) in spatial planning, and support their protection purposes.

In the Pomeranian Bay – Rönne Bank Nature Conservation Area, in the area for sand and gravel extraction, the priority for nature conservation is not downgraded to a reservation (planning option B).

A reservation area for the bird migration corridor is designated in the area between Fehmarn and Lolland, as in planning option C.

For the shipping priority areas through these nature conservation areas, the nature conservation provisions do not have a restrictive effect. Sand and gravel extraction is still permitted in Adler Ground protected area, but in the case of permits and authorisations, it can help to ensure that the interests to be protected are taken into account in addition to the requirements of the nature conservation area regulations.

10 Measures planned to monitor the environmental impact of implementing the Spatial Plan

10.1 Introduction

Pursuant to Annex 1 number 3 point b) to Section 8 subsection 1 of Germany's Federal Regional Planning Act (ROG), the environmental report also contains a description of the planned monitoring measures. Monitoring is necessary in particular to identify unforeseen significant impacts at an early stage and to enable initiation of appropriate remedial action.

With regard to the envisaged monitoring measures, it should be noted that the actual monitoring of potential effects on the marine environment can only start at the moment when the Spatial Plan (ROP) is implemented, i.e. when the specifications stipulated in the plan are actually put into place. However, the natural development of the marine environment, including climate change, must not be overlooked when evaluating the results yielded by monitoring. Nevertheless, general research cannot be carried out in the context of monitoring. Therefore, project-related monitoring of the impacts of the uses regulated in the plan is of particular importance. This mainly concerns specifications for offshore wind energy production, pipelines, and areas for raw materials extraction.

The main task of monitoring the plan is to bring together and evaluate the results of different phases of monitoring at the level of individual projects or clusters of projects developed in a spatial and temporal context. The assessment will also cover unforeseen significant impacts on the marine environment from implementing the plan, as well as review of the forecasts of the environmental report.

In addition, results from existing national and international monitoring programmes must be taken into account, also to avoid duplication of work. The monitoring of the conservation status of certain species and habitats required under Article 11 of the Habitats Directive must also be taken into account. There will also be links to the measures provided for in the Marine Strategy Framework Directive (MSFD).

10.2 The planned measures in detail

The planned measures for monitoring the potential impacts of the plan can be summarised as follows:

- Compilation of data and information that can be used to describe and assess the status of areas and protected assets;
- Development of specialised information networks for assessing potential impacts from the development of individual projects and cumulative impacts on the marine ecosystem:
  - MarinEARS (Marine Explorer and Registry of Sound) and National Sound Registry
  - MARLIN (Marine Life Investigator)
- Development of suitable procedures and criteria for evaluating the results of monitoring the effects and impacts of individual projects;
- Development of procedures and criteria for assessing cumulative impacts;
- Development of procedures and criteria for forecasting the potential impact of the plan in a spatial and temporal context;
- Development of procedures and criteria for evaluating and adapting the plan or, if necessary, optimizing it in the context of updating;
- Evaluation of measures aimed at preventing or reducing significant impacts on the marine environment,
- Development of norms and standards.

The following data and information are required in order to assess the potential impacts of the plan:

1. Data and information available to the German Federal Maritime and Hydrographic Agency (BSH) within the scope of its responsibility:
   - Data sets from prior environmental impact assessments (EIA) and monitoring of offshore projects which are available to the BSH for examination (in accordance with Germany's Offshore Installations Ordinance (SeeAnlV));
   - Data stocks from the right of entry (in accordance with Germany's Offshore Wind Energy Act (WindSeeG));
   - Data sets from the preliminary investigations (in accordance with the WindSeeG);
   - Data sets from the construction and operational monitoring of offshore wind farms and other uses;
   - Data from national monitoring, collected by or on behalf of the BSH;
   - Data from BSH research projects.
2. Data and information from the scopes of responsibility of other federal and *Länder* (state) authorities (on request):
   - Data from national monitoring of the North Sea and Baltic Sea (formerly by the German federal and state-level programme for monitoring the maritime environment (BLMP));
   - Data from monitoring activities in the context of implementing the MSFD;
   - Data from monitoring of Natura2000 sites;
   - Data from other countries on their monitoring in territorial waters;
   - Data from other authorities responsible for authorising uses at sea under other legal bases, such as the Federal Maritime and Maritime Traffic Act (BBergG), maritime traffic monitoring (AIS), fisheries monitoring (VMS).
3. Data and information from federal and state research projects, including
   - HELBIRD / DIVER,
   - Sediment EEZ.
4. Data and information from assessments carried out within the framework of international bodies and conventions:
   - HELCOM
   - ASCOBANS
   - AEWA
   - BirdLife International.

For reasons of practicability and appropriate implementation of the requirements of the SEA, the BSH will pursue an approach that is as ecosystem-based as possible when monitoring the potential impacts of the plan, and which focuses on the interdisciplinary integration of marine environmental information. In order to be able to assess the causes of plan-related changes in parts or individual elements of an ecosystem, anthropogenic variables from spatial observation (e.g. expert information on shipping traffic from the AIS data sets) must also be considered and included in the assessment.

When combining and evaluating the results from monitoring at project level and from other national and international monitoring programmes and from accompanying research, a review of the gaps in knowledge or of the forecasts subject to uncertainties will have to be carried out. This concerns, in particular, projections concerning the assessment of significant impacts of the uses regulated in the draft Spatial Plan on the marine environment. Cumulative effects of defined uses are to be assessed both regionally and supra-regionally.

Investigation of the potential environmental impacts of areas for wind energy production must be carried out at the downstream project level in accordance with the Standard StUK4, *Unter-*

suchung von Auswirkungen von Offshore-Windenergieanlagen (“Investigation of the impacts of offshore wind energy installations) and in co-ordination with the BSH. Monitoring during the construction of foundations by means of pile driving includes, among other elements, measurements of underwater noise and acoustic recordings of the impact of pile driving on marine mammals using porpoise click detector (POD) instrumentation.

With regard to the concrete measures for monitoring the potential impacts of wind energy use, including the impacts from power cables, reference is made to the detailed explanations in the environmental report for the 2019 Site Development Plan (SDP) and the 2020 draft SDP.

For approval of areas for sand and gravel extraction, for example, it must be proven by suitable monitoring prior to the next main operating plan approval that the maximum permitted extraction depth is not exceeded and that the original substrate is demonstrably preserved. It must also be demonstrated that between the excavation tracks there are still sufficient areas that have not yet been excavated, so that sufficient potential for re-colonisation is ensured.

For pipelines, a project-specific monitoring plan for the construction and operating phases must be submitted prior to construction. Monitoring measures during the construction phase include the documentation of turbidity plumes, hydroacoustic measurements and the recording of marine mammals and sea and resting birds. The essential monitoring measures during the operating phase of pipelines include annual documentation of the positional stability of the pipeline and the coverage heights, as well as annual documentation of the epifauna on the overlying pipeline for a period of five years after commissioning.

The SEA for the plan will make use of new findings from the environmental impact studies and from the joint analysis of research and EIA data. Joint evaluation of research and EIA data will also produce products that will provide a better overview of the distribution of biological assets in the EEZ. The pooling of information leads to an increasingly solid basis for impact forecasting.

The general intention is to keep data from research, projects and monitoring uniform, and to make it available for competent evaluation. In particular, the aim is to create common overview products for examining the effects of the plan. The spatial data infrastructure already in place at the BSH with data from physics, chemistry, geology and biology and uses of the sea will be used as a basis for compiling and evaluating ecologically relevant data, and will be further developed accordingly.

With regard to the consolidation and archiving of ecologically relevant data from project-related monitoring and accompanying research, it is planned in detail to consolidate data collected within the framework of accompanying ecological research at the BSH and to archive these data on a long-term basis. The data on biological assets from baseline surveys of offshore wind energy projects and from monitoring the construction and operating phases are already being collected and archived at the BSH in a specialised information network for environmental assessments, known as MARLIN (MarineLife Investigator).

11 Non-technical summary

11.1 Subject and occasion

Maritime spatial planning in the German Exclusive Economic Zone (EEZ) is the responsibility of the German Federal Government under the Federal Regional Planning Act (ROG)[8]. In accordance with Section 17 subsection (1) of the ROG, the competent federal ministry, the Federal Ministry of the Interior, Building and Community (BMI), working in coordination and agreement with the federal ministries concerned, draws up a Spatial Plan (regional development plan) for the German EEZ as a statutory instrument. In accordance with Section 17 subsection (1) third sentence of the ROG, the Federal Maritime and Hydrographic Agency (BSH) carries out the preparatory procedural steps for drawing up the Spatial Plan with the consent of the BMI. When drawing up the Spatial Plan, an environmental assessment called the Strategic Environmental Assessment (SEA).is performed in accordance with the provisions of the ROG and, where applicable, those of Germany's Environmental Impact Assessment Act (UVPG)[9],

According to Article 1 of the SEA Directive 2001/42/EC, the objective of the SEA is to ensure a high level of environmental protection in order to promote sustainable development and to contribute to ensuring that environmental considerations are adequately taken into account during the preparation and adoption of plans well in advance of their actual planning.

The main document of the SEA is the present environmental report. It identifies, describes and assesses the likely significant impacts that implementation of the Spatial Plan will have on the environment, as well as possible and alternative planning options, taking into account the essential purposes of the plan and the geographical scope of the plan.

According to Section 17 subsection (1) of the ROG, the Spatial Plan for the German EEZ shall specify provisions

1. to ensure the safety and ease of navigation,
2. to further economic uses,
3. to promote scientific uses, and
4. to protect and improve the marine environment

while taking into account all interactions between land and sea as well as all related safety aspects.

According to Section 7 subsection (1) of the ROG, the Spatial Plan for a specific planning area and a regular medium-term period must contain specifications as **objectives and principles** of spatial planning for the development, order and safeguarding of the area, in particular for the uses and functions of the area.

Under Section 7 subsection (3) of the ROG, these provisions may also designate areas, such as priority and reservation areas.

In the German EEZ area, a multi-stage planning and approval process is planned for certain uses such as offshore wind energy installations and power transmission cables. In this context, the instrument of maritime spatial planning is at the highest and superordinate level. The Spatial Plan is the forward-looking planning instrument that coordinates the broad range of usage interests of industry, science and research as well as protection requirements.

The Strategic Environmental Assessment for the Spatial Plan is related to various downstream en-

[8] Of 22 December 2008 (BGBl. I p. 2986), last amended by Article 159 of the Ordinance of 19 June 2020 (BGBl. I p. 1328).

[9] In the version promulgated on 24 February 2010, BGBl. I p. 94, last amended by Article 2 of the Act of 30 November 2016 (BGBl. I p. 2749).

vironmental assessments, in particular the directly downstream SEA for the site development plan (SDP).

The SDP is the technical planning instrument for orderly expansion of offshore wind power production. In the next step, the areas for offshore wind energy installations defined in the SDP undergo preliminary investigation. If the suitability of a site for exploitation of offshore wind energy is established, the site is put out to tender and the winning bidder can apply for approval for the construction and operation of wind turbines on the site. In view of the character of the S Plan as a controlling planning instrument, the depth of its assessment of likely significant environmental impacts is characterised by a broader breadth of investigation and, in principle, a lesser depth of investigation. The focus of the assessment is on evaluating cumulative effects and potential alternatives.

Preparation and updating of the Spatial Plan and implementation of the SEA will be carried out taking into account the objectives of environmental protection. These provide information on the environmental status that is to be achieved in the future (as environmental quality objectives). The objectives of environmental protection can be seen in an overall view of the international, European Community and national conventions and regulations that govern marine environmental protection, and on the basis of which the Federal Republic of Germany has committed itself to certain principles and objectives.

11.2 Strategic Environmental Assessment methodology

The present environmental report builds on the existing SEA methodology of the *Land* (i.e. state) development planning and develops it further with a view to the additional stipulations made in the Spatial Plan.

The methodology is based mainly on the provisions of the plan to be investigated. Within the framework of this SEA, it is determined, described and evaluated for each of the specifications whether the specifications are likely to have significant impacts on the protected assets concerned. The object of the environmental report corresponds to the provisions of the Spatial Plan as listed in Section 17 subsection (1) of the ROG. In particular, the impacts of the spatial provisions are decisive. While textual objectives and principles without direct spatial definition often also serve the purpose of preventing or mitigating environmental impacts, they may in turn lead to impacts, so that an assessment is required.

The assessment of the likely significant environmental impacts of implementing the Spatial Plan shall include secondary, cumulative, synergistic, short-, medium- and long-term, permanent and temporary, positive and negative effects in terms of the assets to be protected. A detailed description and assessment of the state of the environment is the basis for the assessment of possible impacts. The SEA has been carried out with regard to the following protected assets, i.e. factors:

- Area
- Soil
- Water
- Plankton
- Biotope types
- Benthos
- Fish
- Marine mammals
- Avifauna
- Bats
- Biological diversity
- Air
- Climate

- Landscape
- Cultural and other material goods
- Human beings, in particular human health
- Interactions between these factors (protected assets)

The description and assessment of the probable significant environmental impacts is carried out for the individual graphical and textual specifications on the use and protection of the EEZs in relation to the protected assets, taking into account the status assessment.

All plan contents that could potentially have significant environmental impacts are examined. Both permanent and temporary, e.g. construction-related, impacts are considered. This is followed by a presentation of possible interactions between factors, a consideration of possible cumulative effects and potential transboundary impacts.

An assessment of the impacts resulting from the provisions of the plan is performed on the one hand on the basis of the status description and assessment and the function and significance of the respective defined areas for the individual protected assets, and on the other hand on the basis of the impacts emanating from these provisions and the resulting potential impacts. A forecast of the project-related impacts during implementation of the Spatial Plan is made depending on the criteria of intensity, scope and duration of the impacts.

Within the framework of the impact prognosis, specific framework parameters are used as a basis for valuation, depending on the specifications for the respective use.

With regard to the priority and reservation areas for offshore wind energy, certain parameters are assumed in the form of bandwidths for a consideration of the protected interests. In detail, these are, for example, output per turbine, hub height, rotor diameter and total height of the turbines. Certain framework parameters are also assumed for pipelines, sand and gravel extraction, fisheries and marine research. In order to assess the environmental impact of shipping, it is necessary to examine what additional effects can be attributed to the specifications in Spatial Plan ROP-E.

11.3 Summary of protection-related audits

11.3.1 Soil/area

The Baltic Sea is a tributary of the Atlantic Ocean and is connected to the North Sea via the Great Belt and Little Belt, and the strait of Øresund. The Baltic Sea bottom relief is characterised by its characteristic basin and threshold structure. The Baltic Sea basins take over the function of sedimentation areas with characteristic silt sediments. For the Baltic Sea ecosystem, however, the sills with their deeply incised channels are of crucial importance because they control the exchange of water and consequently the complex physical, chemical and biological processes. For example, 73% of the total water exchange between the North Sea and the Baltic Sea takes place over the Darss sill (Kadet Trench).

Based on the basin and threshold division of the Baltic Sea, eight sub-areas have been defined using geological, geomorphological and oceanographic criteria.

The Bay of Kiel lies at the southern exit of the Little Belt and Great Belt in the western Baltic Sea. Its eastern boundary is formed by the Fehmarn Belt and the Fehmarn Sound. It is a typical Förden coast with narrow, deeply incised bays. Water depths range from 5 m on the Stoller Grund to 42 m in the Vinds Grav gully near Fehmarn. In terms of sediment distribution, the residual sediment deposits in the EEZ are concentrated in the area west of Fehmarn. The sandy areas are particularly close to the Great

Belt Channel, where sufficiently strong currents form megaripples on the relatively flat sea bed at a depth of 15 to 18 m. Silty sands are common to the west of Fehmarn. Mixed sediments occur in the deep channels of the Great Belt and the Fehmarn Belt. Beneath this Holocene sedimentary layer, late glacial sands and banded clays are deposited. Beneath them, Saalian sedimentary marls and meltwater sands are found in large parts of the Bay of Kiel, which in turn are mostly overlaid by older glacial or tertiary clays and sands.

The 18- to 24-km-wide Fehmarn Belt has a special position for the exchange of water between the Belts and the Baltic Sea basins bordering to the east, in that the exchange between North Sea and Baltic Sea water takes place mainly via the Great Belt – Fehmarn Belt system. These striking hydrodynamic conditions are revealed in several mega or giant ripple fields in the western Fehmarn Belt. These giant ripple fields lie on a continuous layer of residual sediments consisting of stones of varying density, which reach the size of a fist.

To the east of the Fehmarn Belt lies Mecklenburg Bay, which is bounded approximately along the 20 m depth line to the Darss Sill and the Fehmarn Belt. Mecklenburg Bay has a maximum water depth of 28 m. The distribution of the surface sediments is characterised by a silt deposit below the 20 m depth line, which gradually becomes sandier towards the edge of the basin. The thickness of the silt in the centre of the basin is between 5 and 10 m. Medium to coarse sands are found towards the edge of the basin. Larger deposits of coarse sand, gravel and residual sediment (stones, blocks) occur in the shallow water zones south of Fehmarn. The geological structure of the Mecklenburg Basin is determined by the sediments of the different Baltic Sea stages, which overlay on the boulder clay from the last ice age.

The Darss sill is the sea area between the peninsula Fischland – Darss and the Danish islands of Falster and Møn. The characteristic element is a submarine ridge of boulder clay that runs from the steep bank between Wustrow and Ahrenshoop in a north-westerly direction to Gedser Rev. The system of furrows in the Kadet Channel is cut into this ridge to a depth of 32 metres. Here, in irregular succession, bouldermarl ribs of 1 to 2 m in height alternate with flat fine sand and silt surfaces. On the Kadet Channel and especially on its flanks, there is a varying density of stone and block cover. In the channels, giant or mega ripples with ridge distances of about 400 m are observed. The Falster-Rügen-Plate, which is bordering to the north-east, is much flatter in relief and, with the exception of the Plantagenet Ground, which rises up to less than 8 m water depth, and a channel structure into the Arkona Basin to the north of it, has hardly any morphological structure. It is mainly covered by fine sand. The thickness of the sands is between 10 m and 50 m. The geological structure of this sub-area essentially consists of three bedload-aggregate horizons. West of a line Darss Ort – Møn its surface dips into the Arkona Basin. This is followed by sandy to silty sediments of the different Baltic Sea stages.

The Arkona Basin is bordered by the 40-m depth line to the Falster-Rügen plate. In the west the elevation of the Krieger Flak juts into the basin. To the north-east, the Arkona Basin is connected to the Bornholm Basin via Bornholmsgat; to the east, it borders the shallows of Rønne Bank with the Adlergrund as its western extension. The maximum water depth is over 50 metres. The sediment distribution on the seabed consists almost exclusively of silty sediments. The geological structure consists of two bed load-gel horizons overlaid by late and post-glacial clays and silt.

Kriegers Flak (also known as Møn Bank) is a shoal on the western edge of the Arkona Basin. Its water depths range from 16 m in the Danish EEZ to 40 m on the German side. Morphologically, the area appears as a crest that dips east and south into the Arkona Basin. The distribution of surface sediments on the sea floor is very heterogeneous and has the typical threshold character. In the German EEZ, bed load marl is widespread in the north-western corner, and is mainly found on the flanks up to the 25 m depth line in the south and up to the 40 m depth line in the east directly on the sea floor. At shallower depths, it is covered with stones and boulders (erratic blocks), which in places form wall structures. A band of coarse sand and gravel adjoins the boulder clay to the south, which is replaced by sands and clays as the water depth increases. To the east, the patchily distributed, thin sand and clay cover borders directly on the bed load clay. In the area of the stone and boulder deposits, a pronounced mussel growth (Mytilus) is characteristic.

The Adler Ground is the western foothill of the Rønne Bank, a shallow area that stretches southwest from Bornholm. The seabed has a very uneven relief due to its glacial history and post-glacial overprint. The water depths range between 5 and 25 m. In large parts, residual sediments (coarse sand, fine gravel and stones) dominate on the bed load marl. The stones are the size of a fist or a head, and are found in these areas sporadically or all over the area. In addition, boulders (erratic blocks) several metres in length are common, which are covered with shells (Mytilus) of varying density. The shallow sea sands occur in patches between the residual sediments or as elongated bands. At the north-western edge, the sands merge into the silt of the Arkona Basin. Towards the south there is a continuous transition to the sandy areas of the Pomeranian Bay and Oderbank. The geological structure of the Adler Ground is essentially determined by bed load aggregate upheavals, meltwater deposits in the form of sands and gravels, as well as writing chalk which is close to the sea floor and which, due to its glacial-tectonic stress, has fault zones and intermediate layers of sands, gravels or stones.

The southern bordering area of the Oderbank is an elevation with water depths between 7 and approx. 20 m. The largely unstructured seabed consists mainly of fine sand. Residual sediments in the form of isolated stone deposits are found in the Adler Gound Gully, especially north and north-east of the Oderbank. In the north-western area of the Oderbank, in addition to isolated stones with a diameter of up to 1 m, fist-sized mussel fields up to several square metres in size and smaller ripple fields of coarse sand occur. The geological structure of the Oderbank has boulder clay and ice-age sands at its core.

The status assessment was carried out for the aspects "rarity/threat", "diversity/uniqueness" and "legacy impacts". As the sediment types and bottom forms are found in the Baltic Sea as a whole, but are in part characteristic of the southwestern Baltic Sea, the aspect of "rarity/threat" is assessed as medium to low. In the Baltic Sea EEZ, a medium to high "diversity/uniqueness" is found, which is reflected in the form of a heterogeneous sediment distribution in combination with pronounced morphological conditions as well as heterogeneous sediment distribution and lack of bottom forms or homogeneous sediment distribution and pronounced bottom forms. Due to the anthropogenic changes which, however, did not lead to the loss of ecological functions, a medium "legacy impacts" is assumed.

Pollutants emitted by shipping that enter the seabed, such as oil, are independent of the implementation or non-implementation of the plan.

Wind energy installations have a locally limited environmental impact with regard to the seabed as a protected asset. The sediment is only permanently affected in the immediate vicinity by the insertion of foundation elements, including, where applicable, sediment protection, and the resulting use of the seabed.

Due to the construction of wind energy installations, sediments are briefly stirred up and turbidity plumes are formed. The extent of the resuspension depends mainly on the fine grain content of the seabed sediment. In areas with a low fine-grain content, the majority of the released sediment will settle relatively quickly directly in the area of the intervention or in its immediate vicinity. The suspension content will quickly return to the natural background values due to dilution effects and sedimentation of the stirred up sediment particles. However, the impairments to be expected in areas with a higher fine-grain content and the associated increased turbidity remain limited on a small scale due to the low flow near the seabed.

Due to operational conditions, the interaction of foundation and hydrodynamics in the immediate vicinity of the installations may lead to a permanent agitation and rearrangement of sediments. According to previous experience in the North Sea, current-related permanent sediment shifting can only be expected in the immediate vicinity of the wind turbines. For the Baltic Sea, such experience is not yet available. However, due to the low near-bottom flow velocities in the vicinity of the installations, only local scouring is to be expected here as well. Due to the predicted spatially limited extent of scouring, no significant changes in the substrate are to be expected.

When laying the park's internal cabling or pipes, the turbidity of the water column increases due to sediment turbulence. The extent of resuspension depends mainly on the selected laying method and the fine grain content of the soil. In the areas with a lower fine grain content, the majority of the released sediment will settle relatively quickly directly at the construction site or in its immediate vicinity. The suspension content will then decrease back to the natural background values due to dilution effects and sedimentation of the stirred up sediment particles. The expected impairments due to increased turbidity remain locally limited on a small scale.

In areas with soft sediments and correspondingly high fine-grain contents, the released sediment will settle much more slowly. However, since the currents near the seabed are relatively low, it can be assumed that the turbidity plumes that occur here will also be more local in nature and that the sediment will settle again relatively within the immediate vicinity. A substantial change in the sediment composition is not to be expected.

In the short term, pollutants and nutrients can be released from the sediment into the soil water. The possible release of pollutants from the sandy sediment is negligible due to the relatively low fine-grain content (silt and clay) and the low concentrations of heavy metals. In the area of the silty and clayey seabed, a significant release of pollutants from the sediment into the groundwater can occur. The pollutants generally adhere to sinking particles which, due to the low currents in the Baltic Sea basins, hardly drift over long distances and remain within their original environment. Within the medium term, this remobilised material is deposited again in the silty basins.

Impacts in the form of mechanical stress on the seabed sediment due to displacement, compaction and vibrations, which are to be expected during the construction phase, are estimated to be low due to their limited extent.

The described impacts of offshore wind energy installations and of related pipelines and power lines are spatially limited and, with the exception of the sealing of areas by the insertion of foundation structures, are temporary. The impacts occur independently of the implementation or non-implementation of the plan.

In general, gravel and sand is extracted on a large area by trailing suction hopper dredging. This usually creates furrows measuring about 2 to 4 m in width, between which unused seabed remains. In case of selective sediment extraction, the gravel sands are screened on board and the unused fraction (sand or gravel) is returned to the site. The extent of the turbidity plumes resulting from the return of material depends on the grain size and the quantity of the returned material as well as the current and its directional stability. Due to the low flow velocities in the Baltic Sea, locally limited expansion of the turbidity plumes is to be expected.

Selective extraction may result in a change in the substrate; depending on the returned fraction, the original sediment type is refined or coarsened, which may affect the physicochemical parameters and thus lead to a mobilisation of pollutants. Due to the rather low pollution load of the sediments and the low impact on the physicochemical parameters, no significant release of pollutants from the sediment can be assumed overall.

There is currently no production of hydrocarbons in the Baltic Sea EEZ. In general, the following effects on the protected assets “soil” (seabed) or “area” can be expected:

Depending on the manner of construction, the discharge of cuttings/drilling fluid can lead to turbidity plumes or material changes in the sediments. Depending on the given installations, foundation structures can lead to sealing and/or compaction of the seabed. Due to operating conditions, pollutants may be introduced through corrosion protection coatings or through the discharge of production water or other wastewater which could have an impact on the seafloor.

The effects described with regard to the extraction of raw materials would occur both if the plan were implemented and if it were not implemented. However, by defining priority or reservation areas, the use of raw material extraction will be assigned more importance in spatial planning considerations in future. It is therefore more probable that the seabed (soil) in the priority and reservation areas will be affected when the plan is implemented than if it is not implemented.

Trawls and static nets are used for fishing purposes in the Baltic Sea EEZ. The otter boards of bottom trawls generally penetrate the sandy to silty seabed of the Baltic Sea to a depth of a few millimetres to centimetres. In sandy seabeds and corresponding sediment dynamics, relatively rapid regeneration can be expected within days or a few weeks. At greater water depths, and here especially in the Baltic Sea basins, the drag marks remain for longer periods of time due to the low sediment dynamics.

The formation of turbidity plumes near the seabed and possible release of pollutants from the sandy sediments is negligible in areas with a relatively low proportion of fine grain and low heavy metal concentrations. In seabeds with a higher proportion of fine grain, such as the Baltic Sea basins, a significant release of pollutants from the sediment into the bottom water can occur. The pollutants generally adhere to sinking particles which, due to the low currents in the Baltic Sea basins, hardly ever drift over long distances and remain in their original environment.

The impact of fishing on the seabed (soil) as a protected resource is independent of the non-implementation or implementation of the plan.

Overall, the provisions set out in the Spatial Plan do not have any significant impacts on the protected assets “soil” or “area”.

11.3.2 Benthos and biotopes

The inventory of species in the Baltic Sea EEZ, with its approximately 250 macrozoobenthos species, can be regarded as average. The benthic communities are also typical for the Baltic Sea EEZ and for the most part do not exhibit any special features. According to the currently available studies, the macrozoobenthos of the Baltic Sea EEZ is also considered average due to the proven number of Red List species. Investigations of macrozoobenthos in the context of the licensing procedures for offshore wind farms and grid connections from 2002 to 2015 have confirmed this assessment. The species inventory found and the number of Red List species indicate an average importance of the study area for benthic organisms.

Deep foundations of wind turbines and platforms cause small-scale and short-term disturbances of the seabed, sediment upheavals and the formation of turbidity plumes. The resuspension of sediment and the subsequent sedimentation can lead to an impairment or damage of the benthos in the immediate vicinity of the foundations for the duration of construction activities and to the utilisation of biotopes. However, these impairments will probably only have a small-scale effect and are limited in time. Due to the nature of the installations, changes in species composition may occur as a result of local land sealing and the introduction of hard substrates in the immediate vicinity of the structures. As the colonisation of the artificial hard substrates is associated with an accumulation of organic material, a local lack of oxygen can occur due to the biological degradation process.

The laying of the submarine cable systems is also only expected to cause small-scale disturbances of the benthos and biotopes by sediment upheavals and turbidity plumes in the area of the cable route. Possible impacts on the benthos and biotopes depend on the installation methods used and the geological and hydrographic conditions. With the comparatively gentle installation using the flushing method, only minor disturbances in the area of the cable route are to be expected. Local sediment shifts and turbidity plumes are to be expected during the laying of the submarine cable systems. In more cohesive soils, the cable systems are milled in or laid with a heavy plough. These procedures are also associated with disturbance of the sediment and benthic fauna and sediment turbulence.

In areas with a lower proportion of fine grains, most of the released sediment will settle relatively quickly in the immediate vicinity of the cable route. In areas with soft sediments and correspondingly high fine-grain content, the near-bottom currents are relatively low, so that only temporary, local effects can be expected for these areas as well. In the short term, pollutants and nutrients may be released from the sediment into the soil water. The potential release of pollutants from the sandy sediment is negligible. In the area of silty and clayey seabeds, a significant release of pollutants from the sediment into the bottom water can occur. The pollutants generally adhere to sinking particles which, due to the low currents in the Baltic Sea basins, hardly drift over long distances and remain in their original environment. In the medium term, this remobilised material is deposited again in the silty basins.

Benthic habitats are directly overbuilt in the area of necessary rock fills for cable crossings or where it is locally necessary to lay cable sections on the seabed. The resulting habitat loss is permanent but small-scale. The result is a non-native hard substrate that can cause changes in species composition on a small scale. No significant impacts on benthos and biotopes are to be expected from these small-scale areas. In addition, the risk of negative impacts on the benthic soft soil community by non-native species is low, since the recruitment of the species will most probably take place from natural hard substrate habitats.

Due to operating conditions, the uppermost sediment layer of the seabed directly above the cable system may become warmer, which may lead to impairments of benthic communities. The Spatial Plan lays down a planning principle to prevent the adverse effects of sediment warming as far as possible. At the level of sectoral planning (site development planning), the planning principle for sediment warming specifies in concrete terms that the 2C criterion must be met. According to BfN's assessment, this precautionary value ensures with sufficient probability that considerable negative impacts of cable heating on the marine environment will be prevented.

As things stand at present, the planned submarine cable routes are not expected to have any significant impacts on benthos and biotopes provided the 2 K criterion is met. Only very small-scale areas outside protected areas will be used. Due to the usually rapid regenerative capacity of the existing populations of benthic organisms, with short generation cycles and their widespread distribution in the German Baltic Sea, rapid recolonisation is very likely.

With regard to the designation of the SKO1 area as a reserved area for sand and gravel extraction, its location within the "Pomeranian Bay – Rönne Bank" Nature Conservation Area must be taken into account.

There is no concrete information on the SKO1 area. However, for the comparable gravel sand storage area "OAM III" in the North Sea EEZ, which is also located in the nature conservation area, there are currently no indications that the mining activities to date have led to any fundamental change in the sediment structure or composition in the mining area. Overall, the investigations show that it has been possible to preserve the original substrate in the area and that there is a capacity for regeneration, particularly for species-rich gravel, coarse-sand and shell beds. Under similar conditions, it can be assumed that, on the basis of the current state of knowledge, significant impairments of benthic habitats and their communities can be excluded by defining the area SKO1.

With regard to shipping, marine research and other uses, no significant impacts on benthos and biotopes are to be expected based on the provisions of the Spatial Plan which would go beyond the general effects of the undefined uses.

The designation of the designated nature conservation areas of the Baltic Sea EEZ as nature conservation priority areas supports the positive effects on benthic communities and biotopes that can be expected on the basis of appropriate management measures for the nature conservation areas.

11.3.3 Fish

According to current knowledge, the fish communities typical of the habitat occur in the German EEZ. The pelagic fish community, represented by herring, sprat, salmon and sea trout, has been identified, as has the demersal fish community, consisting of large fish species such as cod, plaice, flounder and dab. Due to the habitat-typical fish communities, the fish fauna is of average importance with regard to its specificity. In the eastern part of the EEZ, a total of 45 fish species have been identified in various studies, including 6 Red List species. According to current knowledge, the priority areas for wind energy do not represent a preferred habitat for any of the protected fish species. Consequentially, the fish stock in the planning area is not ecologically significant in comparison with neighbouring marine areas. According to current knowledge, the planned construction of wind farms and the associated platforms and submarine cableways is not expected to have any significant impact on the protected fish species. The effects on the fish fauna during the construction of the wind farms, platforms and submarine cable systems are limited in space and time. During the construction phase of the foundations, the platforms and the laying of the submarine cable systems, the fish fauna may be temporarily and locally affected by sediment upheavals and the formation of turbidity plumes. Due to the prevailing sediment and current conditions, the turbidity of the water is expected to decrease rapidly. Based on current knowledge, the impairments will therefore remain small-scale and temporary. Overall, small-scale impacts on adult fish can be expected to be minimal. In addition, the fish fauna is adapted to the natural sediment upheavals caused by storms that are typical for this area. Furthermore, during the construction phase, fish may be temporarily frightened away by noise and vibrations. Noise during the construction phase must be reduced by appropriate measures. Further local impacts on the fish fauna may be caused by the additional hard substrates introduced as a result of possible changes in benthos.

According to the current state of knowledge, the designation of priority areas for nature conservation can have a significant positive impact on fish fauna and counteract the overexploitation of some fish stocks in the Baltic Sea. According to current knowledge, the definition of other uses in the Spatial Plan (ROP-E), such as raw material extraction or shipping, will not have any significant impact on the fish fauna.

11.3.4 Marine mammals

The German EEZ of the Baltic Sea, like the entire western Baltic Sea, is part of the harbour porpoise habitat. According to current knowledge, the priority areas for wind energy production EO1, EO2 and EO3 as defined in the plan are used by harbour porpoises as transit and feeding areas. There is currently no evidence that these areas have special functions as harbour porpoise nursery grounds. Seals and grey seals only sporadically use the three areas EO1 to EO3 as transit areas. On the basis of the findings from the monitoring of Natura 2000 sites and from studies for offshore wind farms, it is currently possible to deduce a medium to seasonally high importance of the areas EO1 and EO2 for harbour porpoises. The seasonally high importance of the area results from the possible use by individuals of the separate and highly endangered Baltic Sea population of harbour porpoise during the winter months. For harbour seals and grey seals, these areas are of no particular importance.

Hazards to marine mammals can be caused by noise emissions during the installation of the foundations of transformer or collection platforms. Without the use of noise-reducing measures, considerable disturbance to marine mammals during pile driving in individual subspaces cannot be ruled out. In the specific approval procedure, therefore, the driving of piles of the transformer or collection platforms will only be permitted with the use of effective noise abatement measures. For this purpose, the plan specifies principles and objectives.

These stipulate that the installation of the foundations must be carried out in compliance with strict noise reduction measures. In the specific approval procedure, extensive noise reduction measures and monitoring measures are ordered to ensure compliance with applicable noise protection values (sound exposure level (SEL) of 160 dB re 1μPa²s and peak sound pressure level of 190 dB re 1μPa at a distance of 750 m around the pile driving or placement site). Suitable measures are to be taken to ensure that no marine mammals are present in the vicinity of the pile-driving site. According to current knowledge, significant impacts on marine mammals caused by the operation of the transformer or collection platforms can be ruled out.

The establishment of priority areas for wind energy production outside nature conservation areas will help reduce the risk to harbour porpoises in key feeding and breeding areas. The construction and operation of the wind turbines and platforms is not expected to have any significant adverse effects on marine mammals at present, following implementation of the mitigation measures to be ordered in individual procedures in accordance with the planning principle and corresponding compliance with applicable noise protection values. No significant impacts on marine mammals are expected from the laying and operation of submarine cable systems either.

As a result, significant effects of the provisions in the Spatial Plan (ROP-E) on the conservation of marine mammals can be excluded with the necessary certainty.

11.3.5 Seabirds and resting birds

The EEZ of the Baltic Sea can be divided into different sub-areas, each of which has a seabird occurrence to be expected for the respective prevailing hydrographic conditions, the distances from the coast, existing prior pollution and species-specific habitat requirements.

The uses taken into account in the Spatial Plan (ROP-E) have various impacts on seabirds and resting birds, most of which have a spatially and temporally limited effect on the area or for the duration of the activity. For disturbance-sensitive species such as red-throated and black-throated divers, offshore wind farm projects have disturbing effects that lead to avoidance behaviour. So far, no findings on habituation effects are available.

By securing open space or not designating areas for wind energy production in marine nature conservation areas, impacts such as habitat loss in these important habitats will be reduced. The Spatial Plan (ROP-E) also identifies nature conservation areas as priority areas for nature conservation. Principles of the Spatial Plan (ROP-E) also provide for coordination in terms of time and space for the construction of offshore wind farm projects.

The spatial definition of other uses, such as shipping and raw material extraction (especially sand and gravel extraction) does not automatically mean increased intensity of use. On the contrary, these spatial definitions are a tracing of previous activities.

As a result, any significant effects of the provisions in the Spatial Plan (ROP-E) on the protected resources of sea birds and resting birds can be ruled out with the necessary certainty.

11.3.6 Migratory birds

The EEZ of the Baltic Sea is of average to above average importance for bird migration. Up to one billion birds migrate across the Baltic Sea every year. The Baltic Sea is an important transit area for sea ducks and geese from Northern Europe and Russia (as far as Western Siberia), with much of the migration in autumn taking place in an east-west direction close to the coast. The western Baltic Sea is flown over by several species requiring special protection (e.g. white-cheeked geese, whooper swans, eiders, scoters and velvet scoters) at sometimes high intensities. Thermal gliders and other tagging land birds prefer to migrate along the "bird flight line" (islands of Fehmarn, Falster, Møn and Seeland, Falsterbo). East of this main route, these birds migrate at a much lower density. The western Baltic Sea is of above-average importance for crane migration.

The potential impact of offshore wind energy production on migratory birds may be that they constitute a barrier or a risk of collision. By securing open spaces in nature conservation areas, collision and barrier effects in important habitats are reduced. Furthermore, due to its location in an important bird migration area, among other things, EO2 is only designated as a reserved area for offshore wind energy. The other uses considered in the Spatial Plan (ROP-E) do not constitute vertical barriers in the area.

According to the current state of knowledge, the spatial planning provisions are not expected to have any significant impact on migratory birds.

11.3.7 Bats

While migration movements of bats across the Baltic Sea have been documented in various ways, concrete information on migratory species, migration corridors, migration heights and migration concentrations is still lacking. Previous findings only confirm that bats, especially long-distance migratory species, migrate across the Baltic Sea.

Due to the verticality of the airspace, bats may also be at risk of colliding with offshore wind turbines. According to the current state of knowledge, there are no findings on possible significant impairments of the bat migration over the North Sea EEZ. Other uses considered in the Spatial Plan (ROP-E) do not constitute comparable obstacles in the airspace.

According to the information available so far, the spatial provisions of the Spatial Plan do not pose any significant impact on bats.

11.3.8 Air

There are no measurable effects on air quality as a result of the specifications in the Spatial Plan (ROP-E) and their implementation. Emissions of pollutants from shipping are independent of the implementation of the plan.

11.3.9 Climate

The reduction in carbon emissions associated with the provisions on offshore wind energy production can be expected to have a positive long-term impact on the climate.

11.3.10 Landscape

The impairment of the coastal landscape by the planned wind energy installations in the German EEZ can be classified as minor. Due to the coordinated and harmonised overall planning, the provisions of the Spatial Plan (ROP-E) can minimise the space required for the expansion of offshore wind energy production and thus – compared to non-implementation of the plan – also reduce the impacts on the landscape as a protected asset.

As for pipelines and power transmission lines, negative impacts on the landscape can be ruled out due to their installation in or on the seabed.

11.3.11 Cultural and other material goods

With the further expansion of wind energy production in the German EEZ, known and previously undiscovered cultural assets and traces of settlement may be endangered to a greater extent. However, this danger can be reduced by comprehensive coordination and coordination measures with the technical authorities, while at the same time a great gain in knowledge for underwater archaeology with regard to underwater cultural assets and other cultural traces can be expected.

11.3.12 Biological diversity

Biological diversity encompasses the diversity of habitats and biotic communities, the diversity of species and genetic diversity within species (as per Article 2 of the Convention on Biological Diversity, 1992). The public focus is on species diversity.

With regard to the current state of biodiversity in the Baltic Sea, it should be noted that there are countless indications of changes in biodiversity and species structure at all systematic and trophic levels in the Baltic Sea. These are mainly due to human activities, such as fishing and marine pollution, or to climate change. Red lists of endangered animal and plant species have an important monitoring and warning function in this context, as they show the status of the populations of species and biotopes in a region. Possible impacts on biodiversity are dealt with in the environmental report in connection with the individual protected assets. In summary, it can be said that, according to current knowledge, no significant impacts on biological diversity are to be expected from the Spatial Plan's provisions.

11.3.13 Interactions

In general, impacts on a protected asset lead to various consequences and interactions between the protected goods. The essential interdependency of the biotic objects of protection exists via the food chains. Possible interactions during the construction phase result from sediment rearrangements and turbidity plumes, as well as noise emissions. However, these interactions occur only very briefly and are limited to a few days or weeks.

Installations-related interactions, e.g. through the introduction of hard substrate, are permanent, but only locally to be expected. This could lead to a small-scale change in the food supply.

Due to the variability of the habitat, interactions can only be described in a very imprecise manner overall. In principle, it can be stated that, according to the current state of knowledge, no interactions are discernible that could result in a threat to the marine environment.

11.3.14 Cumulative effects

Soil/area, benthos and biotopes

A substantial part of the environmental impacts caused by the areas for offshore wind energy production, pipelines and power transmission cables affecting the seabed, benthos and biotopes will only occur during the construction period (formation of turbidity plumes, sediment relocation etc.), and only within a spatially narrowly defined area. Due to the gradual implementation of the construction projects, cumulative construction-related environmental impacts are unlikely. Possible cumulative impacts on the seabed, which could also have a direct impact on the benthic material to be protected and on specially protected biotopes, result from the permanent direct land use of the installations' foundations and from the pipelines and power lines laid. The individual impacts are generally small-scale and local.

In the area where piping and power lines are laid, the impairment of sediment and benthic organisms will be essentially temporary. In the case of crossing particularly sensitive biotope types such as on reefs or species-rich gravel, coarse-sand and shell beds, permanent impairment would have to be assumed.

For a balance of land use, please refer to the environmental report on the 2019 Site Development Plan (SDP) or 2020 draft SDP. There, an estimation of the direct land use by wind energy installations and submarine power cables is made based on model assumptions.

No statement can be made on the use of specially protected biotope areas under Article 30 of the Federal Nature Conservation Act (BNatSchG) due to the lack of a reliable scientific basis. A comprehensive sediment and biotope mapping of the EEZs currently being carried out will provide a more reliable basis for assessment in future.

In addition to the direct use of the seabed and thus of the habitat of the organisms settled there, installations' foundations, overlying pipelines and submarine power cables and necessary intersection-crossing structures lead to an additional volume of hard substrate. As a result, alien hard substrate loving species can settle and change the species composition. This effect can lead to cumulative effects due to the erection of multiple offshore structures, pipelines, power cables or rock fills in crossing areas of pipelines and cables. The benthic fauna adapted to soft soils also loses habitat due to the hard substrate introduced. However, according to current knowledge, since both the grid infrastructure and the wind farms will use ‰ of the area, no significant impacts are to be expected in the cumulative area which would endanger the marine environment with regard to the seabed and benthos.

Fish

The impact on the fish fauna caused by the regulations is probably most strongly influenced by the implementation of an initial 20 GW of wind energy production in the reservation areas of the North and Baltic Seas. The effects of the offshore wind farms are concentrated on the one hand on the regularly ordered closure of the area for fishing, and on the other hand on habitat changes and their interaction.

The expected fishery-free zones within the wind farm areas could have a positive impact on the fish zone by eliminating the negative effects of fishing, such as disturbance or destruction of the seabed and catch and by-catch of many species. The lack of fishing pressure could lead to a more natural age distribution of the fish fauna, leading to an increase in the number of older individuals. While offshore wind farms could develop into aggregation sites for fish, it is not yet clear whether wind farms attract fish.

In addition to the absence of fishing, an improved food base for fish species with a wide range of diets could be envisaged. The growth of sessile invertebrates on wind turbines could favour benthos-eating species and provide fish with a larger and more diverse food source (Glarou et al. 2020). This could improve the condition of the fish, which in turn would have a positive effect on their fitness. There is currently a need for research to transfer such cumulative effects to the fish population level.

Furthermore, wind farms in the southern North Sea could have an additive effect beyond their immediate location by spreading the mass and measurable production of plankton by currents, which could influence the qualitative and quantitative composition of the zooplankton (FLOETER et al. 2017). This in turn could affect more planktonic fish, including pelagic schooling fish such as herring and sprat, which are the target of one of the largest fisheries in the North Sea. Species composition could also change directly, as species with habitat preferences different from those of established species, e.g. reef dwellers, find more favourable living conditions and are more abundant. In the Danish wind farm Horns Rev, 7 years after its construction, a horizontal gradient in the occurrence of hartsubrate-affected species was found between the surrounding sand areas and near the turbine foundations: Clifffish, eel mother and lumpfish were found much more frequently near the wind turbine foundations than on the surrounding sand areas (LEONHARD et al. 2011). Cumulative effects resulting from a major expansion of offshore wind energy could include

- an increase in the number of older individuals,
- better conditions for fish due to a larger and more diverse food base,
- the further establishment and distribution of fish species adapted to reef structures,
- the recolonisation of previously heavily fished areas,
- better living conditions for territorial species such as cod-like fish.

The natural mechanism for limiting populations is, besides predation, intra- and interspecific competition, also called density limitation. It cannot be excluded that within individual wind farms local density limitation sets in before the favourable effects of the wind farms are spatially reproduced, e.g. through the migration of "surplus" individuals. In such cases, the effects would be local and not cumulative. What effects that changes in the fish fauna could have on other elements of the food web, both below and above their trophic level, cannot be predicted at this stage of knowledge.

Together with the designation of nature conservation areas, wind farms could contribute to positive stock development and thus to the recovery of fish stocks in the Baltic Sea.

Marine mammals

Cumulative effects on marine mammals, in particular harbour porpoises, may occur mainly due to noise exposure during the installation of deep foundations. For example, marine mammals can be significantly affected by the fact that, if ramming is carried out simultaneously at different sites within the EEZ, there is not enough equivalent habitat available for evasion and retreat.

The implementation of offshore wind farms and platforms so far has been relatively slow and gradual. To date, pile driving work has been carried out for three wind farms in the German Baltic Sea EEZ. Since 2011, all pile driving work has been carried out using technical noise reduction measures. Since 2014, the noise protection values have been reliably maintained, and levels have even been lower than the limits thanks to successful use of noise reduction systems. The three construction sites did not overlap in time, so that there was no overlapping of noise-intensive pile driving work which could have led to cumulative effects. Only in the case of the construction of the "EnBW Baltic 2" wind farm was it necessary to coordinate the pile driving work, including aversive measures, due to the installation performed using two installation ships.

The evaluation of the sound results with regard to sound propagation and the possible resulting cumulation has shown that the propagation of impulsive sound is greatly restricted when effective sound-reducing measures are applied (BRANDT et al. 2018, DÄHNE et al., 2017).

In order to prevent and reduce cumulative effects on the population of harbour porpoises in the German EEZ, the orders of the downstream authorisation procedure stipulate a restriction of the sonication of habitats to maximum permitted areas of the EEZ and nature conservation areas. According to these regulations, the propagation of noise emissions must not exceed the defined proportions of the German EEZ and nature conservation areas. This ensures that animals have sufficient high-quality habitats available to them at all times for evasion. The primary purpose of the ordinance is to protect marine habitats by preventing and minimising disturbances caused by impulsive noise. The prevention and mitigation measures in the EO1 and EO2 areas will focus in particular on the protection of animals of the highly endangered population of the central Baltic Sea.

The conclusion is that the implementation of the plan will lead to the prevention and reduction of cumulative effects. This assessment also applies to the cumulative effects of the various uses on marine mammals.

Seabirds and resting birds

Among the uses considered in the Spatial Plan (ROP-E), the production of offshore wind energy by vertical structures such as platforms and offshore wind turbines in particular can have various impacts on seabirds and resting birds, such as habitat loss, an increased risk of collision or a chasing and disturbance effect. These effects are considered site- and project-specifically in the environmental impact assessment and are monitored in the subsequent monitoring of the construction and operation phases of offshore wind farm projects. For seabirds and resting birds in particular, the loss of habitat due to the cumulative effects of multiple structures or offshore wind farms can be significant. By securing open space in marine nature conservation areas, the impact of offshore wind farms on seabirds and resting birds in these important habitats will be reduced. Although the Spatial Plan (ROP-E) also lays down provisions for other uses within the nature conservation areas, no increases in intensity are expected as a result of the spatial planning provisions. Rather, these constitute a record of existing uses or intensities of use.

According to current knowledge, thanks to the SEA, the spatial planning provisions are not expected to pose and substantial cumulative effects on the protected asset sea birds and resting birds.

Migratory birds

Among the uses considered in the Spatial Plan (ROP-E), the use of offshore wind energy in particular can have various impacts on migratory birds, such as barrier effects and collision risk due to the vertical structures of offshore wind turbines. These effects are considered site-specifically within the scope of the environmental impact assessment and are monitored within the subsequent monitoring of the construction and operation phases of offshore wind farm projects.

By defining priority and reservation areas for offshore wind energy in a spatial context to each other and securing open space in nature conservation areas, barrier effects and collision risks in important food and resting habitats are reduced. The designation of area EO2 as reservation areas for offshore wind energy also takes into account the importance of this area for bird migration. The effects of other uses and their definition are comparatively less extensive with regard to the verticality in the airspace.

According to current knowledge, significant cumulative effects of the spatial planning definitions of all uses taken into account on migratory birds can be ruled out with the necessary certainty.

11.3.15 Transboundary effects

The present SEA concludes that, as things stand at present, the provisions of the Spatial Plan do not have a significant impact on the areas of the neighbouring countries bordering the German Baltic Sea EEZ.

For the protected assets soil and water, plankton, benthos, biotope types, landscape, cultural heritage and other material goods and human beings, including human health, any significant transboundary impacts can be ruled out in general. From a cumulative standpoint, the only potentially significant transboundary impacts that could arise in the area of the German Baltic Sea would concern the highly mobile biological assets fish, marine mammals, seabirds and resting birds, as well as migratory birds and bats.

With regard to fish as a protected resource, the SEA comes to the conclusion that, according to the current state of knowledge, no significant transboundary impacts on this protected resource are to be expected as a result of the implementation of the ROP, since the recognisable and predictable effects are of a small-scale and temporary nature.

The same applies to the protected species marine mammals, seabirds and resting birds. These species use the areas mainly as transit areas. There is unlikely to be any significant loss of habitat for strictly protected marine and resting bird species. Based on current knowledge and taking into account impact-reducing and damage-limiting measures, significant transboundary impacts can be ruled out. For example, the installation of the foundations of wind turbines and platforms is only permitted in the specific approval procedure if effective noise reduction measures are applied. Against the background of the particular threat of the separate Baltic Sea population of harbour porpoise, intensive monitoring measures must be carried out as part of enforcement and, if necessary, the noise reduction measures must be adapted or the construction work coordinated in order to rule out any cumulative effects.

For migratory birds, erected wind turbines in particular can pose a barrier or a collision risk. By securing open space in marine nature conservation areas, these impacts are reduced in important resting areas for some migratory bird species. Furthermore, the EO2 area is only designated as a reserved area for offshore wind energy, particularly because of the conflict with bird migration. Of the other uses considered in the Spatial Plan (ROP-E), no comparable spatially extensive

11.4 Review of species protection law

The present review of species protection includes investigation efforts to determine whether the plan meets the requirements of Article 44 subsection (1) numbers 1 and 2 of the Federal Nature Conservation Act for specially and strictly protected animal species. In particular, it will be examined whether the plan violates species conservation prohibitions.

Under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act, the killing or injury of wild animals of specially protected species, i.e. including animals listed in Annex IV to the Habitats Directive and Annex I to the Habitats Directive, is prohibited. The species conservation review under Article 44 subsection (1) number 1 of the Federal Nature Conservation Act always relates to the killing and injury of individuals.

Under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act, it is also prohibited to cause significant disturbance to wild animals of strictly protected species during their reproduction, rearing, moulting, wintering and migration periods.

According to current knowledge, there are two separate populations of harbour porpoise in German waters of the Baltic Sea: the Belt Sea population in the western Baltic Sea – Kattegat, Beltsee, Sund – up to the area north of Rügen and the population of the central Baltic Sea from the area north of Rügen.

The limit of the population of harbour porpoise of the central Baltic Sea, which is classified as endangered, is 13°30' east, taking into account the results of acoustic, morphological, genetic and satellite surveys at the level of Rügen. (SVEEGARD et al. 2015).

The abundance of the separate population of the central Baltic Sea was determined to be 447 individuals on the basis of the acoustic data.

The separate population of the central Baltic Sea was classified as highly endangered by IUCN and HELCOM, among other things because of the very small number of individuals and the spatially limited genetic exchange.

In the Baltic Sea EEZ, three nature conservation areas – "Pomeranian Bay – Rönne Bank" (NSGPBRV), "Fehmarn Belt" (NSGFmbV), and "Kadet Trench" (NSGKdrV) – were established in 2017 with the aim of conserving and, where necessary, restoring to a favourable conservation status the species listed in Annex II to Directive 92/43/EEC, including porpoise, common seal and grey seal. The Pomeranian Bay – Rönnebank Nature Conservation Area is of great importance for harbour porpoises in winter. During this period the nature conservation area and its surroundings up to Rügen are also used by animals of the highly endangered population of harbour porpoise of the central Baltic Sea. No animals of the population of the central Baltic Sea occur west of a longitude of 13° 30'. The Kadet Trench Nature Conservation Area marks the borderline of the population of harbour porpoise from Skagerrak, Kattegat and Beltsee with higher harbour porpoise densities west of the nature conservation area and substantially decreasing densities in the eastern direction. The Fehmarn Belt Nature Conservation Area and its surroundings have the highest density of harbour porpoise in German waters in the Baltic Sea.

Areas EO1 and EO2 are regularly used by harbour porpoises, but to a very limited extent. The presence of harbour porpoise in both areas is low compared to the presence west of the Darss threshold. According to current knowledge, there is no evidence that either area is used as a breeding ground. For harbour porpoises, areas EO1 and EO2 are of low to medium importance. During the winter months, however, the areas are expected to be of high importance due to the potential use by animals of the highly endangered population of the central Baltic Sea. For grey seals and harbour seals these areas are of low importance.

Area EO3 is used by harbour porpoises on an irregular and very small scale. Overall, the abundance of harbour porpoise in area EO3 is low compared to the abundance in the Kadet Trench and further west. According to the current state of knowledge, the area is not used as a nursery area. For harbour porpoises, area EO3 is of minor importance. For grey seals and harbour seals, this area lies on the edge of the distribution area.

The main threats with fatal consequences for harbour porpoise in the ASCOBANS Agreement area, which includes the German EEZ in the North Sea, include by-catch in bottom-set gillnets but also in trawls, attacks by dolphins, depletion of food resources, physiological effects on reproductive capacity and infectious diseases, possibly as a result of contamination with pollutants.

There are indications of collisions with ships for large whale species, such as the fin whale or the humpback whale. However, collisions with ships are extremely rare for small cetaceans such as the harbour porpoise.

According to the current state of knowledge, killing or injury of individual animals as a consequence of the uses specified in the plan is possible by the input of impulse sound during pile driving for the foundation of plants.

Marine mammals, and in particular the highly protected harbour porpoise species, would be likely to be injured or even killed by pile-driving for the foundations of offshore wind turbines, substations or other platforms if no prevention and mitigation measures were taken.

In relation to the harbour porpoise, compliance with the noise limits of 160 dB for the sound exposure level (SEL05) and 190 dB for the peak sound pressure level at a distance of 750 m from the emission point, as laid down in the subordinate licensing procedures, cannot lead to any killing or injury pursuant to Article 44 subsection 1 number 1 of the Federal Nature Conservation Act.

Appropriate measures, such as aversive conditioning and soft-start procedures, will be used to ensure that no harbour porpoises are present within a 750-m radius of the pile-driving site.

The plan sets out objectives and principles that provide a framework for downstream planning levels and individual approval procedures. The downstream procedures stipulate specifications, orders and requirements with regard to the necessary noise abatement measures and other prevention and reduction measures by means of which any implementation of the prohibition can be ruled out. The measures are strictly monitored to ensure with the necessary certainty that killing and injury pursuant to Article 44 subsection (1) number 1 of the Federal Nature Conservation Act will not occur.

The temporary pile driving work is not expected to cause any significant disturbance to harbour porpoises within the meaning of Article 44 subsection (1) number 2 of the Federal Nature Conservation Act.

According to the current state of knowledge, provided that prevention and reduction measures are implemented it cannot be assumed that disturbances which may occur due to sound-intensive construction measures and would worsen the conservation status of the local population.

Negative noise impacts of pile driving on harbour porpoises are not to be expected given implementation of effective noise abatement management, in particular by applying suitable noise abatement systems in accordance with the principles and objectives in the update of the plan and subsequent arrangements in the individual approval procedure of the BSH, and taking into account the requirements of the noise abatement concept of the BMU (2013).

The planning approval decisions of the BSH will contain concretising directives which ensure effective noise abatement management by means of suitable measures.

In accordance with the precautionary principle, measures to avoid and reduce the effects of noise during construction are specified in accordance with the state of the art in science and technology. The specifications in the subordinate procedures and, in particular, the measures ordered in the planning approval decisions to ensure the requirements of species protection are coordinated with the BfN over the course of implementation and adapted as needed. The following noise-reducing and environmental protection measures are regularly ordered within the framework of planning approval procedures:

- Preparation of a sound prognosis under consideration of the site- and installation-specific characteristics (basic design) before the start of construction,
- Selection of the construction method with the lowest noise level based on the state of the art and the existing conditions,
- Preparation of a concrete noise control plan specifically adapted to the selected foundation structures and erection processes, for carrying out the pile driving work, in principle two years before the start of construction, and in any case before the conclusion of contracts concerning the components affected by noise,
- Use of noise-reducing accompanying measures, individually or in combination, pile-remote (bubble curtain system) and, if necessary, pile-related noise-reducing systems in accordance with the state of the art in science and technology,
- Consideration of the characteristics of the hammer and the possibilities of controlling the pile driving process in the acoustic insulation plan,

- Plan for averting the animals from the endangered area (at minimum within a radius of 750 m around the pile-driving site),
- An approach to verifying the effectiveness of the aversive and noise-reducing measures,
- State-of-the-art installation design to reduce operational noise.

As outlined above, aversive measures and a "soft-start" procedure must be applied to ensure that animals in the vicinity of the pile-driving operations have the opportunity to move away or to take evasive action in time.

As explained above, protected species are present in areas EO1 to EO3. These include species listed in Annex I of the Directive, species whose habitats and habitats are protected in the nature conservation areas, as well as characteristic species and regularly occurring migratory bird species.

The region encompassing areas EO1 to EO3 is mainly used by divers as a transit area during migration periods and in winter. According to current knowledge, this area and its surroundings lie outside the main occurrence areas in the Pomeranian Bay.

For other bird species, areas EO1 to EO3 are also of low to medium importance.

In conclusion, based on the current state of knowledge, the construction and operation of offshore wind turbines and their ancillary installations (transformer stations and internal cabling within the wind farm) in the areas covered by the plan are not considered to meet the definition of disturbances under Article 44 subsection (1) number 2 of the Federal Nature Conservation Act (BNatSchG) .

Within the scope of the individual approval procedures, however, an update of the review for compliance with the disturbance requirements in accordance with Article 44 subsection (1) number 2 of the BNatSchG is required, if necessary taking into account further prevention and mitigation measures, but in any case taking into account the specific technical specifications.

In principle, the same considerations of species protection law apply to bats as those already set out in the avifauna assessment.

It can also be expected that any adverse effects of wind turbines on bats will be prevented by the same prevention and mitigation measures that are in place to protect bird migration.

Experiences and results from research projects or from wind farms already in operation will also be adequately considered in further procedures.

According to current knowledge, the killing or injury (by offshore wind farms of other specially protected species such as bats, is ruled out in accordance with Article 44 subsection 1 number 1 of the BNatSchG. Nor is the implementation of the species protection prohibition of significant disturbance (as per Article 44 subsection 1 number 2 of the BNatSchG) of other strictly protected species, such as bats, to be expected.

11.5 Impact assessment

Insofar as a site of Community importance or a European bird sanctuary may be significantly impaired in its elements relevant to the conservation objectives or the purpose of protection, the provisions of Section 7 subsection (6) in conjunction with subsection (7) of the Federal Regional Planning Act (ROG) and the provisions of the Federal Nature Conservation Act on the permissibility and implementation of such interventions, including obtaining the opinion of the European Commission, must be applied when amending and supplementing regional development plans.

The German Baltic Sea EEZ contains the Pomeranian Bay – Rönne Bank Nature Conservation Area which was created by the Regulation on the Establishment of the Pomeranian Bay – Rönne Bank Nature Conservation Area of 22 September 2017 (NSGPBRV, BGBl. I S. 3415), the Fehmarn Belt Nature Conservation created by the Regulation on the Establishment of the Fehmarn Belt Nature Conservation Area of 22 September 2017 (NSGFmbV, Federal Law Gazette I p. 3405), and the Kadet Trench Nature Conservation Area created by the Regulation on the Establishment of the Kadet Trench Nature Conservation Area of 22 September 2017 (Federal Law Gazette I p. 3410, NSGKdrV).

The total area of these three nature conservation area amounts to 2,472 km², with the Pomeranian Bay – Rönne Bank Nature Conservation Area covering an area of 2,092 km², Fehmarn Belt Nature Conservation Area an area of 280 km2, and Kadet Trench Nature Conservation Area 100 km2.

The protected habitats are the habitat types "reefs" and "sandbanks" listed in Annex I of the Habitats Directive, certain fish species (sturgeon and feint) and marine mammals listed in Annex II of the Habitats Directive (harbour porpoise, grey seal and seal) as well as various species of seabirds listed in Annex I of the Birds Directive (red-throated diver, black-throated diver, grebe) and regularly occurring migratory bird species (red-necked grebe, yellow-billed diver, long-tailed duck, common scoter, velvet scoter, petrel, guillemot, razorbill, and black guillemot).

The impact assessment carried out here takes place at a higher level of regional planning and sets a framework for subordinate planning levels, where these exist. It therefore does not replace the assessment at the level of the specific project. Depending on the provisions of the Spatial Plan for the respective use, the assessment is stratified. In the case of wind energy there is a staged planning and approval process. This means that the reviews of the downstream planning levels are taken into account within the scope of the Spatial Plan. If no review has yet been carried out at subordinate planning levels, the review within the framework of this SEA for the Spatial Plan is carried out on the basis of the available data and knowledge.

There is also a staged planning and approval process for the extraction of raw materials. Insofar as data and knowledge are available, an impact assessment is carried out within the scope of this SEA, otherwise the assessments are reserved for the downstream planning levels.

The Spatial Plan contains provisions relevant to the impact assessment concerning priority and reservation areas for wind energy, reservation areas for pipelines and power cables, and reservation areas for hydrocarbons, sand and gravel extraction.

With regard to wind energy production, reference is made to the results of the impact assessment for the 2019 SDP and draft 2020 SDP.

The investigation has shown that any potential impairments of the protection purposes of the Pomeranian Bay – Rönne Bank, Kadet Trench and Fehmarn Belt Nature Conservation Areas arising due to implementation of the plan in question and by complying with the instructions in the subordinate individual approval procedures can be ruled out with certainty.

11.6 Measures for preventing, reducing and offsetting any significant negative impacts of the land use plan on the marine environment

Pursuant to Annex 1 number 2 point c) to Section 8 subsection 1 of the Federal Regional Planning Act (ROG), the environmental report contains a description of the measures planned to prevent, reduce and, as far as possible, compensate for any significant adverse environmental impacts resulting from the implementation of the plan.

The basic principle is that the Spatial Plan takes better account of the concerns of the marine environment. The provisions of the Spatial Plan prevent negative impacts on the marine environment. This is due in particular to the fact that it is not apparent that the uses would not take place or would take place to a lesser extent if the plan were not implemented. The need to develop offshore wind energy production and the associated connecting pipelines and power lines, for example, is clear in any case, and the corresponding infrastructure would have to be created even without the Spatial Plan. In the event of non-implementation of the plan, however, the uses would develop without the space and resource-saving steering and coordination effect of the Spatial Plan.

In addition, the provisions of the Spatial Plan are subject to a continuous optimisation process, as the findings gained on an ongoing basis within the framework of the SEA and the consultation process are taken into account in the preparation of the plan.

While individual prevention, mitigation and compensation measures can be initiated at the planning level, others only come into effect during the concrete implementation phase, and are regulated there in the individual approval procedure on a project- and site-specific basis.

With regard to the planning of prevention and mitigation measures, the Spatial Plan (ROP-E) lays down spatial and textual provisions which, in accordance with the environmental protection objectives, serve to prevent or reduce significant negative impacts on the marine environment arising from implementation of the Spatial Plan (ROP-E). This concerns, among other things, spatial definitions of priority areas for nature conservation and the reserved area for bird migration, the exclusion of uses in priority areas for nature conservation that are not compatible with nature conservation, the principle of noise reduction in the construction of wind energy installations, the principle of preventing as much as possible the heat-up of seabed sediment by submarine power cables, and the principle of taking into account best environmental practice in accordance with the OSPAR Convention and the current state of science and technology in economic and scientific uses.

The following principles ensure that the least possible amount of land is used:

- Economic uses should be as space-saving as possible.
- Fixed installations are to be dismantled at the end of their use.
- When laying power cables, the aim should be to achieve the greatest possible bundling in the sense of parallel routing. In addition, the cable route should be as parallel as possible to existing structures and buildings.

In addition to the above-mentioned measures at the planning level, there are measures for certain specifications or associated uses, such as offshore wind energy production, pipelines power lines, and sand and gravel extraction, to prevent and reduce insignificant and significant negative impacts in the concrete implementation of the Spatial Plan (ROP-E). These prevention and reduction measures are specified and ordered by the respective competent licensing authority at project level for the planning, construction and operation phases.

11.7 Alternative testing

In accordance with Article 5 subsection 1 first 1 of the SEA Directive in conjunction with the criteria in Annex I of the SEA Directive and Section 40 subsection 2 number 8 of the UVPG, the environmental report contains a brief description of the reasons for the selection of the reasonable alternatives examined in the course of preparing the draft Spatial Plan. At the plan level, the conceptual/strategic design and spatial alternatives play a major role.

In principle, it should be noted that a preliminary investigation of possible and conceivable planning options is already inherent in all definitions in the form of objectives and principles of regional planning. As can be seen from the justification of the individual objectives and principles, in particular those relating to the environment, the respective definition is already based on a weighing up of possible affected public interests and legal positions, so that a "preliminary investigation" of possible planning options or alternatives has already taken place.

In addition to the zero alternative, the environmental assessment examines in particular spatial planning options or alternatives, insofar as they are relevant to the individual uses.

The basis for the planning solutions to be investigated and the examination of alternatives is provided by the mission statement and the planning guidelines (Section1 of the Spatial Plan). While three overall plan alternatives were initially examined over the course of preparing the conceptual planning on the basis of selected environmental aspects, especially individual area definitions, further (sub)spatial alternatives or different spatial planning areas (such as priority areas and reservation areas) were considered and evaluated from an environmental perspective for preparation of the first draft plan. The definition of areas for wind energy production in the outer EEZ is subject to a detailed environmental assessment at subordinate planning levels.

The zero alternative is not assessed as a reasonable alternative for updating the Spatial Plan, as requirements and spatial demands have changed considerably since the 2009 Spatial Plan entered into force, and the need for more far-reaching specifications, particularly for nature conservation, has become clear. Through more comprehensive, higher-level and forward-looking planning and coordination taking into account a large number of spatial requirements, the draft plan is likely to lead to comparatively lower land use overall and thus to lower environmental impacts.

The planning solution to be preferred from an environmental point of view was not always included in the draft plan. Rather, the overall context of the plan was to be considered and, in choosing plan solutions in addition to taking into account nature conservation concerns and preventing or reducing possible negative environmental impacts, the aim was to achieve the greatest possible balance with other economic, scientific and safety concerns. The decisive factor is that, at the level of this SEA, no significant impacts on the marine environment are to be expected for the provisions set out in Spatial Plan (ROP-E) on the basis of current knowledge.

11.8 Measures planned to monitor the environmental impact of implementing the Spatial Plan

Pursuant to Annex 1 number 3 point b) to Section 8 subsection (1) of the Federal Regional Planning Act (ROG), the environmental report also contains a description of the planned monitoring measures. Monitoring is necessary, in particular, to identify unforeseen significant impacts at an early stage and to be able to take appropriate remedial action.

This monitoring also serves to verify the gaps in knowledge or the forecasts with uncertainties as presented in the environmental report. According to Section 45 subsection 4 of the UVPG, the results of monitoring are to be taken into account when updating the Spatial Plan.

The actual monitoring of potential impacts on the marine environment can only start once the uses regulated under the plan are implemented. For this reason, project-related monitoring of the impacts of offshore wind farms, pipelines and the extraction of raw materials is of particular importance. The main task of monitoring is to bring together and evaluate the findings of the various monitoring results at project level. In addition, existing national and international monitoring programmes must be taken into account, also to avoid duplication of work.

The investigation of the potential environmental impacts of areas for wind energy production must be carried out at the downstream project level in accordance with Standard StUK4, *Untersuchung von Auswirkungen von Offshore-Windenergieanlagen* (Investigation of the impacts of offshore wind energy installations), and in coordination with the BSH.

With regard to the concrete measures for monitoring the potential impacts of wind energy use, including the effects of power cables, reference is made to the detailed explanations in the environmental report on the 2019 SDP and draft 2020 SDP.

For the approval of areas for sand and gravel extraction, for example, it must be demonstrated by suitable monitoring before the next main operating plan approval that the maximum permitted extraction depth is not exceeded, the original substrate is preserved and sufficient areas that have not been extracted remain to ensure that the potential for re-colonisation is given.

For submarine pipelines and power cables, monitoring measures during the construction phase include the documentation of turbidity plumes, hydrophone measurements and the recording of marine mammals and sea and resting birds. The main monitoring measures during the operating phase of pipelines and power cables include annual documentation of the positional stability of the pipeline and power cables and their coverage heights, as well as annual documentation of epifauna on the overlying pipeline/power cable for a period of five years after commissioning.

The BSH is carrying out a whole series of projects as part of the accompanying research into the possible effects of offshore wind turbines on the marine environment. These include the ANKER project "Approaches to cost reduction in the collection of monitoring data for offshore wind farms", the R&D study BeMo "Evaluation approaches for underwater noise monitoring in connection with offshore licensing procedures, regional planning and MSRL" and various subprojects within the R&D network NavES "Nature-compatible developments at sea". The results of the BSH's current projects will be directly incorporated into the further development of standards and norms, such as the development of Standard StUK5.

The pooling of information creates an increasingly solid basis for impact forecasting. The research projects serve the continuous further development of a uniform, quality-assured basis of marine environmental information for the assessment of possible impacts of offshore installations and form an important basis for updating the Spatial Plan.

11.9 Evaluation of the overall plan

In summary, with regard to the provisions of the Spatial Plan, the aim is to minimise the impacts on the marine environment as far as possible through orderly, coordinated overall planning. Ensuring that the nature conservation areas defined by Regulations are designated as priority nature conservation areas serves to safeguard the protection purposes and to secure open spaces. The areas reserved for pipelines and power cables run mainly outside ecologically significant areas. If avoidance and mitigation measures are strictly adhered to, significant impacts can be avoided, particularly by implementing the provisions for offshore wind energy installations, pipelines and power lines.

On the basis of the above descriptions and assessments as well as the species and area protection law examination, the Strategic Environmental Assessment (SEA) concludes, also with regard to possible interactions, that according to the current state of knowledge and at the comparatively abstract level of regional planning, no significant impacts on the marine environment within the area under investigation are to be expected from the planned specifications.

Most of the environmental impacts of the individual uses for which specifications are made would also occur – based on the same medium-term time horizon – if the plan were not implemented, as it is not apparent that the uses would not take place or would take place to a significantly lesser extent if the plan were not implemented. From this point of view, the provisions of the plan appear in principle "neutral" in terms of their environmental impact. Although it is in principle possible that, due to the concentration/bundling of individual uses in certain areas/regions, some of the plan provisions in the region of this specific area may well have negative environmental impacts, an overall balance of the environmental impacts would tend to be positive due to the bundling effects, since the burden on the remaining areas/regions would be lessened and hazards to the marine environment (e.g. the risk of collision) reduced.

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