BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

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

– unofficial translation –

2 June 2021

Content

List of figures

List of tables

List of abbreviations

AC	Alternating Current
AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
AIS	Automatic identification system (for ships)
ASCOBANS	Agreement on the conservation of small cetaceans in the North and Baltic Seas
BBergG	Federal Mining Act
BfN	Federal Agency for Nature Conservation
BGBl	Federal Law Gazette
Birds-D	Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (Birds Directive)
BMI	Federal Ministry of the Interior, Building and Community
BMUB	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMVI	Federal Ministry of Transport and Digital Infrastructure
BNatSchG	Federal Nature Conservation Act (Bundesnaturschutzgesetz)
BNetzA	Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway
BSH	Federal Maritime and Hydrographic Agency
BWO	German Offshore Wind Energy Association
CMS	Convention on the Conservation of Migratory Species of Wild Animals
dB	Decibel
DC	Direct Current
DDT	Dichlorodiphenyltrichloroethane
EEZ	Exclusive economic zone
EIA	Environmental impact assessment
EIS	Environmental impact study
EMEP	European Monitoring and Evaluation Programme
EMSON	Survey of marine mammals and seabirds in the German EEZ of the North Sea and Baltic Sea
ERASNO	Survey of resting birds in the German EEZ of the North Sea and Baltic Sea
EUNIS	European Nature Information System
EUROBATS	Agreement on the conservation of European bat populations
R&D	Research and development
FEP	Site development plan
FFH	Flora Fauna Habitat
FFH-D	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitats Directive)
GW	Gigawatt
HOLAS	Holistic Assessment of the Ecosystem Health of the Baltic Sea
HELCOM	Helsinki Convention
HCB	Hexachlorobenzene
Hz	Hertz
IBA	Important bird area
ICES	International Council for the Exploration of the Sea
IfAÖ	Institute for Applied Ecosystem Research

IMO	International Maritime Organization
IOW	Leibniz Institute for Baltic Sea Research Warnemünde
IUCN	International Union for Conservation of Nature and Natural Resources (World Conservation Union)
IWC	International Whaling Commission
JOMOPANS	Joint Monitoring and Assessment Programme for the North Sea
K	Kelvin
kHz	Kilo Hertz
LBEG	State Office for Mining, Energy and Geology
AI	Confidence interval
kn	Knot
M	Meter
MARPOL	International Convention for the Prevention of Pollution from Ships
MINOS	Marine warm-blooded animals in the North Sea and Baltic Sea: basics for the assessment of wind turbines in the offshore area
MSFD	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)
MSP	Maritime Spatial Plan
MW	Megawatt
NAO	North Atlantic Oscillation
NN	Normal zero
OSPAR	Oslo-Paris Agreement
OWP	Offshore wind farm
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
POD	Porpoise Click Detector
PSU	Practical Salinity Units
ROG	Federal Spatial Planning Act
RL	Red List
SAMBAH	Static Acoustic Monitoring of the Baltic Sea Harbour porpoise
SCI	Site of Community Importance
SEA	Strategic Environmental Assessment
SECA	Sulphur Emission Control Area
SeeAnlV	Ordinance on Installations Seaward of the Boundary of the German Territorial Sea (Marine 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 impacts of offshore wind turbines".
StUKplus	"Accompanying ecological research on the alpha ventus offshore test field project".
SEA	Strategic environmental assessment

SEA-D	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)
SEL	Sound Event Level
SPA	Special Protection Areas
TOC	Total Organic Carbon (total organic carbon)
UBA	Federal Environment Agency
UNCLOS	United Nations Convention on the Law of the Sea
UVPG	Federal Environmental Impact Assessment Act
VTG	Trafic Seperation Scheme
VwVfG	Federal Administrative Procedure Act
TSO	Transmission system operator
WFD	Water framework Directive
WHG	Water Resources Act
WEA	Wind turbine
WindSeeG	Act on the Development and Promotion of Wind Energy at Sea (Wind Energy at Sea Act - WindSeeG)

1 Introduction

1.1 Legal basis 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 Spatial Planning Act (ROG)[1]. Pursuant to sec. 17 para. 1 ROG, the competent Federal Ministry, the Federal Ministry of the Interior, for Building and the Home Affairs (BMI), draws up a spatial plan for the German EEZ as a statutory instrument in agreement with the Federal Ministries concerned. Pursuant to sec. 17 para. 1 sentence 3 of the ROG, the BSH, with the approval of the BMI, carries out the preparatory procedural steps for the preparation of the maritime spatial plan. During the preparation of the MSP, an environmental assessment is carried out in accordance with the provisions of the ROG and, where applicable, those of the Environmental Impact Assessment Act (UVPG)[2], the so-called Strategic Environmental Assessment (SEA).

The obligation to conduct a strategic environmental assessment, including the preparation of an environmental report, arises for the updating, amendment and repeal of the existing maritime spatial plans from 2009 from sec. 7 para. 7, 8 ROG in conjunction with sec. 35 para. 1 no. 1 ROG in conjunction with sec. 35 para. 1 no. 1 ROG. Sec. 35 para. 1 no. 1 UVPG in conjunction with No. 1.6 of Annex 5. No. 1.6 of Annex 5.

According to Art. 1 of the SEA Directive 2001/42/EC, the objective of the Strategic Environmental Assessment is to ensure a high level of environmental protection in order to promote sustainable development and to help ensure that environmental considerations are adequately taken into account in the preparation and adoption of plans well before the actual planning of the project. Pursuant to sec. 8 ROG, the Strategic Environmental Assessment has the task of identifying the likely significant effects of implementing the plan and describing and assessing them in an environmental report at an early stage. It serves to ensure effective environmental precaution in accordance with the applicable laws and is carried out according to uniform principles and with public participation. All objects of protection pursuant to sec. 8 para. 1 ROG are to be considered:

- people, including human health,
- animals, plants and biodiversity,
- land, soil, water, air, climate and landscape,
- Cultural assets and other material assets as well as
- the interactions between the aforementioned protected interests.

Within the framework of spatial planning, designations are mainly made in the form of priority and reservation areas as well as other objectives and principles.

The requirements and content of the environmental report to be prepared are set out in Annex 1 to sec. 8 para. 1 ROG.

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

According to No. 2d) of Annex 1 to sec. 8 ROG, other planning options that expressly come into consideration should also be named, taking into

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

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

account the objectives and the spatial scope of the MSP.

1.2 Brief description of the content and the most important objectives of the maritime spatial plan

According to sec. 17 para. 1 ROG, the maritime spatial plan for the German EEZ shall, taking into account any interactions between land and sea and taking into account safety aspects, determine

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

Pursuant to sec. 7 para. 1 of the ROG, spatial plans must define **objectives and principles of** spatial planning for the development, organisation and protection of the area, in particular the uses and functions of the area, for a specific planning area and for a regular medium-term period.

Pursuant to sec. 7 para. 3 ROG, these designations may also designate areas. For the EEZ, these may be the following areas:

Priority areas designated for specific spatially significant functions or uses and excluding other spatially significant functions or uses in that area to the extent that they 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 where certain spatially significant functions or uses do not conflict with other spatially significant concerns, where such 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 pursuant to sec. 7 para. 3 sentence 2 no. 4 ROG.

Pursuant to sec. 7 para. 4 ROG, the spatial plans shall also contain those designations on spatially significant plans and measures by public bodies and persons under private law pursuant to sect. 4 para. 1 sentence 2 ROG which are suitable for inclusion in spatial plans and necessary for the coordination of spatial claims and which can be secured by spatial development objectives or principles.

1.3 Relationship with other relevant plans, programmes and projects

In Germany, in order to coordinate all spatial demands and concerns arising in a space, there is a tiered planning system of spatial planning through federal spatial planning as well as state and regional planning, with which, according to sec. 1 para. 1 sentence 2 ROG,**{** XE "ROG" \t "*Raumordnungsgesetz*" **}** different demands on the space are coordinated with each other in order to balance out conflicts arising at the respective planning level and to make provisions for individual uses and functions of the space.

Through the tiered system, the plans are further specified by the subsequent planning levels. According to sec. 1 para. 3 ROG, the development, organisation and safeguarding of the sub-areas should fit 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 sub-areas.

The Federal Ministry of the Interior, Building and Community (BMI**{** XE "BMI" \t "*Bundesministerium des Inneren, für Bau und*

Heimat" **}**) is responsible for spatial planning at federal level in the EEZ. On the other hand, the respective federal state is responsible for regional planning for the entire area of the country, including the respective territorial sea.

In addition to spatial planning for the respective areas of responsibility, sectoral plans exist on the basis of 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 sense of coherent planning, coordination processes with the plans of the coastal federal states and neighbouring states are indicated and must be taken into account in the cumulative assessment of impacts on the marine environment. Currently, the state spatial planning for Schleswig-Holstein is being updated. Regional spatial planning programmes of the coastal regions are taken into account insofar as significant designations for the coastal sea are made.

1.3.1.1 Schleswig-Holstein

In Schleswig-Holstein, the State Development Plan (LEP S-H **{** XE "LEP S-H" \t "*Landesentwicklungsplan Schleswig-Holstein*" **}**) is the basis for the spatial development of the Land. The Ministry of the Interior, Rural Areas, Integration and Equality of Schleswig-Holstein (MILIG) is responsible for its preparation and amendment. The current LEP S-H 2010 is the basis for the spatial development of the Land until 2025. The Land of Schleswig-Holstein has initiated the procedure for an update of the LEP S-H 2010 and conducted a participation procedure in 2019.

1.3.1.2 Mecklenburg-Western Pomerania

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

The current spatial development programme for Mecklenburg-Western Pomerania (LEP M-V**{** XE "LEP M-V" \t "*Landesraumentwicklungsprogramm Mecklenburg-Vorpommern*" **}**) 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 overall spatial plan for the North Sea and the Baltic Sea, which will be binding and cover a timeframe until 2050.

1.3.1.4 Sweden

Sweden is in the final phase of the 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 have more of a management character and are not binding.

1.3.1.5 Poland

In Poland, the first maritime spatial plan is currently being prepared and is also in the 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. Essential to this is the establishment of a programme of measures to achieve or maintain good environmental status and the practical implementation of this programme of measures. The establishment of the programme of measures (BMUB, 2016) is regulated in Germany by sec. 45h of the Federal Water Act (WHG). Under Objective 2.4 "Seas with sustainably and sparingly used resources", the current

MSFD Programme of Measures lists maritime spatial planning as a contribution of existing measures to achieving the operational objectives of the MSFD. The catalogue of measures also formulates a concrete review mandate for the updating of maritime 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 the EEZ nature conservation areas

In September 2017, the ordinances on the designation of the nature conservation areas "Fehmarnbelt" (NSGFmbV), "Kadetrinne" (NSGKdrV) and "Pommersche Bucht - Rönnebank" (NSGPBRV) came into force. According to the ordinances, the measures necessary to achieve the conservation purposes 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 Länder and the public agencies concerned, and with the participation of the interested public and the nature conservation associations recognised by the federal government.

On 16.06.2020, the BfN initiated the participation procedure pursuant to sec. 7 para. 3 NSGFmbV, sec. 7 para. 3 NSGKdrV and sec. 11 para. 3 NSGPBRV for the management plans for the nature conservation areas in the German EEZ of the Baltic Sea. As part of the participation procedure, a hearing on the drafts took place on 17.08.2020.

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

For the area of the German EEZ, a multi-stage planning and approval process - i.e. a subdivision into several stages - is envisaged for some uses, such as offshore wind energy and power cables. In this context, the instrument of maritime spatial planning is at the highest and superordinate level. The maritime spatial plan is the forward-looking planning instrument that coordinates a wide variety of utilisation interests in the fields of business, science and research as well as protection claims. A Strategic Environmental Assessment must be carried out when the maritime spatial plan is drawn up. The SEA for the MSP is related to various downstream environmental assessments, in particular the directly downstream SEA for the site development plan (FEP).

The next step is the FEP. Within the framework of the so-called central model, the FEP is the steering instrument for the orderly expansion of offshore wind energy and the electricity grids in a staged planning process. The FEP 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 spatial planning - by defining areas and sites as well as locations, routes and route corridors for grid connections and for cross-border submarine cable systems. The preparation, updating and amendment of the FEP is always accompanied by a strategic environmental assessment.

In the next step, the areas for offshore wind turbines identified in the FEP are pre-surveyed. The preliminary investigation is followed by a determination of the suitability of the area for the construction and operation of offshore wind turbines if the requirements of sec. 12 para. 2 WindSeeG are met. The preliminary investigation is also accompanied by a strategic environmental assessment.

If the suitability of an area for the use of offshore wind energy is determined, the area is put out to tender and the winning bidder or the person entitled to do so can submit an application for approval (planning approval or planning permission) for the construction and operation of wind turbines on the area specified in the FEP. Within the framework of the planning approval procedure, an environmental impact assessment is carried out if the requirements are met.

While the areas defined in the FEP for the use of offshore wind energy are pre-surveyed and put out to tender, this is not the case for defined sites, routes and route corridors for grid connections or cross-border submarine cable systems. Upon application, a planning approval procedure including environmental assessment is usually carried out for the construction and operation of grid connection lines. The same applies to cross-border submarine cable systems.

Pursuant to sec. 1 para. 4 UVPG, the UVPG also applies where federal or Land legislation does not specify the environmental impact assessment in more detail or does not observe the essential requirements of the UVPG.

Figure 1: Overview of the staged planning and approval process in the EEZ.

In the case of multi-stage planning and approval processes, the relevant sectoral legislation (e.g. Regional Planning Act, WindSeeG and BBergG) or, more generally, sec. 39 para. 3 of the Environmental Impact Assessment Act (UVPG) stipulates that, in the case of plans, it should be determined at the time of defining the scope of the assessment at which of the stages of the process certain environmental impacts are to be assessed. In this way, multiple assessments are to be avoided. The nature and extent of the environmental effects, technical requirements and the content and subject matter of the plan must be taken into account.

In the case of subsequent plans and in the case of subsequent approvals of projects for which the plan sets a framework, the environmental assessment pursuant to sec. 39 para. 3 sentence

3 UVPG shall be limited to additional or other significant environmental effects and to necessary updates and deepening.

Within the framework of the staged planning and approval process, all assessments have in common that environmental impacts on the protected interests specified in sec. 8 para. 1 ROG or sec. 2 para. 1 UVGP, including their interactions, are considered.

According to the definition in sec. 2 para. 2 UVPG, environmental effects within the meaning of the UVPG are direct and indirect effects of a project or the implementation of a plan or programme on the objects of protection.

According to sec. 3 UVPG, environmental assessments comprise the identification, description and evaluation of the significant effects of a project or a plan or programme on the objects of protection. They serve to ensure effective environmental precautions in accordance with the applicable laws and are carried out according to uniform principles and with public participation.

In the offshore area, the special conservation areas of avifauna: seabirds/resting birds and migratory birds, benthos, biotope types, plankton, marine mammals, fish and bats have established themselves as subcategories of the legally named conservation areas of animals, plants and biological diversity.

Figure 2: Overview of the protected goods in the environmental assessments.

In detail, the staged planning process is as follows:

1.3.4.1 Maritime Spatial Planning (EEZ)

At the highest and superordinate level is the instrument of maritime spatial planning. For sustainable spatial development in the EEZ, the BSH prepares a spatial planning plan on behalf of the responsible federal ministry, which comes into force in the form of legal ordinances.

The spatial plans shall, taking into account any interactions between land and sea as well as safety aspects, determine

- to ensure the safety and ease of shipping traffic,
- to other economic uses,
- on scientific uses and
- to protect and enhance the marine environment.

Within the framework of spatial planning, designations are predominantly made in the form of priority and reservation areas as well as other objectives and principles. Pursuant to sec. 8 para. 1 ROG, a strategic environmental assessment must be carried out by the body responsible for the maritime spatial plan when drawing up spatial plans, in which the likely significant effects of the respective spatial plan on the protected assets, including interactions, are to be identified, described and assessed.

The **aim of** the spatial planning instrument is to optimise overall planning solutions. A wider spectrum of uses and functions is considered. At the beginning of a planning process, strategic fundamental questions are to be clarified. Thus, the instrument functions primarily and within the framework of the legal provisions as a steering planning instrument of the planning administrative bodies in order to create a spatially and, if possible, environmentally compatible framework for all uses.

The **depth of assessment in** spatial planning is fundamentally characterised by a greater breadth of investigation, i.e. a fundamentally greater number of planning options, and a lesser depth of investigation in the sense of detailed analyses. Above all, regional, national and global impacts as well as secondary, cumulative and synergetic impacts 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

At the next level is the FEP.

The **designations** to be made by the FEP and to be examined within the framework of the SEA are derived from sec. 5 para. 1 WindSeeG. The plan mainly specifies areas and sites for wind turbines and the expected capacity to be installed on the sites. In addition, the FEP specifies routes, route corridors and locations. Furthermore, planning and technical principles are laid down. Although these also serve to reduce environmental impacts, they can also lead to impacts, so that an assessment is required as part of the SEA.

With regard to the **objectives of** the FEP, 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 regard to the need, purpose, technology and the identification of sites and routes or route corridors. The plan therefore primarily has the function of a steering planning instrument to create a spatially and as far as possible environmentally compatible framework for the realisation of individual projects, i.e. the construction and operation of offshore wind turbines, their grid connections, cross-border submarine cable systems and interconnections.

The **depth of the assessment of** likely significant environmental impacts is characterised by a greater breadth of investigation, i.e. a greater number of alternatives and, in principle, a lesser depth of investigation. As a rule, no detailed analyses are carried out at the level of sectoral planning. Above all, local, national and global impacts as well as secondary, cumulative and synergetic impacts are taken into account in the sense of an overall assessment.

As with the instrument of maritime spatial planning, the **focus of the** assessment is on possible cumulative effects and possible cross-border impacts. In addition, the strategic, technical and spatial alternatives for the use of wind energy and power lines are a focus of the FEP.

1.3.4.3 Suitability test within the scope of the preliminary investigation

The next step in the staged planning process is the suitability assessment of areas for offshore wind turbines.

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

Pursuant to sec. 10 para. 2 of the WindSeeG, the suitability test shall examine whether the construction and operation of offshore wind energy turbines on the site do not conflict with the criteria for the inadmissibility of the designation of a site in the site development plan pursuant to sec. 5 para. 3 of the WindSeeG or, insofar as they can be assessed independently of the subsequent design of the project, with the concerns relevant to the planning approval pursuant to sec. 48 para. 4 sentence 1 of the WindSeeG.

Both the criteria of sec. 5 para. 3 WindSeeG and the concerns of sec. 48 para. 4 sentence 1 WindSeeG require an assessment of whether the marine environment is endangered. With regard to the latter concerns, it must be checked in particular whether pollution of the marine environment within the meaning of sec. 1 para. 1 no. 4 of the United Nations Convention on the Law of the Sea is not to be feared and bird migration is not endangered.

The preliminary investigation with the suitability test or determination is thus the instrument between the FEP and the individual approval procedure for offshore wind turbines. It relates to a specific area designated in the FEP and is therefore much more detailed than the FEP. It is distinguished from the planning approval procedure by the fact that a test approach is to be applied that is independent of the subsequent concrete turbine type and layout. The impact forecast is based on model parameters, for example in two scenarios or ranges, which are intended to represent possible realistic developments.

Compared to the FEP, the SEA of the suitability assessment is thus characterised by a smaller investigation 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 an area on the one hand and the determination of its (possibly also partial) unsuitability (see sec. 12 para. 6 WindSeeG) on the other. Restrictions on the type and extent of development, which are included in the determination of suitability, are not alternatives in this sense.

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

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

The next stage after the preliminary investigation is the approval procedure for the construction and operation of offshore wind turbines. After the pre-investigation area has been put out to tender by the BNetzA, the winning bidder can submit an application for planning approval or - if the requirements are met - for planning permission for the construction and operation of offshore wind turbines, including the necessary ancillary facilities, on the pre-investigated area to the BNetzA in accordance with sec. 46 para. 1 of the WindSeeG.

In addition to the legal requirements of sec. 73 para. 1 sentence 2 VwVfG, the plan must include the information contained in sec. 47 para. 1 WindSeeG. The plan may only be adopted under certain conditions listed in sec. 48 para. 4 of the WindSeeG and, inter alia, only if the marine environment is not endangered, in particular if there is no concern of pollution of the marine environment within the meaning of sec. 1 para. 1 No. 4 of the Convention on the Law of the Sea and bird migration is not endangered.

Pursuant to sec. 24 UVPG, the competent authority shall prepare a summary presentation

- the environmental impact of the project,
- the characteristics of the project and the site that are intended to exclude, mitigate or compensate for significant adverse environmental effects,
- the measures to exclude, reduce or compensate for significant adverse environmental effects, and
- of compensatory measures in the case of interventions in nature and landscape.

Pursuant to sec. 16 para. 1 UVPG, the developer shall submit a report to the competent authority on the likely environmental effects of the project (EIA report), which shall contain at least the following information:

- A description of the project including the location, nature, scope and design, size and other essential characteristics of the project,
- a description of the environment and its components in the area of impact of the project,
- a description of the characteristics of the project and the site which are intended to exclude, reduce or compensate for the occurrence of significant adverse environmental effects of the project,
- a description of the planned measures to exclude, reduce or compensate for the occurrence of significant adverse environmental effects of the project and a description of planned compensatory 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 an indication of the main reasons for the choice made, taking into account the environmental effects of each; and
- a generally understandable, non-technical summary of the EIA report.

Pilot wind turbines are dealt with exclusively within the framework of the environmental assessment in the approval procedure and not already at upstream stages.

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

In the staged planning process, the construction and operation of grid connections for offshore wind turbines (converter platform and submarine cable systems, if applicable) is examined at the level of approval procedures (plan approval and plan authorisation procedures) in implementation of the requirements of regional planning and the specifications of the FEP at the request of the respective developer - the responsible TSO.

Pursuant to sec. 44 para. 1 in conjunction with sec. 45 para. sec. 45 para. 1 WindSeeG, the construction and operation of facilities for the transmission of electricity require plan approval. In addition to the legal requirements of sec. 73 par. 1 sentence 2 VwVfG, the plan must include the information contained in sec. 47 para. 1

WindSeeG. The plan may only be approved under certain conditions listed in sec. 48 para. 4 WindSeeG and only if, inter alia, the marine environment is not endangered, in particular if there is no concern of pollution of the marine environment within the meaning of sec. 1 para. 1 No. 4 of the Convention on the Law of the Sea and bird migration is not endangered.

In all other respects, the requirements for the environmental impact assessment of offshore wind turbines, including ancillary installations, shall apply mutatis mutandis to the environmental assessment pursuant to sec. 1 para. 4 UVPG.

1.3.4.6 Cross-border submarine cable systems

Pursuant to sec. 133 para. 1 in conjunction with sec. 133 para. 4 BBergG, the construction and operation of a submarine cable in or on the continental shelf requires a permit.

- in mining terms (by the competent state mining office) and
- with regard to the ordering of the use and enjoyment of the waters above the continental shelf and of the airspace above these waters (by the BSH).

Pursuant to sec. 133 para. 2 BBergG, the above-mentioned permits may only be refused if there is a risk to the life or health of persons or to material goods or an impairment of overriding public interests which cannot be prevented or compensated for by a time limit, by conditions or obligations. An impairment of overriding public interests exists in particular in the cases mentioned in sec. 132 para. 2 no. 3 BBergG. Pursuant to sec. 132 para. 2 no. 3 (b) and (d) BBergG, an impairment of overriding public interests with regard to the marine environment exists in particular if the flora and fauna would be unacceptably impaired or if there is a risk of pollution of the sea.

According to sec. 1 para. 4 UVPG, the essential requirements of the UVPG must be observed for the construction and operation of transboundary submarine cable systems.

Tabular overview of environmental audits: Focus of the audits

Spatial planning SEA	FEP SEA	Preliminary investigation SUP suitability test	Admission procedure (planning approval or planning permission) Grid connections EA	Approval procedure Cross-border submarine cable systems EA
Strategic planning for the determinations	**Strategic planning for the determinations**	**Strategic Determination of suitability for areas with wind turbines**	**Environmental assessment Request for**	**Environmental assessment Request for**
Determinations and subject of the audit				
Priority and reservation areas • to ensure the safety and ease of shipping traffic, • to further economic uses. especially offshore wind energy and pipelines. • on scientific uses and Protection and enhancement of the marine environment Goals and principles Application of the ecosystem approach	• Areas for offshore wind turbines • Areas for offshore wind turbines, including the expected capacity to be installed. • Locations platforms • Routes and route corridors for submarine cable systems • Technical and planning principles	• Examination of the suitability of the area for the erection and operation of wind turbines, including the power to be installed. • On the basis of the ceded 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 connection lines • in accordance with the requirements of regional planning and the site development plan	• the construction and operation of cross-border submarine cable systems • according to the requirements of spatial 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 (identifies, describes and assesses) the likely significant environmental effects for the construction and operation of wind turbines, which can be assessed independently of the subsequent design of the project, using model assumptions	Analyses (identifies, describes and evaluates) the environmental impacts of the specific project (platform and connection line, if applicable).	Analyses (identifies, describes and evaluates) the environmental impacts of the specific project.
Destination				
Aims to optimise overall planning solutions, i.e. comprehensive bundles of measures. Consideration of a wider range of uses.	For the use of offshore wind energy, deals with the fundamental issues according to the • Need or legal objectives • Purpose • Technology • Capacities • Finding locations for platforms and routes.	For the use of wind turbines, deals with the fundamental questions according to • Capacity • Suitability of the area	Deals with questions about the concrete design ("how") of a project (technical equipment, construction - building permits). Assesses the environmental compatibility of the project and formulates conditions.	Deals with questions about the concrete design ("how") of a project (technical equipment, construction - building permits). Assesses the environmental impact

Starts at the beginning of the planning process to clarify basic strategic issues, i.e. at an early stage when there is still more room for manoeuvre.	Searches for environmentally sound bundles of measures without making an absolute assessment of the environmental compatibility of the planning.	Provides the information on the area regulated by law for the submission of tenders. Searches for environmentally sound bundles of measures without assessing the environmental compatibility of the specific project.		of the project and formulates conditions for this purpose.
Essentially functions as a steering planning instrument for the planning authorities to create an environmentally sound framework for all uses.	Functions predominantly as a steering planning instrument to create an environmentally sound framework for the realisation of individual projects (wind turbines and grid connections, cross-border submarine cables).	Acts as an instrument between the FEP and the approval procedure for wind turbines on a specific site.	Functions primarily as a passive testing instrument that, upon application of the developer.	Functions primarily as a passive review tool that responds to the developer's request.
Depth of inspection				
Characterised by greater breadth of investigation, i.e. a larger number of alternatives, and less depth of investigation (no detailed analyses). Considers spatial, national and global impacts as well as secondary, cumulative and synergistic impacts in the sense of an overall view.	Characterised by greater breadth of investigation, i.e. greater number of alternatives, and less depth of investigation (no detailed analyses). Considers local, national and global impacts as well as secondary, cumulative and synergistic impacts in terms of an overall view.	Characterised by a smaller study area, greater depth of investigation (detailed analyses). The suitability determination may include specifications for the subsequent project, in particular on the type and extent of development of the site and its location.	Characterised by narrower scope of investigation (limited number of alternatives) and greater depth of investigation (detailed analyses). Assesses the environmental compatibility of the project and formulates conditions. Primarily considers local impacts in the vicinity of the project.	Characterised by narrower scope of investigation (limited number of alternatives) and greater depth of investigation (detailed analyses). Primarily considers local impacts in the vicinity of the project.
Focus of the audit				
Cumulative effects Overall plan view Strategic and large-scale alternatives Possible cross-border effects	**Cumulative effects** Overall plan view Strategic, technical and spatial alternatives Possible cross-border effects	**Local impacts** related to the area and its location.	Plant, construction and operational environmental impacts Plant dismantling Testing in relation to the specific system design. Intervention, compensation and replacement measures.	Plant, construction and operational environmental impacts Testing in relation to the specific system design. Intervention, compensation and replacement measures.

Approval procedure (planning approval or planning permission) for wind turbines

MSRP

Subject of the audit

Environmental impact assessment on application for

- the construction and operation of wind turbines
- on the area defined and pre-surveyed in the FEP

- According to the determinations of the FEP and specifications of the preliminary investigation.

Environmental impact assessment

Analyses (identifies, describes and evaluates) the environmental impacts of the specific project (wind turbines, platforms if applicable, and cabling within the park).

Pursuant to sec. 24 UVPG, the competent authority shall prepare a summary presentation

- the environmental impact of the project,
- the characteristics of the project and the site that are intended to exclude, mitigate or compensate for **significant adverse environmental effects,**
- the measures to exclude, reduce or compensate for significant adverse environmental effects, and
- of compensatory measures in the case of interventions in nature and landscape (Note: Exception according to sec. 56 para. 3 BNatSchG

Destination

Deals with the questions of the concrete design ("how") of a project (technical equipment, construction).

Functions primarily as a passive review tool that responds to the request of the tender winner/project sponsor.

Depth of inspection

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

Assesses the environmental compatibility of the project on the pre-surveyed area and formulates conditions for this.

Considers mainly local impacts in the vicinity of the project.

Focus of the audit

The focus of the audit is on:

- Construction and operational environmental impacts.
- Testing in relation to the specific system design.
- Plant dismantling.

Figure 3: Overview of focal points in environmental assessments in planning and approval procedures.

1.3.5 Cables

At the upper level is the instrument of spatial planning. Within this framework, areas or corridors for pipelines and data cables are defined.

Pursuant to sec. 8 para. 1 ROG, the likely significant impacts of the determinations on pipelines on the objects of protection must be identified, described and assessed.

Pursuant to sec. 133 para. 1 i.V.m. para. 4 BBergG, the construction and operation of a transit pipeline or an underwater cable (data cable) in or on the continental shelf requires a permit.

- in mining terms (by the competent state mining office) and
- with regard to the ordering of the use and enjoyment of the waters above the continental shelf and of the airspace above these waters (by the BSH).

Pursuant to sec. 133 para. 2 BBergG, the above-mentioned permits may only be refused if there is a risk to the life or health of persons or to material goods or an impairment of overriding public interests which cannot be prevented or compensated for by a time limit, by conditions or obligations. An impairment of overriding public interests exists in particular in the cases mentioned in sec. 132 para. 2 no. 3 BBergG. Pursuant to sec. 132 para 2 no. 3 (b) and (d) BBergG, an impairment of overriding public interests with regard to the marine environment exists in particular if the flora and fauna would be unacceptably impaired or if there is a risk of pollution of the sea.

Pursuant to sec. 133 para. 2a BBergG, the construction and operation of a transit pipeline which is also a project within the meaning of sec. 1 para. 1 UVPG shall be subject to an environmental impact assessment in the licensing procedure with regard to the ordering of the use and enjoyment of the waters above the continental shelf and the airspace above these waters in accordance with the UVPG.

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

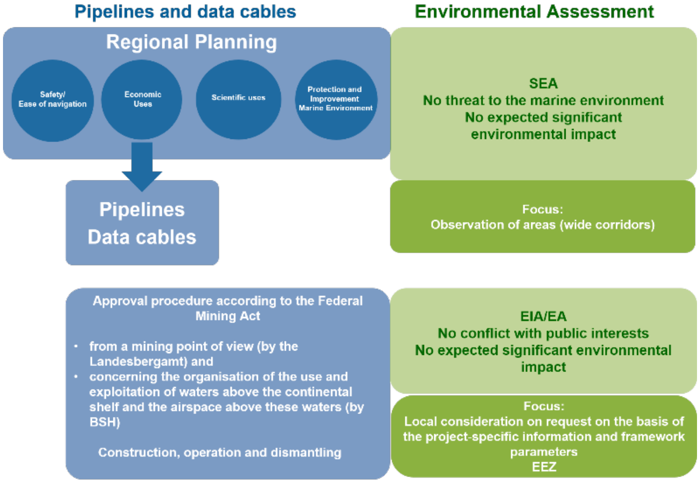

Figure 4: Overview of the focal points of the environmental assessment for pipelines and data cables.

1.3.6 Raw material extraction

In the German North Sea and Baltic Sea, various mineral resources are explored and extracted, e.g. sand, gravel and hydrocarbons. As a superordinate instrument, spatial planning deals with possible large-scale spatial designations, if necessary including other uses. The likely significant environmental impacts are assessed (cf. also Chapter 1.5.4.3).

Raw material extraction is regularly divided into different phases during implementation - exploration, development, operation and aftercare phases.

Exploration serves the exploration of raw material deposits according to sec. 4 para. 1 BBergG. In the marine area, it is carried out regularly by means of geophysical surveys, including seismic surveys and exploratory drilling. In the EEZ, the extraction of raw materials includes the extraction (dissolving, releasing), processing, storage and transport of raw materials.

For exploration in the area of the continental shelf, mining permits (permission, authorisation) must be obtained in accordance with the Federal Mining Act. 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. sec. 51 BBergG). For the establishment and management of an operation, main operating plans must be drawn up for a period not exceeding 2 years as a rule, and must be continuously renewed as required (sec. 52 para. 1 sentence 1 BBergG).

In the case of mining projects that require an EIA, the preparation of an outline operating plan is obligatory, for the approval of which a plan approval procedure must be carried out (sec. 52 para. 2a BBergG). As a rule, general operating plans are valid for a period of 10 to 30 years.

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

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

1.3.7 Shipping

In the context of spatial planning, the shipping sector is regularly defined in the form of areas (priority and/or reservation areas), objectives and principles. A staged planning and approval process, as is the case for the offshore wind energy sector, grid connections, cross-border submarine cables, pipelines and data cables, does not exist for the shipping sector.

With regard to the consideration of the likely significant impacts of the provisions 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 concerns within the framework of spatial planning. There is no staged 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 science

Marine scientific research is considered a concern in the context of spatial planning. A staged planning and approval process does not exist.

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. A staged planning and approval process does not exist.

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 time is also considered. There is no staged 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 the goals of environmental protection

The preparation of the MSP and the implementation of the SEA take into account environmental protection objectives. These provide information on the environmental status to be aimed for in the future (environmental quality objectives). The environmental protection objectives can be derived from an overall view of the international, EU and national conventions and regulations that deal with marine environmental protection and 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 will be checked and what stipulations or measures will be taken.

1.4.1 International conventions on marine environmental protection

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 serve the protection of the marine environment in whole or in part

- Convention for the Prevention of Pollution from Ships, 1973, as amended by the Protocol of 1978 (MARPOL 73/78).
- 1982 United Nations Convention on the Law of the Sea
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London, 1972) and the 1996 Protocol

1.4.1.2 Regional agreements on marine environmental protection

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

1.4.1.3 Agreements specific to protected goods

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

Within the framework of the Bonn Convention, regional agreements on the conservation of the species listed in Appendix II were concluded in accordance with Art. 4 No. 3 Bonn Convention:

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

1.4.2 Environmental and nature conservation requirements at EU level

The relevant EU legislation to be taken into account is:

- 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, Birds Directive).

1.4.3 Environmental and nature conservation requirements at national level

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

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

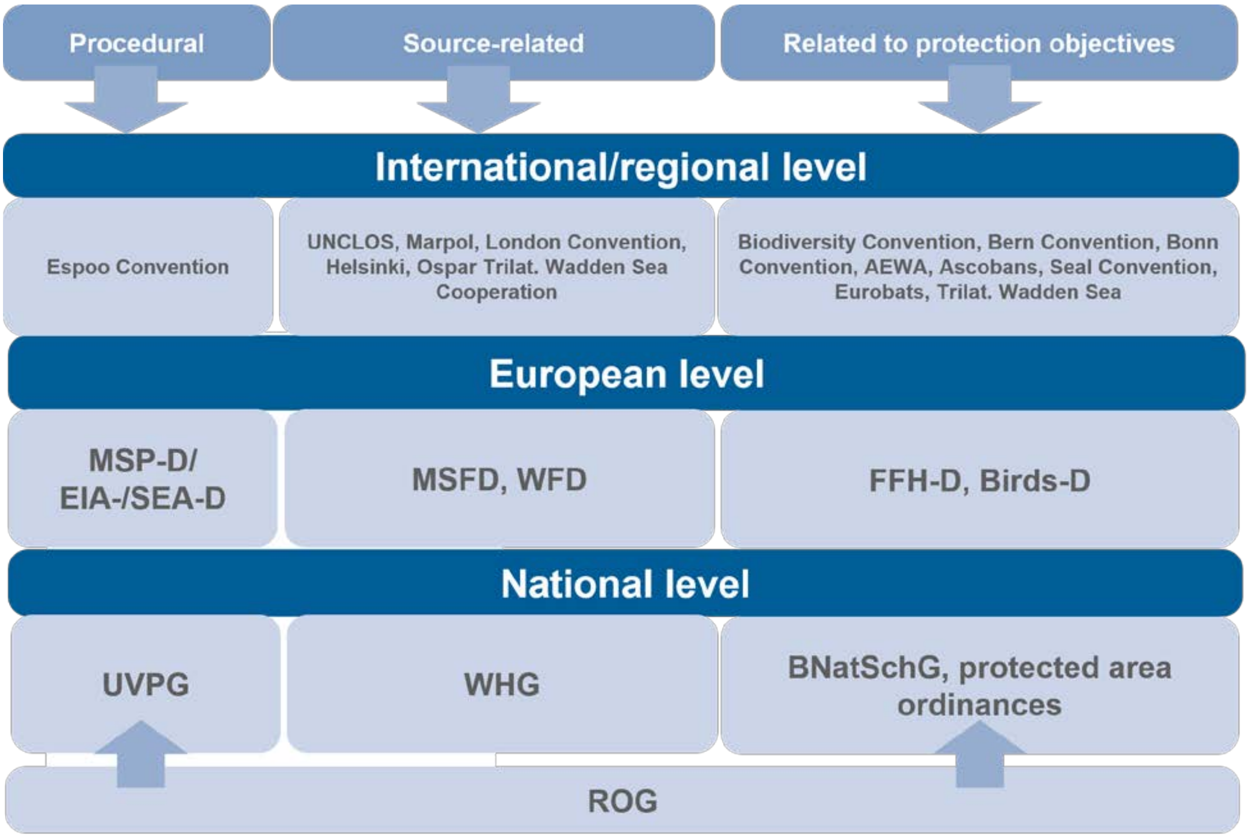

Figure 5: Overview of the norm levels of the relevant legal acts for SEA.

1.4.4 Supporting the objectives of the Marine Strategy Framework Directive

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

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

- Environmental Objective 1: Seas free from degradation caused by anthropogenic eutrophication: Consideration in the objectives and principles to ensure the safety and ease of navigation.
- Environmental Goal 3: Seas not impaired by the impacts of human activities on marine species and habitats: Consideration in the objectives and principles on offshore wind energy and nature conservation
- Environmental Goal 6: Seas free from degradation by anthropogenic energy inputs: Consideration in the objectives and principles on offshore wind energy and power lines

The environmental assessment formulates avoidance and mitigation measures that support Objectives 1, 3 and 6.

In addition, the maritime spatial plan counteracts a deterioration of the environmental status by allowing certain uses only in spatially delimited areas and limited in time. The principles of environmental protection must be taken into account. At the licensing level, the design of the use is specified with conditions, if necessary, in order to avert negative impacts on the marine environment.

An essential basis of the MSFD is the ecosystem approach regulated in sec. 1 para. 3 MSFD, which ensures the sustainable use of marine ecosystems by managing the overall impact of human activities in a way that is compatible with the achievement of good environmental status. The application of the ecosystem approach is described in Chapter 4.3.

1.5 Methodology of the Strategic Environmental Assessment

In principle, various methodological approaches can be considered when carrying out the strategic environmental assessment. This environmental report builds on the methodology already used for the strategic environmental assessment of the sectoral federal plans and the site development plan with regard to the use of offshore wind energy and electricity grid connections.

For all other uses for which designations are made in the MSP, such as shipping, raw material extraction and marine research, sector-specific criteria are used as the basis for an assessment of possible impacts.

The methodology depends primarily on the provisions of the plan to be assessed. Within the framework of this SEA, it is determined, described and assessed for the individual designations whether the designations are likely to have significant effects on the objects of protection concerned. According to sec. 1 para. 4 UVPG in conjunction with sec. 40 para. 3 UVPG. Sec. 40 para. 3 UVPG, the competent authority shall provisionally assess the environmental effects of the designations in the environmental report with a view to effective environmental precaution in accordance with the applicable legislation. Criteria for the assessment can be found, inter alia, in Annex 2 of the Spatial Planning Act.

The subject of the environmental report is the description and assessment of the likely significant impacts of the implementation of the MSP on the marine environment for designations on the use and protection of the EEZ. The assessment is carried out in relation to the respective protected goods.

Pursuant to sec. 7 para. 1 ROG, spatial plans must define spatial development objectives and principles for the development, organisation and safeguarding of space, in particular for the uses and functions of space. According to sec. 7 para. 3 ROG, these designations may also designate areas.

The following uses are the subject of the environmental report, in particular:

- Shipping
- Wind energy at sea
- Lines
- Raw material extraction
- Fisheries and marine aquaculture
- Marine research

Pursuant to sec. 17 para. 1 No.4 ROG, designations for the protection and improvement of the marine environment (nature conservation / seascape / open space) also play a role.

1.5.1 Study area

Two separate environmental reports are prepared for the North Sea EEZ and the Baltic Sea EEZ. The description and assessment of the environmental status in this environmental report refers to the Baltic Sea EEZ, for which the maritime spatial plan makes designations. The SEA study area covers the German EEZ (Figure 6).

The adjacent territorial sea and the adjacent areas of the riparian states are not the subject of this plan, but they will be considered as part of the cumulative and transboundary consideration - and where necessary - in the impact assessment as part of this SEA.

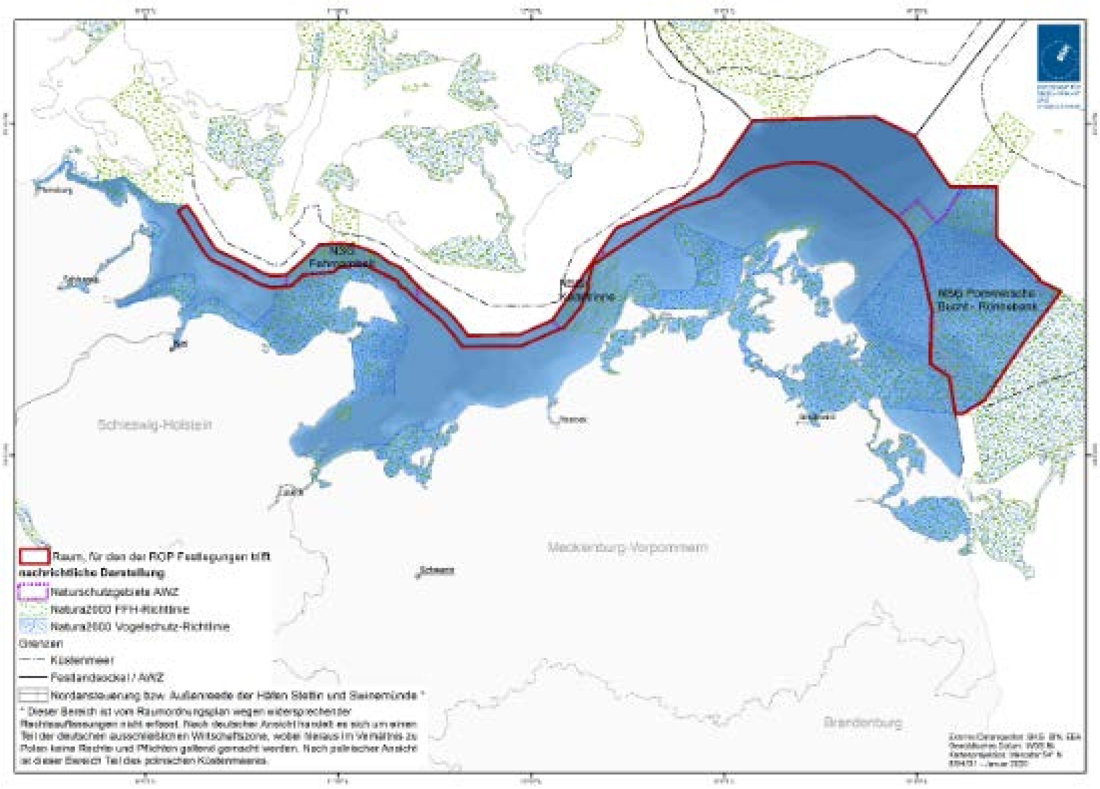

Figure 6: Delimitation of the study area for the SEA Baltic Sea EEZ.

1.5.2 Implementation of the environmental assessment

The assessment of the likely significant environmental effects of the implementation of the maritime spatial plan includes secondary, cumulative, synergetic, short-, medium- and long-term, permanent and temporary, positive and negative effects in relation to the protected assets. Secondary or indirect effects are those that do not take effect immediately and thus possibly only after some time and/or at other locations. Occasionally, we also speak of consequential effects or interactions.

Possible impacts of plan implementation are described and assessed in relation to the protected goods. A uniform definition of the term "significance" does not exist, since it is a matter of "individually determined significance in each case", which cannot be considered independently of the "specific characteristics of plans or programmes" (SOMMER, 2005, 25f.). In general, significant impacts can be understood as those effects that are severe and significant in the context under consideration.

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

- "the likelihood, duration, frequency and irreversibility of the effects;
- the cumulative nature of the effects;
- the transboundary nature of the impacts;
- the risks to human health or the environment (e.g. in the event of accidents);
- the scale and spatial extent of the impact;
- the importance and sensitivity of the area likely to be affected due to its special natural features or cultural heritage, the exceeding of environmental quality standards or limit values, and intensive land use;
- the impact on sites or landscapes whose status is recognised as nationally, community or internationally protected".

Furthermore, the characteristics of the plan are also relevant, in particular with regard to

- 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 in integrating environmental considerations, particularly 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 concerning waste management or water protection) (Annex II SEA Directive).

In some cases, further specifications on when an impact reaches the materiality threshold are derived from sectoral legislation. Thresholds have been developed in sub-legislation in order to be able to make a distinction.

The description and assessment of the potential environmental impacts is carried out for the individual spatial and textual designations on the use and protection of the EEZ in relation to the protected goods, taking into account the status assessment.

Furthermore, where necessary, a differentiation is made according to different technical designs. The description and assessment of the likely significant effects of the implementation of the plan on the marine environment also refer to the protected interests presented. All plan contents that can 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 interactions, a consideration of possible cumulative effects and potential transboundary impacts.

The following objects of protection are considered with regard to the assessment of the state of the environment

- Area
- Floor
- Water
- Plankton
- Biotope types
- Benthos
- Fish
- Marine mammals
- Avifauna
- Bats
- Biodiversity
- Air
- Climate
- Landscape
- Cultural assets and other material assets
- People, especially human health
- Interactions

In general, the following methodological approaches find their way into the environmental assessment:

- Qualitative descriptions and evaluations
- Quantitative descriptions and evaluations
- Evaluation of studies and specialist literature, expert opinions
- Visualisations
- Worst-case assumptions
- Trend assessments (e.g. on the state of the art of installations and the possible development of shipping traffic)
- Assessments by experts/ the professional public

An assessment of the impacts of the provisions of the plan is carried out on the basis of the status description and status assessment and the function and significance of the individual areas for the individual objects of protection on the one hand and the effects and resulting potential impacts of these provisions on the other. A forecast of the project-related impacts in the case of implementation of the MSP is made depending on the criteria of intensity, range and duration or frequency of the effects (cf. Figure 7). Further assessment criteria are the likelihood and reversibility of the effects as set out in Annex 2 to sec. 8 para. 2 of the ROG.

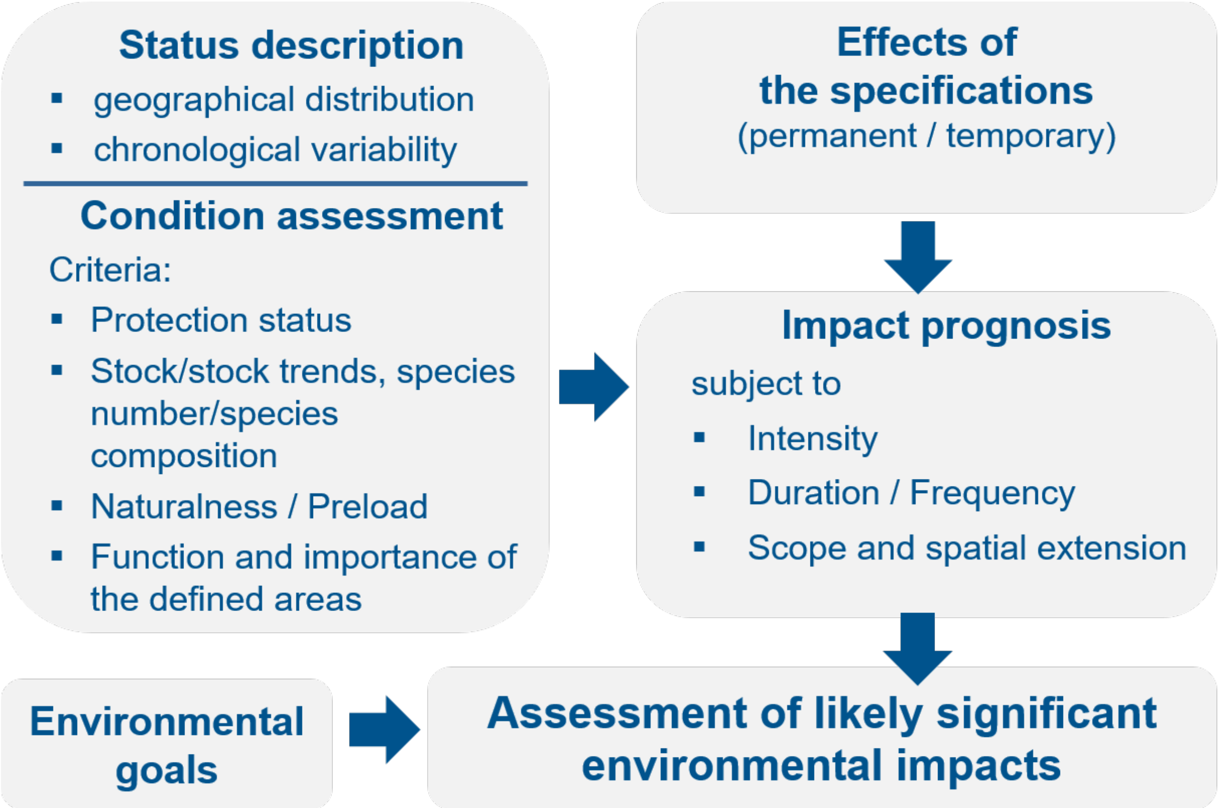

Figure 7: General methodology for the assessment of likely significant environmental effects.

1.5.3 Criteria for condition description and condition assessment

The assessment of the status of the individual protected assets is carried out on the basis of various criteria. For the protected assets surface/soil, benthos and fish, the assessment is based on the aspects of rarity and endangerment, diversity and specificity, and existing pressures. The description and assessment of the protected goods marine mammals and seabirds and resting birds is based on the aspects listed in the figure. As these are highly mobile species, an approach analogous to that for the protected goods surface/soil, benthos and fish is not expedient. For seabirds and resting birds and marine mammals, the criteria of protection status, assessment of occurrence, assessment of spatial units and existing pressures are used as a basis. For migratory birds, in addition to rarity and endangerment and existing pressures, the aspects of assessment of occurrence and large-scale importance of the area for bird migration are considered. For bats, there is currently no reliable data available for a criteria-based assessment. The biodiversity site is assessed textually.

The following is a list of the criteria used to assess the status of the respective protected assets. This overview deals with the protected assets that can be meaningfully delimited on the basis of criteria and are considered in the focus.

Surface/Floor

Aspect: Rarity and endangerment
Criterion: areal proportion of sediments on the seabed and distribution of the morphological form inventory.
Aspect: Diversity and Eigenart
Criterion: Heterogeneity of the sediments on the seabed and formation of the morphological form inventory.
Aspect: Existing pressure
Criterion: Extent of existing anthropogenic pressure of seabed sediments and morphological form inventory.

Benthos

Aspect: Rarity and endangerment
Criterion: Number of rare or endangered species based on the Red List species detected (Red List by RACHOR et al. 2013).
Aspect: Diversity and Eigenart
Criterion: Number of species and composition of species communities. The extent to which species or communities characteristic of the habitat occur and how regularly they occur is assessed.
Aspect: Existing pressure
For this criterion, the intensity of fishing use, which represents the most effective direct disturbance variable, is used as an assessment criterion. Furthermore, benthic communities can be impaired by eutrophication. For other disturbance variables, such as shipping traffic, pollutants, etc., suitable measurement and detection methods are still lacking in order to be able to include them in the assessment.

Biotope types

Aspect: Rarity and endangerment
Criterion: national protection status as well as endangerment of the biotope types according to the Red List of Endangered Biotope Types of Germany (FINCK et al., 2017).
Aspect: Existing pressure
Criterion: Endangerment by anthropogenic influences.

Fish

Aspect: Rarity and endangerment
Criterion: Proportion of species that are considered endangered according to the current Red List of marine fishes (THIEL et al. 2013) and for the diadromous species of the Red List of freshwater fishes (FREYHOF 2009) and have been assigned to Red List categories.
Aspect: Diversity and Eigenart
Criterion: The diversity of a fish community can be described by the number of species (α-diversity, 'species richness'). Species composition can be used to assess the distinctiveness of a fish community, i.e. how regularly habitat-typical species occur. Diversity and species richness are compared and assessed between the Baltic Sea as a whole and the German EEZ, as well as between the EEZ and the individual areas.
Aspect: Existing pressure
Criterion: Due to the removal of target species and bycatch, as well as the impact on the seabed in the case of bottom-disturbing fishing methods, fishing is considered the most effective disturbance to the fish community and therefore serves as a measure of the pre-existing pressure on fish communities in theBaltic Sea. An assessment of the stocks on a smaller spatial scale, such as the German Bight, is not carried out. The input of nutrients into natural waters is another pathway through which human activities can influence fish communities. Therefore, eutrophication is used to assess the pre-stress.

Marine mammals

Aspect: Protection status
Criterion: Status according to Annex II and Annex IV of the Habitats Directive and the following international conservation 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: Population, population 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 identified in the MSP for marine mammals as a passage area, feeding or breeding ground.
Aspect: Existing pressure
Criterion: Hazards due to anthropogenic influences and climate change.

Seabirds and resting birds

Aspect: Protection status
Criterion: Status according to Annex I species of the Birds Directive, European Red List of BirdLife International
Aspect: Assessment of occurrence
Criteria: German Baltic Sea stock and German EEZ stock, large-scale distribution patterns, abundance, variability
Aspect: Assessment of spatial units
Criteria: Function of the areas identified in the MSP for relevant breeding birds, migratory birds, as resting areas, location of the protected areas.
Aspect: Existing pressure
Criterion: Hazards due to anthropogenic influences and climate change.

Migratory birds

Aspect: Large-scale importance of bird migration
Criterion: Guidelines and concentration areas
Aspect: Assessment of occurrence
Criterion: migratory activity and its intensity
Aspect: Rarity and endangerment
Criterion: Number of species and endangerment status of the species involved according to Annex I of the Birds Directive, 1979 Bern Convention on the Conservation of European Wildlife and Natural Habitats, 1979 Bonn Convention on the Conservation of Migratory Species of Wild Animals, AEWA (African-Eurasian Waterbird Agreement) and SPEC (Species of European Conservation Concern).
Aspect: Existing pressure
Criterion: Existing pressures/ hazards due to anthropogenic influences and climate change.

1.5.4 Assumptions for the description and assessment of the likely significant impacts

The description and assessment of the likely significant effects of the implementation of the MSP on the marine environment is carried out for the individual designations for the use and protection of the EEZ in relation to the protected goods, taking into account the status assessment described above. The following table lists, based on the main impact factors, the potential environmental impacts that arise from the respective use and are to be assessed both as an existing impact, in the event of non-implementation of the plan, or as a likely significant environmental impact as a result of the designations in the MSP. The impacts are differentiated according to whether they are permanent or temporary.

Table 1: Overview of the potentially significant impacts of the uses identified in the MSP

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
Marine uses with spatial designations in the maritime spatial plan																			
Areas for offshore wind energy	Placement of hard substrate (foundations)	Habitat modification	x	x			x		x	x	x	x							
		Habitat and land loss	x	x			x			x	x	x	x					x	
		Attraction effects, increase in species diversity, change in species composition	x	x	x		x		x		x								
		Change in hydrographic conditions	x	x			x		x					x					
	Scouring/sediment rearrangement	Habitat modification	x	x					x	x		x	x						
	Sediment resuspension and turbidity plumes (construction phase)	Impairment	x t	x t	x t				x t					x t					
		Physiological effects and chilling effects		x t			x												
	Resuspension of sediment and sedimentation (construction phase)	Impairment	x t	x t					x t					x t					
	Noise emissions during pile driving (construction phase)	Impairment/ scare effect		x t			x												
		Potential disruption/damage		x t			x												
	Visual disturbance due to construction operations	Local scouring and barrier effects		x t	x t														

	Obstacle in airspace	Scare effects, habitat loss			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	
Lines Routes for submarine cable systems and pipelines	Placement of hard substrate (riprap)	Habitat modification	x	x					x	x		x						x	
		Habitat and land loss	x	x						x		x	x					x	
	Heat emissions (live cables)	Impairment/displacement of cold-water-loving species	x								x	x							
	Magnetic fields (live cables)	Impairment	x																
		Impairment of the orientation behaviour of individual migratory species		x															
	Turbidity plumes (construction phase)	Impairment	x t	x t	x t				x t					x t					
		Physiological effects and chilling effects		x t															
Shipping	Underwater sound	Impairment / scare 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				x		x								
	Bringing in rubbish	Impairment/ Damage	x	x	x		x		x					x			x		
	Collision risk	Collision			x	x	x												
	Visual restlessness	Impairment/ scare effect		x	x														

Raw materials Sand and gravel mining / Seismic surveys	Substrate removal	Habitat modification	x	x			x		x	x	x	x						x	
		Habitat and land loss	x	x			x		x	x	x	x	x					x	
	Turbidity plumes	Impairment	x t	x t	x t				x t					x t					

		Physiological effects and chilling effects		x t															
	Physical disorder	Impact on the seabed	x							x		x	x					x	
	Underwater sound during seismic surveys	Impairment / scare effect		x t			x												
	Visual restlessness	Impairment/ scarecrow effect			x														
Marine research	Removal of selected species	Reduction of stocks		x															
	Physical disturbance by trawls	Harm/ damage By-catch	x	x						x		x						x	
Fishing	Removal of selected species	Reduction of stocks	x	x							x								
		Degradation of the food base			x														
	Bycatch	Reduction of stocks	x	x	x		x				x								
	Physical disturbance by trawls	Impairment/ Damage	x	x			x			x		x						x	
National defence	Underwater sound	Impairment/ scare effect		x t			x												
	Introduction of dangerous substances	Impairment	x	x	x		x		x	x	x	x		x			x		
	Collision risk	Collision					x												
	Surrounding water sound	Impairment/ scare effect			x	x		x									x		
	Bringing in rubbish	Impairment	x	x					x					x			x		
Marine uses without spatial designations in the maritime spatial plan																			
Leisure (-traffic)	Removal of species (angling)	Reduction of stocks		x															
	Underwater sound	Impairment / scare effect		x			x												
	Emission of air pollutants	Impairment of air quality			x	x		x							x	x	x		
	Bringing in rubbish	Impairment	x	x	x		x		x					x			x		
	Visual restlessness	Impairment/ scare effect			x														
Aquaculture	Introduction of nutrients	Impairment	x	x					x					x					
	Bringing in fixed installations	Habitat modification	x	x					x	x	x								x
		Habitat and land loss	x	x	x					x			x					x	x

	Introduction and spread of invasive species	Change in species composition	x	x	x				x		x								
	Insertion of medicines	Impairment	x	x										x			x		
	Removal from wild stocks	Impairment	x	x															
	Attraction/shying effects	Attraction / scare effect		x	x		x												

x Potential impact on the protected good

x t potential temporary impact on the protected good

In addition to the effects on the individual protected goods, cumulative effects and interactions between protected goods are also examined.

1.5.4.1 Cumulative view

According to Art. 5 para. 1 SEA Directive, the environmental report also includes the assessment of cumulative effects. Cumulative effects result from the interaction of various independent individual effects that either add up through their interaction (cumulative effects) or mutually reinforce each other and thus produce more than the sum of their individual effects (synergetic effects) (e.g. SCHOMERUS et al., 2006). Cumulative as well as synergetic effects can be caused by temporal as well as spatial coincidence of effects. The effect can be intensified by similar uses or different uses with the same effect and thus increase the impact on one or more protected goods.

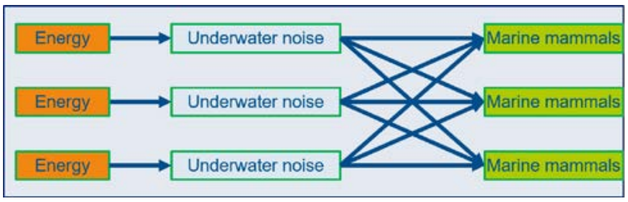

Figure 8: Exemplary cumulative effect of similar uses.

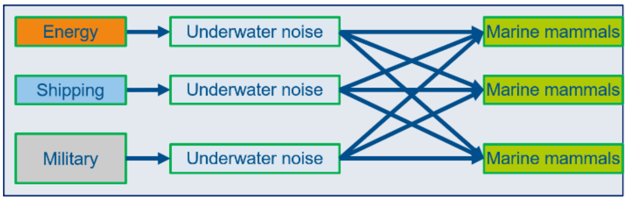

Figure 9: Exemplary cumulative effect of different uses.

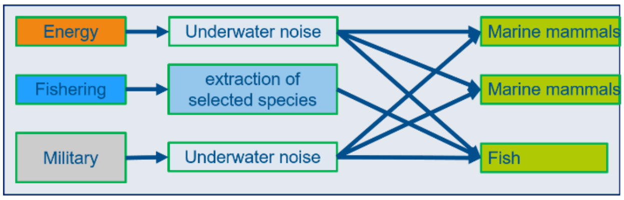

Figure 10: Exemplary cumulative effect of different uses with different impacts.

In order to assess the cumulative effects, it is necessary to evaluate the extent to which a significant adverse effect can be attributed to the provisions of the plan in combination. An assessment of the designations is carried out on the basis of the current state of knowledge within the meaning of sec. 5 para. 2 of the SEA Directive.

1.5.4.2 Interactions

In general, impacts on a protected good lead to various consequences and interactions between the protected goods. The main interdependence of the biotic protected goods exists via the food chains. Due to the variability of the habitat, interactions can only be described very imprecisely.

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

In detail, the analysis and examination of the respective determinations is carried out as follows:

Wind energy at sea

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

In particular, the SEA takes into account the following input parameters:

- Plants already in operation or in the approval procedure (as reference and pre-pollution)
- Transfer of the average parameters of the installations commissioned in the last 5 years on the areas defined in the FEP 2019.
- Forecast of certain technical developments for the additional priority and reservation areas for offshore wind energy defined in the MSP on the basis of the parameters shown in Table 2. It should be noted that these are only partly estimate-based assumptions, as the examination of project-specific parameters does not or cannot take place at SEA level.

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

Parameters WEA	**Bandwidth** *Zone 1 and 2*		**Bandwidth** *Zone 3 to 5*	
	from	to	from	to
Capacity per plant [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, cross-border submarine cable systems or data cables, the cable lengths result from the designations. For pipelines, a width of 1.5 m for the overlying pipeline is assumed for the assessment of environmental impacts, plus 10 m of impairments due to "reef effect" and sediment dynamics in each case.

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

Shipping

In order to assess the environmental impacts of shipping, it is necessary to examine which additional impacts can be attributed to the designations in the maritime spatial plan.

The designated priority areas for shipping are to be kept free of constructional use. This control in the MSP is intended to avoid or at least reduce collisions and accidents. Due to the stipulations in the MSP, the traffic frequency in the priority areas is expected to increase, whereby this is particularly 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 greatly, with over 15 vessels per km² per day in some cases on the busiest route SN1, while on the other, narrower routes it is mostly approx. 1-2 vessels per km² per day. (BfN, 2017).

The BSH has commissioned an expert report on the traffic analysis of shipping traffic, where up-to-date evaluations are expected.

The presentation of general impacts from shipping is presented in Chapter 2 as a pre-impact, especially for birds and marine mammals. The impacts from service transport to the wind farms are dealt with in the chapter on wind energy.

Raw material extraction

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

Sand and gravel extraction

Sand and gravel are extracted using floating suction dredgers. In the process, the extraction field is driven over in strips approx. 2 m wide and the subsoil is extracted to an extraction depth of approx. 2 m. The seabed remains unused between the extraction strips. Between the mining strips, the seabed remains undisturbed. During mining, a sediment-water mixture is conveyed on board the suction dredger. The sediment in the desired grain size is sieved out and the fraction that is not needed is returned to the sea on site. Turbidity plumes are created by the mining and discharge. Potential temporary impacts result from the turbidity plumes, which can lead to disturbance and scouring effects on marine fauna. Potential permanent impacts arise from the removal of substrates and physical disturbance resulting in habitat and area loss, habitat modification and seabed disturbance.

Sand and gravel extraction is carried out on the basis of operational plans on partial areas of the approved permit fields.

Gas extraction

Exploratory or production wells are drilled to explore and develop gas deposits. Drilling through the rock above the reservoir produces drilling debris. 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 deposits, which lead to scaring effects on marine mammals.

Operational discharges into the sea are caused by the discharge of production water and spray water, wastewater from the sewage treatment plant and the shipping traffic generated. Production water is essentially reservoir water, which may contain components from the subsurface, such as salts, hydrocarbons and metals. The amount of gas in the production water increases with the age of the reservoir. Production water can also contain chemicals that are used in production technology to improve extraction or to prevent corrosion of production equipment. The production water is discharged into the sea after state-of-the-art treatment and compliance with national and international standards.

Marine research

The designated areas for marine scientific research correspond to standard study areas ("boxes") of the Thünen Institute in the North Sea as well as the Baltic Sea. In the Baltic Sea, scientific fisheries catches have been carried out several times a year for over thirty years, for which sampling is also carried out outside the reserved research areas within the framework of the BALTBOX, BITS and COBALT programmes. The data sets form an important basis for assessing long-term changes in the bottomfish fauna (commercial and non-commercial species) of the Baltic Sea caused by natural (e.g. climatic) influences or anthropogenic factors (e.g. fishing).

These studies are also used to assess the coastal fish fauna in the neighbouring federal states of Schleswig-Holstein and Mecklenburg within the framework of the MSFD. In two of the areas (west of Fehmarn as well as on the Oderbank), studies have also begun in 2020 as part of an interdisciplinary joint project (DAM mission), which are planned over many years to record possible changes in the bottom fish fauna that are expected due to the planned closures for mobile fishing with bottom-impacting fishing gear in the respective adjacent Natura 2000 areas.

Bottom trawls and beam trawls are used in the Baltic Sea. Details on the gear used, the effort and the catches can be found in the respective cruise reports on the Thünen Institute's research cruises.

Effects are to be expected from the equipment used, especially on the soil / sediment and the habitats affected by it. For this purpose, fish of different age and size classes are taken.

Table 3: Parameters for the consideration of marine research

Frequency of surveys per year / duration per haul	Several times/year, each time approx. 10 to 30 min.
Fishing gear used	Standardised bottom trawl catches 2 metre beam trawl Pelagic nets
Catch	Total quantities for all (sampled) boxes (partly with other research activities) in the double-digit tonne range (area of travel partly also outside the "boxes", or the EEZ)

Nature Conservation / Seascape / Open Space

The provisions on nature conservation in the maritime spatial plan are not expected to have any significant negative environmental impacts.

The designations help to ensure that the marine environment in the EEZ is permanently preserved and developed as an ecologically intact open space over a large area. The size of the designated areas is of particular importance in this respect. Keeping the protected areas free from uses incompatible with nature conservation also contributes to the protection of open space and the marine landscape on a large scale.

The guiding principles of careful and sparing 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 natural balance.

The maritime spatial plan thus contributes to achieving the objectives of the MSFD. However, the influence of spatial planning is limited and cannot have an impact on all objectives.

National and alliance defence

The MSP contains textual provisions on national and alliance defence.

1.6 Data basis

The basis for the SEA is a description and assessment of the state of the environment in the study area. All protected goods are to be included. The data basis is the basis for the assessment of the likely significant environmental impacts, the site and species protection assessment and the alternatives assessment.

Pursuant to sec. 8 para. 1 sentence 3 ROG, the environmental assessment refers to what can reasonably be required according to the current state of knowledge and generally accepted test methods as well as the content and level of detail of the spatial plan.

According to sec. 40 para. 4 UVPG, information available to the competent authority from other procedures or activities may be included in the environmental report if it is suitable for the intended purpose and sufficiently up-to-date.

On the one hand, the environmental report describes and evaluates the current state of the environment and presents the probable development if the plan is not implemented. On the other hand, it forecasts and assesses the likely significant environmental impacts resulting from the implementation of the plan.

The basis for the assessment of possible impacts is a detailed description and evaluation of the state of the environment. The description and assessment of the current state of the environment as well as the probable development in the event of non-implementation of the plan will be carried out with regard to the following objects of protection:

- Surface/Floor
- Water
- Plankton
- Biotope types
- Benthos
- Fish
- Marine mammals
- Avifauna
- Bats
- Biodiversity
- Air
- Climate
- Landscape
- Cultural assets and other material assets
- People, especially human health
- Interactions between protected goods.

1.6.1 Overview data basis

The data and knowledge situation has improved significantly in recent years, in particular due to the extensive data collection within the framework of environmental impact studies as well as the construction and operation monitoring for offshore wind farm projects and the accompanying ecological research.

This information also forms an essential basis for the monitoring of the 2009 maritime spatial plans in accordance with sec. 45 para. 4 UVPG. According to this, the results of the monitoring must be made available to the public and taken into account when the plan is drawn up again. Results of the plan-accompanying monitoring of the current plans are summarised in the status report on the update of spatial planning in the German EEZ in the North Sea and Baltic Sea published in parallel (Chapter 2.5).

In generalised summary, the following data bases 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 from the preliminary investigation of sites
- Results from the monitoring of Natura 2000 sites
- Mapping instructions for sec. 30 biotope types
- MSFD Initial and Progress Assessment
- 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

- Comments from the specialist authorities
- Comments from the (specialist) public

A detailed overview of the individual data and knowledge bases was included in the appendix of the study framework.

1.6.2 Indications of difficulties in compiling the documents

According to No. 3a Annex 1 to sec. 8 para. 1 ROG, indications of difficulties encountered in compiling the information, for example technical gaps or lack of knowledge, must be presented. In some places there are still gaps in knowledge, particularly with regard to the following points:

- Long-term effects from the operation of offshore wind farms
- Effects of shipping on individual protected goods
- Effects of research activities
- Data for assessing the environmental status of the various protected goods for the area of the outer EEZ.

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

In particular, there is no detailed area-wide sediment and biotope mapping outside the nature conservation areas of the EEZ. As a result, there is no scientific basis for assessing the impacts of the possible use of strictly protected biotope structures. Currently, a sediment and biotope mapping with a spatial focus on the nature conservation areas is being carried out on behalf of the BfN and in cooperation with the BSH, research and university institutions and an environmental agency.

In addition, scientific assessment criteria are lacking for some protected goods, 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 both temporally and spatially.

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

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

1.7 Application of the ecosystem approach

The application of the ecosystem approach can contribute to achieving the guiding principle of sustainable spatial development pursuant to sec. 1 para. 2 of the ROG, which reconciles the social and economic demands on space with its ecological functions and leads to a sustainable, large-scale balanced order. Its application is a requirement under sec. 2 para. 3 no. 6 sentence 9 ROG with the aim of guiding human activity, sustainable development and supporting sustainable growth (cf. Art. 5(1) MSP Directive in conjunction with Art. 1(3) of the Marine Strategy Framework Directive).

Recital 14 of the MSP Directive specifies that spatial planning should be based on an ecosystem approach in accordance with the MSFD. Likewise, it is made clear here - as in preamble 8 of the MSFD - that the sustainable development and use of the seas must be compatible with good environmental status.

According to Art. 5(1) of the MSP 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 marine area, applying an ecosystem approach, and to promote the coexistence of relevant activities and uses. “

Art. 1 para. 3 MSFD specifies that "marine strategies shall apply an ecosystem approach to the management of human activities that ensures that the overall impact of such activities is limited to a level compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced change is not compromised, while allowing for the sustainable use of marine goods and services now and by future generations. “

The ecosystem approach enables 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 with the interactions of their uses. The approach is to manage ecosystems within the 'limits of their functioning' to safeguard them for use by future generations. Furthermore, understanding ecosystems enables effective and sustainable use of resources.

A comprehensive understanding, protection and enhancement of the marine environment, as well as effective and sustainable use of resources within carrying capacity limits, will secure marine ecosystems for future generations. The ecosystem approach can therefore contribute - at least in part - to a good state of the marine environment.

Based on the so-called twelve Malawi principles of the Biodiversity Convention, the ecosystem approach has also been concretised and specified for marine spatial planning by the HELCOM-VASAB working group on maritime 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 should promote the most comprehensive overall picture possible:

- Use of the current state of knowledge;
- Precautionary principle;
- Examination of alternatives;
- Identification of ecosystem services;
- Prevention and mitigation of impacts;
- Understanding of contexts;
- 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 biggest challenges is dealing with knowledge gaps. 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 be able to use the broadest possible knowledge base of all stakeholders as well as to achieve the greatest possible acceptance of the plan.

Figure 11 shows the understanding of the application of the ecosystem approach. This takes place equally in the planning process, in the MSP and in the Strategic Environmental Assessment (SEA). The SEA proves to be the central instrument for applying the ecosystem approach. (Altvater, 2019) and offers versatile points of connection to the content and process-oriented key elements.

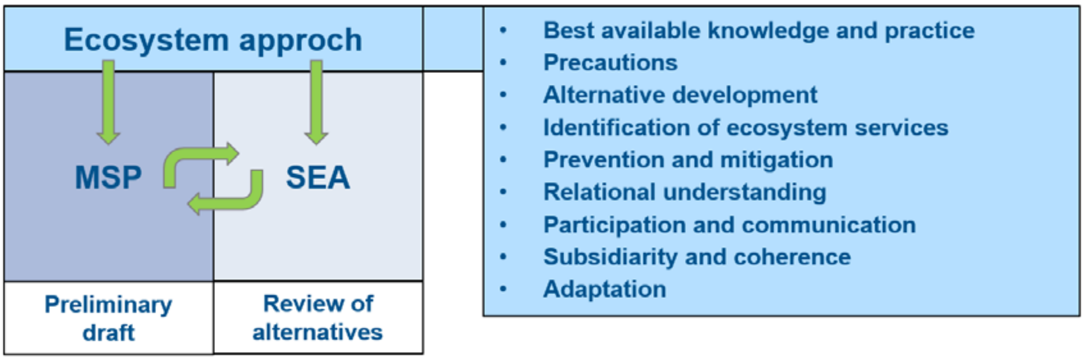

Figure 11: The ecosystem approach as a structuring concept in the planning process, the MSP and the Strategic Environmental Assessments

The ecosystem approach is anchored in the mission statement as the basis of the maritime spatial plan. In addition, its importance is explicitly highlighted in the following principles:

- Principles on general requirements for economic uses: Prevention of harm to the marine environment and best environmental practice (4.1) and monitoring (4.2);
- Principle on offshore wind energy: protection of the marine environment (6);
- Nature conservation principles: bird migration (5) and preservation of the EEZ as a natural area (6)

The spatial and textual designations for marine nature conservation fundamentally contribute to the protection and improvement of the state of the marine environment (see MSP vision). In addition, the provisions of the MSP promote the resilience of the marine environment - against impacts from economic uses and against changes caused by climate change.

A quantification of the carrying capacity of the ecosystem cannot be considered conclusively due to a lack of data and knowledge. This is a task for the future development of the ecosystem approach. Even if quantification is not possible at present, the SEA and cumulative consideration of impacts ensure that the MSP, with its stipulations on economic uses, does not exceed the limits of ecosystem functioning.

The assessment of the likely significant environmental impacts of the implementation of the maritime spatial are methodologically described in Chapter 4. The ecosystem approach does not itself constitute an assessment, but encompasses a variety of important aspects and instruments for sustainable spatial development. The SEA comprehensively serves 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 versatility and comprehensive consideration of the relationships between the marine environment and economic uses. The key elements also interact with each other, which underlines the interconnectedness and holistic perspective. Figure 12 shows abstractly the relationships between the key elements. This approach becomes tangible and applicable through consideration at the level of the individual key elements, here in particular those of the HELCOM/VASAB Guideline (2016).

The application in the spatial plan for the German EEZ follows the understanding that this approach is to be constantly further developed. Existing knowledge gaps and the need for conceptual broadening result in the necessity to consider the ecosystem approach as a permanent task of further development.

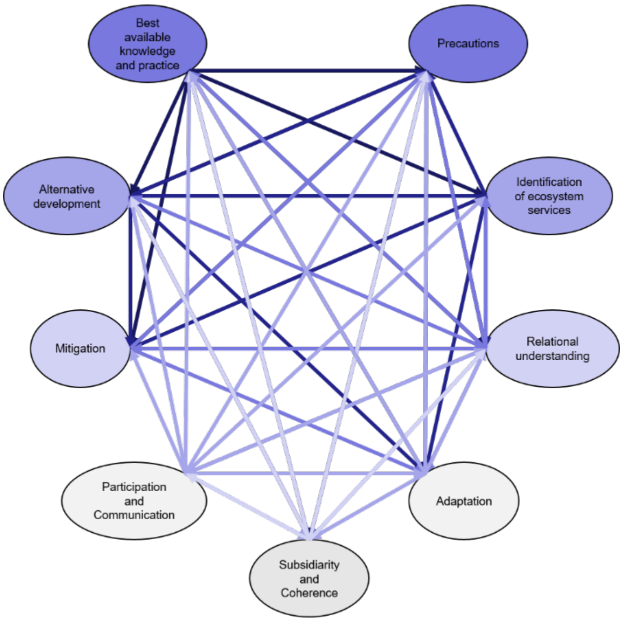

Figure 12: Networking between key elements.

Use of the current state of knowledge

"Allocation and development of human uses shall be based on the latest knowledge of ecosystems as such and the practice of best protection of the components of the marine ecosystem." (HELCOM/VASAB, 2016).

The use of the current (well-founded) state of knowledge is fundamentally indispensable for planning processes and the basis of the planning understanding for updating maritime spatial plans. This key element thus also affects the other elements mentioned, such as the precautionary principle, the prevention and mitigation of impacts and the understanding of interrelationships.

In the context 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 expert discussions were held with various stakeholders even before the concept for the update was drawn up.

The Scientific Advisory Group (WiBeK) on the update of maritime spatial planning in the EEZ in the North Sea and Baltic Sea provides scientific advice on issues such as content, the procedure and the participation process.

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

In-house research and developments, such as databases and other analysis tools, are developed, validated and used at the BSH for a wide range of applications, e.g. MARLIN and MarineEARS. These can support the planning process and 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 maritime spatial plan promote the use of the current state of knowledge in economic uses as a basic requirement:

- Principle on shipping: sustainability, protection of the marine environment (4);
- Principles on general requirements for economic uses: Best Environmental Practice (4.1) and Monitoring (4.2);
-
- Principle on offshore wind energy: protection of the marine environment (6);
- Principle on marine research: sustainability, protection of the marine environment (3).

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 environmental impact studies and monitoring of offshore wind farm projects according to StUK, scientific research activities and from national and international monitoring programmes.

Precautionary principle

"Far-sighted, anticipatory and preventive planning should promote sustainable use in marine areas and eliminate risks and threats to the marine ecosystem from human activities. Those activities which, according to the current state of scientific knowledge, may lead to significant or irreversible impacts on the marine ecosystem, and the effects of which may not be sufficiently foreseeable at present, either in whole or in part, require particularly careful study and weighting of risks." (HELCOM/VASAB, 2016).

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

The provisions of the maritime spatial plan clarify the consideration of the precautionary principle in economic uses as a fundamental requirement (Principle 6 Nature Conservation / Marine Landscape / Open Space) as well as in the following uses:

- Objective on navigation: Priority areas for navigation (1);
- Objective on general requirements for economic uses: Deconstruction (2);
- Principles on general requirements for economic uses: Sustainability, land conservation (1) and prevention of harm to the marine environment and best environmental practice (4.1);
- Principle on offshore wind energy: protection of the marine environment (6);
- Principles on pipelines: Minimisation of Impacts (5) and Marine Environment (6);
-
- Principle on nature conservation: Preservation of the EEZ as a natural area (6).

The SEA examines the significance of the impacts of the MSP provisions on uses on the protected goods (Section 4).

Examination of alternatives

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

The development and examination of alternatives was given high priority in the process of updating the maritime spatial plans and alternative planning options were publicly consulted even before the first draft of the plan. The early and comprehensive consideration of several planning options represents an essential planning and examination step in the updating of maritime spatial plans.

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

- Planning option A: Perspective Traditional uses
- Planning option B: Climate protection perspective
- Planning option C: Perspective on marine nature conservation

The alternatives presented as planning options are integrated approaches that take into account the spatial and contextual interdependencies and interactions on a large scale.

A preliminary assessment of selected environmental aspects was already carried out for the concept before the preparation of this environmental report. This preliminary assessment allowed a comparison of the three planning options from an environmental perspective in the sense of an early examination of variants and alternatives.

The conceptual design and the preliminary assessment of selected environmental aspects were consulted so that the knowledge and assessment of the stakeholders involved on the planning options could be incorporated into the planning process at an early stage.

An assessment of alternatives to the MSP takes place 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 need to 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 more comprehensive understanding, as they can clarify the multiple functions of ecosystems. In the case of marine ecosystems, the function as natural carbon sinks and other contributions to climate protection and adaptation should be highlighted in particular. This consideration should be taken into account in future updates of the maritime spatial plan and the development of the necessary tools should be continued.

With the MARLIN (Marine Life Investigator) application, the BSH is currently developing a large-scale and high-resolution information network on marine ecological data from environmental investigations in the context of environmental impact studies, preliminary investigations of sites and monitoring of offshore wind farm projects. Various data analyses at different spatial and temporal levels are possible in order to support the BSH's tasks as required. MARLIN also combines the integrated marine ecological data with various environmental data and thus supports the understanding of 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, it will be possible in future to consider all offshore wind farm procedures and to create large-scale studies. Based on this, an identification of ecosystem services can begin. 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 spatial planning.

Prevention and mitigation of impacts

"Measures are provided to prevent, reduce and offset as fully as possible any significant adverse effects [of implementing the plan] on the environment" (HELCOM/VASAB, 2016).

The MSP's guiding principle defines the contribution to the protection and improvement of the state of the marine environment also by stipulating the prevention or reduction of disturbance and pollution.

The provisions of the maritime spatial plan clarify this consideration with measures for the prevention and mitigation of negative impacts for individual uses:

- Principle on shipping: sustainability, protection of the marine environment (4);
- Principle on general requirements for economic uses: Best Environmental Practice (4.1);
- Principle on offshore wind energy: protection of the marine environment (6);
- Principles on pipelines: Minimisation of Impacts (5) and Marine Environment (6);
- Raw material extraction principle: divers (2);
- Principle on marine research: sustainability, protection of the marine environment (3);
- Nature conservation objective: Priority areas for nature conservation and priority area for divers (1);
- Principles of nature conservation: seasonal reservation area for harbour porpoise (3), bird migration corridors (5) and safeguarding and preserving the seascape (8).

In the SEA, measures to avoid, reduce and compensate for significant negative impacts of the implementation of the maritime spatial plan are comprehensively presented in Chapter 8.

Understanding of interrelationships

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

Understanding interconnections and interrelationships is of high importance for the planning process and the tasks of spatial planning. In this sense, the guiding principle of the MSP emphasises the holistic view and includes the consideration of land-sea relationships.

This is addressed and examined in the Strategic Environmental Assessment in chapters 4.10Interactions and 4.11Cumulative Consideration.

Here, too, reference can be made to the current development of the MARLIN (Marine Life Investigator) specialist application at the BSH, which supports the understanding of impacts and interrelationships.

Further experience, e.g. on cumulative consideration, was gained in European cooperation projects (Pan Baltic Scope, SEANSE) and is incorporated into the conceptual development just as much as 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 exemplifies the interconnectedness and relationships of the key elements. The knowledge gained can contribute to all other key elements.

Within the framework of the update process, participation and communication have been carried out intensively from the beginning. The early and comprehensive participation was able to significantly expand the knowledge base through the sector-specific expertise of the stakeholders and through the assessments received in comments.

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

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

Additional support for the process is provided by the Scientific Advisory Group (WiBeK). The WiBeK on the update of maritime spatial planning in the Exclusive Economic Zone in the North Sea and Baltic Sea has been providing advice from a scientific perspective since 2018, among other things with regard to substantive issues as well as the course of the procedure and the participation process.

Subsidiarity and coherence

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

Spatial planning aims to create coherent plans in the North Sea and Baltic Sea through coordination with the coastal federal states and neighbouring states. 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 neighbouring countries' plan preparation procedures in the context of international cooperation are taken into account in the plan preparation process. A further contribution is made by the international consultation procedures.

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

At the level of designations, the following objectives and principles highlight the need for coordination in planning cross-border structures:

- Objectives for navigation: Priority areas for navigation (1) and temporary priority area for navigation (2);
- Target to be piped: Coastal Sea Boundary Corridors (3);
- Principle on pipelines: Suitable transition points at the territorial sea and border corridors to adjacent states (4);
- Nature conservation principle: Bird migration corridors (5).

Within the framework of the SEA, the transboundary impacts for the adjacent areas of the neighbouring states are considered (Chapter 4.12).

Adaptation

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

Monitoring and evaluation in the context of spatial planning for the German EEZ take place at different levels.

First, the plan and its implementation will be evaluated. A monitoring and evaluation concept will be developed for this purpose.

In addition, the planned measures for monitoring the effects of the implementation of the maritime spatial plan on the environment are listed in Chapter 10 part of the SEA.

The mission statement already stipulates a situation-specific adaptation of the provisions for all sectoral concerns as an ongoing evaluation process, with the involvement of the competent federal ministries.

Effects of economic uses on the marine environment should be investigated and evaluated at project level by means of effect monitoring. This is stipulated in Principle 4.2 of the general requirements for economic uses in the MSP.

Summary

In sum and beyond, the key elements and their implementation in the planning process, the MSP as well as 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 Consideration of climate change

Anthropogenic climate change as one of the greatest societal challenges is of particular importance for changes in the seas and their use. Figure 13 the interrelationships between climate change, the marine ecosystem, uses and maritime spatial planning, also as an instrument for achieving the Sustainable Development Goals.

In changing seas, the consideration and integration of climate impacts into MSP is of great importance in order to do justice to the precautionary and future-oriented nature of MSP and to develop plans that are sustainable in the long term.

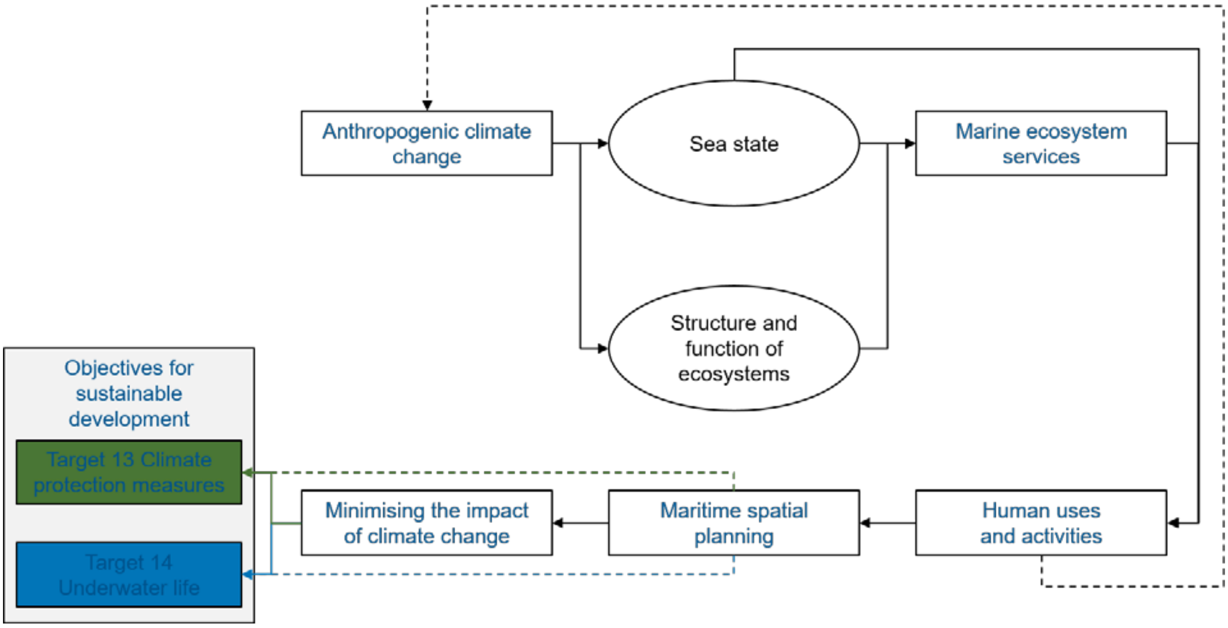

Figure 13: Illustration of the interrelationships of climate change, marine ecosystems and maritime spatial planning, according to (Frazão Santos, 2020)

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 uses, e.g. for shipping, renewable energy or raw material extraction. (Frazão Santos, 2020).

The following table shows projections of some relevant parameters.

Table 4: Climate projections for selected parameters [1] (UBA, in Vorbereitung), [2] (IPCC, 2019), [3] (Schade N, 2020)

	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 - 110cm	61 - 110cm
Increase in extreme wind speeds (RCP8.5 scenario compared to 1971-2000)[3]	0 - 0.5 m/s	No majority significant increases west of the Stralsund-Trelleborg line; east of it 0-0.5 m/s

The provisions on offshore wind energy are the main contribution to climate protection. Assuming that the current CO2 avoidance factor for electricity from offshore wind energy is extrapolated to the year 2040, this results in a CO2 avoidance potential of (UBA, 2019) to the year 2040, this results in a CO2 avoidance potential of 62.9 Mt CO2 equivalents per year on average for the period between 2020 and 2040. By way of comparison, annual emissions from power plants in the energy industry in 2016 were 294.5 Mt CO2 equivalents per year. (BMU, 2019). Table 5shows the abatement potential for the years 2020, 2040 and the annual average for the entire period.

Table 5: Calculation of the CO2 avoidance potential of the provisions on offshore wind energy.

	installed capacity	Full load hours	Annual electricity production	CO2 avoidance factor	CO2 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 CO2 avoidance per year					62,9

Furthermore, keeping nature conservation priority areas free and the potential of ecosystems as natural carbon sinks contributes to climate protection. The designation of priority and reservation areas for nature conservation can also contribute to strengthening 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 goals.

The development of risk and vulnerability analyses for 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.

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

For the comprehensive inclusion of climate change in MSP, it is necessary to strengthen institutional cooperation, including international cooperation in the North and Baltic Seas. 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 the conceptual development of marine ecosystem services and especially the potential of natural carbon sinks.

2 Description and assessment of the state of the environment

According to sec. 8 ROG in conjunction with. Annex 1 and 2 to sec. 8 ROG, the environmental report contains a description of the characteristics of the environment and the current state of the environment in the SEA study area. The description of the current state of the environment is necessary in order to be able to forecast its change upon implementation of the plan. The subject of the inventory are the protected goods listed in sec. 8 para. 1 ROG as well as interactions between them. The presentation is problem-oriented. Emphasis is therefore placed on possible existing pressures, environmental elements that are particularly worthy of protection, and on those protected assets that 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. These vary in extent depending on the type of impact and the protected property concerned, and may extend beyond the boundaries of the plan.

2.1 Area

The German EEZ in the North Sea and Baltic Sea is of great importance for many uses and for the marine environment. At the same time, its area is limited, so land-saving use is imperative. Land sparing is therefore also reflected in the guidelines and principles of the maritime spatial plan, as a result of which the protected resource of land is of particular importance in the MSP, both in principle and across all uses.

One guiding principle of spatial planning is the sustainable development of space (cf. sec. 1 para. 2 ROG). The basis for this sustainable development of the limited resource of land in the EEZ of the North Sea and Baltic Sea is the most efficient and sparing use of land, especially in the case of competing uses. This can lead to a situation where the MSP does not always specify the desirable area for uses, but rather the sufficient area. Therefore, the spatial planning process, under the premise of sparing use of land and in consideration of the various protection and use interests, is in itself a treatment of land as an object of protection.

When all the provisions of the plan are considered together, the impression can arise that hardly any area in the German EEZ remains unused. On the one hand, the designation of an area for a particular use does not necessarily mean that 100 % of this area will be used for that use. Secondly, not all uses take place at the same time. Spatial planning in the sea has a three-dimensional space at its disposal, which can lead to an overlapping of uses on one area, as in the case of the uses of pipelines and shipping, for example. Even uses that actually take up space in the sense of land do not necessarily take up 100% of it. An example of this is the use of wind energy at sea. The actual land consumption by wind turbines and platforms (incl. scour protection) as well as cabling within the park amounts to less than 0.5 % of the areas defined for offshore wind energy.

Another aspect of sustainable and economical use of land resources is the obligation to dismantle structures, submarine cables, etc. after the end of their operating life, so that these areas are available for subsequent use.

2.2 Soil

2.2.1 Data situation

One of the most important bases for describing the surface sediments in the EEZ of the German Baltic Sea is the map of sediment distribution in the western Baltic Sea (BSH/IOW, 2012). It is essentially based on point data surveys that have been interpolated into the area. In order to obtain more precise information, especially on the location and distribution of coarse sand and fine gravel areas as well as residual sediments (incl. gravel, stones and boulders), area-wide sediment mapping has been successively carried out for several years using hydroacoustic methods. The resulting detailed maps and illustrations of the shape and extent of bottom structures and of small-scale structural and sediment changes at the seabed surface are not available due to the selective data basis for the BSH/IOW sediment distribution map. (BSH / IOW, 2012) is not given. In particular, the distribution of coarse sediments (gravel and stony residual sediment) is, according to current knowledge, greater than shown in the BSH/IOW map. (BSH / IOW, 2012) map. The same applies to the distribution of stones and boulders.

These sediment cover maps are not yet available for the entire Baltic Sea EEZ. All results are available for the Fehmarn Belt protected area and the Kadetrinne protected area is largely complete. The results of the surveys for the Arkona Sea and the Pomeranian Bay - Rönnebank Protected Area are not yet available for the entire area. Further information comes from data and reports of the subsoil investigations of the procedures and the BSH's own investigations.

The descriptions of the structure of the subsurface near the surface are mainly based on boreholes, pressure soundings and reports of the subsoil investigations, the literature and the BSH's own investigations and evaluations.

The data and information used to describe the distribution of pollutants in the sediment, suspended matter and turbidity, as well as nutrient and pollutant distribution, are collected during the BSH's annual monitoring cruises in cooperation with the IOW.

2.2.2 Geomorphology and sedimentology

The Baltic Sea is a secondary sea 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 EEZ of the German Baltic Sea.

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

- Baltic ice reservoir (up to 10,200 years before present),
- Yoldia Sea (10,200 - 9,300 years before present),
- Lake Ancylus (9,300 - 8,000 years before present) and
- Litorina Sea (8,000 years - present).

The bottom relief is characterised by a basin and sill structure. The following Figure 14 on bathymetry in the German Baltic Sea illustrates this sequence of basins and sills and serves as a basis for the structure of the geomorphological and sedimentological description of this environmental report.

Based on the basin and sill structure of the Baltic Sea, eight sub-areas were delineated using geological, geomorphological and oceanographic criteria:

- Bay of Kiel
- Fehmarn Belt
- Bay of Mecklenburg
- Darss Threshold
- Arkona Basin
- Krieger's flak
- Adlergrund
- Orbank.

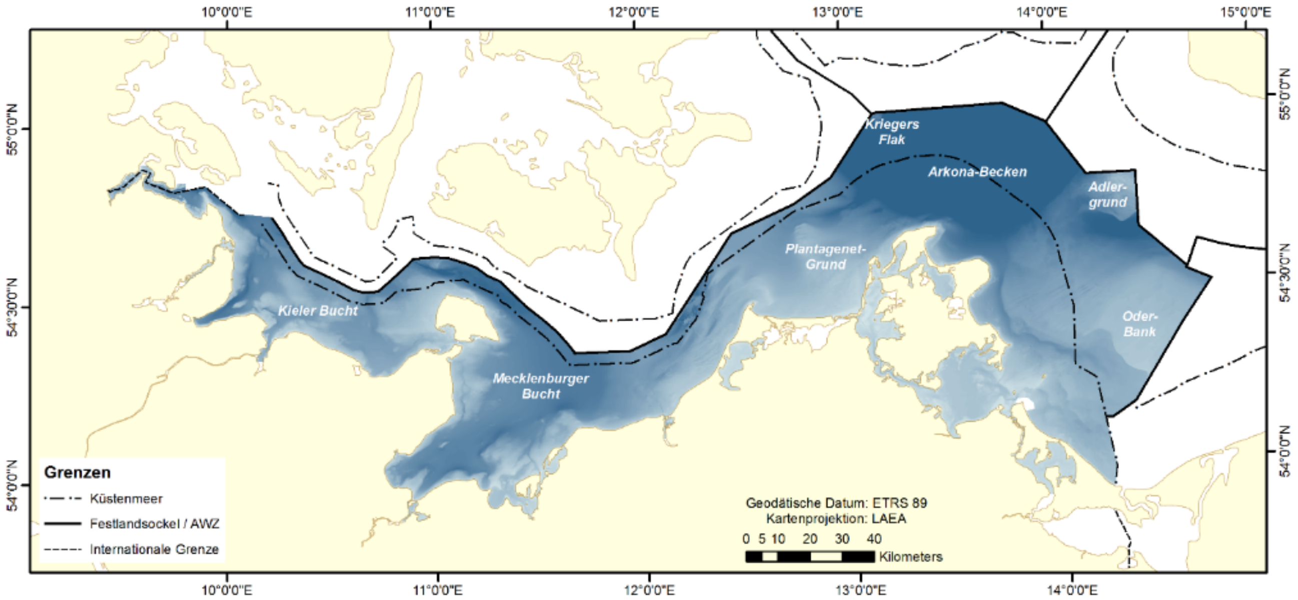

Figure 14: Illustration of the seabed relief (bathymetry, BSH/IOW, 2012) in the German Baltic Sea. The Bay of Kiel and the Bay of Mecklenburg together form the Belt Sea. The dark blue areas indicate the basins (e.g. Mecklenburg Bay or Arkona Basin), the shallower areas have correspondingly lighter shades of blue (e.g. Plantagenet Ground, Adler Ground 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 outlet of the Little and Great Belt. The Fehmarn Belt and Fehmarn Sound form the eastern boundary. The Bay of Kiel is a typical fjord coast whose narrow, deeply incised bays were formed by the erosive activity of the Weichsel glacier.

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

Figure 15 shows the sediment distribution on the seabed in the Bay of Kiel. Residual sediment deposits (coarse sand, gravel and also stone deposits) are mainly found in a narrow area along large parts of the Schleswig-Holstein coast, on shoals in the Bay of Kiel and west of Fehmarn. Silt deposits (mostly silts, but also clays) occur mainly in the deeper areas of the western Kiel Bight (Eckernförder Bight, Flensburg Fjord and the deeper areas of the EEZ). The central part of the Kiel Bight is dominated by fine and medium sands, which change to silty sands and silts in the depression west of Fehmarn.

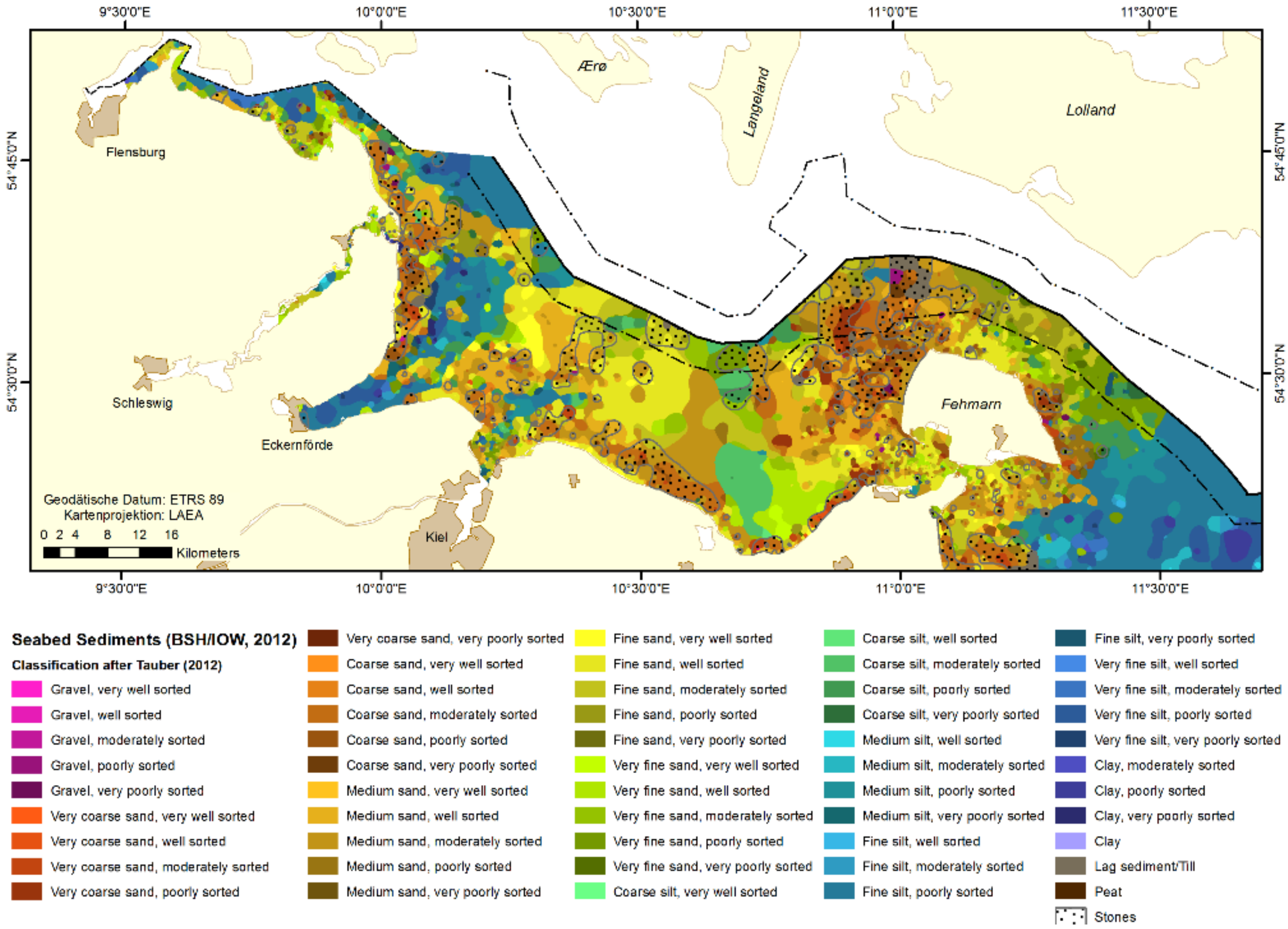

Figure 15: Sediment distribution on the seabed in the Kiel Bight area. (BSH / IOW, 2012).

It is significant 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 Litorina transgression about 8,000 years ago. According to Atzler (Atzler, 1995) the Holocene sedimentary layer consists of late glacial sands and ribbon clays in addition to the sediment distribution already described. While the sands occur exclusively in the outer area of the Kiel Fjord, the ribbon clays were deposited in old channel systems distributed over the entire Kiel Bight. The Holocene sediments lie on a Weichselian, 4 to 5 m thick boulder clay, which consists of a younger and older unit and reaches a maximum thickness of 70 m in the Kossauer Rinne (west of Fehmarn). Locally, Weichselian meltwater sands are intercalated in the boulder clay, which can carry numerous stones and erratic boulders.

In large parts of the Kiel Bight, the Weichselian deposits are followed by a Saaleian boulder clay and meltwater sands, which in turn usually lie on older glacial or Tertiary clays and sands. Several large, Pleistocene channel systems occur in this sea area, which are largely filled in today, but are still partly preserved as slight depressions in the seabed and correlate with the recent silt distribution.

Fehmarn Belt

The 18 to 24 km wide Fehmarn Belt occupies a central position for the exchange of water between the Belts and the neighbouring Baltic Sea basins to the east. The exchange between North Sea and Baltic Sea water mainly takes place 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 ice edge of the Öjet rises to a water depth of 10 m and narrows the cross-section of the Fehmarn Belt in such a way that the high current velocities have further cleared out the Vinds Grav formed during the overflow of Lake Anclyus, to a depth of 42 m.

As a result of the hydrodynamic conditions in the western part of the Fehmarn Belt, several mega- and giant ripple fields have formed in the western Fehmarn Belt. Figure 16 shows these mega- and giant ripple fields as elongated sandy structures running from SW to NE, lying on coarse to residual sediments. The giant ripples occur in 11 to 18 m water depth and consist mainly of medium sand. They have crest heights of up to 2 m and wave distances of 60 to 70 m. Smaller forms with distances of 25 m are found in water depths of 24 m.

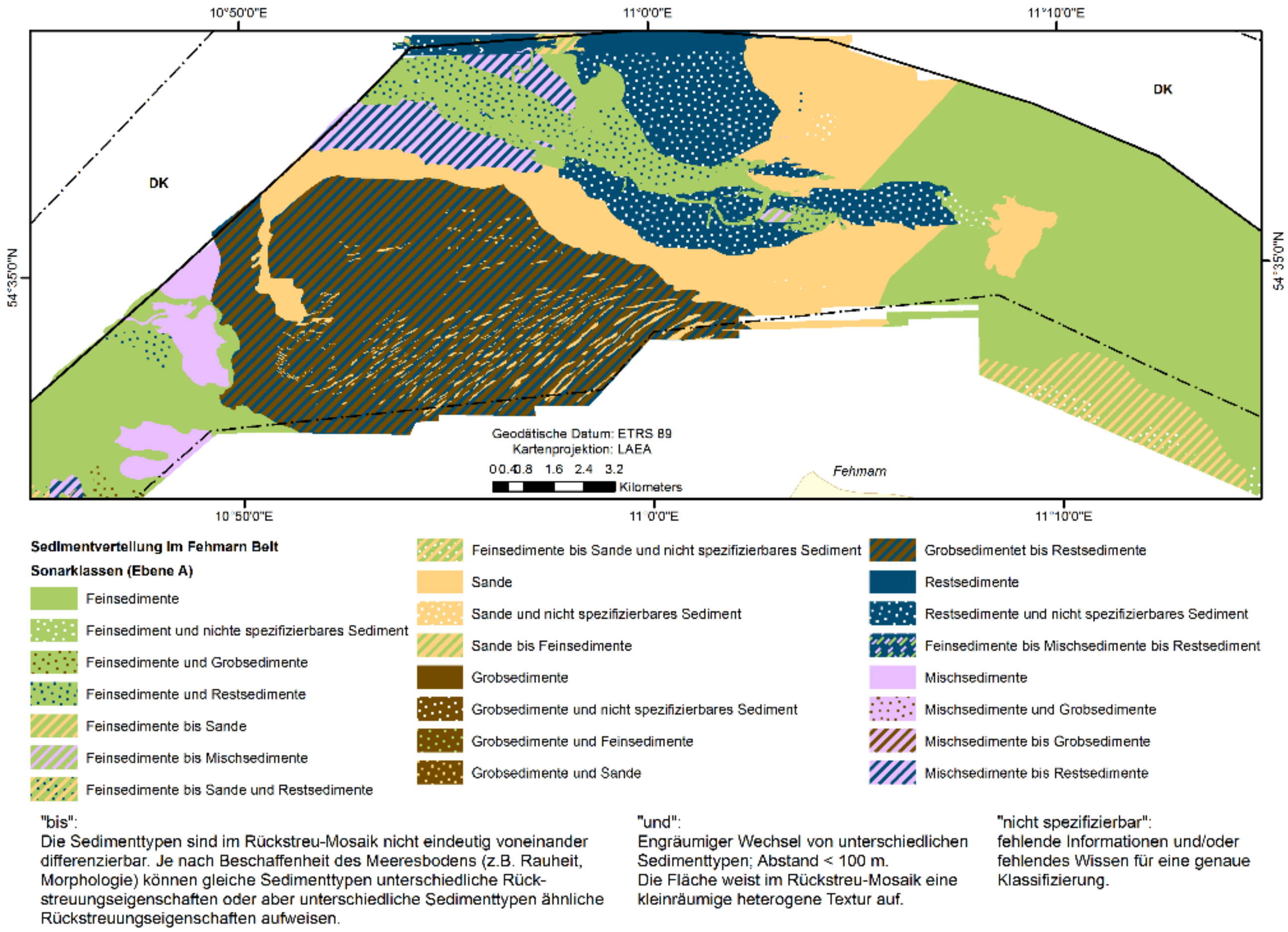

Figure 16: Sediment distribution on the seabed in the western part of the Fehmarn Belt. The sediment distribution map is based on side-scan sonar records. The sediment classification of level A is based on the simplified ternary system for clastic sediment types according to Folk (1954). Source: Project "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 of varying density (Figure 17).

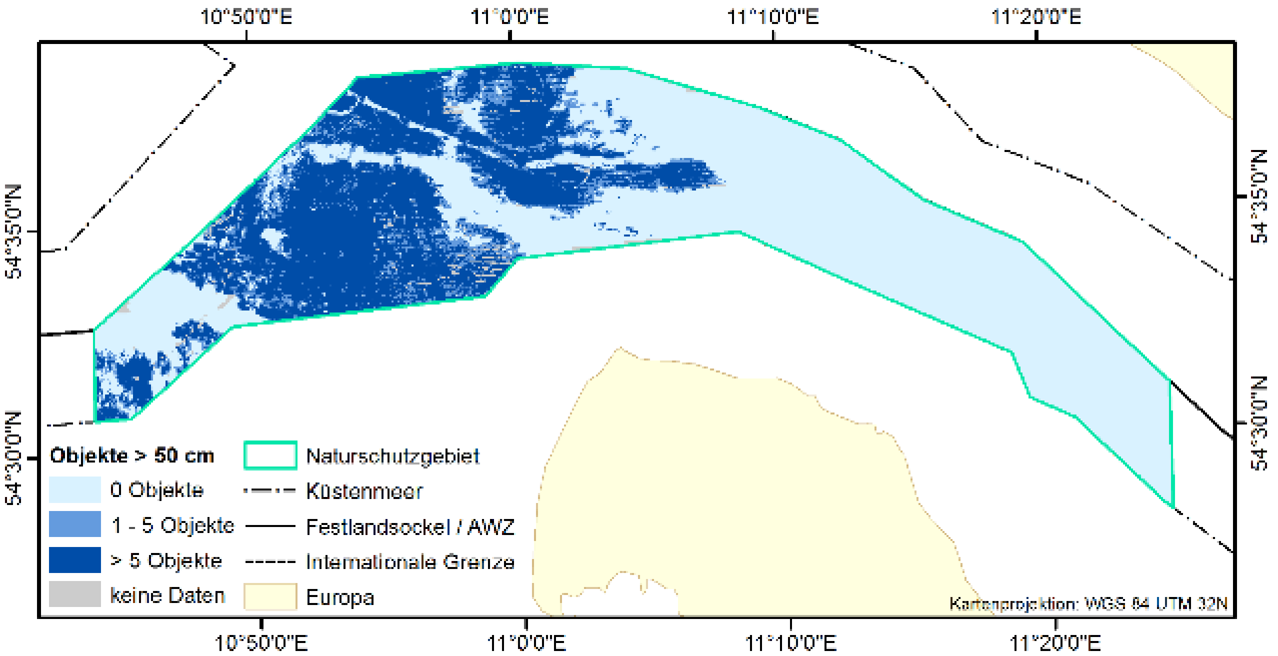

Figure 17: Representation of the occupation density of objects (stones or blocks from a size of about 50 cm) in the area of the Fehmarn Belt nature reserve. The representation is based on the 100x100 m EU grid, which was divided into 50x50 m grid cells. The number of objects per 50x50 grid cell is shown. 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.

In isolated cases, boulder clay may also be present on the seabed. In the eastern Fehmarn Belt, the boulder clay surface dips to the east and residual sediments or medium sands change into fine and ultrafine sands and silts, which are increasingly overlain by silt in the direction of the Mecklenburg Bay.

Figure 18 shows a geological profile section through the Fehmarn Belt between Put-garden and Rødby Havn. Above Tertiary clays and Cretaceous limestones lies a 6 to 57 m thick boulder clay, which in turn is overlain by up to 9 m thick basin clays of the central Fehmarn Belt. In the shallow water areas at the edge of the channel, predominantly sandy and silty gyttjen and peats occur, whose step-like offsets are associated with deep-seated faults in the Tertiary clays and Pleistocene boulder clay. Fault-related settlement and deposition of this sedimentary unit probably occurred simultaneously, so that tectonic movements influenced late and post-glacial sedimentation.

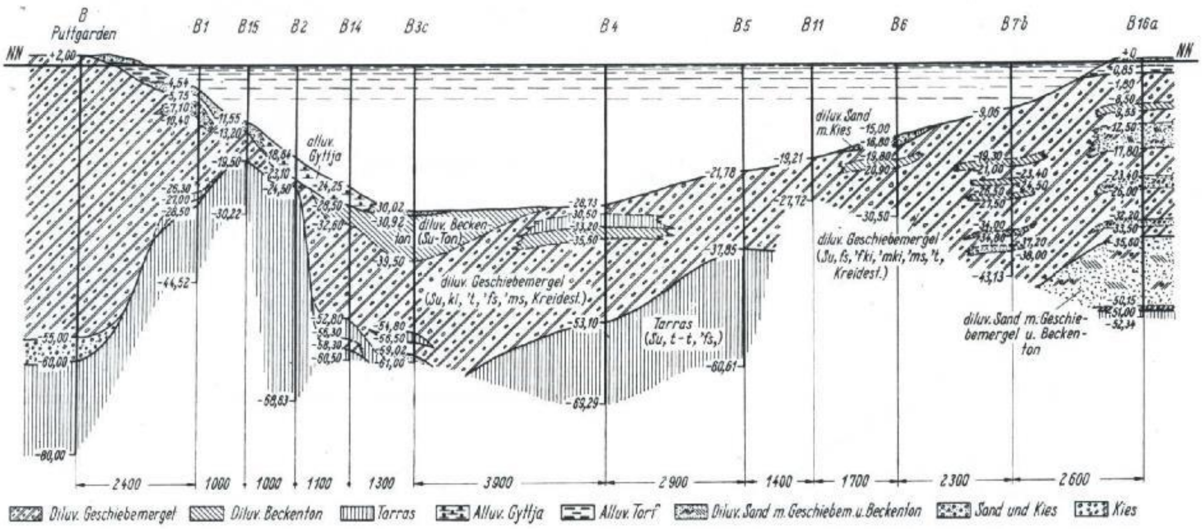

Figure 18: Geological profile section through the Fehmarn Belt between Puttgarden and Rødby-Havn (RUCK, 1969)

Mecklenburg Bay

To the east of the Fehmarn Belt is the Mecklenburg Bay, which, according to KOLP (1976), is delimited roughly along the 20 m depth line to the Darss Sill and the Fehmarn Belt. On average, the Mecklenburg Bight is somewhat deeper than the Kiel Bight, but significantly shallower than the Arkona Basin. The maximum water depth is about 28 m. In contrast to the Kiel Bight, the Mecklenburg Bight and the Arkona Basin lack the pronounced channel structures in today's seabed relief.

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

Towards the edge of the basin, above the 20 m depth line, the silt changes to fine and medium sands, in places also to coarse sands and residual sediments. Larger occurrences 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 Mecklenburg Bay (north-west of the island of Poel, Figure 19). In the north-east of the Mecklenburg Bay, the sediments change to silty fine and ultrafine sands in the direction of the Darss Sill.

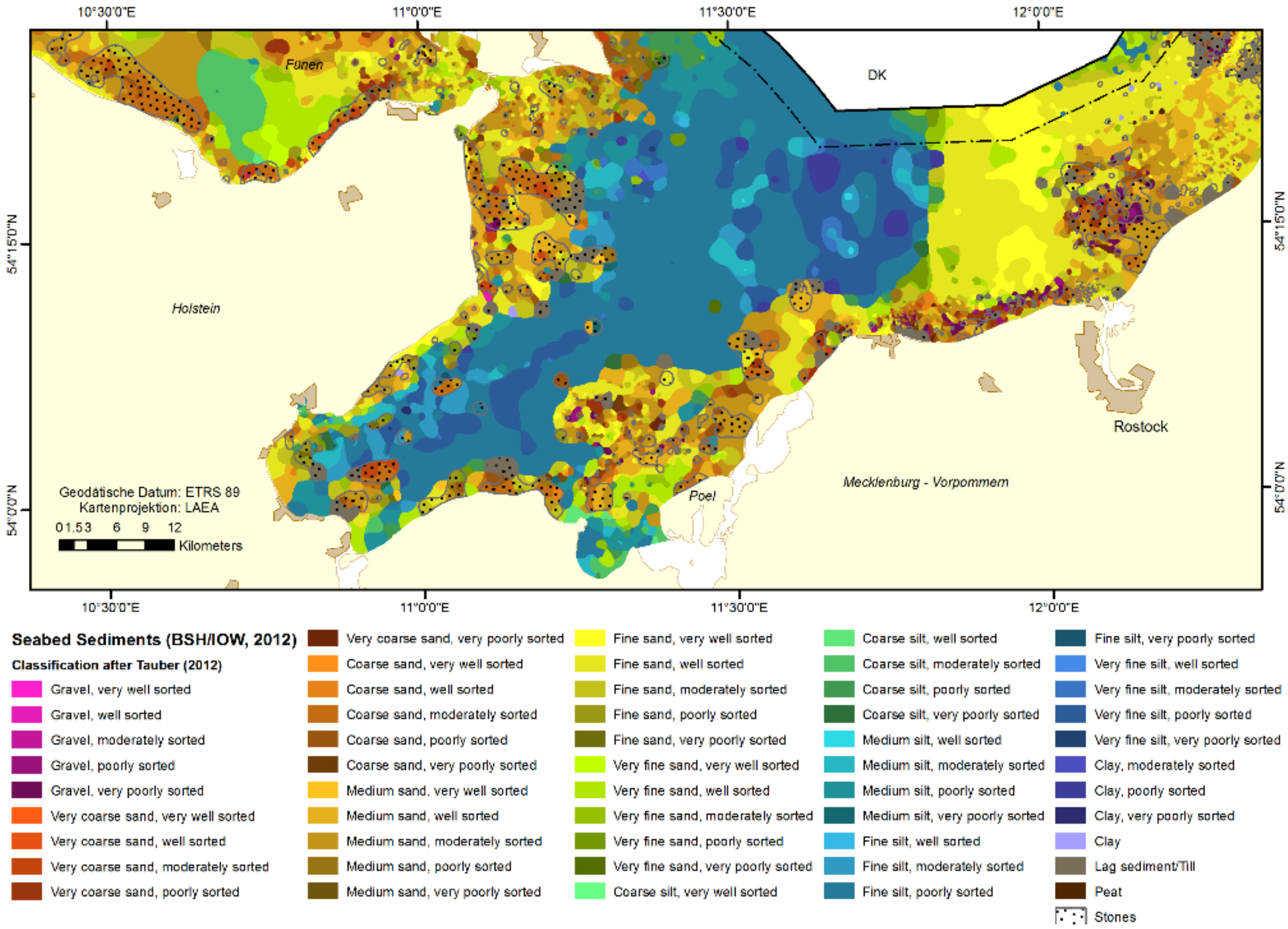

Figure 19: Sediment distribution in the area of the Mecklenburg Bight (BSH/IOW, 2012). The marginal areas of the silt (blue colours in the centre of the basin) trace the 20 m depth line quite well. The EEZ in the area of the Mecklenburg Bay lies entirely in the northern part of the silt area.

The Quaternary base of the Mecklenburg Bay probably consists of Tertiary sediments and lies at depths between 50 and 120 m below sea level. Above this follows the boulder clay, which can be subdivided into two units similar to those in the Bay of Kiel or the Arkona Basin. The lower boulder clay is probably between 20 and 120 m thick. The upper boulder clay, on the other hand, is less thick; the values are in the metre range. It has a grey to grey-brown colour and contains numerous Cretaceous and Flint gravels. In the deepest parts of the Mecklenburg Bight and the Fehmarn Belt, sediments from the time of the early Baltic Ice Lake (W2) are found, which largely follow the morphology of the boulder clay.

In water depths above 20 m, late glacial sediments from the phase of the Late Baltic Ice Reservoir (W3) occur. They consist of stratified clays that change to fine sands towards the basin margin. In the deeper areas they also follow the morphology of the underlying strata, outside these late glacial basins they are horizontally bedded. The early Holocene freshwater formations of the W4 unit are 1 to 2 m thick in the central Mecklenburg Bight and extraordinarily diverse lithologically: in addition to grey medium to coarse sands and grey clayey silts, there are peat gyttjen and peats as well as strongly calcareous gyttjen and sea chalk. Plant remains frequently occur in these sediments, the surface of which has been partially eroded. The youngest deposits are the littoral and younger marine sediments (W5). They even out the relief of the subsoil and are generally up to 7 m thick, locally thicknesses of over 10 m can be reached. Towards the edge of the basin, the unit wedges out and merges into low thickness sands. The base of the silt forms a transgres-sion contact, which can often only be recognised via various mollusc species.

Darss Sill

The Darss Sill is the sea area between the Fischland-Darss peninsula 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 line (KOLP, 1976). It represents an elevated position with an average water depth of 17 m, which separates the lower-lying silt accumulation areas of the Mecklenburg Bay and the Arkona Basin. In a geological sense, the Darss Sill is more narrowly defined as an approximately 12 km wide strip between Fischland-Darß and Falster, which is enclosed by two submarine moraine trains (Darß Sill in the narrower sense) and merges eastwards into the Falster-Rügen Plate (KOLP, 1965).

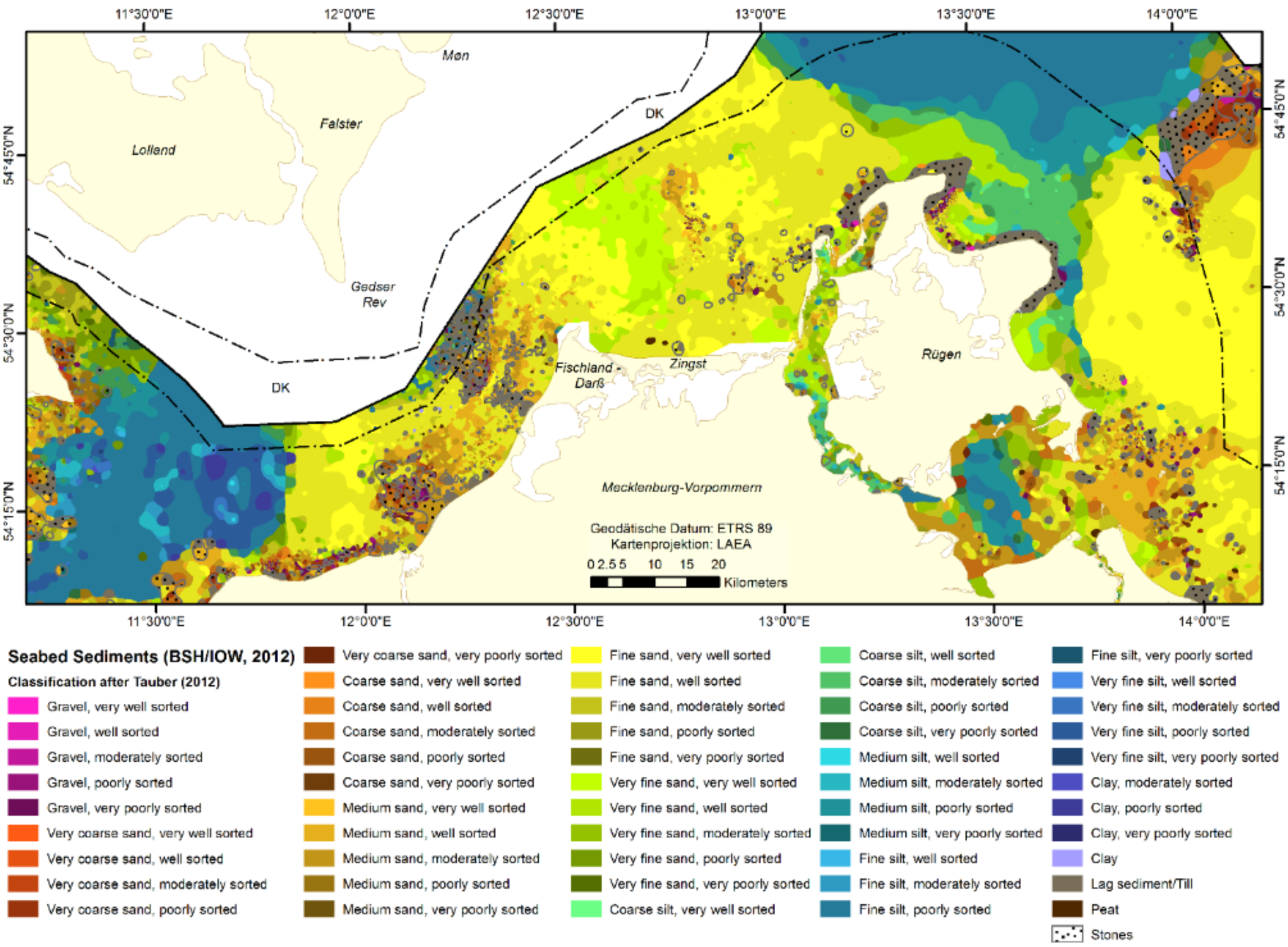

Figure 20: Sediment distribution on the seabed in the area of the Darss Sill between the Mecklenburg Bay in the west and the Arkona Basin in the east. The Darss Sill in the narrower sense is characterised by a submarine boulder clay ridge that runs from the steep shore between Wustrow and Ahrenshoop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

The Darss Sill in the narrower sense and the Falster-Rügen Plateau show great morphological differences. The relief of the Darss Sill in the narrower sense is characterised by striking, small-scale changes in morphological forms. The dominant element is a submarine ridge of boulder clay, which runs from the steep shore between Wustrow and Ahrenshoop in a north-westerly direction to Gedser Rev (Figure 20). The furrow system of the Kadetrinne is cut up to 32 m deep into this ridge. South-east of the actual Kadetrinne, the V-shaped, elongated Grenztal-Rinne with a maximum water depth of 22 m runs parallel. The water depths are predominantly between 10 and 20 m, with spatially narrowly delineated, 2 to 3 m high uplifts of the seabed observed particularly on the flanks. In the deepest parts of the cadastral channel, which on closer inspection consists of three channels, the strong bottom currents have carved out a strongly varying, small-scale relief depending on the bottom conditions. Here, boulder clay ribs of 1 to 2 m height alternate with flat fine sand and silt surfaces in irregular succession. Mixed sediments occur along the entire course of the cadastral channel. The Kadet Channel is subject to aperiodic silt sedimentation, with interruption or clearing occurring when the thermocline between saline deep water and lower saline surface water becomes ineffective in strong inflow and presumably also outflow situations. The highest and steepest outcrops are observed in the central part of the cadastral channel. The channels have an irregular valley floor and are characterised by very steep slopes in places. Giant or megaripples with crests of about 400 m are observed in the gullies (SHD, 1987; DIESING and SCHWARZER, 2003). Comparable forms with crest heights of up to 5 m are found on the Darss Sill (LEMKE et al., 1994). The morphological structures indicate pronounced sedimentary dynamic processes similar to those in the Fehmarn Belt or the Danish Belts.

The Darß sill in the narrower sense consists of an elevated bed of boulder clay, on whose back and especially on the flanks of the gullies there is a varying density of stone and block cover. The bottom and flanks of the Grenztal gully, on the other hand, are free of residual sediments. Here, more than 10 m thick sands overlie the boulder clay. An elongated sand ridge at a water depth of 14 to 15 m separates the Grenztal channel from the channel system of the Kadet channel (TAUBER and LEMKE, 1995).

The Gedser Rev (Falster Island, DK) is the submarine southern spur of the island of Falster and represents the geological-morphological continuation of the broad boulder clay high layer 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 boulder- and boulder-covered boulder clay surface with local uplifts. In extension of the southwest slope, a 50 to 60 cm thick gravel layer is found on the Gedser Rev at depths of 8 to 10 m, which was subject to extraction for construction purposes over a longer period of time (KOLP, 1966).

The Falster-Rügen Plateau, which borders the Darss Sill to the east, is much lower in relief and, with the exception of the Plantagenet Ground, which rises to a water depth of less than 8 m, and a gully structure to the north of it in the direction of the Arkona Basin, has hardly any morphological structure. It is predominantly covered by calcareous fine sand with humic particles and tiny plant remains as well as peat layers. The thickness of the sands ranges from 10 m to 50 m. They largely level the late glacial relief (TAUBER et al., 1999).

The base consists of three boulder clay horizons, which are presumably of Elster, Saale and Weichselian age. The Elsterian boulder clay (unit 1a) is recorded in the area of the cadastral channel, but not directly exposed on the seabed. It is brownish-grey to greenish in colour and has a high strength. Its thickness varies between 2 and 26 m. The Saale period boulder clay (unit

1b) is firm, grey and contains numerous Cretaceous boulders. It occurs almost extensively in the area of the Darss Sill in the narrower sense. Its thickness ranges from a few decimetres in the area of deep gullies to up to 26 metres. In the deeper sections of the Kadet channel, the middle boulder clay is underlain by a thin layer of silt or residual sediments. The Weichselian boulder clay (Unit 1c) can be clearly traced in the seismograms on the Darss Sill in the narrow sense. On the Falster-Rügen plateau, only the upper edge of the boulder clay is recorded, without a reliable chronological assignment being possible. West of a line Darßer Ort - Møn its surface dips into the Arkona Basin. The thickness of the Weichselian boulder clay varies between 1.6 m and 16.9 m. It is grey to brown in colour. It is grey to brownish grey, has a plastic to very firm consistency and is characterised by numerous Cretaceous debris. Its surface is covered on the seabed by unsorted, coarse residual sediments consisting of stones and boulders up to over 1 m in diameter. Scouring around the stones and boulders indicates the intense effect of the strong current conditions.

Units 2 and 3 are sandy to silty sediments, which were deposited as meltwater deposits of the gullies cut into the boulder clay up to 50 m below sea level. Their thickness reaches up to 15 m. Plant remains prove the relatively old age of the fine sands, which occur under a 30 cm thick sand layer and originate from the Yoldia stage (about 10,200 - 9,300 years before today) of the Baltic Sea. In places, the fine sands contain clays several metres thick, which accumulated in late glacial reservoirs. The distribution of Unit 3 is essentially restricted to the western edge of the Arkona Basin, the Grenztal and Vierendehl channels. They are predominantly well to moderately sorted olive-grey fine sands with high calcareous content, which pass to the Arkona Basin into the fine-grained facies of the Late Glacial clays. The sediments of unit 4 are characterised by a great lithological diversity. On the Falster-Rügen plate they occur mainly bound in shallow channel and basin structures. In the area of the Darss Sill in the narrower sense, they are represented by peats, peat and lime gyttjen and interbedded fine sands. Unit 5 comprises the post-Ancylusian sediments (marine sands, after about 8,000 years before present), which rarely exceed 2 m in 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 rather patchily distributed and only locally more than 3 m thick in backfilled gullies.

The Quaternary base lies at about 90 m below sea level and is formed by Jurassic sedimentary rocks (LEMKE, 1998). It rises from Fischland to the north-east, where Cretaceous rocks form the base. In the Prerow fault zone, the base of the Quaternary is 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 sub-area "Arkona Basin" is bounded by the 40 m depth line to the Fals-ter-Rügen plateau. In the west, the Kriegers Flak elevation protrudes into the basin. In the northeast, the Arkona Basin is connected to the Bornholm Basin via Bornholmsgat; in the east, it borders on the shoal of Rønne Bank with Adlergrund as its southwestern extension. The Arkona Basin is characterised by a uniform basin structure. The maximum water depth is over 50 m.

The sediment distribution on the seabed in the Arkona Basin (Figure 21) consists of clayey, fine and medium, poorly sorted silts (silt) of mostly very soft to mushy consistency. The silt is of grey-olive colouration and usually carries little shill (shell remains); in places bioturbate structures are described. Towards the edges of the basin, the silt sediments become sandier.

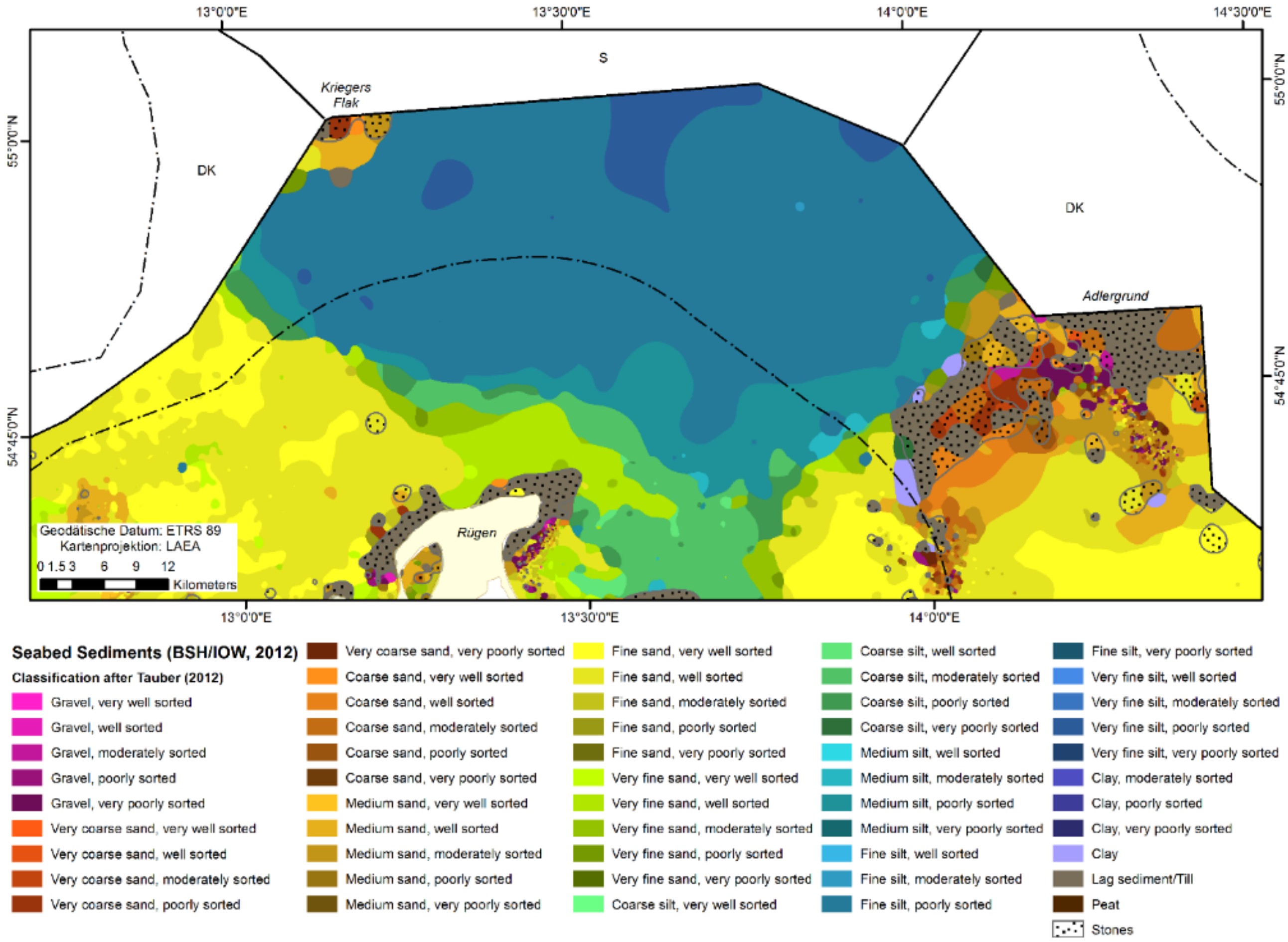

Figure 21: Sediment distribution on the seabed in the Arkone Basin area (BSH/IOW, 2012.) The seabed consists mainly of clayey, fine to medium, poorly sorted silts of soft to mushy consistency.

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

Due to the high gas content of the silt sediments, large areas of the Arkona Basin cannot be mapped with reflection seismic methods, or only to a limited extent. Nevertheless, the geological structure of the subsurface can be reconstructed using locally available results from so-called "seismic windows".

In the Arkona Basin, the lowest unit can be divided into two boulder clay horizons (E1b and E1c), both of which are presumably of Weichselian age. The upper limit of the lower boulder clay horizon can be traced over large areas of the Arkona Basin. The greatest depth of 78 m below sea level occurs north-northeast of Cape Arkona. The lower boulder clay is grey in colour and consists mostly of clayey, partly fine sandy material of high strength. It carries numerous small boulders, the composition of which is dominated by scribal chalk and flint boulders. The lower boulder clay is up to 35 m thick. The upper boulder clay (E1c) traces the relief of the lower boulder clay (E1b) in large parts. It has thicknesses of hardly more than 12 m, is partly patchily distributed and wedges out towards the edge of the basin.

This is followed by the late glacial "pink" clays of units E2 and E3. Their differentiation in the seismograms is only possible in the area of the basin margin, such as in the lake area between Tromper Wiek and Adlergrund. They are found throughout the southern Arkona Basin and consist of stratified reddish to reddish brown warp clays (E2) and a homogeneous, strongly silty, reddish clay (E3), which can be up to 16 m thick in areas with low-lying boulder clay. They trace the surface of the boulder clay. Unit E4 consists of grey, postglacial silty clays, silts and humic sediments of the Yoldia and Ancylus stages, which occur on the southern and western margins of the Arkona Basin. Characteristic features of the grey silts are the dark grey to black layers, lenses and mottles. Their surface generally follows the relief of the reddish to reddish brown clays. They reach thicknesses of up to 5 m. Unit E5 consists of silt in the central part, which changes to sandy silt or silty sands towards the basin edge. The thickness is usually 2 to 4 m, although depending on the relief, thicknesses of up to 10 m may be possible, which is particularly the case in the centre of the southern sub-basin. Silt sedimentation has led to extensive levelling of the relief. The silt has an olive to dark grey colour and is soft plastic. It often has streaks, lenses and narrow lamellae consisting of slightly lighter, coarse silty to fine sandy material, which are due to bioturbation. The surface of the silt is covered by a few millimetres thick, brownish, fluffy layer. Immediately below this 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 dissolved mollusc shells.

Kriegers Flak In
the west of the Arkona Basin, the foothills of the Kriegers Flak shoal protrude into the area of the German EEZ. Here, the water depths range from 21 m in the area of the shoal to 40 m in the direction of the Arkona Basin. In contrast to the Arkona Basin, the Kriegers Flak shallow (see also Figure 21) has a highly structured morphology and a very heterogeneous lithological composition of the surface sediments, which show the typical sill character and are closely related to the geological formation and postglacial overprinting. In the higher areas of the Kriegers Flak shallow, the seabed surface mainly consists of residual sediments, boulder clay, gravels and medium to coarse sands. Especially in the northern part of Kriegers Flak shallow, there are also numerous stones and boulders, some of which form wall-like structures. Towards the Arkona Basin, the coarse sands change into medium and fine sands and, with increasing depth, into silts and clays.

The boulder clay is more than 25 m thick in the northwestern area of the shoal. It is clearly consolidated and inhomogeneous in its lithological composition. Characteristic are the numerous stones and boulders, which also occur below the seabed surface and led to the premature abandonment of drilling during exploratory drilling for the location of the FINO 3 measuring platform. To the south, its surface dips below late glacial clays about 5 m thick, which can reach over 10 m in thickness in gully fillings, where they can be formed as very soft ribbon clays. In addition, sand, gravel, silt and peat can be expected in these old gullies. In the southern slope area, the late glacial clays are buried under an approx. 8 m thick sand wedge.

Adlergrund
The Adlergrund is the south-western outlet of the Rønnebank, which stretches as a shoal from Bornholm towards the south-west. The seabed has a very uneven relief due to its glacial formation history and postglacial overprinting. The water depths range from 5 m at the Foule bottom to 25 m.

Like the Kriegers Flak shallow, the Adlergrund has a very inhomogeneous sediment composition (Figure 21), with large areas dominated by residual sediments (coarse sand, fine gravel and stones) on overlying boulder clay. The stones are fist- to head-sized and occur sporadically to extensively in these areas. In addition, blocks (erratic blocks) with a length of several metres are common, which are covered with mussels (Mytilus) of varying density. In the southeast, the boulder clay forms regular outcrops. In the southern half, a residual sediment band with low sand cover runs parallel to the slope through the area. The low-density marine 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 mud of the Arkona Basin. To the south, there is a continuous transition to the sandy areas of the Pomeranian Bay and Oder Bank (DIESING and SCHWARZER, 2003).

The Adlergrund owes its formation to the activity of the Weichsel glacier. In the course of various ice advances and retreats, considerable accumulations of meltwater deposits in the form of sands and gravels occurred in connection with significant thrusts of boulder clay. In the southern area, delta-like fillings created sandbank-like structures. The base is the Cretaceous Cretaceous, which due to its glacial-tectonic stress has fault zones and intermediate layers of sands, gravels or stones. This is followed by a 6 to 10 m thick boulder clay, which is close to the surface in the central area of the Adlergrund. On its flanks it is overlain by a sequence of coarse and gravel sands, medium to coarse sands and fine sands. Underneath, late glacial clays and silts of the Bornholm and Arkona Basins wedge out. During the Litorina transgression (about 8000 years ago), the sand complexes were worked up on their surface, forming complexly built up accumulation bodies.

Oderbank

This sub-basin is bounded to the north roughly along the southern foothills of the Adlergrund and merges with the Bornholm Basin to the east on Polish territory. The water depths are about 7 m in the shallowest parts of the Oderbank and reach maximum values of 31 m. The actual Oderbank is defined by the 10 m depth line. The actual Odra bank is limited by the 10 m depth line (KRA-MARSKA, 1998). Between the relatively steep southern slope of the Oder Bank and the coast, the seabed morphology is characterised by depressions and shoals with a height difference of up to 3 m; the northern slope, on the other hand, dips gently towards the northeast.

Sedimentologically, the largely structureless seabed in the area of the Oderbank is essentially 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 area of the Oderbank. Residual sediments in the form of isolated rock deposits predominate off the Greifswalder Bodden and off Usedom as well as north to north-east of the Oder Bank in the Adlergrund channel, but not in the same density as on the Adlergrund (BOBERTZ et al., 2004). In the northwestern area of the Oderbank, isolated residual sediment deposits (stones up to 1 m in diameter) occur as well as mussel fields ranging in size from a fist to several square metres and smaller ripple fields of coarse sand (SCHULZ-OHLBERG et al., 2002).

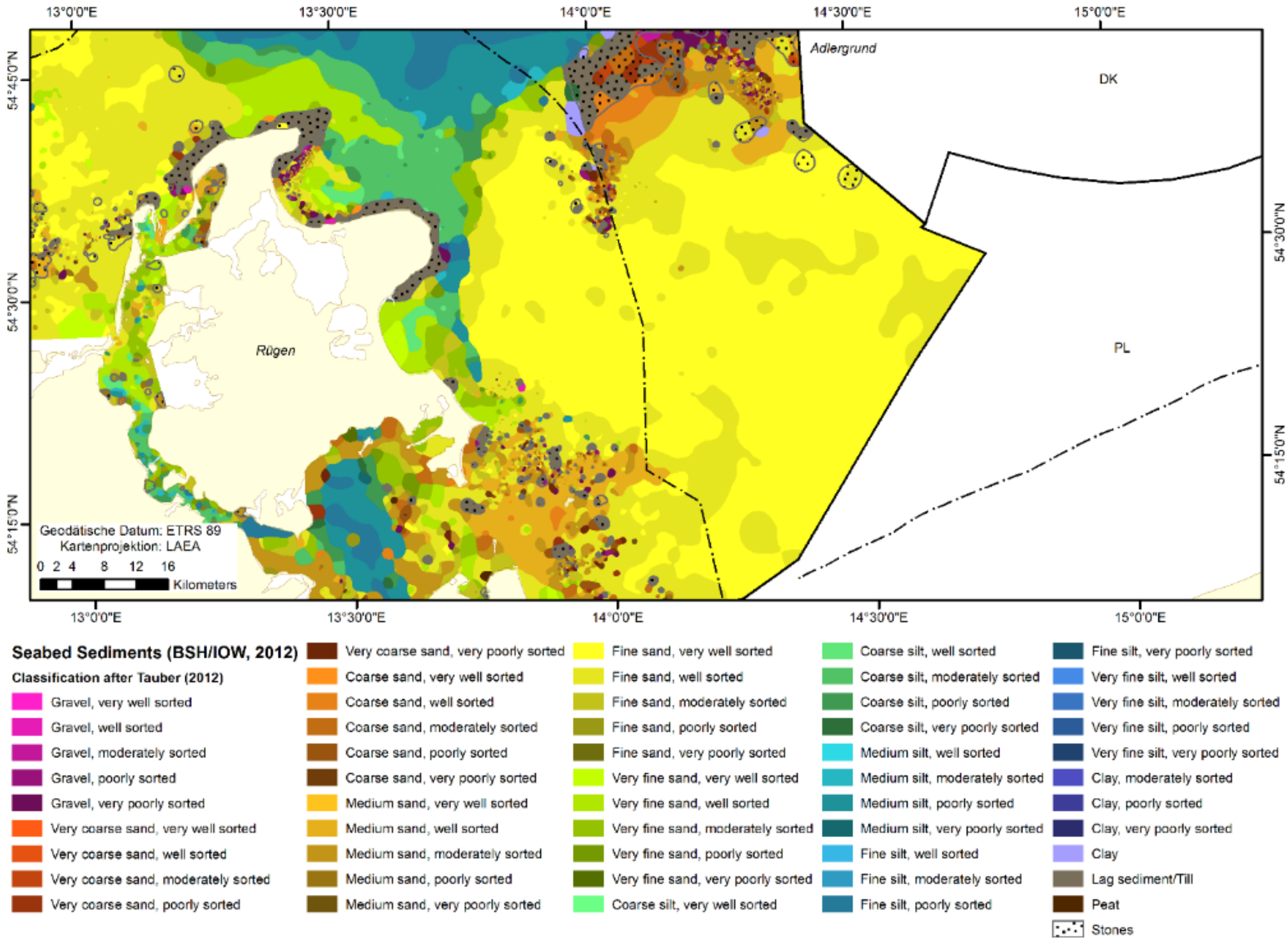

Figure 22: Sediment distribution on the seabed in the area of the Oderbank (BSH/IOW, 2012). The seabed in the area of the Oderbank is dominated by well to very well sorted fine sands.

In addition, elongated to oval formations with a higher reflectivity than the surrounding sandy bottom were observed in the sonograms (side-view sonar recordings), which can be 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 Oderbank has glacial and fluvioglacial sediments at its core (Figure 23). The boulder clay forms two locally different units, whereby the older one has so far been recorded exclusively in seismograms and lies directly on the Cretaceous basement. The younger boulder clay is closely under the seabed and extends as a low thickness deposit from the coast to the Oder Bank, probably disappearing in the northern slope area and resurfacing in the Bornholm Basin. The two boulder clay layers are separated by a Pleistocene sand package up to 30 m thick.

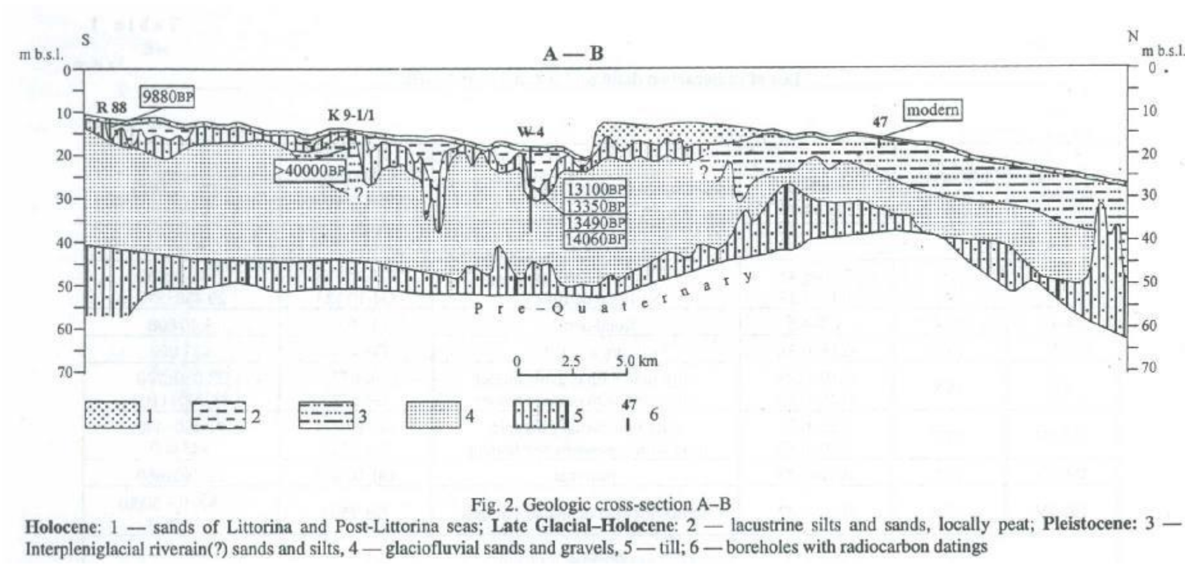

Figure 23: Geological profile section through the eastern foothills of the Oderbank on the Polish side (from: KRAMARSKA, 1998).

On the Polish side of the Oder Bank, the pronounced palaeorelief of the boulder clay was levelled by marsh and lake sediments in the Late and Postglacial. On the Oderbank, littoral and postlittoral sand barrier deposits overlie the younger boulder clay, which carry gravel and mollusc shells at their base and are presumably covered by former dune sands at their surface. The sands reach thicknesses of about 6 to over 10 m. To the north, they submerge at a water depth of about 20 m under wedging marine sands of the Baltic Sea, the thickness of which hardly exceeds 1 m. The southeastern extension at 12 m is probably covered by former dune sands. The south-eastern extension in 12.5 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 primeval 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).

2.2.3 Pollutant distribution in the sediment

2.2.3.1 Metals

In the western Baltic Sea (Mecklenburg Bay to Arkona Basin), due to the shortness of the available measurement series, no trend in the metal content of the surface sediments can be identified to date. The main areas of contamination are in the Lübeck Bay and in the western Arkona Basin. In addition to the historical loads, metals are mainly discharged into the Baltic Sea via rivers and atmospheric deposition. In addition, there are possible input pathways from the various forms of use, such as maritime shipping and the offshore industry, which will have to be quantified more precisely in the future.

With the capping of the contaminated site in the Bay of Lübeck and the associated containment of the resuspension (resuspension) of contaminated material, a normalisation of the sediment quality in this area is expected in the long term. In the western Arkona Basin, elevated mercury and lead levels in particular have been measured for years. The causes of this anomaly are not yet known. Towards the coast, an increase in element contents in the surface sediment is usually observed. This is especially true for mercury and cadmium, but also for zinc and copper. The lead contents measured in the EEZ, on the other hand, are quite comparable with the values observed near the coast, and in some cases even exceed them. In the MSFD Report 2018, the concentrations of the HELCOM indicator substances lead, cadmium and mercury in sediment in the EEZ exceed the threshold values (Zustand der deutschen Ostseegewäs-ser 2018).

2.2.3.2 Organic substances

A summary overview of sediment loads 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 the TOC content (TOC=total organic carbon) or a grain size standardisation.

Pollutants reach the Baltic Sea via direct discharges, rivers and the atmosphere as well as indirect sources. Rivers and the atmosphere represent the main input pathways into the marine environment. Besides input sources, input quantities and input pathways (directly via rivers, offshore industry or diffusely 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 pollution hotspots often occur.

Further regional assessments require the consideration of sediment parameters (TOC, grain size distribution). In the EEZ, there is a relatively homogeneous distribution with comparable TOC contents in the sediments; at stations with a low proportion of fines and low TOC values (sandy sediments), the load is always very low. Compared to the North Sea (German Bight), concentrations in the Baltic Sea EEZ are on average significantly higher; this is most likely due to the higher TOC and silt contents of Baltic Sea sediments. In the MSFD Report 2018, the concentrations of the HEL-COM indicator substances anthracene and TBT in the sediment of the EEZ exceed the threshold values (State of the German Baltic Sea Waters 2018). However, the data situation is insufficient, so that no statements on temporal trends are possible.

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

2.2.3.3 Radioactive substances (radionuclides)

Compared to other marine areas, the surface sediments of the Baltic Sea have significantly higher specific activities than, for example, those of the North Sea. This statement also applies in most cases to natural radio-nuclides. On the one hand, this effect is due to the fact that the grain size of the more silty and thus finer-grained sediments of the Baltic Sea is smaller; on the other hand, this is also due to the fact that the lower turbulence in the water of the Baltic Sea leads to sedimentation of the finer particles. The radioactive load of the Baltic Sea is determined by the fallout from the Chernobyl accident in 1986. The higher surface deposition of the Chernobyl discharge on the area of the western Baltic Sea compared to the North Sea is also reflected in the increased activities. In the development, it can be observed that the inventory in the sediments increased steadily in the first years after the Chernobyl accident. For about 10 years, a stagnation has been observed, which can be explained by a quasi-equilibrium between radioactive decay (half-life of Cs-137: 30 years) and further deposition. Although the radioactive contamination of the Baltic Sea by artificial radionuclides is higher than in the North Sea, it does not pose a danger to humans and nature according to current knowledge.

2.2.3.4 Contaminated sites

Possible contaminated sites in the Baltic Sea include munitions remnants. In 2011, a federal-state working group published a basic report on the ammunition contamination of German marine waters, which is updated annually. According to official estimates, the seabed of the North Sea and the Baltic Sea contains 1.6 million tonnes of old ammunition and various types of ordnance. A significant part of these munitions legacies originate from the Second World War. Even after the end of the war, large quantities of ammunition were dumped in the North and Baltic Seas to disarm Germany. According to current knowledge, the explosive ordnance load in the German Baltic Sea, especially in the territorial sea, is estimated at up to 0.3 million tonnes. The overall data situation is insufficient, so that it can be assumed that explosive ordnance deposits are also to be expected in the area of the German EEZ (e.g. remnants of mine barriers, combat operations and military exercises).

In principle, the ammunition remnants can silting up or be exposed on the seabed if the sediment properties are appropriate. In addition, storm events or strong currents can lead to ammunition bodies in the sediment being exposed. Ammunition bodies can thus represent artificial hard substrates.

Current research results indicate that the state of corrosion of ammunition stored in the sea may be advanced. Whether and to what extent the marine environment is affected by the release of toxic substances (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, agenda item 27.

The location of the known munitions disposal areas can be found on the official nautical charts and in the 2011 report (which also includes suspected areas for munitions-contaminated areas). The reports of the Federal Government/Länder Working Group are available at www.munition-im-meer.de.

2.2.4 Condition assessment

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

2.2.4.1 Rarity and endangerment

The aspect "rarity and endangerment" takes into account the areal proportion of sediments on the seabed and the distribution of the morphological form inventory in the southwestern 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 Mecklenburg Bay or the Arkona Basin as well as the form inventory essentially correspond to basin sediments that can be found in this or similar forms in all basins of the Baltic Sea. The sediment types found on the sills and shoals (e.g. Kriegers Flak, Adlergrund or Darßer Schwelle), such as boulder clay and residual sediments as well as rock and boulder deposits, are common in the western and southwestern Baltic Sea.

The aspect "rarity and endangerment" is therefore assessed as "medium-low".

2.2.4.2 Diversity and Eigenart

The aspect "diversity and uniqueness" considers the heterogeneity of the described surface sediments and the expression of the morphological form inventory.

Both the sills and shoals such as Kriegers Flak, Adlergrund and Darßer Schwelle as well as large areas of the Bay of Kiel and the Fehmarn Belt show a heterogeneous distribution of sediment and a partly quite distinct inventory of forms. This applies in particular to the distinctive, inflow-related bottom forms in the Fehmarn Belt and the Darss Sill in the narrower sense. In contrast, the basin areas such as the Mecklenburg Bay or the Arkona Basin show a very homogeneous sediment distribution and a structureless seabed.

The aspect "diversity and distinctiveness" is therefore assessed as "medium - high", mainly due to the distinctive structures in the Fehmarn Belt and the Darss Sill in the narrower sense.

2.2.4.3 Existing pressures

Natural factors

Climate change and sea level rise: The Baltic Sea region has experienced dramatic climate change over the last 11,800 years, with a profound change in land/sea distribution due to a global sea level rise of 130 metres. For about 2,000 years, the sea level of the Baltic Sea has adjusted to today's level and is subject to short-term, meteorologically induced changes. Storms cause the most sweeping changes on the seabed. All sediment dynamic processes can be traced back to meteorological and climatic processes, which are essentially controlled by the weather patterns in the North Atlantic.

Tectonic and isostatic movements, earthquakes: the tectonic and isostatic processes are secular processes, i.e. they cover periods of several millennia. They have their causes in the plate-tectonic movements of the earth's crust and therefore run over a large area. ANDREN and ANDREN (2001) found evidence in sediment cores that the Tsumani wave of the submarine Storegga landslide in the Norwegian Sea may have spread into the Baltic Sea about 8,000 years ago. The trigger was probably a seaquake. The analysis of earthquake frequency and magnitude for the southwestern Baltic Sea region illustrates 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 southwestern 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 deficiencies leading to the formation of gyttja, which has a much softer consistency than silt deposits.

Fisheries: In the Baltic Sea, bottom trawls with otter trawls have been used almost exclusively in commercial fisheries since the end of the First World War. Beam trawling does not take place in this sea area (RUMOHR 2003). For the area under consideration, there are only singular observations of fishing tracks.

In general, the investigations in the Bay of Kiel show that the distribution density of trawl tracks increases with water depth and the decreasing mechanical resistance of the sediments. The absence of trawl tracks on sandy bottoms is less due to lower fishing activity than to the higher re-deposition potential of these sediments. For the remaining part of the southwestern Baltic Sea, there are only singular observations.

LEMKE (1998) describes numerous fishing tracks in the mudflats of the Arkona Basin. In the area of the Pomeranian Bay, shear board tracks are limited to an area southwest of the Oder Bank (SCHULZ-OHLBERG et al. 2002). Penetration depths can reach up to 23 cm in mud (WERNER et al. 1990), up to 15 cm in muddy fine sands (ARNTZ & WEBER 1970) and up to 5 cm in sands (KROST et al. 1990). Far smaller traces are left by the roll and ball harness, which according to diver observations can be 2 to 5 cm deep (KROST et al. 1990).

Experimental investigations with a 3 m crab trawl in the Baltic Sea showed penetration depths of max. 17 mm for the chains and over 40 mm for the skids (PASCHEN et al., 2000). The width of the shear board tracks depends on the angle of attack, which in turn is influenced by the nature of the sediments. In the case of "bouncing" shearboards, it is between 1 and 2 m. This phenomenon occurs when the shear boards penetrate too deeply into the soft soil and bounce over the compressed sediment. Mostly, however, the shear boards are pulled "over corner" at an angle of attack of 35° to 40°, leaving tracks less than 1 m wide (KROST et al., 1990). Mounded edge ramparts are only clearly observed in the narrow shear board tracks. Often the ramparts are rounded at their edges, indicating the levelling of the tracks by the natural sediment dynamic processes during storm conditions. On the silt bottoms, there are often bounce tracks strung together like pearl strings, leaving behind scholen-like sediment accumulations. Roller and ball tracks are rare due to their shallow penetration depth and are also easily overprinted by the shear board tracks. In mudflats, shear board tracks may persist for a period of at least 4 to 5 years (KROST et al., 1990). In this context, the formation of turbidity plumes also plays a role. WERNER et al. (1990) were able to detect a 5 m high turbidity plume in the Eckernförde Bay 90 minutes after a tow with a otter trawl.

Historical stone fishing: From around 1800 until the mid-1970s, large stones and boulders were taken from the shallow water areas off the German Baltic coast for the construction of harbour piers, buildings and roads, among other things. In Schleswig-Holstein, stone fishing was banned in 1976 in order not to further undermine coastal protection measures. Stone fishing was limited to water depths up to a maximum of 20 m, with about 100 million t of stones being taken in the entire Baltic Sea (ZANDER, 1991). For the Bay of Kiel, estimates by BREUER and SCHRAMM (1988) gave about 1.5 million t of stones in the period between 1930 and 1970. This figure was corrected by BOCK (2003) and BOCK et al. (2004) to 3.5 million t (total quantity), not including illegal extractions. KAREZ and SCHORIES (2005) estimate that a total of about 5.6 km² of settlement area for hard substrate dwellers off the coast of Schleswig-Holstein was lost due to rock fishing. No such information is available for the coast of Mecklenburg-Vorpommern. However, it can be assumed that, just as in Schleswig-Holstein, extraction activities were limited to the area of the coastal sea for economic reasons. Therefore, it can be assumed that the rock deposits in the EEZ were not affected by rock fishing.

Sand and gravel extraction: Since the 1960s, sand and gravel have been extracted from the southwestern Baltic Sea as raw materials for coastal protection and the construction industry. In the Bay of Kiel, sand was extracted in the period from 1971 to 1981 on the Gabelsflach, Stoller Grund and near the Kiel Lighthouse, primarily for harbour construction; sand and gravel extraction has been taking place off the coast of Mecklenburg-Western Pomerania since the 1960s. While no figures are available for the period before 1989, the extraction volume from 1990 to 2003 amounts to approx. 18 million m³. On the Danish continental shelf, sands and gravels were extracted at Gedser Rev, Kriegers Flak and Rønnebank. There are two different types of extraction with different ecological impacts to consider: surface extraction is carried out with a suction trailer hopper dredging and leads to the formation of decimetre-deep furrows, while stationary extraction with anchor suction hooper dredging can create funnel-like structures up to several metres deep (ICES, 2001). Depending on water depth, sediment supply, exposure and extraction method, the potential and duration of backfilling of extraction structures varies. In the case of backfilling, finer-grained sediments usually provide the filling material. Particularly in the case of gravel sand deposits, a funnel- or trough-shaped relief remains because the recent hydro- and sediment dynamic processes are unable to achieve complete refilling or even regeneration of the seabed due to the sediment supply (ZEILER et al., 2004).

Oil production: About 4 km off the coast of Schleswig-Holstein, a total of 3.4 million tonnes of oil were extracted from depths of between

1,400 and 1,600 m between 1984 and 2000 on the platforms "Schwedeneck A" and "Schwedeneck B", which have since been dismantled. 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 excluded.

Wind turbines and platforms: Wind turbines and platforms are currently almost exclusively installed as deep foundations. To protect against scouring, either scour protection in the form of mudmats or riprap is installed around the foundation elements, or the foundation piles of deep foundations are installed deeper into the ground. In addition to the temporary sediment swirl during installation, the wind turbines and platforms result in a locally limited, permanent sealing of the seabed with regard to soil as a protected resource. The land use (sealing) for platforms, which are almost exclusively founded on jacket constructions (without scour protection), amounts to approx. 600 ^{m2} to 900 m² depending on the size of the platform. Wind turbines are also almost exclusively realised as deep foundations. By far the most common foundation variant for wind turbines is the monopile. With a monopile diameter of 8.5 m, an area of about 1400 ^{m2} is required, including scour protection.

Submarine cables (telecommunications and energy transmission): Submarine cables are usually washed in. The turbidity of the water column increases as a result of the sediment turbulence caused by the flushing process. The extent of the resuspension depends mainly on the installation method and the fine-grain content of the soil. In areas with a lower proportion of fines, most of the released sediment will settle relatively quickly directly at the construction site or in its immediate vicinity. In the process, the suspension content decreases again to the natural background levels 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 again much more slowly. However, since the near-bottom currents are relatively low in these areas, it can be assumed that the turbidity plumes that occur here will also have a rather localised character and that the sediment will settle again relatively in the immediate vicinity. A substantial change in the sediment composition is not to be expected.

Former munitions dumping: After the end of World War II, 35,000 t of chemical munitions were dumped east of Bornholm. The cargoes were transported from the loading ports in Wolgast and Peenemünde to the dumping area in the Bornholm Basin along fixed routes. According to eyewitness reports, some of the cargo was already thrown overboard during transport. From 1994 to 1996, the BSH surveyed these transport routes, beginning at the exit of the Greifswald Bodden and extending to the border of the EEZ, using side-scan sonar and magnetometers at 50-metre intervals in order to locate possible ammunition residues. As a result, about 100 suspicious objects were identified. In the course of the detailed examination by the responsible office of the German Navy, the suspicion of rusted ammunition remnants could be substantiated for only four objects (SCHULZ-OHLBERG et al., 2002), all of which are located within the 12 nautical mile zone.

Military exercises at sea: during naval and air force firing exercises at sea, ammunition residues (shell casings, etc.) sediment on the mud and sand bottoms. Over time, they sink into the soft mud or silt up and can be exposed again in the course of natural sediment redeposition. In addition, the weight of submarines can compress sediments to varying degrees when they are set down on the seabed.

Shipping: Depending on the water depth, type and amount of sediment present, wrecks can become silted up and exposed again. Depending on their size, they influence the small-scale sediment dynamics by causing scouring in the vicinity or sedimentation of sands in the current shadow. In the case of anchor drop, depending on the size of the anchor and the type of sediment, material is stirred up to a depth of about 1.5 to 2 m in a narrow local area. In silty sediments, a turbidity plume is created that is much smaller in extent than bottom trawling due to the size and duration of the intervention.

Anthropogenic factors affect seabed in the following ways:

- Ablation,
- Intermixing,
- Sealing,
- Resuspension,
- Material sorting,
- Displacement and
- Compaction.

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

The extent of anthropogenic existing pressure of the sediments and the morphological form inventory is decisive for the assessment of the aspect "preloading". With regard to the criterion "prior pollution", the soil as a protected resource is assigned a medium level of pollution, since the above-mentioned prior pollution is present, but does not result in a loss of ecological function.

2.3 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 Øre Sound. This provides a connection to the North Sea and thus to the Atlantic via the Skagerrak. Due to the shallow depths of the straits, there is little water exchange with the North Sea. In total, the Baltic Sea covers an 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 a brackish sea. The water circulation of the Baltic Sea is characterised by freshwater inflow via rivers on the one hand and the exchange of water masses with the North Sea on the other. Due to the morphological conditions, a vertical salinity and temperature stratification can form in the Baltic Sea, which cannot be broken up by the primarily wind-driven water currents and the minimum tide (< 10 cm) (JENSEN & MÜLLER-NAVARRA 2008, FENNEL & SEIFERT 2008).

2.3.1 Currents

The circulation of the Baltic Sea is characterised by an exchange of water masses with the North Sea through the Belts and the Sound. Near the surface, brackish Baltic Sea water flows into the North Sea, while at the bottom, heavier, saltier North Sea water from the Kattegat pushes forward into the Baltic Sea. This inflow of saline water is impeded by the Drogden Sill (sill depth 9 m) at the southern exit of the Sound and the Darß Sill (sill depth 19 m) east of the Belt Sea. Due to specific weather conditions, saltwater intrusions occur sporadically, during which salty and oxygen-rich water partly penetrates into the deeper eastern basins of the Baltic Sea.

These influxes of saline water from the Kattegat into the Baltic Sea, which contribute significantly to the "aeration" of the deeper Baltic Sea basins, are divided into two processes: On the one hand, there are the large saltwater intrusions, which transport large quantities of saltwater into the Baltic Sea over a period of at least five days. In the process, large parts of the Arkona Basin are filled with salt water. The second process is inflow events of medium strength, which occur about 3 to 5 times per winter. Here, the bottom water flows into the Arkona Basin as a dense bottom current after overflowing the Darss Sill and the Drogden Sill. The denser water flowing 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 salt water flowing in over the Darss Sill is superimposed on this band. From there, the band continues along the southern edge of the Arkona Basin eastwards towards Bornholm Gatt, where it drains into the Bornholm Basin (BURCHARD & LASS 2004, LASS 2003).

Model investigations (BURCHARD et al. 2005) with a simplified numerical model modify this picture: According to this model, the majority of the water flowing in via the Drogdenschwelle flows clockwise around Kriegers Flak and influences the sector located in the German EEZ less than the observations and model results published so far indicate. Measurements made with an acoustic Doppler profiler on the ground to the east of Kriegers Flak could support these model results. Since the new model investigations are limited exclusively to the inflow from the Öresund, there are no new findings regarding the inflow from the Belt Sea (Darss Sill). It can be assumed that this inflow essentially spreads eastwards along the southern edge of the Arkona Basin and thus also influences the deeper areas of the Adlergrund.

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

	Fehmarnbelt	**Mecklenburg Bay**	**Arkona Basin**
Water depth [m]	28	26	31
Close to the surface:			
mean amount [cm/s]	28,7	17,7	9,6
maximum amount [cm/s]	117,6	74,8	78,0
Residual current [cm/s]	7,6	1,4	2,3
Direction [°]	347	332	184
Ground level:			
mean amount [cm/s]	16,4	12,9	6,0
maximum amount [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 the wind (drift current). If a current meets a coast, downward currents also occur as a result of the jam. A third factor is the freshwater runoff of the rivers with about 480 km³/year. If precipitation and evaporation are taken into account, there is a freshwater surplus of 540 km³/year, which corresponds to about 2.5% of the water volume of the Baltic Sea. Tidal currents are negligible in the Baltic Sea. In the Fehmarn Belt, an annual mean net outflow of 8 cm/s is observed at the surface and a net inflow of 7 cm/s at the bottom (LANGE et al. 1991). The mean velocities here are in the order of 30 cm/s at the surface and 16 cm/s at the bottom. In the large basins east of the Belts, velocities are in the order of 10-18 cm/s near the surface and 7-13 cm/s near the bottom. Table 6shows characteristic flow parameters for the Fehmarn Belt, the Mecklenburg Bay and the Arkona Basin.

2.3.2 Sea state and water level fluctuations

In the case of swell, a distinction is made between waves generated by the local wind, the so-called wind sea, and swell. Swells are waves that have left their area of origin. Due to the small size and the strong dissection of the Baltic Sea, a fully developed swell rarely occurs. In the Arkona Sea, the proportion of swell is only about 4%. The swell has a longer wavelength and a longer period than the wind sea.

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

In the climatological annual cycle (1961-1990), the highest wind speeds in the Arkona Sea occur in December at about 19 knots and then drop continuously to 13 knots until June. After that, the wind speed rises steadily again until the end of November. (BSH 1996). The annual average wind speed is 16.2 knots.

This annual variation can be transferred to the mean wave height of the swell. 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 spring tidal range of the half-day tide 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). Extreme high or low tides are primarily caused by the wind. Water levels of more than 100 cm above or below sea level are called storm high or storm low water. The long-term average for these extreme water levels is about 110 to 128 cm above and 115 to 130 cm below sea level. Individual events can be significantly above these values. In addition to storm high and low tides, natural oscillations of the Baltic Sea basins (Seiches) cause water level fluctuations of up to one metre.

For the 20th century, the annual maximum water levels of 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 greater than one year are also correlated with North Atlantic Oscillation Index (NAO) fluctuations.

Long-term factors influencing the mean sea level of the Baltic Sea are the isostatic land uplift in the area of 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 are between 0.09 and 0.88 m by 2100, provided that the West Antarctic ice mass remains stable. Its melting would cause a global sea level rise of up to 6 m.

2.3.3 Surface temperature and temperature stratification

Figure 24: Climatological monthly mean of surface temperature (1900 - 1996) according to JANSSEN et al. (1999). shows, based on the

data of JANSSEN et al. (1999), an areal distribution of the monthly averaged surface temperatures. On climatological average, the lowest temperatures occur in February. The data set of JANSSEN et al. (1999) includes all available temperature measurements from 1900 to 1996. The summer warming begins in April and reaches its maximum in August. The cooling phase begins in September.

Between May and June, a strong thermal stratification builds up, reaching its maximum in August with temperature differences between surface and bottom of up to 12 °C. In the course of September, the thermal stratification quickly dissipates, and in October the western Baltic Sea is largely vertically homothermal. Depending on the meteorological boundary conditions, significant deviations from the long-term mean may occur in individual years.

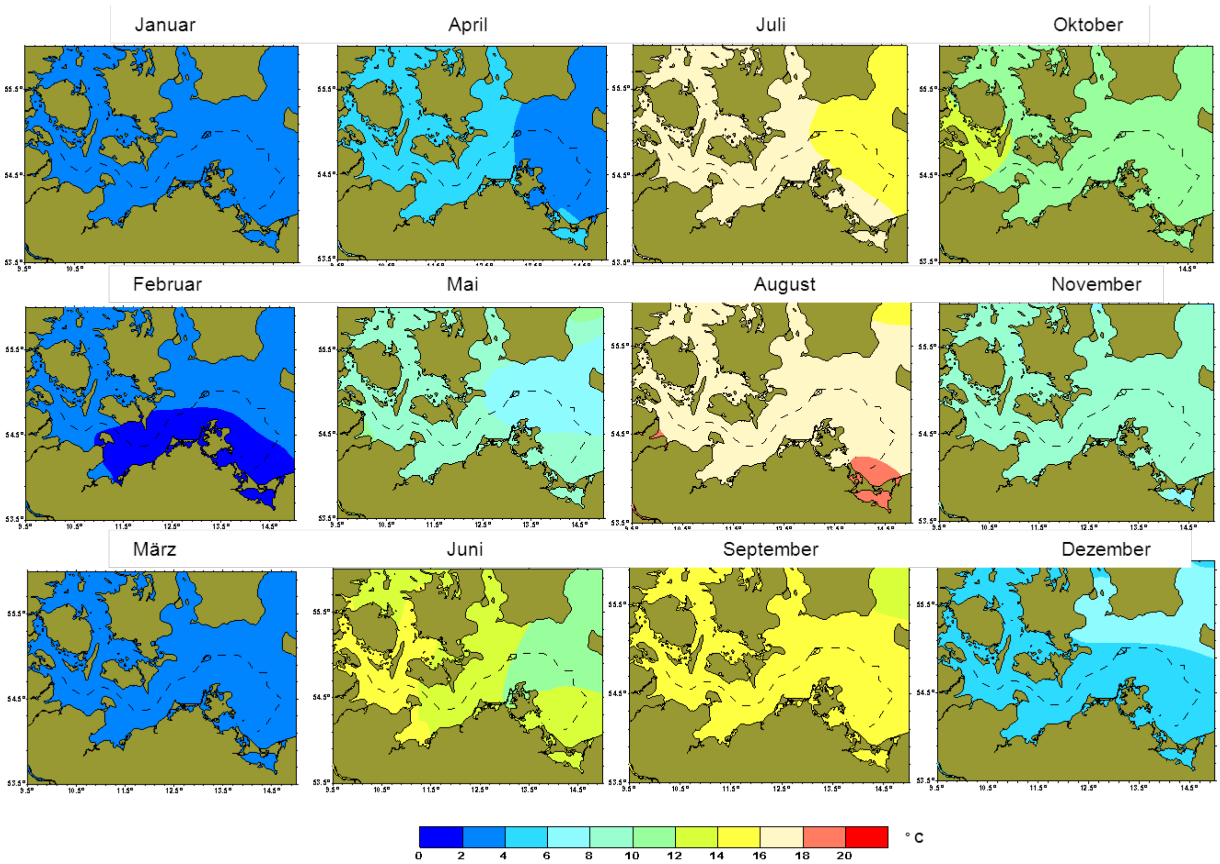

Figure 24: Climatological monthly mean of surface temperature (1900 - 1996) according to JANSSEN et al. (1999).

2.3.4 Surface salinity and salinity stratification

The salinity in the western Baltic Sea generally decreases from west to east, with particularly pronounced horizontal gradients in the Belts and the Sound. Figure 25 shows the mean annual variation of the salinity of the surface layer according to JANSSEN et al. (1999). In the long-term mean, the 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 that flows into the western Baltic Sea from the Kattegat through the Belts and the Sound from the west. Due to the higher density of the more saline water, this inflow occurs primarily at the bottom and is layered under the lighter surface water. The 10 isohaline reaches its westernmost position in the summer months and its easternmost position in December, when the strong winter storms from westerly directions push water from the Skagerrak and Kattegat into the western Baltic Sea.

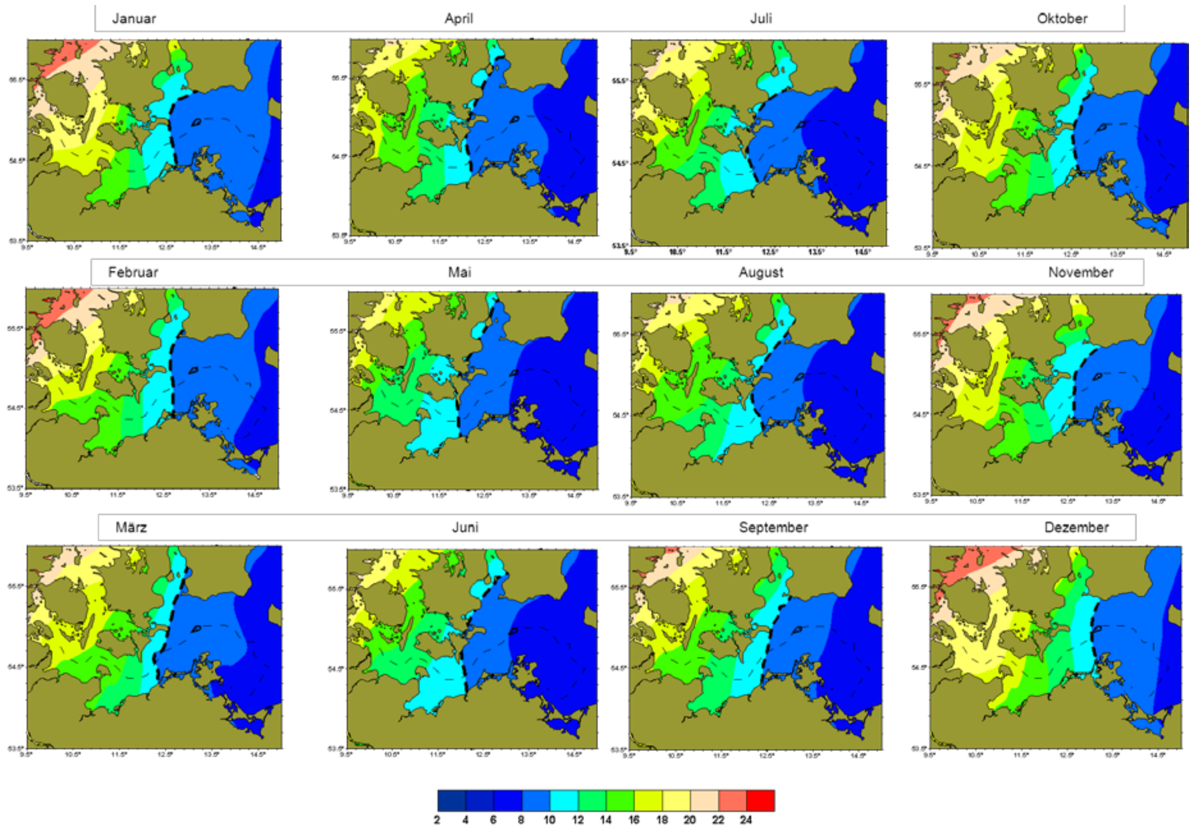

Figure 25: Climatological monthly mean of surface salinity (1900 - 1996) according to JANSSEN et al. (1999).

For salinity, Figure 26 stratification based on the difference between bottom and surface salinity. Large parts of the Belt Sea and the deep basins are haline stratified all year round (water stratification caused by different salinities) while shallow areas like the Pomeranian Bay are vertically homohaline all year round or show only very weak stratification. The haline stratification in the Belt Sea and the deep basins intensifies in spring and reaches differences between surface and bottom salinity of over 10 in summer.

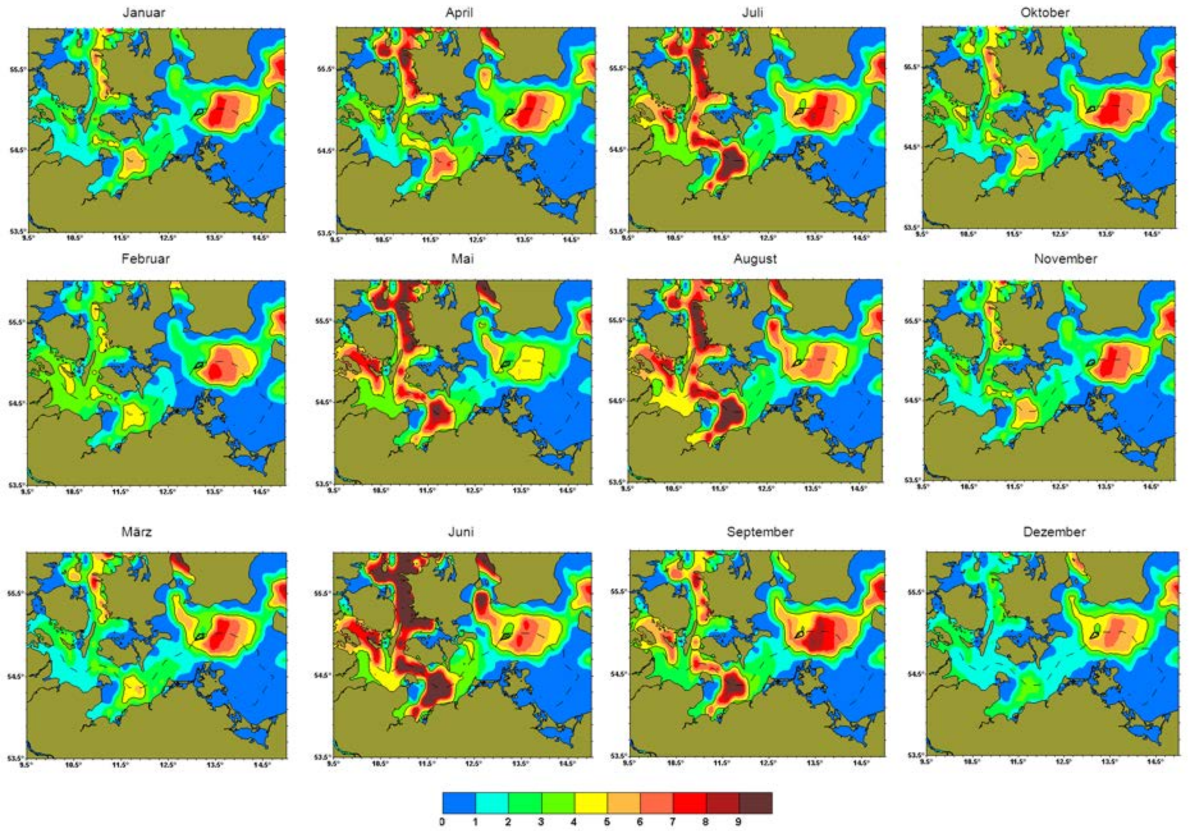

Figure 26: Salinity stratification in the western Baltic Sea according to JANSSEN et al. (1999).

2.3.5 Ice conditions

In the Baltic Sea south of 56° N, ice does not form regularly in winter. The large spatial and temporal fluctuations in ice cover are due to the nature and constancy of the large-scale weather conditions prevailing over Europe. Here, glaciation can pass through four characteristic stages of development, which are determined by the severity of the winter, the regional oceanographic conditions and also by the coastal morphology and sea depth. They are reflected in Figure 27 by the frequency distribution of ice occurrence.

In moderate ice winters, only the shallow bays freeze over completely, as they have no significant water exchange with the warmer open sea due to their relatively enclosed position towards the sea. To a lesser extent, ice also forms on the outer coasts, especially off the east coast of Rügen and off Usedom.

In strong ice winters, the surface layer of the Bay of Kiel and Mecklenburg as well as the Fehmarn Belt is cooled down to such an extent that ice forms on the open sea. It grows into grey ice (10-15 cm thick). The degree of cover is usually less than 6/10 of the water surface over large areas. East of the Darss Sill, ice occurs only in a narrow strip outside the Baltic Sea coasts, where the degree of cover is predominantly less than 6/10.

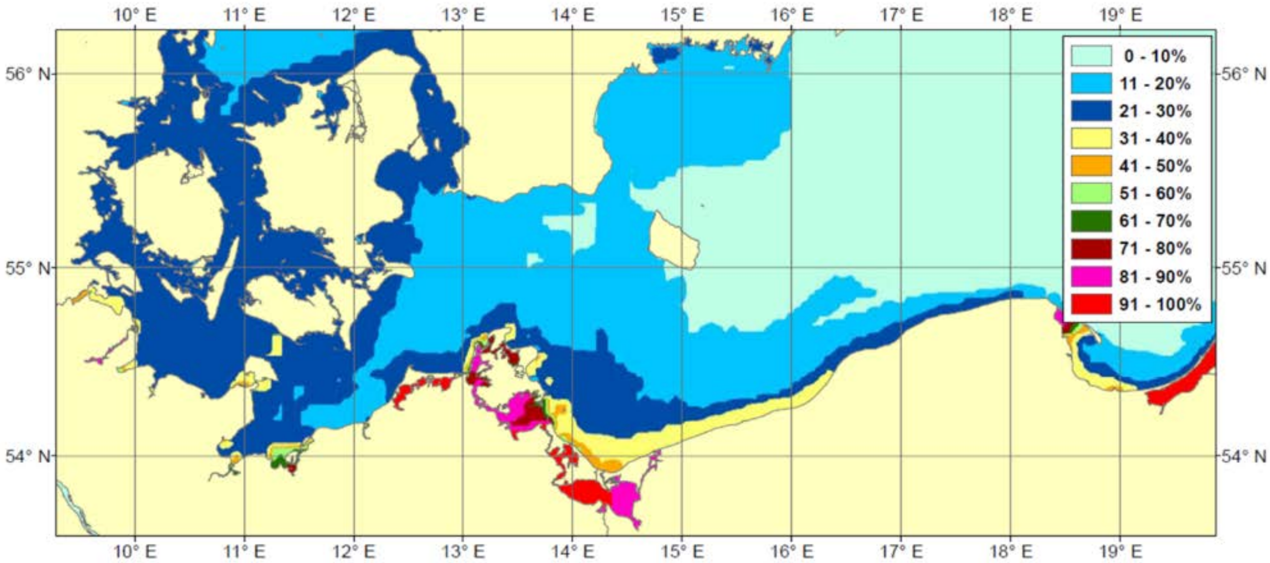

Figure 27: Frequency of ice occurrence in the Baltic Sea south of 56° N in the 50-year period 1961-2010 (BSH 2012).

In strong ice winters, the surface layer of the Bay of Kiel and Mecklenburg as well as the Fehmarn Belt is cooled down to such an extent that ice forms on the open sea. It grows into grey ice (10-15 cm thick). The degree of cover is usually less than 6/10 of the water surface over large areas. East of the Darss Sill, ice occurs only in a narrow strip outside the Baltic Sea coasts, where the degree of cover is predominantly less than 6/10.

In the very rare extremely strong ice winters, the heat reserve of the water in the sea area between Bornholm and the Baltic coast, which is quite considerable due to its great depth, is also used up, so that a closed ice cover can also form there. This very rare icing condition was reached in the last century in the winters 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, 20 to 50% on the outer coasts and 5 to 30% in the sea area.

2.3.6 Suspended solids and turbidity

The term "suspended matter" is understood to mean all particles with a diameter >0.4 µm suspended in seawater. Suspended matter consists of mineral and/or organic material. The organic content is strongly dependent on the season; the highest values occur during the plankton blooms in early summer. During stormy weather conditions with high sea states, the suspended sediment content in the entire water column rises sharply due to silty-sandy bottom sediments being stirred up. Wind seas and, in deeper water, swell in particular have the strongest effect. In the shallow water areas of the Baltic Sea, the sandy sediment is often covered by a layer of fluffy material, which is very easily resuspended and has a high content of organic material (EMEIS et al. 2000).

For the German EEZ of the Baltic Sea, the data situation for in-situ measurements is very inhomogeneous and not sufficient for statistically reliable statements. For a first estimation of the near-surface suspended matter distribution, Figure 28 monthly means of the near-surface suspended matter content (SPM = Suspended Particular Matter) from the MERIS[3] data of the ENVISAT satellite of the European Space Agency (ESA) for 2004.

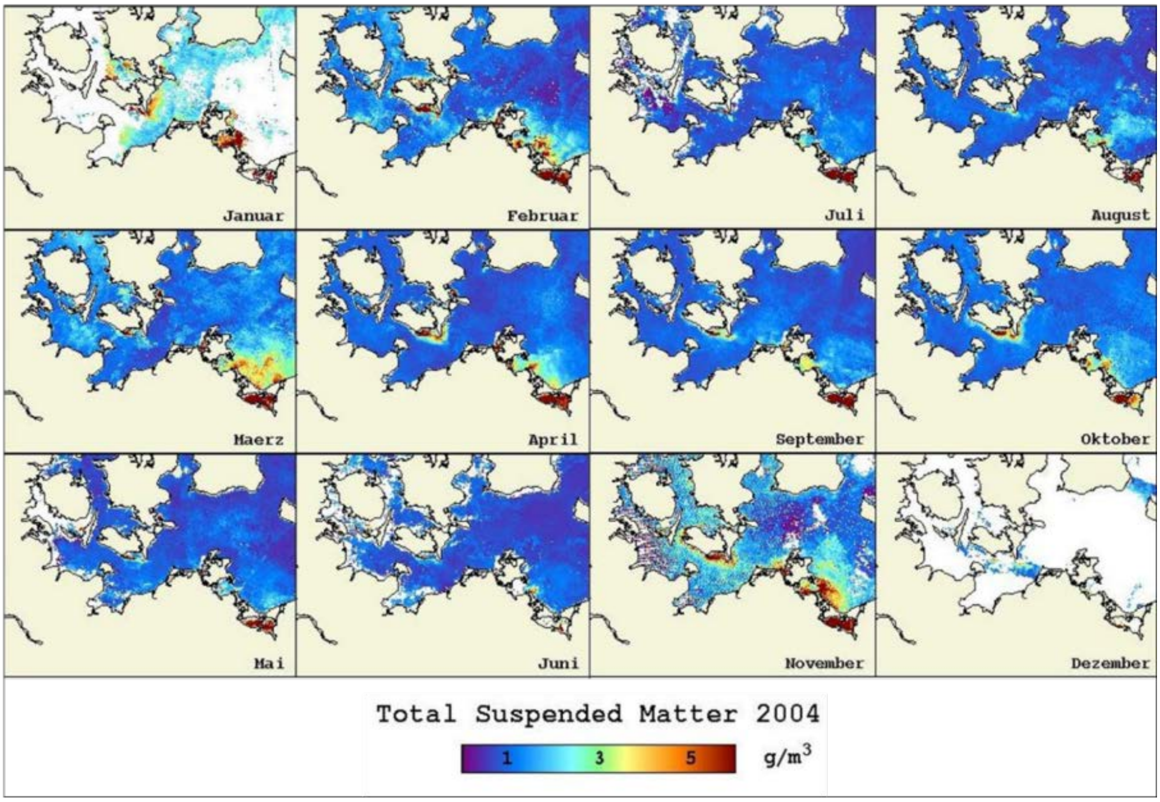

Figure 28: Monthly mean of near-surface total suspended sediment content from the MERIS data of the ENVISAT satellite for 2004.

The highest concentrations are observed in the Oder Lagoon and in the Bodden. In spring, the strong freshwater runoff (snowmelt) increases the amount of suspended matter entering the Pomeranian Bay. As easterly winds dominate in spring, the suspended sediments are mainly transported 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. Between the southern tip of Falster, Gedser Odde, and the south-eastern coast of Lolland, an increased suspended sediment concentration is also visible over the Röd Sand throughout the year. This is primarily caused by current-induced cliff erosion.

2.3.7 Status assessment with regard to nutrient and pollutant distribution

Overall, the Baltic Sea area is a sensitive ecosystem because nutrients and pollutants linger in this area over long periods of time as a result of the restricted water exchange through the Belt Sea. Major problems still result from excessive nutrient loading and the resulting eutrophication phenomena. The load of nutrients and pollutants

[3] Medium Resolution Imaging Spectrometer" remote sensing method

is naturally higher at the river mouths and coasts and decreases towards the open sea.

2.3.7.1 Nutrients

Nutrient salts such as phosphate and inorganic nitrogen compounds (nitrate, nitrite, ammonium) as well as silicate are of fundamental importance for life in the sea. They are vital substances for the build-up of phytoplankton (the 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 due to extremely high nutrient inputs caused by industry, traffic and agriculture in the 1970s and 1980s, leads to a strong accumulation of nutrients in the seawater and thus to overfertilisation (eutrophication). This continues today in the coastal regions. As a result, there can be an increased occurrence of algal blooms (in the Baltic Sea these are particularly cynobacterial blooms), reduced visibility depths, shifts in the species spectrum and oxygen deficiency situations near the bottom.

To monitor nutrients and acidity, the IOW carries out several monitoring cruises a year on behalf of the BSH. In the Baltic Sea, a typical annual cycle of nutrients can be observed as in the North Sea, with high nutrient concentrations in winter, followed by a strong decrease in concentrations with the onset of biological activity in spring.

Spatially, nutrient concentrations in the inner coastal waters are generally two to three times higher than on the outer coast in the offshore open sea; these differences are more pronounced for nitrate concentrations than for phosphate concentrations. Especially in the shallow areas of the Baltic Sea, varying stratification of temperature and salinity lead to highly variable nutrient distributions. Furthermore, in these shallower areas, exchange processes between water and sediment - especially the dissolution of phosphorus - play a major role for the concentrations in the water column.

The occurrence of oxygen deficiency areas is a natural phenomenon in the Baltic Sea due to the low water exchange with the North Sea and the partly permanent stratification of the water body. However, due to eutrophication and the associated increased decomposition of organic material, there is an increase in the frequency, intensity and spatial extent of oxygen deficiency areas. Since the dissolution of phosphorus from the sediment occurs particularly under oxygen deficiency, eutrophication is further intensified here.

Even though the loads of phosphorus and nitrogen compounds of German tributaries to the Baltic Sea have been declining since the 1990s, the eutrophication problems of the Baltic Sea due to this internal fertilisation are decreasing only very slowly. The follow-up assessment according to the EU MSFD therefore concludes that 100% of the German Baltic Sea continues to be eutrophic (BMU 2018). The highest exceedance of dissolved inorganic nitrogen (DIN) concentrations was found in the Bornholm Basin due to the influence of the Odra plume. The same applies to the concentrations of total nitrogen (TN) and total phosphorus (TP). The assessment is based (except for the assessment of TN and TP as additional national indicators) on the HELCOM Eutrophication Assessment Tool HEAT 3.0, which classifies the entire Baltic Sea - except for smaller areas in the northern Baltic Sea and the Kattegat - as eutrophic (HELCOM 2017).

2.3.7.2 Oxygen

The deeper areas of the western Baltic Sea are characterised by oxygen depletion in summer. The intensity of the oxygen depletion depends on meteorological (temperature, wind) and hydrographical (stratification) factors as well as the level of nutrient inputs from the catchment area. The year 2002 represents an extreme situation with extreme oxygen depletion, especially off the

Danish and Schleswig-Holstein coasts. Hydrogen sulphide was widespread, with negative consequences for the bottom fauna. In the deep basins of the central Baltic Sea, the frequency and intensity of saline water influxes from the North Sea, which are necessary for water renewal and oxygen supply, have 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 were long periods of stagnation with considerable concentrations of hydrogen sulphide in the deep water.

As a result of the limited water exchange with the North Sea, the bottom morphology and the permanent haline stratification, there are regular periods of stagnation in the deep waters of the central Baltic Sea. Salinity and oxygen concentrations decline and considerable amounts of hydrogen sulphide are formed. Renewal of the deep water can only take place through saltwater intrusions, which transport water rich in salt and oxygen into the deep basins.

2.3.7.3 Metals

The metals cadmium, mercury, lead and zinc show a typical spatial distribution with a decreasing gradient from west to east in the surface water of the EEZ (cf. BMU, 2012b). The elements lead, cadmium and mercury show below the reference values. According to the current state of knowledge, the above-mentioned metal pollutants in seawater do not pose a direct threat to the marine ecosystem.

2.3.7.4 Organic pollutants

The more polar compounds such as the HCH isomers and the modern pesticides (triazines, phenylureas and phenoxyacetic acids) are present in the water in significantly higher concentrations than the more lipophilic, "classical" pollutants such as HCB, DDT, PCBs and PAHs. The herbicide diflufenican exceeded the threshold values on the coasts of MV (< 1sm) in the period 2012-2018 (MSFD status report 2018).

For the new priority substance perfluorooctane sulfonic acid (PFOS), the HELCOM indicator shows that PFOS concentrations in water clearly exceed the threshold values, especially on 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. Temporal trends cannot be observed due to the high variability and the limited data available.

The Baltic Sea is polluted with organotin compounds, which were often used as marine paints in the past. For example, dibutyltin (DBT) shows an exceedance in the Lower Warnow. The HELCOM indicator for TBT shows an exceedance of the threshold value in the Baltic Sea with TBT (HELCOM 2018, MSFD Status Report 2018).

The pollution of the Baltic Sea water with petroleum hydrocarbons is low. The determination of the individual components shows that the aliphatic hydrocarbons originate mainly from biogenic sources. The concentrations of PAHs are also relatively low and show no particular spatial distribution. The contents of higher condensed PAHs (4-6 ring aromatics) increase near the coast, which is largely due to higher suspended sediment contents. Due to the high variability, no temporal trends can be observed for any of the different hydrocarbon classes, but there are seasonal differences with highest values in winter (PAH). The levels of toxically relevant PAHs are two to three orders of magnitude lower than the concentrations at which the first signs of carcinogenic effects appeared in animal experiments (VARANASI 1989).

Most of the pollutant concentrations in the eastern seawater are in similar ranges as in the German Bight. Slightly higher concentrations have been observed in the Baltic Sea for the DDT group. The values for γ-HCH are also slightly elevated. The concentrations of α-HCH are about three times, those of β-HCH at least ten times as high as 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, only small or no gradients are observed. Long-term trends have only been found for the HCH isomers. Here, very clear decreases in concentrations are observed both in the short term and in the long term.

Pollutants in the water of the Baltic Sea that exceed the threshold values are mainly pollutants that are already subject to regulation or bans. Due to the persistence of these substances, however, only a slow decline in concentrations can be expected. An influx of further pollutants would lead to an increased burden on the Baltic Sea.

2.3.7.5 Radioactive substances (radionuclides)

The Chernobyl accident and subsequent fallout significantly altered the inventory of artificial radionuclides, especially Cs-134 and Cs-137, with high depositions in the Gulf of Bothnia and the Gulf of Finland. In the following years, these high contaminations also penetrated into the western Baltic Sea with the surface water. The contamination of the Baltic Sea by radioactive substances has decreased in recent years. Due to the very low water exchange of the Baltic Sea with the North Sea through the Danish straits, the activity introduced by Chernobyl remains in the water of the Baltic Sea over a longer period of time. The concentrations of Cs-137 continue to increase slightly towards the east - towards the centre of gravity of the Chernobyl fallout. The concentrations of Cs-137 are still above the values from before the Chernobyl accident in April 1986, which is also the HELCOM threshold value (15 Bq/m^3) (HELCOM 2018). For the next status reporting in 2024, the concentrations are expected to be below this threshold.

This nuclide provides the highest contribution of the artificial radionuclides for a possible dose from the exposure pathway "consumption of seafood". However, a significant dose from this source or from spending time at sea or on the beach is not to be feared.

2.4 Plankton

Plankton includes all organisms that float in the water. These mostly very small organisms form a fundamental component of the marine ecosystem. Plankton includes, among others, 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 (funghi).

2.4.1 Data situation and monitoring programmes

In the Baltic Sea, regular surveys of phyto- and zooplankton have taken place since 1979 within the framework of the Helsinki Convention (HELCOM). Within the framework of the COMBINE monitoring programme of HELCOM, surveys of both phyto- and zooplankton have been carried out by the Baltic Sea littoral states in a large-scale network of stations in the Baltic Sea. These data are now freely available through ICES. In addition, coastal waters are sampled for plankton as part of the national marine monitoring 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 coastal waters and in the German EEZ as part of national monitoring. The German EEZ of the Baltic Sea has been covered by a total of 5 stations since 1979: one in the Mecklenburg Bay, one at the Darss Sill, two in the Arkona Sea and one at the Oder Bank. The IOW takes two samples (outward and return) per station each year during a total of five ship cruises. In addition, the number of samples per station is adjusted to the prevailing water stratification (thermocline and halocline) so that statements can be made about the vertical distribution of the plankton. Vertical sampling is particularly relevant for the recording of zooplankton, as this occurs in different communities in the vertical distribution of the water column. In 2015, a total of 65 samples were taken. The monitoring trips took place in February, March, April/May, July and October/November. However, there is no continuous sampling of the plankton. Due to the lack of continuous sampling, the picture of the occurrence of the plankton communities is patchy. In particular, long-term changes in the plankton and their causes cannot be precisely tracked as a result.

2.4.2 Spatial distribution and temporal variability of phytoplankton

Phytoplankton forms the lowest living component of marine food chains and comprises small organisms, mostly up to 200 µm in size, which are taxonomically assigned to the realm of plants. They are microalgae that mostly consist of a single cell or are able to form chains or colonies from several cells. The organisms of the phytoplankton feed predominantly autotrophically, i.e. through photosynthesis they are able to use the inorganic nutrients dissolved in the water to synthesise organic molecules for growth. Phytoplankton also includes microorganisms that can feed heterotrophically, i.e. from other microorganisms. In addition, there are mixotrophic organisms that can feed auto- or heterotrophically depending on the situation. Many microalgae, for example, are able to change the type of nutrition in the course of their life cycle. Bacteria and fungi also form separate groups phylogenetically (evolutionary history). When considering phytoplankton, bacteria, fungi and such organisms that are closer to the animal kingdom due to their physiological characteristics 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). The phytoplankton of the western Baltic Sea includes the following important taxonomic groups:

- Diatoms or diatoms (Bacillariophyta*),*
- Dinoflagellates or flagellate algae (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 reach high abundance.

Phytoplankton serves as a food source for organisms that specialise in filtering the water for food. The most important 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 secondary 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 a decreasing salinity from 20 PSU in the western area to 1 PSU in the eastern area. The water masses of the Baltic Sea also show very strong stratification. As a result, the species spectrum consists of both marine species and freshwater species. The special conditions of the Baltic Sea also mean that the marine food chains of the Baltic Sea react very sensitively to changes.

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

In addition to physical processes, the concentration of nutrients dissolved in the water determines the abundance and biomass development of phytoplankton. An additional influence on the distribution and abundance of plankton arises from various natural, but also anthropogenic factors. In the North and Baltic Seas, for example, the North-East Atlantic Oscillation (NAO) is decisive for the natural succession of plankton. River inputs also influence the development of plankton - both through freshwater discharge and through nutrient and pollutant loads. Some plankton species or developmental or resting stages also use the sediment as a habitat. However, the actual habitat of the plankton is the water masses. A spatial delimitation of habitat types is therefore only possible to a very limited extent for the plankton, unlike for the benthos, for example. For associations of plankton species, the hydrographic properties of water masses are much more decisive.

Seasonal phytoplankton growth shows fixed patterns of occurrence in the Baltic Sea. Salinity, water depth and residence time of the water determine the occurrence and development of phytoplankton (THAMM et al. 2004). In spring, shallow coastal waters warm up faster 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 an associated warming of the water.

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

From year to year, different diatom species such as *Thalassiosira levanderi, Skeletonema costatum, Thalassiosira baltica, Dictyocha speculum* and *Chaetoceros* sp. provide the spring algal bloom. In May, diatom blooms usually end abruptly. Dinoflagellates increase at the same time. In particular, dinoflagellates are then found in high concentrations even in deeper areas (15 m). Flagellates probably use nutrients from deeper water layers or even low concentrations of regenerated nutrients. *Gymnodinium* sp. and *Peridiniella* sp. are among the most abundant 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, radiation of more than 120 W/m2 (daily averages) and wind speeds lower than 6 m/s. The development of blue-green algal blooms comes to an end with deteriorating weather conditions (low solar radiation or strong winds) (WASMUND 1997). In autumn, diatom blooms develop again, but they are very weak compared to the spring blooms (WASMUND et al. 2005). Over the last 30 years, there has been a continuous change in the species composition of the diatom group in the summer and autumn blooms. Thus, the species of the diatom genera Skeletonema and Chaetoceros are successively replaced by *Ceratulina pelagica*, *Dactyliosolen fragilissimus*, *Proboscia alata*, *Pseudo-nitzschia* spp. (WASMUND et al. 2016a).

Eutrophication is a major threat to the marine ecosystem of the Baltic Sea. The concentration of chlorophyllsa in the water, as a measure of the biomass of phytoplankton, provides information about the degree of eutrophication. In the Arkona Sea, the concentration of chlorophyllsa in the water is much lower than in the Bay of Finland or the northern Baltic Sea (HELCOM 2004). In the period 1993 to 1997, the mean primary production in the Arkona Sea varied from 37 mg C*m-2 per day in January to February to 941 mg C*m-2 per day in June to September (WASMUND et al. 2000).

From measurement series of the IOW from 1979 to approx. 1995, a clear increase in Chlorophylla concentration is evident during this time. Since this time, measurements have been recorded at an approximately constant high level or slightly decreasing values (WASMUND et al. 2016a). The high nutrient concentrations (significantly nitrate, phosphate) flushed in during the 1970s had a particular impact on the proliferation of the spring bloom, with the summer and autumn blooms largely achieving the same levels. The Mecklenburg Bay is an exception, with a continuous decrease in the spring bloom since the beginning of measurements in 1979 (WASMUND et al. 2016b).

2.4.3 Spatial distribution and temporal variability of zooplankton

Zooplankton includes all marine animals floating or migrating 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 as a food source for carnivorous zooplankton species, fish, marine mammals and seabirds. On the other hand, zooplankton has a special significance as the primary consumer (grazer) of phytoplankton. Eating away or grazing can stop the algal bloom and regulate the degradation processes of the microbial cycle by consuming the cells.

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

Zooplankton are divided into two major groups based on the life strategies of the organisms:

- *Holozooplankton:* The entire life cycle of organisms takes place exclusively in the water column. The best-known *holoplanktonic* groups important for the Baltic Sea include crustaceans such as *Copepoda* (*copepods*) and *Cladocera* (water fleas).
- *Merozooplankton:* Only certain stages of the organisms' life cycle, mostly the early life stages such as eggs and larvae, are planktonic. The adult individuals then switch to benthic habitats or join the nekton. These include early life stages of bristle worms, bivalves, snails, crustaceans and fish. Pelagic

fish eggs/ larvae are abundant in meroplankton during the reproductive period.

Merozooplankton were particularly abundant in Kiel Bight in 2015, but reached below-average abundances in Arkona Basin and Mecklenburg Bight. The main representatives included larvae of polychaetes and mussels (Wasmund et al. 2016a).

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

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

Two transport mechanisms influence the dispersal of larvae and their settlement in the final habitat: horizontal advection of larvae with the prevailing flow direction and diffusion through small- and mesoscale turbulence, i.e. mixing processes in the water body. From field studies it became clear that larval settlement can occur both locally and in distant areas. The dispersal of larvae from coastal waters is mostly regulated by frontal zones between coastal waters and the open sea. However, larvae are conditionally able to seek out areas that allow them to cross the boundary layer, such as areas of increased turbulence, through vertical migration within the water column. Species-specifically, the organisms develop strategies that serve the dispersal of the larvae and successful settlement. Such strategies, which ultimately ensure the survival of the species, range from the adaptation of reproduction time, depth and area to vertical movements of larvae and active crossing of boundary layers. Larval competence, or maintaining the ability to initiate metamorphosis until favourable conditions arrive, regulates the settlement success of individuals of each species in the species-specific habitat (Graham & Sebens 1996).

Characterising habitat types based on the presence of zooplankton is difficult. As already explained for phytoplankton, water masses actually form the habitat of zooplankton. Therefore, a characterisation of water masses and the associated zooplankton associations is useful for this purpose. For the differentiation of water masses, it is not the species spectrum of the zooplankton populations that is important, but rather the share of the respective species, especially the key species, in the composition of the associations.

In biotic communities of the Baltic Sea, a shift in vertical distribution occurs due to variability in salinity. This phenomenon was termed submergence by Remane (1955). Animals of the marine eulittoral and supralittoral tolerate greater fluctuations in salinity than animals of the sublittoral or marine depth. They can therefore penetrate further into brackish water than marine deep forms. Only a few species can also penetrate deep water, and these are those that can feed carnivorously. The phenomenon of brackish water submergence is, however, not a special feature of the Baltic Sea, but typical of brackish waters (Remmert 1968). In the Bay of Kiel, for example, the copepod *Oithona similis occurs* in concentrations of several thousand individuals per $^{m3\ in}$ the near-surface area. East of the faunistic boundary of the Darss Sill, on the other hand, this species is found in the saline deep water. Sampling at the

Arkona Sea station in 2003 after the saltwater intrusion showed that with increasing water depth, the abundance of this species increased from 2,400 females per m3 in the upper 5 m to 31,500 females per m3 between 18 and 22 m water depth (WASMUND et al. 2004).

On average, 22 zooplankton taxa occur per year in the Baltic Sea (WASMUND et al. 2005). However, only 12 taxa were found throughout the year in the period 1999 to 2002 (POSTEL 2005). In general, the species spectrum, abundance and dominance ratios 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 anthomedus *Euphysa aurata*. After the autumn and winter storms, the arrow worm *Sagitta elegans* appears.

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, but also warm summers also influence the occurrence and abundance. Thus, heat-loving species such as the copepod *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 reproductive cycles of the benthic organisms.

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

Usually, high abundances of Cladocera (water fleas) are found in the waters of the Mecklenburg Bay and the Arkona Basin. In 2015, contrary to their usual distribution, no occurrence of Cladocera could be detected (WASMUND et al. 2016a). Zooplankton development in the Mecklenburg Bight and Arkona Basin in 2015 was characterised by early growth compared to previous years. This led to an early maximum of the population in spring (March), which is usually only reached in summer/autumn. Overall, zooplankton abundance has been declining since 2000. This trend continued in 2015. At 130 x 103 individuals per m3, total zooplankton abundance was the lowest since 1995 (WASMUND et al. 2016a).

2.4.4 Condition assessment of the plankton

Based on the findings presented, it becomes clear that only very limited conclusions can be drawn about the state of the plankton and the resulting impacts on marine food chains. On the one hand, there is a lack of consistently implemented monitoring programmes and long-term series to be able to identify or differentiate between natural processes and anthropogenically caused changes in the development of plankton. On the other hand, the influence of physical processes or hydrodynamics on plankton is very striking: for example, it is only possible to a limited extent to distinguish between the effects of eutrophication and natural processes on the basis of phytoplankton data (ICES 2004).

The entire Baltic Sea ecosystem has undergone changes in recent years. Anthropogenic influences and climate change, in addition to natural variability, control these changes. From the beginning of the 1980s onwards, slow changes, and in 1987/1988 sudden changes can be observed in the entire ecosystem of the Baltic Sea.

The changes in plankton are also related to these observations.

Phytoplankton

Thus, the evaluation of the phytoplankton data shows changes with regard to the species spectrum, abundance or 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 addition, an increased occurrence of algal blooms, an aperiodic and unpredictable occurrence of toxic algal blooms and the introduction of non-native species have been observed in recent years. 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 controls and possibly limits biological events.

However, there are pronounced seasonal effects of nutrient concentrations or the subsequent reactions of phytoplankton to nutrient supply. Nutrient supply is much more crucial for phytoplankton growth, especially in the summer months, than nutrient enrichment in winter, which can actually only stimulate spring growth. The spatial variability in the uptake and utilisation of nutrients between phytoplankton in coastal waters and phytoplankton in offshore areas further complicates the evaluation of eutrophication effects on plankton development, for example (PAINTING et al. 2005). Findings from large-scale studies and research projects (HELCOM, IOW) have documented the high variability of phytoplankton occurrence in the Baltic Sea.

Parallel to the increase in nutrient inputs, phytoplankton growth also developed: from the beginning of chlorophyll measurements (1979) until the mid-1990s, the chlorophyll concentration increased significantly, i.e. successively more mass of microalgae grew up per 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. However, an excessive supply of nutrients causes changes in the structure and functionality of the ecosystem.

For phytoplankton, the following direct effects are described with regard to eutrophication (HELCOM 2006): increase in primary production and biomass, change in the species spectrum, increase in the occurrence of algal blooms, increase in turbidity and reduction in light penetration depth in the water, and increase in sedimentation of organic material.

The IOW annually compiles comprehensive lists of diatoms and dinoflagellates for the Baltic Sea. For years, it has been observed how the number of diatoms in the spring bloom decreases in favour of the dinoflagellates (WASMUND et al. 2000). ALHEIT et al. (2005) analysed the available long-term data from the Helgoland Reede and the Baltic Sea station "K2 Bornholm" for changes. It was found that the ecosystems of the North Sea and the Baltic Sea have undergone simultaneous changes with different consequences for the marine food chains since 1987. This is all the more significant when one considers the completely different hydrographic conditions of the North Sea and the Baltic Sea. These changes affect all levels of the food chains, starting with the phytoplankton and ending with the upper secondary consumers. For both ecosystems, the changes correlated with the change in the NAO.

Under certain conditions, phytoplankton can pose hazards 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. In the Baltic Sea, toxic and potentially toxic species have been regularly detected 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 its spread and density compared to previous years (ÖBERG 2016).

Avoidance responses to toxic algal blooms in the coastal sea have been documented in seabirds (KVITEK & Bretz 2005). Similar avoidance reactions are less common in piscivorous seabirds, so that they are often victims of algal toxins enriched in fish (SHUMWAY et al. 2003).

Zooplankton

Zooplankton are also affected by natural and anthropogenic changes. For the zooplankton of the western Baltic Sea, a gradual change can be detected in recent years. The species composition and dominance ratios within the zooplankton groups have changed. The number of non-indigenous species has increased. Many non-native species have already become established. Many area-typical species have declined, including those that are part of the natural food resources of the marine ecosystem. Analyses of data from IOW monitoring cruises have shown that the abundance of some zooplankton taxa has declined 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, clear shifts in the species spectrum are occurring (POSTEL 2005).

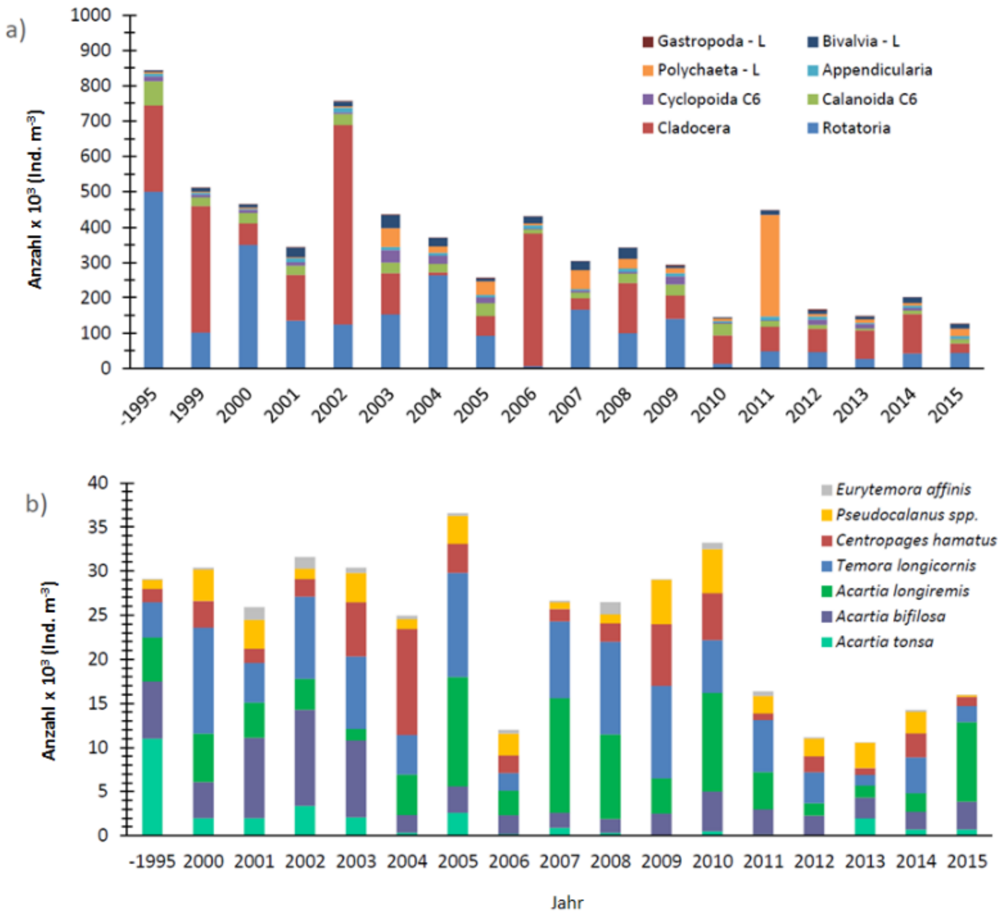

Figure 29: Course of abundance maxima of a) five holoplanktic taxa (Rotatoria, Cladocera, Cyclopoida, Calanoida and Copelata) and three meroplanktic taxa (Polychaeta, Bivalvia, Gastropoda) and b) seven calanoid copepods from 1995 - 2015 (WASMUND et al. 2016a).

Results of the IOW status report tend to show a decline in the total abundance of holozooplankton from 1995 - 2015 (Figure 29). Apart from the years 2002 and 1995 with relatively high concentrations, the sum of the maxima of all taxa considered shrank from 850 x ^{103} to 130 x ^{103} ind. per m³ in the period 1995 to 2015. In 2011, however, the sum of the respective maximum concentrations doubled compared to the previous year, due to a strong increase in polychaetes larvae and a moderate increase in rotatoria. The unusually high concentration of polychaete larvae is due to the synchronous release of larvae, which must have coincided exactly with the sampling date in March. The low abundances in 2015 are due to a strong decrease in *Cladocera* and *Calanoida* compared to previous years (Figure 29). Looking at individual calanoid copepods, we see that the abundance of the species *Pseudocalanus spp.*, *Temora longicornis* and *Centropages hamatus* tends to decrease. For *Acartia spp.* no clear trend can be identified (Figure 29).

Changes were also observed in the zooplankton of the North Sea. Due to the exchange between the ecosystems of the North Sea and the Baltic Sea, these changes are also relevant for the Baltic Sea. For example, the abundance of *scyphomedusae* (jellyfish) has decreased with increasing 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 - in this case by decreasing predator species - positive effects of climate change on the recovery of fish stocks. Nevertheless, the simultaneous effect of other factors, such as eutrophication and fishing activity, cannot be ruled out here either.

Increasingly, alien species are also having an impact on succession. These are introduced mainly by shipping (ballast water) and shellfish aquaculture. Changes in species composition and possibly species shifts due to the spread of non-native plankton species cannot be ruled out. Indirect effects of the non-indigenous species on the marine food chain cannot be ruled out either. Overall, the introduction of non-indigenous species can be expected to endanger natural processes in the plankton. Many non-native zooplankton species have already become established. 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 ribbed jellyfish *Mnemiopsis leydei has caused* increased concern. Should the ribbed jellyfish become established in the Baltic Sea and multiply excessively due to warming, this would pose a threat to fish stocks. The large ribbed jellyfish feeds on larger zooplankton and especially on fish larvae. However, there was no evidence of this in 2011 (WASMUND et al. 2012). Currently, no large populations of the ribbed jellyfish have been detected (WASMUND et al. 2016a).

As phytoplankton is transported and dispersed by currents, phytoplankton species from the Atlantic also enter the Baltic Sea with the water masses and affect natural succession (REID et al. 1990). Among the phytoplankton, the most important immigrant was identified as *Prorocentrum minimum*, which probably entered the Baltic Sea naturally, spreading strongly from the west since 1981 and forming strong blooms especially in the 1990s. In the meantime, *Prorocentrum minimum* (now called *Prorocentrum cordatum*) has become established in the Baltic Sea and occasionally develops dominant populations (WASMUND et al. 2016a).

Effects of climate change

Climate changes and the consequences for the marine ecosystem have been of increasing concern to scientists in recent years. BEAUGRAND (2004) analysed and summarised previous findings on phenology, causes or mechanisms and consequences of changes in the marine ecosystem of the Northeast Atlantic and the North Sea. Taking into account data from the period 1960 to 1999, the statistical analyses revealed a clear change or increase in phytoplankton biomass after 1985. The increase in phytoplankton biomass was particularly pronounced in 1988. Temporally, the biomass increase correlates with the strong climatic and hydrographic changes of the years 1987 to 1988. BEAUGRAND (2004) assumes that changes in the marine ecosystem due to changes in hydrographic and meteorological conditions, especially after 1987, correlate strongly with the NAO development and that a shift of biogeographical boundaries could already have taken place since the beginning of the 1980s due to reorganisation of the biological structure of the ecosystem in the Northeast Atlantic.

According to HAYS et al. (2005), climate changes have particularly affected distributional boundaries of species and groups of the marine ecosystem. Zooplankton associations of warm-water species, for example, have shifted their distribution by almost 1,000 km northwards in the Northeast Atlantic. In contrast, the ranges of cold-water associations have shrunk. In addition, climate changes have an impact on the seasonal occurrence of abundance maxima of different groups. Staggered population development can have consequences throughout marine food chains. EDWARDS and RICHARDSON (2004) even suggest that temperate marine ecosystems are particularly vulnerable to changes or temporal offsets 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, seabirds). Analyses of long-term data for the period 1958 to 2002 for 66 marine taxa have confirmed that marine planktonic associations respond to climate change. However, the responses vary greatly in terms of association or group and seasonality.

BEAUGRAND & Reid (2003) 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 shown that changes occurred in all three pelagic levels with a time lag. In 1982, a decrease in euphasiaceae (luminous shrimps) 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. This was followed in 1988 by 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.

Studies by SOMMER et al. (2007) also show that climate change can affect several trophic levels. Here, higher mortality rates of Nauplius larvae, a developmental stage of copepods, were observed with temperature increases of 2 - 6°C. Nauplius larvae are an important organism in the trophic web, as they are the main food of many fish larvae.

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

Another consequence of the temperature increase could be a change in the size distribution of phytoplankton. SOMMER et al. (2007) found lower abundances of larger phytoplankton organisms already with a temperature increase of 2°C.

Changes in the seasonal pattern of growth in phytoplankton can also lead to trophic mismatch (temporally staggered occurrence of groups that are interdependent in their food base) within marine food chains: Delayed diatom growth can affect the growth of primary consumers. Small copepods may suffer food shortages due to lack of diatoms during the growth phase. Copepods are in turn an important component of the diet of fish larvae. Fish larvae would starve to death due to reduced growth of copepods. Trophic mismatch has often been observed in various areas in recent years.

Plankton organisms react to adverse situations through species-specific protection and defence mechanisms. Among the best known of these mechanisms, which are important for survival, are diapause and sporulation (PANOV et al. 2004). Diatoms and dinoflagellates are able to develop resting cysts, which then overwinter in the sediment or wait for conditions favourable to growth.

2.5 Biotope types

According to VON NORDHEIM & MERCK (1995), a marine biotope type is a characteristic, typified marine habitat. With its ecological conditions, a marine biotope type offers largely uniform conditions for biotic communities in the sea that differ from other types. The typification includes abiotic (e.g. moisture, nutrient content) and biotic characteristics (occurrence of certain vegetation types and structures, plant communities, animal species).

The majority of Central European types are also shaped in their concrete expression by the prevailing anthropogenic uses (agriculture, traffic, etc.) and impairments (pollutants, eutrophication, recreational use, etc.).

The current biotope type classification of the Baltic Sea has been published by the Federal Agency for Nature Conservation (BfN) in the Red List of Endangered Biotope Types of Germany (FINCK et al. 2017).

2.5.1 Data situation

Within the framework of the R&D project "Marine Landscape Types of the North and Baltic Seas" of the BfN, a spatial distribution pattern of the ecologically most important sediment classes and partly also of higher-level biotope type classes was developed (cf Figure 30 Schuchardt ET al. 2010). On this basis, however, it is not possible to represent areas of marine biotope types that can be delineated with sufficient scientific reliability. A modelled area-wide distribution of marine biotopes in the German Baltic Sea according to the HELCOM "Underwater Biotope and Habitat Classification System" (HELCOM HUB) was developed by SCHIELE et al. (2015). For this purpose, modelled distributions of low-mobility macrozoobenthos species were blended with abiotic data (e.g. grain size, salinity, temperature, water depth, etc.). Furthermore, the occurrences of reefs and sandbanks reported by the BfN can be used. Further important findings are provided by the results of biotope occurrences determined in the context of approval procedures for grid connections and wind farms. In the area of the EO1 priority area for wind energy, the results of the biotope protection assessment can be used, which were collected during the two-year baseline surveys from 2011-2013 (IFAÖ 2015, IFAÖ 2016).

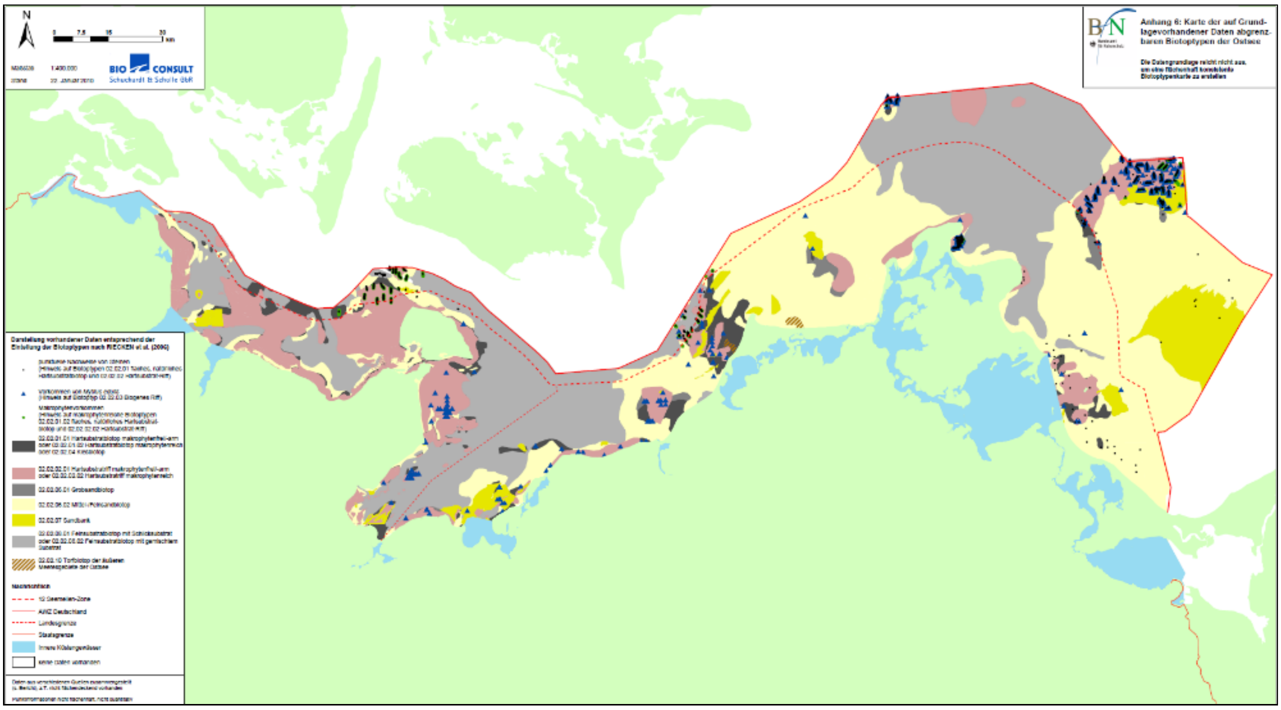

Figure 30: Map of the biotope types of the German Baltic Sea that can be delimited on the basis of existing data (after SCHUCHARDT et al. 2010).

2.5.2 Biotope types of the German Baltic Sea

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

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

In the aphotic zone of deep Baltic Sea waters, there have been prolonged periods of oxygen deficiency near the seabed due to only a few strong saltwater intrusions in recent decades. This has had a negative impact on Icelandic mussel populations in the deep Baltic Sea basins. For this reason, the two HUB biotopes characterised by Arctica islandica colonisation in their aphotic variants are listed as endangered biotope types in the HELCOM Red List (HELCOM 2013a).

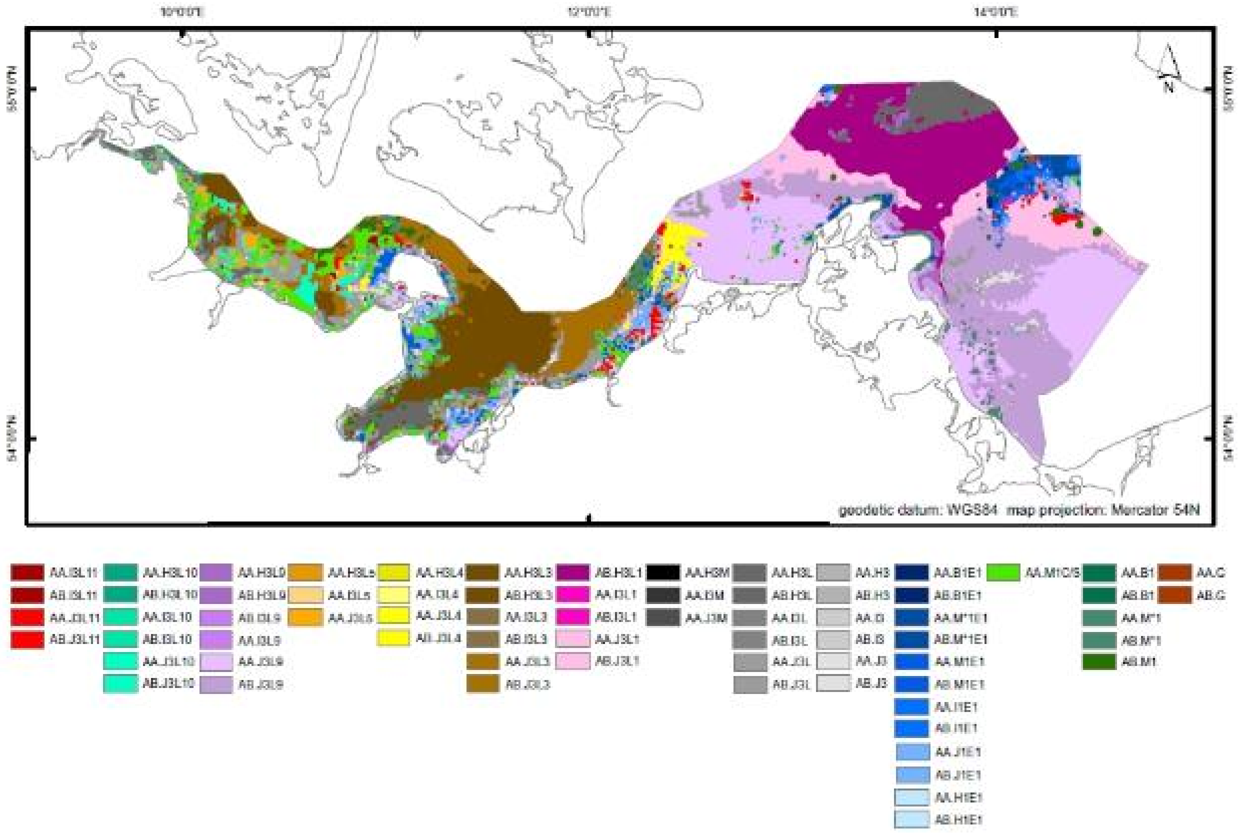

Figure 31: Biotope map of the German Baltic Sea according to SCHIELE et al. (2015). HELCOM HUB codes explained in HELCOM (2013a).

2.5.3 Legally protected marine biotopes according to sec. 30 BNatSchG and FFH habitat types

According to sec. 30 BNatSchG, a number of marine biotopes are subject to direct protection under federal law. Sec. 30 para. 2 of the BNatSchG generally prohibits actions that may 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 Habitats Directive, reefs and sandbanks, the two biotopes "seagrass meadows and other marine macrophyte stands" and "species-rich gravel, coarse sand and shingle beds in the marine and coastal areas" enjoy statutory protection status in the Baltic Sea EEZ under sec. 30 para. 2 sentence 1 no. 6 of the BNatSchG. The biotope type "mudflats with drilling megafauna", which is also protected, does not occur in the German Baltic Sea.

2.5.3.1 Reefs

Habitat type 1170 (reefs) according to the Habitats Directive and at the same time a protected biotope type according to sec.30 BNatSchG is defined as follows: "Reefs can be either biogenic intergrowths or geogenic in origin. They are hard substrates on firm and soft ground rising from the seabed in the sublittoral and littoral zone. Reefs can support the proliferation of benthic algal and animal species communities, as well as intergrowths and coral formations." (DOC.HAB. 06-09/03). "Hard substrate" includes rocks (including soft rocks such as chalk rocks), as well as boulders and boulders. Since 09.07.2018, the "BfN Mapping Guidance for "Reefs" in the German Exclusive Economic Zone (EEZ)" (https://www.bfn.de/fileadmin/BfN/meeresund-kuestenschutz/Dokumente/BfN-Kartieranleitungen/BfN-Kartieranleitung-Riffe-in-der-deutschen-AWZ.pdf) has been published, which has not yet been applied in the projects.

In the Baltic Sea EEZ, reefs and reef-like structures occur mainly as block fields on moraine ridges. They have been found mainly in the area of the Adlergrund, the Rönnebank, the Kadetrinne and the Fehmarn Belt. There are pronounced mussel beds with their accompanying species, which show comparatively high species numbers for the Baltic Sea. Plant cover with large algae, especially laminaria (sugar kelp), red algae or seaweed, is also of great importance here. According to the BfN, reefs covering an area of approx. 460 km2 have been identified in the German EEZ of the Baltic Sea. A large part of these areas (270 km2) have now also been placed under protection as nature conservation areas with the legal ordinance of 22.09.2017 establishing the nature conservation area "Pommersche Bucht - Rönnebank", the legal ordinance of 22.09.2017 establishing the nature conservation area "Kadetrinne" and the legal ordinance of 22.09.2017 establishing the nature conservation area "Fehmarnbelt". With these legal ordinances, the already existing nature conservation or FFH areas were declared nature conservation areas and partly regrouped within this framework. In the context of the approval procedure for the grid connection "Cable 1 to 6 / cross connection", further reef suspected areas were identified in the area of site EO1 in addition to the reef occurrences reported by the BfN. For the survey of the biotope type "reefs" in the German EEZ, the corresponding mapping instructions of the BfN are to be consulted (BFN 2018).

2.5.3.2 Sandbanks

Habitat type 1110 (according to the Habitats Directive) denotes "sandbanks with only slight permanent overtopping by seawater" (DOC.HAB. 06-09/03) and is defined as follows: "Sandbanks are elevated, elongated, rounded or irregular topographical features that are permanently overtopped by water and surrounded predominantly by deeper water. They consist mainly of sandy sediments, but may also have coarse field and stone fragments or smaller grain sizes including silt. Banks whose sandy sediments occur as a layer over hard substrate are classified as sandbanks if the biota living in them is dependent on sand rather than hard substrate for life". Sandbanks are also protected biotopes according to sec.30 BNatSchG.

In the German Baltic Sea EEZ, several sandbanks worthy of protection have now been identified from a nature conservation perspective. "Sandbanks" in the definition of FFH habitat types occur in the German EEZ east of the Darss Sill at the edge of the Arkona Basin and in the Pomeranian Bay. They are covered with residual sediments (blocks, boulders, coarse sand, medium sand) and are accordingly colonised by sandy bottom communities or covered with large algae on hard bottoms in the euphotic area. The total area is approx. 570 km2, with the Oderbank being a particularly large sandbank.

For these reasons, the identified sandbanks have been placed under protection by the FFH site notifications "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 bottoms is species-poor and mainly consists of mussels covered with fouling species and substrate-bound species such as small crustaceans. The majority of species live in the sand (infauna). Mollusc and polychaete species dominate. The number of species at Adlergrund and Kriegers Flak is about 110, while only 21 species were recorded on the Oderbank. The decline in species compared to the Belt Sea is due to the low salinity.

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

There are currently no mapping instructions for the biotope type "sandbanks with only weak permanent overtopping by seawater".

2.5.3.3 Seagrass beds and other marine macrophyte stands

The biotope "Seagrass meadows and other marine macrophyte stands" describes a habitat characterised by submerged flowering plants and/or large algae under the influence of light. According to current knowledge, it occurs in the EEZ of the Baltic Sea only in association with reefs. In the coastal area, however, extensive "marine macrophyte stands" also occur beyond reefs. Various biotope types characterised by marine macrophyte stands are included 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 stands". According to current knowledge, no specific areas can be identified for this biotope type.

2.5.3.4 Species-rich gravel, coarse sand and shingle beds in marine and coastal areas

This legally protected biotope includes species-rich sublittoral pure or mixed occurrences of gravel, coarse sand or shingle sediments of the seabed, which are colonised by a specific endofauna (including sand gap fauna) and macrozoobenthos community regardless of the large-scale location.

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

The colonisation of species-rich gravel, coarse sand and shingle beds is spatially very heterogeneous. Gravel and coarse sand biotopes occur in the outer coastal waters of the Baltic Sea, predominantly in a water depth of 5-15 m, e.g. in submarine sills and together with reefs. An example is the Adlergrund, whose sediment also contains coarse sand and gravel in some areas. Pure shingle biotopes are generally rare.

Based on the area-wide mapping of HELCOM HUB biotope types in the German Baltic Sea presented by SCHIELE et al. (2015), certain conclusions can be drawn about possible occurrences of "Species-rich gravel, coarse sand and shingle beds". However, since the distributions of the corresponding character species *Ophelia* spp. and *Travisia forbesii on which the* study is based are based on presence-absence modelling, the mapping guide "Species-rich gravel, coarse sand and shingle grounds in marine and coastal areas" (BFN, 2012b) must also be consulted for the survey of this biotope.

2.5.4 Condition assessment

The stock assessment of the biotope types occurring in the German marine area is based on the national protection status as well as the endangerment of these biotope types according to the Red List of Endangered Biotope Types of Germany (FINCK et al. 2017). The above-mentioned legally protected biotopes are generally of high importance. In the Baltic Sea, these biotopes are primarily endangered by current or past nutrient and pollutant inputs (including wastewater discharges, oil pollution, dumping, waste and rubble dumping), by fishing activities that come into contact with the ground, and possibly also by the impacts of construction activities. As fishing in contact with the ground is largely excluded within the wind farms, a certain degree of recovery of the biotopes occurring there can be expected in the area of the sites.

2.5.4.1 Importance of the areas for wind energy for biotope types

Priority area wind energy EO1

In the area of site EO1, occurrences of the biotope "reefs" are known. Particularly in the south-east of the area, there are stone fields with distinct mussel beds that extend into the area from the Adlergrund. Mainly mussel beds, gravel and stone beds, as well as overlying boulder clay were identified. The stone cover in the south-eastern area is >10 % in large areas. In the south-western area of site EO1, the stone cover is lower at <10 %. According to BfN estimates, this section of the reef area No. 33 designated by BfN has a reef content of 26 %.

Reservation area for wind energy EO2

The area EO2 has a low structural richness overall. According to the Red List (FINCK et al. 2017), the biotope type "Sublittoral mudflat of the Baltic Sea" (code 05.02.11), which occurs in the entire EO2 area, is currently not endangered. No legally protected biotopes are expected to occur in this area.

Priority area wind energy EO3

In the northern shallow area of site EO3, there are rock and boulder beds with distinct mussel beds. The wall-like boulder accumulations found there may be classified as a "reef" biotope type. Verification by means of BfN mapping instructions is still pending.

2.6 Benthos

Benthos is the term used to describe all biotic communities at the bottom of water bodies that are bound to substrate surfaces or live in soft substrates. 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), the benthos includes microorganisms such as bacteria and fungi, unicellular animals (protozoa) and plants as well as multicellular organisms and large algae and living organisms up to bottom-dwelling fish. The term zoobenthos refers to animals that live predominantly in or on the soil. These organisms largely limit their activities to the vertical boundary area between the free water and the uppermost soil layer, which is usually only a few decimetres.

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

These usually spread via planktonic larvae. In older stages, however, the ability to move is less. Overall, most representatives of the benthos are characterised by a lack of or limited mobility compared to those of the plankton and nekton. Therefore, due to its relative stability, soil fauna can hardly evade natural and anthropogenic changes and pressures and is thus in many cases an indicator of changed environmental conditions (RACHOR 1990).

A relief seabed and a very heterogeneous surface structure are characteristic of the German part of the Baltic Sea. The Baltic Sea floor partly has coarse sand, boulders and stones, but consists largely of sandy or silty sediments, so that animals can also penetrate the bottom. In addition to the epifauna living on the soil surface, a typical infauna (syn. endofauna) living in the soil has therefore also developed. Very small animals of less than 1 mm body size (micro- and meiofauna) make up the majority of these soil dwellers. Better known, however, are the larger animals, the macrofauna, and here especially the more sedentary forms such as annelids, mussels and snails, echinoderms and various crustaceans (RACHOR 1990). Therefore, for practical reasons, the macrozoobenthos (animals > 1 mm) is studied internationally as a representative of the entire zoobenthos (Armonies & Asmus 2002).

2.6.1 Data situation

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 work began on collecting and cataloguing them (MÖBIUS, 1873). In the 20th century, the macrozoobenthos of Kiel and Mecklenburg Bight was 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 is provided in particular by the IOW's long-standing biological monitoring and benthic surveys, which have been carried out since 2002 in the context of approval procedures for offshore wind farm projects. Research projects such as the benthological work on the ecological assessment of wind energy suitability areas by ZETTLER et al. (2003) or BeoFINO as well as the monitoring of benthic communities in nature conservation areas also provide important information.

2.6.2 Spatial distribution and temporal variability

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

Salinity is the determining factor for the occurrence and distribution of benthic species in the Baltic Sea. Aperiodic saltwater intrusions cause the salinity in deeper areas (> 40 m) to temporarily rise above 15 PSU, while the 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 behaviour. Overall, this fauna is quite well studied and therefore allows comparisons with conditions a few decades ago.

Natural classification of the German Baltic Sea EEZ: Benthos

The following proposal for a natural classification of the German Baltic Sea EEZ under benthological aspects deviates from the classification according to sedimentological criteria. The main structuring factor for the composition of the macrozoobenthos is salinity. Furthermore, the occurrence of macrozoobenthos species in the Baltic Sea depends on hydrographic conditions and water depth. The natural area classification is based on the BfN's nature conservation planning contribution to regional planning (BFN 2006). According to this, five natural units can be distinguished from west to east: the still quite marine Kiel Bay (A) and the Mecklenburg Bay

(B), the transitional area of the Darss Sill (C), followed by the Arkona Basin (D) and the Pomeranian Bay (E) (Figure 32).

The German part of the Baltic Sea lies in the transition area between the marine dominated Belt Sea and the brackish water dominated Central Baltic Sea. A prominent ecological boundary between the two different bodies of water is formed by the Darss Sill.

Table 7: Natural spatial classification 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∅salinity > 20, frequent oxygen depletion in the near-bottom water layers; icing rare	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 as well as very species-rich phytal communities
Mecklenburg Bay AEZ	**B**	Relatively low current speeds; thermohaline stratification with regular oxygen depletion, ∅salinity > 7 < 20; occasional icing	from 20 m to 30 m	Silt, clay in the central area, residual sediment in the marginal areas	Marine species dominate, partly species-rich endofauna communities as well as very species-rich phytal communities
Darss Threshold	**C**	Water exchange between the central and western Baltic Sea through the Kadet Trench	from 18 m to 25 m; sill between Belt Sea/ Mecklenburg Bay and Arkona Basin; embedded is the up to 25 m deep Cadet Trench	Medium and coarse sand, gravel, residual sediment areas and block fields (reef)	Transitional area, decrease in marine species (*Macoma balthica*; at lower altitudes from -20 m also *Abra alba*, Arctica islandica - communities as well as phytal communities in the cadastral channel).
Arkona Basin-AWZ	**D**	Relatively low current 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 stenothermic cold-water relicts in unique combination with freshwater species
Pomeranian Bay (with Adlergrund and Oderbank)	**E**	relatively low current velocities; icing possible in winter: (Adlergrund: rare freezing; Oderbank: frequent winter freezing), salinity > 7	Flat bottom from 6 m to 30 m	Medium and coarse sand, gravel, boulders, in the central areas large areas of homogeneous sands.	Species-poor brackish water communities in unique combination with freshwater species (*Macoma balthica*; *Mya arenaria, Theodoxus fluviatilis*).

The Kadet Trench acts as a link between them. Over 70% of the water exchange in the entire Baltic Sea passes through the Fehmarnbelt and the Kadet Trench.

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

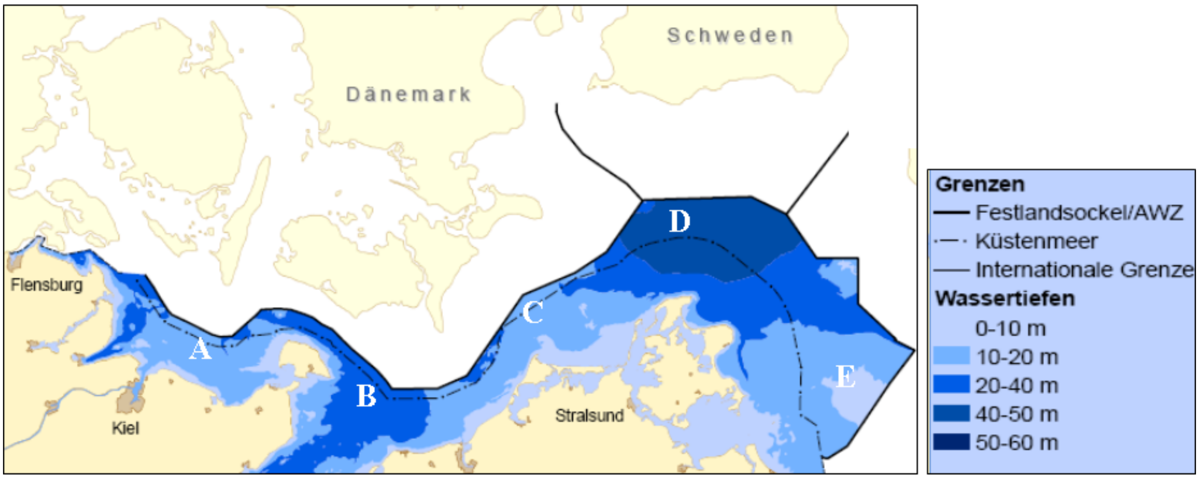

Figure 32: Natural spatial classification of the German Baltic Sea EEZ (after BFN 2006).

2.6.2.1 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 glacial relicts (GOSSELCK et al. 1996). The majority of species are marine euryhaline species, which penetrate the Baltic Sea to different extents depending on their tolerance to decreasing salinity. Many marine species do not penetrate into the areas east of the Darss Sill, or only after extreme events. Thus, marine species decrease from the Belt Sea towards the central and eastern Baltic Sea in favour of brackish water and limnic species and reach their eastern distribution limit in the area of the Arkona Basin. As the marine euryhaline species are not replaced to the same extent by freshwater species, the number of species consequently decreases.

The decline in species as a result of increasing salinity from west to east is illustrated by the data analysis of long-term monitoring at 8 monitoring stations in the western Baltic Sea shown in Figure 33 (WASMUND et al. 2017). The result shows a clear decrease in species numbers from the Bay of Kiel (83 species) to the central Mecklenburg Bay (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 Mecklenburg Bight and the Darss Sill. East of the Darss Sill to the Pomeranian Bay, lower (18-28 species) and the lowest species numbers in the long-term trend are again recorded (WASMUND et al. 2017).

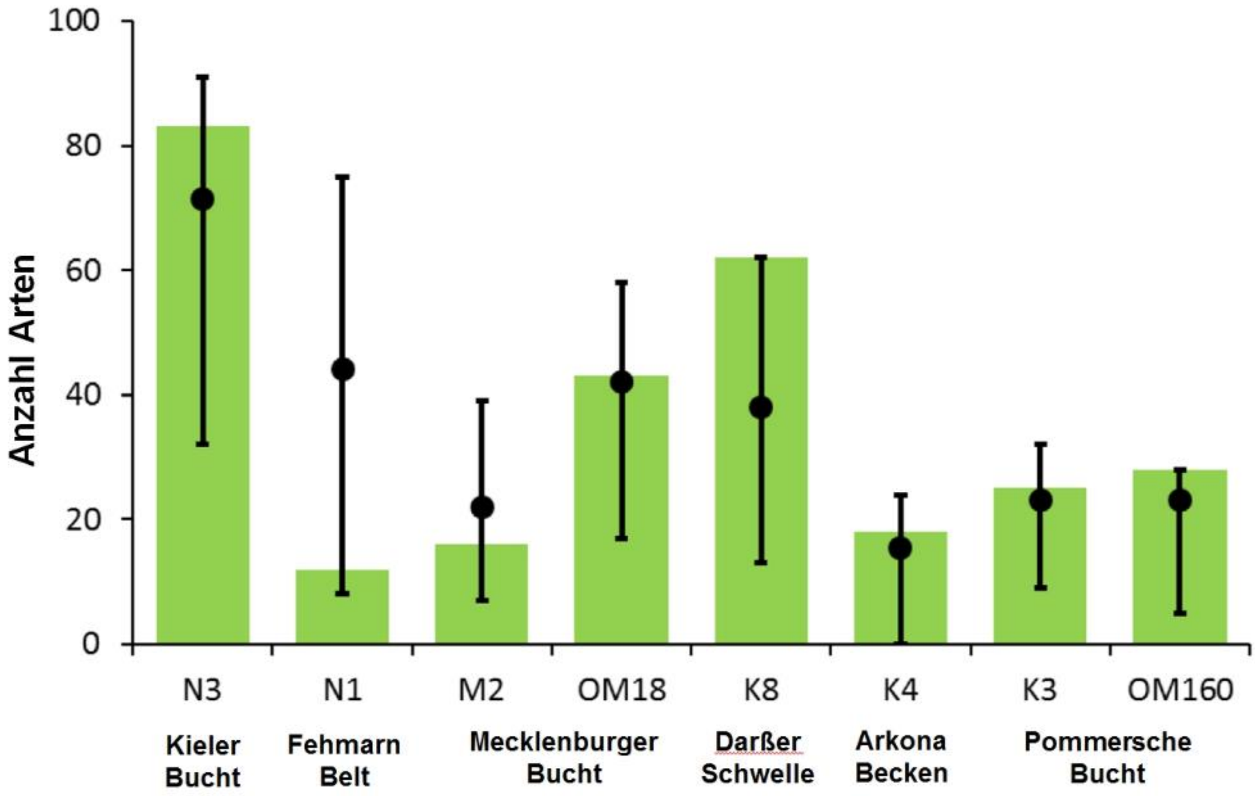

Figure 33: Number of macrozoobenthic species at 8 monitoring stations in November 2016 (green bars). Black dots and error bars show median, minimum and maximum species numbers between 1991 and 2016 (modified after WASMUND et al. 2017).

There is a close correlation between macrozoobenthos species numbers and salinity on the one hand and sediment conditions on the other (REMANE 1934; ZETTLER et al. 2014). Both higher mean salinity and hard substrate or fine substrate habitats (including silty areas) have been shown to be particularly rich in macrozoobenthos species.

When looking at the detailed results for the Fehmarnbelt station, it becomes clear that the benthic communities are subject to strong fluctuations from year to year, both in terms of their individual densities and their species composition (Figure 34). The highest abundances are found in the less species-rich molluscs, with *Macoma baltica* (Baltic mussel) and *Mytilus edulis* (blue mussel) being the most abundant. Crustaceans and polychaetes are less consistent in their densities.

The highest numbers of species over the years are found in the polychaetes. This is due to their high adaptability to changing environmental conditions (e.g. lower salt concentrations or low oxygen concentrations).

Fluctuations in abundance of other species can be explained by the strong annual fluctuations of the saltwater inflow from the North Sea. A strong influx of saltwater can lead to a significant increase in the number of individuals among the macrozoobenthos species within a few weeks. Frequent oxygen deficiency events have reduced species diversity and population density in recent decades. However, after a saltwater intrusion in 2014, euhaline species such as the mussels *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 or for the first time (WASMUND et al. 2016a).

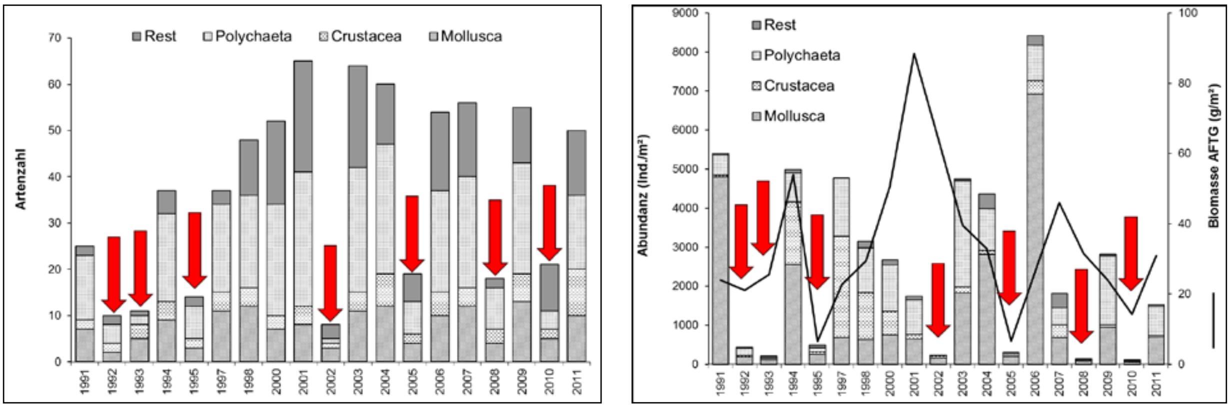

Figure 34: Development of species numbers, abundance and biomass of macrozoobenthos at the Fehmarnbelt station from 1991 to 2011. The arrows mark summer oxygen deficiency events in the near-bottom water body (from WASMUND et al. 2012).

A total of 383 benthic species are listed by GOSSELCK et al. (1996) for the German marine and coastal area of the Baltic Sea. In comparison, a total of 2,035 macrozoobenthic species can be detected in the entire Baltic Sea, which are divided into 1,423 marine species and 612 freshwater or brackish water species (ZETTLER et al. 2014). A total of 51 of these species are classified as neozoa.

WASMUND et al. (2017) state that a total of 260 taxa were recorded at eight stations in the Baltic Sea (Kiel Bight to Pomeranian Bay) between 1991 and 2016. However, about one third of these only appear occasionally. In the Bay of Kiel, 150 regularly occurring macrozoobenthos species were recorded in the 1980s (BREY 1984; WEIGELT 1985). Within the framework of the long-term monitoring of the outer coasts of Mecklenburg-Western Pomerania (IFAÖ 2005b), about 140 taxa were identified in the Mecklenburg Bay. The high proportion of marine "guest species" that are introduced into the Mecklenburg Bay during saltwater inflows is striking. ZETTLER et al. (2000) identified a total of over 240 macrozoobenthos species in the Mecklenburg Bay. 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, as well as to the fact that at the time of the study in 1999, due to the favourable hydrographic conditions, a large number of marine immigrants were present in the benthic area of Mecklenburg Bay.

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

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 areas (40 m) with muddy bottoms that lie below the salinity spring layer (halocline) are considered to be very poor in species. For example, ZETTLER et al. (2000)

found the greatest species diversity in the Mecklenburg Bay, with 140 taxa, in the water depth between 10 and 20 m. In the depth zone of 25 - 30 m, the species diversity is very low. In the depth zone of 25 - 30 m, which was the deepest part of the study area, the lowest species diversity was found with about 70 taxa.

Stratified waters have a special status. The increased salinity in the near-bottom water body and temporary oxygen deficiency lead to different colonisation patterns of the benthos. With the saline water from the North Sea/Kattegat area, larvae of marine evertebrates enter the Baltic Sea, so that marine faunal elements settle in the mixohaline waters, at least temporarily. On the other hand, the oxygen deficiency that occurs 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. Salty water is deposited in the basins and depressions and provides a habitat for species that can also be found in shallower water depths in the fully marine area. In doing so, they may also switch to substrates that do not correspond to their preferred habitat in the fully marine area. Due to the constant exchange processes between the North Sea and the Baltic Sea, the submergence areas can change, so that this area is not fixed. According to TISCHLER (1993), macrozoobenthic species that can serve as examples of "brackish water submergence" in the Baltic Sea include *Mytilus edulis (*blue mussel), *Macoma baltica (Baltic* flat mussel), *Hydrobia ulvae (*common mudflat snail) and the worms *Pygospio elegans (*Pygospio worm) and *Scoloplos armiger* (mudflat annelid).

2.6.2.2 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 flat mussel) community. While the lower distribution limit of the community in the North Sea is 10 to 15 m depth, this extends to the range between 75 - 100 m, especially in the low-salinity central part of the Baltic Sea, due to the higher salt concentrations at depth (TISCHLER 1993). In the western Baltic Sea, the species of the *Macoma balthica community* can also be found in shallower areas of the coastal waters. The "real" deep-water communities of the western Baltic Sea, on the other hand, are dominated by the *Abra-alba* or *Arctica-islandica communities. A* clear distinction between shallow and deep-water benthic communities is also pointed out by GLOCKZIN & ZETTLER (2008).

According to KOCK (2001), the fauna of the deeper Fehmarn Belt (19-28 m) can be regarded as an impoverished *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 character species are the mussels *Abra alba, Phaxas pellucidus, Aloides gibba* and *Nucula* sp., the polychaetes *Pectinaria koreni* and *Nephtys* sp. as well as the sea *urchin Echinocardium* sp.

In the Mecklenburg Bight, the delineation of biotic communities according to ZETTLER et al. (2000) is directly linked to depth zonation (salt, temperature, sediments). Three main communities can be characterised: The first group can be called the *Mya-arenaria-Pygospio-elegans community of* shallow sandy areas in water depths below 15m. Here, in addition to the sand clam and the spionid *Pygospio elegans, Hydrobia ulvae, Mytilus edulis, Macoma balthica* and *Scoloplos armiger,* among others, are substantially represented. The second group is the biocoenosis of sandy mud and mudflats in water depths above 15 m. The main species are *Arctica islandica* and *Abra alba*. Other essential taxa are *Diastylis rathkei, Euchone papillosa* and *Terebellides stroemi*. This *Abra-alba-Arctica-islandica community* is found in the Mecklenburg Bight at depths between 15 and 29.6 metres. After a longer period of oxygen depression, this monocoenosis can be reduced to *A. islandica* and *Halicryptus spinulosus* (PRENA et al. 1997). The third group are species of silty sands in water depths between 12 and 22 m. This transitional area from sands to mud has also produced a definable biocoenosis. This community can be called the *Mysella bidentata-Astarte borealis* community. This area is mainly dominated by five mussel species. Besides *Mysella bidentata* and *Astarte borealis, Corbula gibba, Parvicardium ovale* and *A. elliptica* are regularly represented. This zone is also the main occurrence area of *Asterias rubens*.

The exposed hilltops with their shifting coarse sands are a special habitat. Here, various specialists settle, such as manyborster species or the sand flea crab *Bathyporeia sarsi*. Silt-poor fine sands predominate, which are colonised by a typical, species-poor community with a high degree of stability. Dominant species in these areas are the Baltic flat clam, sand clam, lagoon cockle, blue mussel and the smooth mudflat snail from the mollusc group, as well as the iridescent sea annelid, *Pygospio elegans*, *Marenzelleria neglecta* and *Heterochaeta costata* from the annelid group (Polychaeta and Oligochaeta). Special communities are also found on the boulder and scree grounds. The epifauna community of the hard bottoms is dominated by the blue mussel (*Mytilus edulis*) and barnacles (*B. improvisus*). This community, as well as the phytocenosis, is mainly accompanied by sessile colony formers (bryozoans, cnidarians) and vagile isopods and amphipods (SORDYL et al. 2010).

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

Priority area wind energy EO1

In area EO1, three communities (A, B and C) could be identified. Community A is mainly distributed above the halocline, locally also in the area of hard bottoms below the halocline. The community is dominated by the blue 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 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 community of mud-rich soft bottoms below the halocline. Characteristic species include *Scoloplos armiger, Halicryptus spinulosus, Pontoporeia femorata, Diastylis rathkei, Ampharete* spp. and *Terebellides stroemi*.

Reservation area for wind energy EO2

Throughout area EO2, the *Macoma balthica community* is formed, which is widespread in large parts of the Baltic Sea. The three main species, measured by total number of individuals, are the Baltic flat mussel, the gill ringworm

Scoloplos armiger and the cumacean crab *Diastylis rathkei*. The predominant benthic species are mainly composed of species that regenerate quickly after disturbance.

Priority area wind energy EO3

In the Arkona Sea, two communities can be named in area EO3. The first community lives in shallow areas (up to 30 m water depth). Here, the polychaetes *Travisia forbesii, the* mussel *Mya arenaria,* the snail *Hydrobia ulvae* and the crab *Bathyporeia pilosa are* typical representatives of the community. Due to their feeding habits, all four are typical of slightly to moderately exposed areas of coastal waters and are rarely found below 20 m water depth. The areas in the central and northern parts of site EO3 can be assigned to this community. The second community is found in the deeper areas (30 to 40 m) and includes cold-water species such as the mussel *Astarte borealis*, the glacial relict amphipods *Monoporeia affinis* and *Pontoporeia femorata*, the relict *isopod Saduria entomon* and the polychaet *Terebellides stroemi*.

2.6.2.3 Red List species

According to current knowledge, a possible occurrence of at least 30 Red List species according to RACHOR et al. (2013) and HELCOM (2013b) can be expected in the area of the German EEZ (

Table 8). The main causes of threat are the destruction of habitats through direct anthropogenic impacts and effects of eutrophication such as oxygen deficiency and increasing siltation of sandy soils. For coldest-thermic species, climate-induced warming of the Baltic Sea will be a significant cause of endangerment in the future (SORDYL et al. 2010).

During the macrozoobenthos surveys carried out as part of HELCOM monitoring at eight stations in the western Baltic Sea (WASMUND et al. 2017), a total of 23 species from the Red List for the North Sea and Baltic Sea (RACHOR et al. 2013) were detected in November 2016. Two of these species are listed as threatened with extinction (category 1), including the calcareous flat mussel (*Macoma calcarea*), which, as in previous years, was detected in low abundance in the area of the Bay of Kiel. The anthozoan *Halcampa duodecimcirrata,* also classified as endangered, was found in small numbers in the southern Mecklenburg Bight, but outside the German EEZ. Among the species categorised as critically endangered (category 2) according to RACHOR et al. (2013), the whelk (*Buccinum undatum) occurred in* the Kiel Bight area. The polychaet *Euchone papillosa,* also categorised as critically endangered, was found in the Mecklenburg Bay. Among the species classified as endangered (category 3), the globe astarte (*Astarte montagui*) was found exclusively in the area of the Bay of Kiel, while the Iceland mussel (*Arctica islandica*) was found at several stations in the western Baltic Sea as well as in the Arkona Basin.

In the HELCOM Red List of the entire Baltic Sea (HELCOM 2013b), which was developed according to global criteria of the International Union for Conservation of Nature (IUCN), fewer species are listed as endangered compared to the national Red List according to RACHOR et al. (2013) due to different assessment criteria (

Table 8). Due to the different assessment criteria of the two Red Lists, the endangerment classifications also differ.

Most of the species listed as critically endangered (category EN) or endangered (category VU) on the HELCOM list occur outside the German EEZ in the area of the Kattegat or are restricted to shallow coastal waters or beaches. Of the species potentially occurring in the German EEZ, HELCOM (2013b) lists the three mussel species *Macoma calcarea*, *Modiolus modiolus* and *Nucula nucleus* as vulnerable (category VU). Three species that occur in the EEZ are on the forewarned list (category NT), among them the clam (*Mya truncata) as* well as the Icelandic auger snail (*Amauropsis islandica)* and the purple snail (*Boreotrophon truncatus*).

From the surveys of the wind farm projects "Wikinger", "Wikinger Süd", "Wikinger Nord", "Arkonabcken Südost", "Baltic Eagle" and "EnBW Baltic 2" as well as the grid connection "Kabel 1 to 6 / Querverbindung", another 6 Red List species were detected. These include the endangered bryozoan *Alcyonidium gelatinosum* and the amphipod *Monoporeia affinis*. Another four species are endangered to an unknown extent. So far, 10 endangered species have been detected in the surveys of area EO1 (

Table 8).

The *Icelandic* mussel *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 muddy sand and requires a high salinity of at least 14 PSU as well as low temperatures. Since 1960, a decline in the Baltic Sea population has been described, caused by a prolonged lack of oxygen in the deep water (SCHULZ 1968). In the depth zones of 20 to 15 m, which are seldom affected by oxygen deficiency, the Icelandic mussel continues to occur in the Mecklenburg Bight, or occurs again in high densities (ZETTLER et al. 2001). It has a high recolonisation potential and is almost always one of the first colonisers of the desolate soils in the deep zones of the Lübeck and Mecklenburg Bight after oxygen deficiency situations (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 is in principle widespread throughout the German marine area.

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

Art	Status according to Rachor et al., 2013	Status according to HELCOM, 2013	Area EO1	Area EO2	Area EO3
Anthozoa (floral animals)					
Halcampa duodecimcirrata	1	-			
Bivalvia (mussels)					
Arctica islandica	3	-	X	X	X
Astarte borealis	G	-	X		X
Astarte elliptica	G	-	X		X
Astarte montagui	3	-			X
Macoma calcarea	1	VU			
Modiolus modiolus	2	VU			
Musculus discors	G	-			
Musculus niger	G	-			
Subpictus muscle	G	-			
Mya truncata	2	NT	X		
Gastropoda (snails)					
Amauropsis islandica	2	NT			

Art	Status according to Rachor et al., 2013	Status according to HELCOM, 2013	Area EO1	Area EO2	Area EO3
Aporrhais pespelicani	G	-			
Boreotrophon truncatus	2	NT			
Buccinum undatum	2	-			
Nassarius reticulatus	G	-			
Neptunea antiqua	G	-			
Crustacea (crustaceans)					
Monoporeia affinis	3	-	X		X
Saduria entomon	G	-	X		X
Oligochaeta (Fewborers)					
Clitellio arenarius	G	-			X
Tubificoides pseudogaster	G	-			X
Polychaeta (Vielborster)					
Euchone papillosa	2	-			
Fabriciola baltica	G	-	X		X
Nereimyra punctata	G	-			
Scalibregma inflatum	G	-			
Travisia forbesii	G	-	X		X
Echinodermata (Echino-derms)					
Echinocyamus pusillus	G	-			
Hydrozoa (Hydrozoans)					
Sertularia cupressina	G	-			
Halitholus yoldiaearcticae	3	-	X		
Bryozoa (bryozoans)					
Alcyonidium gelatinosum	3	-	X		

The branch species are represented by three species in the EEZ. *Astarte borealis* and *Astarte elliptica* were documented in area EO1. As marine species, they colonise the sublittoral sandy-silty to muddy-sandy zone between about 12 m to 20 m water depth. *Astarte montagui* has never been frequently recorded. It belongs to the marine species that temporarily colonise the area of the Belt Sea after saltwater intrusions.

The presumably always small population of *Mya truncata* has been further decimated by oxygen deficiency. Eutrophication and near-bottom fishing also have an influence on the occurrence of *M. truncata,* as the species does not burrow very deeply into the sediment (HELCOM 2013b). Since 1994, and more frequently since 1997, *M. truncata has been* detected again at the deep stations (15 to 20 m) of the M-V coastal monitoring programme.

The species has so far been recorded in small numbers in the area of the Bay of Kiel as well as during surveys of area EO1.

Macoma calcarea, the large relative of the Baltic flat mussel, occurred until the 1970s along the saltwater zone between 15 and 20 m water depth in the Belt Sea, the northern Arkona Basin and the Bornholm Basin. Lack of oxygen led to the decline of the population in the Baltic Sea and Mecklenburg Bay. Currently, the occurrence of this species is restricted to the western part of the German EEZ (HELCOM 2013b).

The marine snails *Amauropsis islandica* and *Boreotrophon truncatus* are marine species that require cold water and high salinities. Their occurrence is currently restricted to the western part of the German EEZ and their populations are threatened mainly 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 bottoms and is bound to cold water temperatures. It resides in the upper 5 cm of the sediment and is an active bioturbator, influencing sediment structure, nutrient fluxes and oxygen availability in the sediment. Settled phytoplankton and organic substances of the detritus are considered the main food source. In the German EEZ, *M. affinis* has been detected in the area of site EO3.

2.6.2.4 Benthic algae

The biotopes of the Baltic EEZ are primarily colonised by benthic invertebrates. Submerged vegetation is represented by large algae (red and brown algae) on hard bottoms (boulders, blocks) in the area of knolls (Adlergrund, Kriegers Flak) and channels (Kadetrinne). There are no observations of seagrass (*Zostera marina*) from the EEZ area, although it could certainly occur given the water depth.

Macrophyte populations have not yet been detected in area EO1.

2.6.3 Status assessment of the benthos as a protected resource

The benthos of the Baltic 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 alien species and eutrophication of the water body, as well as climate change.

2.6.3.1 Importance of the areas for benthic communities

For the assessment of the benthic communities, criteria are used that have already proven successful in the environmental impact assessments for offshore wind farm projects in the EEZ.

Criterion: Rarity and endangerment

The criterion "rarity and endangerment" 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 detected.

According to the currently available studies, the macrozoobenthos of the Baltic Sea EEZ is considered average due to the number of Red List species detected. A species list for the entire EEZ is not currently available. However, the studies by KOCK (2001), in the course of which more than 110 different macrozoobenthos species were found in the deep-water area of the Fehmarn Belt, provide indications of species diversity. According to ZETTLER et al. (2003), more than 126 species have been found in the Arkona Sea.

For the German marine and coastal area of the Baltic Sea, GOSSELCK et al. (1996) list a total of 383 benthic species. WASMUND et al. (2016) state that a total of 251 macrozoobenthic taxa were detected at eight stations in the Baltic Sea

(Bay of Kiel and Mecklenburg, Arkona Sea) between 1991 and 2015. The 29 Red List species detected in the German EEZ thus correspond to approx. 8-12% of the total population. Species on the Forewarned List and species with insufficient data are not taken into account here.

Criterion: Diversity and distinctiveness

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

The species inventory of the Baltic EEZ can be considered average with its approx. 200 macrozoobenthos species. The benthic communities also show no special features for the most part. At higher salinities, such as still prevail in the deeper horizons (from approx. 20 m) in the German Belt Sea, the conditions are given for a relatively species-rich *abra alba community,* whose name-giving lesser pepper clam (Abra *alba) is accompanied* by the basket clam (*Corbula gibba), the* Iceland clam (*Arctica islandica), the caddis* worm (*Lagis koreni), the* polyborster *Nephtys* spec, the crab *Diastylis rathkei* or the common brittle star (*Ophiura albida*). In addition, there are a number of other marine euryhaline multiborsters, crabs and molluscs. In the Baltic Sea proper, the shallower areas are dominated by the *Macoma balthica monocoenosis,* with a decrease in species due to salinity.

Criterion: Existing pressure

For this criterion, the intensity of fishing exploitation, which is the most effective direct disturbance variable (e.g. HIDDINK et al. 2019, EIGAARD ET AL. 2016, BUHL-MORTENSEN et al. 2015 and literature cited therein), is used as an assessment criterion. Furthermore, benthic communities can be affected by eutrophication. For other disturbance variables, such as shipping traffic, pollutants, etc., suitable measurement and detection methods are currently still lacking in order to be able to include them in the assessment.

The benthos of the Baltic Sea is pre-stressed by various anthropogenic disturbance factors and deviates from its original state. Therefore, neither the species composition nor the biomass of the zoobenthos today corresponds to the state that would be expected without human uses. Particularly noteworthy is the direct disturbance of the bottom surface by intensive fishing activity, which poses a high risk potential for the epibenthos and causes a shift from long-lived species (mussels) to short-lived, rapidly reproducing species. Other major influencing factors are eutrophication and shipping. The most important effects of eutrophication on the Baltic Sea ecosystem were the increase in planktonic primary production, the increase in benthic biomass (CEDERWALL and ELMGREN, 1980) and the increase in oxygen deficiency events. Increasing oxygen consumption due to eutrophication processes and reduced water exchange due to climate variability or change are considered to be causes of the frequent and extreme oxygen deficiency events in the Baltic Sea (HELCOM 2009). Threats to the benthos can also come from the warfare agents dumped in the Baltic Sea.

In addition to the assessment criteria mentioned above, the Baltic Sea succession model by RUMOHR (1996) can be used to describe the situation of the benthic communities in the Baltic Sea. Applying this model shows that the benthological condition of the Baltic Sea deteriorated by at least one stage between 1932 and 1989. The particular hydrographic and morphological characteristics of the Baltic Sea as well as natural events (saltwater intrusion, oxygen deficiency) and anthropogenic influences (eutrophication, pollutant inputs) reveal a sequence (succession) of typical benthic states. RUMOHR (1996) distinguishes a sequence of typical conditions and defines a total of five different stages, which begin with a stable (climax) community dominated by long-lived bivalves or echinoderms (stage 1, rarely found today) and, with increasing eutrophication, change to a community dominated by bivalves and long-lived polychaetes and subject to strong fluctuations with increased biomass (stage 2). If conditions deteriorate further, a short-lived, low-biomass small polychaete community 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 off and only occasionally a mobile epifauna is found. Stage 5 shows a long-term animal-free (azoic) sediment with laminated fine stratification.

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

Priority area wind energy EO1

In preparatory studies by ZETTLER et al. (2003) for the designation of the special suitability area "Westlich Adlergrund" (area EO1), a total of 69 macrozoobenthos species were detected. Total densities of between 750 and 31,250 individuals/m² were found, with abundances being significantly influenced by the occurrence of the blue mussel (*Mytilus edulis*). Accordingly, the biomass correlates mainly with their occurrence. ZETTLER et al. (2003) identified a total of six species that can be regarded as so-called glacial relicts (*Halitholus yoldiaearcticae*, *Astarte borealis, A. elliptica, Monoporeia affinis, Pontoporeia femorata and Saduria entomon*). These species, like *Arctica islandica,* are dependent on cold and relatively salty water and therefore their occurrence is largely restricted to the deeper areas of the site. From a macrozoobenthic perspective, the areas with *Astarte borealis* are particularly valuable for the region. Strong aperiodic saltwater intrusions can flush marine species into the eastern Arkona Basin and thus contribute to species diversity. In the southern half, bivalve communities of *Mytilus edulis* and *Macoma baltica have been* found.

The investigations of the benthos in the area of Site 1 carried out as part of the baseline survey (MARILIM 2016) could only partially confirm the results of ZETTLER et al. (2003). The species found were assigned to the *Macoma balthica community*, which is widespread in the western and central Baltic Sea. Accordingly, in area EO1 the species *Macoma balthica, Scoloplos armiger* and *Pygospio elegans were* most abundant, with the biomass dominated by the Baltic flat mussel (*Macoma balthica*). In the southern part of area EO1, however, the three main species *Mytilus edulis*, *Pygospio elegans* and *Macoma balthica were* most abundant. The biomass in this area was constantly dominated by mussels (*Mytilus edulis* and *Macoma balthica*).

The benthic community in the area of site EO1 is considered to be of high quality due to the species richness, the rare relict species and the Red List species. The area thus has a comparatively high proportion of endangered species. From a macrozoobenthic point of view, the stone fields with their distinct mussel beds are particularly valuable. In the south-east, they extend from the Adlergrund into the EO1 area with their very high numbers of benthic species for the region. Mainly mussel beds, gravel and stone beds as well as in-situ boulder clay were identified.

Reservation area for wind energy EO2

The results of the environmental assessments of the proposed offshore wind farms "Baltic Eagle" and "Ostseeschatz" are used to assess the benthos in area EO2. The *Macoma balthica community*, which is widespread in large parts of the Baltic Sea, is formed in the entire area. Besides the eponymous Baltic flat mussel, various other bivalves, polychaetes, crustaceans and gastropods dominate the benthic community. The three main species, measured by total number of individuals, are the Baltic flat mussel, the gill ringworm *Scoloplos armiger* and the cumacean crustacean *Diastylis rathkei*. Apart from the mussels, these are mainly fast-growing, short-lived "opportunists", which are characterised by rapid attainment of sexual maturity, high numbers of offspring and short life cycles. These are crucial characteristics to survive in the highly variable environmental factors of the habitat.

In the project areas of "Baltic Eagle" and "Ostseeschatz" a total of 42 macrozoobenthos species were determined. The average density of individuals in the project area "Ostseeschatz" 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 found, only the Icelandic mussel (*Arctica islandica) is* classified as endangered according to the Red List (Rachor et al., 2013) (cf.

Table 8).

Overall, the EO2 area has a low structural richness. The predominant benthic species are mainly composed of species that regenerate quickly. The distinctive ability to recover quickly after disturbance is a feature of the benthic fauna present (RUMOHR 1995). The area is therefore of low importance for both infauna and epifauna.

Priority area wind energy EO3

The description of area EO3 is based on the results of the preparatory investigations for the designation of the special suitability area "Kriegers Flak" and the results of the benthos investigations within the scope of the EIA and the monitoring accompanying the construction of the wind farm "EnBW Baltic 2".

Within the scope of the investigations by ZETTLER et al. (2003), a total of 77 macrozoobenthos species were detected. Total densities between 386 and 8875 individuals/m² were recorded, whereby the abundances were significantly influenced by the presence or absence of the Baltic flat mussel (*Macoma balthica*) and the polychaete *Pygospio elegans. The* biomass was mainly dependent on the larger mussel species (*Macoma balthica*, *Mya arenaria* and *Mytilus edulis*). At the silt stations in water depths above 35 m, the polychaet *Terebellides stroemi* was regularly recorded in relatively high abundances. Of the species recorded, seven can be regarded as so-called glacial relicts (including *Astarte borealis*, *Monoporeia affinis* and *Pontoporeia femorata)*. These species, as well as *Arctica islandica,* are dependent on cold and relatively salty water and therefore their occurrence is largely restricted to the deeper areas of the area. These areas are particularly valuable for the Kriegers Flak region from a macrozoobenthic perspective.

With the exception of a few findings of rare species, the results of the investigations carried out as part of the EIA on the current population of benthic communities are consistent with the results of the investigations carried out as part of the R&D project commissioned by the BfN (Zettler ET al. 2003). In the study area of the "EnBW Baltic 2" wind farm, a total of 83 macrozoobenthos taxa were detected in the EIA. A total of 60 species and 20 supraspecific taxa were also detected during the investigations carried out as part of the monitoring during construction (IFAÖ 2015a). The most frequently present were the Baltic flat mussel (*Macoma balthica*) and the blue mussel, the smooth mudflat snail (*Hydrobia ulvae*), the polychaetes *Pygospio elegans* and

Scoloplos armiger, and the cumacean *Diastylis rathkei*.

A total of 10 endangered species on the Red List according to RACHOR et al. (2013) were detected in the area of site EO3 between 2002 and 2014 (cf. Table 8).

The benthic community in area EO3 is considered to be of high quality due to the species richness, the rare relict species and the number of Red List species. This follows on the one hand from the fact that a total of 83 species have been identified in the study area of the "EnBW Baltic 2" wind farm, 10 of which are Red List species. The southern and partly the north-eastern area of the site are of particular importance, as cold-water-loving species (e.g. *Astarte borealis, Monoporeia affinis*), which are rare in the Baltic Sea, occur here. According to ZETTLER et al. (2003), the rock and scree beds in the northern shallow area with the distinct mussel beds are also particularly valuable from a macrozoobenthic perspective.

Reservation area for pipelines LO6

Within the scope of the benthic investigations for the grid connection of the offshore wind farm "Arkona Basin Southeast", a total of 36 macrozoobenthos species were detected on the basis of grab sampling. The most species-rich groups were polychaetes and crustaceans. The average density of individuals was 3,396 per m². A total of 61 species were detected in the course of the route surveys carried out in 2012 for the planned grid connections for area EO1.

The soft bottom vegetation found along the route outside area EO1 is relatively species-poor. The individual densities and total biomasses found are also comparatively low. Soft bottom-dwelling species such as *Halicryptus spinulosus, Macoma balthica, Terrebellides stroemi, Diastylis rathkei* and *Pontoporeia femorata* dominate. Especially in summer, aperiodic oxygen deficiency events can occur in the silt bottoms and lead to large-scale die-off of the benthic fauna. Overall, the significance of the route for the macrozoobenthos is to be classified as low to maximum medium. The transect surveys within area EO1 show a significantly more species-rich benthic community with higher individual densities. Here, the blue mussel dominates the hard-bottom benthic community.

More recent surveys of the benthic communities were carried out as part of the "Cable 1 to 6 / cross-connection" approval procedure for the grid connection in the area of Areas 1 and 2 (50 HERTZ 2014), the routes of which largely coincide with the routes of the connections. A total of 42 taxa were detected along the planned cable routes, with Polychaetes (14 species), Crustacea (12 species) and Mollusca (5 species) as the most species-rich taxonomic groups. Two of the recorded species are listed in the Red List according to RACHOR et al. (2013) with a degree of endangerment of unknown extent (RL category G) due to their population situation or population development. These are the mussel *Astarte borealis* and the giant isopod *Saduria entomon*. At least locally, the endangered, long-lived mussel *Arctica islandica* (RL category 3) may also occur, even though it was not detected during the above surveys. The occurrence of typical reef species or reef communities is to be expected within the stone fields found in the area. Thus, the benthic community is to be classified as "regionally significant", especially in the area of site EO1.

2.7 Fish

As the most species-rich of all vertebrate groups living today, fish are equally important as predators and prey in marine ecosystems. Bottom-dwelling fish feed primarily 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 as well as in the open water and the energy bound in it also becomes available to seabirds and marine mammals.

For a first subdivision of the fish fauna, the way of life of the adults in the water body is useful, according to which bottom-dwelling species (demersal) can be distinguished from those that live in the open water (pelagic). Mixed forms of both (benthopelagic) are also common. However, this separation is not strict: demersal fish also ascend into the water column, just as pelagic fish temporarily reside near the bottom. At 53%, demersal fish make up the largest proportion, ahead of benthopelagic (27%) and pelagic (17%) species. Only about 3% cannot be assigned to any of the three life stages due to a close habitat connection (FROESE & PAULY 2000). The individual life stages of the species often differ more from each other in form and behaviour than the same stages of different species: the pelagic herring *Clupea harengus* lays its eggs in thick mats on sandy-gravelly bottoms or sticks them to suitable substrate such as algae or stones (DICKEY-COLLAS et al. 2015), all flatfish have pelagic larvae that transition to bottom life as they transform into their characteristic body shape (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 fisheries and climate change (HOLLOWED et al. 2013, HEESSEN ET AL. 2015). These factors interact and can hardly be distinguished in their relative effect on fish population dynamics (DAAN et al. 1990, VAN BEUSEKOM ET AL. 2018). Added to this are the hydrographic conditions and the influences of diverse human activities. Thus, although 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).

Another mechanism by which increased temperatures due to climatic changes can affect fish population dynamics is a weakening of the synchronicity between temperature-controlled zooplankton development and daylength-controlled phytoplankton development. Due to this "mismatch" (CUSHING 1990), fish larvae may find a reduced density of zooplankton when they rely on external food after consuming their yolk sac. Across species, survival rates of early life stages have a disproportionate effect on population dynamics (HOUDE 1987, 2008). This variability may propagate 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 as humans respond to climate change by installing offshore wind farms (EEA 2015). On the one hand, this would create large areas from which fishing is excluded, and on the other hand, artificial hard substrates would be introduced on a large scale, creating habitats for species that do not otherwise occur in the areas concerned (EHRICH et al. 2007). These mechanisms are basically also effective in the Baltic Sea, whose hydrographic dependence on wind-driven influxes of salty and oxygen-rich North Sea water is the decisive factor for fish populations (MÖLLMANN et al. 2009). Thus, oxygen deficiency occurs repeatedly in the deep basins. Stable stratification of the water body with oxygen depletion below the temperature spring layer can massively impair the reproductive success of fish whose eggs float in these layers (e.g. the 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 by the decline of the seal population and severe eutrophication.

2.7.1 Data situation

Since data are almost exclusively available from bottom trawling, but not from pelagic sampling, the following assessment can only be made for demersal fish. For pelagic fish, no data are available that fully represent the species spectrum. A reliable assessment of the pelagic fish community is therefore not possible. The bases for the assessment of the status of (bottom-dwelling) fish are as follows

- the results from environmental impact studies and cluster investigations for the compilation 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).
- the International Council for the Exploration of the Sea (ICES) trawl survey database (DATRAS) (accessed 12 March 2018). Here, only the standard areas and plan squares covering the German EEZ of the Baltic Sea 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 Q4 2017 and Q1 2018 have been combined.

It should be taken into account that the supplementary DATRAS data were carried out with different fishing gear as well as deviating haul numbers and towing times compared to the investigations of the environmental impact studies and cluster investigations.

For a historical reference, EHRICH et al. (2006) and KLOPPMANN et al. (2003) were considered. The classification in the Baltic Sea-wide context was done with the help of HEESSEN et al. (2015). For the current assessment (2017/2018) of the fished stocks, the internet portal "Fischbestände online" (BARZ & ZIMMERMANN 2018) was used, which summarises the scientific stock assessment of ICES.

2.7.2 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 that take effect at different spatial and temporal scales. On a large scale, hydrographic and climatic factors such as swell and, above all, wind-induced currents have an effect, controlling the inflow of cold, oxygen-rich saltwater from the North Sea, which significantly shapes the living conditions for fish in the Baltic Sea. On medium (regional) to small (local) space-time scales, water temperature and other hydrophysical and hydrochemical parameters, as well as food availability, intraspecific and interspecific competition and predation, which includes fishing, have an effect. Another crucial factor for the distribution of fish in time and space is habitat, which in a broader sense means not only physical structures but also hydrographic phenomena such as fronts (MUNK et al. 2009) and upwelling areas (GUTIERREZ et al. 2007), where prey can aggregate and thus initiate and maintain entire trophic cascades.

The diverse human activities and influences are further factors that structure fish distribution. They range from nutrient and pollutant discharges to the obstruction of migratory routes of migratory species and fisheries to construction works in the sea.

Newly introduced structures can serve as spawning substrate (sheet piling for herring spawn) or food source (fouling of artificial structures) for some fish species (EEA 2015). Some fish species, such as cod, aggregate on artificial structures (e.g. GLAROU et al. 2020). In addition, with the exception of the vehicles required to operate the wind farm (maintenance vessels), a general prohibition of navigation and use is regularly provided within the OWP areas, with the consequence that no fishing takes place in the area. There is a need for research to determine whether the fish community uses the fishery-free area as a refuge. Further information on the effects of newly introduced structures is described in Chapter 3.2.3

2.7.2.1 Fish fauna in the German EEZ

The special hydrography and the decreasing 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 fish species community. As of November 2015, the Fishbase fish database (FROESE & PAULY 2000) lists 160 species that have been recorded in the entire Baltic Sea. THIEL et al. (1996) put the number of Baltic Sea fish species at 144, consisting of 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. Here, the reference area comprises the Baltic coasts of Schleswig-Holstein and Mecklenburg-Western Pomerania, bounded externally by the centre line established with the neighbouring countries (according to the definition by FRICKE et al. 1996). The documentation contains all species for which there is a scientifically verified record from the German Baltic Sea region. If all individual records ever found in the Baltic Sea are taken into account, the list of Baltic Sea fishes consists of 176 species (WINKLER et al. 2000). Following MÖBIUS & HEINCKE (1883), the species are divided into four categories according to the way the area is used as a habitat:

- Marine standing fish that migrate but are constantly found in the area and also reproduce there,
- Marine migrants and stray visitors that migrate regularly, sporadically or extremely rarely from the North Sea but do not reproduce in the Baltic Sea,
- Diadromous migratory fish that reproduce in freshwater and grow up in the sea or vice versa,
- Freshwater fishes with stationary occurrence or migratory, reproducing in brackish or pure freshwater.

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

- anadromous species such as salmon, finback *Alosa fallax* and river lamprey *Lampetra fluviatilis,* which spawn in freshwater and grow up in the estuary or sea,
- semi-anadromous species such as Zährte *Vimba vimba*, Ziege *Pelecus cultratus*, Ostseeschnäpel *Coregonus maraena* or Stint *Osmerus eperlanus,* which spawn in the upper estuary/saline brackish or freshwater and
- catadromous species such as eel or flounder, which spawn in the sea and grow up in brackish or fresh water.

While guest species are usually regular visitors to the area during their foraging migrations, stray visitors appear hardly predictably and mostly as a result of unusual hydrographic and meteorological phenomena. In the Baltic Sea, almost half of all species are stationary in the area, 18% can be classified as regular guests, 29% as stray guests and 8% have been introduced into the Baltic Sea via intended or unintended stocking measures, mostly only temporarily.

The total number of species has almost doubled compared to the 16th century, mainly due to the occurrence of marine species, although the ratio between marine 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% diadromous migrants and 21% freshwater fish. Of the 151 species occurring in the Baltic Sea, 44 are considered very rare, 36 rare, 33 regular, 24 common, and 13 species occur very frequently in the German Baltic Sea. Thus, about 46% of the fish species (70 of 151) occur regularly to very frequently and about 54% rarely to very rarely in the German Baltic Sea (WINKLER & SCHRÖDER 2003).

2.7.2.2 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 exchange, e.g. when pelagic fish such as herring visit their spawning grounds on the coast. In addition to spawning grounds, feeding areas of many fish species are also located on the coast. The pelagic fish community is dominated by the herring, which is found throughout the Baltic Sea. Sprat, salmon and sea trout are other characteristic representatives. The economically most important representatives of the benthic fish community are cod, flounder and plaice. In addition to the commercially exploited species mentioned above, 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, the Bodden and Haffe, is characterised by dense growth of algae and seagrass as well as by abundance of food, which explains its function as a nursery area also for economically important species and as a habitat for small fish.

2.7.2.3 Typical regional communities

The distribution of Baltic fish is largely determined by their tolerance or preference to abiotic factors such as salinity, temperature and oxygen content. In particular, the more sensitive developmental stages are decisive here. Freshwater fish reach their physiological limits in the brackish Baltic Sea, as do marine fish from the North Sea, and the distribution of fish species reflects the salinity gradient, which decreases from the east and north (RHEINHEIMER 1996). Along the same gradient, both the number of species and the species-specific abundance decrease, which can be largely explained by the fact that marine fish avoid areas that are too low in salinity. Thus, marine fish are predominantly found in the Kattegat and in the western Baltic Sea (NELLEN & THIEL 1995), while freshwater fish are represented with the most species in the coastal waters of the central Baltic Sea. REMANE (1958), for example, reports 120 marine fish species in the North Sea, only 70 in the Kiel and Mecklenburg Bight, 40 to 50 in the southern and central Baltic Sea, and only 20 species in the Aland Sea, the Gulf of Finland and the Bothnian Sea. In addition to salinity, water temperature is apparently also a factor that structures the fish community. The fish fauna of the North Sea is composed of species whose main distribution is either in the north (Norway, Iceland) or in the south (English Channel, Bay of Biscay). In the western Baltic Sea, with few exceptions, all common marine fish are predominantly cold-adapted, e.g. cod, whiting, plaice and dab. In contrast, fish species with a more southern distribution focus are rare guests of the western Baltic Sea, including mackerel *Scomber scombrus,* horse mackerel *Trachurus trachurus*, haddock *Melanogrammus aeglefinus,* red gurnard *Chelidonichthys lucernus*, anchovy *Engraulis encrasicolus* and mullet *Chelon labrosus*. Nevertheless, some representatives of the "southern type" can be found among the stagnant fish of the western Baltic Sea with turbot, garfish, sprat, black goby *Gobius niger and* sand goby (NELLEN & THIEL 1995). The occurrence of freshwater fish in the Baltic Sea is limited to the river estuaries, Bodden and Haff waters (THIEL et al. 1996).

2.7.2.4 Red List species in the German EEZ

For the 89 species of fish and lamprey established in the Baltic Sea, the endangerment was assessed in the context of the Red List, based on the current population situation as well as long-term and short-term population trends (THIEL et al. 2013). According to this, 9% (8 species) of the marine fish and lampreys established in the Baltic Sea are classified as extinct or endangered according to the Red List status. Taking into account the extremely rare species, the proportion of Red List species increases to

16.9% (15 species). A total of 4 species with a Red List status in the Baltic Sea were detected in the eastern EEZ (FREYHOF 2009; THIEL ET AL. 2013). The river lamprey is threatened with extinction (1) (FREYHOF 2009). The European eel is critically endangered in the Baltic Sea (2), and the fin and salmon are endangered (3) (THIEL et al. 2013).

Three of the Red List species are listed in Annex II of the Habitats Directive, namely the feint, river lamprey and the salmon, which, however, only has FFH status in freshwater areas. The sturgeon *Acipenser oxyrhinchus is* considered extinct in the Baltic Sea (FREYHOF 2009). According to genetic and morphometric studies, the "Baltic" or "Baltic sturgeon" is not the Atlantic sturgeon *Acipenser sturio*, as previously assumed, but a descendant of *A. oxyrhinchus, which* is 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 have been transmitted, have been released in the Odra River since 2007/2008. So far, no natural reproduction has taken place and all reported sturgeon catches can be traced back to these stocking measures (GESSNER et al. 2000).

2.7.3 Assessment of the status of fish as a protected resource

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

Rarity and endangerment

The rarity and endangerment of the fish community is assessed on the basis of the proportion of species that are considered endangered according to the current Red List of Marine Fishes (THIEL et al. 2013) and for the diadromous species of the Red List of Freshwater Fishes (FREYHOF 2009) and have been assigned to one of the following Red List categories: Extinct or missing (0), Critically endangered (1), Endangered (2), Endangered (3), Endangerment of unknown extent (G), Extremely rare (R), Forewarned list (V), Data insufficient (D) or Endangered (*) (THIEL et al. 2013). The endangerment situation of species listed in Annex II of the Habitats Directive requires special attention. They are the focus of Europe-wide conservation efforts and require special protection measures, e.g. of their habitats.

In the Baltic Sea areas where **sites EO1, EO2 and EO3 are** located, a total of 45 fish species were identified during the environmental impact assessments and in the context of fish monitoring for stock assessment in the above-mentioned period (2.8.1). According to THIEL et al. (2013) and FREYHOF (2009), no species is considered extinct or lost (0) or threatened with extinction (1). With eel, haddock and lake stickleback, three highly endangered species (2) were detected (6.7%). The greater petrel *Trachinus draco* and the dwarf cod *Trisopterus minutus are* considered endangered (3) (2 species, 4.4%). No endangerment of unknown extent (G) was identified for any of the species present. Pollock is considered extremely rare (R, 1 species, 2.2%), turbot, mackerel and sole *Solea solea* are on the forewarned list (V; 3 species, 6.7%). For the sand eels *Ammodytes tobianus*, *Hyperoplus immaculatus* and *H. lanceolatus* as well as for hake and sea-bull (5 species, 11.1%), the data situation for an assessment is considered insufficient (D). The vast majority of species (31, 68.9%) are classified as non-endangered (*).

In the lake areas where **site EO1** is located, a total of 38 species were detected during the environmental impact studies and in the context of fish monitoring for stock assessment, none of which are considered extinct or lost (0), threatened with extinction or endangered to an unknown degree (G) according to FREYHOF (2009) and THIEL et al. (2013). With eel, haddock and lake stickleback, three highly endangered species (2) were detected (7.9%), the greater petrale is endangered (3, 1 species, 2.6%). Pollock is considered extremely rare (R, 1 species, 2.6%), turbot, mackerel and sole are on the forewarned list (V; 3 species, 7.9%). For the large spotted sandeel and the large unspotted sandeel, the available data do not allow an assessment (D, 3 species 7.9%). The remaining 27 species (71.1%) are considered to be threatened (*) (Table 9).

Table 9: Relative proportions of Red List categories of fish species detected in areas 1, 2 and 3. Extinct or lost (0), threatened with extinction (1), critically endangered (2), endangered (3), endangerment of unknown extent (G), extremely rare (R), forewarned list (V), insufficient data (D) or not endangered (*) (THIEL et al. 2013). (EIS data Area 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.

Area	Red List Category								
	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
Baltic Sea (Thiel et al. 2013)	**1,1**	**2,1**	**1,1**	**3,2**	**1,1**	**7,4**	**1,1**	**19,1**	**63,8**

In the lake areas where the **EO2 site is** located, a total of 42 species were identified during the environmental impact studies and in the context of fish monitoring for stock assessment, none of which are considered extinct or lost (0), threatened with extinction or endangered to an unknown degree (G) according to FREYHOF (2009) and THIEL et al. (2013). With eel, haddock and lake stickleback, three highly endangered species (2) were detected (7.1%), the greater petrale is endangered (3, 1 species, 2.4%). Pollock is considered extremely rare (R, 1 species, 2.4%), turbot, mackerel and sole are on the forewarned list (V; 3 species, 7.1%). For sand eels and hake, the available data do not allow an assessment (D, 4 species, 9.5%). The remaining 30 species (71.4%) are considered to be endangered (*) (Table 9).

In the lake areas where **site EO3** is located, a total of 40 species were identified during the environmental impact assessments and fish monitoring for stock assessment, none of which are considered extinct or lost (0), threatened with extinction or endangered to an unknown degree (G) according to FREYHOF (2009) and THIEL et al. (2013).

With eel, haddock and lake stickleback, three highly endangered species (2) were detected (7.5%). The greater petrale and the dwarf cod are considered endangered (3) (2 species, 5.0%). Pollock is considered extremely rare (R, 1 species, 2.5%), turbot, mackerel and sole are on the forewarned list (V; 3 species, 7.5%).

For the large spotted sandeel and the large unspotted sandeel, the available data do not allow an assessment (D, 2 species 5.0%). The remaining 29 species (72.5%) are considered to be non-endangered (*) (Table 9).

In the Red Lists of marine fishes for the Baltic Sea (THIEL et al. 2013) and freshwater fishes (FREYHOF 2009), a total of 16.0% of the assessed species were assigned to an endangerment category (0, 1, 2, 3, G or R), 1.1% are on the forewarned list, for 19.1% no assessment is possible due to lack of data. A total of 63.8% of the species are considered to be threatened (FREYHOF 2009, THIEL et al. 2013) (Table 9). In comparison, fewer species with an endangered status were found in all three Baltic Sea areas (1: 13.1%, 2: 11.9%, 3: 15.0%), while there were always more non-endangered species than listed in the Red Lists (1: 71.1%, 2: 71.4%, 3: 72.5%).

As expected, extinct or lost species (category 0) were not found in any of the areas. For species threatened with extinction (1), the importance of the areas is below average, while highly endangered species (2) were relatively more frequent in all areas than in the Red Lists. This was also true for endangered species (3) in area 3. For these species, the areas have above-average importance. Endangered species accounted for a lower proportion in Area 1 and 2 (Table 9). Category G species (endangerment of unknown extent) and extremely rare species were found in all three areas in lower proportions than in the Red Lists, while the proportion of species on the Forewarned List was higher. The proportion of species not assessable 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-dangerous species (*) were found in all areas, which thus have an above-average importance for species in this category (Table 9).

FFH species were not detected during the environmental impact assessments nor in the fisheries management surveys. Against this background, the fish fauna of the areas under consideration is assessed as average with regard to the criterion of rarity and endangerment.

Diversity and Eigenart

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

If all documented species are taken into account, there are 176 species in the Baltic Sea (WINKLER et al. 2000). According to the Fishbase fish database, 160 fish species have been recorded in the entire Baltic Sea as of November 2015, and WINKLER & SCHRÖDER (2003) list 151 species for the entire German Baltic Sea coast for which there is a scientifically verified record from the German Baltic Sea region. THIEL ET AL. (1996) put the number of Baltic Sea fish species at 144, including 97 marine fish species, 7 migratory and 40 freshwater fish species. By far the majority are rare individual records, and only slightly more than half of them reproduce regularly in the German Exclusive Economic Zone (EEZ) or are found as larvae, juveniles or adults. According to 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 in the entire Baltic Sea between 2014 and 2018. In the German EEZ, represented here by 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 detected (Table 10 The number of species was very close to each other in the individual areas, ranging from 38 to 42 (cf. "Rarity and endangerment"). Most species were caught in the fisheries management surveys, but species were detected in the EISs that did not appear in the BITS survey. These were tobias fish, anchovy, three-spined stickleback, large disc belly *Liparis liparis,* hake, sand goby, sea bull and French porpoise. Most species were found in Area 2, followed by Areas 3 and 1 (Table 10).

All demersal flatfish and roundfish species typical of the Baltic Sea were recorded across all areas. All flatfish species (Dogger dab *Hippoglossoides platessoides*, dab, flounder, plaice, turbot, brill and sole) were present in all areas surveyed (Table 10).

Although the bottom trawls used are unsuitable for detecting pelagic fish, species typical of the pelagic part of the fish community, such as Tobias fish, herring, large spotted and unspotted sand eel, smelt, mackerel, sprat and dolphinfish, were detected in all clusters (Table 10).

Of the 45 species detected in the German EEZ during the observation period, 37 species occurred in all areas, one species (sand goby) was found in two areas, and 7 species were detected in one area each (Table 10). A spatial structure of the occurrence of different species, e.g. according to their preferred habitat or salinity preference, could not be identified: Freshwater fish such as perch and pikeperch and species with an affinity to the coast such as flounder or smelt were represented in all three areas, while marine species such as anchovy or hake were caught in only one area (Table 10). It is possible that in the area under consideration the environmental gradients are not pronounced enough to structure the occurrence of species in a measurable way. The fish species composition differs between the areas only with regard to individual, rare species, while there are great similarities in the characteristic, more common species (Table 10).

Between 1977 and 2005, EHRICH et al. (2006) recorded 58 fish species in the Baltic Sea. Compared to these reports and to the data from the entire Baltic Sea, the diversity in all areas can be considered average. The typical and characteristic species of both the pelagic and demersal components of the fish communities considered were also represented in all areas (see above). The characteristics of the fish communities found are thus also rated as average.

Table 10: Total species list of fishes German Baltic EEZ and species records in clusters 1, 2 and 3 (EIS data from 2014 and 2017/2018 data from ICES DATRAS database , see 2.8.1).

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

Existing pressure

The pre-stress of a fish community is defined as the absence of anthropogenic influences, of which fishing has the greatest impact. It is true that fish are also under other direct or indirect human influences, such as eutrophication, shipping traffic, pollutants, sand and gravel extraction. However, these effects cannot yet be reliably measured. In principle, the relative impacts of the individual anthropogenic factors on the fish community and their interactions with natural biotic (predators, prey, competitors, reproduction) and abiotic (hydrography, meteorology, sediment dynamics) variables influencing the German EEZ cannot be clearly separated.

However, due to the removal of target species and bycatch, as well as the impact on the seabed in the case of bottom-disturbing fishing methods, fishing is the most effective disturbance to the fish community and can therefore serve as a measure of the pre-existing pressure on fish communities in the Baltic Sea. An assessment of the stocks on a smaller spatial scale, such as the German EEZ, is not carried out within the framework of fisheries management, so that 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 commercially fished (ICES 2019). The assessment of the pre-existing pressure is based on the Fisheries overview - Baltic Sea Ecoregion of the International Council for the Exploration of the Sea (ICES 2019).

Fisheries have two main effects on the ecosystem: the disturbance of benthic habitats by bottom-set nets and the take of target species and bycatch species. The latter often include protected, endangered or threatened species, including not only fish but also birds and mammals (ICES 2019).

The German fleet comprises more than 700 fishing vessels, but only 60 of these operate in offshore areas. Commercial fisheries and spawning stock sizes are assessed against maximum sustainable yield (MSY), taking into account the precautionary approach.

A total of 17 stocks were assessed for fishing intensity, of which 14 are scientifically assessed and only three are not. Of the 17 stocks assessed, seven are managed sustainably, five are considered overexploited, and no reference points have yet been defined for another five (Figure 35, ICES 2019). Ten of the 17 stocks were assessed for their reproductive capacity (spawning biomass). Six of them have full reproductive capacity, two are below it, while for nine stocks no reference points are defined in terms of reproductive capacity (Figure 35, ICES 2019). The biomass share of the total Baltic Sea catch (756,100 t in 2019) from stocks managed at too high a fishing intensity outweighs the shares of sustainably caught and unassessed stocks by a large margin (>75%). Nevertheless, fish from stocks whose reproductive capacity is above the defined reference levels account for the majority of biomass in the catch (>75%). The biomass from assessed stocks and those whose reproductive potential is below the reference level accounts for less than 25% in total (Figure 35).

For the target species and the by-catch species of fisheries in the Baltic Sea, it can be assumed that fisheries have a direct influence on population development, for example through the targeted removal of larger individuals, which make an important contribution to the stability of the population through disproportionately large and survivable offspring.

Besides fisheries, eutrophication is one of the greatest ecological problems for the marine environment in the Baltic Sea (BMU 2018). Despite reduced nutrient inputs and lower nutrient concentrations, the German Baltic Sea is still considered eutrophic. Nitrates and phosphates are predominantly discharged via rivers, resulting in a pronounced gradient of nutrient concentrations from the coast to the open sea (BROCKMANN et al. 2017).

Significant direct effects of eutrophication are increased chlorophyll-a concentrations, reduced visibility depths, local decline in seagrass areas and seagrass density with associated mass proliferation of green algae, and increased cell counts of potentially harmful phytoplankton species. Above all, the coastal seagrass beds in the Baltic Sea have an important protective function for fish spawn and juveniles (BOBSIEN & BRENDELBERGER 2006). As seagrass meadows decline due to eutrophication, there are fewer refuges and potentially higher predation rates. The indirect effects of nutrient enrichment, such as oxygen deficiency and altered species composition of the macro-zoobenthos, can also have an impact on fish fauna. The survival and development of fish eggs and larvae depends on the oxygen concentration in many species (SERIGSTAD 1987). Depending on how much oxygen is needed, a lack of oxygen can lead to the death of fish spawn and larvae.

In the synopsis of fishery metrics (ICES 2019), ecosystem effects of bottom-dwelling fisheries (WATLING & Norse 1998, Hiddink ET al. 2006) and set net fisheries, the pre-existing pressure on fish fauna is classified as average.

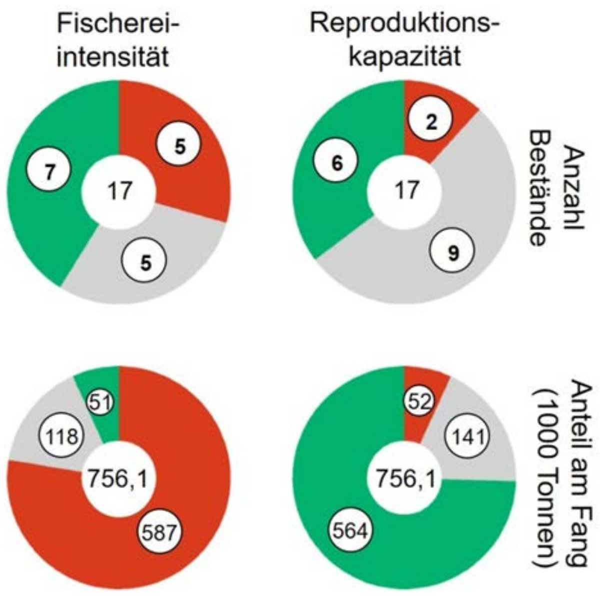

Figure 35: Fishing intensity and reproductive capacity of 17 fish stocks in the Baltic Sea that together delivered more than 750 000 tonnes of catch in 2019. Number of stocks (top) and biomass share of catch (bottom). Reference level of fishing intensity: sustainable sustainable yield (FMSY; red: above FMSY, green: below FMSY, grey: not defined); reference level of reproductive capacity: spawning biomass (MSY Btrigger; red: below MSY, green: above MSY, grey: not defined). Modified according to ICES (2019)

2.7.3.1 Importance of the areas for fish

The overarching criterion for the importance of the areas for fish is the relationship to the life cycle, within which different stations with stage-specific habitat requirements are linked by more or less long migrations in between. In none of the data sets used was information on reproductive status collected, so that the importance of the areas for fish can only be described in general terms. An area-specific assessment is also hindered by the fact that the catch data used were collected using methods that do not allow for a habitat reference. The overview of species records by area did not show any particular importance of a specific area for the constant, frequent character species. There is no discernible tendency for species with special lifestyles to possibly prefer certain areas (Table 10), which may, however, 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. On their regular migrations between the spawning grounds and nursery areas near the coast and the deeper areas that characterise the life cycle of most species, the fish also pass through the wind farm areas. They are therefore important as transit areas, at least for marine species. Freshwater species are concentrated on 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. For these species, the importance of the wind farm areas is low. However, the relatively higher proportion of highly endangered fish species in all three areas indicates a higher importance of these areas for these species (eel, haddock and lake stickleback).

2.8 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. Migrations, especially in search of food, are not limited to the EEZ, but also include the coastal sea and large areas of the Baltic Sea across borders. The two seal species have their resting and littering sites on islands and beaches in the area of the territorial sea. To search for food, they undertake extensive migrations in the open sea from the berths. Due to their high mobility and the use of very extensive areas, it is necessary to consider the occurrence not only in the German EEZ, but in the entire area of the western Baltic Sea.

Marine mammals belong to the upper consumers of the marine food chain. They are thus 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.

2.8.1 Data situation

Due to a large number of survey programmes, especially in German waters, the data situation has improved significantly in recent years compared to previous years and can now be considered good. However, there is no continuous survey or monitoring programme for marine mammals in the EEZ and the territorial sea.

Data are available at different spatial levels:

- for the entire area of northern European waters through surveys in the framework of SCANS I, II and III i[4] 1994, 2005 and 2016 as well as the so-called mini-SCANS of 2012 (SCANS, however, only covers the western Baltic Sea up to the German part of the Pomeranian Bay),
- Research projects in the German EEZ and in the coastal sea, such as MINOS[5] - and MINOSplus surveys in the years 2002 to 2006,
- Investigations within the scope of approval and planning approval procedures for offshore wind farms as well as planning approval procedures for pipelines,
- Monitoring of Natura2000 sites / acoustic monitoring by the German Maritime Museum,the EU research project SAMBAH[6] .

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

2.8.2 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 the occurrence of marine mammals. Both the distribution and abundance of animals vary over the seasons. In order to draw conclusions about seasonal distribution patterns and the use of different sub-areas, a good database is necessary. In order to be able to identify effects of intra- and interannual variability, large-scale long-term studies are particularly necessary.

Harbour porpoises occur year-round in the German EEZ of the Baltic Sea, but show focal points in their occurrence and spatial distribution depending on the season (GILLES et al. 2008, 2009). However, the seasonal distribution patterns are less pronounced than in the North Sea.

2.8.2.1 Porpoises

The harbour porpoise is a common cetacean species in the temperate waters of the North Atlantic and North Pacific, as well as in some secondary seas such as the Baltic Sea. Due to its hunting and diving behaviour, the distribution of the harbour porpoise is restricted to continental shelf seas (READ 1999). In the Baltic Sea, the harbour porpoise is the only cetacean species to occur regularly.

Studies indicate that three separate subpopulations are found in the waters between the North Sea and the Baltic Sea: a) the North Sea and Skagerrak subpopulation, b) the Belt Sea subpopulation (Kattegat, Belt Sea, Sound and western Baltic Sea) and c) the separate subpopulation of the central Baltic Sea (TEILMANN et al. 2011, BENKE ET LA., 2014, CARLEN ET AL., 2018).

---

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

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

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

The existence of the separate subpopulation in the eastern Baltic Sea with a population of a few hundred animals is indicated by the results of morphometric and genetic studies as well as the results of the SAMBAH research project (e.g. GALATIUS et al. 2012).

Harbour porpoises migrate in search of abundant food sources and temporarily concentrate in areas of high food quality and/or quantity (REIJNDERS 1992, EVANS 1990). Fish, predominantly herring and cod-related species, are part of the harbour porpoise's preferred food spectrum. The harbour porpoise predominantly hunts schools of fish (READ 1999). Pelagic and semi-pelagic fish species dominate the food spectrum. Breeding areas are mainly described as coastal areas with water depths below 20 m, e.g. in the Belt Sea and on the coasts of Mecklenburg-Western Pomerania (KINZE1990,SCHULZE1996).

Occurrence of the harbour porpoise in the German Baltic Sea

For the entire area of the Kattegat, Belt Sea, the Sound and the western Baltic Sea, there was a clear decline in population numbers between 1994 and 2005. According to BENKE et al., (2014), the subpopulation of the central Baltic Sea counts only a few hundred individuals and is classified as threatened with extinction in the IUCN list. The Belt Sea subpopulation also appears to have declined, at least in the past, and is classified as vulnerable in the IUCN list. While 27,800 (95% confidence interval = 11,946-64,549) animals were still identified in this area in 1994 during SCANS I, only 10,900 animals (CI = 5,840-20,214) were identified for the area in 2005 (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 Threshold is not covered by the SCANS survey.

SCHEIDAT et al. (2008) showed that stock densities in the southwestern Baltic Sea are subject to both seasonal and spatial fluctuations. The highest densities occur in the area of the Bay of Kiel. Abundance estimates from harbour porpoise surveys varied from 457 individuals in March 2003 (CI: 0-1,632) to the highest estimates in May 2005 with 4,610 individuals (CI: 2,259-9,098). Population estimates for the Bay of Kiel (incl. Danish waters up 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 Sills to Øland and the outer Gdansk Bay, a total of only 599 individuals were recorded in 1995 (HIBY& LOVELL 1995). These values reflect a clear decrease in population density along a gradient from the Kattegat to Polish waters (KOSCHINSKI 2002).

An analysis of data from aircraft-based counts, 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 (GILLESPIEet al. 2003, VERFUSSet al2004). Through the use of stationary click detectors (POD), harbour porpoises were detected almost every day at Fehmarn. During the survey period 2008 to 2010, 90 to 100% harbour porpoise positive days (SPT) were recorded around Fehmarn and in the Mecklenburg Bay. The results from Adlergrund and Oderbank showed overall significantly lower harbour porpoise registration rates than in the western study areas with a maximum of 21% harbour porpoise positive days in February 2010 (cf. Fig.14; GALLUS et al. 2010).

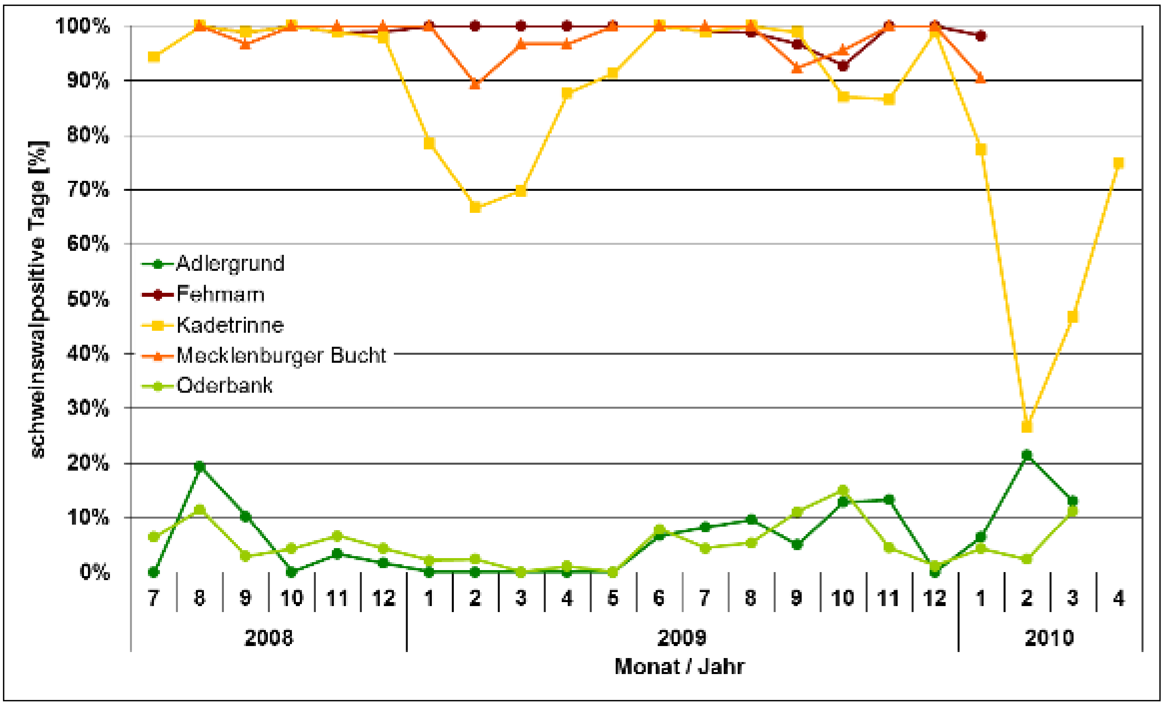

Figure 36: Percentage of harbour porpoise positive days out of the total number of all recording days for the study areas Fehmarn (3 stations), Mecklenburg Bight (1 station), Kadetrinne (3 stations), Adlergrund (2 stations) and Oderbank (3 stations). Fehmarn, Kadetrinne and Mecklenburger Bucht were automatically evaluated with *Cet All,* while Oderbank and Adlergrund were verified visually. The values for 2010 on Adlergrund can only be seen as a trend, since at that time usable data were only provided by one station and only 6 days were observed in March (source: GALLUS et al. 2010).

For the large-scale studies within 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 (Kiel Bight) covers the western part of the EEZ and the territorial sea, area F (Mecklenburg Bight) the area up to the Darss Sill and area G (Rügen) covers the eastern part of the German EEZ and the territorial sea. In the entire study period, the mapping effort reached 24,360 km. However, only a total of 335 harbour porpoises were sighted. During the study period 2002 to 2006, the density of harbour porpoises in the areas varied from 0.06 individuals/km² in spring 2005, to 0.08 individuals/km² in June 2003, to 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.

In the winter months from December to February, the mapping effort remained low due to weather conditions, so that no calculations can be made. In spring, most animals 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 large number of animals were sighted on the Oderbank in July 2002 (84), none were encountered in the following years. Therefore, it cannot be excluded that this was a temporary immigration of animals from the western Baltic Sea in search of food. In autumn, many animals were sighted in the western area, although fewer than in summer. With the exception of a single sighting on the Adlergrund, no animals were sighted east of the Darß peninsula. The density gradient from west to east persisted over the entire period and was particularly pronounced in autumn (GILLES et al. 2007).

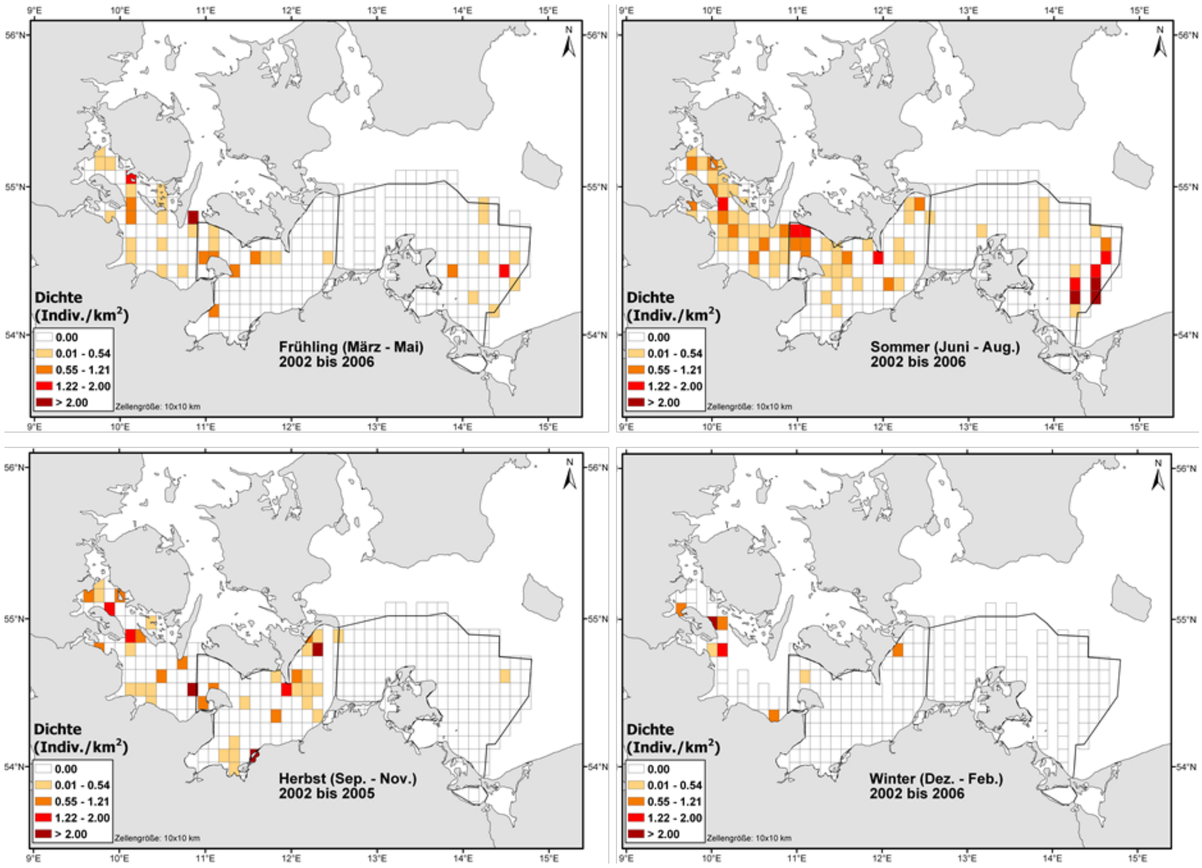

Figure 37: Seasonal distribution patterns of harbour porpoises in the south-western Baltic Sea (2002-2006). The grid maps are effort-adjusted. Shown is the mean density of harbour porpoises per grid cell (10x10km) in a) spring (March-May), b) summer (June-August), c) autumn (September-November) and d) winter (December-February, Source: GILLES et al. 2007, p.126f.).

Occurrence in nature reserves

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 FFH areas Fehmarnbelt, Kadetrinne, Adlergrund, Westliche Rönnebank and Pommersche Bucht with Oderbank. During systematic flight counts, harbour porpoises were only sighted at Adlergrund and Pommersche Bucht in May 2002 (GILLESet al.2004). The abundance for Adlergrund extrapolated from the sightings is 33 animals.

For the Pomeranian Bay, an abundance calculation is only possible with a very large error. For methodological reasons, it leads to inflated values. The observation of 84 animals on the Oder Bank in July 2002 remained unique. Despite a high mapping effort, no more animals were

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

sighted here in the following years. Echolocation sounds were regularly recorded around the island of Fehmarn and in the Kadet Trench (VERFUSSet al.2004). The Kadet Trench is regularly frequented by harbour porpoises, especially during migration. Beyond that, the importance of the area for the animals is still unclear. Between 1996 and 2002, the proportion of calves among stranded animals in the area from the Bay of Kiel to Fehmarn was 36%. From this, a high importance of the area for reproduction is deduced (SCHEIDATet al.2004).

The high echolocation frequencies recorded in winter at some stations near Fehmarn (VERFUSSet al.2004) suggest that it is used as a wintering area. Overall, the analysed data indicate a strongly seasonal occurrence with abundance maxima in summer.

With the 2017 regulations, the FFH areas in the German EEZ of the Baltic Sea have been given the status of nature conservation areas:

- Ordinance on the Establishment of the "Fehmarnbelt" Nature Conservation Area (NSGFmbV), Federal Law Gazette I, I p. 3405 of 22.09.2017,
- Ordinance on the Establishment of the "Kadetrinne" Nature Conservation Area (NSGKdrV), Federal Law Gazette I, I p. 3410 of 22.09.2017,
- Ordinance on the Establishment of the Nature Reserve "Pommersche Bucht - Oderbank" (NSGPBRV), Federal Law Gazette I, I p. 3415 of 22.09.2017.

Occurrence in the areas for wind energy EO1 and EO2

The areas for wind energy EO1 and EO2 are allocated based on sightings in the indirect vicinity during the MINOS and EIS surveys, monitoring of the offshore projects "Viking" and "Arkona Basin Southeast" and on the results of acoustic recording of harbour porpoise activity from the area of Adlergrund, the harbour porpoise habitat.

All previous results from investigations in the two areas as well as from the indirect surroundings can be summarised as follows:

- The areas are used irregularly by harbour porpoises for passage, staging and as feeding grounds.
- The occurrence of harbour porpoises in these areas is low compared to the occurrence west of the Darss Sill and especially around the island of Fehmarn, in 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 by enriching the food supply.
- There is no clear evidence of the areas being used as breeding grounds.
- For harbour porpoises, these areas have a medium to seasonally high importance.
- The high seasonal importance of the areas results from the possible use by individuals of the separate and highly endangered Baltic subpopulation of harbour porpoise in the winter months.
- For seals and harbour seals, these areas have a low to at most medium importance.

Threats to harbour porpoises and seals in areas EO1 and EO2 may be caused by the construction of the wind turbines and the substations, in particular by noise emissions during the installation of the foundations, if no prevention or minimisation measures are taken.

Occurrence in the priority area for wind energy EO3

The EO3 priority area for wind energy is assigned to the harbour porpoise habitat based on the sightings in the immediate vicinity during the MINOS and EIS surveys, monitoring of the offshore project "EnBW Baltic 2" and the results of the acoustic recording of harbour porpoise activity within the framework of research projects and monitoring by the BfN.

All previous results from investigations in the area EO3 as well as from the indirect surroundings can be summarised as follows:

- The area is used irregularly by harbour porpoises for passage.
- The occurrence of harbour porpoises in this area is low compared to the occurrence east of the Darss Sill and especially around the island of Fehmarn, in the Bay of Kiel, the Belt Sea and the Kattegat.
- According to current knowledge, there is no evidence of the area being used as a breeding ground.
- This area is of medium importance for harbour porpoises.
- This area is of little importance for seals and harbour seals.

Hazards to harbour porpoises and seals in area EO3 may be caused by the construction of the substations, in particular by noise emissions during the installation of the foundations, if no prevention or minimisation measures are taken.

2.8.2.2 Seals and grey seals

In 2015, a number of 16,000 harbour seals was determined for the Kattegat and south-western Baltic Sea. It is assumed that the growth rate of the Kattegat population differs from that in the south-western Baltic Sea. The abundance of the Kalmarsund population, which also occurs in the Pomeranian Bay, was estimated at 1,100 individuals in 2016. The Kalmarsund population is genetically distinct from the Kattegat and Southwest Baltic populations and has a growth rate that does not yet meet the criteria and was therefore classified as vulnerable in the 2013 HELCOM Red List (HELCOM, 2018a, 2018b).

Suitable undisturbed moorings are of crucial importance for the occurrence of harbour seals. Due to the significantly lower diving depths and distances covered in telemetric studies (DIETZet al.2003) - compared to grey seals - harbour seals in the southern Baltic Sea probably mainly use shallow water areas close to the coast as hunting grounds. Potential feeding habitats are therefore found in German waters along the Bodden coast of Mecklenburg-Vorpommern, especially within a radius of up to 60 km around the resting sites. Telemetric studies show that adult harbour seals in particular rarely move more than 50 km from their ancestral resting places (TOLLITet al.1998).

Based on regular airborne counts in 2002 and 2003 on the resting sites off the Danish and Swedish coasts closest to the German EEZ, the authors calculate a total population of 655 animals in the area of the southern Baltic Sea for 2003, taking into account a correction factor for harbour seals in the water (TEILMANNet al., 2004).

Suitable, undisturbed casting and resting sites are also crucial for the occurrence of grey seals. Potential lying areas are offered by 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 moorings closest to the German EEZ are on the Rødsand off the Danish island of Falster, in the Øresund and Måkläppen near Falsterbo in southern Sweden (TEILMANN& Heide-Jørgen-senEIDE-JØRGENSEN, 2001, SCHWARZ ETal. 2003). In the German EEZ, foraging habitats are mainly used east of the Darß, while areas further west probably play only a minor role (SCHWARZet al. 2003).

Grey seal counts at the time of the hair change, in the Baltic Sea between May and June, yielded a total number of 17,640 animals for the Baltic Sea in 2004 (KARLSSON & Helander HELANDER, 2005). From this, a total population of approx. 21,000 animals is inferred.

In 2016, a number of 30,000 grey seals was determined for the entire Baltic Sea. The determined number of animals exceeds the reference value of 10,000 individuals set within the framework of the assessment (HOLAS II), which is to serve as a criterion for determining the positive population trend. However, other criteria such as reproductive and nutritional status were not met, so that the overall status of the grey seal was assessed as not good (HELCOM, 2018a, 2018b).

The distribution of Baltic grey seals is probably dependent on ice cover, among other factors. Grey seals use both nearshore and offshore shallow water areas as well as submarine slopes and reefs as hunting grounds (SCHWARZet al.2003). Accordingly, potential hunting grounds can be found in the EEZ, for example in the area of the Kadetrinne, the Adlergrund or the Oderbank. According to current knowledge, however, no prediction can be made about the use of these potential habitats, because both the food composition and the preferences in the selection of feeding habitats can vary greatly during the course of the year and over the years (SCHWARZet al.2003).

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

Neither harbour seals nor grey seals were sighted on the airborne surveys in the Baltic Sea (GILLESet al.2004). The telemetric surveys from the southern Baltic Sea (DIETZet al., 2003) and observations in the area of Wismar Bay (HARDER& SCHULZE, 1997) suggest an occasional use of the Fehmarn Belt as feeding habitat for harbour seals. The telemetric study from the southern Baltic Sea (DIETZet al., 2003) and individual observations as well as dead finds (HARDERet al.1995) suggest a use of the Kadetrinne, the Adlergrund or the Oderbank as migration corridor or feeding habitat for grey seals. According to a current population survey by the BfN, around 50 to 60 grey seals live in the waters around Rügen - 30 of them in the Greifswalder Bodden alone.

2.8.3 Status assessment of marine mammals as an object of conservation

The harbour porpoise population in the Baltic Sea has declined over the last centuries. The situation of the harbour porpoise in the Baltic Sea has deteriorated due to commercial fishing of the animals in earlier times, but also due to extreme ice winters, and has finally been further aggravated by bycatch, pollution, noise and food limitation (ASCOBANS, 2003). The separate subpopulation of the eastern Baltic Sea is additionally particularly endangered due to the small number of individuals, the geographical restriction and the lack of gene exchange and is therefore considered to be threatened with extinction (ASCOBANS, 2010).

The population of harbour seals has declined after the severe virus epidemics, most recently in 2002. Since then, the population has increased again, as already described in 2.8.2.2. The status of the grey seal is not considered good (HELCOM, 2018a, 2018b).

2.8.3.1 Importance of the sites for marine mammals

Based on large-scale aerial surveys and acoustic surveys with click detectors, especially within the framework of research projects such as MINOS and MINOSplus, as well as within the framework of the monitoring of Natura2000 areas by the German Maritime Museum on behalf of the BfN, reliable estimates of the occurrence of harbour porpoise for the area of the German waters of the North Sea and Baltic Sea were made. A density gradient from west to east was found in the Baltic Sea. This gradient is already present in summer and increases in autumn. According to current knowledge, 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). However, it is conceivable that the population could increase through appropriate measures (ASCOBANS, 2003/2010) and that the eastern area could then also be increasingly used 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 littoral states have shown, based on acoustic data, that the abundance of the central Baltic Sea subpopulation consists of about 447 individuals (95% confidence interval, 90-997) (SAMBAH, 2014 and 2016).

The subpopulation of the central Baltic Sea has been classified as threatened with extinction by the IUCN and HELCOM (HELCOM Red List Species, 2013) due to the very small number of individuals and the spatially restricted genetic exchange.

Importance of the 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 a solid data basis for assessing the importance of the areas in the German EEZ.

Based on current knowledge, areas EO1 and EO2 are predominantly assigned to the habitat of harbour porpoises of the highly endangered Baltic Sea subpopulation. However, the area is irregularly used by harbour porpoises for passage, residence and as a feeding ground. The occurrence of harbour porpoises in these areas is low compared to the occurrence west of the Darss Sill and especially around the island of Fehmarn, in 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 by enriching the food supply. Use of the areas as nursery grounds has not been clearly demonstrated. For harbour porpoises, these areas are of medium to high seasonal importance in the winter months. The importance of the areas EO1 and EO2 results from the possible use by individuals of the separate and highly endangered Baltic Sea subpopulation of harbour porpoise. Research results have shown that, especially in the winter months, individuals of the highly endangered harbour porpoise subpopulation of the central Baltic Sea migrate into German waters and also use the planning area. For seals and harbour seals, these areas are of little importance. Seals and grey seals pass through the areas sporadically during their migrations.

Since 2003, data for the vicinity of areas EO1 and EO2 have been collected within the framework of various research projects, such as MINOS, as well as from the acoustic monitoring of harbour porpoise in the German Baltic Sea by the German Oceanographic Museum on behalf of the Federal Agency for Nature Conservation. The data from the long-term monitoring of the German Oceanographic Museum show that mainly harbour porpoises of the Belt Sea population occur in the German waters of the Baltic Sea. The presence rates of harbour porpoises west of the Darss Sill are much higher than east of it (BENKE et al., 2015. Akustisches Monitoring von Schweinswalen in der Ostsee, Teil B *in* Monitoring marine mammals 2014 in the German North Sea and Baltic Sea on behalf of BfN).

The limit of the subpopulation of the harbour porpoise in the central Baltic Sea, which is classified as endangered, lies at 13°30' E, taking into account the results of acoustic, morphological, genetic and satellite-based surveys at the level of Rügen (SVEEGARD et al., 2015).

The results of the multi-year SAMBAH project have also shown that in the winter months until

April, the animals of the central Baltic Sea subpopulation are distributed over a large area and occur close to the coast. In summer, on the other hand, a clearly defined boundary emerges east of Bornholm (SAMBAH, 2015; CARLEN et al., 2018).

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

Visual surveys using observers or digital technology are not a suitable survey method in this area of the western Baltic Sea due to the rather low occurrence. No marine mammals were observed during the ship-based survey for the Nord Stream pipeline from June 2010 to the end of 2013. In the period 2015 to 2016, one harbour porpoise was sighted from the ship. No marine mammals were detected during a total of four airborne surveys using digital recording.

Further current findings on the occurrence of marine mammals in areas EO1 and EO2 are provided by the ongoing monitoring of the "Westlich Adlergrund" cluster for the offshore wind farms "Wikinger" and "Arkonabcken Südost".

From March 2015 up to and including February 2016, a total of 8 harbour porpoises, two harbour seals and one undetermined seal were sighted during ten video-based surveys from aircraft in the 2,620 km2 survey area. During 12 ship-based surveys conducted in the same period, one each month, a single grey seal has been sighted. For the determination of continuous use of the area by harbour porpoises, data from acoustic recording by means of C-PODs at two measuring stations far away to the north of the planned pipeline were analysed.

The data from the acoustic recording 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 monitoring station at a distance of approx. 18 km in Area I of the nature reserve "Pommersche Bucht - Rönnebank", a total of 17.8 % 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 cluster "Westlich Austerngrund", expert opinion 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 registered porpoise clicks within one month (PPT/month).

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

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

The presence rates of harbour porpoise start to slowly increase from June onwards. The highest presence rates have always been recorded in late summer and autumn. The area is only sporadically used by harbour porpoises during the winter months and in spring.

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

Very low presence rates, on the other hand, were recorded in the southern part of the area in shallower areas of the Pomeranian Bay. A seasonal pattern was not discernible in this area.

Based on all previous findings, this area can be clearly assigned to harbour porpoise habitat.

- Areas EO1 and EO2 are regularly used by harbour porpoises, but to a very low extent.
- The occurrence of harbour porpoise in the vicinity of areas EO1 and EO2 is low compared to the occurrence west of the Darss Sill.
- According to current knowledge, there is no evidence of the area being used as a breeding ground.
- For harbour porpoises, these areas are of medium importance, and even of high importance in the winter months.
- These areas are of little importance for grey seals and harbour seals.

Existing pressures on harbour porpoises and seals in the vicinity of the above-mentioned areas include bycatch in gillnets, fishing and reduction of food supply, pollution, eutrophication and climate change.

According to current knowledge, the three areas are used by harbour porpoises as passage areas. There are currently no indications that these areas have special functions as feeding grounds or nursery areas for harbour porpoises. Seals and grey seals use the areas only sporadically as migration areas. Based on the findings from the monitoring of the Natura 2000 sites and from research results, a medium to seasonally high importance of sites EO1 and EO2 for harbour porpoises can currently be deduced. The seasonal high importance of the area results from the possible use by individuals of the separate and highly endangered Baltic Sea subpopulation of harbour porpoise in the winter months. For harbour seals and grey seals, these areas have a low to at most medium importance.

Significance of the priority area for wind energy EO3

Area EO3 is of medium importance for marine mammals. The use of the area by harbour porpoises varies seasonally. The occurrence of harbour porpoises in this area is average to very low compared to the occurrence in the Bay of Kiel, the Belt Sea and the Kattegat. The area has no special function as a nursery ground for harbour porpoises. For seals and harbour seals, it is of little importance due to the distance to the nearest moorings.

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

- The area is used by harbour porpoises irregularly and to a very small extent.
- The occurrence of harbour porpoise in area EO3 is low compared to the occurrence in the cadet channel.
- According to current knowledge, there is no evidence of the area being used as a nursery area for harbour porpoises.
- This area is of medium importance for harbour porpoises.
- For grey seals and harbour seals, this area is on the edge of the distribution range of the respective species and is of little importance.

2.8.3.2 Protection status

Harbour porpoises are protected under several international conservation agreements. Harbour porpoises fall under the protection mandate of the European Habitats Directive, under which special areas are designated to protect the species. The harbour porpoise is listed in both Annex II and Annex IV of the Habitats Directive. As an Annex IV species, it enjoys general strict species protection according to Art. 12 and 16 of the Habitats Directive.

Furthermore, the harbour porpoise is listed in Appendix II of the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, CMS). Under the auspices of CMS, the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) was also adopted. In 2002, a special conservation plan for Baltic harbour porpoises, the so-called Jastarnia Plan, was adopted within the framework of ASCOBANS after it was determined that the harbour porpoise populations in the Baltic Sea are independent and particularly threatened. The aim of the Jastarnia Plan, revised in 2009, is to restore a 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) should be mentioned, in Annex II of which the harbour porpoise is also listed.

In the IUCN list of endangered species, the harbour porpoise population of the central Baltic Sea is considered threatened with extinction (Cetacean update of the 2008 IUCN Red List of Threatened Species).

In Germany, the harbour porpoise is listed in the Red List of Threatened Animals (Meinig et al., 2020). Here it is classified in endangerment category 2 (critically endangered). The authors point out that the endangerment classification for Germany results from the joint consideration of threats in the North Sea and Baltic Sea.

Grey seal and harbour seal are also listed in Annex II of the Habitats Directive.

In the current Red List of Mammals of Germany, the grey seal is classified from endangerment category 2 (severely endangered) to category 3 (endangered) (Meinig et al., 2020).

The common seal is classified in category G (threats of unknown magnitude). The authors confirm that there are two separate populations in the German North Sea and Baltic Sea. The German North Sea population has seen an increase in juveniles since 2013 and after the two distemper virus epidemics, and would be classified as "not endangered" on its own, unlike the German Baltic Sea population (Meinig et al., 2020).

2.8.3.3 Existing pressures

Prior pressures on marine mammals result from fishing, underwater sound emissions and pollution. The greatest threat to harbour porpoise stocks in the Baltic Sea comes from fishing due to unwanted bycatch in gillnets (ASCOBANS2010). Bycatch in the Baltic Sea is much higher than in the North Sea. In particular, the separate subpopulation is already severely threatened at low bycatch levels (ASCOBANS, 2019).

Threats to harbour porpoise populations in the Baltic Sea also stem from a variety of anthropogenic activities, changes in the marine ecosystem and climate change (CARLE'N ET AL. 2021).

The International Whaling Commission (IWC) has agreed that bycatch mortality should not exceed 1% of the estimated stock (IWC, 2000). At higher bycatch rates, the conservation goal of recovering populations to 80% of the carrying capacity of the habitat is at risk (ASCOBANS2010).

From individual reports on bycatch in the Baltic Sea (KASCHNER, 2001), it can be assumed that bycatch is mainly responsible. However, bycatch rates cannot be determined for the Baltic Sea due to the limited information available (KASCHNER, 2001, 2003). In Poland about 5 bycatches per year are reported, in Sweden also 5 in the early 1990s (SGFEN, 2001). An extrapolation based on questionnaires assumes 57 bycatches per year for German fisheries in the western Baltic Sea (21 in sideline fisheries, 36 in professional fisheries) (RUBSCH& KOCK KOCK, 2004).

For the area west of the Darss Sill, 25 by-catches (1 incidental, 24 commercial) are reported. This is much higher than the official figures reported by fishermen and exceeds the tolerable bycatch rates according to IWC and ASCOBANS (IWC, 2000).

Several scientific studies address the development of methods to avoid and reduce bycatch by scaring or warning animals away from fishing nets (Kratzer et al., 2020; Omeyer et al., 2020). ICES (2020) has a recommendation on behalf of the EU with regard to emergency measures to avoid bycatch of animals of the endangered sub-population of harbour porpoise in the Baltic Sea. Bycatch is also a threat to harbour seals and grey seals.

In extreme cases, underwater sound from anthropogenic sources can cause physical damage, but can also disrupt communication or lead to behavioural changes - e.g. interrupt social and prey capture behaviour or trigger escape behaviour. Current anthropogenic uses in the EEZ with high sound impacts include shipping, sand and gravel extraction, seismic exploration and, in some cases, military use. Hazards may be caused for marine mammals during the construction of wind turbines and transformer platforms, especially due to noise emissions during the installation of the foundations, if no mitigation measures are taken. There is currently no experience of possible effects of water stratification under certain hydrographic conditions on the propagation of pile driving sound in the Baltic Sea and associated effects on marine mammals. In general, sound propagation in the Baltic Sea is considered to be particularly difficult to describe and thus to predict (THIELE, 2005).

In addition to pressures from the discharge of organic and inorganic pollutants, threats to the stock can also come from diseases (of bacterial or viral origin), eutrophication and climate change (impact on the marine food web). At present, porpoises are probably immigrating to the southern North Sea due to climate change (CAMPHUYSEN, 2005; ABT, 2005). The extent to which this has an indirect influence on the harbour porpoise population of the Baltic Sea is not known.

2.9 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 "birds that stay in an area outside the breeding territory, usually for a longer period of time, e.g. for moulting, feeding, resting, wintering". Foraging visitors are defined as birds "that regularly forage in the surveyed area, do not breed there, but breed or could breed in the wider region".

Seabirds are bird species whose way of life is predominantly bound to the sea and which only come ashore for a short time to breed. These include, for example, fulmars, gannets and alcids (guillemots, razorbills). Terns and gulls, on the other hand, usually have a distribution closer to the coast than seabirds.

2.9.1 Data situation

In order to draw conclusions about seasonal distribution patterns and the use of different sub-areas, a good database is necessary. In particular, large-scale long-term studies are needed to identify correlations in distribution patterns and effects of intra- and interannual variability.

The findings on the spatial and temporal variability of the occurrence of seabirds 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, especially sea ducks, in the nearshore area and in the Pomeranian Bay.

For the EEZ area, the information base has 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 surveys during the construction and operation phases. In addition, findings from various research projects contribute to a better understanding of seabird abundance. In the period 2001-2004, studies on the designation of bird sanctuaries in the EEZ were carried out as part of the ERASNO and EMSON R&D projects. In the framework of the MINOS and MINOSplus projects, ship- and aircraft-based counts were carried out in the entire German Baltic Sea from 2002 to 2006 (DIEDERICHS et al., 2002; GARTHE ET al., 2004). GARTHE et al. (2003) summarised the findings on winter occurrence, threats and protection of seabirds and waterbirds in the German Baltic Sea in a study based on the results of various research projects and literature sources. SONNTAG et al. (2006) analysed for the first time the distribution and abundance of seabirds and waterbirds over the course of the year, with a focus on the offshore area, on the basis of systematic ship-based counts carried out in the period 2000-2005. In addition, 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 bird species occurring regularly or in high numbers 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).

The available data basis can therefore be assessed as very good.

2.9.2 Spatial distribution and temporal variability

Seabirds have the highest mobility within the upper consumers of the marine food chains. This enables them to search large areas for food and to pursue species-specific prey organisms such as fish over long distances. The high mobility - depending on special conditions in the marine environment - leads to a high spatial and temporal variability of the occurrence of seabirds. The distribution and abundance of birds vary with the seasons 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. Furthermore, the occurrence is influenced by distinct natural events (e.g. ice winters) and anthropogenic factors such as nutrient and pollutant inputs, shipping and fishing. 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 populations shift further west in winter due to ice formation or ice cover in the eastern Baltic Sea (VAITKUS, 1999).

Several million birds winter on the Baltic Sea every year. It is one of the most important areas for seabirds and waterbirds in the Palaearctic. A number of studies also show the great importance of the German Baltic Sea for seabirds and waterbirds - not only nationally, but also internationally (DURINCK et al., 1994; Garthe et al., 2003; SONNTAG et al., 2006; SKOV ET AL., 2011). In particular, the nature reserve "Pommersche Bucht - Rönnebank" with the main resting and feeding grounds Adlergrund and Oderbank, which has been part of the European network of protected areas Natura2000 since 2007 and was established by decree on 22 September 2017, should be mentioned here.

2.9.2.1 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. In the German Baltic Sea, 38 species of seabirds and resting birds regularly occur (SONNTAG et al., 2006). The following

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

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

German name (*scientific Name*)	Stock German Baltic Sea	Stock German EEZ
Iron 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
Slavonian Grebe (thin-billed) (*Podiceps auritus*)	1.000	700
Red-throated diver (*Gavia stellata*)	3.200	550
Black-throated diver (*Gavia arctica*)	2.400	550
Cormorant (*Phalacrocorax carbo*)	10.500	< 50
Tordalk *(Alca torda)*	3.600	310
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

German name (*scientific Name*)	Stock German Baltic Sea	Stock German EEZ
Common gull (*Larus canus*)	11.500	1.100
Great black-backed gull (*Larus marinus*)	7.000	800
Herring Gull (*Larus argentatus*)	70.000	4.200

2.9.2.2 Frequently occurring species and species of special importance for the nature reserve "Pomeranian Bay - Rönnebank

Long-term observations and systematic counts 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 illustrates the high species-specific spatial and temporal variability of the occurrence of seabirds and resting birds in the German waters of the Baltic Sea. Numerous current studies can be used to underline the topicality of these descriptions.

Sea ducks prefer nearshore areas with shallow water depths as well as shallow grounds offshore such as the Adlergrund and the Oderbank. Great Crested Grebes and Red-breasted Mergansers are almost exclusively found in nearshore waters, while Slavonian Grebes prefer shallow water areas further offshore. Common Guillemot and Razorbill spend most of their time in offshore areas with greater water depths. Terns only occur sporadically in the offshore area during migration periods. They almost exclusively use Bodden waters and inland lakes for foraging (SONNTAG et al., 2006; MENDEL et al., 2008).

Red-throated diver (*Gavia stellata*) and black-throated diver (*Gavia arctica*)

Common divers occur 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 and only in small numbers in spring, sporadically also in summer. Both species prefer an area east of the island of Rügen or the Pomeranian Bay up to the Oder Bank (see Figure 38 and Figure 39; SONNTAG et al., 2006).

Red-throated divers rest in the Baltic Sea primarily in waters with a water depth of less than 20 m (DURINCK et al., 1994). The most important resting areas are in the sea area around Rügen, in the area of the Oder Bank and in the Mecklenburg Bay. In spring, the main distribution is in the Pomeranian Bay, especially in the coastal waters off Rügen. Black-throated divers have their main distribution in the eastern part of the German Baltic Sea. In winter they are widespread in the Pomeranian Bay. Here, the highest densities can usually be recorded in the coastal area of Rügen, at the Adlergrund and on the Oderbank (MENDEL et al., 2008). Towards spring, the occurrences are mainly in areas of the Pomeranian Bay far from the coast. Surveys conducted as part of the BfN seabird monitoring in the German Baltic Sea confirm this distribution (MARKONES et al., 2014).

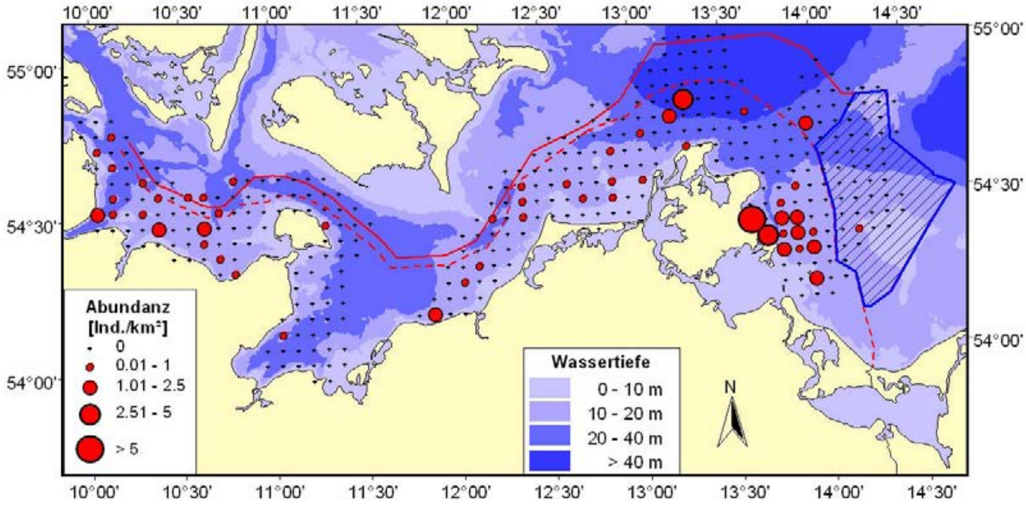

Figure 38: Distribution of divers (*Gavia stellata/G. arctica*) throughout the German Baltic Sea in January/February 2009 (aircraft-based survey; MARKONES & GARTHE, 2009).

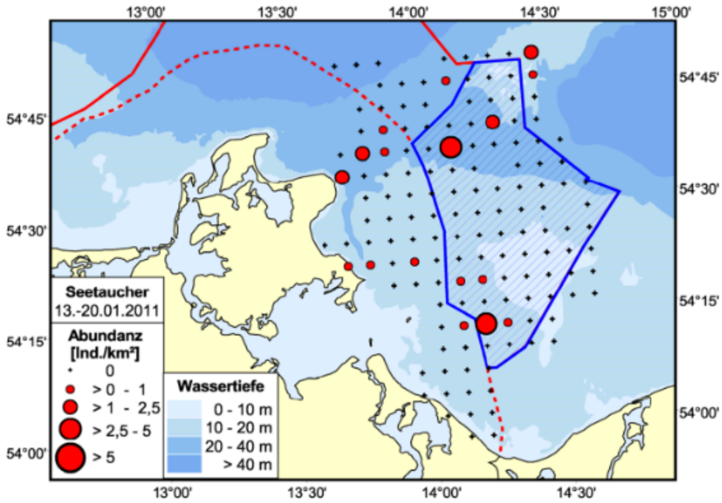

Figure 39: Occurrence of Common Divers (*Gavia stellata/ G. arctica) in the* German Baltic Sea during a ship-based survey from 13-20 January 2011 (MARKONES & GARTHE, 2011).

Slavonian Grebe (*Podiceps auritus*)

The main occurrence of Slavonian Grebes in the German Baltic Sea is in the Pomeranian Bay. This is the most important wintering area in NW European waters (DURINCK et al., 1994). The distribution centre of the approx. 1,000 Slavonian Grebes (German winter population) is on the Oder Bank. Especially waters with water depths below 10 m are used. Eared Grebes migrate to shallow waters in autumn and spend the winter there (SONNTAG et al., 2006). Eared Grebes are also increasingly present on the Oder Bank in spring, but also spend time in the coastal area off Usedom. Surveys on wind farm projects in the EEZ revealed only very isolated sightings of Slavonian Grebes (BIOCONSULT SH GmbH & Co.KG, 2016; Oecos GMBH, 2015).

Little Gull (*Larus minutus*)

In spring and summer, Lesser Black-backed Gulls occur offshore only in small numbers. The main focus of occurrence is in the inner coastal waters. Lesser Black-backed Gulls migrate mainly along the coastline. During autumn migration, they occur in large numbers in the Pomeranian Bay. Lesser Black-backed Gulls then prefer to use coastal areas for foraging and resting (SONNTAG et al., 2006).

Long-tailed duck (*Clangula hyemalis*)

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 roosting population has decreased by 65.3 % between 1992 and 2009. One of the most important winter resting areas is the Pomeranian Bay in the southern Baltic Sea. Analogous to the Baltic Sea as a whole, a decline of 82% in the occurrence of long-tailed ducks was also recorded here by 2010 (BELLEBAUM et al., 2014). A consideration of further resting habitats suggests a shift to the north (SKOV et al., 2011). However, it is generally assumed that the Pomeranian Bay can continue to host larger numbers (BELLEBAUM et al., 2014). The long-tailed duck has further extensive main winter and spring habitats east of Rügen and north of Usedom

(Garthe et al., 2003; Garthe et al., 2004). From the end of October, there is a strong migration to the German Baltic Sea areas. In summer, on the other hand, only very few long-tailed ducks are found in the German Baltic Sea. The absence of the species in the offshore EEZ area north and north-east 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 close to the coast or shallow grounds in the offshore area up to 20 m water depth (SONNTAG et al., 2006; MARKONES & GARTHE, 2009). Recent studies confirm a widespread winter occurrence of the long-tailed duck with focal points at Adlergrund and Oderbank, among others (MARKONES et al., 2014; BIOCONSULT SH & Co.KG, 2016).

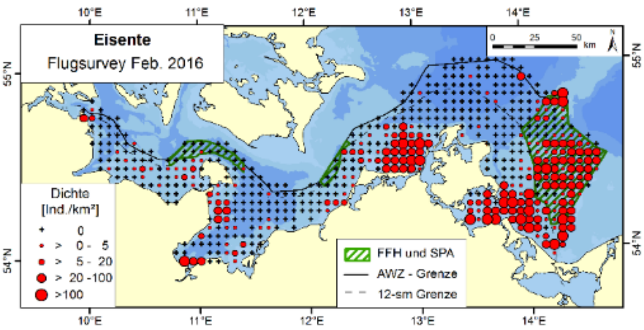

Figure 40: Occurrence of LONG-TAILED ducks (*Clangula hyemalis*) in the German Baltic Sea in February 2016 (flight-based surveys, BORKENHAGEN et al., 2017).

Velvet Scoter (*Melanitta fusca*)

Velvet Scoters use the northern Kattegat, the Bay of Riga and the northern Pomeranian Bay as wintering grounds. In the Pomeranian Bay, the Velvet Scoter has its main distribution in winter and spring in the area between Oderbank and Adlergrund (Garthe et al., 2003; GARTHE et al. 2004). During ice-free winter months, the Velvet Scoter mainly uses central areas of the Oderbank; when ice cover is present, its occurrence seems to be limited to immediately adjacent ice-free areas in the northern part of the Oderbank (MARKONES et al., 2013; MARKONES ET AL., 2014; BORKENHAGEN ET AL., 2018; BORKENHAGEN ET AL., 2019).

Black Scoter (*Melanitta nigra*)

In the Pomeranian Bay, the Oder Bank is one of the most important resting areas for Common Scoters in the entire Baltic Sea (DURINCK et al. 1994, Garthe et al. 2003). Other resting areas include the shallow grounds of the Bay of Kiel and north of the Darß-Zingst peninsula (Figure 41). According to Garthe et al. (2003, 2004) and SONNTAG et al. (2006), Common Scoters occur year-round in the German Baltic Sea. The Pomeranian Bay plays a key role as a resting and moulting habitat for scoters. In the summer of 2012, around 2000 Common Scoters were sighted moulting in the north-west of the Oder Bank on a single survey day (MARKONES et al. 2013).

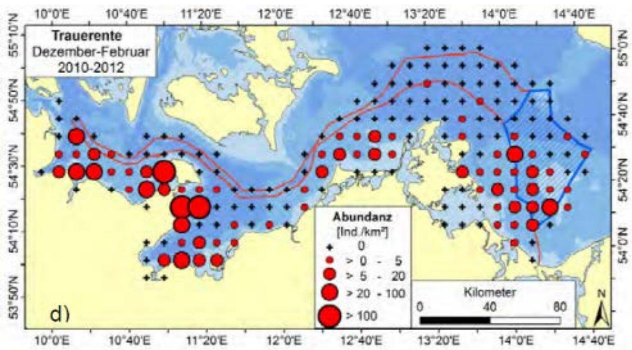

Figure 41: Mean winter occurrence of Common Scoters (*Melanitta nigra*) in the German Baltic Sea in 2010 - 2012 (flight- and ship-based surveys, MARKONES et al. 2015).

Common Eider (*Somateria mollissima*)

Eider ducks are very common in the winter half-year and occur in high densities in some areas 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 Pomeranian Bay. In summer, only a few eiders are found in the western Baltic Sea (SONNTAG et al. 2006).

Common Guillemot (*Uria aalge*)

DURINCK et al. (1994) estimate the winter roosting population of the Common Guillemot in the Baltic Sea at about 85,000 individuals. In spring, summer and autumn it occurs only sporadically. Common 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 the breeding colonies. Their distribution focus is in the offshore areas of the Pomeranian Bay, especially in the deeper waters between Oderbank and Adlergrund and northwest of Adlergrund (see Figure 42) (MENDEL et al., 2006). According to GARTHE et al. (2003, 2004), Common Guillemots occur northeast of Rügen in low to medium densities.

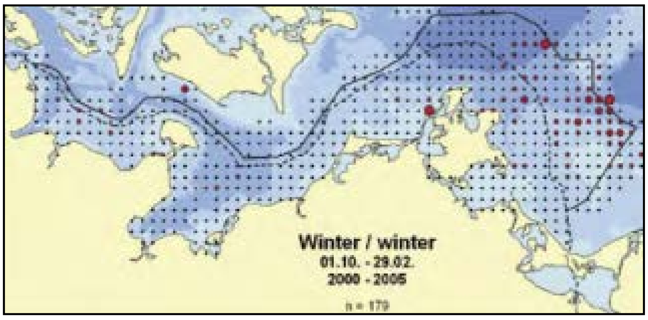

Figure 42: Distribution of Common Guillemot in the German Baltic Sea (winter 2000-2005; SONNTAG et al. 2006).

Razorbill (*Alca torda*)

The winter resting area of razorbills is over the deeper areas of the central Baltic Sea. Razorbills occur mainly in winter in the German Baltic Sea. They occur in low to medium densities in large parts of the coastal and offshore areas of the Pomeranian Bay (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. The preferred winter resting areas of Black Guillemots include shallower areas and rocky bottoms. In the German Baltic Sea, Black Guillemots are predominantly found in the Eagle's Ground area from autumn to spring (see Figure 43). Despite relatively low densities, this occurrence is classified as internationally important according to Garthe et al. (2003) (MENDEL et al. 2008).

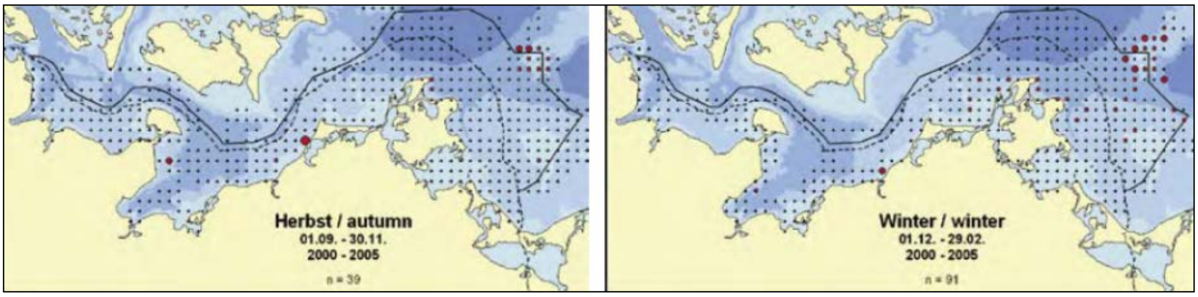

Figure 43: Distribution of Black Guillemot in the western Baltic Sea in autumn (left) and winter 2000 to 2005 (right) from SONNTAG et al. (2006).

Red-necked grebe (*Podiceps grisegna*)

The main occurrence of red-necked grebes in the German Baltic Sea is in the Pomeranian Bay (see Figure 44). Like divers, they are mainly winter visitors and migrants. The highest resting populations are reached here in winter and decrease again in spring (MENDEL et al. 2008).

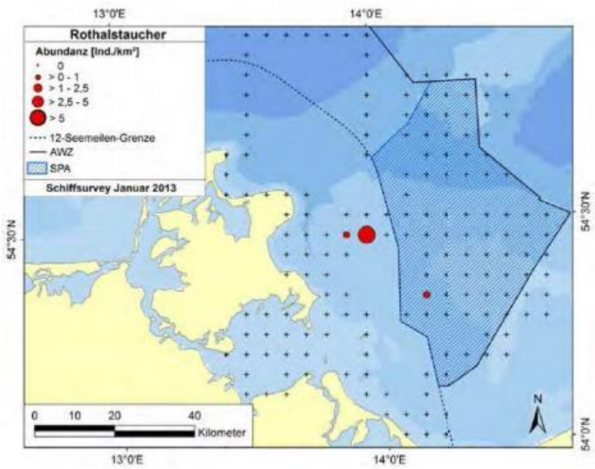

Figure 44: Distribution of Red-necked Grebes (*Podiceps grisegena)* in the Pomeranian Bay, Baltic Sea, in January 2013 (MARKONES et al. 2014).

Yellow-billed diver (*Gavia adamsii*)

Yellow-billed Grebes are found in the Baltic Sea as migrants during migration periods and for winter resting in the western Baltic Sea. The winter occurrence is low and limited to the offshore areas of the Pomeranian Bay (BELLEBAUM et al., 2010).

Common Gull (*Larus canus*)

Gulls occur in the Baltic Sea in much lower densities than in the North Sea. This is also due to the fact that their food is of terrestrial origin during the entire breeding season (KUBETZKI et al. 1999). In summer, therefore, only sporadic gulls occur in the German Baltic Sea. The largest numbers are reached in winter and spring. Storm-petrels then occur mainly in the nearshore and offshore areas of the Pomeranian Bay (SONNTAG et al., 2006).

Other Larus Gulls

As the most common gull species in the Baltic Sea, the Herring Gull (*Larus argentatus*) occurs throughout the year. In winter and spring, Herring Gulls occur in high concentrations both in coastal waters and in the EEZ. In particular, they are present in the areas of the Bight of Kiel and Mecklenburg, around Fehmarn and northwest of

Rügen. Particularly high concentrations occur in connection with fishing activities (SONNTAG et al. 2006). Naturally, the Herring Gull is probably not a breeding bird in the western Baltic Sea.

Only the establishment of motorised trawling led to immigration and population increase since the 1930s (VAUK & Prüter, 1987).

Great black-backed gulls *(Larus marinus)* are present in the western Baltic Sea all year round. However, populations are low during the breeding period from April to July. The winter population may depend on the ice conditions in the Baltic Sea. However, the great black-backed gull occurs more frequently during migration and in the winter months. Like the Herring Gull, this species often concentrates near fishing boats (SONNTAG et al., 2006).

Herring Gulls *(Larus fuscus)* occur sporadically in the Baltic Sea during the summer half-year, occasionally also in connection with fishing activities (MENDEL et al., 2008).

2.9.2.3 Occurrence of seabirds in the "Pomeranian Bay - Rönnebank" nature reserve

By decree of 22.09.2017, the nature reserve (NSG) "Pommersche Bucht - Rönnebank" was placed under protection as a complex area according to national law. The protected 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 km2. Subarea IV of the NSG corresponds to the bird sanctuary "Pomeranian Bay", which was designated as a nature reserve with effect from 15.09.2005 and included in the list of specially protected areas (SPA) as a bird sanctuary (DE 1552-401). Subarea II covers an area of 2,004 km2. Three species listed in Annex I of the European Birds Directive, the red-throated diver, the black-throated diver and the horned grebe, occur in sub-area II. Regularly occurring migratory bird species include red-necked grebe, yellow-billed grebe, long-tailed duck, common scoter, velvet scoter, common gull, guillemot, razorbill and black guillemot (sec. 7 para. 1 nos. 1 and 2 NSGPBRV).

In the context of the description and status assessment of the nature reserve "Pommersche Bucht - Rönnebank" (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 belong to the actual bird sanctuary, has a size of only 86 km2 (BfN, 2020).

Below lists the populations determined in BfN (2020) for the species protected according to the conservation purpose of sub-area IV in the seasons of high occurrence.

Table 12 Populations of protected bird species in the nature reserve "Pommersche Bucht - Rönnebank" in the seasons of high occurrence according to BfN (2020).

German name (*scientific Name*)	**Season**	**Stock NSG "Pomeranian Bay - Rönnebank**
Red-throated diver (*Gavia stella*)	Spring	1.600
Black-throated diver (*Gavia arctica*)	Winter	850
Slavonian Grebe (*Podiceps auritus*)	Winter	1.500
Red-necked grebe (*Podiceps grisegena*)	Winter	430
Yellow-billed diver (*Gavia admasii)*)	Autumn	6-10
Iron 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
Guillemot (*Uria aalge*)	Autumn	1.400
Tordalk (*Alca torda*)	Summer	550
Black Guillemot (*Cepphus grylle*)	Spring	90

2.9.2.4 Occurrence of seabirds and resting birds in the areas

Priority area wind energy EO1

The investigations carried out to date on the wind farm projects in area EO1 show a medium seabird occurrence.

The extensive resting habitats of the Pomeranian Bay and the Adlergrund (with their northern and northwestern fringes, respectively) only extend as far as the southern and south-eastern areas of site EO1. According to GARTHE et al. (2003), the sub-area is not a valuable resting habitat or a preferred staging area in the Baltic Sea for the seabird species listed in Annex I of the Birds Directive. Current surveys in area EO1 show only a low occurrence of divers south of area EO1 (BIOCONSULT SH & CO.KG, 2017A; BioConsult SH & CO.KG, 2018; BIOCONSULT SH & CO.KG, 2019). Slavonian grebes have only been sighted very sporadically in the area. Lesser Black-backed Gulls occur sporadically as migrants in spring (BIOCONSULT SH & CO.KG, 2016; BioConsult SH & Co.KG, 2018, BIOCONSULT SH & CO.KG, 2019).

Even during a pronounced ice cover in the coastal sea and on the Oder Bank in winter 2010, the ice-free area of site EO1 was not used as an avoidance area by seabirds and resting birds (SONNTAG et al., 2010). Similar observations were also made during an ice cover of the Pomeranian Bay 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 Pomeranian Bay and the Adlergrund. Thus, diving sea ducks occur only on average in the area of site EO1. In recent surveys, Common Scoters were sighted in high to very high densities to the east and south of Area EO1, but in the area itself there were only a few individuals. Velvet Scoters and Common Scoters were mainly observed during migration periods in the south 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 the area of site EO1, but with a southern focus. For the two species of alcids, this sub-area is part of the southern foothills of their main winter range in the Baltic Sea. Black guillemots are observed only very sporadically east of the area. Herring Gulls are among the most common species in the area of EO1 during migration periods and also occur widely in winter. Great Black-backed Gulls and Common Gulls, on the other hand, only occur in low densities during these periods, but are sometimes widespread (BIOCONSULT SH & CO.KG, 2016; BIOCONSULT SH & CO.KG, 2017A; BIOCONSULT SH & CO.KG, 2018; BIOCONSULT SH & CO.KG, 2019).

Reservation area for wind energy EO2

Area EO2 is home to a seabird community consisting predominantly of seabird species such as common guillemots as migrants and gulls. The centre of diver occurrence in the German Baltic Sea is far south of Area EO2, south-east of Rügen. All previous findings indicate that the entire area surrounding Site EO2 is home to seabird and resting bird species for which this area of the German Baltic Sea has more the character of a passage area and less a function as 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).

Priority area wind energy EO3

A comparison of the data for area EO3 with data from the Pomeranian Bay shows a below-average seabird occurrence for the area (GARTHE et al. 2003). In site EO3, a seabird community was identified that generally consists of species that tend to use the site as a passage area. According to GARTHE et al. 2003, site EO3 is not one of the preferred habitats in the Baltic Sea for the divers (red-throated divers and black-throated divers) and eared divers listed in Annex I of the Birds Directive, which are in need of special protection. The same applies to Lesser Black-backed Gulls. More recent surveys have also revealed only isolated sightings of these species in this area (IFAÖ, 2016). Sea ducks diving for food, such as long-tailed ducks, velvet scoters and common scoters, occur mainly as migrants in spring, but to a lesser extent also during winter resting in this part of the EEZ. However, their range then extends to the shoal "Kriegers Flak" in the northwest of area EO3 (IFAÖ, 2016, 2017a). Herring Gulls and Mantled Gulls are among the most common species in the EO3 area and its surroundings. Common gulls occur in winter in areas with greater water depths. Razorbills have been observed more frequently than guillemots in the vicinity of site EO3 in recent surveys. However, this area is not particularly important as a resting habitat for either species. Black Guillemots have been sighted only very sporadically (IFAÖ, 2016, 2017a).

2.9.3 Status assessment of seabirds and resting birds

The high mapping effort in recent years and the current state of knowledge allow a good assessment of the importance and condition of the areas considered here as habitats for seabirds. This importance results from the assessments of occurrence and spatial units or functions. In addition, the criteria of protection status and existing pressures at a higher level are considered.

2.9.3.1 Protection status

The German Baltic EEZ hosts significant populations of long-tailed duck, common scoter, velvet scoter and black guillemot. Red-throated and black-throated divers, eared grebes and lesser black-backed gulls are subject to special protection. The remaining species are migratory bird species whose protection must also be ensured in accordance with sec. 4 para. 2 of the Birds Directive.

Table 13 below summarises the current classifications in endangerment categories of the European Red List (Europe and EU27) and the HELCOM Red List. Deviations in the category assignments result from different geographical reference frames.

Table 13: Assignment of the most important resting bird species of the German EEZ in the Baltic Sea to the endangerment categories of the European Red List and according to HELCOM. Definition according to IUCN (also applies to HELCOM): **LC** = Least Concern, not endangered; **NT** = Near Threatened; **VU** = Vulnerable; **EN =** Endangered; **CR =** Critically Endangered).

	Annex I V-RL	**IUCN Red List Europaa)**	**IUCN Red List EU 27 [a)]**	**HELCOM winter rest population [b)]**
Red-throated diver	X	LC	LC	CR
Black-throated diver	X	LC	LC	CR
Slavonian 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	
Iron Duck		VU	VU	EN
Velvet Scoter		VU	VU	EN
Common Scoter		LC	LC	EN
Eider duck		VU	EN	EN
Black Guillemot		LC	VU	NT
Guillemot		NT	LC	
Tordalk		NT	LC	

[a] BirdLife International (2015) European Red List of Birds

[b] HELCOM (2013c)

According to the European Red List, Ferruginous Duck, Velvet Scoter and Common Eider are considered "vulnerable" due to negative population trends in recent years. The drastic decline of the winter population of the long-tailed duck in the Baltic Sea (Skov et al., 2011) is also reflected in the HELCOM Red List. There, the long-tailed duck, along with other sea duck species, is classified as "critically endangered". The winter roosting populations of red-throated and black-throated divers in the Baltic Sea are even considered "threatened with extinction", although their pan-European population is classified as "not threatened". The populations of Little Gull and Slavonian Grebe are listed as "potentially threatened" in Europe as a whole and in the Baltic Sea (winter resting population). Mantled Gull and Common Gull are generally considered "not endangered". Herring Gull, Guillemot and Razorbill are listed as "potentially vulnerable" in the pan-European Red List, but their winter roosting population in the Baltic Sea has not been given endangered status. The opposite is true for the Black Guillemot population.

2.9.3.2 Existing pressures

As part of the marine ecosystem, seabirds are exposed to many pressures that may pose a potential threat but also influence 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. Fishing can reduce the food supply or even limit it. Selective fishing of fish species or sizes can lead to changes in the food supply for seabirds. Set net fishing causes high losses of seabirds in the Baltic Sea every year due to entanglement and drowning in the nets (ERDMANN et al. 2005). In particular divers, grebes and diving ducks are among the victims of gillnets (SCHIRMEISTER, 2003; DAGYS & Zydelis, 2002). According to ZYDELIS et al. (2009), bycatch in the entire Baltic Sea is around 73,000 and 20,000 birds in the southern Baltic annually. Fishing discards provide additional food sources for some seabird species (CAMPHUYSEN & Garthe, 2000). In particular, many seabird species such as herring gull and great black-backed gull benefit from the discards.
- ***Shipping***: Shipping traffic can exert scaring effects on species sensitive to disturbance, 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 species sensitive to disturbance as shipping traffic. In addition, there is an increase in the volume of shipping traffic, e.g. due to maintenance trips. There is also a risk of collision with such structures.
- ***Hunting***: Almost all migratory ducks in the Baltic Sea region are affected by hunting. From 1996 to 2001, 122,500 eider ducks were shot annually in Scandinavia, 92,820 of them in Denmark alone (ASFERG, 2002). This already corresponds to 16% of the winter population of 760,000 individuals (DESHOLM et al., 2002).
- ***Climate changes***: Changes in water temperature are accompanied by changes in water circulation, plankton distribution and the composition of fish fauna, among other things. 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 hardly possible to predict the effects of climate change on seabirds.
- ***Other existing pressures: In*** addition, eutrophication, the accumulation of pollutants in marine food chains and rubbish floating in the water, e.g. parts of fishing nets and plastic parts, can affect the occurrence and distribution of seabirds. Epidemics of viral or bacterial origin can pose a threat to populations of seabirds and resting birds.

In summary, the seabird community of the German EEZ of the North Sea is clearly subject to anthropogenic influence. The seabird community in the EEZ cannot be considered natural for the reasons mentioned here.

2.9.3.3 Significance of sub-area IV of the nature reserve "Pomeranian Bay - Rönnebank

Sub-area IV of the Pomeranian Bay - Rönnebank National Park has an outstanding function in the German Baltic Sea as a feeding, wintering, moulting, transit and resting area for species listed in Annex I of the WFD occurring there (in particular red-throated divers, black-throated divers, eared divers) and regularly occurring migratory bird species (in particular red-necked grebe, yellow-billed grebe, common scoter, velvet scoter, common gull), black-throated diver, horned grebe) and regularly occurring migratory bird species (in particular red-necked grebe, yellow-billed grebe, long-tailed duck, common scoter, velvet scoter, common gull, 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 reserve for resting and migratory birds varies from year to year as a result of the hydrographic conditions and weather patterns. Within the bird sanctuary, numerous migratory and resting birds use the existing high biomass.

2.9.3.4 Importance of the areas for seabirds and resting birds

Priority area wind energy EO1

All findings to date indicate that site EO1 is of medium importance for seabirds. It only touches the southern and south-eastern margins of the extensive resting habitats of the Pomeranian Bay and the Adlergrund. Overall, the area has a medium seabird occurrence and also only a medium occurrence of endangered species and species in need of special protection. It is not one of the main resting, feeding or wintering habitats of species listed in Annex I of the Birds Directive or of species worthy of protection in the nature reserve "Pomeranian Bay - Rönnebank".

Site 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 water depth (over 20 m) and the bottom conditions, it is not an important feeding ground for diving sea ducks. These use the area as a passage area in spring and autumn. Herring Gulls are common in the area, and Mantled and Common Gulls in comparatively lower densities. Divers use the sub-area exclusively as a migration area. Area EO1 touches the outermost fringes of the winter resting habitats of razorbills and guillemots. Black guillemots are sighted only very rarely. The impact of fishing and shipping is at least of medium intensity for seabirds.

Reservation area for wind energy EO2

All findings to date indicate that the area EO2 is of low importance for seabirds. The area has a low occurrence of endangered species and species in need of special protection. It is not one of the main resting, feeding or wintering habitats of species listed in Annex I of the Birds Directive or of species worthy of protection in the nature reserve "Pomeranian Bay - Rönnebank". The impact of fishing and shipping is at least of medium intensity for seabirds.

Priority area wind energy EO3

According to the information available so far, site EO3 is of low importance as a feeding and resting habitat for seabirds. Overall, the area has a low seabird occurrence. It is not one of the main resting, feeding or wintering habitats of species listed in Annex I of the Birds Directive or of species in need of special protection in the nature reserve "Pomeranian Bay - Rönnebank". 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 water depth and bottom conditions, the area is also of no importance as a feeding ground for diving sea ducks. The impact of fishing and shipping is at least of medium intensity for seabirds.

2.9.3.5 Conclusion

The EEZ of the Baltic Sea, in particular the priority and reservation areas for offshore wind energy considered in more detail here, has or have a seabird occurrence that can be expected for the respective prevailing hydrographic conditions, the distances to the coast and existing existing pollution.

2.10 Migratory birds

The term bird migration usually refers to periodic migrations between the breeding area and a separate non-breeding area, which for birds at higher latitudes usually includes the winter quarters. In addition to a resting place, one or more intermediate destinations are often reached, e.g. for moulting or to find favourable feeding areas. According to the distance covered and physiological criteria, a distinction is made between long-distance and short-distance migrants.

2.10.1 Data situation

Systematic studies of bird migration have a long tradition in the Baltic Sea region; they began as early as 1901 at the former Rossitten ornithological station on the Curonian Spit. In Falsterbo at the southern tip of Sweden, bird migration has been observed since 1972 and ringing of migrating birds has been carried out. In addition, numerous experiments have been carried out here, which have provided detailed insights into various aspects of migration behaviour (e.g. choice of migration direction). On the Swedish side, there is also the Ottenby ringing station at the southern tip of the island of Öland, which has been in operation since 1948. Another ringing station is located on the Danish island of Christiansø near Bornholm (LAUSTEN & Lyngs, 2004). Since 1995, the Jordsand Association has been conducting a registration trapping of migrating songbirds on the island of Greifswalder Oie, south-east of Rügen (VON RÖNN, 2001).

As a result of many years of research activities, more than 1,000 publications on bird migration in the western Baltic Sea have been produced. Some of the ringing stations have detailed long-term data that allow population trends to be assessed. The majority of these data refer to songbird and raptor migration, but visual observations of waterbirds and waders are also available in some cases. These figures describe migration in the coastal area.

Long-term data on migration activities over the open sea hardly exist. An exception are the records on the lightship in the Fehmarn Belt, from which bird migration over the sea was systematically observed between 1955 and 1957. Migration behaviour over the sea has also been studied for a number of species using military radar 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 as part of approval procedures for offshore wind farms and research projects of the BMU (cf. Figure 45). In parallel, bird migration up to 1,000 m altitude is quantified using vertical radar. Further studies in the context 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 observation stations and points of IfAÖ radar coverage of bird migration in the western Baltic Sea (Falsterbo: no own observations; from BELLEBAUM et al., 2008).

For population estimates of migratory birds, in addition to data from ringing stations, various other sources should be consulted (national breeding bird monitoring programmes in Scandinavia, BIRDLIFE INTERNATIONAL, 2004a). For migratory songbirds and raptors, breeding populations in Sweden and Finland are relevant. For divers and sea ducks, on the other hand, population sizes crossing the Baltic Sea on migration from their breeding grounds in western Siberia to their wintering grounds in western Europe are of interest. Population estimates of waders at resting places along the "East Atlantic Flyway" can be used to estimate the extent of migration of this bird group in the Baltic Sea region. Despite many years of observations, the available knowledge is not yet sufficient for specific questions in the German EEZ of the Baltic Sea.

2.10.2 Spatial distribution and temporal variability of migratory birds

According to current knowledge, migratory bird behaviour can be roughly differentiated into two phenomena: broad-front migration and migration along migration routes. It is known that most migratory bird species fly over at least large parts of their migration areas in a broad front. According to KNUST et al. (2003), this also applies to the North Sea and Baltic Sea. In particular, species migrating at night, which cannot be guided by geographical structures due to darkness, move across the sea in broad-front migration. However, many species are known to migrate in narrow corridors or on migration corridors without a direct guiding effect being responsible for this. This is the case for cranes, for example. The crane migrates from its huge range, which stretches across almost the whole of northern Eurasia, along only a relatively few traditional narrow migration routes to just under ten fixed wintering grounds, which are spread from Spain across North and East Africa to China. In this case, the so-called narrow-front migration is present.

Especially in the case of diurnal migrants, geographical barriers or guidelines, such as estuaries and large bodies of water, are known to influence migration routes. According to PFEIFER (1974), three main migration routes can be distinguished in the western Baltic Sea:

- Southern Sweden - Danish islands (Zealand, Møn, Falster, Lolland) - Fehmarn (so-called "bird flight line"). This route is preferred above all by day-migrating songbirds as well as by thermal gliders such as birds of prey. Only short distances have to be covered over water surfaces.
- South Sweden - Rügen. In addition to cranes and birds of prey, this route is probably also used in spring by songbirds crossing the Baltic Sea from Darß and Rügen in a northerly direction.
- Coming from the Baltic States/Finland/Siberia, following the narrowing funnel of the western Baltic Sea towards the southwest/west. A distinction is made 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 (e.g.

BERTHOLD, 2000). In addition to these largely endogenously controlled annual rhythms in migratory activity, the concrete course of migration is primarily determined by weather conditions. Weather factors also influence the altitude and speed at which the animals migrate.

In general, birds wait for favourable weather conditions (e.g. good visibility, tailwind, no precipitation) for their migration in order to optimise it in an energetic sense. As a result, bird migration is concentrated on individual days or nights in autumn or spring. According to the results of an R & D project (Knust ET al., 2003), half of all birds migrate in only 5 to 10% of all days. Furthermore, migration intensity is also subject to diurnal fluctuations. About two thirds of all bird species migrate mainly or exclusively at night (HÜPPOP et al. 2009).

2.10.2.1 Bird migration over the western Baltic Sea

Bird migration has been documented over the western Baltic Sea using various methods (radar and visual observations, acoustic surveys, ring finding analyses) throughout the year, although there are strong seasonal fluctuations with a focus in spring and autumn. The Baltic Sea is on the migration route of numerous bird species. Every year in autumn, about 500 million birds (see Table 14) migrate across the western Baltic Sea from their northern breeding grounds to their wintering grounds further south (Berthold, 2000). In spring there are considerably fewer (200-300 million). The reason is the high mortality of young birds in their first winter. More than 95% of these birds are land-dwelling small birds.

In order to analyse migration rates and migration routes, it is useful to differentiate migratory birds into migration types. Basically, waterbirds and landbirds as well as diurnal and nocturnal migration are to be distinguished due to the different migration conditions. Among the day-migrating land birds are some facultative thermal users (cranes, large birds of prey), which use thermals over land to gain altitude, but migrate over water in active rowing flight (BELLEBAUM et al., 2008).

Table 14: Population estimates for migratory birds of different flight types in the southern Baltic Sea region (data apply to the autumn season only; source: BELLEBAUM et al. (2008); calculated according to HEATH ET AL. 2000 and SKOV et al. 1998).

Train type	Species groups	Autumn stock
Waterbirds	Divers, grebes, ruddy-footed ducks, geese, mergansers, waders, gulls, terns, alcids	10-20 m
Shorebirds: facultative thermal gliders	Birds of prey	< 0.5 m
	Cranes	60.000
Land Birds: Rowing Flyers	Night puller	200-250 m
	Day/night migrants, pure day migrants	150-200 m

About 200 bird species are involved in bird migration in the western Baltic Sea every year. In addition, there are another 100 rare species and stray visitors. Figure 46 schematically shows the general migration systems of the western Baltic Sea, whereby the arrows stand for migration areas whose concrete course cannot be so narrowly defined. The important migratory populations of waterbirds (sea ducks, divers, geese and swans) originate mainly from Siberia, so that their migration route is generally west-east oriented. Sea ducks and divers fly low over the water, mostly below 10 m, and often close to the coast (e.g. KRÜGER & GARTHE, 2001). Waders flying at high altitudes (on average 2,000 m, GREEN, 2005), at least in spring, have been observed relatively few in the Baltic Sea. Birds of prey migrate over the "bird flight line" as well as over the open Baltic Sea. Flight behaviour differs both species-specifically and seasonally. Active oarsmen are more likely/ also fly over the sea, while thermal gliders such as buzzards generally use the "bird flight line".

Crane migration across the Baltic Sea mainly takes place between the Rügen-Bock region in the "Vorpommernsche Boddenlandschaft" National Park and the Swedish south coast in a north-south direction (ALERSTAM, 1990).

For songbirds migrating during the day, especially short- and medium-distance migrants such as finches and wagtails (BERTHOLD, 2000), the "bird flight line" is important, as guidelines play a role for this species group, at least for the orientation of low migrating individuals. However, a large part of the migration also takes place over the open Baltic Sea in a north-south direction when there is a tailwind at high altitude (ALERSTAM & ULFSTRAND, 1972). Due to the limited visual orientation possibilities, broad-front migration is assumed for small birds migrating at night, especially medium-range migrants such as thrushes and robins or long-range migrants such as reed warblers (BERTHOLD, 2000; ZEHNDER et al., 2001; BRUDERER & LIECHTI, 2005). KNUST et al. (2003) were able to establish the main direction of migration SW to SSW for autumn migration in the German Baltic Sea region at the Fehmarn and Rügen sites.

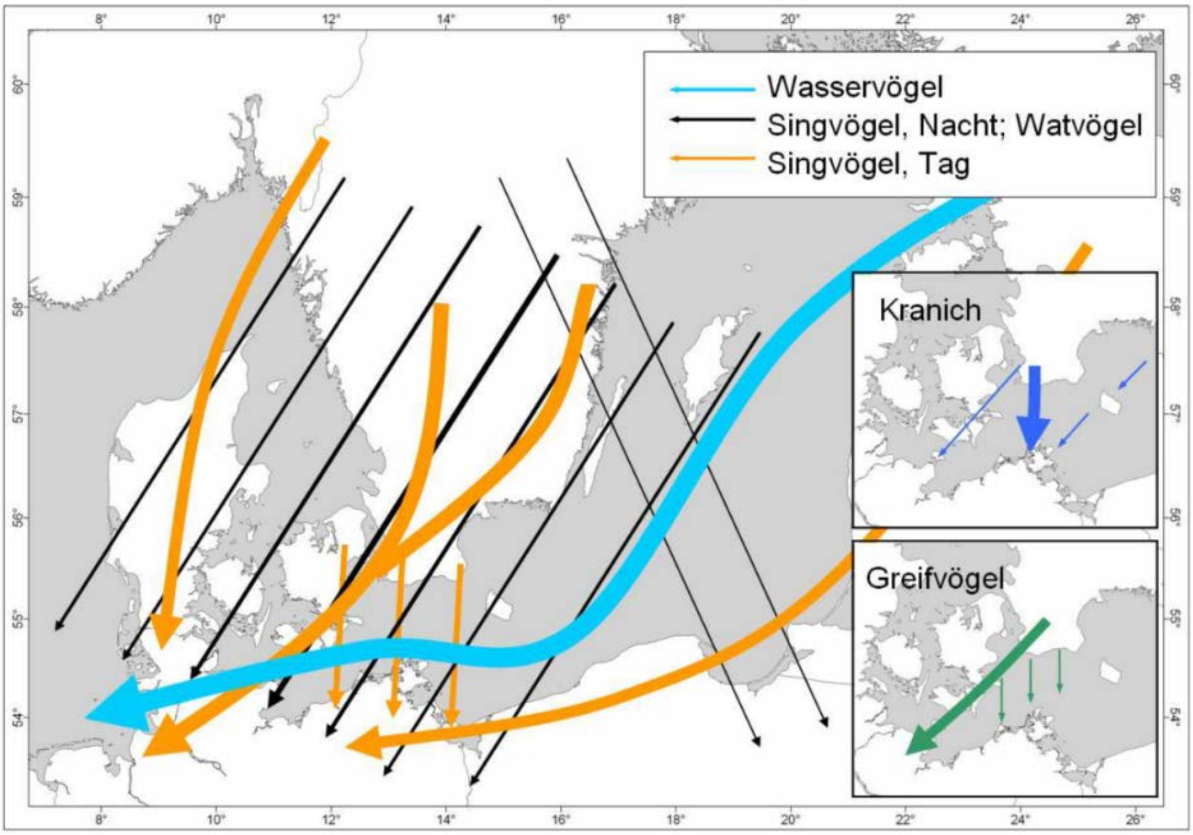

Figure 46: Schematic representation of the main migration routes in the Baltic Sea region for autumn migration (BELLEBAUM et al., 2008).

Over open water, migration altitude seems to increase in general (BEZZEL & PRINZINGER, 1990). Ultimately, flight heights during migration depend on various factors (e.g. time of year and day, wind and weather conditions). Night migrants generally migrate higher than day migrants. Wind conditions also have a great influence on migration altitude. For example, KRÜGER & GARTHE (2001) found that divers and sea ducks (eider, scoter) often fly very low over the water (less than 1.5 m high) when the wind is against them, whereas their flight heights increase when the wind is behind them. This is probably due to the fact that the wind strength usually increases with increasing altitude. By adjusting the flight altitude to the wind conditions, the flight speed can be greatly increased and the energy consumption significantly reduced (LIECHTI et al., 2000; LIECHTI & BRUDERER, 1998).

2.10.2.2 Species composition

Waterbirds (rowing birds, day/night migrants)

The exact migration routes are known for only one third of the approximately 70 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 altitudes (diving ducks, waders, e.g. GREEN, 2005). The flight paths of most species/populations cross the area in an east-west direction to reach their western European wintering grounds from their Arctic breeding grounds in western Siberia (e.g. geese, sea ducks, sandpipers, divers; cf. Figure 46 and Figure 47). These birds often orient themselves along the coastlines. Other species/populations that breed in Scandinavian wetlands and use freshwater biotopes as habitat migrate in a north-south direction (field geese, green ducks, mergansers, sandpipers). These species often follow traditional, population-specific migration routes. Species migrating at night probably also fly on a broad front (e.g. snipe).

In terms of diurnal migrants, there are three main known routes for waterbirds through the western Baltic Sea:

- Along the Swedish coast (main route of most eiders, white-cheeked and brent geese),
- along the German coast (main route of most mourning ducks, as well as many divers and terns) and
- in a north-south direction (swans, field geese, green ducks, mergansers).

Geese

During autumn migration, the Russian and Baltic populations of White-fronted Goose (*Branta leucopsis*) and 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 in the course of spring migration in the western Baltic Sea between the two species. White-fronted Geese fly to a greater extent over the open sea or over the southernmost tip of southern Sweden, while Brent Geese tend to fly further inland (GREEN & ALERSTAM, 2000). The mean migration direction of the White-footed Goose is north-easterly, while Brent Geese tend to fly easterly. In spring, White-fronted Geese usually migrate in April, while Brent Geese mostly migrate at the end of May. The main migration days fall in periods with tailwinds, which are selectively preferred. Both species fly over the German EEZ mainly in the area of Kiel Bay/Fehmarn Belt. Brent Geese show higher flight speeds in spring than in autumn, and they migrate in larger flocks and at higher altitudes (mean in spring: 341 m, autumn 215 m).

Other goose species probably migrate mainly at higher altitudes over the Baltic Sea or prefer to follow the coasts. In 25 years, only White-fronted Geese *Anser albifrons* have been observed in larger numbers on the Danish island of Christiansø (LAUSTEN & LYNGS, 2004). Also during the previous migration observations of the IfAÖ, mainly White-fronted Geese were seen crossing the Baltic Sea. In May 2003, a conspicuous moulting migration of the Greylag Goose *Anser anser (*and also of the Mute Swan *Cygnus olor*) from Darßer Ort to the Danish Islands at low altitude (< 100 m) was recorded (IfAÖ, 2005).

Sea ducks

For sea ducks, the southern and western Baltic Sea is an important migration area to the wintering grounds in the North Sea and the northern Kattegat. Although most of the migration tends to take place near the coast (many sea ducks fly with visual contact to land structures), sea duck migration also takes place on the open sea (IfAÖ 2005).

During spring, the **Eider**'s home migration takes place along the southern Swedish coast in a relatively narrow corridor very close to the coast. They show a strong relation to topographical structures (coastline): first, coming from the Kattegat or the Belt Sea, they migrate eastwards (partly over land) and then keep very concentrated along the coastline in a north-easterly direction (ALERSTAM, 1990). In autumn, migration follows more or less the same route. Although eiders migrate both during the day and at night, the main focus of migration is clearly during the day. Radar surveys of eider migration off the coast of southern Sweden showed that less than 10% of the total migration occurred in the dark (ALERSTAM et al., 1974). Mainly due to favourable weather conditions, a large part of the eider migration can take place on only a few days (ELLESTRÖM, 2002).

The spring migration of the **Common Scoter** is mainly along the German coast. Apparently, most of the Common Scoters wintering in the North Sea fly so far south during their migration home that they hit the western beach of Darss and then fly around Darßer Ort and then Cape Arkona relatively close. In spring 2003, about 9% of the biogeographical population (1.6 million individuals, Wetlands International, 2006) was observed at Darßer Ort alone (WENDELN & KUBE, 2005). However, with a 35% share of synchronous observations (to the observations at Darßer Ort itself) at sea 20 km north of Darßer Ort in spring (24% in autumn), larger numbers of Common Scoters can also be expected offshore. An unknown proportion of the birds migrate at night.

While the moulting and autumn migration of mourning ducks north of Cape Arkona on the island of Rügen is very 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). Apparently, autumn migration in the area between Darßer Ort and Falsterbo does not take place close to the coast. The birds presumably head for the Danish island of Møn from Cape Arkona. In the Fehmarn Belt, hardly any Black 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 migrate in this area already at high altitude in order to fly over Schleswig-Holstein afterwards/before (cf. Berndt and Busche, 1991).

Velvet Scoter migration is hardly observed in the German Baltic Sea (GARTHE et al., 2003; WENDELN & KUBE, 2005). Apparently there are hardly any exchange movements between the main wintering areas in the northern Kattegat and the Pomeranian Bay. 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 to the west and east of Rügen.

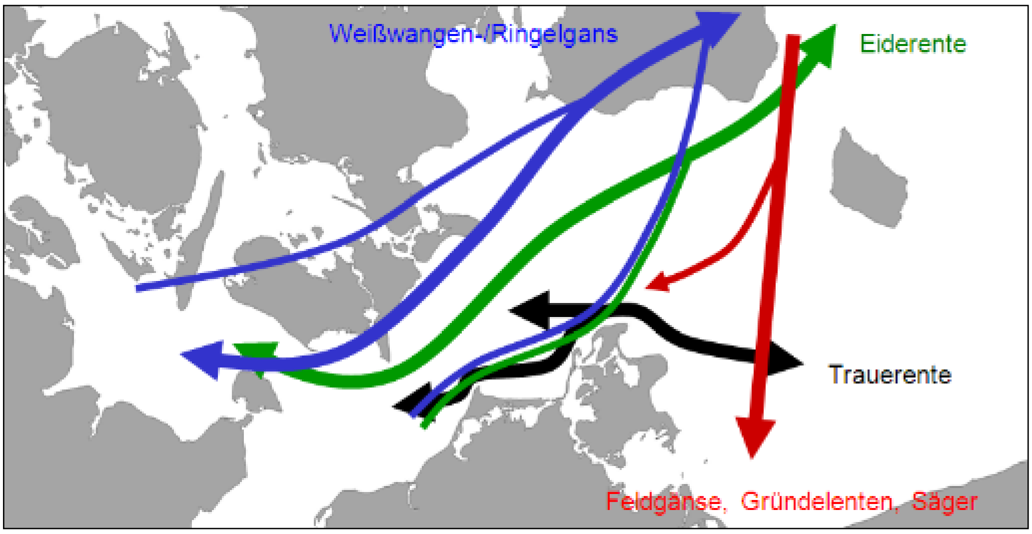

Figure 47: Scheme of selected migratory routes of waterbirds in the western Baltic Sea (compiled by IfAÖ from literature sources and own observations in the Arkona Sea; from BSH, 2009).

Field geese, swans, green ducks and mergansers

Limnetic waterbird species with a Scandinavian breeding home (swans, gudgeon and diving ducks, mergansers) migrate north-south across the Arkona Sea according to IfAÖ observations and presumably mainly head for the Oder estuary (incl. Greifswalder Bodden). Birds encountering the north coast of Rügen then turn west and follow the coastline. Observations from southern Sweden suggest that the birds initially migrated along the Swedish Baltic coast (FLYCKT et al., 2003; 2004). At present, however, there is a lack of sufficient data to describe the existing north-south migration in detail. What is striking about many of these species is that generally only a few individuals are seen per season (exceptions: Wigeon and Red-breasted Merganser, cf. also LAUSTEN & LYNGS, 2004). This suggests that many duck species migrate mainly at night at high altitudes.

Waders from the Siberian Arctic

Adult waders from Arctic breeding areas (sandpipers, plovers, etc.) usually migrate over the Baltic Sea at high altitudes into the Wadden Sea, often crossing southern Sweden. The young birds, on the other hand, migrate in small steps along the coasts and rest several times in wind mudflats (KUBE & STRUWE, 1994). In spring, almost all the limousines migrate at high altitude from the Wadden Sea to western Siberia. Their average flight altitude is about 2,000 m (GREEN, 2005). Generally, limousines prefer tailwinds for migration (GREEN, 2005). In strong headwinds or precipitation, there is occasional emergency rest in the western Baltic Sea or migration flat over the sea along the Swedish (in autumn with SW winds) or German coast (in autumn with NW winds). On the open sea, however, limousines are very rarely recorded. Calling records during the night predominate (IFAÖ, 2005).

Cranes/ Birds of prey (thermal gliders/rowing gliders/daydwellers)

Cranes

The cranes (*Grus grus*) of northern Europe use different migration routes. While eastern populations (Finland, Baltic States) migrate south-southeast (to Israel, northwest and east Africa), birds of the subpopulation following the western European migration route from Norway, Sweden, Poland and Germany to their wintering grounds in France, Spain and northwest Africa fly off to the southwest. This population is currently estimated at about 150,000 individuals (G. NOWALD pers. comm.).

For the western Baltic Sea, the Scandinavian birds that cross the Baltic Sea on migration are of particular interest. For these cranes, the Rügen-Bock region represents the most important resting place on the southern Baltic Sea coast (up to 40,000 resting cranes at the same time).

Scandinavian cranes reach their resting areas in the area of the pre-Pomeranian Bodden waters on two migration routes: From Finland partially along the southern Baltic coast and from Sweden by a non-stop flight of 1-2 hours duration over the Arkona Basin. On the latter migration route, an estimated 50,000-60,000 individuals are on the move. The home migration from the resting places in Western Pomerania to Sweden runs in the opposite direction in a northerly direction (ALERSTAM 1990, Figure 48).

Cranes cross the Baltic Sea in an almost direct north-south direction. The flight directions of the cranes recorded by IfAÖ deviated by a good 10° from the direct north-south direction during both the outward and return migration. This could be related to only partial compensation of wind drift over sea. Over land, on the other hand, there is full compensation of wind drift (ALERSTAM, 1975). Both autumn and spring migration were not uniform, but were characterised by mass migration on relatively few days. The cranes specifically used tailwind phases 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, due to their large wing area in relation to their weight, count as thermal gliders. Phases with rising flight altitudes alternate in thermal columns with gliding phases. This behaviour enables a very energy-saving way of flying. However, it is not possible to cross the Baltic Sea in gliding flight because of the distance of about 80 km to be covered. At a take-off altitude of 1,000 m, cranes can glide over a maximum distance of 16 km (ALERSTAM, 1990).

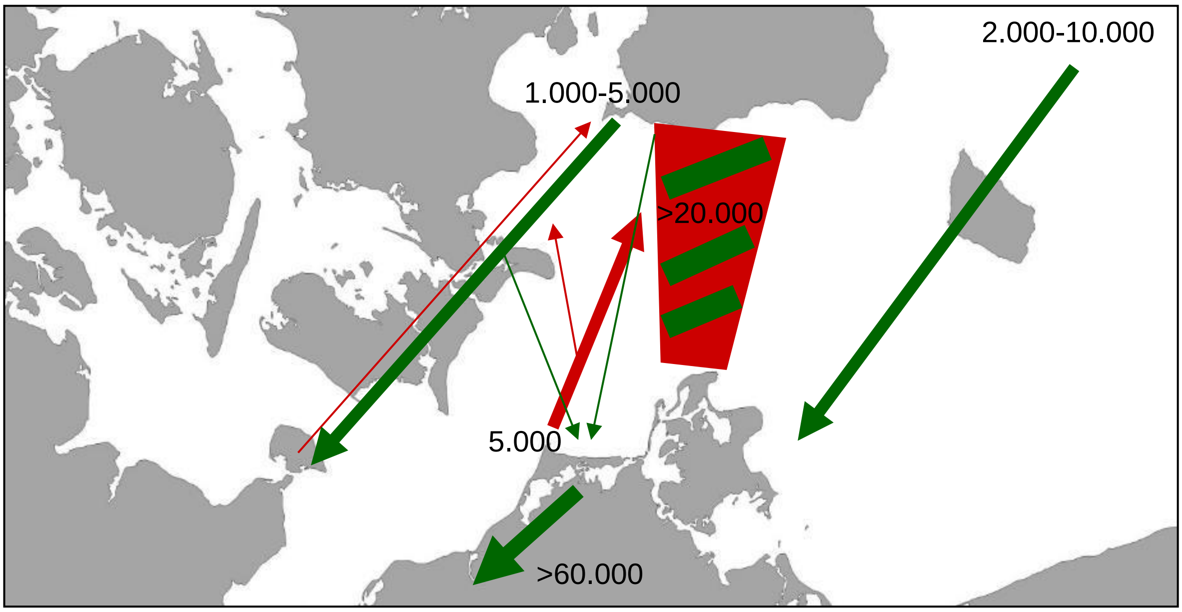

Figure 48: Scheme of crane migration routes in the western Baltic Sea (red=home migration, green=path migration; compilation IfAÖ according to observation data from Falsterbo, Bornholm and own observations in the Arkona Sea; from: BSH, 2009).

Since there are no upwinds over sea surfaces, they have to cover most of the distance in active rudder flight (probably alternating with gliding phases in the beginning). They usually wait for weather conditions with tailwinds (ALERSTAM & BAUER, 1973). Migration speed is also strongly dependent on the wind, averaging about 70 km*h-1 (ALERSTAM, 1975). Flight altitudes of 200-700 m have been measured over the southern tip of Sweden after crossing the Baltic Sea in spring (KARLSSON & ALERSTAM, 1974). Especially over land, the crane groups recorded by IfAÖ showed circling flight movements to gain altitude. However, cranes regularly circled over water close to land up to 15 km from the coast, gaining considerable altitude (Wendeln et al., 2008). The proportion of nocturnal migration was estimated at around 10% based on the available data (BELLEBAUM et al., 2008).

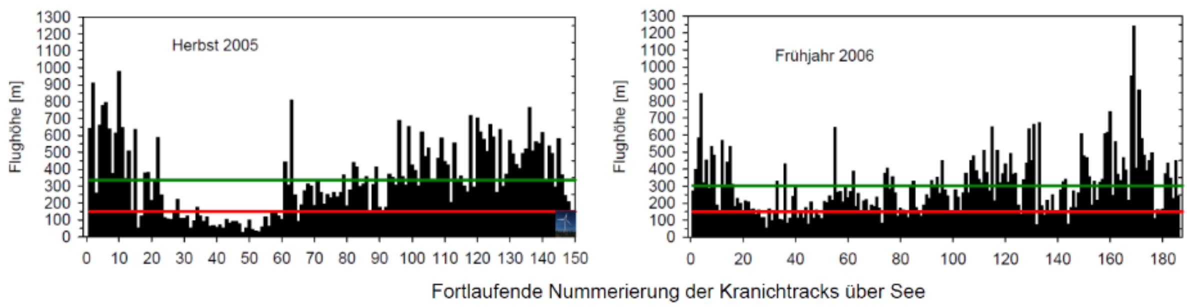

Figure 49: Flight heights of crane groups over the lake during autumn and spring migration (green line: mean flight height over the entire season; red line: max. height of wind turbines; BELLEBAUM et al. 2008).

The results of the observations with the target radar on the coast of Rügen show that the flight altitude over sea can be very variable. About one 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 in the height range of wind turbines.

Birds of prey

Birds of prey are often counted as thermal gliders. Thermal-sailing birds of prey soar on land to an altitude of several 100 m and then begin their migration. However, there are also species that migrate in rowing flight (e.g. sparrowhawks, ospreys, falcons). While the majority of diurnal raptors in Swedish populations follow the "bird flight line" over Falsterbo in autumn, some of them cross the Baltic Sea in a north-south direction (partly species-specific, e.g. Rough-legged Buzzard). For example, the migration patterns of sparrowhawks ringed in Falsterbo and Ottenby show parallel offset breeding and wintering areas: Birds breeding further east presumably also migrate along a route further east and must therefore also fly over larger water areas when crossing the Baltic Sea. Birds of prey that mainly follow the "bird flight line" in autumn have a south-south-western migration direction. Birds of prey that mainly cross the open sea between the southern Swedish coast and the Mecklenburg coast migrate more in a southerly direction.

Every autumn, up to 50,000 Scandinavian birds of prey migrate south over Falsterbo. These birds then cross the Fehmarn Belt. Depending on the prevailing wind direction, the crossing of this sea area takes place on a somewhat broader front (KOOP, 2005). The migration height of the raptors is predominantly above 50 m (IFAÖ, 2005).

During spring migration, the Fehmarnbelt is less important for migrating birds of prey. Presumably, many birds pass north of the Fehmarn Belt via Schleswig-Holstein and the Danish islands at this time of year. However, a not insignificant part also follows the southern Baltic Sea coast and crosses 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 clustering of migrants at Darßer Ort. The proportion of individuals observed exceeded the 10% limit for almost all species in relation to autumn migration in Falsterbo (Red Kite: approx. 30%, Osprey/ Buzzard: approx. 20%). Birds of prey migration was also observed on Rügen in spring. However, the proportions in relation to autumn migration at Falsterbo rarely exceed 10% and are thus significantly lower than the values recorded at Darßer Ort (BELLEBAUM et al., 2008).

Table 15: Comparison of raptor autumn migration in Falsterbo 2002 and 2003 with spring migration 2003 at Darßer Ort (M-V) 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	Ruegen Spring 2007	Ruegen Spring 2008
Honey buzzard	3.232	3.076	574	2.745	0	30
Red Kite	1.148	1.441	390	2.381	308	255
Marsh Harrier	801	969	142	569	44	90
Sparrowhawk	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

Over the Arkona Sea, only a few migrating birds of prey can be detected by visual observations (IFAÖ own observations). It is possible that the raptors migrate mainly above the 200 m visibility range in spring. Thermal-sailing raptors fly over other sea areas mainly at higher altitudes, e.g. rarely below 400 m when crossing Gibraltar (MEYER et al. 2000). In autumn, however, with frequent headwinds, migration altitudes in the area of the "bird flight line" are often lower (Falsterbo/Fehmarnbelt).

Land Birds (Rowing Birds)

Land birds (day migrants)

Many land bird species migrate during the day. Apart from the birds of prey already described, these are pigeons and songbirds (Table 16). Among the songbirds, short-distance migrants (especially finches and buntings; but also peepers, stilts, tits and crows) are day migrants. Of the long-distance migrants, swallows are an exception as pure day migrants. Some diurnal landbirds are among the most common breeding species in Scandinavia. In relation to the western Baltic Sea, Swedish and partly also Finnish breeding birds are of particular relevance (see ring findings in LAUSTEN & LYNGS, 2004).

Table 16: Visible proportion of autumn migration of common Scandinavian diurnal migrants: migration rates at different locations and breeding populations of Swedish populations, and estimation of the proportion of visually undetectable daytime bird migration (from BELLEBAUM et al. 2008).

	Chaffinch and brambling	Field lark	Meadow pipit	Barn Swallow	House Martin
Average migration rate [Ind. per h]					
Falsterbo	1.002,0	4,7	16,5	25,3	12,9
Krieger's flak	1,1	0,2	0,5	0,7	0,05
Adlergrund	3,8	0,5	1,9	1,6	0,2
Darss village	22,3	4,0	4,1	5,4	0,6
Total number of visible birds					
Falsterbo (Medium 1973-2001)[1]	760.758	1.571	8.324	23.279	5.283
Offshore2	664.160	136.320	292.800	618.240	29.280
Breeding stock Sweden/ migration volume					
Breeding pairs3	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
Visible share (%)					
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
Visible share, total (%)	2,81	4,60	10,04	71,28	5,76
Invisible share (%) Migration via the Danish islands/ high migration/ night migration/ wintering in Scandinavia	**97,19**	**95,40**	**89,96**	**28,72**	**94,24**

1 http://www.skov.se/fbo/index_e.html
2Assumption : Broad-front migration of Swedish breeding birds, migration rates at Kriegers Flak as basis for sea area between Mön and Bornholm (150 km), max. recording distance on ship
3 Number of breeding pairs according to HEATH et al. (2001)
4conservative estimate of reproduction rate (= 2 fledged juveniles per pair): migration volume autumn = (2 adults + 2 juveniles)*number of breeding pairs

The migration of diurnal landbirds in the western Baltic Sea follows two basic rules:

- Many day migrants prefer to cross the Baltic Sea in the area of the Danish islands. They fly partially in the visible range (below 50-100 m). Woodpigeons migrate e.g. over the Swedish inland in a broad-front migration, but in the area of the southern tip of Sweden near Falsterbo there is a clear concentration of migrants. Large numbers of woodpigeons are observed near Falsterbo and on Fehmarn (KOOP 2005).
- Day migrants avoid crossing the Arkona Sea during the day at low altitudes (below 100 m). They migrate either at very high altitudes (e.g. chaffinch > 1,000 m, IfAÖ own observations) or partly at night (e.g. skylark, starling, brambling).

Given the methodological difficulties in surveying diurnal landbirds over the sea (only possible with target tracking radar), little is known about the migratory behaviour of these species. Only some species are known to cross the Baltic Sea in a broad front (e.g. Swallows, Stilts and Pipits).

Land birds (night migrants)

Nocturnal migrants account for more than half of all migratory birds in the western Baltic Sea (long- and short-distance migrants). The distinct nocturnal migrants are mainly insectivorous small birds such as warblers, warblers, flycatchers, wheatears (*Oenanthe oenanthe*) and robins (*Erithacus rubecula*), but also thrushes (Table 17 (Alerstam et al., 1974).

Table 17). A number of bird species that also migrate during the day (ducks, geese, swans, waders and gulls) can also be observed migrating at night. Often, however, the main migration of these species is during the day. Radar surveys of eider migration off the coast of southern Sweden, for example, showed that a maximum of 10-20% of the total migration fell in the dark (Alerstam et al., 1974).

Table 17: Population sizes (number of breeding pairs; as of 2000) for the most common nocturnal migrant songbird species in Sweden (T = partly diurnal; after BIRDLIFE INTERNATIONAL, 2004a).

Art	**Number of breeding pairs**	**Art**	**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 (T)	1.000.000 – 3.000.000
Thrush	20.000 – 50.000	Blackcap (T)	400.000 – 1.000.000
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	Winter Goldcrest	2.000.000 – 4.000.000
Redwing (T)	750.000 – 1.500.000	Spotted Flycatcher (T)	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 of the nocturnal bird migration takes place in a broad front over the Baltic Sea. The birds of individual sub-populations fly in parallel neighbouring sectors according to their (mainly endogenously) determined migration direction, resulting in area-wide migration patterns (e.g. BERTHOLD, 2000). An indication of broad-front migration can be found, for example, in comparisons of catch figures from the ringing stations at Falsterbo and Ottenby, which are about 240 km apart. Winter Goldcrests have been caught there annually in almost identical numbers over a period of more than 20 years. Special features, such as the almost complete loss of the Winter Goldcrest migration in 2002, are also reflected in both trapping stations. This can only be explained by the fact that the nocturnal birds migrate southwards in a broad front (GRENMYR, 2003).

Surveys of the species composition during the autumn migration on Rügen in 2005 by means of vertical radar showed that songbirds accounted for the largest share of the nocturnal bird migration with about 90%, while waders only achieved a share of about 5%. Large songbirds, especially thrushes, were more common than small songbirds (cf. Figure 50). The relative share of small songbirds compared to large songbirds increased with altitude.

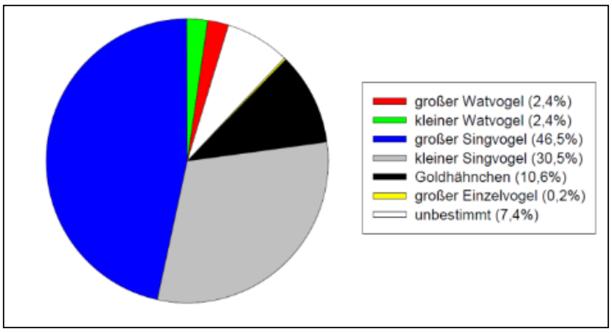

Figure 50: Species composition of nocturnal bird migration on Rügen in autumn 2005 (n= 26,612 echoes; from BELLEBAUM et al., 2008).

The main direction of migration of nocturnal migrants is the same for many species. In autumn it is approximately south-southwest and in spring north-northwest (cf. Figure 51). The recording of migration directions of nocturnal migrants with the target tracking radar on Rügen (mean over 9 nights; n = 712 measurements) resulted in a median of 213° for the flight direction in autumn 2005, the intrinsic direction was slightly more southward (median: 207°). In addition, there are species whose wintering grounds are located in a south-easterly direction (e.g. Barred Warbler, Marsh Warbler, Clapper Warbler, Red-backed Shrike, etc.). However, night migrants with a main direction of migration to the southwest also regularly migrate strongly to the southeast, especially in conjunction with northwesterly winds. The active selection of a migration direction depending on the wind direction is also called "pseudodrift".

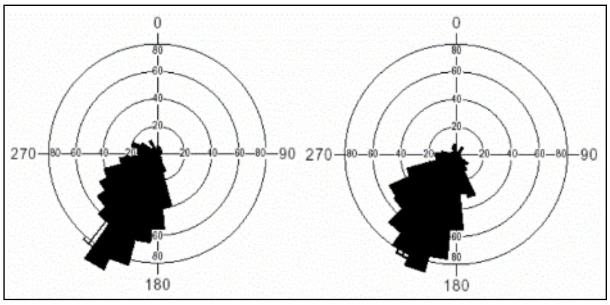

Figure 51: Frequency of migration directions of nocturnal bird migration (left direction of flight, right own direction/ heading) based on measurements with the target-following radar "Superfledermaus" in autumn 2005 on Rügen (from BELLEBAUM et al., 2008).

Land birds cross the Baltic Sea throughout the year. However, there are seasonal differences with high migration intensities from March to May (home migration) and in September/October (departure). Within the main migration periods, migration intensity varies greatly from day to day. These variations are caused by differences in weather conditions, with wind conditions often playing the decisive role (cf. LIECHTI & BRUDERER, 1998; Erni ET al., 2002). There are fundamental differences in the seasonal migration phenologies of nocturnal migratory songbirds between long-distance and short/medium-distance migrants. Short- and medium-distance migrants (e.g. winter goldcrest, wren, thrushes, robins) migrate earlier to the breeding area (often as early as March/April) and leave it later (September to November), while the breeding season of long-distance migrants (e.g. warblers, reed warblers) is shorter. (e.g. warblers, reed warblers, flycatchers, yellow warblers Hippolais icterina) is much shorter, i.e. they often arrive in May/June and leave the breeding area by the end of July/beginning of August (e.g. KARLSSON, 1992).

With the help of vertical radar equipment, migration rates were determined from ships at various coastal locations and on the Baltic Sea between 2002 and 2006 in order to gain an impression of the spatial distribution of nocturnal migration.

The highest nocturnal migration intensities were recorded at the land sites of Darßer Ort and Fehmarn (approx. 1,000 echoes/ (h*km) on average in spring and approx. 500-600 in autumn). The rates recorded on Rügen were about half of these values, here the migration rates of Fehmarn and Darßer Ort were not reached on any night. Significantly lower migration rates were measured at the offshore sites. On a few nights, however, higher migration rates were recorded (e.g. Kriegers Flak on 7.10.2003: mean 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 h and km in one night (max. hourly value: 15,278 echoes/(h*km)).

A comparison of the different sites and study years illustrates the pronounced fluctuations in nocturnal migration rates at the land sites where continuous measurements could be taken (cf. Figure 52). However, the data suggest that higher migration rates also occur at night along the "bird flight line" and that these decrease towards the east. The low migration rates at sea are probably related to the patchy recording and insufficient consistency of the recording conditions (BELLEBAUM et al., 2008).

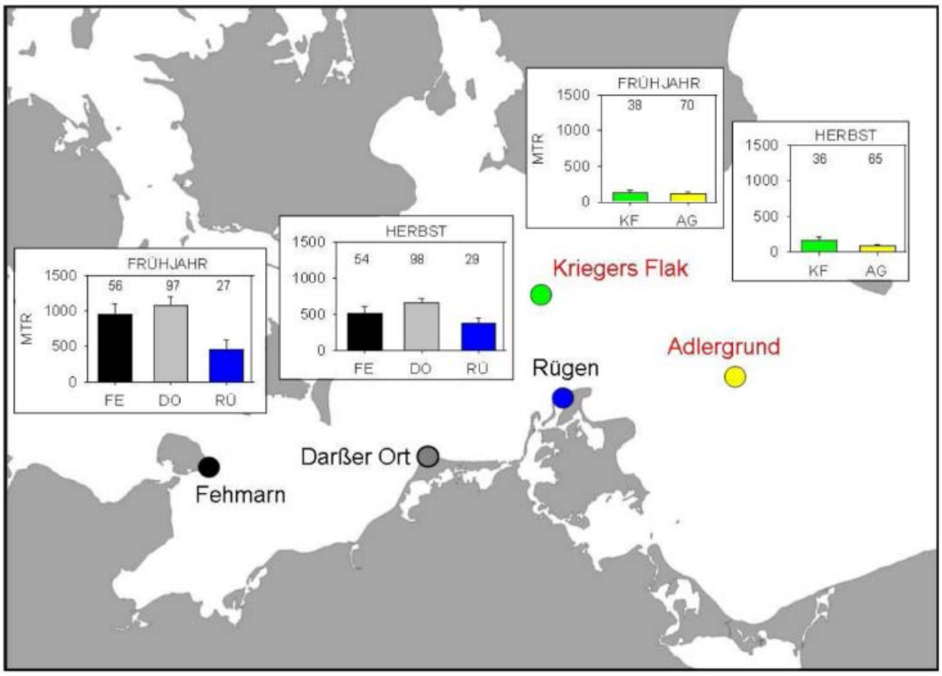

Figure 52: Mean traffic rate (MTR = birds per kilometre and hour) at different monitoring sites in spring and autumn (from BELLEBAUM et al., 2008).

2.10.3 Status assessment of migratory birds as an object of protection

The assessment of the status of migratory birds in the EEZ of the German Baltic Sea is based on the following assessment criteria:

- Large-scale importance of bird migration
- Assessment of the occurrence
- Rarity and endangerment
- Existing pressures

In the following, the status assessment for the EEZ is carried out separately for the main groups of waterbirds, cranes and birds of prey as well as landbirds. For the species requiring special protection according to Annex I of the Birds Directive and the bird species subject to special protection under Art. 4 para. 2 of the Birds Directive, an additional individual assessment is made.

According to current knowledge, several million birds migrate across the western Baltic Sea every year. In particular, the nocturnal migration of land birds takes place on a broad front between Central Europe and Scandinavia. Due to the broad-front migration of these birds, there is no land-sea gradient. In the western Baltic Sea, land-sea gradients are limited to the immediate coastal area, where the guideline effect of the beach line leads to local concentration of migratory activity even in the dark (in autumn in southern Sweden, in spring in Mecklenburg-Western Pomerania).

Concentration areas and guidelines of bird migration are given in the western Baltic Sea for day migrants. Thermal swifts and other diurnal land birds such as woodpigeons prefer to migrate along the "bird flight line" (islands of Fehmarn, Falster, Møn and Zealand, Falsterbo). East of this main route, these birds migrate in much lower densities (e.g. FRANSSON & PETTERSSON, 2001).

Waterbirds

The western Baltic Sea is an important migration area for sea ducks and geese breeding in northern Europe and Russia (up to western Siberia) to their wintering grounds in the North Sea and the northern Kattegat. As sea ducks are mainly diurnal migrants that prefer to orientate themselves to landmarks, a large part of the migration takes place near the coast. Common scoters, for example, usually fly in visual contact with land structures. Radar measurements in the area of Cape Arkona and Hiddensee within the framework of an R & D project (Knust ET al., 2003) revealed a largely coast-parallel migration. In addition, a broad-frontal migration across the open sea also takes place in the area of the western Baltic Sea (RAUTENBERG, 1956; KNUST et al., 2003). According to observations by the IfAÖ, gulls and alke migrate over the open sea without being bound to specific routes.

Diver

The species grouped under the term common diver and black-throated diver are also species according to Annex I of the V-RL. A main route takes most divers along the German coast. Results from the EIS'n monitoring reports indicate that the migration of divers in the EEZ is of minor importance (see Chapter 2.10.3.2 more details).

Sea ducks

Common eiders, long-tailed ducks, scoters and velvet scoters are among the regularly occurring migratory bird species not listed in Annex I of the Birds Directive, for which special protection measures must be taken according to Art. 4 para. 2 of the Birds Directive. According to BIRDLIFE INTERNATIONAL (2004b), sea duck populations (with the exception of Velvet Scoter) show a predominantly positive trend. According to more recent estimates by WETLANDS INTERNATIONAL (2012), however, this only applies to the Common Eider, with the population of the biogeographical population of the Common Eider currently reported at 976,000 individuals. The populations of the biogeographical populations of the other three duck species have declined by more than 50 per cent in recent years. Current figures for the long-tailed duck are 1.6 million, for the common scoter 550,000 and for the velvet scoter 450,000 individuals (WETLANDS INTERNATIONAL, 2012).

As primarily diurnal migrants, the four duck species show a strong relationship to topographical structures and therefore migrate increasingly along the coastline. However, studies within the framework of an R&D project (Knust ET al., 2003) have shown that the ducks also migrate across the Baltic Sea in broad-front migration.

According to current knowledge, eider migration occurs on a large scale along the coast of Sweden. In the current daily observations between autumn 2013 and autumn 2015 in area EO3, the sighting rates of eider ducks varied greatly. For example, in autumn 2013 the most eider ducks were sighted with 10,832 individuals and in spring 2015 the fewest eider ducks were sighted with 1,823 individuals (IFAÖ, 2016a and b). In area EO1, the number of eiders sighted 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 migration on the Swedish coast is about 40 times higher than in area EO3. Based on these results and the observations that eiders have a strong relationship to topographic structures (coastline), the German EEZ has an average importance for eider migration.

The migration of the Common Scoters, on the other hand, takes place increasingly along the German coast. In spring, approx. 9% of the biogeographical population was recorded at Darßer Ort (WENDELN & KUBE, 2005), although a not insignificant proportion was also sighted at sea 20 km north of Darßer Ort, so that larger numbers of Common Scoters also migrate in the EEZ. Approximately 0.33% of the biogeographical population was sighted in area EO1 in 2014 (BIOCONSULT, 2016) and approximately 0.5% (2014) and 0.12% (2015) in area EO3 (IfAÖ, 2016a and b). Velvet scoter migration is hardly 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 velvet scoters in priority area EO1. The same applies to the long-tailed duck in area EO3. Although 6,728 long-tailed ducks (0.4% of the biogeographical population) were sighted in area EO1 in 2014, the EEZ is of only minor importance for the migration of the two duck species.

Overall, the German EEZ of the Baltic Sea is of average to above-average importance for migratory waterbirds. This follows from the fact that in the western Baltic Sea there are two main routes for diurnal migratory waterbirds along the Swedish and German coasts, and the German EEZ is at least on the border of the coastal migration centre along the coast of Mecklenburg (KNUST et al. 2003). Furthermore, there are concentration areas in 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. white-cheeked goose, whooper swan, eider, mourning duck and velvet scoter), sometimes at high intensities.

White-cheeked Goose (Branta leucopsis)

The Russian-Baltic breeding population of the White-cheeked Goose is crucial for the western Baltic Sea. This is because this breeding population crosses the Baltic Sea on its way to its main wintering grounds (including the German and Dutch coasts). The biogeographical population of the White-fronted Goose is estimated at 770,000 individuals (WETLANDS INTERNATIONAL, 2012). The population has seen a very strong increase in individuals in recent decades. According to literature, the migration focus in the western Baltic Sea is along the Swedish coast. During spring migration, however, there is also increased migration over the open sea (GREEN & ALERSTAM, 2000).

The EEZ is mainly overflown in the area of the Bay of Kiel/Fehmarn Belt. However, in the area of the EO3 priority area, 8,190 migrating White-fronted Geese were recorded in 2014 and 2,622 in 2015 as part of the monitoring of the "EnBW Baltic 2" OWP project (IfAÖ, 2016a and b). These are approx. 1.06% and 0.34% of the biogeographical population, respectively. Accordingly, the area around Kriegers Flak is of high importance for the migration of White-footed Geese. Area EO1, on the other hand, is of low importance, as only up to 42 migrating White-footed Geese (BioConsult, 2016) - i.e. approx. 0.01% of the biogeographical population - were recorded. In the EO2 area, a total of 3,340 White-cheeked Geese were recorded during the bird migration observations to the offshore wind farm "Baltic Eagle" in the period 2008 - 2012 (OECOS, 2015). This corresponds to an average annual sighting rate of about 850 individuals (= 0.11% of the biogeographical population). Overall, according to the current state of knowledge, the EEZ has an average to high importance for the migration of the White-footed Goose. The average importance is due to the fact that the migration centre is generally located outside the EEZ. Sections are of high importance, e.g. in the Kriegers Flak area, where White-fronted Geese migrate at a significant intensity (> 1% of the biogeographical population).

Whooper Swan (Cygnus cygnus)

According to BAUER & BERTHOLD (1997), Song Swan populations have been steadily increasing in all European countries with breeding populations for several decades. The biogeographical population crossing the Baltic Sea on its migration route is estimated at 59,000 individuals (WETLANDS INTERNATIONAL, 2012). In the area of priority area EO1, approx. 0.3% and in priority area EO3 approx. 0.03% of the biogeographical population were recorded in one year. In area EO2 the sighting rate is about 0.01%. The three areas are therefore of low importance for the migration of Whooper Swans. Overall, the importance of the EEZ for whooper swan migration can be assessed as average at best, as it cannot be ruled out that whooper swans, as predominantly diurnal migrants, may use the known migration routes ("bird flight line") with greater intensity.

Cranes

The crane is subject to special protection status as a bird species listed in Annex I of the V-Directive. While the European population experienced a sharp decline between 1970 and 1990, it has now been showing significantly increasing numbers for many years (Birdlife International, 2004; Prange, 2005). According to WETLANDS INTERNATIONAL (2012), the biogeographical population comprises 90,000 individuals. The cranes from the different breeding areas in Northern Europe use different migration routes to their wintering area. Of particular interest for the western Baltic Sea are the Scandinavian birds that cross the Baltic Sea on migration.

If we consider the western Baltic Sea and thus the German EEZ as a whole, it is of above-average importance for crane migration, as the majority of the biogeographical population inevitably has to cross the Baltic Sea on its way south. However, as the crane is a narrow-front migrant, the migration route across the EEZ is bundled in individual concentration areas. It is assumed that about 50,000 to 60,000 cranes migrate from southern Sweden across the Arkona Basin. This means that about 55% of the biogeographical population uses this migration route alone. However, due to stronger winds, increased crane migration can also be observed in neighbouring areas.

In autumn 2014 and autumn 2015, a very high number of 5,028 and 3,517 cranes, respectively, were recorded in the area of site EO3 (IFAÖ 2016a and b). This means that approx. 5.6% and 3.9% of the biogeographical population flew through the area of site EO3. The reason for this is presumably stronger easterly winds, so that the cranes drifted into the area of the OWP project area "EnBW Baltic 2". This is supported by the fact that in autumn 2015 the cranes at "EnBW Baltic 2" were only observed with wind forces of 2 - 5 Beaufort from the north-east or east. In the EO2 area, the annual sighting rates were between 500 and 700 individuals, with 550 cranes seen on two days in autumn 2008 alone in westerly breezes between 4 and 5 Beaufort (OECOS 2015). In the area of the EO1 priority area, a total of 546 migrating cranes were recorded during autumn migration in 2014 (BIOCONSULT SH, 2016), corresponding to about 1.4% of the resting population in Western Pomerania (resting numbers: over 40,000 individuals at any one time) or 0.6% of the biogeographical population. Again, the majority of these birds may have been drifted southeast by northwesterly winds from a southern Sweden-Rügen flyway. However, cranes from Finnish (and Baltic) populations may be more likely to appear in the Eagle Ground area. On 12.10.2003, for example, strong migratory movements were recorded on Christiansö and Bornholm with 5,490 and 6,300 cranes respectively (flight direction W to SW), so that it can be assumed that larger numbers of cranes may also appear in the Adlergrund area from time to time.

Taking this migration behaviour into account, a differentiated consideration is necessary. The known main migration routes are undoubtedly of above-average importance. The neighbouring areas of these main migration routes are probably of average to above-average importance, depending on wind strength and direction. Away from these areas, the importance is probably low. Based on the determined flight heights and flight directions, it can be assumed that some of the cranes migrating over the Baltic Sea will encounter the planned wind farms. Since cranes usually migrate in favourable weather conditions with tailwinds and good visibility, evasive movements can be assumed as at land sites. However, corresponding studies on the open sea are still missing. Ultimately, it is necessary to carry out crane migration studies for individual projects at project level in order to assess the status of the affected migration route.

Birds of prey

Day-migrating raptors of Swedish populations mostly use the "bird flight line" over Fehmarn, coming from Falsterbo. However, some also cross the Baltic Sea in autumn in a north-south direction. In total, up to 50,000 Scandinavian birds of prey migrate southwards via Falsterbo. Among them are Annex I species (V-RL) that migrate over the Baltic Sea in significant numbers. These are 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 migration behaviour, so that a differentiated consideration is necessary. The known main migration routes are undoubtedly of above-average importance. The neighbouring areas of these main migration routes are probably of average to above-average importance, depending on wind strength and direction. Away from these areas, the importance is probably low. Ultimately, it is necessary to carry out raptor migration surveys at project level for individual projects, which will allow a status assessment of the affected area.

Landbirds

In the case of shorebirds, a distinction must be made between diurnal and nocturnal migrants.

Daytime migratory birds

Pigeons and songbirds are the main diurnal migrants. Guidelines play an important role for them. Therefore, they mainly use the Danish islands when crossing the Baltic Sea. A further concentration of migrants takes place via the "bird flight line". Thus, these areas have an above-average importance. Outside these main migration routes, the migration intensities of diurnal migrants in offshore marine areas are comparatively low and therefore have a low to average importance.

However, it must be taken into account that hardly anything is known about migration across the free Baltic Sea. It is known that only a few species (e.g. Swallows, Stilts, Pipits) migrate across the Baltic Sea in a broad front.

Nocturnal migratory birds

Nightime migrants account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place in a broad front over the Baltic Sea. Due to the very high numbers of individuals expected and the significant proportion of endangered species, the EEZ is of above-average importance for night migrants.

2.10.3.1 Existing pressures

Migratory birds are subject to a variety of anthropogenic pressures. Anthropogenic factors contribute in many ways to the mortality of migratory birds and can, in their complex interaction, affect population size and determine current migration patterns. On the one hand, this concerns the loss of breeding, resting and wintering areas due to various human activities and, in the long term, climate change. In addition, a large number of birds die each year as a direct result of human activity. In Scandinavia and the Baltic region alone, more than 100 million birds die each year due to active hunting, collisions with anthropogenic structures, fishing or oil and chemical pollution. The various factors have a cumulative effect, so that the isolated significance is usually difficult to determine.

Ring finding analyses of birds ringed on Helgoland show that in the course of the last century anthropogenic causes of death have increased in all species groups, with building and vehicle approaches standing out above all ("passive cause of death", 14% of all deaths in the last two decades, 49% in raptors and owls; HÜPPOP & HÜPPOP, 2002).

Numerous migratory bird species in Scandinavia are listed in Annex II/1 or II/2 of the Birds Directive and are subject to hunting in at least part of their annual habitat. Almost all migratory ducks (ducks, swans, geese) in the Baltic Sea region are affected by hunting. From 1996 to 2001, 122,500 eider ducks were shot annually in Scandinavia, 92,820 of them in Denmark alone (ASFERG, 2002). This corresponds to 16% of the winter population of 760,000 individuals (DESHOLM et al., 2002), to which must be added the shooting in the successor states of the former Soviet Union, for which no data are available. Particularly in the western Mediterranean, an important wintering ground for Scandinavian mid-range migrants, a statistically insufficient proportion of hunting still takes place (HÜPPOP & HÜPPOP, 2002).

In the western Baltic Sea itself, there are currently only a few existing impacts on Scandinavian migratory birds apart from hunting. These usually concern collision risks for night migrants with ships, bridges, offshore wind turbines and lighthouses.

The results of the investigations on lightships and platforms suggest that the collision risk of nocturnal migratory shorebirds with offshore wind turbines is to be considered high. The collision risk at lighthouses in the western Baltic Sea has been studied several times (e.g. HANSEN, 1954; BANZHAF, 1936). HANSEN (1954) analysed the approach victims 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 approach victims came from the 12 Danish lightships, although it should be noted that presumably only some of the collision victims were found on board and a much larger proportion fell into the sea. Obviously, therefore, the collision risk for birds was generally greater over sea than on land. In relation to the lightships, the annual collision rate was at least 100-200 birds. The risk of collision varies greatly from species to species. In HANSEN'S (1954) studies, five species accounted for about 75% of all victims, namely skylark, song thrush, redwing, starling and robin. Almost without exception, the approach victims were nocturnal migrants. Day migrants only died in exceptional cases and thermal gliders hardly at all (three individuals).

Similar findings are available for the research platform "FINO1" (HÜPPOP et al., 2009) and the "Research Platform North Sea" (MÜLLER, 1981). The species concerned are characterised by night migration and relatively large populations. It is striking that almost 50% of the collisions recorded at "FINO1" occurred on only two nights. Both nights saw southeasterly winds, which may have promoted migration over sea, and poor visibility, which may have led to a reduction in flight altitude and increased attraction by the illuminated platform (HÜPPOP et al., 2009). Illuminated bridges over extensive water areas may also pose a threat to night migrants. After the completion of the Øresund Bridge, mass collisions occurred in autumn 2000 at the heavily lit bridge during limited visibility, causing several thousand casualties over a few days. Surveys initiated by this event in the following year revealed 295 dead birds with significantly reduced lighting, with robins, song thrushes and winter goldcrests predominating (BENGTSSON comm.). The studies also show the endangerment of night migrating songbirds over the lake.

Quantitative data on the collision risk of 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. The investigations by means of infrared camera in the OWP "Nysted" (DESHOLM, 2005) do not yet allow any conclusions to be drawn on the collision risk of small birds for methodological reasons.

Global warming and climate change also have measurable effects on bird migration, e.g. through changes in phenology or altered arrival and departure times, which, however, are species-specific and vary regionally (cf. BAIRLEIN & Hüppop, 2004; Crick, 2004, Bairlein & WINKEL, 2001).

Clear relationships between large-scale climate cycles such as the North Atlantic Oscillation (NAO) and the condition of songbirds caught during spring migration have also been demonstrated (HÜPPOP & HÜPPOP, 2003). Climate change can also influence the conditions in breeding, resting and wintering areas or the supply of these habitats.

2.10.3.2 Importance of individual sub-areas of the EEZ for bird migration

For the assessment of the importance of individual sub-areas of the EEZ for bird migration, the assessment criteria listed in Chapter 2.11.3 are used, taking into account the main groups of waterbirds, cranes and birds of prey as well as landbirds. For species in need of special protection according to Annex I of the Birds Directive and bird species subject to special protection under Art. 4 para. 2 of the Birds Directive, an additional individual assessment is carried out. The sub-areas considered include the reservation and priority areas for offshore wind energy identified in the maritime spatial plan and the bird migration corridor Fehmarnbelt Lolland (so-called "bird flight line"), which is identified as a reservation area for nature conservation.

Priority area wind energy EO1

Waterbirds

Overall, site EO1 is of average importance for migratory waterbirds. This follows from the fact that the area is overflown by several species requiring special protection (e.g. white-cheeked goose, whooper swan, eider, mourning duck and velvet scoter), but lies outside the main route along the German coast. However, the results from the environmental monitoring in the area EO1 "Westlich Adlergrund" indicate that the migration of protected waterbird species is of minor importance (BioConsult SH 2016, 2017). For example, divers sighted only 26 individuals in 2014 and only 105 individuals in 2015. The number of eiders sighted was 457 in 2014 and 2786 in 2015, representing approximately 0.3% of the biogeographic population sighted in area EO1 in 2015. Sighting rates of Common Scoter, Velvet Scoter and Long-tailed Duck were also below 0.5% of the respective biogeographical populations in both years (2014 and 2015) (Common Scoter 0.33%, Velvet Scoter 0.05% and Long-tailed Duck 0.4%). The sighting of 42 migrating White-fronted Geese (BioConsult, 2016) corresponds to a share of approx. 0.01 % of the biogeographical population. With regard to the Whooper Swan, it can also be stated that the area is not of great importance for migration, as only approx. 0.3 % of the biogeographical population was recorded in one year.

Cranes

In the area of site EO1, a total of 546 migrating cranes were recorded during the 2014 autumn migration and 110 during the 2015 autumn migration (BioConsult SH 2016, 2017). The 546 cranes correspond to about 1.4% of the resting population in Western Pomerania (resting numbers: over 40,000 individuals at a time) or 0.6% of the biogeographical population. Here, the majority of these birds may have been drifted southeast by northwesterly winds from a southern Sweden-Rügen flyway. However, cranes from Finnish (and Baltic) populations may be more likely to appear in the Eagle Ground area. On 12.10.2003, for example, strong migratory movements were recorded on Christiansö and Bornholm with 5,490 and 6,300 cranes respectively (flight direction W to SW), so that it can be assumed that larger numbers of cranes may also appear in the Adlergrund area from time to time.

Taking this migration behaviour into account, a differentiated consideration is necessary. The known main migration routes are undoubtedly of above-average importance. The neighbouring areas of these main migration routes are presumably of average to above-average importance depending on wind strength and direction. This also applies to area EO1.

Birds of prey

According to current survey results, area EO1 is only of minor importance for raptor migration, as only very low numbers of individuals were recorded. Thus, of the Annex I species (V-RL) honey buzzard 2 individuals, marsh harrier 4 individuals and merlin 1 individual were sighted.

Landbirds

In the case of shorebirds, a distinction must be made between diurnal and nocturnal migrants.

Daytime migratory birds

Pigeons and songbirds are the main diurnal migrants. Guidelines play an important role for them. Therefore, they mainly use the Danish islands when crossing the Baltic Sea. A further concentration of migrants takes place via the "bird flight line". Thus, these areas have an above-average importance. Outside these main migration routes, the migration intensities of diurnal migrants in offshore marine areas are comparatively low and therefore have a low to average importance.

Nocturnal migratory birds

Night migrants account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place in a broad front over the Baltic Sea. Due to the very high expected numbers of individuals and the significant proportion of endangered species, site EO1 has an average to above-average importance for night migrants.

Priority area wind energy EO2

Waterbirds

Overall, site EO2 is of average to above-average importance for migratory waterbirds. This follows from the fact that the area is overflown by several species requiring special protection (e.g. White-fronted Goose, Whooper Swan, Eider, Black Scoter and Velvet Scoter), but lies outside the main route along the German coast. However, although the results from 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 individuals were sighted by divers in 2011. The number of eiders sighted in 2011 was 140, representing approximately 0.01% of the biogeographical population recorded in the EO2 area in 2011. 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 populations. In contrast, the Common Scoter was recorded in high numbers of individuals. In 2011, 8174 individuals were counted. This means that approx. 1.5 % of the biogeographical population passed through the EO2 area. This means that the area is of above-average importance for mourning duck migration. The sighting of 2619 migrating white-cheeked geese (OECOS, 2012a) corresponds to a share of approx. 0.34 % of the biogeographical population and thus the area has an average importance. With regard to the Whooper Swan, it can be stated that the area is not of great importance for migration, as only 30 individuals were recorded in one year.

Cranes

In the area of the EO2 site, a total of 1231 migrating cranes were recorded during the autumn migration in 2008 (OECOS, 2012a). The 1231 cranes correspond to about 3.1 % of the resting population in Western Pomerania (resting numbers: more than 40,000 individuals at a time) or 1.37 % of the biogeographical population. Here, the majority of these birds may have been drifted southeast by northwesterly winds from a flight path of southern Sweden-Rügen. However, cranes from Finnish (and Baltic) populations may be more likely to appear in the Eagle Ground area. For example, strong migratory movements were recorded on Christiansö and Bornholm on 12.10.2003 with 5,490 and 6,300 cranes respectively (flight direction W to SW), so that it can be assumed that at times larger numbers of cranes may also appear in the area of the EO2 site.

Taking this migration behaviour into account, a differentiated consideration is necessary. The known main migration routes are undoubtedly of above-average importance. The neighbouring areas of these main migration routes are presumably of average to above-average importance depending on wind strength and direction. This also applies to the area EO2.

Birds of prey

According to current survey results, the area EO2 is only of minor importance for raptor migration, as only very low numbers of individuals were recorded. Thus, of the Annex I species (V-RL) honey buzzard 1 individual, marsh harrier 4 individuals, white-tailed eagle 2 individuals and merlin 4 individuals were sighted (OECOS, 2012a).

Landbirds

In the case of shorebirds, a distinction must be made between diurnal and nocturnal migrants.

Daytime migratory birds

Pigeons and songbirds are the main diurnal migrants. Guidelines play an important role for them. Therefore, they mainly use the Danish islands when crossing the Baltic Sea. A further concentration of migrants takes place via the "bird flight line". Thus, these areas have an above-average importance. Outside these main migration routes, the migration intensities of diurnal migrants in offshore marine areas are comparatively low and therefore have a low to average importance.

Nocturnal migratory birds

Night migrants account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place in a broad front over the Baltic Sea. Due to the very high expected numbers of individuals and the significant proportion of endangered species, the EO2 area has an average to above-average importance for night migrants.

Priority area wind energy EO3

Waterbirds

Overall, the area of site EO3 is of average to above-average importance for migratory waterbirds. This follows from the fact that the area is overflown by several species requiring special protection (e.g. White-fronted Goose, Whooper Swan, Eider, Black Scoter and Velvet Scoter), but lies outside the main route along the German coast. However, the results from 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, of the common divers, only 91 animals were sighted in 2014 and as few as 18 in 2015. With regard to the common scoter, approximately 0.5% (2014) and 0.12% (2015) of the biogeographical population were sighted in area EO3 (IFAÖ, 2016b). The sighting rate of the Velvet Scoter was 105 individuals and the same applies to the Long-tailed Duck. During the daily observations between autumn 2013 and autumn 2015 in area EO3, the sighting rates of eider ducks varied greatly. For example, the most eider ducks were sighted 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 biogeographical population was sighted in a small area of the EEZ during a migration period and thus the area EO3 has an above-average importance for eider migration. The area of EO3 has a comparable importance for the migration of the white-cheeked geese. For example, 8,190 migrating white-cheeked geese were recorded in 2014 and 2,622 in 2015 as part of the monitoring of the "EnBW Baltic 2" OWP project (IfAÖ, 2016a and b). These are approx. 1.06% and 0.34% of the biogeographical population, respectively. With regard to the Whooper Swan, it should be noted that the area is not of great importance for migration, as only approx. 0.03% of the biogeographical population was recorded in one year.

Cranes

In the area of site EO3, a very high number of 5,028 and 3,517 cranes were recorded in autumn 2014 and autumn 2015, respectively (IfAÖ, 2016a and b). This means that approx. 5.6% and 3.9% of the biogeographical population flew through the area of site EO3. The reason for this is presumably stronger easterly winds, so that the cranes drifted into the area of the OWP project area "EnBW Baltic 2". This is supported by the fact that in autumn 2015 the cranes at "EnBW Baltic 2" were only observed with wind forces of 2 - 5 Beaufort from the north-east or east. Considering the migration behaviour, a differentiated analysis is necessary. The known main migration routes are undoubtedly of above-average importance. The neighbouring areas of these main migration routes are presumably of average to above-average importance depending on the wind strength and direction. This also applies to area EO3.

Birds of prey

According to current survey results, area EO3 is of only minor importance for raptor migration, as only very low numbers of individuals were recorded.

Landbirds

In the case of shorebirds, a distinction must be made between diurnal and nocturnal migrants.

Daytime migratory birds

Pigeons and songbirds are the main diurnal migrants. Guidelines play an important role for them. Therefore, they mainly use the Danish islands when crossing the Baltic Sea. A further concentration of migrants takes place via the "bird flight line". Thus, these areas have an above-average importance. Outside these main migration routes, the migration intensities of diurnal migrants in offshore marine areas are comparatively low and therefore have a low to average importance.

Nocturnal migratory birds

Night migrants account for more than half of all migratory birds in the western Baltic Sea. Most of the nocturnal bird migration takes place in a broad front over the Baltic Sea. Due to the very high expected numbers of individuals and the significant proportion of endangered species, site EO3 has an average to above-average importance for night migrants.

Fehmarnbelt ("Vogelfluglinie")

The BfN describes the bird migration corridor in the area of the Fehmarn Belt in its nature conservation planning contribution as follows (BfN, 2020):

The Fehmarnbelt 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 "bird flight line", is used twice a year in considerable concentrations by both migrating land birds and water birds. According to estimates, 100 million birds, mainly songbirds, pass through the Fehmarnbelt every year in autumn alone (Koop, 2004). It thus occupies a prominent position in the Eurasian bird migration system.

For land birds, the Fehmarnbelt, as the shortest link between Germany, eastern Denmark and Sweden, is an important stepping stone on the migration route from Scandinavia to Central Europe. In particular, thermals such as large birds of prey, but also diurnal songbirds, avoid long flights over the water and concentrate on migration at geographical bottlenecks such as the Fehmarnbelt in order to fly the shortest route over the water (Hüppop et al., 2018). With sizes of approx. 10,000 to 25,000 raptors per migration period, internationally important migratory bird concentrations are reached that fulfil the IBA criterion Category "A 4 iv" (Globally important congregations, "bottleneck site").

The Fehmarnbelt is also of outstanding importance for waterbird migration. In the area, various migratory routes come together that previously ran parallel to the coast or across the open Baltic Sea when coming 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 larolan limousines and > 1,000 divers cross the area on their way from their Scandinavian to West Siberian breeding grounds to the Wadden Sea. There are no alternative routes to the Fehmarnbelt that could be used by larger numbers.

For songbirds migrating at night, more extensive migration patterns can be observed due to the limited optical orientation possibilities. However, measurements of migration with radar on the Baltic Sea and at various coastal sites suggest that higher migration rates also occur at night along the "bird flight line" over the Danish islands and Fehmarn, with decreasing rates in an easterly direction (Bellebaum et al., 2008).

The Fehmarnbelt is therefore a hub of bird migration. While the predominant direction of migration for land birds during the migration period is from north-east to south-west, water birds cross the area from east to west during this period. Home migration is in the opposite direction. The area is of special nature conservation importance for bird migration across the Baltic Sea, which is why it should be protected as a priority area for bird migration.

2.11 Bats and bat migration

Bats are characterised by a very high mobility. While bats can travel up to 60 km per day in search of food, nesting or summer roosting sites and hibernation areas are located several hundreds of kilometres apart. Migratory movements of bats in search of extensive food sources and suitable resting places are very often observed on land, but mainly aperiodically.

In contrast to irregular migratory movements, migratory movements occur periodically or seasonally. The migratory behaviour of bats varies greatly from species to species and from sex to sex. Differences in migration 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 search of nesting, feeding and resting sites, bats undertake short- and medium-distance migrations. For medium distances, corridors along flowing waters, around lakes and Bodden waters are known (BACH & MEYER-CORDS, 2005). Long-distance migrations, however, are still largely unexplored. In contrast to bird migration, which has been documented by extensive studies, very little is known about bat migration due to the lack of suitable methods or large-scale special monitoring programmes.

The long-distance migratory species include the greater evening bat (*Nyctalus noctula*), rough-skinned bat (*Pipistrellus nathusii*), two-coloured bat (*Vespertilio murinus)* and lesser evening bat (*Nyctalus leislerii*). For these four species, migrations over a distance of 1,500 to 2,000 km are regularly recorded (TRESS et al. 2004, HUTTERER et al. 2005). Long-distance migrations are also suspected for the species of mosquito bat (*Pipistrellus pygmaeus*) and common pipistrelle (*Pipistrellus pipistrellus) (*BACH & MEYER-CORDS, 2005). Some long-distance migratory species occur in Germany and countries bordering the Baltic Sea and have occasionally been found on ships and in coastal regions of the Baltic Sea.

Common nightjar (*Nyctalus noctula*): In coastal regions of southern Sweden, individuals have been observed leaving the land for the sea during the usual bird migration season. Winter findings of animals ringed in Sweden have also been recorded in Germany (AHLEN, 1997; AHLEN et al., 2009).

Rough-skinned bat (*Pipistrellus nathusii):* Migrating animals are often observed in spring and autumn. There is increasing evidence that Rough-skinned Bats also hibernate in northern Germany. In coastal regions of southern Sweden, individuals have been observed flying towards the sea, as in the case of the common evening bat. Rough-skinned bats have also been found to hibernate in Germany after being ringed in Sweden (AHLEN, 1997; AHLEN et al., 2009).

According to BOYE et al. (1999), the common *pipistrelle (Pipistrellus pipistrellus*) is the most frequently recorded bat species in Germany. It occurs throughout the year and is widespread. There is some evidence that these species also undertake long-distance migrations, possibly over the sea.

The Northern Bat (*Eptesicus nilssoni*) is a northern species with a distribution centre north of 60°N, reaching its southernmost limit in Germany. Assemblages of northern bats have been observed in coastal regions of southern Sweden (AHLEN 1997). The observations so far indicate that the Northern Bat may undertake long-distance migrations over the sea.

2.11.1 Data situation

Migration movements of bats over the Baltic Sea have been documented by ringing findings. However, migration directions, migration times and especially possible migration corridors in the Baltic Sea are still largely unknown for bats. The data basis is therefore insufficient for a detailed description of the occurrence and intensity of bat migration in the offshore area and the areas included in the MSP for wind energy. In the following, reference is therefore made to general literature and publications on bats and bat migration over the Baltic Sea in order to reflect the current state of knowledge.

2.11.2 Migratory movements 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 migrations in the marine area. Visual observations, e.g. on the coast or on ships, provide indications, but are hardly suitable to fully record the migration behaviour of nocturnal and night-migrating bats over the sea. Visual observations are also of little or very limited use for recording migration behaviour due to the height of the flight movements (e.g. 1,200 m for the greater evening bat). WALTER et al. (2005) have summarised all previous sightings of bats from ships or platforms.

A number of observations lead to the assumption that bats regularly cross the Baltic Sea during seasonal migrations. The few systematic scientific studies on bat migration over the Baltic Sea were carried out in Scandinavia. According to observations of bat concentrations at different coastal sites in southern Sweden (e.g. Falsterbo, Ottenby) by AHLEN (1997) and AHLEN et al. (2009), at least four out of 18 bat species occurring in Sweden migrate southwards. Observations of individuals that have left the country for the sea are available for the Rough-skinned bat, the Common evening bat and the Two-coloured bat. However, only the Rough-skinned Bat and the Greater Evensong Bat have been found in winter in Germany from animals that were ringed in Sweden.

Further insights based on ringing findings are provided by studies on the migratory behaviour of the Rough-skinned Bat from Latvia (PETERSONS, 2004). It was found that the bats roosting in Latvia during the summer months visit hibernation roosts in western, central and southern Europe. The ringed animals were recorded at a distance of up to 1,905 km. The average distance of all detections was 1,365.5 km for males and 1,216.5 km for females. The calculated average migration speed of the rough-skinned bat was around 47.8 km per night. Among others, ringed bats were found in resting habitats in northern and north-eastern Germany. Ringed bats 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 bats. When foraging for food (insects), the common evening bat usually flies at an altitude of 500 metres. According to observations from Falsterbo, the Greater Evening Bat even flies at altitudes of 1,200 m (AHLEN, 1997). The Common Evening Swift is also known to be a diurnal species (EKÖLF, 2003). It is assumed that migratory movements during daylight preferentially take place at altitudes of more than 500 m in order to escape hunting by birds of prey.

Ringing findings can only provide evidence of the individual whereabouts of the marked individuals, but not of the migration routes in between. To date, there is no suitable method for precisely recording the flight paths of individual bats over longer distances (HOLLAND & WIKELSKI, 2009). Conclusions about the number of regularly migrating bats are therefore also not possible.

The use of ultrasonic detectors, the so-called bat detectors, provides good results on the occurrence of bats on land (SKIBA, 2003). However, their use in the offshore area is associated with difficulties. Given the low detection range of the system, records do prove the occurrence of bats in the offshore area. However, with this recording method, stronger winds, which occur more frequently at sea, lead to background noise, which makes it difficult to reliably record bat signals. There is still a need for research in this area.

A good summary of the current state of knowledge is provided by the expert report "Fledermauszug im Bereich der deutschen Ostseeküste" commissioned by the BSH (SEEBENS, et al. 2013). It summarises and discusses the results of different surveys of bats off the coast of Mecklenburg-Western Pomerania. Among others, surveys on the Greifswalder Oie, the survey from the platform "Riff Rosenort" and the survey on a ferry ship are taken into account. On the working platform "Riff Rosenort" about 2 km off the coast, a total of 23 rough-skinned bats and 7 evening bats were recorded from mid-May to mid-June 2012 using real-time/time-stretching detectors. The detections suggest migratory activity. However, due to the coastal location, hunting flights of both species on the Baltic Sea cannot be excluded (SEEBENS et al., 2013).

On the island of Greifswalder Oie, which lies about 12 km north of Usedom and 10 km east of Rügen, bat surveys were carried out in 2011 and 2012 using automatic detectors, net catches and the inspection of buildings suitable as roosts. During the surveys, nine species were detected, some of them in remarkable numbers, including the greater evening bat, lesser evening bat, common pipistrelle and rough-skinned bat. In May in particular, high activity was recorded, and on only a few days. The analysis of the automatically recorded bat calls shows a total of 4,788 contacts of the Rough-skinned bat in 2012 (2011: 3,644 contacts), 2,178 for the Common pipistrelle (2011: 1,750 contacts) and 817 contacts for the Greater evening bat (2011: 1,056 contacts). On 6.5.2011, 48 rough-skinned bats and one greater evening bat were recorded via net catches at wind speeds of 2-3 Beaufort (SEEBENS et al. 2013). The authors conclude from the high activity of the species Rauhautfledermaus and Großer Abendsegler during a few days in spring that there is clear evidence of migration in the area of the Greifswalder Oie.

Findings on the occurrence of bats in the offshore area were obtained with the help of a bioacoustic recording system installed on a ferry. The ferry shuttles between Rostock and Trelleborg in Sweden. In May 2012, 11 echolocation calls of bats were recorded offshore during the surveys in 180 of a total of 540 migration-relevant night hours. Seven of these contacts were within 20 km of the coast of Mecklenburg-Vorpommern, two were within 20 km of the Swedish and Danish coasts, and two were more than 20 km from the nearest coast. The recorded calls could be assigned to the common evening bat and the rough-skinned bat (SEEBENS et al., 2013).

Despite this evidence, there is currently no concrete knowledge to quantify the migration of bats over the Baltic Sea. This applies accordingly to migrating species, migration corridors, migration altitude, migration direction and concentration areas. Previous findings only indicate that bats, especially long-distance migratory species, migrate over the Baltic Sea.

Based on the results of the above-mentioned survey, the recording of bat migratory activity was included in the current standard survey concept (StUK4) in order to obtain more concrete indications of the importance of the Baltic Sea EEZ as a migration area for bats. The surveys are to be carried out in parallel with the nocturnal call survey of migratory birds using bat detectors to record calling activity. Within the framework of this obligatory bat monitoring of wind farm projects in area EO1, only four bats (two of which were rough-skinned bats) were detected in nine nights in spring 2014 (May). In autumn (August - October) of the same year, three rough-skinned bats were recorded on 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 EEZ of the Baltic Sea, individual sightings of bats were recorded during night-time bird migration surveys.

During the surveys for the offshore wind farm project "Arkona Basin Southeast", one bat each was sighted from the ship in autumn 2003 and 2004. Another bat was sighted in autumn 2003 during the surveys for the offshore wind farm project "Wikinger". During further ship trips, individual specimens were sighted twice in the area of site EO1. In area EO2, three bat calls were recorded using bioacoustic hand-held recording devices on 21.5.2012. In spring 2011, two additional rough-skinned bats were sighted on board the vessel used for the bird surveys. In area EO3, one specimen each of an undetermined species was observed during the baseline surveys in July and September 2003. Some of the sightings even took place during the day.

In summary, it can be stated for the bat populations of species relevant to the Baltic Sea that the populations and distribution of migratory species have not been conclusively recorded, mainly due to the high migration dynamics. There is a lack of adequate methods and monitoring programmes to record and quantify population trends, migrations and migration movements across the open sea.

Based on the findings to date, it can be stated that bats migrate across the Baltic Sea: Observations and ringing findings indicate that some species such as the greater evening bat, rough-skinned bat, two-coloured bat, common pipistrelle and northern bat migrate across the Baltic Sea.

It is assumed that broad-front migration takes place along prominent landscape elements such as coastlines. However, migration directions, migration heights, migration times and especially possible migration corridors in the Baltic Sea are still largely unknown for bats.

2.11.3 Conservation status of potential migratory bat species in Baltic Sea littoral states

Some species, such as the rough-skinned bat and the greater evening bat, are listed in Appendix II of the 1979 Convention on the Conservation of Migratory Species (CMS) (Bonn Convention). Within the CMS Convention, the adoption of the Agreement on the Conservation of Bats in Europe (EUROBATS) in 1991 and its ratification in 1994 established the framework for a conservation and management plan for bats in Europe.

As part of the reporting obligations for EUROBATS, reports on the respective regional occurrence, population development and status of bats are compiled by all Contracting Parties. Data from the EUROBATS reports of some Baltic Sea countries, including the Baltic States and Scandinavia, provide information on the species range and occurrence or on possible migration or passage across the Baltic Sea.

In Denmark, 17 bat species have been identified; 14 of them nest in Denmark. The populations of the three long-distance migratory species Rough-skinned bat, Greater evening bat and Two-coloured bat have not been quantified, but there are numerous records of roosts. The presumed long-distance migrants common pipistrelle and northern bat are also among the species nesting in Denmark. The five previously mentioned species are considered "not endangered" in Denmark (The Danish Nature Agency, 2015).

The bat occurrence in Sweden was last described in a national report from 2006 within the framework of EUROBATS (Swedish Environmental Protection Agency, 2006). There are 18 species of bats in Sweden. Populations have increased in five species in recent decades, including the rough-skinned bat and the northern bat. Decreases in populations are assumed for three other species, including the migratory two-coloured bat. Among the migratory species, only the Rough-skinned bat is on the Red List as potentially endangered in Sweden. The common evening bat was already removed from the Red List in 2000. Overall, Swedish surveys showed that populations of the Rough-skinned Bat have increased over the last two decades, with an extended geographical range up to 60°N. The common night bat, on the other hand, is relatively common only in southern Sweden and in coastal areas. In contrast to the above-mentioned species, the two-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 widespread is the northern bat. The three migratory species, the rough-skinned bat, the greater evening bat and the two-coloured bat, only occur in southern Finland during the summer months. However, their populations and trends are largely unknown. The rough-skinned bat is classified as "endangered".

Latvia has 15 bat species (MINISTRY OF ENVIRONMENTAL PROTECTION AND REGIONAL DEVELOPMENT OF THE REPUBLIC OF LATVIA, 2014). A comparison of the occurrence of bats in Latvia with the occurrence in Estonia and north-western Russia has shown that at least four species reach their northernmost distribution limit in Latvia. Rough-skinned bat, greater evening bat and two-coloured bat occur widely in the summer months. Two other species, the common pipistrelle and the little evening bat, have been classified as migratory in Latvia on the basis of ring finds. This brings the total number of migratory species in Latvia to five. The Rough-skinned bat and the Common nightjar are not classified as endangered in Latvia. The two-coloured bat, the common pipistrelle and the lesser evening bat are only considered rare.

Fifteen bat species have been recorded in Lithuania, including the long-distance roosting bat, greater and lesser evening bats, common pipistrelle and bi-coloured bat. Population trends are largely unknown and most are not considered endangered (THE PROTECTED AREAS AND LANDSCAPE DEPARTMENT OF THE MINISTRY OF ENVIRONMENT OF THE REPUBLIC OF LITHUANIA, 2014).

A total of 21 bat species occur in Poland (MINISTRY OF THE ENVIRONMENT POLAND, 2014). Among the migratory species, the common pipistrelle is classified as endangered in Poland. The two-coloured bat, on the other hand, is considered to be of low concern.

A total of 25 bat species are native to Germany. Of these, the current Red List of Mammals (MEINIG et al., 2008) assigns two species to the category "endangerment of unknown extent", four species to the category "severely endangered" and three species to the category "threatened with extinction". The long-winged bat (*Miniopterus schreibersii)* is considered "extinct or lost". Of the species more frequently found in Germany's marine and coastal areas, the common evening bat is on the forewarned list, and the common pipistrelle and rough-skinned bats are considered "endangered". There is insufficient data to assess the endangerment status of the lesser evening bat.

2.11.4 Hazards to bats

Anthropogenic threats to migratory bats result in particular from the loss of summer roosts due to the felling of old trees, the loss of winter roosts due to the renovation of old buildings and the use of wood preservatives, the intensification of agriculture and the use of pesticides. According to the BTO (British Trust for Ornithology) report on the effects of climate change on migratory species, some effects of climate change can be predicted based on previous findings on the abundance, distribution and habitat preferences of bats. These include loss of roosting sites along migration routes, decimation of breeding habitats and changes in food supply (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 mortality will have an increased negative impact on bats. Temporal offset in the development of bat broods and their food can have particular consequences for the breeding success of bats. In addition, high structures such as buildings, bridges or wind turbines may pose a threat to bats due to barrier effects and possible collisions (e.g. AHLEN, 2002).

2.12 Biodiversity

Biological diversity (or biodiversity for short) comprises the diversity of habitats and biotic communities, the diversity of species and the genetic diversity within species (Art. 2 Convention on Biological Diversity 1992). Biodiversity is the focus of public attention. Species diversity is the result of over 3.5 billion years of evolution, a dynamic process of extinction and speciation. Of the approximately 1.7 million species that have been described by science to date, about 250,000 occur in the sea, and although considerably more species have been described on land to date, the sea is more comprehensive and phylogenetically more highly developed than the land in terms of its phylogenetic biodiversity. Of the 33 known animal phyla, 32 are found in the sea, 15 of which are exclusively marine (VON WESTERNHAGEN & Dethlefsen, 2003). Recent projections by MORA et al. (2011) show that there are about 8.7 million species worldwide, with 2.2 million of them occurring in the sea.

Marine diversity eludes direct observation and is therefore difficult to estimate. Aids such as nets, fish traps, snares, traps or optical registration methods must always be used for their estimation. However, the use of such devices can only ever provide a section of the actual species spectrum, precisely that which is specific to the fishing gear in question. It can be deduced from this that in areas that cannot be reached with the available gear (e.g. the deep sea), there must still be a large number of species that are not even known yet. The situation in the Baltic Sea is different because, as a relatively shallow inland sea, it is more easily accessible, so that intensive marine research took place as early as the mid-19th century, leading to an increase in knowledge about its fauna and flora. Over 800 phytoplankton taxa have been recorded in the Baltic Sea as part of HELCOM monitoring (WASMUND et al., 2016a). About 61 zooplankton taxa were recorded (WASMUND et al., 2016a). Of the macrozoobenthos, more than 700 species are known in the Bay of Kiel alone (GERLACH, 2000). According to WINKLER et al. (2000), the fish fauna of the Baltic Sea currently consists of 176 fish and lamprey species. 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 assemblages in all systematic and trophic levels of the Baltic Sea. The changes in biodiversity 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 control and warning function in this context, as they show the state of the populations of species and biotopes in a region. Based on the Red Lists, it can be seen that more than 17% of the macrozoobenthos species (GOSSELCK et al., 1996) and around 16.9% of the cyclostomes and marine fishes permanently present in the Baltic Sea (THIEL et al., 2013) are endangered. The marine mammals form a species group in which all representatives are currently endangered (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, according to the Birds Directive, all wild native bird species are to be conserved and thus protected.

2.13 Air

Shipping traffic causes emissions of nitrogen oxides, sulphur dioxides, carbon dioxide and soot particles. These can have a negative impact on air quality and are largely discharged into the sea as atmospheric deposition. Since the Baltic Sea has been one of the emission control areas according to Annex VI of the MARPOL Convention, the so-called "Sulphur Emission Control Area" (SECA), since 2006, stricter regulations for emissions from shipping apply there. Since 1 January 2015, ships there are only allowed to use heavy fuel oil with a maximum sulphur content of 0.10%. According to HELCOM, this led to an 88% reduction in sulphur emissions compared to 2014. Worldwide, the limit is currently still 3.50%. According to a resolution of the International Maritime Organization (IMO) in 2016, this limit 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 emissions 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 inputs to the Baltic Sea region through the North Sea and Baltic Sea ECA measure is estimated at 22,000 t in total (European Monitoring and Evaluation Programme (EMEP, 2016)).

2.14 Climate

The German Baltic Sea lies in the temperate climate zone. As an inland sea, it is isolated from the influence of the Gulf Stream. It does not develop its own maritime climate because it is quite small and the salinity of the Baltic Sea water is also relatively low. Therefore, parts of it freeze over every winter, sometimes even completely. There is widespread 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 signs of this are already being felt. According to the latest report of the Intergovernmental Panel on Climate Change (IPCC, 2019) large-scale impacts of climate change on the oceans are expected to include in particular an increase in sea surface temperature, further acidification, and a decline in oxygen levels. Sea levels continue to rise at an increasing rate. Many marine ecosystems react sensitively to climate change. Global warming is also expected to have a significant impact on the Baltic Sea.

2.15 Landscape

The marine landscape above water

The marine landscape visible today above the water column is characterised by a large-scale open space structure and is largely unaffected by disturbances. So far, there are only a few elevated structures in the German EEZ of the Baltic Sea. These are the offshore wind farm "Baltic 2", located approx. 33 km northwest of Rügen, and the wind farm "Wikinger", the latter approx. 34 km northeast of Rügen. Additional high-rise structures are two measurement masts for measurement and research purposes: the Arkona Basin measurement mast, approx. 35 km north-east of Rügen, and the research platform "FINO 2" in the Kriegers Flak area, approx. 39 km north-west of Rügen. However, these are not visible from land due to the large distances involved. The construction of further wind farms will further change the landscape in the future. The required lighting can also lead to visual impairments of the landscape. The extent to which the landscape is affected by vertical structures is strongly dependent on the visibility conditions in each case. The space in which a structure is visible in the landscape is the visual impact area. It is defined by the visual relationship between the structure and its surroundings, whereby the intensity of an effect decreases with increasing distance (GASSNER et al., 2005). For met 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 low. At such a distance, the platforms and wind farms will hardly be perceptible even in good visibility conditions. This also applies with regard to night-time security lighting.

2.16 Cultural and other material assets (underwater cultural heritage)

2.16.1 Recording of the protected property and data situation on the underwater cultural heritage in the EEZ

Known underwater cultural heritage in the coastal sea and to some extent in the EEZ is recorded in the registers of sites and monuments of the northern 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 only responsible for state waters. Therefore, a systematic processing of information on the underwater cultural heritage in the EEZ has largely been omitted. The quality of the data also varies, for example from identified historical wrecks to site-specific information from records, and may need to be improved for a concrete planning statement. The registers of sites and monuments therefore reflect the respective state of knowledge, but not the real stock of underwater cultural heritage.

An active survey of underwater obstacles - and thus also shipwrecks - in the North German coastal sea is only carried out by the Federal Maritime and Hydrographic Agency (BSH). However, this wreck search does not focus on underwater cultural heritage, but serves to locate and assess obstacles to navigation and therefore concentrates on objects rising from the seabed that could pose a threat to maritime navigation or fisheries. Although the BSH's findings are regularly incorporated into the coastal states' registers of sites and monuments, underwater cultural heritage that is covered by sediment or barely visible on the seabed is not normally recorded in the wreck search.

An impression of the actual density of soil monuments in the coastal sea is provided by maritime construction projects such as submarine cable connections or pipelines, in the course of which a large number of previously unknown soil monuments regularly come to light during preliminary investigations.

The risk of unexpected discovery of soil monuments in the course of a construction project can only be minimised by a qualified inventory as part of the environmental impact assessment.

2.16.2 Potential for prehistoric settlement traces in the German EEZ

Areas of the German EEZ in the Baltic Sea were also land-locked regions in the early Holocene that were settled by humans between about 10,000 and 6,000 years ago (Schmölcke et al,. 2006; Behre, 2003). In water depths of up to 20 m, preserved palaeolandscape remains in the form of peat and tree remains have been detected so far (Tauber 2014). Archaeological cultural heritage in the form of settlement sites has been explored in water depths of up to 10 m (Hartz et al., 2014). Consequently, preserved prehistoric settlement traces in palaeolandscapes can be expected in the German EEZ with water depths between 10 m and 40 m and only in exceptional cases of up to 50 m depth in the Baltic Sea. Landscape reconstructions can be used to identify special potential areas for archaeological sites. By evaluating erosion zones, areas with no longer preserved traces of occupation can be highlighted.

Due to the overformation of the Baltic Sea basin by the glacier during the Vistula Glacial, sites from the Old Stone Age (Palaeolithic) and older phases of human history have not been preserved in this region.

However, the landscape in the south-western Baltic Sea region that became free with the melting of the glaciers 10,000 years ago was immediately settled by people of the Mesolithic period. Subsistence was ensured by hunting, fishing and gathering plant food. The Stone Age inhabitants of this landscape have left traces at their living and hunting places. These include, for example, fireplaces, pits, simple buildings, tools and their manufacturing waste, hunting weapons, food remains, watercraft, religious deposits, jewellery and signs of artistic activity. Due to the favourable conditions for locomotion and transport along the coast and the diverse marine food resources, a particular focus of settlement was in the respective coastal zones. But wetlands with lakes, rivers and bogs also offered rich food resources. Therefore, the reconstruction of the landscape at that time is essential for understanding the way of life and at the same time the key to finding settlement sites, as certain topographical locations were used preferentially.

The depositional and preservation conditions of settlement waste in the moist to wet shore area also characterises the respective sediments and cultural layers and makes them meaningful archaeological sources. Due to the rise in sea level since the end of the last ice age, these sites and their landscape context have sunk. As a result, the traces of settlement lie at the bottom of the Baltic Sea, mostly covered by younger sediments.

In the course of the SINCOS research project from 2002 to 2009, diving excavations in water depths of up to 10 m at nearshore sites in Schleswig-Holstein and Mecklenburg-Vorpommern provided important insights into the settlement history and regional development of economic practices (Hartz et al., 2014). Furthermore, sidescan sonar cruises detected palaeolandscapes with the potential of older sites in areas further offshore (Tauber et al. 2014) and sampling of tree remains down to a water depth of approx. 20 m enabled dating of former landmarks (Westphal et al. 2014).

Peat layers on the seabed are an important indicator for preserved remnants of palaeolandscapes, as they represent flooded landscape parts formerly influenced by freshwater. Moreover, they are palaeoecological archives that can be used to reconstruct vegetation and landscape development as well as their human use and anthropogenic influence (Anton et al., 2019, 35f).

2.16.3 Wrecks of watercraft and wreckage

This genre of underwater cultural heritage includes not only the wrecks of watercraft but also wreck parts and associated equipment, cargoes and inventories. The majority of known wreck sites are boats and ships of various ages. The spectrum ranges from Stone Age dugouts to wooden trading vessels of the Middle Ages and warships from the World Wars.

In the Baltic Sea, marine navigation is documented from the Iron Age onwards with the Hjortspring boat (350 BC) and the Nydam boat (320 AD) from Denmark. Earlier references to watercraft can be found on Bronze Age rock carvings depicting boats from Sweden. From the Wendel period, for example, a boat burial (7th/8th century AD) is documented in Salme, Estonia. Ship finds from the Viking Age (8th-11th century AD), such as those from Haddeby 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 the Viking Age, navigational skills were already so advanced that sea voyages could take place for long distances from the coast and often without land visibility, as evidenced by a contemporary seafarer's account of Wulfstan's voyage from Haithabu to Truso (cf. Englert & Trakadas, 2009).

One of the few examples of prehistoric sites further offshore is the recovery of vessels dating to the Iron Age by fishermen in 1927 and 1931 from a depth of around -25 m in the Fehmarn Belt. This position was verified with side-view sonar and sediment echo sounder records, which revealed anomalies in the form of slight elevations (Tauber, 2018). It can be assumed that this anomaly is a wreck of a ship on which the pottery was transported.

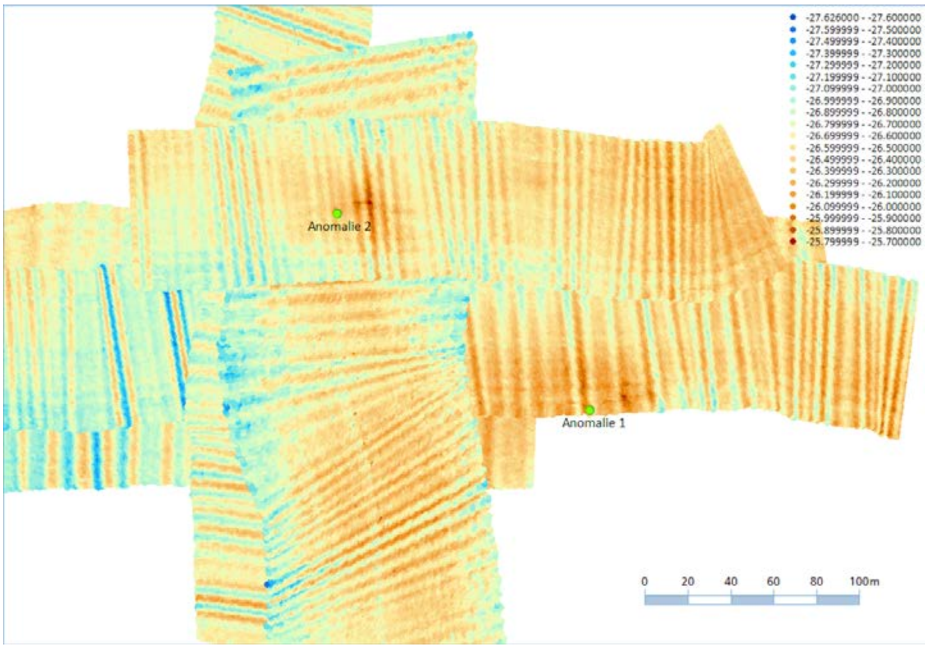

Figure 53: Iron Age anomalies in the Fehmarn Belt: seabed relief calculated from multibeam echo sounding. The stripes across the direction of travel are caused by strong swells. The highest points (reddish brown) are located near the anomaly points (Tauber, 2018).

.

From the Middle Ages onwards, the sea routes of the long-distance traders ran across the open sea, as the 12th chapter of the Hanseatic Sea Book in the "House Sea" of the Hanseatic League shows. Although ship finds from this period have so far tended to be found in the immediate coastal area and in silted-up former harbour areas, more and more new finds are being made in the open sea. Examples from the Baltic Sea include the wreck of an almost completely preserved Dutch fleute from around 1650 discovered a few years ago at a depth of 130 m (Erikson & Rönnby, 2012) or the "Mars", a Swedish warship from 1561, discovered in 2011 at a depth of 75 m.

Shipping in the North and Baltic Seas of the 16th-18th centuries is characterised above all by the strengthening 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 "Princessan Hedvig Sophia", which sank in 1715, the frigate "Mynden", which sank off Rügen in 1718, and the Danish Orlog ship "Lindormen" of 1644 (Auer, 2004; Auer, 2010; Segschneider, 2014).

In the course of the 18th and 19th centuries, enormous increases in the volume of trade across the North and Baltic Seas can be recorded. Examples of this are coal exports from the British Isles and timber exports from the Baltic. These goods were transported on wooden sailing ships and later on iron steamships. The brisk 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 and iron or steel shipbuilding from the mid-19th century onwards, the knowledge gained from written and pictorial sources predominates. Because they are often better preserved, wrecks from the 19th and 20th centuries are currently far more present in the archaeological record than wooden wrecks (Oppelt, 2019). In the longer term, however, this is likely to change due to the progressive corrosion of steel wrecks.

Due to their historical significance and the partial lack of written sources on certain military and war-related aspects, wrecks from the two World Wars up to and including 1945 are listed as archaeological cultural monuments. They also have an important function as places of remembrance (Ickerodt, 2014). Particularly in the course of the First World War, naval battles also resulted in the loss of several vehicles in a limited space. For example, three small cruisers and one torpedo boat sank during a naval battle between the Imperial German and British navies west of Helgoland in August 1914, the wrecks of which are all located in the German EEZ (Huber & Witt, 2018).

Equipment or parts of cargo can provide evidence of maritime activities in the past. Among the most common objects are anchors that, for various reasons, could not be recovered after an anchoring manoeuvre and remained on the seabed.

So-called ballast piles, accumulations of stone ballast on the bottom, were formed, for example, when ships were loaded off a natural harbour, but can also be an indication of the lightering of a ship that has run aground. However, it is not uncommon for ballast material to conceal a shipwreck.

2.16.4 Aircraft wrecks and rockets

Most of the known findings of aircraft wrecks in the North Sea and Baltic Sea are related to the Second World War. 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 ditchings can result in relatively well-preserved aircraft wrecks, crash sites are often characterised by extensive fields of debris on the bottom of the water. In addition to providing insights into technical aspects of construction and deployment, the aircraft wrecks of World War II also bear eloquent witness to the events of the war.

Another aspect is the possible presence of human remains. Wrecks from the last two wars in particular are often not only ground 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-Vorpommern, among other places, where glide bombs and rockets were developed and tested in Peenemünde from 1936 to 1938. The munition-free elements of these constructions offer detailed insights into the development of rocket technology and, like the aforementioned aircraft wrecks, constitute ground monuments.

2.16.5 Potential for wrecks in the German EEZ

Although prehistoric and early historic wrecks were mostly discovered in coastal waters or come from burial sites, under favourable conditions they could also be present in the German EEZ. At the latest, medieval shipwrecks are known from the high Baltic Sea from depths of more than -50 metres. There, the wooden wrecks are particularly well preserved thanks to the low temperatures and the low infestation by wood-decomposing organisms.

In general, wooden ships or their remains may have survived undiscovered under sediment layers. Even in the case of wreckage that is barely visible above ground, considerable remains of a ship's hull together with the ship's inventory may lie hidden under the sediment. Cargo residues and parts of the equipment or armament are thus in a closed find context and allow unique insights into the past like "time capsules".

2.16.6 Assessment of the state of the cultural heritage and other material assets

Central factors for the definition of an archaeological monument (ground monument or monument under water) are its cultural-historical significance (monument eligibility) and the public interest in its exploration and preservation (monument worthiness).

The assessment of the significance of the protected property or its monument value is carried out according to the following criteria (see also the monument protection laws of the federal states; see also Ickerodt 2014):

- Historical testimonial value
- Scientific or technical value, research value
- Social significance (place of remembrance, e.g. sepulchre)
- Rarity value
- Integrity (degree of preservation, condition, threat)

The testimonial value varies depending on the preservation and type of site. For example, the historical testimonial value of underwater sites is generally very high due to the very good preservation conditions for organic materials. In the land area, Middle Stone Age sites are mostly limited to scattered flint objects. Only through the preservation of bones, antlers, wood and other plant remains in boggy and submerged sites can the way of life, the settlement structure or the social organisation of the people of that time be researched further. The same applies to finds of organic materials from well-preserved shipwrecks, which may belong to personal equipment, cargo or armament, for example. Well-preserved wrecks with preserved inventory and construction elements have a high testimonial value.

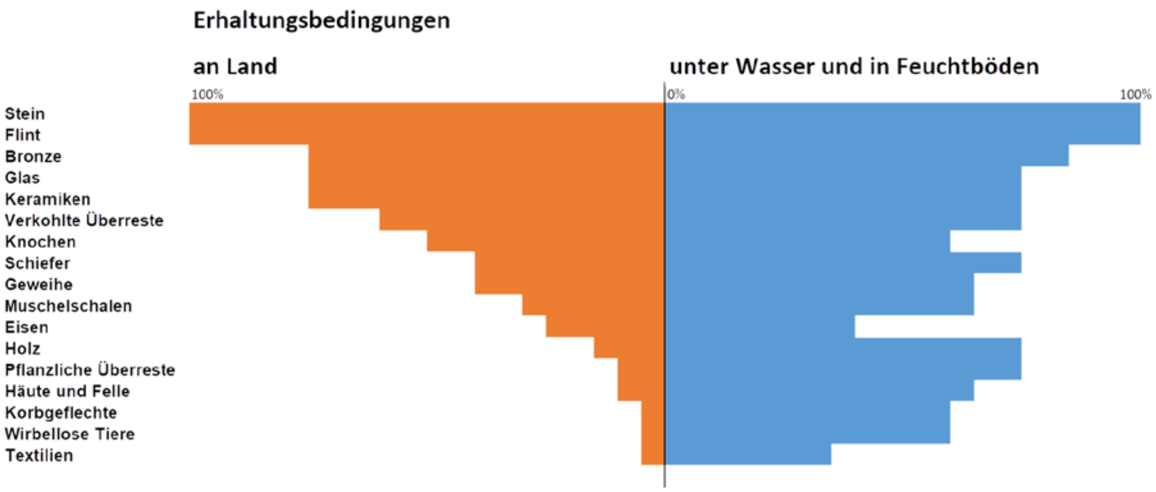

Figure 54: Comparison of the preservation conditions of archaeological finds on land and under water (after Coles, 1988) .

The technical value can be seen in the example of watercraft. 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 combat platforms, but also had to meet high standards of seaworthiness, manoeuvrability and speed, and also had a representative function. Therefore, the scientific, technical and testimonial value of shipwrecks with well-preserved construction elements is high.

Since the loss of a vehicle with cargo and inventory captures a specific moment in the past, wrecks are often referred to as "time capsules". If properly preserved, an analysis of the wreck find offers detailed insights into everyday life on board. In addition to technological progress, it is therefore often possible to draw conclusions from ship finds about political, economic and landscape-typical factors as well as the social structure of a society. This illustrates the extraordinary research value of underwater sites and also their special integrity compared to sites on land.

The social commemorative value is considered to be particularly high in the case of the shipwrecks and aircraft wrecks of the First and Second World Wars.

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 with good preservation. Modern wreck finds can also have a high rarity value if they are distinguished by special technical features or construction characteristics.

The integrity or state of preservation of an underwater site must be determined and assessed individually. Both the conditions of deposition during the genesis of a site or the sinking and emplacement of a wreck as well as later destruction, for example by abiotic factors such as erosion by currents or decomposition by organisms, influence the completeness and preservation of a site or parts of a site. As already mentioned, the preservation conditions for organic materials under oxygen exclusion in the underwater environment are particularly outstanding. While exposed wrecks are subject to erosion and may be damaged by various uses on the seabed, fully covered sites offer excellent preservation conditions.

So far, there is little further information available on archaeological monuments, such as settlement remains, in the EEZ. Nevertheless, the existence of numerous important relics of climate, landscape and cultural history can be assumed. With systematic monitoring of construction work and other earth interventions, it can be assumed that the number of prehistoric settlement traces in the EEZ and thus the source material on the history of the development of the North Sea and Baltic Sea will increase significantly.

2.17 Human beings as a protected resource, including human health

Overall, the area defined in the MSP has a low significance for the human resource. In a broader sense, the marine area represents the working environment for people employed on ships. Exact numbers of people regularly in the area are not available. The significance as a working environment can be regarded as low. Direct use for recreation and leisure occasionally takes place by recreational boats and tourist watercraft. The existing impacts can be described as low. No special significance of the planning area for human health and well-being can be derived.

2.18 Interactions between the protected goods

The components of the marine ecosystem, from bacteria and plankton to marine mammals and birds, influence each other through complex processes. The biological assets plankton, benthos, fish, marine mammals and birds described individually in Chapter 2 are interdependent within the marine food chains.

Phytoplankton serves as a food source for organisms that specialise in filtering the water for food. The most important primary consumers of phytoplankton include zooplanktic organisms such as copepods and water fleas. Zooplankton has a central role in the marine ecosystem as a primary consumer of phytoplankton on the one hand and as the lowest secondary producer within marine food chains on the other. Zooplankton serve as food for the secondary consumers of the marine food chains, from carnivorous zooplankton species to benthos, fish to marine mammals and seabirds. Among the top components of marine food chains are the so-called predators. Upper predators within marine food chains include aquatic birds, seabirds and marine mammals. In 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. A depletion of the producer results in the decline of the consumer. Consumers in turn control the growth of producers by eating away at them. Food limitation affects the individual level by impairing the condition of the individual. At the population level, food limitation leads to changes in the abundance and distribution of species. Food competition within a species or between different species has similar effects.

The timed succession or sequencing of growth between the different components of marine food chains is critical. 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, energetic value). Temporally or spatially offset occurrence of succession and abundance of species from different trophic levels leads to disruption of food chains. Temporal offset, the so-called trophic "mismatch", causes early developmental stages of organisms in particular to become undernourished or even starve to death. Disruptions in marine food chains can affect not only individuals but also 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 had a positive effect on the development of sprat stocks. However, the extraordinary increase in sprat was limited by the available food resources (zooplankton). Thus, the abundant sprats ultimately remained undernourished and thus had a low energy content. The poor nutritional status of the sprats was reflected in the nutritional status of their consumers, the guillemot juveniles. The growth and survival of juvenile guillemots temporarily decreased due to the reduced food quality (ÖSTERBLOM et al., 2008).

Trophic relationships and interactions between plankton, benthos, fish, marine mammals and seabirds are controlled by multiple control mechanisms. Such mechanisms operate from the bottom of food chains, starting with nutrient, oxygen or light availability, upwards to upper predators. Such a bottom-up control mechanism may act by increasing or decreasing primary production. Effects emanating from the upper predators downwards, via so-called "top-down" mechanisms, can also control food availability.

The interactions within the components of marine food chains are influenced by abiotic and biotic factors. For example, dynamic hydrographic structures, water stratification and currents play a crucial role in food availability (increasing primary production) and utilisation by upper predators. Exceptional events, such as storms and ice winters, also influence trophic relationships within marine food chains. Biotic factors, such as toxic algal blooms, parasite infestations 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 chains. Overexploitation of fish stocks, for example, confronts upper predators, seabirds and marine mammals with food limitations or forces them to seek new food resources.

Furthermore, shipping and mariculture are an additional factor that can lead to positive or negative changes in marine food chains through the introduction of non-indigenous species. Discharges of nutrients and pollutants via rivers and the atmosphere also influence 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 plankton, can influence the entire food chain and shift and possibly endanger the balance of the marine ecosystem. Examples of the very complex interactions and control mechanisms within the marine food chains were presented in detail in the description of the individual protected goods.

The complex interactions between the various components ultimately result in changes in the entire marine ecosystem of the Baltic Sea, as already shown in the example of the trophic interactions between common guillemot, cod, sprat and zooplankton. On the basis of the changes already described in Chapter 2 in relation to the protected goods, it can be summarised for the marine ecosystem of the Baltic Sea:

- There are slow changes in the living marine environment.
- Since 1987/88, rapid changes in the living marine environment have been observed.

The following aspects or changes can influence the interactions between the different components of the living marine environment: Change in species composition (phyto- and zooplankton, benthos, fish), introduction and partial establishment of non-indigenous species (phyto- and zooplankton, benthos, fish), change in abundance and dominance ratios (phyto- and zooplankton), change in available biomass (phytoplankton), decline of many area-typical species (plankton, benthos, fish), decline in the food base for upper predators (seabirds).

3 Expected development in the event of non-implementation of the plans

According to Annex 1 No. 2b) to sec. 8 ROG, a forecast of the development of the state of the environment must be included in the environmental report even if the planning is not carried out.

3.1 Shipping

Alongside fishing, shipping is one of the traditional uses of the sea. Several shipping routes run through the territorial 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 Sea and Baltic Sea.

Prior to the adoption of the maritime spatial plans in 2009 and the associated designation of priority and reservation areas for shipping, only traffic separation zones (VTGs) had been established in the North Sea by the International Maritime Organisation (IMO) to ensure ship safety and minimise collision hazards.

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 obstacle-free shipping routes and thus the added value of the designations in the marine spatial planning became clear.

The legal situation of shipping is strongly influenced by international regulations. Particular mention should be made here of the Act on the United Nations Convention on the Law of the Sea of 10 December 1982 (Convention on the Law of the Sea Treaty Act), in which freedom of navigation is guaranteed under Article 58. In addition, internationally applicable rules and standards are laid down by the IMO. For spatial planning, the definition of traffic separation zones is of particular importance here. At potential danger points, they stipulate binding routing in one-way traffic with separate lanes.

The Act on the Tasks of the Federation 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 traffic and for the prevention of 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 Protocol of 1978 (MARPOL 73/78), which includes regulations on the discharge of sewage and ship-generated waste, and on the phased reduction of air pollutant emissions.

As the North Sea and the Baltic Sea are SOx emission control areas (SECA), the limit values for sulphur emissions are particularly low here. From 2021, the North Sea and the Baltic Sea will also become NOx emission control areas (NECAs).

The International Convention for the Control and Management of Ships' Ballast Water and Sediments is an international agreement adopted in 2004 within the framework of the International Maritime Organization. The aim of the Convention is to mitigate the damage caused by ballast water to the marine environment, in particular to prevent the introduction of non-indigenous 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 (Discharge Criteria) are set for total nitrogen and total phosphorus for passenger ships.

The HELCOM Baltic Sea Action Plan, adopted by all coastal states and the EU in 2007, contains measures to restore the good ecological status of the marine environment in the Baltic Sea. For shipping, it includes enforcement of international regulations, especially on illegal discharges, ensuring safe shipping to prevent accidental pollution, measures to prevent the introduction of non-indigenous species, and measures to minimise waste and air pollution from ships.

The average traffic density resulting from the analysis of AIS data shows an increasing demand for space, not least driven by construction, maintenance and supply trips for the growing offshore wind industry, the increasing number of cruise ships and a higher demand for anchor and roadstead space.

In its 2030 maritime transport forecast, the Federal Ministry of Transport and Digital Infrastructure (BMVI) published the forecast development of the handling volume of German seaports (BMVI, 2014). For the period 2010 to 2030, an increase in the transhipment volume from 438 million tonnes to 712 million tonnes is forecast. This involves transshipments from German and foreign ports and their hinterland traffic that use German transport infrastructure. The main drivers for the forecast increase in transhipment volume 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 uncertainties 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 cleaning systems or alternative fuels are used to comply with the emission limits for NOx and SOx. The IMO strategy to reduce CO2 emissions, adopted in April 2018, will also require alternative fuels and increased energy efficiency (DNV GL, 2019).

Shipping has various impacts on the marine environment. These include illegal oil disposal at sea, propulsion-related emissions, waste disposal, noise emissions, the consequences of shipwrecks, inputs of toxic substances such as TBT, and the introduction of exotic species. The impacts can be of a supraregional, temporary or permanent nature. These can be summarised as follows:

- supra-regional, temporary impact due to oil input, emissions and input of toxic substances;
- transregional, permanent effect due to the introduction of exotic species.

The following table provides an overview of the impacts caused by shipping and their potential effects on the protected goods. The impacts are predominantly classified as existing impacts (Chapter 2) and as impacts that will occur even if the plan is not implemented.

Table 18: Effects and potential effects of shipping (t=temporary).

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
Ship-ping	Underwater sound	Impairment / scare effect		x			x												
	Emissions and discharges of hazardous substances (acci-dents)	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 in-vasive species	Change in species com-position	x	x	x				x		x								
	Bringing in rubbish	Impairment/ Damage	x	x	x		x		x					x			x		
	Collision risk	Collision			x	x	x												
	Visual restlessness	Impairment/ scare effect		x	x														

3.1.1 Floor

Shipping emits pollutants that contribute to water and sediment pollution.

The discharge of oil contaminates water and sediment to varying degrees with pollutants, some of which are highly toxic. Depending on the amount, type and composition, oil slicks or car-pets can form, which can spread over a wide area and sink to the seabed under appropriate weather conditions.

The above impacts occur regardless of whether or not the Plan is implemented.

3.1.2 Water

Shipping emits pollutants that contribute to water and sediment pollution.

The discharge of oil contaminates water and sediment to varying degrees with pollutants, some of which are highly toxic. Depending on the amount, type and composition, oil slicks or car-pets can form, which can spread over a wide area and sink to the seabed under appropriate weather conditions.

The above impacts occur regardless of whether or not the Plan is implemented.

3.1.3 Benthos and biotope types

The following remarks are limited to the impacts of the uses on benthic communities. Since bio-topes are the habitats of a regularly recurring community of species, impairments of biotopes have a direct impact on the biotic communities. Impacts of shipping on the benthos occur due to the following factors:

<u>Oil input.</u> Even the smallest oil spills pose a threat to living organisms. The effects of chronic oil pollution on birds are well documented. In

contrast, there are only a 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 EEZ are not known, although oil can drift below the water surface and sink to the bottom.

Input of toxic substances. Since the beginning of the 1970s, effects of TBT on aquatic organisms, which should not actually be affected by the biocidal effect of the chemical, have become known primarily in coastal waters. TBT was shown to be endocrine disrupting, i.e. it interferes with the hormone system of organisms. TBT is capable of inducing a pathomorphosis called imposex not only in mussels but also in separately sexed anterior gastropods. Imposex describes a masculinisation of female animals in snail populations. In the female whelk (*Buccinum undatum*), an additional formation of male sex organs occurs. Proliferating male genitalia lead to sterilisation and often death of the affected females in the final stage of imposex development in most species (WATERMANN et al., 2003). Ultimately, entire populations can become extinct (WEIGEL, 2003).

This ultimately led to a far-reaching international ban on organotin antifouling agents in 2008.

Physical disturbances during anchoring

When ships are anchored, there is a local and temporary disturbance of the seabed and thus a small-scale impairment of benthic communities.

Introduction of non-native species. Since 1970, an increasing tendency of first findings of non-indigenous species can be observed. In addition to aquaculture, which in part deliberately uses alien species, ship traffic via ballast water, the sediments of ballast tanks and the outer walls of ships has contributed to this (GOLLASCH, 2003). The spectrum of introduced species ranges from macroalgae to invertebrates. If the alien species find optimal living conditions, mass reproduction can occur, which in turn can cause high ecological and economic damage. However, none of the newly introduced species has led to drastic negative impacts in recent years. The species that cause 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 became firmly established, or various phytoplankton species, have been native to our region 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 vessels. The current ballast water exchange is only possible under certain conditions and is only possible in the North Sea. With biofouling, species are released, but these are sessile species that require suitable environmental conditions (hard substrates) to settle and establish when released.

The introduction of alien species through the fouling of ships, including smaller recreational boats, is also increasingly coming into focus.

In summary, the main impacts of shipping on the marine benthos are as follows:

- Supraregional, temporary impact due to oil input, emissions and input of toxic substances, anchorages
- supra-regional, permanent effect due to the introduction of non-native species.

The above-mentioned impacts on benthic communities and biotope types occur 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 discharge of hazardous substances, the introduction of waste, and the introduction and spread of invasive species.

Most ships, especially the larger ones, 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 produced by ships could have an impact on fish fauna. The hearing ability of fish varies greatly. Some species, such as herring, 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. This means that herring are probably more sensitive to underwater sound than fish species without a swim bladder, such as flatfish or sand eels. Hearing allows fish, for example, 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). The continuous underwater sound could mask communication, especially during spawning (DE JONG et al., 2020). Some fish species, such as herring or cod, also showed typical avoidance responses to ship traffic, such as change in swimming direction, increased diving or horizontal movements (MITSON, 1995; SIMMONDS & MACLENNAN, 2005). In general, fish responses to direct and indirect impacts of shipping are not consistent (POPPER AND HASTINGS, 2009) and can vary species-specifically. Even the response of a single species to vessel noise may change depending on its life stage (DE ROBERTIS & HANDEGARD, 2013). There is evidence in the literature of possible behavioural changes due to ship noise, but the results are not robust to draw conclusions about significance. Scientific reviews of the existing literature on possible effects of ship noise on fish clearly point to the lack of comparability, transferability and reproducibility of results (POPPER & HAWKINS, 2019). Furthermore, long-term studies on the effects of continuous noise emissions on fish in their natural habitat are needed to draw conclusions at the population level (WEILGART, 2018; DE JONG et al., 2020).

In addition to acoustic stimuli, the input of pollutants as an effect of shipping traffic should be mentioned in particular. Shipping can have a major impact on the marine environment as a result of accidents and the potential leakage of pollutants, especially **heavy fuel oil.** Several factors, such as the type, condition and quantity of oil, determine the degree of impact (VAN BERNEM, 2003).

It is possible that species with a pelagic lifestyle are able to avoid oil-polluted areas, as has been observed in laboratory studies on salmon (VAN BERNEM, 2003). Bottom-dwelling fish species can be harmed by prolonged contact with oily sediments. Possible consequences are the uptake of hydrocarbons from the sediment, the occurrence of certain diseases (including fin rot) and the decline of stocks. Scientific findings from the natural habitat that could be used for a significance assessment are not known.

Fish eggs and juveniles are generally more vulnerable than adults because sensory abilities 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 first detections of alien species has been observed. Shipping traffic via ballast water and the outer walls 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 alien 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 mainly on benthic invertebrates (see BMU, 2018). Fish could be spread mainly through the transport of eggs and larvae in ballast water (LLUR, 2014). Originating from the

Black Sea, the blackmouth goby has spread westwards in the Baltic Sea since 1990 from the Gdansk Bay (SAPOTA & SKORA, 2005) and into Estonian and Latvian coastal waters (Ojaveer, 2006). In Germany, the first record dates back to 1998 (WINKLER, 2006). It is assumed that ground eggs or larvae entered the Baltic Sea via the ballast water of ships (SAPOTA, 2004). In the meantime, the up to 20 cm long goby has established itself in the food web as far as birds (KARLSON et al., 2007; ALMQVIST et al., 2010). Competitive situations with native species may arise due to aggressive territorial behaviour, limited spawning sites or available food resources (LLUR 2014). However, serious competition with other small fish, such as sticklebacks, has not yet been proven on the German Baltic Sea coast (LLUR, 2014).

Marine pollution is a global threat to the marine ecosystem and can also have negative impacts in the Baltic Sea. At 68%, plastic is the dominant category of litter on the seabed of the Baltic Sea (THÜNEN, 2020). Shipping also contributes a part 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 Thünen Institute for Fisheries Ecology is working on the PlasM project, which is expected to run until 2021, on the risk posed by plastic in the marine environment.

The above-mentioned impacts of navigation on fish fauna occur independently of the non-implementation or implementation of the plan.

3.1.5 Marine mammals

Impacts of shipping on marine mammals can be caused by, among other things: Noise emissions, pollution during normal operation or in the event of accidents involving ships. During normal operation, shipping poses a potential threat to marine mammals. The impacts are of low, medium or even high intensity depending on the area. Impacts are also site-specific and temporary or recurrent, e.g. along busy shipping routes.

Direct disturbance of marine mammals by sound emissions is expected to be more frequent, especially along busy traffic separation areas, e.g. in the Fehmarn Belt and the Kadet Trench. Unlike other cetacean species, harbour porpoises are not known to be attracted by ships. In general, harbour porpoises are rather shy. Collisions with ships are also not known for harbour porpoises and seals.

In recent years, numerous studies have been conducted to investigate impacts due to ship noise. The measurement, modelling and characterisation of sound emitted by ships in marine areas with different abiotic environmental parameters has produced valuable findings (ARVESON & VENDITIS, 2000; WALES ET AL., 2002; HATCH ET AL, 2008; DEROBERTIS ET AL, 2013; MCKENNA ET AL, 2013; MERCHANT ET AL, 2014; WITTEKIND, 2014; RUDD ET AL, 2015; GARRETT ET AL, 2016; GASSMANN ET AL, 2017; HERMANNSEN ET AL, 2014; HERMANNSEN ET AL, 2017; KINDA ET AL, 2017). In a recent study, the strongly pronounced differences of up to 30 dB broadband levels for ships of the same class and under comparable operating conditions, were analysed in the context of the now numerous published results. It was found that parameters such as speed over the seabed, width of the vessel and class, as well as the distance of the measuring hydrophone from the vessel and the surface reflection have a great influence on the results. Although it is assumed in the studies that a reduction in sound input can be accompanied by a reduction in speed, it became clear that standardisation in measurement and evaluation is necessary in order to be able to draw correct conclusions in the context of environmental assessments (CHION ET AL., 2019).

Standardisation of the measurement of sound emitted by ships in deep waters took place in 2017 (ISO 17208-:2016, ISO 17208-2:2019).

A majority of international studies also focused on the effects of sound emitted by ships on marine mammals (whales, seals) or on fish and invertebrate species (COSENS ET AL., 1993; ERBE 2000, 2003; KRAUS ET LA., 2005; CLARK ET AL., 2009; GÖTZ ET AL., 2009; HUNTIGTON, 2009; CASTELLOTE ET AL., 2012; HATCH ET AL, 2012; ERBE ET AL, 2012; ROLAND ET AL, 2012; ANDERWALT ET AL, 2013; WILLIAMS ET AL, 2014; BLUNDELL ET AL 2015; DYNDO ET AL 2015; FINNERAN, 2015; CULLOCH ET AL., 2016; ELLISSON ET AL., 2016; PINE ET AL., 2016; CHEN ET AL., 2017; HALLIDAY ET AL., 2017; FRANKEL & GABRIELE, 2017; WISNIEWSKA ET AL., 2018; MIKKELSEN ET AL., 2019).

Many of these studies assume that interference can occur through masking of communication, especially in bearded whales, which echo and communicate in the low frequency range, overlapping with ship sounds. Evidence is found in numerous studies, but their results are often not comparable with each other, transferable and reproducible (Erbe et al., 2019). The potential effects of disturbance from ship noise are also difficult to quantify and differentiate from other sources of disturbance. Furthermore, marine mammals have evolved adaptive mechanisms to maintain communication in noisy environments. 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 ensure communication between conspecifics by changing the volume, vocalisation rate and frequency even in noisy environments and has been demonstrated in various animal groups. Cetaceans, such as the harbour porpoise, are also able to increase the volume and frequency of vocalisation as well as change the frequency spectrum. This adaptation is a survival strategy to effectively and efficiently forage for food, escape predators, maintain mother-calf contact, but also seek out conspecifics (Erbe et al., 2019).

The assessment of the impact of underwater sound, including sound emitted by ships, is the subject of several studies (AZZELLINO ET AL, 2012, SOUTHALL ET AL, 2009, DEKELING ET AL, 2014, GOMEZ ET AL, 2016, SOUTHALL ET AL, 2019). In the North Sea, further knowledge was gained from 2016 to 2020 as part of the EU research project JOMOPANS (Joint Monitoring and Assessment Programme for the North Sea), taking into account the results from the EU project BIAS (Baltic Sea acoustic Soundscape). The regular assessments of OSPAR and HELCOM also use the current findings. Finally, within the framework of the implementation of the MSFD, the TG-Noise expert group of the EU Commission is concerned with the development of standardised methods and criteria for the assessment of continuous underwater noise with a focus on noise emitted by ships and taking into account the current state of knowledge. The results of the TG-Noise are expected for the time after the completion of the present report and will be decisive for the assessment for the evaluation of the Good Environmental Status with regard to continuous underwater noise. The standardised methods and criteria will be used to design and implement measures to avoid and reduce impacts across Europe.

In recent years, studies have carried out concepts to avoid and reduce the impact of sound emitted by ships and have developed projects of a model character that provide indications on possible measures (ERBE ET AL., 2012; FRISK, G.V., 2012; LEAPER & RENILSON, 2012; MCKENNA ET LA. 2013; LEAPER ET AL., 2014; WILLIAMS ET AL., 2014; WRIGHT, A.J., 2014; HUNTINGTON ET AL., 2015; MIKHALEVSKY ET AL., 2015; SPENCE & FISCHER, 2017; WILSON ET LA., 2017; ERBE ET AL., 2020; LEAPER R., 2020; PINE ET AL., 2020).

As early as 2014, the IMO addressed adverse impacts on the marine environment and issued guidelines for the reduction of underwater noise from commercial shipping (IMO, 2014). Among the pilot projects dealing with the design and implementation of noise abatement measures by shipping, Project ECHO through the Port of Vancoucer, in Canada was initiated. The voluntary speed reduction has shown first positive signals with regard to the occurrence and behaviour of southern resident killer whales (ECHO ANNUAL REPORT, 2020; RUTH 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 expected in major oil spills (GERACI and ST AUBIN, 1990; FROST and LOWRY, 1993). Oil spills can cause lung and brain damage in marine mammals. An observed long-term consequence of an oil spill has also been increased juvenile mortality in harbour seals.

Loss of cargo can also lead to contamination with toxic substances. Even during normal ship operation, oil and oil residues, lipophilic detergents from tank cleaning, ballast water containing non-indigenous organisms and solid waste enter the marine environment (OSPAR, 2000). Pollutants discharged from ships into the sea can accumulate in food chains, contributing to pollution and contamination. Impacts on marine mammals via the accumulation of pollutants in food chains are also possible.

Effects at population level can hardly be assessed according to current knowledge. It is therefore recommended that all uses always follow the precautionary principle (Evans, 2020).

The non-implementation of the plan would not affect the existing or described impacts of shipping on harbour porpoise and harbour seal and grey seal.

3.1.6 Seabirds and resting birds

The impacts of shipping on seabirds and resting birds include visual disturbance, attraction effects and collisions, as well as pollution and the introduction of invasive species.

Visual disturbance can cause shying or avoidance reactions in species that are sensitive to disturbance. According to a recent study by FLIEßBACH et al. (2019), red-throated divers, black guillemots, black-throated divers, velvet scoters and red-breasted mergansers are among the most sensitive species to ship traffic. The most common response is to fly up. Flying distances vary across species and individuals and can be related to various individual and ecological factors (FLIEßBACH et al., 2019). The sensitivity of divers to ships is also known from other studies (GARTHE & HÜPPOP, 2004, Schwemmer ET al., 2011; Mendel et al. 2019; Burger ET AL., 2019).

Direct impacts on seabirds due to visual disturbance are to be expected in particular along busy traffic routes or traffic separation areas. The effects of shipping through visual disturbance on seabirds and resting birds are regionally and temporally dependent on the occurrence of ships. Findings on divers' reactions to ships indicate that the duration and intensity of the startle response may be related to the type of ship and associated factors such as ship speed (BURGER et al., 2019).

Shipping traffic can release oil and oil residues, lipophilic detergents from tank cleaning, ballast water containing non-indigenous organisms, and solid waste into the marine environment (OSPAR, 2000). WIESE AND RYAN (2003) found signs of chronic oil pollution in seabirds. Nearly 62% of all seabird deaths in the southeastern coasts of Newfoundland in 1984-1999 were contaminated with oil from ship operations. Alcids were the most frequently contaminated with oil.

Loss of cargo can also lead to contamination with toxic substances. Pollutants discharged from ships into the sea can accumulate in the food chain, contributing to pollution and contamination. Shipwrecks can also result in massive spills of environmentally hazardous substances such as oil and chemicals.

Various effects are known to be caused by oil spills. After the Prestige accident in 2003, for example, up to 50% less breeding success was observed at breeding colonies affected by oil pollution compared to undisturbed breeding colonies (VELANDO et al., 2005a). Indirect effects of the Prestige spill on the breeding success of the cormorant were also observed: high contamination in sediment, plankton and benthos reduced the sand eel population. The reduction of sand eels has in turn had an impact on the breeding success of the crow cormorant. Fewer breeding pairs successfully bred in 2003 than expected from long-term data. The condition of the chicks was also exceptionally weak due to lack of food or reduced food quality (VELANDO et al., 2005b).

The above-mentioned impacts on seabirds and resting birds occur independently of the non-implementation or implementation of the plan.

3.1.7 Migratory birds

For migratory birds, impacts of shipping are possible through visual stimuli and the input of pollutants. Migratory birds can be attracted by ship lighting at night. This is especially true for nights with poor visibility due to clouds, fog and rain. The possible consequences are collisions.

A risk to migratory birds from oil or pollutants is not very likely. Only those migratory birds would be affected, e.g. seabirds that interrupt their migration by watering, either to feed or to wait out bad weather conditions (such as headwinds and poor visibility). The consequence would be that the birds die due to the oiling of their plumage and the absorption of oil into the gastrointestinal tract due to their preening behaviour or the consumption of oily food.

The above-mentioned impacts on migratory birds occur independently of the non-implementation or implementation of the plan.

3.1.8 Bats and bat migration

Effects of shipping on bats are largely unknown. There are only isolated reports of bats being found on ships. WALTER et al. (2005) have summarised such observations/findings on ships in the context of investigations for offshore wind energy projects. Accordingly, it is assumed that attraction effects by ships can occur.

Insects can be attracted to ships by lighting and heat generation. Bats that are looking for food can subsequently be attracted by the insects. It is also assumed that migrating bats also visit ships to rest. However, this does not necessarily mean that there is a risk of collision.

No other direct or indirect effects of shipping on bats are known. The attraction effects already described can occur at most regionally and for a limited period of time.

The above-mentioned impacts on bats occur regardless of whether the plan is not implemented or is implemented.

3.1.9 Climate

The pollutant emissions from shipping described in Chapter 3.1.10contribute to climate change. Globally, the 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 MSP.

3.1.10 Air

Shipping causes pollutant emissions, especially nitrogen oxides, sulphur dioxides, carbon dioxide and soot particles. These can have a negative impact on air quality. These impacts will occur regardless of whether or not the plan is implemented.

3.1.11 Cultural assets and other material assets

In connection with shipping, measures to deepen, shift or widen fairways, for example through dredging, can lead to the destruction of the neighbouring underwater cultural heritage. Furthermore, the underwater cultural heritage is threatened, especially in shallower 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 anchor-laying, especially during construction measures with anchor-positioned working vessels.

Indirectly, the increasing trend since 1970 of introducing non-native species via ballast water and on the ship's hull itself (Gollasch, 2003) poses the greatest threat to the underwater heritage. Three species of teredinids are active in native waters, among them Teredo navalis as the best-known representative, which was already detected in the Baltic Sea from 1872 onwards and has been causing great damage to wooden harbour structures, ship walls and pile works ever since. Its spread is bound to tolerance ranges with regard to salinity, water temperature and oxygen (cf. Björdal et al. 2012, 208; Lippert et al., 2013, 47). However, shipping can lead to the immigration of further destructive organisms that are adapted to a different tolerance range and can penetrate previously undisturbed areas.

An indirect consequence of recreational shipping is recreational diving in the EEZ. In the past, objects were taken from historical wrecks or even deliberately dismantled, as the example of the wreck of the SMS Mainz, which was looted by Dutch divers in 2011, shows (Huber & Knepel, 2015).

In the past, the Explosive Ordnance Disposal Service blasted wrecks from the time of the World Wars on the suspicion that there might still be ammunition on board. Here, safety aspects must be weighed against the protection of cultural heritage.

3.2 Wind energy at sea

The increasing demand for space by offshore wind energy and the ambitious goals of the Federal Government for the use of wind energy at sea were the main reasons for the preparation of the 2009 maritime spatial plans for the German EEZ of the North Sea and Baltic Sea. The preparation of the spatial plans was an explicitly mentioned measure to promote the expansion of renewable energies.

When the maritime spatial plans were enacted in 2009, a first offshore wind farm, the alpha ventus test field, with 12 individual turbines was nearing completion in the North Sea. In the meantime, 21 wind farms with a total of 1,399 turbines and an installed capacity of approx. 7.2 GW in (trial) operation, in the Baltic Sea EEZ 3 wind farms with 1023 turbines and approx. 1 GW installed capacity.

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 power over time.

Specialist planning:

With the FEP 2020, there is a current technical plan to guide the planning of the expansion of offshore wind energy and the electricity grid connections.

The current FEP 2020 defines areas O-1 to O-3 for offshore wind energy in the Baltic Sea EEZ to achieve the expansion target of 20 GW by 2030. The increased expansion path for offshore wind energy results from the draft law amending the Wind Energy at Sea Act and other regulations adopted by the Federal Cabinet on 3 June 2020.

Various impacts on the marine environment may arise in connection with the construction and operation of wind turbines, including local habitat loss due to permanent surface sealing, scouring and barrier effects and a resulting loss of habitat for avifauna. Also to be considered are potential impacts from maintenance and service traffic.

For the assessment of the designations for offshore wind energy, the following possible impacts are examined:

Table 19: Effects and potential effects of offshore wind energy (t = temporary).

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
Areas for offshore wind energy	Placement of hard substrate (foundations)	Habitat modification	x	x			x		x	x	x	x							
		Habitat and land loss	x	x			x			x	x	x	x					x	
		Attraction effects, increase in species diversity, change in species composition	x	x	x		x		x		x								
		Change in hydrographic conditions	x	x			x		x					x					
	Scouring/sediment rearrangement	Habitat modification	x	x					x	x		x	x						
	Sediment resuspension and turbidity plumes (construction phase)	Impairment	x t	x t	x t				x t					x t					
		Physiological effects and chilling effects		x t			x												
	Resuspension of sediment and sedimentation (construction phase)	Impairment	x t	x t					x t					x t					
	Noise emissions during pile driving (construction phase)	Impairment/ scare effect		x t			x												
		Potential disruption/damage		x t			x												
	Visual disturbance due to construction operations	Local scouring and barrier effects		x t	x t														
	Obstacle in airspace	Scare effects, habitat loss			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	

3.2.1 Floor

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 protected resource soil. The sediment is only permanently affected in the immediate vicinity by the installation of the foundation elements (including scour protection if necessary) and the resulting land use.

During the foundation of the wind turbines and platforms as well as the flushing in of cabling within the park, there is a temporary resuspension of sediments and the formation of turbidity plumes due to construction. The extent of resuspension depends mainly on the fine grain content (clays and silts) 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 their immediate vicinity. The suspension content quickly decreases again to the 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 proportion of fines and the associated increased turbidity remain limited on a small scale due to the low flow near the bottom.

In the areas with soft sediments and correspondingly high fine grain contents (e.g. Arkona Basin or Mecklenburg Bay), the released sediment will settle again much more slowly. However, as the near-bottom currents are low (in the Arkona Basin with an average magnitude of around 0.06 m/s; near the surface 0.1 m/s), it can be assumed that the turbidity plumes that occur here will also have a rather local character and the sediment will settle again relatively close to the construction site. A simulation of the effects of 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). In this case, the released material remains long enough in the water column to spread over a large area, so that hardly detectable thicknesses of the deposited material are to be expected due to the comparatively small volumes. At most 12 hours after release, the concentration drops below 0.001 kg/m³. Also in the context of the environmental impact assessment for the "Nord Stream Pipeline", the monitoring results during the construction phase showed overall only small- to medium-scale, temporary impacts due to sediment drift (turbidity plumes) and confirmed the forecasts of the environmental expert (IFAÖ, 2009), who classified the impacts overall as low structural and functional impairment. Based on these results, it can be assumed that turbidity plumes released during the foundation of wind turbines and platforms or the laying of submarine cables in areas with soft sediments will be at a maximum distance of 500 m above the natural suspended sediment maxima.

Studies by ANDRULEWICZ et al. (2003) also show that the seabed of the Baltic Sea undergoes re-levelling due to the natural sediment dynamics along the affected routes. However, various model calculations carried out within the framework of procedures and the experience gained from the procedures show that re-levelling tends to take place in the long term.

In the short term, pollutants and nutrients can be released from the sediment into the soil water. The possible release of pollutants from sandy sediments is negligible with a relatively low fine grain content and low heavy metal concentrations. In areas with a high proportion of fines (e.g. basins), a significant release of pollutants from the sediment into the groundwater can occur. The pollutants usually adhere to sinking particles which, due to the low currents in the Baltic Sea basins, are hardly drifted over larger distances and remain in their native environment. In the medium term, this remobilised material is deposited again in the silty basins.

Impacts in the form of mechanical stress on the soil due to displacement, compaction and vibrations that are to be expected in the course of the construction phase are assessed as low due to their small-scale nature.

The interaction of the foundation and hydrodynamics in the immediate vicinity of the facilities and platforms can lead to the permanent stirring up and relocation of sediments. According to previous experience in the North Sea, permanent sediment redistribution due to currents is only to 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-bottom current velocities, only local scour is to be expected in the area of the foundation structures, even in the Baltic Sea. Due to the predicted spatially narrow scope of the scouring, no significant substrate changes are to be expected.

In the case of cabling inside the park, the surrounding sediment heats up radially around the cables due to their operation. The heat emission results from the thermal losses of the cable systems during energy transmission. The installation depth of the cable systems is also decisive for the temperature development in the sediment layer near the surface. According to the current state of knowledge, no significant impacts from cable-induced sediment heating are to be expected if a sufficient installation depth is maintained and state-of-the-art cable configurations are used.

The described impacts from offshore wind energy are spatially limited and, with the exception of land sealing due to the installation of foundation structures, temporary. The impacts occur independently of the implementation or non-implementation of the plan.

The MSP provides for three priority areas and no reservation areas for the Baltic Sea EEZ. If the plan is not implemented, a less coordinated expansion of offshore wind energy is to be expected. This could lead to a comparatively high land consumption, increased sediment relocation and thus to increased negative impacts on the protected goods soil and land compared to a spatially and temporally coordinated relocation. In addition, an uncoordinated expansion would result in an increased number of crossing structures, which would make the introduction of hard substrate necessary. For example, riprap could also become necessary in areas with predominantly homogeneous sandy seabed, which could otherwise be avoided.

3.2.2 Benthos and biotope types

Benthic communities and biotopes would be partially affected by the impacts of various uses, such as resource extraction and fishing, even if the plan were not implemented. In addition, the warming of the water that has already begun due to climate change is expected to continue in the future. This also has an impact on benthic communities. This may lead to the settlement 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, a spatially less coordinated planning of the wind farms would have to be expected. As a result of not implementing the plan, there could be a comparatively higher land take and thus an increase in possible impacts on benthos and biotopes compared to implementing the plan. Possible impacts result from the placement of the foundations of the wind turbines and platforms. During the construction phase, impacts on benthic communities could occur due to direct disturbance of near-surface sediments, pollutant inputs, resuspension of sediment, formation of turbidity plumes and increase in sedimentation.

In the vicinity of the foundations of the plants and platforms, changes in the existing species composition may occur due to the introduction of artificial hard substrate.

Since the provisions of the plan aim to minimise the use of the seabed, the protection of benthos and biotopes would probably be more difficult to ensure if the plan were not implemented than if it were.

3.2.3 Fish

The construction-, installation- and operation-related impacts of offshore wind farms on fish fauna are spatially and partly also temporally limited and are essentially concentrated on the area of the planned project. The effects of the different wind farm phases are described in detail below.

Construction-related impacts

- Noise emissions from driving the foundations
- Sedimentation and turbidity plumes

In the area of the project, construction-related **noise emissions are** to be expected from the use of ships, cranes and construction platforms as well as from the installation of the foundations and, if necessary, from the installation of scour protection. It is known from the literature that pile driving underwater produces high sound pressures in the low-frequency range. All fish species and their life stages studied so far 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 sound events, sound could have a direct negative impact on fish development, growth and behaviour, or override environmental acoustic signals that are sometimes crucial for fish survival (KUNC et al., 2016; WEILGART, 2018; DE JONG et al., 2020). However, the majority of previous evidence on the effects of sound on fish comes from laboratory studies (WEILGART, 2018). The range of perception and possible species-specific behavioural responses in marine habitat have been little studied. The construction-related impacts of wind farms on fish fauna are limited in space and time. It is likely that during the construction phase, short, intense sound events - especially during the installation of the foundations - will cause fish to become distressed. 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 of the swim bladder in cod. This effect was found at a distance of 1,400 m or closer from a pile driving sound source without any sound protection (DE BACKER et al., 2017). Such studies indicate that significant disturbance or even killing of individual fish in the vicinity of pile driving sites is possible. Hydroacoustic measurements showed that construction measures (pile driving and other construction activities) in the "alpha ventus" test field resulted in a strongly reduced population of pelagic fish relative to the surrounding area (KRÄGEFSKY, 2014). After temporary displacement, however, the fish are likely to return after the sound-intensive construction measures have ended. Studies on sound effects on fish by NEO et al. (2016) showed that the animals largely returned to their usual behaviour 30 min after the auditory stimuli.

The construction activities of the foundations of wind turbines as well as the transformer platform and the cabling within the park result in **sediment turbulence and turbidity plumes**, which - albeit for a limited period of time and depending on the species - can have physiological effects on fish fauna, especially on fish spawning. However, significant impacts on fish fauna due to sediment turbulence, turbidity plumes and sedimentation are not to be expected. Detailed information on this can be found in Chapter 3.4.3

Plant-related effects

- Land use
- Placement of hard substrate
- Fishing ban
- Operating sound

The construction of the foundations of the WTGs and technical platforms as well as the scour protection will overbuild habitats and they will no longer be available for fish. There is a permanent **loss of habitat** for demersal fish species and their food base, the macrozoobenthos, due to local overbuilding. However, this habitat loss is limited to the immediate, small-scale location of the individual WTGs and platforms.

The construction of wind farms changes the structure of the often uniformly sandy seabeds of the Baltic Sea through newly introduced hard substrate (foundations, scour protection). An **attraction effect of artificial reefs** on fish has been observed in the majority of cases (METHRATTA & DARDICK, 2019).

Near Norwegian oil platforms, higher catches of cod and saithe were obtained than before their construction (VALDEMARSEN, 1979; SOLDAL et al., 2002). Increased densities of flatfish have been found near artificial reefs (POLOVINA & SAKI, 1989). At the monopiles of the existing wind farm "Horns Rev I", according to expert reports and video recordings of the accompanying monitoring, a large number of fish species occur which use the artificial hard substrate (LEONHARD et al., 2011). In addition to this positive effect, the change in dominance ratios and size structure within the fish community due to 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 within 16 m of a drilling platform in the Gulf of Mexico. Transferred to the foundations of wind turbines, it can be assumed, due to the distance of the individual turbines from each other, that each individual foundation, regardless of the type of foundation, acts as a separate, relatively unstructured substrate and that the impact does not encompass the entire wind farm area.

COUPERUS et al. (2010) detected 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 Franzosendorschen at the foundations than over the surrounding soft substrate, feeding predominantly on the fouling on the foundations. GLAROU et al. (2020) reviewed 89 scientific studies on artificial reefs, 94% of which demonstrated positive or no effects of artificial reefs on fish fauna abundance and biodiversity. 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).

Recent biological studies have shown that cod reproduce in the wind farms of the "Nördlich Helgoland" cluster (GIMPEL et al. in prep.). It remains to be clarified to what extent the increased productivity can be transferred to other fish species.

The **elimination of fishing** due to the anticipated prohibition of navigation in the wind farm areas could have a further positive effect on the fish population. Associated negative fishing effects, such as disturbance or destruction of the seabed as well as catch and bycatch of many species, would be eliminated. Due to the lack of fishing pressure, the age structure of the fish fauna within the project area could develop into a more natural distribution again, so that the number of older individuals increases. In addition to the absence of fishing, an improved food basis for fish species with a wide variety of diets would also be conceivable. The vegetation of the wind turbines with sessile invertebrates could favour benthophagous species and make a larger and more diverse food source accessible to the fish (GLAROU et al., 2020). This could improve the condition of the fish, which in turn would have a positive impact on fitness. Currently, research is needed to translate such cumulative effects to the population level of fish. To date, the effects on fish fauna that could result from the elimination 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. in prep.).

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. The sound emitted by the WTs 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 to the turbine, the sound 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 could not provide clear evidence of negative effects, such as persistent stress reactions (WEILGART, 2018).

The objectives and principles of the MSP on offshore wind energy, in particular orderly and sustainable spatial development, would not be met if the plan were not implemented. The protection of the marine environment, e.g. by taking into account the ecosystem approach and the precautionary principle, could be more difficult to ensure if the plan is not implemented.

3.2.4 Marine mammals

Construction-related: Hazards may be caused to harbour porpoises, grey seals and harbour seals by noise emissions during the construction of offshore wind turbines and the transformer station if no preventive and mitigation measures are taken. Depending on the foundation method, impulse sound or continuous sound can be introduced. The input of impulse sound, which occurs e.g. when driving piles with hydraulic hammers, has been well studied. The current state of knowledge on impulse sound contributes significantly to the development of technical sound reduction systems. In contrast, the current state of knowledge on the input of continuous sound as a result of the installation of foundation piles using alternative methods is very limited.

The Federal Environment Agency (UBA) recommends compliance with noise protection values during the construction of foundations for offshore wind turbines. The sound event level (SEL) should not exceed 160 dB (re 1 µPa) outside a circle with a radius of 750 m around the pile driving or installation site. The maximum peak sound pressure level should not exceed 190 dB if possible. The UBA recommendation does not contain any further specifications 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 the UBA has already been developed through preliminary work of various projects (UNIVERSITY OF HANOVER, ITAP, FTZ 2003). For precautionary reasons, "safety margins" were taken into account, e.g. for the interindividual dispersion of hearing sensitivity documented so far and above all because of the problem of repeated exposure to loud sound impulses, such as those that will occur during the pile driving of foundations (ELMER et al., 2007). There are currently only very limited reliable data available to assess the impact duration of pile driving noise. However, pile driving activities that can last several hours have a much higher damage potential than a single pile driving impact. At present, it is unclear how much of a reduction to the above-mentioned limit value should be applied to a sequence of individual events. A reduction of 3 dB to 5 dB for each tenfold increase in the number of pile driving impulses is discussed in expert circles. Due to the uncertainties shown here in the evaluation of the impact duration, the limit value used in licensing practice is below the limit value proposed by SOUTHALL et al. (2007).

Within the framework of establishing measurement regulations for recording and assessing underwater noise from offshore wind farms, the BSH has concretised and standardised as far as possible the specifications from the UBA recommendation (UBA 2011) and from the findings of the research projects with regard to noise protection values. 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 within the framework of the efficiency control show that the SEL5 is up to 3 dB higher than the SEL50. Thus, by defining the SEL5 value as an assessment level, a further tightening of the noise protection value was undertaken in order to take the precautionary principle into account.

Thus, based on an 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 exclude any adverse effects on harbour porpoises with the necessary certainty.

Results on the acoustic resilience of harbour porpoises were obtained in 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. Furthermore, the hearing threshold shift was found to last for more than 24 hours. Behavioural changes were already registered in the animal at a reception level of 174 pk-pk dB re 1 µPa (LUCKE et al. 2009). However, in addition to the absolute loudness, the duration of the signal also determines the effects on the exposure limit. The exposure limit decreases with increasing duration of the signal, i.e. continuous exposure can cause damage to the animals' hearing even at lower volumes. Based on these latest findings, it is clear that harbour porpoises suffer a hearing threshold shift at a level of 200 decibels (dB) at the latest, which can possibly also lead to damage to vital sensory organs.

The scientific findings that have led to the recommendation or establishment of so-called noise protection values are mostly based on observations in other cetacean species (SOUTHALL et al., 2007) or on experiments on harbour porpoises in captivity using so-called airguns or air pulsers (LUCKE et al., 2009).

Without the use of sound mitigation measures, significant disturbance of marine mammals during the pile driving of the foundations cannot be ruled out. The pile driving of the wind turbines and the transformer station will therefore only be permitted in the specific approval procedure with the use of effective noise reduction measures. Principles are included for this purpose. These principles state that pile-driving work during the installation of the foundations of offshore wind turbines and platforms may only be carried out in compliance with strict noise reduction measures. In the actual approval procedure, extensive noise reduction and monitoring measures will be ordered to ensure compliance with the applicable noise protection values (sound event level (SEL) of 160 dB re 1µPa and maximum peak level of 190 dB re 1µPa at a distance of 750 m from the pile driving or installation site). Suitable measures shall 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 underwater noise mitigation show that the use of suitable systems can significantly reduce or even completely avoid impacts on marine mammals caused by sound (Bellmann, 2020).

Taking into account the current state of knowledge, conditions will be imposed as part of the specification of the foundation types to be constructed in the approval procedure, with the aim of avoiding impacts on harbour porpoises caused by sound as far as possible. The extent of the required conditions will be determined at the approval level on a site- and project-specific basis by examining the design of the respective project on the basis of the requirements of species protection law and site protection law.

The BSH's approval notices contain two orders to protect the marine environment from noise pollution caused by pile driving:

a) Reduction of noise input at source: Mandatory use of low-noise working methods in accordance with the state of the art when installing foundation piles and mandatory restriction of noise emissions during pile driving. The order primarily serves to protect marine species from impulsive noise emissions by avoiding killing and injury.

b) Avoidance of significant cumulative impacts: The dispersion of sound emissions must not exceed defined proportions of the area of the German EEZ and nature conservation areas. This ensures that sufficient high-quality habitats are available to animals for escape at all times. The arrangement primarily serves to protect marine habitats by avoiding and minimising disturbances caused by impulsive sound emissions.

The order under a) specifies the mandatory noise protection values to be complied with and the maximum duration of the impulsive sound input, the use of technical sound reduction systems and deterrent measures as well as the extent to which the protective measures are to be monitored.

Under order b), provisions are made, inter alia, for the prevention and mitigation of significant cumulative impacts or disturbance to the harbour porpoise population that may be caused by impulsive sound inputs.

In general, the considerations mentioned for harbour porpoises regarding noise exposure from construction and operation activities of wind turbines and platforms also apply to all other marine mammals occurring in the indirect vicinity of the structures.

Especially during pile driving, direct disturbance of marine mammals at the individual level is to be expected locally around the pile driving site and for a limited period of time, whereby - as explained above - the duration of the work also has an impact on the exposure limit. In order to prevent a resulting threat to the marine environment, the specific approval procedure must include an order to limit the effective pile-driving time (including the entanglement) to a minimum. The effective pile-driving time to be complied with in each case (including deterrence) will be specified later in the approval procedure on a site- and installation-specific basis. In addition, coordination of noise-intensive works with other construction projects is reserved within the framework of the enforcement procedure in order to prevent or reduce cumulative effects.

Based on the function-dependent importance of the areas for harbour porpoises and taking into account the noise protection measures to avoid disturbance and cumulative effects, the provisions made in the site development plan (FEP, 2019), the requirements within the framework of the suitability test and the conditions within the framework of individual approval procedures to reduce noise inputs, the potential impacts of noise-intensive construction work on harbour porpoises are assessed as not significant. The designation of priority areas for wind energy production outside nature conservation areas rules out any adverse effects on important feeding and breeding grounds for harbour porpoises.

According to current knowledge, operational noise from the wind turbines and the transformer platform has no impact on highly mobile animals such as marine mammals. The investigations carried out as part of the operational monitoring for offshore wind farms have so far not provided any indications of avoidance by wind farm-related shipping traffic. Avoidance has so far only been detected during the installation of the foundations, which may be related to the large number and varying operating conditions of vehicles at the 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. With increasing distance to the wind turbine, however, the noise of the wind turbine is only insignificantly different from the ambient noise. Even at a distance of 1 km from the wind farm, higher sound levels are always measured than in the centre 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. The wind farm-related ship traffic could also hardly be differentiated from the general ambient sound, which is introduced by various sound sources, such as other ship traffic, wind and waves, rain and other uses (MATUSCHEK et al., 2018).

All measurements showed that not only the offshore wind turbines emit sound into the water, but also various natural sound sources, such as wind and waves (permanent background sound), can be detected in the water over a broad band and contribute to the broadband permanent background sound.

In the measurement regulations for recording and evaluating underwater sound (BSH, 2011), a level difference between impulse and background sound of at least 10 dB is required for a technically unambiguous calculation of impulse sound 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 of at least 6 dB between system and background sound is required for the unambiguous assessment of system or 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 available results from the measurements of underwater sound show that such a 6 dB criterion based on airborne sound can at most be fulfilled in the immediate vicinity of one of the turbines. However, this criterion is no longer fulfilled even at a short distance from the edge of the wind farm. As a result, the sound emitted by the operation of the turbines is not clearly distinguishable from the existing ambient sound from an acoustic point of view outside the project areas.

The biological relevance of continuous sound on marine species and especially on harbour porpoises has not yet been reliably clarified. Continuous sound is the result of emissions from various anthropogenic uses, but also from natural sources. 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 in order to avoid collisions, among other things. In contrast, reactions not observed in the immediate vicinity of sound sources can no longer be assigned to a specific source.

Behavioural changes are in their vast majority the result of a variety of influences. Noise can certainly be a possible cause of behavioural changes. However, behavioural changes are primarily driven by the survival strategies of animals to capture food, escape predators and to communicate with conspecifics. For this reason, behavioural changes always occur situationally and in varying degrees.

There are indications in the literature of possible behavioural changes due to ship noise, but the results are not valid for drawing conclusions on the significance of behavioural changes or even for developing and implementing appropriate mitigation measures.

However, scientific reviews of the existing literature on possible effects of ship noise on cetaceans but also on fish clearly point to the lack of comparability, transferability and reproducibility of results (Popper & Hawkins, 2019; Erbe et la., 2019).

It is known from oil and gas platforms that the attraction of various fish species leads to an enrichment of the food supply (Fabi et al., 2004; Lokkeborg et al., 2002). Monitoring 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 potentially increased food supply in the vicinity of the wind turbines and the transformer platform is very likely to attract marine mammals.

As a result of the SEA, it can be stated that, according to current knowledge, no significant impacts on marine mammals are to be expected from the construction and operation of wind turbines and the transformer platform.

The non-implementation of the plan would have had an influence on the existing or described impacts 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

Construction-related: During the construction of offshore wind turbines, impacts on seabirds and resting birds can be expected, although the nature and extent of these impacts will be limited in time and space.

Species sensitive to disturbance can be expected to avoid the construction site, the intensity of which varies according to the species and can most likely be attributed to a reaction to the construction-related shipping traffic.

Construction-related turbidity plumes occur locally and for a limited time. Attraction effects due to the lighting of the construction site and the construction site vehicles cannot be ruled out.

Operational and installation-related: Erected wind turbines can be an obstacle in the airspace and can also cause collisions with the vertical structures of seabirds and resting birds (GARTHE 2000). To date, the extent of such occurrences is difficult to estimate, as it is assumed that a large proportion of collided birds do not land on a fixed structure (HÜPPOP et al., 2006). However, the collision risk for disturbance-sensitive species such as white-throated divers and black-throated divers is estimated to be very low, 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 of a species (GARTHE & HÜPPOP, 2004). The collision risk for seabirds and resting birds must therefore be assessed differently depending on the species.

The corresponding height parameters of the turbines are an important indicator for estimating the potential collision risk for seabirds and resting birds with wind turbines at sea. In the MSP, bandwidths for the height parameters of currently installed or potential turbine types were included in accordance with the current technical developments of wind turbines (cf. Chapter 1.5). Here, on the one hand, wind farm projects that are already in operation are taken into account, as well as those that will go into operation within the framework of the transitional system and the first commissioning years of the central system in zones 1 and 2. For already realised or future wind farm projects in zones 1 and 2, data or assumptions are available for 5 to 12 MW turbines, which have 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 height of the wind turbine is between 170 m and 270 m. The lower rotor-free height of the wind turbine is between 170 m and 270 m. This means that the lower rotor-free height of the wind turbine is between 170 m and 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 flight height distribution of, among others, the three species of Great Black-backed Gull, Herring Gull and Great Black-backed Gull, as well as the smaller species of Lesser Black-backed Gull and Common Gull were determined using rangefinders. The Great Black-backed Gulls flew at heights of 30 - 150 m in the majority of recorded flights, while the Common Gull and Lesser Black-backed Gull were mainly observed at lower heights up to 30 m (MENDEL et al. 2015). A recent study at the Thanet Offshore Wind Farm in England also investigated the flight height distribution of, among others, the three great black-backed gull species Herring Gull, Great Black-backed Gull and Lesser Black-backed Gull using the rangefinder (SKOV et al., 2018). The flight altitude measurements of the Great Black-backed Gulls were comparable to the altitudes determined by Mendel et al. (2015).

In general, large and small gulls have a high 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 the immediate, small-scale and large-scale evasive behaviour of the species considered was investigated in addition to flight altitude. Furthermore, the investigations using radar and thermal imaging cameras revealed low nocturnal activity. The collision risk at night due to attraction effects caused by the illumination of the wind turbines can therefore also be assessed as low.

Garthe & Hüppop (2004) confirmed that diving sea ducks as well as great crested grebes and red-necked grebes have a low manoeuvring ability, but these species generally fly at heights of max. 5- 10 m and thus outside the rotor range.

For species sensitive to disturbance, species-specific avoidance of the wind farm areas can be assumed during the operational phase of the wind farms.
Red-throated and black-throated divers (hereafter summarised as divers) are considered to be particularly sensitive to wind farms and also moving ships. The latter are known to cause a scaring reaction 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 in the context of operational monitoring of wind farm projects in the North Sea have meanwhile resulted in 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 diver 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 of divers are not known from the Baltic Sea (IfAÖ, 2018a).

This may be due to the fact that the areas designated in the MSP and the EEZ of the Baltic Sea are generally not of particular importance for this species group and divers are only occasionally encountered as migrants and in winter. The same applies to other species such as guillemot, razorbill and lesser black-backed gull, which are known to have small-scale avoidance behaviour (IFAÖ et al., 2017b; IBL UMWELTPLANUNG GMBH ET AL., 2017; IBL UMWELTPLANUNG GMBH et al., 2018).

It can also be assumed that the fish stocks will recover during the operational phase due to a regular ban on fishing within the wind farms, which is accompanied by a prohibition of navigation for ships. In addition to the introduction of hard substrate, the species spectrum of the fish present could thus increase and offer an attractive food supply for foraging seabirds.

If the MSP is not implemented, the planning of wind farm projects would be less spatially coordinated. This would probably increase the amount of land taken up, which in turn could have an impact on species sensitive to disturbance. Furthermore, the MSP is based on planning principles that provide not only for spatial but also temporal coordination of construction projects in order to reduce temporary factors affecting seabirds and resting birds, such as additional construction-related shipping traffic.

Even though similar factors would basically affect the protected species of seabirds and resting birds both if the MSP were implemented and if it were not, the protection of seabirds and resting birds would be more difficult to ensure if it were not implemented due to the lack of planning principles and their coordinating requirements.

3.2.6 Migratory birds

Construction-related: During the construction phase, impacts are primarily caused by light emissions and visual disturbance. These can cause scaring and barrier effects on migrating birds to varying degrees depending on the species. However, the illumination of construction equipment can also lead to attraction effects for migrating birds and increase the risk of collision.

Installation and operational: Possible impacts of offshore wind farms during the operational phase may be that they constitute a barrier for migrating birds or a collision risk. Flying around them or otherwise disturbing their flight behaviour can lead to higher energy consumption, which can affect the birds' fitness and subsequently their survival rate or breeding success. Bird strike events may occur on vertical structures (such as rotors and support structures of wind turbines, substations and converter platforms). Poor weather conditions - especially at night and in strong winds - and high migration intensities increase the risk of bird strikes. In addition, there are possible glare or attraction effects caused by the safety lighting of the installations, which can lead to birds becoming disoriented. Furthermore, birds caught in wake currents and air turbulence at the rotors could be impaired in their manoeuvrability. However, for the aforementioned factors, as well as for the scaring and barrier effects, it can be assumed that the sensitivities and risks are different for each species.

As a general rule, a threat to bird migration does not already exist if there is an abstract danger that individual birds will be harmed during their passage through an offshore wind farm. A threat to bird migration only exists if sufficient knowledge justifies the prognosis that the number of potentially affected birds is so large that, taking into account their respective population size, a significant impairment of individual or several different populations can be assumed with a sufficient degree of probability. The biogeographical population of the respective migratory bird species is the reference 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 poses many dangers and subjects populations to harsh selection. The mortality rate can be around 60 to 80 % for small birds, while the natural mortality rate is lower for larger species. Also, different species have different reproductive rates, so the loss of individuals can be of different consequence for each species.

Due to a lack of sufficient knowledge, it has not yet been possible to determine a generally valid acceptance threshold.

The corresponding height parameters of the turbines are an important indicator for estimating the potential collision risk for seabirds and resting birds with wind turbines at sea. In the MSP, bandwidths for the height parameters of currently installed or potential turbine types were included in accordance with the current technical developments of wind turbines (cf. Chapter 1.5). Here, on the one hand, wind farm projects that are already in operation are taken into account, as well as those that will go into operation within the framework of the transitional system and the first commissioning years of the central system in zones 1 and 2. For already realised or future wind farm projects in zones 1 and 2, data or assumptions are available for 5 to 12 MW turbines, which have 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 height of the wind turbine is between 170 m and 270 m. The lower rotor-free height of the wind turbine is between 170 m and 270 m. This means that the lower rotor-free height of the wind turbine is between 170 m and 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 via migration plan 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, for example, about 90 % of migratory movements took place at altitudes up to 20 m (BioConsult SH, 2017).

Previous studies of bird migration using vertical radar in the EEZ in the Baltic Sea showed that there was a diurnal dependency in the altitude distribution. In area EO3, bird migration took place predominantly 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. Thus, in the altitude range up to 200m, between 65.2% (spring) and 66.7% (autumn) of the flight movements were registered during the day, at night between 28.8% (spring) and 26.8% (autumn). Furthermore, a dependence of the migration altitude on the migration intensity was found. Especially at night, bird detections were more often in the lower altitude layers in periods with few migrants. This could reflect poorer migration conditions (weather), which reduce the number of migrating birds and cause them to move to lower migration altitudes.

During the long-term investigations of bird migration in the North Sea EEZ in the area "North of Borkum", a bimodal distribution pattern to the recorded bird movements emerged in the 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 each were recorded at altitudes 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 with altitude profiles that deviated from the basic pattern. On 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, suggesting that bird migration was underestimated on this night and that a high (but unknown) proportion of migrating birds flew over the radar measurement range. Also on the very strong bird migration night 09/10 November, bird migration was comparatively strongly shifted upwards.

Avitec Research therefore assumes that its vertical radar system registers on average at least 2/3 of the total bird migration with its considered data basis up to 1,000 m altitude. In individual cases, depending on the vertical wind profile, the recorded proportion can be significantly higher in the case of strong bird migration. Conversely, more than half of all migratory birds will be missed on nights when the altitude distribution decreases or even increases slowly with altitude. However, this is usually only the case on a small number of nights.

For cranes, there are findings that the altitude range between 20 - 200 m is used preferentially. For cranes, 91% of the visible migration was detected at altitudes between 20 and 200 m (BIOCONSULT SH, 2017). Intensive radar surveys of migrating cranes on 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, crane groups migrated at about 300 m altitude. Two different flight patterns were recorded: 'simple' straight flight without loss of altitude and straight flight interrupted by regular circling. During circling, altitude was gained, while the stretches of straight flight were associated with loss of altitude. The circling flight movements were mainly observed close to land and presumably took advantage of updrafts in this area. A study with 3D GPS devices on eight cranes crossing the Baltic Sea between the south coast of Sweden and the German Baltic coast showed similar flight behaviour (SKOV et al., 2015). Four cranes travelled the entire distance over the open sea at a constant altitude of below 200 m. Two individuals, on the other hand, climbed to altitudes of about 1,000 m before reaching the Swedish coast, continuously lost altitude during the crossing and reached land at a flight altitude of about 200 m.

Extensive measurements with a laser rangefinder from the FINO2 platform in the vicinity of the Baltic 2 OWP also showed a clear dominance of flight altitudes below 200 m as well as a dependence of the flight altitude distribution on wind conditions, both in spring and autumn (SKOV et al., 2015). In contrast to radar surveys, 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 altitude range above 200 m (cf. IFAÖ, 2010).

The results of the investigations at plot O.1-3 by means of visual observations and rangefinder measurements confirm the flight altitude distributions of the cranes in the lower altitude range up to 200 m already known using these methods (IFAÖ et al., 2020).

Migrating birds generally fly higher in good weather than in bad weather. In addition, most birds usually start their migration in good weather and are able to choose their departure conditions so that they are reasonably likely to reach their destination in the best possible weather. In the clear weather conditions preferred by birds for their migration, the probability of a collision with wind turbines is therefore low because the flight altitude of most birds will be above the range of the rotor blades and the turbines are clearly visible. On the other hand, unexpected fog and rain, which lead to poor visibility and low flight altitudes, pose a potential hazard. The coincidence of bad weather with so-called mass migration events is particularly problematic. According to information from various environmental impact studies, mass migration events, in which birds of various species fly over the North Sea at the same time, occur about 5 to 10 times a year. An analysis of all existing bird migration studies from the mandatory monitoring of offshore wind farms in the EEZ of the North Sea and Baltic Sea (observation period 2008 - 2016) confirms that particularly intensive bird migration coincides with extremely bad weather conditions at less than 1 % of the migration times (WELCKER, 2019b).

In addition to the risk to bird migration from bird strikes, another risk for migrating birds is that the migration route could be diverted and thus extended by the presence of wind turbines. However, this does not affect bird migration in its entirety, as a large part of the migration takes place at altitudes outside the sphere of influence of wind turbines. Many songbirds, for example, migrate at altitudes between 1,000 and 2,000 metres. Waders are also known to migrate at very high altitudes (JELLMANN, 1989). However, significant numbers migrate at altitudes <200 m and thus within the range of influence of wind turbines. Many of the low-migrating species belong to the group of waterbirds and seabirds that are able to land on the water to rest and possibly feed. For species like these, any detours will therefore have little impact. It could be problematic for migratory land birds that are not capable of landing on the water. It should be noted that migratory birds are capable of impressive non-stop flight performances, especially when migrating non-aquatic species over seas. The non-stop flight performance of many species, including small birds, is over 1,000 km (TULP et al., 1994). It is therefore not to be expected that the possibly required additional energy demand due to a diversion necessary in the Baltic Sea EEZ would lead to a threat to bird migration.

If the MSP were not implemented, the planning of wind farm projects would be less spatially coordinated. This would probably increase the amount of land taken up. Furthermore, the MSP is based on planning principles that provide for both spatial and temporal coordination of construction projects.

Even though similar factors would basically affect migratory birds both if the MSP were implemented and if it were not, it would be more difficult to ensure the protection of migratory birds if it were not implemented due to the lack of planning principles and their coordinating requirements.

3.2.7 Bats and bat migration

At present, there are no reliable findings 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 have an impact on bats:

Construction-related: Construction activities during the erection of WTGs are associated with increased vessel traffic. The illumination of the ships and the construction site can cause attraction effects on bats migrating across the sea. The risk of collision with the ships and the construction site would then be possible.

Installation- and operation-related: During the operational phase, the lighting of the installations may possibly cause attraction effects that could lead to collisions.

If the plan is not implemented, the same impacts on bats may occur as if the plan were implemented.

3.2.8 Climate

Negative impacts on the climate from offshore wind farms are not expected, as no measurable climate-relevant emissions occur either during construction or operation. On the contrary, the coordinated expansion of the grid infrastructure in the offshore area creates greater planning certainty for the expansion of offshore wind energy. The CO2 savings associated with the expansion of offshore wind energy (cf. Chapter 1.8) can be expected to have a positive impact on the climate in the long term.

3.2.9 Air

The construction and operation of the wind turbines and platforms as well as the laying of submarine cable systems will increase shipping traffic. However, there are no measurable effects on air quality. Therefore, the air quality will develop in the same way if the plan is implemented as if it is not implemented.

3.2.10 Landscape

The realisation of offshore wind farms has an impact on the landscape, as it is altered by the erection of vertical structures. The turbines also have to be fired at night or in poor visibility for safety reasons. This can also have a visual impact on the landscape. The erection of platforms can also lead to visual changes in the landscape. The extent to which the landscape is affected 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 image of a seascape, can be perceived partly as disturbing, but also partly 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 based on the specific weather conditions, the height of the viewer's location (e.g. beach, viewing platform, lighthouse) and the capacity of the human eye. Due to the considerable distance (more than 30 km) of the planned and already reached wind energy plants and platforms to the coast, the plants will only be perceptible from land to a very limited extent, and only under good visibility conditions. This also applies to the night-time safety lights.

Overall, the impairment of the landscape by offshore installations from the coast can be classified as quite low.

The development of the landscape in the case of non-implementation of the MSP is not expected to differ significantly from the development in the case of implementation of the MSP. However, it should be noted that the necessary land requirements can be minimised by the provisions of the MSP (and the site development plan). The potential impacts on the landscape as a protected resource can thus be reduced by spatially coordinated, foresighted and coordinated overall planning. Insufficient spatial coordination in the event of non-implementation of the plan could lead to more fragmented wind farm areas and a greater land take and slightly increased visibility from the coast.

For the submarine cable systems, negative impacts on the landscape during the operational phase can be ruled out due to the laying as underwater cables.

3.2.11 Cultural assets and other material assets

During the deep foundation of the wind turbines, the seabed is disturbed due to construction, which can affect discovered and undiscovered cultural heritage. The cultural heritage will be completely or partially destroyed or its context affected during excavation or pile driving. In addition, extensive secondary impacts on the underwater cultural heritage property from construction vehicles are to be expected during construction work.

Due to the foundation acting as a flow obstacle, the long-term formation of scouring funnels is to be expected, especially on fine-sand seabeds, whereby cultural traces that remained undiscovered during the construction measures can erode freely.

3.3 Lines

Lines within the meaning of the maritime spatial plan include pipelines and submarine cables. Submarine cables include cross-border power lines and connection lines for offshore wind farms as well as data cables. So-called internal submarine cables are not included in this definition. Reference is made to the designations within the framework of the technical planning (FEP) in this regard.

The two Nord Stream 1 pipelines run through the Baltic Sea EEZ and land on the German coast. The two pipelines Nord Stream 2 are under construction. The pipelines transport natural gas from Russia to Germany. They land on the coast of Mecklenburg-Western Pomerania.

The reservation areas for power lines serve to secure routes for existing and future pipelines and submarine cables. Cables carrying electricity 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.

In addition, three transnational power cables are currently in operation in the Baltic Sea EEZ: Baltic Cable, Kontek and the so-called Kriegers Flak Combined Grid Solution. Transnational data cables - usually fibre optic cables for telecommunications - cross the German Baltic Sea in large numbers. In addition, there are also quite a number of decommissioned cables in the seabed that were not removed after they ceased to be used.

Pipelines have different impacts on the marine environment. Power lines primarily affect the protected resources of soil, benthos and fish; here, the potential impacts due to the introduction of hard substrate, turbidity plumes and, for current-carrying cables, operation-related heat emissions and, where applicable, magnetic fields are assessed.

For the assessment of the determinations for pipelines, the following possible impacts are examined:

Table 20: Effects and potential effects due to power lines (t = temporary).

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
Lines Routes for submarine cable systems and pipelines	Placement of hard substrate (riprap)	Habitat modification	x	x					x	x		x						x	
		Habitat and land loss	x	x						x		x	x					x	
	Heat emissions (live cables)	Impairment/displacement of cold-water-loving species	x								x	x							
	Magnetic fields (live cables)	Impairment	x																
		Impairment of the orientation behaviour of individual migratory species		x															
	Turbidity plumes (construction phase)	Impairment	x t	x t	x t				x t					x t					
		Physiological effects and chilling effects		x t															

3.3.1 Floor

PipelinesDuring
installation in the seabed, the formation of a near-bottom turbidity plume as well as small-scale changes in morphology and sediment composition are 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 clearly below those observed 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 natural resuspension of sediments caused by storms.

The formation of undercutting ("freespans") can lead to a change in sediment properties or grain composition, which is, however, spatially limited. Depending on the sand supply and geological structure of the subsoil, these undercutting processes can stabilise or only occur temporarily. In the case of sand deficits, a change in the substrate can occur, e.g. when boulder clay, clover or similar material is temporarily deposited on the seabed.

To protect the pipeline from external corrosion, sacrificial nano-denes of zinc and aluminium are applied at regular intervals, which are only dissolved in small quantities 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 to sinking or resuspended sediment particles and sediment on the seabed.

Submarine cables

The laying of submarine cables generally leads to changes in the soil morphology and the original sediment structure in the cable area as a result of the cable laying and to the formation of a near-bottom turbidity plume. The MSP defines the reservation areas for pipelines LO1 to LO8. Pipelines within the meaning of the MSP include pipelines and submarine cables. Submarine cables include cross-border power lines and connection lines for wind farms as well as data cables. So-called intra-park submarine cables are not included in this definition. In addition, the MSP sets the goal of routing lines at the transition to the territorial sea through the border corridors GO1 to GO5.

Overall, the effects are similar to those of cabling within the park, as described in Chapter 3.2.1 on offshore wind energy.

Due to the construction process, sediment is stirred up and turbidity plumes form when the submarine cables are flushed in. The extent of the resuspension depends mainly on the fine grain content in the sediment. In the 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 their immediate vicinity. The suspension content quickly decreases again to the natural background values due to dilution effects and sedimentation of the stirred-up sediment particles. The expected impairments in areas with a higher proportion of fines and the associated increased turbidity remain limited on a small scale due to the low flow near the bottom.

In areas with soft sediments and correspondingly high fine grain contents (e.g. Ar-kona Basin or Mecklenburg Bay), the released sediment will settle again much more slowly. However, since the near-bottom currents are very low, it can be assumed that the turbidity plumes that occur here will also have a rather localised character and that the sediment will settle again relatively close to the construction site.

In the context of the environmental impact assessment for the Nord Stream Pipeline, the results of the monitoring rings during the construction phase showed only small to medium-scale, temporary impacts due to sediment drift (turbidity plumes) and confirmed the forecasts of the environmental expert (IFAÖ, 2009), who classified the overall impact as a minor structural and functional impairment. Based on these results, it can be assumed that turbidity plumes released during the laying of submarine cables in areas with soft sediments will be at most up to a distance of 500 m above the natural suspended sediment maxima.

Studies by ANDRULEWICZ et al. (2003) also show that the seabed of the Baltic Sea undergoes re-levelling due to natural sediment dynamics along the affected routes. However, various model calculations carried out within the framework of procedures and the experience gained from the procedures show that re-levelling tends to take place in the long term.

When submarine cables are used to transmit energy, the surrounding sediment heats up radially around the cables. The heat emission results from the thermal losses of the submarine cable systems during energy transmission. The laying depth of the cable systems 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 state-of-the-art cable configurations are used.

The potential impacts of the construction and operation of pipelines and submarine cables on soil and land are locally limited and occur independently of the implementation of the plan.

If the plan is not implemented, a less coordinated laying of cables and possibly a larger number or longer cables, especially for submarine cables, would have to be expected. This could lead to a higher land use and thus to an increase in the potential impacts on the protected goods soil and land compared to the implementation of the plan. If the plan is not implemented, an increased number of crossing structures would also have to be expected, which would lead to an increased placement of riprap also in areas with sandy sediments or soft sediments, which could otherwise be avoided.

3.3.2 Benthos and biotope types

With regard to benthos and biotopes, the statements in Chapter 3.2.2apply analogously. If the plan were not implemented, a spatially less coordinated planning of the pipeline systems would have to be expected. In addition, an increased number of pipeline crossings or crossing 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.

Since the provisions of the plan aim to minimise the impact on the seabed by reducing the number of pipeline routes and minimising the number of crossing structures, 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, fish fauna can be temporarily scared away by **noise and vibrations caused by the** use of ships and cranes as well as by the installation of the pipeline systems (see also chapter 3.1.4). Furthermore, construction-related **turbidity plumes** can occur near the bottom and local sediment shifting can take place, which can harm fish, especially spawn and larvae. The ecological effects of turbidity plumes on fish are described in detail in Chapter 3.4.3 The effects on fish in the areas with sediment redistribution are short-term and spatially limited.

Submarine cable

The construction-related adverse effects on fish fauna from submarine cables, as well as from pipelines, are to be expected from **sound emissions and turbidity plumes.** Detailed information can be found in chapters 3.1.4and 3.4.3

Due to the rock fills in the area of the planned pipeline crossings, a **local change in the fish community is** to be expected. A change in the fish community may lead to a change in the dominance ratios and the food web. However, due to the small scale of the planned cable crossing structures, these effects are to be considered minor.

With regard to the possible operational impacts of the submarine cable systems of OWPs, such as **sediment heating and electromagnetic fields,** no significant impacts on fish fauna are to be 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 planned 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 and are significantly below the strength of the natural earth's magnetic field. According to TdV, the magnetic field generated during operation of the Ostwind 2 cable system amounts to a maximum of 20 μT at the seabed surface. In comparison, the natural earth's magnetic field is 30 to 60 μT, depending on the location. The field strength decreases rapidly with increasing distance from the cable. Especially diadromous species, 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 showed no clear results. In the Danish wind farm "Nysted", no behavioural changes of the eel could be recorded (BIO/CONSULT AS, 2004). On the other hand, both WESTERBERG AND LAGENFELT (2008) and GILL AND BARTLETT (2010) recorded short-term changes in their swimming activity. Overall, due to the expected moderate and small-scale change in the magnetic field in the area of the cable, a blockage of the migratory movements of marine fish is unlikely. However, magnetosensitive fish species might avoid the immediate area of the cable.

In the case of the three-wire three-phase cables and bipolar direct current cables planned for the German EEZ, magnetic effects during operation can be neglected or excluded, as the magnetic fields almost cancel each other out. Significant impacts on sensitive fish species are therefore not to be expected.

The objectives and principles for pipelines in the MSP take into account the gentlest possible laying methods, the bundling of pipelines and optimised routing. The impacts on fish fauna are thus likely to be minimised, which would not be the case if the plan were not implemented.

3.3.4 Marine mammals

Pipelines

Marine mammals may be affected during the laying, operation, maintenance and dismantling of pipelines in the sea. These include: Vessel traffic, noise emissions, sediment plumes and pollution. During normal operation, impacts on marine mammals can almost certainly be ruled out. During maintenance work, increased shipping traffic with noise emissions and pollution is possible.

Construction-related: During the laying of pipelines, temporary noise pollution and sediment turbidity plumes occur. The intensity and duration of sound emissions depend mainly on the installation method. Overall, however, disturbances to marine mammals caused by pipe-laying work are small-scale, local and of short duration.

Impacts due to alteration of sediment structure and damage to benthos during installation are in any case negligible for marine mammals. These changes occur on a small scale along the pipeline. Impacts due to long-term changes in sediment structure and benthos are insignificant for marine mammals, as they predominantly forage for prey organisms in the water column in widespread areas.

Direct disturbance of marine mammals at the individual level may occur during the laying and dismantling of pipelines. Impacts from shipping traffic and, in particular, from noise emissions during pipe-laying work are only to be expected on a regional and temporary basis. The formation of sediment plumes is largely expected to be local and temporary. Overall, a loss of habitat for marine mammals at the individual level could only occur locally and for a limited period of time.

Operational: The pipelines laid on the seabed can cause attraction effects on marine mammals, triggered by increased fish occurrence in the area of the pipelines (these in turn can be attracted by benthic organisms settling on the pipelines).

During normal operation, pipelines have no significant impact on marine mammals. In the event of damage to the pipeline or inspection and maintenance work, regional and temporal disturbances due to shipping traffic with noise emissions and pollutant leakage are possible.

Impacts from sediment and benthic changes are insignificant for marine mammals, as they forage for prey organisms predominantly in the water column in widespread areas. Should the benthic species spectrum change along pipelines laid on the seabed, the change would possibly attract fish more strongly. Increased fish abundance could in turn also attract marine mammals.

During normal operation, impacts on the population level are not known. Due to the narrow, linear course of pipelines, negative impacts on the population level can be excluded with certainty.

Non-implementation of the plan would not affect the existing or described impacts of pipelines on harbour porpoise, harbour seal and grey seal.

Submarine cable

Potential impacts on marine mammals during the laying and, in some cases, dismantling of submarine cables are: Shipping traffic, noise emissions and turbidity plumes. Potential operational impacts on marine mammals from the generation of electric and magnetic fields in the immediate vicinity of submarine cables depend on the type of cable.

Construction-related: During the laying of cables, noise emissions occur for a limited period of time, which can potentially cause disturbance to marine mammals. The duration and intensity of sound emissions vary depending on the installation method. However, the effects of noise emissions during installation are local and temporary. The intensity of the impact can vary between medium and high depending on the installation method. This also applies to effects caused by the formation of turbidity plumes. Changes in sediment structure and associated temporary benthic changes have no impact on marine mammals. Marine mammals forage 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 impact on highly mobile animals such as marine mammals.

Overall, no significant impacts are expected from cables used to dissipate energy or from bundling cables in a common route on marine mammals either at individual or population level.

The non-implementation of the plan would not affect the existing or described impacts of submarine cables on harbour porpoise, harbour seals and grey seals.

3.3.5 Seabirds and resting birds

Pipelines

Construction-related*:* During the laying of pipelines, temporary sediment turbidity plumes and local sediment and benthic changes occur. During the laying work, construction-related shipping traffic can cause visual disturbance and trigger shying or avoidance reactions in species sensitive to disturbance.

Overall, potential construction-related impacts are only temporary and local for the duration and immediate area of the relocation.

Operational: Impacts due to sediment and benthic changes are of minor importance for seabirds and resting birds, as they forage for prey organisms mainly in the water column in widespread areas. If the benthic species spectrum were to change along pipelines laid on the seabed, the change would possibly attract fish more strongly. Increased fish abundance could in turn also attract seabirds. During the operational phase, maintenance-related vessel traffic may cause visual disturbance and trigger temporary shying or avoidance reactions in species sensitive to disturbance.

Submarine cable

Construction-related*:* During the laying of submarine cables, temporary sediment turbidity plumes and local sediment and benthic changes occur. During the laying work, construction-related shipping traffic can cause visual disturbance and trigger shying or avoidance reactions in species sensitive to disturbance.

Overall, potential construction-related impacts are only temporary and local for the duration and immediate area of the relocation.

Operational: Impacts due to sediment and benthic changes are of minor importance for seabirds and resting birds, as they mainly search for their prey organisms in the water column in extensive areas. During the operational phase, maintenance-related shipping traffic may cause visual disturbance and trigger temporary shying or avoidance reactions in species sensitive to disturbance.

If the plan were not implemented, there would be less spatial coordination in the planning of pipelines and border corridors. The MSP is based on planning principles that provide for spatial as well as temporal coordination of construction projects in order to minimise impacts on, among others, the marine environment and thus also seabirds and resting birds.

Even if, in principle, similar factors would have an effect on the protected species of seabirds and resting birds both if the MSP were implemented and if it were not implemented, it would be more difficult to ensure the protection of the marine environment and thus of seabirds and resting birds if it were not implemented, due to the lack of planning principles and their coordinating requirements.

3.3.6 Migratory birds

Pipelines

Potential impacts of pipelines on migratory birds are mainly limited to the construction phase. Illuminated construction vehicles can cause attraction effects, which can lead to collisions.

Submarine cable

Potential impacts of pipelines on migratory birds are mainly limited to the construction phase. Illuminated construction vehicles can cause attraction effects, which can lead to collisions.

The potential impacts on migratory birds occur regardless of whether the Plan is not implemented or is implemented.

3.3.7 Bats and bat migration

Potential impacts of power lines on bats are mainly limited to the construction phase. Illuminated construction vehicles can cause attraction effects, which can lead to collisions.

The potential impacts on bats occur regardless of whether the Plan is not implemented or is implemented.

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 cables

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 assets and other material assets

Construction-related impacts from pipelines and submarine cables on underwater cultural heritage depend on the installation methods used. Both flushing and dredging can lead to the destruction of underwater cultural heritage on the seabed. But pipelines resting directly on the bottom can also have corresponding effects. In addition to the direct effects of the installation methods used, indirect effects, e.g. through anchor work or screw water, must also be considered.

3.4 Raw material extraction

The extraction of raw materials from the sea takes place both for commercial purposes and - especially the extraction of stone, gravel and sand - for coastal protection. In addition, large areas, especially in the North Sea, were already occupied with permit fields for the exploration of hydrocarbons. In the German EEZ, these are primarily natural gas deposits. The importance is particularly evident for the Baltic Sea bordering Schleswig-Holstein; here the production volumes at sea clearly exceed those on land.

The Federal Mining Act (BBergG) is the federal law regulating mining law issues and covers, among other things, the exploration and extraction of raw materials. The raw material safeguarding clause of sec. 48 para. 1 sentence 2 BBergG is intended to apply extra-mining regulations of other competent authorities in such a way that the exploration and extraction of raw materials are impaired as little as possible. Furthermore, the BBergG provides in sec. 48 ff. the BBergG also provides regulations 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.

Under sec. 7 BBergG, permits grant the authorised permit holder the exclusive right to explore for mineral resources in a specific field. Under sec. 8 BBergG, permits grant in particular the exclusive right to extract a raw material. The refusal of the permit or authorisation is based on the existence of the grounds specified in sec. 11 or sec. 12 BBergG.

Raw material extraction is regularly divided into different phases during implementation - exploration, development, operation and aftercare phases.

Exploration serves the exploration of raw material deposits according to sec. 4 para. 1 BBergG. In the marine area, it is carried out regularly by means of geophysical surveys, including seismic surveys and exploratory drilling. In the EEZ, the extraction of raw materials includes the extraction (dissolving, releasing), processing, storage and transport of raw materials.

For exploration in the area of the continental shelf, mining permits (permission, authorisation) must be obtained in accordance with the Federal Mining Act. 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. sec. 51 BBergG). For the establishment and management of an operation, main operating plans must be drawn up for a period not exceeding 2 years as a rule, and must be continuously renewed as required (sec. 52 para. 1 sentence 1 BBergG).

In the case of mining projects that require an EIA, the preparation of an outline operating plan is obligatory, for the approval of which a plan approval procedure must be carried out (sec. 52 para. 2a BBergG). Framework operating plans are usually valid for a period of 10 to 30 years. Marine sand and gravel extraction on extraction areas of more than 25 ha or in a designated nature conservation area or Natura 2000 site require an EIA according to sec. 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-Western Pomerania, the fields Adlergrund Nord, Adlergrund Nordost and Adlergrund Südwest were approved for sand and gravel extraction in the EEZ during the planning period 2004 to 2009. These permits were partly based on extraction rights from the time before the reunification of Germany. Even at the beginning of the planning process, the main operating plan approvals for these areas had expired, so that no more extraction took place. The permit for Adlergrund Nordost runs until 2020, the permits for the two fields Adlergrund Nord and Südwest expired in 1991.

In the period 2009 to 2019, there has been no approval of new permit or authorisation fields for sand and gravel mining or hydrocarbons in the German EEZ of the Baltic Sea.

As part of the procedure for the construction of the Fehmarnbelt tunnel, a permit (Feste Fehmarnbeltquerung) was granted for the extraction of sand and gravel in the coastal sea of Schleswig-Holstein and in the adjacent EEZ (source: LBEG).

In the Adlergrund, only the Adlergrund Nordost permit (responsibility of the Stralsund Mining Authority) has been granted, which is valid until 31 December 2040. Three permit 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 protected goods.

Table 21: Effects and potential effects of raw material extraction (t= temporary).

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
Raw materials Sand and gravel mining / Seismic surveys	Substrate removal	Habitat modification	x	x			x		x	x	x	x						x	
		Habitat and land loss	x	x			x		x	x	x	x	x					x	
	Turbidity plumes	Impairment	x t	x t	x t				x t					x t					
		Physiological effects and chilling effects		x t															
	Physical disorder	Impact on the seabed	x							x		x	x					x	
	Underwater sound during seismic surveys	Impairment / scare effect		x t			x												
	Visual restlessness	Impairment/ scarecrow effect			x														

Potential temporary impacts result from underwater sound during seismic surveys and from turbidity plumes during resource extraction and may result in disturbance and scouring effects. Potential permanent impacts from substrate extraction and physical disturbance involve habitat and area loss, habitat modification and seabed disturbance.

3.4.1 Floor

Sand and gravel extraction

There is currently no sand and gravel extraction in the German Baltic Sea EEZ. There is a permit for the area Adlergrund Nordost according to sec. 8 BBergG (SKO1).

Generally, gravel sands and sands are extracted over a large area using a suction trailer hopper dredger. In this process, a suction dredger with a trailing head of usually 2 m width passes over the extraction field several times for technical and navigational reasons until the maximum permissible extraction depth is reached. As a rule, about 2 to 4 m wide furrows are created between which unstressed seabed remains. A residual thickness of recoverable sediment must be preserved in order to maintain the original substrate for recolonisation. In the case of selective sediment extraction, the gravel sands are screened on board and the unused fraction (sand or gravel) is returned to site.

Due to the described mining technique, a relief of multiple crossing furrows and original seabed is created on the seabed. This topographical and morphological change affects the near-bottom current pattern.

The extent of the turbidity plumes that arise during material recirculation depends on the grain size and the quantity of the recirculated material as well as the current and its directional stability. Due to the low current 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, a sorting of the refluxed grain mixture takes place: the coarse fractions are deposited first, which are largely covered by the finer particles. In the further course, a progressive sorting occurs as the finer sands are redeposited by the natural sediment dynamics; the coarser sand fraction remains in the area of the backflow and undergoes less redeposition (ZEILER et al. 2004, DIESING, 2003).

In principle, the original substrate should be preserved by surface mining, provided that the thickness of the sands, gravel sands and gravels that can be mined is sufficient. Selective extraction leads to a change in the substrate; depending on the recycled fraction, a refinement or coarsening of the original sediment type 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, a trap effect of the furrows occurs, in which redeposited, usually finer-grained sand accumulates and permanently changes the substrate (BOYD et al., 2004; ZEILER et al., 2004). The substrate change can alter some of the physicochemical parameters. A change in the grain composition results in different penetration depths of oxygen. This is consumed during the aerobic decomposition of organic matter, whereby the sediments worthy of decomposition generally carry only a very low proportion of organic matter. Due to the low load of pollutants and the low impact on the physicochemical parameters that play a decisive role in the mobilisation of pollutants, no significant release of pollutants from the sediment can be assumed.

Extraction of hydrocarbons

Currently, there is no production of hydrocarbons in the Baltic Sea EEZ. Three permit fields have been approved for the exploration of hydrocarbons in the territorial sea: Oderbank, Plantagenet KW and Ribnitz. Each of these extends from the territorial sea into the EEZ.

In general, the following impacts on the protected resource soil are to be expected (planning approval decision of the Clausthal-Zellerfeld Upper Mining Authority; now LBEG - State Office for Mining, Energy and Geology):

Construction-related: The discharge of cuttings/drilling fluid may result in impacts due to load-related compaction and material changes in the sediments. During the discharge of cuttings/drilling fluid, turbidity may occur for a limited period of time.

Installation-related: Impacts may occur in the form of foundation-related compaction of the seabed, pollution from coatings and changes in the flow conditions caused by the platform.

Operational: Corrosion coatings, sheathing materials, sacrificial anodes used for corrosion protection may release pollutants. The discharge of production water and waste water from the sewage treatment plant can lead to effects on the water and sediment.

In addition, long-term seabed subsidence of the order of several metres is to be expected as a consequence of the extraction of natural gas deposits, which has been described or predicted for Norwegian and Dutch oil and gas fields (FLUIT AND HULSCHER, 2002; MES, 1990; SULAK AND DANIELSEN, 1989).

The effects described would exist both if the plan were implemented and if it were not, as the extraction of raw materials is approved and monitored by the competent authority (Stralsund Mining Authority). However, by defining reservation areas, the use of raw material extraction will be given more importance in future in spatial planning considerations. An impact on the soil as an object of protection in the reservation areas is therefore more likely if the plan is implemented than if it is not implemented.

3.4.2 Benthos and biotope types

The following remarks are limited to the impacts of the uses on benthic communities. Since biotopes are the habitats of a regularly recurring community of species, impairments of the biotopes have direct effects 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 the marine benthos:

Substrate removal and alteration of soil topography. The most serious ecological impact of sand and gravel extraction is the reduction of the invertebrate or epifauna. The aspects of settlement density and biomass of benthic organisms are usually more affected than the number of species. In Dutch studies by MOORSEL AND WAARDENBURG (1990, 1991, currently ICES WGEXT 1998), settlement density was reduced by 70 % and biomass by 80 % immediately after extraction, while species numbers were reduced by only 30 %. Depending on the intensity and duration of the change in environmental conditions and sediment character, as well as the spatial distance for migrating species, the regeneration of the benthic fauna can take periods ranging from one month to 15 years or more (HERRMANN and KRAUSE, 2000). Recolonisation depends not only on physical factors such as water depth, current and sea state as well as sedimentological parameters, but also on species composition. It is particularly important that the sediment character has not been changed by dredging. In general, the recolonisation process can be divided into three phases (HERRMANN and KRAUSE, 2000):

- *Phase I*: Rapid recolonisation by species that were also dominant before degradation (predominantly opportunistic species); species and individual numbers increase rapidly and can sometimes reach the initial level after a short time; biomass, however, remains low.
- *Phase II*: Biomass remains significantly reduced over a longer period of time (several months to years). This may be caused by the loss of older year classes of long-lived species (e.g. bivalves such as *Mya arenaria, Cerastoderma* spp. and *Macoma balthica*) or the impediment of recolonisation due to the continued rearrangement of sediments disturbed by degradation.
- *Phase III*: The biomass increases markedly, the zoos regenerate completely.

  Very long-lasting changes in the benthic communities are observed in quarrying areas where a different sediment remains after dredging. The result is a permanent change in the bottom fauna, often towards soft bottom communities (HYGUM, 1993 cited in HERRMANN and KRAUSE, 2000). In certain cases, a permanent change from soft to hard soils with corresponding faunal change may also occur (HERRMANN and KRAUSE, 2000). According to ICES (2016), the recolonisation process is supported if the substrate after removal has comparable properties to the substrate before removal.

No concrete information is available on the SKO1 area. However, for the comparable gravel sand storage area "OAM III" in the EEZ of the North Sea, which is also located in a nature reserve, the environmental monitoring showed that the previous extraction activities have not led to any fundamental change in the sediment structure or composition in the extraction area. The abundance and species structure of the macroinvertebrates in the extraction and reference areas showed no statistically significant differences. Only the total biomass was statistically significantly lower in the extraction area than in the reference area, as expected (IFAÖ, 2019). Overall, the studies show that the original substrate could be preserved in the area and that there is a regenerative capacity, especially for species-rich gravel, coarse sand and shingle beds.

Change in hydrographic conditions. The change in bottom topography can cause changes in hydrographic conditions and thus also in water exchange and sediment transport. As a result of changes in bathymetry, there may be a local decrease in flow velocity, leading to deposition of fine sediments and local oxygen deficiencies (NORDEN ANDERSEN et al., 1992). This can be associated with consequences for the bottom fauna. According to GOSSELCK et al. (1996), although no effects on large-scale flow conditions are to be expected from sand and gravel extraction, small- and meso-scale changes must be considered.

Turbidity plumes. *Turbidity plumes* can essentially arise at three points in the degradation process (HERRMANN and KRAUSE, 2000):

- Due to the mechanical disturbance of the sediment in the seabed by the dredge head
- The overflow water flowing back from the dredger into the sea
- The dumping of unwanted sediment fractions (screening).

Although increased turbidity can be observed up to several hundred metres away from the dredge, and in individual cases can even be detected several kilometres away, the concentration of suspended material usually decreases very rapidly with distance (HERRMANN AND KRAUSE, 2000). A short-term occurrence of elevated concentrations of suspended matter does not appear to be harmful to adult mussels. The growth of filter-feeding mussels may even be promoted. However, eggs and larvae of a species generally react more sensitively than adults.

Although the concentration of suspended particles can reach levels that are harmful to certain organisms, the impact on marine organisms is considered to be relatively low, since such concentrations occur only spatially and temporally and are quickly degraded 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 can 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 increased by a factor of 3 to 100 (HYGUM, 1993). With regard to nutrient levels, increases were measured up to a distance of 180 m behind the dredger, with the highest concentrations registered 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 impacts are generally considered to be relatively low, as the commercially used sands and gravels usually have a low content of organic and clay components and thus hardly show any chemical interactions with the water column. Furthermore, the degradation activities are limited in time and space. In addition, waves and currents quickly dilute any increases in the concentration of nutrients and pollutants that may occur (ICES, 1992; ICES WGEXT, 1998).

Sedimentation and over-sanding: The dispersal of sediment particles is highly dependent on the content of fine constituents and the hydrographic situation (especially sea state, current) (Herrmann and Krause, 2000). Drifting of suspended particles could be demonstrated in some cases up to 1,000 m from the dredging site. However, most of the material sediments at the extraction site or in its immediate vicinity. Furthermore, studies by Kenny and Rees (1996) showed that sediments once disturbed by dredging can remain more easily mobile by tides and waves for a longer period of time. Such a degradation-induced increase in sediment mobility can also lead to over-sanding and impaired development of benthic organisms.

The practice of "screening" (dumping of unwanted sediment fractions) can also lead to a change in the bottom substrate towards mobile sand areas. The effects of sediment fallout from vessel spill on the benthic communities of areas not directly affected by dredging can vary widely. The following possibilities have been observed in previous studies (ICES, 1992):

- Initially, as in the dredging area, an almost complete die-off of the benthic fauna, but the subsequent recolonisation is faster.
- The benthic fauna is damaged, but less severely than in the quarrying area, and subsequent recolonisation is faster.
- Species diversity and abundance are promoted in the sedimentation area.
- The impact is insignificant.

The main risk of sedimentation is the burial of sessile benthic organisms such as mussels and polychaetes. In addition, crustaceans such as lobsters may lose their habitat if the burrows and crevices they inhabit are buried. The edible crab, which is immobile during reproduction, is also at risk of burial and suffocation (ICES, 1992).

In summary, the main impacts of sand and gravel extraction on the 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 remobilisation of chemical substances
- Temporary (short-term) and regional (small-scale) developmental impairments, possibly also loss of individuals of benthic organisms due to sedimentation and over-sanding.

<u>Indirect effects:</u>

- Temporary (short-term) and regional (small-scale) loss of settlement habitat for benthic organisms due to substrate removal, if sediment character is not altered by dredging.
- Permanent and regional (local) loss of settlement space due to possible changes in hydrographic conditions.
- Temporary (short-term) and regional (small-scale) influence on the food supply for benthic organisms through impairment of primary production (phyto- and zooplankton) due to remobilisation of chemical substances.

Extraction of hydrocarbons

Currently, no hydrocarbon production takes place in the Baltic Sea EEZ. Three permit fields are approved for the exploration of hydrocarbons in the territorial sea: Oderbank, Plantagenet KW and Ribnitz. Each of these extends from the territorial sea into the EEZ.

The conceivable impacts on benthic communities caused by offshore platforms for the extraction of hydrocarbons can be divided into three areas. These include construction- and installation-related effects as well as operational effects.

The construction and installation-related impacts can largely be taken from Chapter 3.2.2 on offshore wind energy.

In summary, the main impacts of hydrocarbon extraction on marine benthos are as follows:

<u>Direct effects:</u>

- Small-scale and short-term habitat loss for the duration of foundation installation due to sediment stirring and turbidity plumes.
- Short-term and small-scale damage to individuals, eggs and larvae of benthic organisms due to turbidity plumes.

- Short-term and small-scale impairment of benthic organisms due to possible remobilisation of chemical substances.
- Small-scale and permanent loss of settlement space due to the piers of the platform because of the land use.
- Small-scale and permanent supply of artificial hard substrate due to the layout of the platform.
- Small-scale and permanent change in sediment parameters due to the installation of the platform.

Indirect effects:

Short-term and small-scale influence on the food supply for benthic organisms through impairment of primary production (phyto- and zooplankton) due to possible remobilisation of chemical substances.

The non-implementation of the plan would have no influence on the existing or described impacts of raw material extraction on the benthos and biotope types.

3.4.3 Fish

Sand and gravel extraction

The extraction of sand and gravel in the Baltic Sea can alter habitats and mean a loss of habitat for fish fauna. In addition, substrate extraction results in turbidity plumes with associated sedimentation and resuspension of sediment particles, which can affect fish fauna.

During the removal of substrates, fish are usually scared away from their habitat. Loss **of area depends on the** geological composition of the removed material. A change in sediment type after removal may make recolonisation difficult for some species. Impacts are local and are not expected to be significant for the fish community. Fish themselves will be indirectly affected by the loss of food resources, as sand and gravel extraction will result in a reduction of invertebrate invertebrate and epifauna in the area.

Sand and gravel mining also creates **sediment swirls and turbidity plumes, which** - albeit temporary and species-specific - can cause physiological impairments and entanglement. Predators that hunt in open water, such as mackerel and wood mackerel, avoid areas with high sediment loads and thus avoid the danger of adhesion of the gill apparatus (Ehrich & Stransky, 1999). A threat to these species as a result of sediment turbulence does not appear likely due to their high mobility. A negative impact on bottom-dwelling fish is also not to be expected due to their good swimming characteristics and the associated possibilities for evasion. In plaice and sole, increased foraging activity has even been observed after storm-induced sediment turbulence (EHRICH et al., 1998). In principle, however, fish can avoid disturbances due to their well-developed sensory abilities (lateral line organ) and their high 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 not very well developed, are generally more sensitive than adult conspecifics. After fertilisation, fish eggs develop a dermis that makes them robust to mechanical stimuli, e.g. to swirling sediments. Although the concentration of suspended particles can reach levels that are harmful to certain organisms, the effects on fish are considered to be relatively low, as such concentrations occur only spatially and temporally and are quickly degraded again by dilution and distribution effects (HERRMANN & KRAUSE, 2000).

This also applies to possible increases in concentrations of nutrients and pollutants due to the **resuspension of** sediment particles (ICES, 1992; ICES WGEXT, 1998). Resuspension of sediment particles can lead to the release of chemical compounds such as nutrients and heavy metals. Oxygen levels may decrease when organic matter is brought into solution (HERRMANN & Krause, 2000). The chemical impacts are generally considered to be relatively low for the Baltic Sea, as the commercially used sands and gravels usually have a low content of organic and clay components and thus show hardly any chemical interactions with the water column.

During **sedimentation of** the released substrate, the main risk is coverage of fish spawn deposited on the bottom. This can result in an undersupply of oxygen to the eggs and, depending on the degree of effectiveness and duration, can lead to damage or even death of the spawn. For most fish species occurring in the EEZ, spawning damage is not to be expected, as they either have pelagic eggs and/or spawn in shallow water outside the EEZ. The early life stages may also be adapted to turbulence, which is a regular occurrence in the Baltic Sea as a result of natural phenomena such as storms or currents. The above-mentioned impacts of resource extraction on fish fauna occur independently of the non-implementation or implementation of the plan.

Extraction of hydrocarbons

Production platforms are erected for the extraction of hydrocarbons, which can affect the fish community during the construction and operation phases.
During seismic surveys and exploration drilling of the natural gas fields, as well as during platform construction, there are increased sound emissions. The effects of sound on fish are described in detail in Chapter 3.2.3 Construction-related sediment turbulence, turbidity plumes and resuspension of sediment particles can affect fish locally and in the short term, as already described for sand and gravel extraction. Due to the construction-related impairments, short-term and small-scale scaring effects for fish may therefore occur.

The impacts caused by the foundation of the platform are comparable to those of offshore wind turbines. There is a permanent loss of habitat for demersal fish species and their food base, the macrozoobenthos, in the area of the foundations.

Furthermore, the newly introduced substrate changes the structure of the seabed in the Baltic Sea. Detailed information on the effects of newly introduced structures on fish fauna is described in Chapter 3.2.3

Effects due to the escape of pollutants in the event of an accident cannot be ruled out and can be considerable.

The above-mentioned impacts of natural gas extraction on fish fauna occur independently of the non-implementation or implementation of the plan.

3.4.4 Marine mammals

Sand and gravel extraction

Sand and gravel extraction may cause sediment plumes and sediment alteration, with associated damage or alteration to benthic communities. Temporary impacts on marine mammals due to noise emissions from the vehicles involved in the extraction would also be expected. In particular, turbidity plumes and changes in sediment structure and benthos may impact on the quality of habitat for marine mammals. However, these are local and temporary and thus any disturbance would be insignificant.

Non-implementation of the plan would not affect the existing or described impacts of sand and gravel extraction on harbour porpoise, harbour seal and grey seal.

Extraction of hydrocarbons

Possible impacts on marine mammals from the construction and operation of offshore platforms for the extraction of natural gas may be caused by vessel traffic, noise emissions, pollution from pollutant spills and sediment plumes. During normal operation, sediment and benthic changes are to be expected from platforms. Attraction effects on fish caused by changes in the composition of the 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 may be released into the marine environment, which may lead to contamination of marine mammals.

Direct disturbance of marine mammals at the individual level can only occur during the construction phase of gas production platforms. However, impacts from shipping traffic and especially from noise emissions during the construction phase are only to be expected regionally and for a limited period of time. The formation of sediment plumes is largely to be expected only 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 state of the art measures. Impacts due to pollutant leakage in the event of a malfunction or accident cannot be ruled out. These would predominantly occur selectively.

Non-implementation of the plan would not affect the existing or described impacts of carbon extraction on harbour porpoise and harbour seal and grey seal.

3.4.5 Seabirds and resting birds

Sand and gravel extraction

For seabirds, the extraction of sand and gravel can lead to temporary impacts, mainly through turbidity plumes and visual disturbance caused by shipping traffic. Indirectly, sediment changes and associated changes in benthic communities can affect seabirds and resting birds through the food chain. These impacts are generally weak for seabirds and resting birds, as the birds forage for their prey organisms predominantly in the water column in widespread areas.

The direct impact of turbidity plumes on seabirds varies according to species and feeding strategy. Moreover, the turbidity plumes only lead to local water turbidity.

Shipping traffic during mining operations can lead to avoidance behaviour and thus a temporary loss of habitat for species sensitive to disturbance.

Overall, impacts on seabirds and shorebirds due to shipping traffic and the formation of turbidity plumes as a result of dredging are regional and limited to the duration of the extraction work.

The above-mentioned impacts on seabirds and resting birds occur independently of the non-implementation or implementation of the plan.

Extraction of hydrocarbons

For seabirds and resting birds, the construction and operation of hydrocarbon extraction facilities may potentially result in impacts from 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 altered 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). In the event of accidents, pollutants and oil can be released into the marine environment, which can also result in contamination of seabirds. Depending on the technical implementation of hydrocarbon extraction, there may be plant-related impacts comparable to those of offshore wind energy (see Chapter 3.2.5).

Impacts from use-related shipping traffic are to be expected above all for species sensitive to disturbance, such as divers, but have only a regional and temporary effect.

The formation of sediment plumes is largely to be expected only locally and also for a limited period of time.

Impacts due to sediment and benthic changes are generally weak for seabirds, as they predominantly search for their prey organisms in the water column in widespread areas.

According to current knowledge, the impacts on seabirds and resting birds caused by the extraction of hydrocarbons 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 impacts on seabirds and resting birds occur independently of the non-implementation or implementation of the plan.

3.4.6 Migratory birds

Sand and gravel extraction

Effects of sand and gravel extraction on migratory birds may exist to a minor extent due to attraction effects of the illuminated extraction vehicles. These can be particularly effective at night in poor visibility and weather conditions, which can lead to collisions.

The above-mentioned impacts on migratory birds occur independently of the non-implementation or implementation of the plan.

Extraction of hydrocarbons

The extraction of hydrocarbons can lead to attraction effects from illuminated structures. Depending on the technical implementation of hydrocarbon extraction, there may be plant-related effects comparable to those of offshore wind energy (see Chapter 3.2.7).

The above-mentioned impacts on migratory birds occur independently of the non-implementation or implementation of the plan.

3.4.7 Bats

Sand and gravel extraction

Effects of sand and gravel extraction on bats may exist to a minor extent due to attraction effects of the illuminated extraction vehicles.

The above-mentioned impacts on bats occur regardless of whether the plan is not implemented or is implemented.

Extraction of hydrocarbons

The extraction of hydrocarbons can lead to attraction effects from illuminated structures. Depending on the technical implementation of hydrocarbon extraction, there may be plant-related effects comparable to those of offshore wind energy (see Chapter 3.2.7).

The above-mentioned impacts on bats occur regardless of whether the plan is not implemented or is implemented.

3.4.8 Air

Sand and gravel extraction

Shipping traffic associated with sand and gravel extraction will result in pollutant emissions that may affect air quality. Significant adverse impacts on air quality are not expected.

Extraction of hydrocarbons

There are emissions associated with the extraction of hydrocarbons that can affect air quality. In particular, emissions come from the shipping traffic associated with offshore activities (e.g. utilities), drilling activities, construction activities (e.g. driving foundation piles) and from the operation of the production platforms. The operation of the platforms emits e.g. carbon dioxide, nitrogen oxides and volatile organic compounds including methane. Significant adverse impacts on air quality are not expected.

3.4.9 Cultural assets and other tangible assets

In principle, large-scale intervention in the seabed, for example dredging for sand and gravel extraction, increases the probability of encountering archaeological traces. The primary risk here is completely covered, previously unknown wrecks and prehistoric sites. In addition, dredging can influence currents and thus lead to local erosion, which successively covers and eventually destroys new archaeological sites (cf. Gosselck et al., 1996).

The same applies to the removal of stone material, which was practised as nearshore stone fishing as early as 1840-1930 and to depths of 6-12 m in 1930-1976 (Bock et al., 2003). Besides the change in flow and erosion conditions, wrecks can also be directly affected when the ballast stones above a wreck site are removed.

3.5 Fisheries and aquaculture

Traditionally, the entire EEZ in the North Sea and Baltic Sea is used for fishing. In the Baltic Sea, coastal fishing and cutter fishing are the main activities. The larger cutters (18 - 24 m) are mainly active in trawling for herring and cod, while the much larger small-scale cutter fishery mainly uses gillnets, fish traps and fishing rods. In addition to German fishermen, Polish and Danish fishermen are also active in German waters, mostly with larger vessels.

The number of businesses is declining sharply; in 2019, around 300 full-time and around 500 part-time cutters were still operating in Schleswig-Holstein and Mecklenburg-Western Pomerania. This development is promoted by greatly reduced quotas for the most important target species, cod and herring, whose stocks are partly endangered by overfishing, but also by climatic influences.

Aquaculture

Currently, no specific aquaculture projects are planned in the German EEZ of the North Sea and the Baltic Sea. However, in order to keep options open for such marine use in the future, the maritime spatial plan contains a general definition of possible facilities in the vicinity of offshore wind energy plants, but without a specific spatial definition. Unlike for the North Sea, there are also no assessments of possible suitability areas for aquaculture in the EEZ.

For the EEZ, however, due to the greater distance from the coast and for ecological reasons, cultivation of extractive species such as mussels or algae and relatively extensive management are assumed. The joint use of infrastructure for the operation of the respective wind farm is considered desirable (ships, transfer of people, etc.). However, site conditions and impacts have already been investigated for the Schleswig-Holstein coastal sea: An overview of possible natural influencing factors with regard to possible sites, as well as potential impacts of turbines on the environment, can be found in a concept study commissioned by the MELUND Schleswig-Holstein (Haas S. et.al., 2015).

The following potential impacts may occur from fishing exploitation of the EEZ, as well as from aquaculture of extractive species:

Table 22: Effects and potential effects of fisheries and aquaculture (t= temporary).

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
Fishing	Removal of selected species	Reduction of stocks	x	x							x								
		Degradation of the food base			x														
	Bycatch	Reduction of stocks	x	x	x		x				x								
	Physical disturbance by trawls	Impairment/ Damage	x	x			x			x		x						x	
Aquaculture	Introduction of nutrients	Impairment	x	x					x					x					
	Bringing in fixed installations	Habitat modification	x	x					x	x	x								x
		Habitat and land loss	x	x	x					x			x					x	x
	Introduction and spread of invasive species	Change in species composition	x	x	x				x		x								
	Insertion of medicines	Impairment	x	x										x			x		
	Removal from wild stocks	Impairment	x	x															
	Attraction/shying effects	Attraction / scare effect		x	x		x												

3.5.1 Floor

Fishing

Trawls and bottom-set gillnets are used for fishing purposes in the Baltic Sea EEZ. The otter boards of bottom trawls usually penetrate the sandy to silty seabed of the Baltic Sea to a depth of a few millimetres to centimetres. This temporally and spatially variable intrusion is subject to relatively rapid regeneration in the course of the natural sediment dynamics on the sandy seabed, so that the trawl marks usually disappear within a few days to weeks. In greater water depths, especially in the Baltic Sea basins, the relatively deep drag marks remain for long periods due to the low sediment dynamics.

The near-bottom formation of turbidity plumes and possible release of pollutants from the sandy sediments is negligible in areas with relatively low fine grain content (silt and clay) and low heavy metal concentrations. In the area of silty seabeds, a significant release of pollutants from the sediment into the bottom water may occur. The pollutants usually adhere to sinking particles which, due to the low currents in the Baltic Sea basins, are hardly drifted over larger distances and remain in their native environment. An exception are individual events such as saltwater intrusions over the Danish Belts and Sunds, which can laterally transport near-bottom turbidity under certain conditions and for a limited period of time. In the long term, this remobilised material is deposited again in the muddy basins.

The impacts on soil as a protected resource are independent of the non-implementation or implementation of the plan.

Aquaculture

Currently, there are no concrete plans regarding co-use of aquaculture in the EEZ of the North Sea and Baltic Sea.

Depending on the type of aquaculture, nutrients and solids may enter the seabed directly or indirectly via the water column through feed or the excretions of the cultures used. Further adverse effects are to be expected from the preventive or treatment use of medicines and other chemical substances for various purposes. All of the substances introduced can lead directly or indirectly via the water column to pollutant loads or to an increased input of organic substances into the seabed. The extent of the impact on the seabed will depend on the type and intensity of aquaculture.

The preconditions for marine aquaculture are to be examined at downstream planning levels. The described impacts of aquaculture on soil as a protected resource therefore arise independently of the non-implementation or implementation of the plan.

3.5.2 Benthos and biotope types

Fishing

Fishing for demersal fish species is important for the 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 sandy bottoms the observed penetration depth of the boards is less than 5 cm, on silty bottoms the tracks have depths of up to 23 cm (WEBER AND BAGGE, 1996). The influences of bottom trawling on the seabed and its living inhabitants have been little studied overall. Ultimately, fishing activities can kill off organisms of the epi- and endobenthos due to the mechanical stress, or they are removed from the system and usually returned overboard damaged. For the Baltic Sea, the destruction of the Icelandic mussel *Arctica islandica* by the otter boards is discussed by several authors. According to RUMOHR & Krost (1991), thin-shelled and large mussels are most affected. The most frequent damage is found on the fragile white pepper clam *Syndosmya alba*, but large specimens of the Iceland clam are also destroyed by the shearboards to about 50 %.

The degree of damage depends not only on the type of sediment 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 separated into short-term and long-term effects (WEBER et al., 1990):

- Short-term consequences: Some of the animals exposed by the fishing gear are 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 dab are more numerous and more voracious in the tow than in the surrounding area.
- Long-term consequences: Fishing activities increase the mortality of sensitive species until only opportunists can exist. Diversity, a measure of species abundance, decreases at the same time. Abundance increases for those species that are not harmed by fishing gear as the sensitive species disappear from the biotope. Organic matter production may increase first as the older, slow-growing

specimens are replaced by fast-growing, young specimens. As trawla activity increases, the younger animals will then also die, so that production decreases.

In summary, the main impacts of fishing on marine macrozoobenthos are as follows:

- Loss of individuals, especially of long-lived and sensitive species, due to fishing gear
- Reduction of sessile epifauna
- Decrease in biodiversity
- Shift in the size spectrum of the soil fauna
- Habitat levelling by fishing away stones.

Aquaculture

Aquaculture involves the production of fish, crustaceans (shrimp), molluscs (mussels) and algae under controlled conditions in dedicated facilities in saline or brackish water. Mariculture is a growing market worldwide. There is currently no mariculture in the German EEZ of the North Sea. Only in the coastal waters of the North Sea are mussels kept in largely protected locations.

Larger amounts of nutrients can be released from aquaculture facilities, e.g. net cage facilities for rearing fish, depending on the species reared, as not all nutrients fed in fish cultures are converted into biomass. In addition to the soluble excretory products of farming, solids can be distributed in the water column and lead to a constant increase in nutrient concentrations in the vicinity of cage facilities and benthic habitats. Since microalgae cannot convert the nutrient supply in time, excreted solids and uneaten food pellets could therefore accumulate under the cages (depending on the current), possibly causing local eutrophication effects (WALTER et al., 2003). Due to the microbial degradation of the substances, there is a risk of oxygen deficiency situations and thus an impairment of the benthic habitats.

Intensive farming of fish in aquaculture requires the use of medicines to prevent and treat diseases to which mass cultures are particularly susceptible. Apart from veterinary substances, disinfectants and antifouling agents are also used in aquaculture (WALTER et al., 2003). The substances introduced into the system can lead to pollutant loads in the water column and sediments.

Bivalve cultures can also have impacts on the taxonomic and functional diversity of benthic communities and biogeochemical processes through biodeposition of faeces or pseudofaeces (LACOSTE et al., 2020). These impacts vary depending on the species harboured and are also variable over time. Possible ecosystem impacts, for example through attraction, avoidance effects and food web interactions, cannot be ruled out, but have so far been insufficiently studied (LACOSTE et al., 2020).

Often the species cultivated in aquaculture are not native species. If such cultured organisms escape, there is a risk that they will spread. An example of this is the Pacific oyster, which was introduced into German waters through aquaculture.

However, the escape of native species from farms may also endanger the environment. In addition, parasites from aquaculture facilities can also enter the marine environment (WALTER et al., 2003).

The above-mentioned impacts of aquaculture on benthos and biotopes occur independently of the non-implementation or implementation of the plan.

3.5.3 Fish

Fishing

The fishery in the entire Baltic Sea comprises about 5300 vessels and is concentrated on 17 fish stocks of 9 different species (ICES, 2019). The main target species are cod, herring and sprat. The flatfish fishery in the German EEZ targets, among others, the fish species plaice, flounder, turbot or brill. When fishing, not only heavy bottom gears are often towed, but also relatively small meshes are used, as a result of which the bycatch 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 fundamental problem is the excessive fishing effort and the overfishing of some stocks (see also Chapter 2.7.3 Prior exposure). Negative to critical stock development is a major problem in the Baltic Sea, as is the by-catch of juvenile yearlings, because this deprives the stocks of their future reproductive potential. As a result, commercial fish stocks in the Baltic Sea often do not have their full reproductive potential. In addition to the direct mortality of target species, non-targeted bycatch species are potentially at risk from fishing. In addition, demersal fishing has a negative impact on invertebrates, which serve as an important food source for many bony and cartilaginous fish.

Another effect of intensive fishing is the change in the age and length structure of the fish due to size-selective fishing methods. Primarily larger older individuals are taken, so that the proportion of smaller younger individuals in the fish community increasingly predominates. This change in the fish community probably has consequences above all for the reproduction of fish stocks. In general, small fish produce fewer and smaller eggs than their larger counterparts. Their fry are also more sensitive to a variable environment and may be subject to increased mortality (TRIPPEL et al., 1997). This impact of fishing can lead to population declines and changes within the community (such as dominance relationships).

In addition to the direct impacts of fishing, the discharge of marine litter can lead to indirect negative impacts on fish fauna.

The above-mentioned impacts of fishing on fish fauna occur regardless of whether the plan is not implemented or is implemented.

Aquaculture

The implementation of co-use, e.g. which species are kept in which stocking densities, has not been specified at the present time and must be regulated at subsequent planning levels, taking into account the special features of the project area. Suitable aquaculture sites could primarily be the OWPs closer to the coast, as costs and effort increase with increasing distance from the coast.

In general, aquaculture can reduce fishing pressure on some wild fish stocks. Avoiding the use of juvenile fish from wild stocks is crucial here. Adverse effects of marine aquaculture on fish fauna can come in particular from the introduction of diseases and invasive species, as well as from the increase in nutrients and pollutants.

In the case of disease outbreaks, parasites and pathogens can lead to an increased risk of transmission to natural stocks in the surrounding water close to the plant. The escape of cultured organisms is also problematic; if they mix with natural conspecifics and participate in reproduction, genetic diversity can be endangered (WALTER et al., 2003). If alien fish species escape and are able to establish themselves, native fish species can be displaced. Stocking of net cages for fish rearing should therefore only be done with native species.

A further impairment can come from the input of nutrients and pollutants. Intensive feeding, especially when fish are reared in net cages, increases the nutrient concentration and can pollute the seabed with organic load. These environmental impacts could be reduced with an adapted stocking density and a more extensive distribution of net cages in the area (HUBOLD & KLEPPER, 2013). Exposure to medicines or other environmental chemicals (e.g. anti-fouling) could also be reduced in this way. In general, a tolerable level of nutrients and pollutants should enter the marine environment through aquaculture in order to exclude significant impacts on wild stocks of fish fauna.

The above-mentioned preconditions for marine aquaculture are to be examined at downstream planning levels. The above-mentioned impacts of aquaculture on fish fauna therefore arise independently of the non-implementation or implementation of the plan.

3.5.4 Marine mammals

Fishing

In the Baltic Sea, bottom-set nets are used by fisheries due to the bottom conditions. The main threat to harbour porpoises in the Baltic Sea is unwanted bycatch in nets (ASCOBANS, 2003; Evans, 2020; ICES, 2020).

The non-implementation of the plan would not affect the existing or described impacts of fishing on harbour porpoise, harbour seal and grey seal.

Aquaculture

Marine mammals would be affected indirectly via water quality degradation and food chains in the case of mariculture establishment: contaminants, especially growth hormone preparations and antibiotics, could affect the immune system of marine mammals. Changes in the lowest part of the food chains could affect the entire food chains and thus upper predators, such as marine mammals.

It cannot be ruled out that seal deterrence measures, which are often used in fish aquaculture operations, would also have a disturbance effect on the harbour porpoise population.

According to current knowledge and due to a lack of concrete planning, it is not possible to assess impacts from aquaculture in the EEZ.

Non-implementation of the plan would not affect the existing or described impacts of mariculture on harbour porpoise, harbour seal and grey seal.

3.5.5 Seabirds and resting birds

Fishing

Fisheries influence the occurrence of seabirds. Discards of bycatch from fishing activities provide additional food sources for some seabird species. This creates concentrations around fishing vessels. In particular, herring gull, herring gull and great black-backed gull benefit from discards. In one study, a trend towards increased numbers of birds (herring gull, herring gull, storm-petrel and black-headed gull) with a corresponding increase in the number of fishing vessels could be clearly established (GARTHE et al., 2006). In addition, fishing can have disturbance and scaring effects on seabirds and resting birds, which depend on the frequency of use of the marine areas. In addition, there is a risk of birds dying as bycatch in fishing nets.

The overfishing of important stocks that provide food for various species of seabirds also leads to food limitation. Indirect effects of food limitation or switching to other fish species as a food source are reduced reproductive success and impaired survival of many bird species. In the North Sea, for example, the effects of overfishing and the decline of sand eel stocks are known (FREDERIKSEN et al., 2006). For example, observations of reduced reproductive success in kittiwakes and guillemots from British breeding colonies are linked to the decline of sand eel as the main food for chicks. The spread of the sandeel-like snake gadfly in the North Sea, which is often used by parent birds to feed chicks instead of sandeel, is not scientifically proven to be an equivalent food. Because of the hard consistency of the snake needles, 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).

Effects of fishing can thus be limited in time and space by the actual fishing process, but can also be large-scale and long-lasting through changes in food availability and prey range.

Aquaculture

Seabirds and resting birds would be indirectly affected by the establishment of aquacultures through potential degradation of water quality and through the food chains: pollutants, especially growth hormone preparations and antibiotics, could also affect upper predators such as seabirds through accumulation in the food chain. Direct impacts could also result from seabirds becoming entangled in cages or holders in riparian aquaculture.

The above-mentioned impacts of fisheries and aquaculture on seabirds and resting birds occur independently of the non-implementation or implementation of the plan.

3.5.6 Migratory birds

Fishing

Migratory birds may be disturbed and frightened by fishing, depending on the frequency of use of the marine areas. For migratory waterfowl that interrupt their migration to feed, there is also the risk of becoming entangled in fishing nets and drowning.

Aquaculture

The management of aquaculture facilities is associated with vessel transport and various offshore activities at the facilities, which cause small-scale visual and acoustic disturbance and scaring.

The above impacts of fisheries and aquaculture on migratory birds occur irrespective of the non-implementation or implementation of the plan.

3.5.7 Cultural assets and other material assets

Trawl fishing can contribute to the destruction of archaeological layers and wreck finds. The trawls and their otter boards penetrate the sediment of the seabed and can leave furrows up to 50 cm deep and 100 cm wide on fine sandy bottoms, which are even visible in the side-scan sonar image (Firth et al., 2013, 17). In individual cases, the proximity to wrecks is deliberately sought, which form natural habitats as a hard substrate and in whose vicinity larger fish populations can be expected. Worldwide, there are already many documented examples of 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 Sea and Baltic Sea. According to Art. 56 para. 1 UNCLOS, the coastal state has sovereign rights to explore and exploit, conserve and manage 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 the measuring stations in the German EEZ and a few more in the coastal seas in the North Sea and Baltic Sea. The systematically designed measurements are used for long-term marine environmental monitoring. Unmarked ground racks with measuring instruments are installed around the stations at a distance of about 500 - 1000 m. The measuring stations are located in the coastal sea.

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 Fehmarnbelt large buoys, and the Arkona Basin main diving buoy.

The Thünen Institute, the Institute for Baltic Sea Research (IOW) and other research institutions operate measuring stations in the Baltic Sea and conduct surveys on various research and monitoring questions and tasks (especially within the framework of "BALTBOX", "BITS" and "COBALT"). This is associated with different requirements for accessibility or avoidance of disturbances.

In the four areas designated as reservation areas, scientific fisheries catches with bottom trawl gear have been carried out several times a year for over thirty years to study the composition and possible changes in the fish fauna (commercial and non-commercial species). Bottom trawls and beam trawls are used in the fishery catches, which are usually towed for between 10 and 30 minutes, depending on the gear.

These studies are also used to assess the coastal fish fauna in the neighbouring federal states of Schleswig-Holstein and Mecklenburg within the framework of the MSFD. In addition, in two of the areas (west of Fehmarn as well as on the Oderbank), investigations have begun in 2020 as part of an interdisciplinary joint project (DAM mission), which are planned over many years in order to record possible changes in the bottom fish fauna that are expected as a result of the planned closures for mobile fishing with bottom-impacting fishing gear in the respective adjacent Natura 2000 areas.

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).

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
Marine research	Removal of selected species	Reduction of stocks		x															
	Physical disturbance by trawls	Harm/ damage By-catch	x	x						x		x						x	

3.6.1 Floor

The various marine research activities are associated with different environmental impacts depending on the type of methods and equipment used. Of particular importance for the soil as a protected resource are fisheries research activities that involve physical disturbance of the seabed surface by trawl nets. Bottom trawls on sandy soils generally penetrate the seabed to a depth of a few millimetres to centimetres.

It cannot be ruled out that grain sorting takes place on the seabed as a result of regular fishing, with formerly stirred-up, fine-sand sediment accumulating on the seabed surface. This is contradicted by the fact that due to the natural sediment dynamics, especially during intensive sand relocations during storms, the upper decimetres are completely mixed and thus a largely natural sediment composition is restored.

The near-bottom formation of turbidity plumes and possible release of pollutants from the sediment is negligible in areas with a relatively low fine grain content and low heavy metal concentrations. In areas with a high proportion of fines (e.g. the basins), there may be a significant release of pollutants from the sediment into the bottom water. The pollutants usually adhere to sinking particles which, due to the low bottom currents in the Baltic Sea basins, are hardly drifted over larger distances and remain in their native environment. In the medium term, this remobilised material is deposited again in the silty basins.

The impacts on soil as a protected resource are independent of the non-implementation or implementation of the plan.

3.6.2 Benthos and biotope types

The various activities of marine research are associated with different environmental impacts depending on the type of methods and equipment used. Sampling can lead to varying degrees of damage and even death of individual benthic organisms. Similarly, the use of specific methods and equipment can lead to a small amount of material emissions of various kinds. In principle, it can be assumed that intensive research activities, especially on sensitive species or in sensitive habitats, can lead to significant environmental impacts. Overall, however, it can be assumed that marine research is geared towards minimising environmental impacts and is adapted to the requirements for the protection of endangered species.

In summary, the main impacts of the research actions on the marine macrozoobenthos are as follows:

- Local, temporary damage or loss of individuals due to sampling.
- local, temporary impact due to the increase in pollutant inputs.

The above-mentioned impacts on benthic communities and biotope types occur independently of the non-implementation or implementation of the plan.

3.6.3 Fish

The various marine research activities are associated with different impacts on fish fauna depending on the type of methods and equipment used. Sampling, for example, can lead to varying degrees of harm, even death, to fish. The removal of fish could contribute to the decline of some, especially endangered, species. Intensive research activities, especially on sensitive species or in sensitive habitats, could lead to significant environmental impacts. In general, however, marine research in the Baltic Sea serves to identify negative developments in the ecosystem at an early stage and to make targeted recommendations. In the long term, diverse marine research can thus make an important contribution to the conservation of the marine environment.

The impacts of marine research on fish fauna occur regardless of whether the plan is not implemented or is implemented.

3.6.4 Marine mammals

The potential impacts of research on marine mammals are: small-scale and temporal impacts from bycatch in fisheries research; local temporal impacts from fishing vessels; and sub-regional temporal impacts from seismic and other sound-intensive research activities.

The non-implementation of the plan would have no impact on the existing or described impacts by marine research on harbour porpoise and harbour seal and grey seal.

3.6.5 Seabirds and resting birds

Marine research can have different impacts on seabirds and resting birds, depending on its objectives and design. In the case of fisheries research, bycatch and discard effects are the main concerns. The use of vessels can cause visual disturbance effects on species sensitive to disturbance, which can trigger avoidance behaviour. Indirectly, fisheries research can affect the marine food chain and influence the food supply for seabirds and resting birds.

Overall, 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 of scientific research, significant impacts on seabirds can be ruled out with certainty.

The above-mentioned impacts on seabirds and resting birds occur independently of the non-implementation or implementation of the plan.

3.6.6 Migratory birds

The various marine research activities are associated with different environmental impacts depending on the type of methods and equipment used. For migratory birds, short-term and small-scale visual disturbance effects can be relevant. However, these effects are small-scale and limited in time.

In addition, research activities may be associated with the installation of tall structures. These could conceivably have an impact at night in poor weather conditions when migratory birds are attracted by illuminated structures and could potentially collide.

The above-mentioned impacts on migratory birds occur independently of the non-implementation or implementation of the plan.

3.6.7 Bats

Research activities may involve the installation of tall structures that may have an attracting effect on bats through lighting.

If the plan is not implemented, the same impacts on bats may occur as if the plan is implemented.

3.6.8 Cultural assets and other material assets

When assessing the impacts of marine research or 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 impacts. On the contrary, the results could also be used for research into the underwater cultural heritage.

When taking soil samples by coring, archaeologically relevant layers could be pierced, but their disturbance is insignificant due to the small scale. Sampling by excavator grabs may interfere more with the potential cultural property, but an information gain in the recording and reporting of archaeological finds is usually of higher value than the destruction would be problematic.

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 the other types of use, marine nature conservation is not a use in the narrower sense, but rather an existing basic area-wide spatial function claim that must be taken into account when other uses are claimed. 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 borders.

With the legal ordinances of 22.09.2017, the already existing bird protection or FFH areas in the German EEZ were included in the national area categories and declared nature conservation areas in accordance with sec. 57 BNatSchG. Within this framework, they were partly regrouped. Thus, through the Ordinance on the Establishment of the Nature Reserve "Fehmarnbelt" (NSGFmbV), the Ordinance on the Establishment of the Nature Reserve "Kadetrinne" (NSGKdrV) and the Ordinance on the Establishment of the Nature Reserve "Pommersche Bucht - Rönnebank" (NSGPBRV), the nature reserves "Fehmarnbelt", "Kadetrinne" and "Pommersche Bucht - Rönnebank" now exist.

Art. I 6 (1) of the Habitats Directive provides that Member States shall establish the necessary conservation measures and, where appropriate, prepare management plans (also called 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 Soil

The establishment of national marine protected areas is intended, among other things, to achieve or maintain the favourable conservation status of habitat types such as "reefs" and "sandbanks" and biotope types such as the "KGS grounds". The protection of these habitat or biotope types also goes hand in hand with the 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 for the protected resource soil. 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 the national marine protected areas would probably be less well ensured if the plan were not implemented.

3.7.2 Benthos and biotope types

The aim of the designated nature conservation areas and the conservation area measures is to safeguard the ecological functions of the protected species and habitats. Among other things, the target states for the FFH habitat types "reefs" and "sandbanks" with the corresponding benthic communities are to be achieved through appropriate measures. If the plan were not implemented, the positive effects of designating nature conservation areas as priority areas on benthic habitats would probably be less well guaranteed.

3.7.3 Fish

Marine protected areas of sufficient size could have a positive impact on fish populations and counteract the overexploitation of fish stocks.

The Habitats Directive species Baltic sturgeon and common scaup are both protected in the nature reserve "Pommersche Bucht - Rönnebank" (BfN, 2020). Both species are anadromous migratory fish and use the marine protected area as a feeding habitat. Overall, diverse fish species, whether FFH, Red List (Thiel et al., 2013) or commercial species, can occur in and benefit from all three marine protected areas. Previous studies showed 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 change towards older larger individuals that show 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 effects of nature reserves 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 not taken into account. In general, according to scientific findings, the benefits for fish fauna are higher in nature reserves without any uses compared to partially protected areas (LESTER & HALPERN, 2008, Sciberas ET al. 2013). In the German marine protected areas, other uses, such as fishing, are partly permitted. In the most relevant protected area for fish fauna "Pomeranian Bay - Rönnebank", there are currently no uses. Accordingly, the fish community has a refuge at its disposal from which they could benefit considerably. The extent to which the fish community of the Baltic Sea has recovered through marine protected areas cannot be conclusively assessed due to the lack of studies. Overall, according to current 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 for the preservation of healthy marine ecosystems and marine biodiversity. The development of the Natura2000 network and the designation of the nature reserves "Pomeranian Bay - Rönnebank", "Kadet Trench" and "Fehmarn Belt" contribute to the conservation or restoration of populations of protected and characteristic species and their habitats.

3.7.5 Seabirds and resting birds

The protection of nature and habitats contributes to the conservation or restoration of populations and habitats. In this context, nature reserves and other areas of special importance have an important function in maintaining ecological connectivity between the different levels of the food web. Adequate protection of habitats also serves the protection of endangered species and species conservation in particular.

3.7.6 Migratory birds

Many bird species migrating across the German Baltic Sea rest in the EEZ on their way to their wintering or breeding grounds. The general impacts of nature conservation on seabirds and resting birds described in Chapter 3.7.5therefore also apply accordingly to many migratory bird species.

3.8 National and alliance defence

The realisation of national defence and alliance obligations includes training, exercise and testing activities. In the EEZ, the military exercise areas are established on the basis of the United Nations Convention on the Law of the Sea.

In the German coastal seas and the German EEZ in the North Sea and Baltic Sea, special exercise areas in and over the sea have been established for the armed forces in the past.

The exercise requirements of the German naval and maritime air forces as well as the German air and land forces in and over the sea have increased in recent years. In addition to training and exercises for basic operations, continuous operations and foreign missions, military activities include the testing of new procedures and systems.

The exercise areas can be subdivided according to the type of exercises taking place there and can involve airspace, the water surface or areas under water.

The following types of training areas are available to the armed forces in the German EEZ of the North Sea and Baltic Sea: Artillery firing areas, torpedo firing areas, submarine diving areas, (air) danger areas over sea from sea level are available.

In the areas, the navy and the air force practise firing with barrel weapons (machine gun, shipboard gun) against air and sea targets, with missiles and with light and heavyweight torpedoes. Furthermore, the use of electronic countermeasures or decoys, mine laying and mine hunting (sonar use) are practised.

The navy conducts firing exercises with different types of ammunition throughout the year. A detailed list is subject to military secrecy. In principle, firing and blasting can be carried out anywhere at sea if the necessary conditions (water depths, weather conditions, sea area checked and free of vehicles) are available. Firing exercises are predominantly conducted within the boundaries of the artillery firing ranges. Exercises outside these areas are limited to exceptions with single shots. The German Navy does not conduct regionally related evaluations for consumption of different ammunition types and calibres. In general, practice ammunition consisting of metal and concrete as well as ammunition that self-destructs in the air is used in the artillery firing ranges. Apart from a few exceptions, the airborne combat units of the German Air Force use only practice ammunition in the training areas.

During firing exercises with barrel weapons, missiles and torpedoes in "live" fire, only small residues are produced. When missiles are used, - they or their seeker heads are recovered immediately after the end of the exercise, provided they do not detonate. When firing practice ammunition with barrelled weapons, the metal projectiles filled with a gypsum-concrete mixture remain in the exercise area. After firing practice torpedoes, they are retrieved and returned to the depot.

Some areas are subject to voluntary restrictions on use; for example, underwater blasting is not carried out in the exercise areas during certain periods to minimise negative impacts on fisheries and marine mammals.

For military training operations, regulations are in place to protect marine mammals during the use/generation of underwater sound, both during the use of sonars and underwater blasting. The following measures are foreseen:

- Obtain information on the possible presence of marine mammals.
- Visual and acoustic monitoring of hazard areas prior to blasting.
- Carry out deterrence measures before blasting.
- If marine mammals are sighted within two nautical miles, blasting will be suspended until the animals have moved away from the area.

The following table shows the effects of the exercise areas on national and allied defence and potential impacts on the protected goods.

Table 24: Effects and potential effects of national and alliance defence (t= temporary).

Use	Effect	Potential impact	Protected goods																
			Benthos	Fish	Seabirds and	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biodiversity	Floor	Area	Water	Air	Climate	Man/ Health	Cultural and mate-	Landscape
National defence	Underwater sound	Impairment/ scare effect		x t			x												
	Introduction of dangerous substances	Impairment	x	x	x		x		x	x	x	x		x			x		
	Collision risk	Collision					x												
	Surrounding water sound	Impairment/ scare effect			x	x		x									x		
	Bringing in rubbish	Impairment	x	x					x					x			x		

3.8.1 Soil

Military activities in connection with national and alliance defence may result in the discharge of pollutants through the associated shipping (see also Chapters 3.1.1 and 3.1.2).

Another possible source of pollutants that can lead to soil and water contamination is the ammunition residues left in the shooting areas or the remains of blasting operations.

The general effects of national and alliance defence on the protected resource of soil arise independently of the implementation or non-implementation of the plan.

3.8.2 Benthos and biotopes

Due to the ammunition residues remaining in shooting areas, there may be a release of pollutants, which can affect benthic communities in their biotopes.

The effects of national and alliance defence arise independently of the non-implementation or implementation of the plan.

3.8.3 Fish

The impact of military uses on fish fauna is difficult to assess due to military secrecy. Fish fauna could be affected in particular by underwater sound and the introduction of hazardous substances. Depending on the level, underwater sound can lead to scaring effects (ship traffic) and even the death of individual fish (e.g. detonation). For detailed effects of underwater sound on fish fauna, see Chapters 3.1.4 and 3.2.3 In general, military activities such as shooting exercises or submarine manoeuvres are limited in space and time.

Further impairments from military events could result from the release of toxins from the munitions dumps and wrecks located on the seabed of the Baltic Sea. Chemical combat munitions were predominantly dumped in deep areas of the Baltic Sea (LANG et al., 2017) Findings on the extent to which progressive corrosion promotes the release of toxic substances and how these affect the health of fish are scarcely known. Initial results from the Thünen Institute of Fisheries Ecology showed no difference in the health status of cod from the main dumping area for chemical warfare munitions east of Bornholm compared to an uncontaminated reference area (LANG et al., 2017). Nevertheless, increased pollutant accumulation in fish cannot be ruled out. There is a need for research on effects on different species and life stages, reproductive capacity or the spread of toxic substances via the food web.

The impacts of the Land and Alliance Defence on fish fauna arise independently of the non-implementation or implementation of the Plan.

3.8.4 Marine mammals

For marine mammals, possible impacts from military exercises involving the input of underwater sound are possible. In particular, sonar and blasting are relevant. Studies in marine areas with deep waters (>1000 m) have shown that the use of military sonars has led to disturbance, injury and even stranding of cetaceans (Azzellino et al., 2011; Zirbel et al., 2011). Blasting of old munitions also has the potential to injure and kill animals if no protective measures are taken. For this reason, protective measures are regularly taken during blasting operations, including observation of the immediate vicinity and deterrence.

The overall impact of land defence on marine mammals does not differ between non-implementation or implementation of the plan.

3.8.5 Avifauna

General impacts of national defence on birds can be caused in particular by visual disturbance from ship or low-flying air traffic. In general, military activities, such as shooting exercises or submarine manoeuvres, are limited in space and time. In addition, direct and indirect impacts, e.g. via the food chain, are possible through the introduction of hazardous substances, such as the release of toxic substances.

The general effects of land defence on birds do not differ between non-implementation and implementation of the Plan.

3.9 Other uses without spatial designations

No spatial designations are made for other uses in the MSP, only general textual designations.

3.9.1 Leisure

3.9.1.1 Fish

Impacts of recreational activities on fish fauna are expected in particular from sea angling and recreational traffic. In 2013/2014, recreational fishing had an expenditure of about 1.4 million days of active fishing in the German Bight, 90% of which in the Baltic Sea (HYDER et al., 2018).

For individual species, the European Fisheries Policy regulates extraction for recreational fishing. This applies, for example, to cod fishing in the western Baltic Sea (bag limit) or the temporary fishing ban to protect the European eel.

Catches by recreational fisheries do not usually have to be reported to state institutions from the marine area. Since 2005, the Thünen Institute for Baltic Sea Fisheries has continuously and annually surveyed the angling catches in the Baltic Sea based on a population survey (German Marine Angling Programme). Recreational fishing in the Baltic Sea generally focuses on the species cod, herring, mackerel, flounder, plaice, dab, sea trout and salmon (HYDER et al., 2018). The European eel, which is highly endangered according to the current Red List (THIEL et al., 2013), is also taken by recreational fisheries (ICES, 2020).

The taking of individual fish by anglers and hobby fishermen could therefore contribute to the decline in the stocks of the species caught, with particularly negative effects on the population situation of endangered species. EU regulations for recreational fisheries could reduce such significant impacts.

Further impacts from recreational traffic are caused by underwater noise (see chapter 3.1.4) and by sludge inputs (see chapter 3.5.3).

The impacts of recreational activities on fish fauna occur regardless of whether the plan is not implemented or is implemented.

3.9.1.2 Avifauna

General effects of recreational activities on birds may occur, particularly from visual disturbance caused by recreational traffic. In addition, there may be direct and indirect effects through the food chain from the disposal and introduction of litter into the marine environment.

The general impacts of recreational use on birds in the absence or implementation of the Plan do not differ.

3.10 Interactions

It is assumed that the interactions between the protected goods will develop in the same way if the plan is not implemented. At this point, reference is made to Chapter 2.18.

4 Description and assessment of the likely significant effects of the implementation of the maritime spatial plan on the marine environment.

In the following, the description and assessment of the environmental impacts of the plan concentrates on the protected assets for which significant impacts cannot be ruled out from the outset through the implementation of the maritime spatial plan.

According to sec. 8 ROG, the likely significant impacts of the MSP on the protected goods must be described and assessed. In doing so, the maritime spatial plan sets a framework for downstream planning levels.

The protected assets for which a significant adverse effect could already be ruled out in the previous chapter 2 are not taken into account. This concerns the protected goods plankton, air, cultural heritage and other material goods, as well as the protected good humans, including human health.

Possible impacts on biodiversity are dealt with under the individual biological assets. Overall, the protected goods listed in sec. 8 para. ROG are examined before the species protection and site protection assessments are presented.

The basic impacts of the MSP's designations on the protected resource "land" - in particular land use by the uses - are summarised in Chapter 2.1. Due to the following points, it is only possible to assess the extent to which the MSP designations have an impact on the site as a protected resource by looking at all uses together:

- Temporally and spatially overlapping uses possible
- Mostly no 100% permanent land consumption of a use
- Not all uses, unlike on land, actually consume land in the sense of seabed.

In the MSP itself, such a summary consideration was carried out in the context of the designations on uses with regard to the protected resource of land. For this reason, the protected resource of land will not be considered further in the following, which avoids having to repeatedly discuss the fundamental impacts and designations of the MSP - in the context of land use.

4.1 Shipping

In the Baltic Sea 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 specific impacts attributable to the provisions in the MSP.

The designated priority areas for shipping are to be kept free of constructional use. This control in the MSP will reduce collisions and accidents. As a result of the stipulations in the MSP, traffic frequency in the priority areas is expected to increase, whereby this is controlled in particular by the increase in offshore wind farms along the shipping routes. Vessel movements on the shipping routes SO1 to SO4 vary greatly, with approximately 1 to 6 vessels per day on the routes (BfN, 2017).

The designation of only priority areas for shipping serves as a precautionary measure to minimise risks. In addition, it must be taken into account that freedom of navigation is to be ensured according to UNCLOS and the possibility of regulation by the IMO in international conventions is significantly stronger than in the MSP.

The presentation of general impacts from shipping is presented in Chapter 2 as a pre-impact, especially for birds and marine mammals. The impacts from service transport to the wind farms are dealt with in the chapter on wind energy.

4.1.1 Floor

As the impacts of shipping on the seabed occur independently of the implementation or non-implementation of the Plan, the MSP provisions do not result in any impacts other than those described in Chapter 3.1.1. The MSP principle of reducing pressures on the marine environment through best environmental practice in accordance with international conventions can contribute to the reduction or avoidance of pollutant inputs.

Significant negative impacts on the seabed due to the MSP's provisions on shipping can be ruled out.

4.1.2 Water

The impacts of shipping on water as a protected resource are independent of the implementation or non-implementation of the MSP. Significant impacts of the MSP provisions on shipping on the protected resource can be ruled out.

4.1.3 Benthos and biotope types

With regard to the use of shipping, there are no further specific effects of the MSP's designations compared to the general effects of use described in Chapter 3.1.3 Significant impacts on benthic communities and biotopes due to the MSP provisions on shipping can therefore be ruled out.

4.1.4 Fish

The effects of shipping on fish are described in Chapter 3.1.4

National spatial planning is subject to the freedoms of the UN Convention on the Law of the Sea, including freedom of navigation. Furthermore, shipping is regulated in international conventions by the IMO. The area designations for navigation in the MSP are therefore not expected to have any additional or significant impacts on fish fauna.

4.1.5 Marine mammals

The priority area designations for shipping are based in particular on existing shipping routes identified in the procedure for updating the maritime spatial plan. These designations are intended to help reduce risks by separating important shipping routes from incompatible uses. The designation of priority areas for shipping does not have any direct concentration or steering effect on shipping traffic. Shipping can continue to use the entire maritime space in the future. In this respect, the designation of areas for shipping has no additional impact on marine mammals as a whole compared to the current situation and the zero option.

The maritime spatial plan also contains statements on the reduction of the impact on the marine environment by observing the IMO regulations and best environmental practice in accordance with the OSPAR and HELCOM Conventions as well as the respective state of the art in shipping. This avoids negative impacts on the protected goods.

On the basis of the above statements and the presentations in Chapter 3, it can be concluded for the SEA that no significant impacts on marine mammals are to be expected as a result of the designations for navigation in the maritime spatial plan, but rather that adverse impacts are avoided in comparison with the non-implementation of the plan, in particular by reducing conflicts of use.

4.1.6 Seabirds and resting birds

The general impacts of shipping on seabirds and resting birds are described in Chapter 3.1.6.

The spatial planning designations of priority areas for shipping map the main traffic flows in the EEZ, in which shipping is given priority over other spatially significant uses. This spatial planning objective serves in particular to prevent conflicts (collisions) with offshore wind farms and consequently to prevent potential accidents affecting the marine environment and thus also seabirds and resting birds. The designations for shipping do not automatically lead to an increase in traffic in the priority areas, as shipping enjoys special freedom under Article 58 of the Convention on the Law of the Sea and is therefore not bound to certain routes.

Additional or significant impacts of the designations for navigation on seabirds and resting birds can thus be excluded with the necessary certainty.

4.1.7 Migratory birds

With regard to the use of shipping, there are no further specific impacts of the MSP's designations compared to the general impacts described in Chapter 3.1.7. Significant impacts on migratory birds due to the MSP's provisions on 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 further specific impacts of the MSP provisions compared to the general impacts described in Chapter 3.1.8. Significant impacts on bats due to the MSP provisions on shipping can be ruled out with the necessary certainty.

4.1.9 Air

Shipping causes pollutant emissions. These can have a negative impact on air quality. However, this is independent of the implementation of the MSP.

4.1.10 Climate

No significant impacts on the climate are expected as a result of the designations on shipping.

4.1.11 Cultural assets and other material assets

The general impacts of shipping on cultural and other material assets are described in Chapter 3. Significant impacts of the spatial planning designations can be excluded with the necessary certainty.

4.2 Wind energy at sea

In the Baltic Sea EEZ, areas EO1 to EO3 are designated as priority areas for wind energy.

4.2.1 Floor

The construction and operation of offshore wind turbines tends to have local impacts on the soil as a protected resource (see Chapter 3.2.1), which occur independently of the implementation of the maritime spatial plan. However, the designation of priority and reservation areas for the use of offshore wind energy reduces negative impacts on the seabed, as the priority and reservation areas designated for offshore wind energy enable coordinated development and thus also reduce land take.

The priority areas in the Baltic Sea shown in the MSP correspond to the priority areas defined in the current FEP, which are necessary to achieve the expansion target of 20 GW. The aim of the FEP is the spatially and temporally coordinated expansion of offshore wind energy, so that the impacts on the protected resource soil resulting from this use can be reduced or even avoided.

Overall, the designations in the MSP are not expected to have any significant impacts on soil as a protected resource.

4.2.2 Benthos

Wind energy use may have an impact on macrozoobenthos. These impacts apply equally to all designated areas for wind energy use.

The species inventory of the Baltic EEZ can be considered average with its approx. 260 macrozoobenthos species.

<u>Construction-related:</u> The deep foundation of the wind turbines causes disturbance of the seabed, sediment turbulence and the formation of turbid-

ity plumes. This can lead to impairment or damage to benthic organisms or communities in the immediate vicinity of the turbines for the duration of the construction activities.

During the construction of the facilities, the resuspension of sediment in particular leads to direct impairments of the benthic community. Turbidity plumes are to be expected during the foundation work for the facilities. 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.

Construction-related impacts due to turbidity plumes and sedimentation are classified as short-term and small-scale.

Changes in the benthic community can occur as a result of the local sealing of surfaces, the introduction of hard substrate and the change in flow conditions around the facilities. In addition to local habitat losses or habitat changes, new off-site hard substrate habitats are created.

According to current knowledge, operational impacts of the wind turbines on the macrozoobenthos are not to be expected.

On the basis of the above statements and representations, the result of the SEA is that, according to current knowledge, no significant impacts on the benthic ecosystem are to be expected as a result of wind energy use. Overall, the impacts on the benthic ecosystem are assessed as short-term and small-scale. Only small-scale areas outside protected areas are affected, and due to the mostly rapid regeneration capacity of the benthic organism populations with short generation cycles and their widespread distribution in the German Baltic Sea, rapid recolonisation is very likely.

4.2.3 Biotope types

Possible impacts of wind energy use on biotope types as an object of protection may result from direct use of protected biotopes by the foundations of the wind turbines, possible cover by sedimentation of material released due to construction, and potential habitat changes. These impacts apply equally to all designated areas for wind energy use.

A significant construction-related impact on protected biotopes is not to be expected, as protected biotopes according to sec. 30 BNatSchG are to be avoided as far as possible in the context of the specific approval procedure. Due to the prevailing sediment characteristics in the areas where occurrences of protected biotopes are to be expected, impairments due to sedimentation are likely to be small-scale, as the released sediment will settle quickly.

Permanent habitat changes occur as a result of the installation, but these are limited to the immediate area of the installations. The artificial hard substrate provides new habitat 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 a significant impact on the biotope types. In addition, the recruitment of species is very likely to occur from the natural hard substrate habitats, such as superficial boulder clay and stones. Thus, the risk of a negative impact on the benthic soft-bottom community by species untypical of the area 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 the demersal fish communities of the Baltic Sea were consistently identified. According to the current state of knowledge, the construction, foundations and operation of wind turbines are not expected to have any significant impact on the population level in all priority areas. Detailed information on the impacts of offshore wind energy on fish fauna is described in Chapter 3.2.3

The designation of areas for offshore wind energy in the MSP offers the possibility of sustainable development with as few conflicts of use as possible. The protection requirements of the marine environment are coordinated by the designations, thus avoiding disturbance of valuable habitats.

Based on the current state of knowledge, the SEA concludes that the designations for wind energy in the maritime spatial plan are not expected to have any additional or significant impacts on fish as a protected resource compared to the non-implementation of the plan.

4.2.5 Marine mammals

The overall impact of wind turbines on marine mammals due to the designation of priority areas for wind energy is expected to be insignificant. This also applies to a cumulative assessment.

The function and importance of the priority areas in the German Baltic Sea EEZ for harbour porpoises were assessed in Chapter 2 according to current knowledge.

By defining the priority areas for offshore wind energy at ecologically suitable locations outside nature conservation areas, negative impacts on marine mammals are avoided and reduced. In addition, provisions were made to protect the marine environment with regard to the consideration of best environmental practice in accordance with the OSPAR and Helsinki Conventions as well as the state of the art. In this context, regulations on the avoidance and reduction of negative impacts on marine mammals caused by the construction and operation of wind turbines, in particular in the form of noise minimisation requirements, which may also provide for the coordination of construction work on simultaneously constructed projects, are to be adopted at the approval level. This is in line with current licensing practice. On the basis of the function-dependent significance of the priority areas for wind energy and the principles adopted in the maritime spatial plan, as well as the measures ordered in the downstream approval procedures and taking into account the current state of science and technology in the reduction of impulsive noise emissions, significant impacts on harbour porpoises, harbour seals and grey seals can be ruled out.Direct disturbance of marine mammals at the individual level due to noise emissions during the construction phase, in particular during pile driving, is to be expected on a regional and temporary basis. However, due to the high mobility of the animals and the above-mentioned measures to be taken to avoid and reduce intensive sound emissions, significant impacts can be ruled out with a high degree of certainty. This also applies under the aspect that shipping could have an impact on marine mammals sensitive to disturbance, as these effects are only very short and local. Sediment plumes are largely expected to occur on a local and temporal scale. Habitat loss for marine mammals could thus occur on a local and temporal scale. Impacts from sediment and benthic changes are insignificant for marine mammals, as they forage for prey organisms predominantly in the water column in widespread areas. Effects on the population level are not known and are rather unlikely due to predominantly short-term and local effects in the construction phase.

Significant impacts of the wind turbines in the priority areas on marine mammals during the operational phase can also be ruled out with certainty according to the current state of knowledge. The investigations carried out as part of the operational monitoring for offshore wind farms have so far not provided any indications of avoidance effects on harbour porpoises caused by wind farm-related shipping traffic. So far, avoidance has only been observed during the installation of the foundations, which may be related to the large number and varying operating conditions of vehicles at the construction site.

In summary, the designation of priority areas outside the main feeding and breeding areas for harbour porpoises indirectly serves to protect the species. At the same time, the priority areas for nature conservation contribute to the protection of open spaces, as they exclude uses that are incompatible with nature conservation. This reduces threats to harbour porpoises in important feeding and breeding grounds. On the basis of the above statements and the descriptions in Chapter 3, it can be concluded for the SEA that no significant impacts on marine mammals are to be expected from the designation of the priority areas for wind energy in the spatial plan for the German EEZ of the Baltic Sea, even from a transboundary perspective, but rather that adverse impacts are avoided in comparison with the non-implementation of the plan.

4.2.6 Seabirds and resting birds

The general impacts of the offshore wind series on seabirds and resting birds are described in Chapter 3.2.5

The MSP designates areas EO1 and EO3 as priority areas for offshore wind energy in the Baltic Sea EEZ. Area EO2 is designated as a reservation area.

Priority areas are designated in areas where offshore wind farm projects have already been realised. The designation of the EO2 area as a reservation area for offshore wind energy takes into account the review of the area in the FEP 2019, among other things due to bird migration (BSH 2019). The priority areas for nature conservation contribute to safeguarding open space, as they exclude uses that are incompatible with nature conservation. This reduces negative impacts on seabirds and contributes to the protection of these important habitats.

The designations for offshore wind energy may lead to a spatial concentration of shipping traffic in some parts of the EEZ due to the applicable traffic regulations. However, it can be assumed that this concentration will take place in traffic areas that already have a higher level of shipping activity.

According to current knowledge, the provisions of the MSP for offshore wind energy do not have any additional or significant impacts on seabirds and resting birds.

4.2.7 Migratory birds

The general effects of offshore wind energy on migratory birds were described in Chapter 3.2.6

The designation of priority areas, including the conditional reservation area EO2-West, in a spatial context to each other reduces barrier effects and collision risks in important feeding and resting habitats.

The provisions of the MSP under 2.4 (5) are expressly referred to at this point. This environmental report refers to these provisions in Chapter 4.7.6

Against the background of the current state of knowledge and taking into account MSP provision 2.4 (5), significant impacts of the provisions on migratory birds can be excluded with the required degree of certainty, especially in comparison with the non-implementation of the MSP.

4.2.8 Bats and bat migration

The general impacts of offshore wind energy on bats and the current state of knowledge on bat migration over the Baltic Sea are described in Chapter 3.2.7

There are currently no indications that the spatial planning designations have a significant impact on bats. The designation of priority and reservation areas in a spatial context reduces barrier effects and protects important habitats. The priority areas for nature conservation contribute to the protection of open spaces, as they exclude uses that are incompatible with nature conservation.

4.2.9 Climate

The provisions on offshore wind energy are not expected to have any significant negative impacts on the climate.

The CO2 savings associated with the expansion of offshore wind energy (cf. Chapter 1.8) can be expected to have a positive impact 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 resource, as it will be altered by the erection of vertical structures and the safety lights. The extent of these visual impairments of the landscape by the planned offshore installations will depend strongly on the respective visibility conditions. Due to the distance of more than 25 km between the priority areas and the Baltic Sea coast, the turbines will only be visible from land to a very limited extent (HASLØV & KJÆRSGAARD, 2000), and only under good visibility conditions. This also applies to the night-time security lights. Due to subjective perceptions as well as the basic attitude of the observer towards offshore wind energy, the vertical structures - which are untypical for a marine and coastal landscape - can be perceived partly as disturbing, but partly also as technically interesting. In any case, they bring about a change in the landscape and the character of the area is modified.

Beyond the coast, the visual impact on the landscape changes with greater spatial proximity to the priority areas. The type of use is decisive here. Thus, the value of the landscape plays a subordinate role in industrial or traffic use. For recreational use, however, as in the case of water sports enthusiasts and tourists, the landscape has a high value. However, direct use for recreation and leisure by recreational boats and tourist watercraft occurs only sporadically in the planned priority areas for wind energy. These are primarily located in areas used by shipping and the offshore industry, which means that the impact on recreational use by water sports enthusiasts can be considered low.

As a result, the impact on the landscape caused by the planned wind turbines on the coast can be classified as low. For the submarine cable systems, negative impacts on the landscape can be ruled out because they are laid as underwater cables.

4.3 Lines

The MSP defines the reservation areas for pipelines LO1 to LO8. Pipelines within the meaning of the MSP include pipelines and submarine cables. Submarine cables include cross-border power lines and connection lines for wind farms as well as data cables. So-called intra-park submarine cables are not included in this definition. addition, the MSP sets the goal of routing lines at the transition to the territorial sea through the border corridors GO1 to GO5, and at the transition to bordering states through the border corridors GO6 to GO12.

4.3.1 Floor

The impacts described in Chapter 3.3.1 for the construction and operation of pipelines and submarine cables on the seabed occur independently of the provisions of the MSP.

The MSP makes statements regarding the reduction of pollution of the marine environment to be aimed for by taking into account best environmental practice in accordance with international conventions and the state of the art in science and technology. This can reduce adverse impacts on the marine environment. For example, when laying and operating pipelines, damage to or destruction of biotopes in accordance with sec. 30 BNatSchG must be avoided.

In addition, the definition of reservation areas for pipelines in the maritime spatial plan means that interactions between uses and cumulative effects on protected assets can be better assessed and predicted for existing and, above all, future plans.

Thus, no significant impacts are to be expected with regard to soil as a protected resource as a result of the designations for pipelines in the MSP. On the contrary, compared to non-implementation of the plan, adverse impacts are avoided, as the designations in the plan aim to minimise the use of the seabed by bundling and reducing the number of pipeline routes.

4.3.2 Benthos

Pipelines may have an impact on macrozoobenthos. These impacts apply equally to all designated reservation areas for pipelines.

Construction-related: Possible impacts on the benthos depend on the installation methods used. Only small-scale, short-term and thus minor disturbances of the benthos are to be expected due to a gentle laying of the submarine cable systems and pipelines by means of flush-in methods or laying of pipelines.

The impairments during the construction phase according to current knowledge remain small-scale and generally short-term.

In the event of a population decline due to natural or anthropogenic disturbance (e.g. cable laying), enough potential organisms remain in the overall system for recolonisation (KNUST et al., 2003). The linear character of the submarine cable systems favours recolonisation from the undisturbed marginal areas. In the monitoring of the Nord Stream pipeline (2011-2013), recolonisation of the claimed areas in the Greifswalder Bodden and the Pomeranian Bay was recorded by all species native to these areas.

Also in the short term and on a small scale, benthic organisms can be affected by the release of nutrients and pollutants associated with the resuspension of sediment particles. In the medium term, this remobilised material is deposited again in the silty basins.

Plant-related: Overlying pipelines or locally required riprap permanently provide an off-site hard substrate. This provides new habitat for the benthos, which enables species and communities to settle in areas where they did not previously occur, so that their distribution areas can expand (SCHOMERUS et al., 2006).

Operational heating of the top sediment layer of the seabed directly above live cables can cause a reduction in the winter mortality of the infauna and lead to a change in the species communities in the area of the submarine cable routes. In particular, cold-water-loving species (e.g. *Arctica islandica*) that occur in deeper areas may be displaced from the area of the cable routes. According to the current state of knowledge, no significant impacts from cable-induced sediment heating are to be expected if sufficient installation depth is maintained and state-of-the-art cable configurations are used.

Electric and electromagnetic fields are also not expected to have a significant impact on macrozoobenthos.

Based on the above statements, the SEA concludes that, according to the current state of knowledge and taking into account mitigation measures, the laying and operation of pipelines is not expected to have any significant impacts on benthos.

For pipelines, the chemicals resulting from an impression test can be discharged into the water body in high dilution. To protect the pipeline from external corrosion, sacrificial anodes made of zinc and aluminium are attached at regular intervals, which are only dissolved in small quantities 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 to sinking or resuspended sediment particles and sediment on the seabed.

4.3.3 Biotope types

Pipelines can have an impact on biotopes. These impacts apply equally to all designated reservation areas for pipelines.

Due to construction, possible impacts of pipelines on the protected biotope types may result from a direct claim on protected biotopes, a possible overlap due to sedimentation of released material and potential habitat changes. Direct use of protected biotopes is avoided as far as possible through the planning of the pipeline systems. Furthermore, protected biotope structures according to sec. 30 BNatSchG are to be treated with special weight in the context of the concrete approval procedure and avoided as far as possible in the context of the fine routing.

Due to the prevailing sediment characteristics in the areas where occurrences of protected biotopes are expected, impairments due to overburden are likely to be small-scale, as the released sediment will settle quickly.

Permanent habitat alterations caused by installations are limited to the immediate area of riprap used for pipeline crossings or in the event that pipelines or submarine cable sections are laid on the seabed. The rockfills permanently represent an off-site hard substrate. This provides new habitat 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 biotope types.

4.3.4 Fish

The general effects of submarine cables and pipelines on fish fauna are presented in Chapter 3.3.3

The spatial planning area designations for the MSP lines are not expected to have any additional or significant impacts on fish fauna.

4.3.5 Marine mammals

The MSP makes statements regarding the reduction of the impact on the marine environment to be aimed for by taking into account the best environmental practice according to the OSPAR and HELCOM Conventions as well as the respective state of the art in the laying, operation, maintenance and dismantling of pipelines and submarine cables. This can reduce adverse impacts on the marine environment.

The designation of areas for pipelines in the MSP means that interactions between uses and cumulative effects on biological assets can be better assessed and predicted in existing and, above all, future planning.

4.3.6 Avifauna

The general impacts of power lines on seabirds, resting birds and migratory birds are described in Chapters 3.3.5and 3.3.6 The effects are exclusively temporary and local.

Significant impacts of the spatial planning designations can be ruled out with the necessary certainty.

4.3.7 Bats and bat migration

The general effects of power lines on bats are described in Chapter 3.3.7 The effects are exclusively temporary and local.

Significant impacts of the spatial planning designations can be ruled out with the necessary certainty.

4.3.8 Cultural and material assets

The designations for the planning, construction and operation of wind turbines and power lines aim to avoid or reduce construction-related disturbances to the seabed affecting discovered and undiscovered cultural heritage by involving the specialist authorities at an early stage. Synergy effects are to be promoted through cooperation in the evaluation of subsoil investigations and soil samples, which will be carried out in the context of the large-scale development of marine areas for wind energy, and which can provide new insights into cultural traces such as submerged landscapes.

The general impacts of offshore wind energy on cultural assets and other material assets are described in Chapter 3. Significant impacts of the spatial planning designations can be ruled out with the necessary certainty.

4.4 Raw material extraction

As a principle of spatial planning, the area SKO1 is designated as a reservation area for sand and gravel extraction.

The effects of raw material extraction on the marine environment must also be attributed to the provisions of spatial planning, as these mean long-term land protection with possible use. This can be longer than the duration of the currently valid operational plans.

4.4.1 Floor

The MSP provides for a reservation area for sand and gravel extraction in the Baltic Sea EEZ in the area of the "Pomeranian Bay-Rönnebank" protected area.

By establishing the principle of exploiting the existing extraction fields as completely as possible, the aim is to achieve a land-saving and concentrated extraction of raw material deposits - as far as this is compatible with the interests of the marine environment and while preserving an original substrate necessary for the regeneration of biotic communities. In the case of sand and gravel extraction, this avoids, above all, the impairment of coarse sand and gravel areas that are important as spawning and feeding grounds.

The MSP also contains statements on the reduction of the impact on the marine environment by taking into account the best environmental practice according to the OSPAR and Helsinki Conventions as well as the state of the art in the exploration and extraction of raw materials. In order to ensure that resource extraction is as environmentally compatible as possible, the impacts of resource extraction on the marine environment are to be investigated and presented within the framework of project-related monitoring. Dispersal processes and long-range ecological interactions of species and their habitats should be taken into account in site selection. In addition, the concerns of cultural assets are to be taken into account. These regulations will reduce or avoid negative impacts on soil as a protected resource and on the marine environment as a whole.

The only extraction activities in the German EEZ are currently taking place in the North Sea in the OAM III permit field. These extraction activities are adapted to the local conditions. By means of appropriate ancillary provisions, the coarse sand and gravel areas there as the original substrate for species-rich KGS grounds as well as the reef types "Mariner Findling" and "Steinfeld/ Blockfeld Nordsee" are to be protected from significant impairments, among other things by checking the impacts of the extraction activities by means of locally adapted monitoring studies. This practice should also be applied to potential raw material extraction within the Adlergrund Nordost (SKO1) permit field, as the substrate type coarse sand and gravel surfaces as well as the reef types "marine erratics" and "Blockfeld Ostsee" are also present there. In addition, large-scale occurrences of the substrate "Residual sediment with stones" are recorded there, which represent potential reefs in the sense of the BfN reef mapping guide (2018).

Taking into account the above-mentioned experience and practice from the North Sea and adapted to the local, very heterogeneous sediment conditions in the Adlergrund Nordost area, the designations made in the MSP for the extraction of raw materials are not expected to have any significant impacts on soil as a protected resource.

4.4.2 Benthos and biotope types

The general impacts of raw material use are described in Chapter 3.4.2

With regard to the designation of area SKO1 as a reservation area for sand and gravel extraction, its location within the nature conservation area "Pomeranian Bay - Rönnebank" must be taken into account.

Under similar conditions as for the gravel sand storage area "OAM III" in the North Sea EEZ (cf. Chapter 3.4.2) and adapted to the local conditions and taking into account the protected biotopes occurring in the extraction area, it can be assumed that significant impairments of benthic habitats and their communities can be ruled out by the designation of area SKO1 according to current knowledge.

4.4.3 Fish

The general effects of raw material extraction on fish fauna can be found inChapter 3.4.3

The exact formulation of the spatial planning designations for raw material extraction takes place in the mining law procedure. The designations are redrawings of already approved or existing activities.

The designation of areas for raw material extraction in the MSP therefore has no additional impact on the fish community.

4.4.4 Marine mammals

The general impacts of raw material use are described in Chapter 3.4.4

The plan designates the area SKO1 as a reservation area for gravel and sand extraction. The reservation area SKO1 is located in subarea II of the nature reserve "Pommersche Bucht - Rönnebank". The permit for the fields "Adlergrund Nordost" and "Adlergrund Nord" is valid until 2040. However, no extraction of sand and gravel has taken place since 2004.

The determination in the update of the plan has no implications for marine mammals.

4.4.5 Avifauna

The general impacts of resource extraction (in this case sand and gravel extraction and hydrocarbon extraction) on seabirds, resting birds and migratory birds are described in Chapters 3.4.5 and 3.4.6

In the MSP, the area SKO1 is defined as a reservation 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 extraction only took place between 1993 and 2004. In the "Adlergrund Nord" permit area, mining has also not taken place since 2004 (BfN, 2020).

The reservation area SKO1 is located in subarea II of the nature reserve "Pomeranian Bay - Rönnebank". As already explained, no extraction of sand and gravel has taken place in the permit fields in Adlergrund since 2004. According to previous findings, it cannot be assumed that the designation of the SKO1 reservation area will be accompanied by an increase in activity.

Significant impacts of the designation on avifauna can be excluded with the necessary certainty.

4.4.6 Cultural and material assets

The general impacts of raw material extraction on cultural assets and other material assets are described in Chapter 3. Significant impacts of the spatial planning designations can be ruled out with the necessary certainty.

4.5 Fisheries and aquaculture

The MSP does not contain any designations for fisheries in the Baltic Sea EEZ.

The MSP contains a general definition for aquaculture.

The general impacts of aquaculture on the various protected goods are described in Chapter 3.5

Since the aquaculture designation is not a spatial but only a general designation, both the future location and the concrete design of the use are currently unknown. In order to be able to exclude a significant impact on the marine environment, the following requirements must be met and their fulfilment must be examined in downstream plans or at project level:

- Inputs of nutrients and excreta limited to a tolerable level
- No entries of medicines/antibiotics
- Aquaculture limited to native species
- No use of organisms from wild stocks
- Prevention of negative impacts on wildlife populations
- Any deterrence measures limited to a tolerable level

4.6 Marine research

In the Baltic Sea EEZ, the areas FoO1 to FoO4 are designated as reservation areas for research.

The designation is made to safeguard existing long-term research series in the field of fisheries research. The aim is to keep these areas free from uses that could devalue the long-term research series.

The results of marine science research should be continuously recorded to explain ecosystem interrelationships as comprehensively as possible and thus create an important basis for sustainable development of the EEZ.

As this is a question of safeguarding the existing situation, the area designations have no further effects on the protected goods and the marine environment as a whole compared to the current situation and the zero variant.

4.6.1 Floor

The MSP designations do not result in any further specific impacts on the seabed than those described in Chapter 3.6.1. Significant impacts on the soil as a protected resource as a result of the MSP designations for marine research use can therefore be ruled out.

4.6.2 Benthos & biotope types

With regard to the use of marine research, there are no further specific effects of the MSP's designations compared to the general effects of use described in Chapter 3.6.2 Significant impacts on benthic communities and biotopes due to the MSP provisions on marine research can therefore be ruled out.

4.6.3 Fish

Compared to the impacts on fish fauna described in Chapter 3.6.3spatial planning stipulations of the research are not expected to result in any additional or significant changes.

4.6.4 Marine mammals

The designation of reservation areas for scientific research in the MSP for the German Baltic Sea EEZ means that interactions between uses and cumulative effects on biological assets can be better assessed in existing and, above all, future planning.

Based on the above statements and the presentations in Chapter 3, it can be concluded for the SEA that no significant impacts on marine mammals are to be expected as a result of the designations for scientific research in the MSP, but rather that adverse impacts are avoided in comparison with the non-implementation of the plan.

4.6.5 Avifauna

With regard to marine research, there are no further specific effects of the MSP's provisions compared to the general effects of use described in Chapters 3.6.5 and 3.6.6 Significant impacts on seabirds, resting birds and migratory birds due to the MSP's provisions on marine research can be ruled out with the necessary degree of certainty.

4.7 Nature conservation

The national marine protected areas in the Fehmarn Belt EEZ, the Kadet Trench and the Pomeranian Bay - Rönnebank in the Baltic Sea are designated as nature conservation priority areas in accordance with their conservation purposes.

In the bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen", the operation of wind turbines and any construction or maintenance work affecting them shall not take place during periods of mass migration events.

The designations help to ensure that the marine environment in the EEZ is permanently preserved and developed as an ecologically intact open space over a large area.

The MSP thus contributes to achieving the objectives of the MSFD. However, the influence of spatial planning is limited and cannot have an impact on all objectives.

4.7.1 Floor

The MSP strengthens nature conservation in the German EEZ by designating priority areas. Due to the expected positive impacts on soil as a protected resource, a negative impact can be ruled out through the MSP's designations.

4.7.2 Benthos and biotope types

The designation of the designated nature conservation areas of the Baltic Sea EEZ as priority areas for nature conservation supports the positive effects on benthic communities and biotopes that can be expected on the basis of appropriate management measures of 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 that characterise the nature conservation areas according to Annex I of Directive 92/43/EEC (sandbanks with only slight permanent overtopping by seawater (EU code 1110) and reefs (EU code 1170), as well as a natural or near-natural development of species-rich gravel, coarse sand and shingle beds and the function of these habitats as a regeneration area for benthic communities.

4.7.3 Fish

The general impact of nature reserves on the fish community is described in chapter 3.7.3

The designation of marine protected areas in the EEZ could generally increase the species diversity and condition of the fish population in particular and counteract the overexploitation of fish stocks. The nature reserve "Pommersche Bucht - Rönnebank" is of particular importance for fish as a protected resource, as the FFH species Baltic sturgeon and common sculpin are both protected under the Protected Area Ordinance. Overall, all marine protected areas could increase the species diversity and condition of the fish community, counteract the overexploitation of fish stocks and thus have a significant positive impact on the fish community of the Baltic Sea.

4.7.4 Marine mammals

The MSP designates the three nature conservation areas "Pomeranian Bay - Rönnebank", "Kadet Trench" and "Fehmarn Belt" as priority areas. The harbour porpoise is a protected species in all three priority areas. The designation of priority areas for wind energy production outside of nature conservation areas leads to the prevention and mitigation of negative impacts on harbour porpoise populations in the German Baltic Sea EEZ.

As a result, the nature conservation designations have a positive impact on the conservation status of the **harbour** porpoise population.

4.7.5 Seabirds and resting birds

Among other things, the MSP designates the nature reserve "Pomeranian Bay - Rönnebank" with the bird sanctuary in sub-area IV of the complex area as a priority area for nature conservation. This provides special protection for the habitat of specially protected species and regularly occurring migratory bird species. addition, the MSP states that wind energy use is generally not likely to be compatible with the protective purpose of the priority areas for nature conservation. The priority areas for nature conservation contribute to the protection of open spaces, as they exclude uses that are incompatible with nature conservation. This reduces impacts such as habitat loss and collision risks from offshore wind energy on protected and other bird species and their habitat.

Overall, the spatial planning provisions on nature conservation in the EEZ have exclusively significant positive effects on seabird and resting bird species.

4.7.6 Migratory birds

The MSP takes account of the bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" (cf. MSP Principle (5) Chap. 2.4 Nature conservation). In principle, the corridors can be used by wind energy if they are designated as priority or reservation areas for wind energy. During periods of mass migration events, wind turbines shall not be operated in bird migration corridors if other measures are not sufficient to exclude a proven significantly increased collision risk of birds with wind turbines. Under the same conditions, construction and maintenance work shall not take place.

The need for preventive and mitigation measures - this could be, for example, the shutdown during mass migration events - in the "bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" supports MSFD environmental objective 3 "Seas not affected by the impact of human activities on marine species and habitats" and contributes to the implementation of operational objective UZ3-02 "Measures to protect migratory species in the marine environment".

Clear and operational specifications are needed for measuring and shutdown systems and for the presence of a mass migration event during spring and autumn migration. Insofar as mass migration passes the area of offshore wind turbines according to these measuring systems and specifications, measures for the protection of bird migration must be initiated immediately, in particular those that exclude a collision of birds with wind turbines if there is an increased risk of collision.

Many birds migrating across the German Baltic Sea stop over in the EEZ on their way to their winter or breeding grounds. The significant positive effects of the spatial planning provisions on nature conservation described in Chapter 4.7.4 therefore also apply accordingly to migratory birds.

4.7.7 Cultural and material assets

The general impacts of marine research on cultural and other material assets are described in Chapter 3. Significant impacts of the spatial planning designations can be ruled out with the necessary certainty.

4.8 National and alliance defence

In the EEZ of the Baltic Sea, the reservation areas for national and alliance defence are defined.

The reservation areas are used for training, exercise and testing activities of the navy and air force of the Bundeswehr and alliance partners.

With regard to national and alliance defence, there are no further specific effects of the MSP's designations compared to the general effects of use on the various protected goods described in Chapter 3. Significant impacts due to the MSP's provisions on national and alliance defence can therefore be ruled out.

4.9 Other uses without spatial designations

4.9.1 Air traffic

Air traffic over the EEZ takes place in the context of commercial flights at higher altitudes. No direct impact on the marine environment is to be expected from the provisions of the MSP.

4.9.2 Leisure

Recreational activities in the EEZ are mainly carried out by traffic with smaller private motor and sailing boats. In contrast to areas closer to the coast, relatively low frequencies and environmental impacts are assumed. No direct impact on the marine environment is expected as a result of the provisions of the MSP.

4.10 Interactions

In general, impacts on a protected good lead to various consequential effects and interactions between the protected goods. For example, impacts on the soil or the water body usually also have consequential effects on the biotic protected goods in these habitats. For example, pollutant leaks can reduce water and/or sediment quality and be taken up by benthic and pelagic organisms from the surrounding medium. The essential interconnection of the biotic protected goods exists via the food chains. These interrelationships between the different protected goods and possible impacts on biodiversity are described in detail for the respective protected goods.

Sediment rearrangement and turbidity plumes

During the construction phase of wind farms and platforms or the laying of a submarine cable system, sediment redistribution and turbidity plumes occur. Fish are temporarily scared away. The macrozoobenthos is locally covered. Thus, the feeding conditions for benthic fish and for fish-eating seabirds and harbour porpoises also change for a short time and locally (decrease in the supply of available food). However, due to the mobility of the species and the temporal and spatial limitation of sediment redistribution and turbidity plumes, significant impacts on the biotic protected goods and thus on the existing interactions between them can be excluded with the necessary certainty.

Noise emissions

The installation of the turbines can lead to temporary flight reactions and temporary avoidance of the area by marine mammals, some fish species and seabird species. However, the use of sound-reducing measures is obligatory during pile driving of the foundations of platforms and wind turbines. In this way, significant impacts on the interaction of the protected goods can be excluded with the necessary certainty.

Land use

The installation of foundations results in a local withdrawal of settlement area for the benthic ecosystem, which can lead to a potential deterioration of the food base for the fish, birds and marine mammals that follow within the food pyramid. A significant impairment of food availability can thus be excluded with the necessary certainty.

Placement of artificial hard substrate

The introduction of artificial or off-site hard substrate (foundations, required riprap for cable crossing structures or local cable laying on the seabed) leads locally to a change in soil composition and sediment conditions. As a result, the composition of the macrozoobenthos may change. According to Knust et al. (2003), the introduction of artificial hard substrate into soft bottoms leads to the colonisation of additional species. The recruitment of these species will most likely come from the natural hard substrate habitats, such as superficial boulder clay and stones. Thus, the risk of a negative impact on the benthic soft-bottom communities by species untypical of the area is low. However, settlement areas of soft-bottom fauna are lost at these sites. By changing the species composition of the macrozoobenthic community, the food basis of the fish community at the site can be influenced (bottom-up regulation).

However, this could attract certain fish species, which in turn increase the feeding pressure on the benthos through predation and thus shape the dominance relationships through selection of certain species (top-down regulation). Furthermore, the growth on the hard substrate could serve as a new food source for benthic sea ducks.

Prohibition of use and driving

Within and in the vicinity of wind farms, fishing is prohibited. The resulting discontinuation of fishing can lead to an increase in the population of both fishery target species and non-utilised fish species. A shift in the length spectrum of these fish species is also conceivable. In the case of an increase in fish stocks, an enrichment of the food supply for harbour porpoises is to be expected. Furthermore, it is expected that a macrozoobenthic community undisturbed by fishing activity will develop. This could mean that the diversity of the species community will increase, with sensitive and long-lived species of the current epi- and infauna having a better chance of survival and developing stable populations.

Due to the variability of the habitat, interactions can only be described very imprecisely. In principle, it can be stated that the implementation of the MSP does not currently have any effects on existing interactions that could result in a threat to the marine environment. Therefore, the SEA concludes that, based on the current state of knowledge, no significant effects on the living marine environment are to be expected as a result of the provisions in the MSP, but rather that adverse effects can be avoided in comparison with non-implementation of the plan.

4.11 Cumulative effects

4.11.1 Soil, benthos and biotope types

A significant part of the environmental impacts of the areas for offshore wind energy and the reservation areas for transmission lines on soil, benthos and biotopes will only occur during the construction period (formation of turbidity plumes, sediment relocation, etc.) and in a spatially limited area. Due to the gradual implementation of the construction projects, construction-related cumulative environmental impacts are unlikely. Possible cumulative impacts on the seabed, which could also have a direct impact on the benthos and specially protected biotopes, result from the permanent direct land use of the turbine foundations and the installed pipelines. The individual impacts are generally small-scale and local.

In the area of pipeline trenching, the impact on sediment and benthic organisms will be essentially temporary. In the case of crossing particularly sensitive biotope types such as reefs or species-rich gravel, coarse sand and shingle beds, permanent impairment would have to be assumed.

With regard to a balance of the land consumption, reference is made to the environmental report on the FEP 2019 and the FEP draft 2020. There, the direct land use by wind energy and power cables is estimated on the basis of model assumptions.

Due to the lack of a reliable scientific basis, no statement can be made on the use of specially protected biotopes according to sec. 30 BNatSchG. An area-wide sediment and biotope mapping of the EEZ, which is currently being carried out, will provide a more reliable basis for assessment in the future.

In addition to the direct use of the seabed and thus the habitat of the organisms settled there, plant foundations, overlying pipelines and necessary crossing structures lead to an additional supply of hard substrate. As a result, non-native hard substrate-loving species can settle and change the species composition. This effect can lead to cumulative effects through the construction of several offshore structures, pipelines or rockfills in pipeline crossing areas. The hard substrate introduced also results in the loss of habitat for benthic fauna adapted to soft bottoms. However, as the land use for both the grid infrastructure and the wind farms will be within the ‰ range, no significant impacts are to be expected, even in the cumulative effect, which could endanger the marine environment in relation to the seabed and the benthos.

4.11.2 Fish

The impacts on fish fauna due to the designations are probably most strongly influenced by the realisation of initially 20 GW of wind energy in the reserved areas of the North Sea and Baltic Sea. Here, the impacts of the offshore wind farms are concentrated on the one hand on the regularly ordered closure of the area to fishing, and on the other hand on the change in habitat and its interaction.

The anticipated fishery-free zones within the wind farm areas could have a positive impact on the fish fauna by eliminating negative fishing effects, such as disturbance or destruction of the seabed and catch and bycatch of many species. Due to the lack of fishing pressure, the age structure of the fish fauna could return to a more natural distribution, so that the number of older individuals increases. The OWP could develop into an aggregation site for fish, although it has not yet been conclusively clarified whether wind farms attract fish.

In addition to the absence of fisheries, an improved food base for fish species with a wide variety of diets would also be conceivable. The vegetation of the wind turbines with sessile invertebrates could favour benthophagous species and make a larger and more diverse food source accessible to the fish (GLAROU et al., 2020). This could improve the condition of the fish, which in turn would have a positive impact on fitness. Currently, research is needed to translate such cumulative effects to the population level of fish.

Furthermore, the species composition could change directly, as species with different habitat preferences than the established species, e.g. reef dwellers, find more favourable living conditions and occur more frequently. At the Danish wind farm Horns Rev, a horizontal gradient in the occurrence of hard-substrate species was observed between the surrounding sandy areas and near the turbine foundations 7 years after construction: Cliff perch, eelpout and lumpfish occurred much more frequently near the wind turbine foundations than on the surrounding sand flats (LEONHARD et al., 2011). Cumulative effects resulting from extensive offshore wind energy development could include

- an increase in the number of older individuals,
- better conditions for the fish due to a larger and more diverse food base,
- 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.

In addition to predation, the natural mechanism for limiting populations is intra- and interspecific competition, which is also called density limitation. It cannot be ruled out that within individual wind farms local density limitation sets in before the favourable effects of the wind farms propagate spatially, e.g. through the migration of "surplus" individuals. In this case, the effects would be local and not cumulative. What effects changes in fish fauna might have on other elements of the food web, both below and above their trophic level, cannot be predicted at the current state of knowledge.

Together with the designation of nature reserves, wind farm areas could contribute to positive stock developments and thus to the recovery of fish stocks in the Baltic Sea.

4.11.3 Marine mammals

Cumulative impacts on marine mammals, in particular harbour porpoises, may occur primarily due to noise exposure during the installation of deep foundations. Thus, marine mammals can be significantly affected by the fact that - if pile driving is carried out simultaneously at different locations within the EEZ - not enough equivalent habitat is available to avoid and retreat to.

The realisation of offshore wind farms and platforms so far has been relatively slow and gradual. To date, pile driving has been carried out in three wind farms in the German EEZ of the Baltic Sea. Since 2011, all pile driving work has been carried out using technical noise reduction measures. Since 2014, the noise protection values have been reliably complied with and even undercut through the successful use of noise reduction systems. There was no temporal overlap of the three construction sites so far, so that there was no overlapping of noise-intensive pile driving works that 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 the deterrence measures, due to the installation with two erection ships.

The evaluation of the sound results with regard to sound propagation and the possibly resulting accumulation has shown that the propagation of impulsive sound is strongly restricted when effective sound minimising measures are applied (BRANDT et al. 2018, DÄHNE et al., 2017).

In order to avoid and reduce cumulative impacts on the harbour porpoise population in the German EEZ, a restriction of sound emissions from habitats to maximum permissible proportions of the EEZ and nature conservation areas is specified in the orders of the downstream approval procedure. Accordingly, the propagation of sound emissions may not exceed defined areas of the German EEZ and nature conservation areas. This ensures that sufficient suitable habitats are available to the animals at all times. The order primarily serves to protect marine habitats by avoiding and minimising disturbances caused by impulsive sound emissions. The order of avoidance and mitigation measures in areas EO1 and EO2 will also focus in particular on the protection of animals of the highly endangered population of the central Baltic Sea.

In conclusion, the implementation of the plan will lead to avoidance and mitigation of cumulative impacts. This assessment also applies with regard to cumulative impacts of the various uses on marine mammals.

4.11.4 Seabirds and resting birds

The uses considered in the MSP can have different effects on seabirds and resting birds, in particular from the use of wind energy through the vertical structures such as platforms or wind turbines, such as habitat loss, an increased risk of collision or a scaring and disturbing effect. These effects are considered on a site- and project-specific basis as part of the environmental impact assessment and monitored as part of the subsequent monitoring of the construction and operation phases of offshore wind farm projects. For seabirds and resting birds, habitat loss due to cumulative impacts of several structures or wind farms can be particularly significant. The priority areas for nature conservation contribute to safeguarding open space, as they exclude uses that are incompatible with nature conservation. This reduces the impacts on seabirds and resting birds (see Chapter 3.2.5) in these important habitats. Although the MSP also specifies other uses within the nature conservation areas, no increases in intensity are expected as a result of the spatial planning designations. Rather, these are redrawings of already existing uses or intensities of use.

As a result of the SEA, significant cumulative impacts of the spatial planning designations on the protected species of seabirds and resting birds are not to be expected according to the current state of knowledge.

4.11.5 Migratory birds

The uses taken into account in the spatial plan can have different effects on migratory birds, such as barrier effects and collision risk, in particular from the use of offshore wind energy due to the vertical structures of the offshore wind turbines. These effects are considered on a site-specific basis as part of the environmental impact assessment and monitored as part of the subsequent monitoring of the construction and operation phases of offshore wind farm projects.

The designation of priority areas, including the conditional reservation area EO2-West, in a spatial context to each other reduces barrier effects and collision risks in important feeding and resting habitats.

The provisions of the MSP under 2.4 (5) are expressly referred to at this point. This environmental report refers to these provisions in Chapter 4.7.6

Against the background of the current state of knowledge and taking into account MSP 2.4 (5), significant cumulative impacts on migratory birds can be excluded with the necessary certainty.

According to the current state of knowledge, significant cumulative impacts of the spatial planning designations of all considered uses on migratory birds can be excluded with the necessary certainty.

4.12 Cross-border effects

The present SEA concludes that, as things stand at present, no significant impacts on the areas of neighbouring states adjacent to the German Baltic Sea EEZ are discernible as a result of the stipulations made in the MSP.

For the protected goods soil and water, plankton, benthos, biotope types, landscape, cultural heritage and other material goods and humans, including human health, significant transboundary impacts can generally be excluded. Possible significant transboundary impacts could only result from a cumulative assessment 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.

For the protected resource fish, the SEA concludes that, according to current knowledge, no significant transboundary impacts on the protected resource are to be expected from the implementation of the MSP, as the identifiable and predictable effects are of a small-scale and temporary nature.

This also applies to marine mammals and seabirds and resting birds. These use the areas predominantly as migration areas. No significant loss of habitat for strictly protected species of seabirds and resting birds is to be expected. Based on current knowledge and taking into account impact minimisation and damage limitation measures, significant transboundary impacts can be excluded. For example, the installation of the foundations of wind turbines and platforms will only be permitted in the specific approval procedure if effective noise reduction measures are applied. Against the background of the particular threat to the separate Baltic Sea population of harbour porpoises, intensive monitoring measures are to be carried out as part of the enforcement process and, if necessary, the noise mitigation measures are to be adapted or the construction work coordinated in order to exclude any cumulative effects.

For migratory birds, erected wind turbines in particular can represent a barrier or a collision risk. The priority areas for nature conservation contribute to the protection of open spaces, as they exclude uses that are incompatible with nature conservation. This reduces impacts such as those caused by wind energy in important resting areas for some migratory bird species. Furthermore, the area EO2 is only designated as a reservation area for offshore wind energy, in particular due to the conflict with bird migration. The other uses considered in the MSP do not have any comparable spatial impacts. Significant transboundary impacts of the MSP designations on migratory birds are not to be expected according to current knowledge.

5 Species protection law assessment

5.1 General part

In the plan area, the German EEZ in the Baltic Sea, various European wild bird species as defined in Art. 1 of the Birds Directive as well as marine mammal species of Annexes II and IV of the Habitats Directive occur, as explained.

The present species protection assessment examines whether the plan meets the requirements of sec. 44 para. 1 no. 1 and no. 2 BNatSchG for specially and strictly protected animal species. In particular, it is examined whether the plan violates species protection prohibitions.

According to sec. 44 para. 1 no. 1 BNatSchG, killing or injuring wild animals of specially protected species, i.e. animals listed in Annex IV of the Habitats Directive and Annex I of the V Directive, is prohibited. The species protection assessment pursuant to sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act always refers to the killing and injury of individuals.

Pursuant to sec. 44 para. 1 no. 2 BNatSchG, it is also prohibited to significantly disturb wild animals of strictly protected species during the breeding, rearing, moulting, hibernation and migration periods, whereby significant disturbance exists if the disturbance worsens the conservation status of the local population of a species.

In this context, it does not matter whether a relevant harm or disturbance is based on reasonable grounds, nor do motivations, motives or subjective tendencies play a role in the fulfilment of the prohibited acts (Landmann/Rohmer, 2018).

According to the legal definition of sec. 44 para. 1 no. 2, 2nd half-sentence BNatSchG, a significant disturbance exists if the conservation status of the local population of a species is worsened. According to the Guidelines on the Strict System of Protection for Species of Community Interest under the Habitats Directive (marg. no. 39), disturbance within the meaning of Art. 12 of the Habitats Directive occurs if the act in question reduces the chances of survival, reproductive success or reproductive capacity of a protected species, or if this act leads to a reduction in its range. On the other hand, occasional disturbances with no foreseeable negative effects on the species concerned are not to be regarded as disturbance within the meaning of Art. 12 Habitats Directive.

Among the uses defined in the plan, wind energy production is the most intensive use. In recent years, the use of preventive and mitigation measures and their monitoring has increased the level of knowledge in connection with impacts relevant to species protection.

In the following, species protection concerns 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, the common seal and the grey seal are species listed in Annex II (animal and plant species of Community interest whose conservation requires the designation of special Habitats Directive sites) or Annex IV (animal and plant species of Community interest requiring strict protection) of the Habitats Directive, which are to be protected under sec. 12 of the Habitats Directive. Harbour porpoises occur in varying densities throughout the year, depending on the area. This also applies to harbour seals and grey seals. In general, it can be assumed that the entire German EEZ of the Baltic Sea belongs to the habitat of the harbour porpoise. The German EEZ is used for transiting, but also for stopping over and as a feeding and breeding ground.

The occurrence of animals in the individual areas varies greatly both spatially and temporally. For marine mammals and in particular for the strictly protected species harbour porpoise, the effects of implementing the plan must be assessed in terms of species protection law.

According to current knowledge, two separate populations of harbour porpoise occur in the German waters of the Baltic Sea: the Belt Sea population in the western Baltic Sea - Kattegat, Belt Sea, Sound - up to the area north of Rügen, and the population of the central Baltic Sea from the area north of Rügen onwards.

The limit of the population of harbour porpoise in the central Baltic Sea classified as endangered, taking into account the results from acoustic, morphological, genetic as well as satellite-based surveys, lies at the level of Rügen at 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) based on the acoustic data (SAMBAH, 2014, 2016).

The separate population of the central Baltic Sea has been classified as critically endangered by the IUCN and HELCOM (HELCOM -Red List Species, 2013) due to the very low number of individuals and the spatially restricted genetic exchange.

In the Baltic Sea EEZ, three nature conservation areas, "Pommersche Bucht - Rönnebank" (NSGPBRV), "Fehmarnbelt" (NSGFmbV), and "Kadetrinne" (NSGKdrV) were designated in 2017 with the conservation objective of maintaining and, where necessary, restoring the favourable conservation status of the species listed in Annex II of Directive 92/43/EEC harbour porpoise, harbour seal and grey seal. The nature reserve "Pomeranian Bay - Rönnebank" is of great importance for harbour porpoises in winter. During this period, the nature reserve and its surroundings as far as Rügen are also frequented by animals of the highly endangered population of the harbour porpoise of the central Baltic Sea. No animals of the central Baltic Sea population occur west of a longitude of 13° 30'. The nature reserve "Kadetrinne" shows the border area of the population of the harbour porpoise from Skagerrak, Kattegat and Belt Sea with higher densities of the harbour porpoise west of the NSG and strongly decreasing densities in eastern direction with decreasing densities. The protected area "Fehmarnbelt" and its surroundings have the highest density of harbour porpoise in the German waters of the Baltic Sea.

Areas EO1 and EO2 are regularly used by harbour porpoises, but to a very low extent. The occurrence of harbour porpoise in both areas is low compared to the occurrence west of the Darss Sill. According to current knowledge, there is no evidence that the two areas are used as breeding grounds. Areas EO1 and EO2 are of low to medium importance for harbour porpoises. In the winter months, however, a high significance can be assumed due to the possible 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 irregularly and to a very low extent. Overall, the occurrence of harbour porpoise in area EO3 is low compared to the occurrence in the Kadet Trench and further west. According to current knowledge, the area is not used as a nursery area. Area EO3 is of low importance for harbour porpoises. For grey seals and harbour seals, this area is on the edge of their range.

5.2.1 Sec. 44 para. 1 no. 1 BNatSchG (prohibition of killing and injury)

According to sec. 44 para. 1 no. 1 BNatSchG, killing or injuring wild animals of specially protected species, i.e., among others, animals listed in Annex IV of the Habitats Directive, such as the harbour porpoise, is prohibited.

The main threats to harbour porpoise mortality in the ASCOBANS Agreement Area, which includes the German EEZ in the North Sea, include bycatch in gillnets and trawl nets, dolphin attacks, depletion of food resources, physiological effects on reproductive capacity and infectious diseases, possibly as a result of contaminants. The study of 1692 mortalities along the UK coast between 1991 and 2010 found that the cause of death was related to infectious diseases in 23% of cases, attacks by dolphins in 19% and bycatch in 17%. A further 15% were starved to death and 4% stranded alive (EVANS, 2020).

There is evidence of collisions with ships for at least 21 cetacean species (EVANS, 2003, cited in EVANS 2020). However, the risk of collision is greatest for large cetacean species, including the fin whale and humpback whale (EVANS, 2020). A study on the causes of deaths on the coasts of the British Isles found that about 15% to 20% of baleen whales (fin whale, minke whale) had injuries that could have resulted from collisions with ships. In contrast, only 4% to 6% of small cetaceans such as harbour porpoises and dolphins 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 result of the uses defined in the plan is possible due to the input of impulse sound during pile driving for the foundation of facilities.

For marine mammals and in particular for the strictly protected species harbour porpoise, injuries or even kills could be expected from pile driving for the foundations of offshore wind turbines, transformer stations or other platforms if no preventive and mitigation measures were taken.

In its statements, BfN regularly assumes that, according to current knowledge, injuries in the form of temporary hearing loss occur in harbour porpoises when animals are exposed to a single-event sound pressure level (SEL) of 164 dB re 1 µPa2/Hz or a peak level of 200 dB re 1 µPa.

According to the BfN's assessment, it is ensured with sufficient certainty that, if the specified limit values of 160 dB for the sound event level (SEL05) and 190 dB for the peak level at a distance of 750 m from the emission point are complied with, it will not be possible for the harbour porpoise to be killed or injured pursuant to sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act.

In this context, BfN assumes that suitable means, such as deterrence and soft-start procedures, are used to ensure that no harbour porpoises are present within the 750 m radius around the pile driving site.

The BSH agrees with this assessment in the update of the MSP on the basis of existing knowledge, in particular from the enforcement procedures for 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 protection measures and other preventive and mitigation measures, by means of which the realisation of the prohibition can be excluded or the intensity of any impairments can be reduced. The measures are strictly monitored in order to ensure with the necessary certainty that the killing and injury provisions of sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act (BNatSchG) do not come into effect.

The update of the plan contains principles according to which the input of noise into the marine environment during the construction of installations is to be avoided in accordance with the state of the art in science and technology and an overall coordination of the construction work of spatially co-located installations is to take place. Noise abatement measures are to be used. On this basis, the BSH may order appropriate concretisation with regard to individual work steps, such as deterrence measures and a slow increase in pile driving energy, by means of so-called "soft start" procedures within the framework of subordinate procedures, the site development plan, the suitability assessment of sites and, in particular, within the framework of the respective individual licensing procedures as well as within the framework of enforcement. The use of deterrence measures and soft-start procedures can ensure that no harbour porpoises or other marine mammals are present in an adequate area around the pile driving site, but at least up to a distance of 750 m from the construction site.

Following the precautionary principle, the implementation of the killing ban can be ruled out by the preventive and mitigation measures mentioned above. The use of suitable deterrence measures ensures that the animals are located outside the area of 750 metres around the emission point. In addition, the degree of noise reduction required and specified in the draft suitability determination ensures that no lethal or long-term adverse noise impacts are expected outside the area where harbour porpoises are not expected to be present because of the deterrent measures to be implemented.

According to the above, there is sufficient certainty that the prohibition of species protection under sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act will not be fulfilled.

According to the current state of knowledge, neither the operation of the turbines nor the laying and operation of the cabling within the park will have any significant negative impacts on marine mammals that fulfil the killing and injury requirements of sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act (BNatSchG).

Since 2017, the Fauna Guard System has been ordered as a deterrence measure in all construction projects in the German EEZ of the Baltic Sea. The use of the Fauna Guard System is accompanied by strict monitoring measures with good results so far. As part of a research project, the effects of the Fauna Guard System are currently being systematically analysed and - if necessary - the application of the system will be optimised for future construction projects (FaunaGuard Study, 2020, in preparation).

In order to avoid cumulative impacts, prohibitions are imposed within the framework of subordinate planning approval procedures and enforcement, which ensure that no animals are injured or killed by several sources of impulse sound input acting at the same time. For example, no pile driving is permitted during the blasting of non-transportable munitions.

As a result, the principles and objectives laid down in the update of the plan, as well as the measures ordered in the context of subordinate procedures, in particular the approval procedures for individual projects, prevent with sufficient certainty the realisation of the prohibitions of species protection under sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act.

Furthermore, according to current knowledge, neither the operation of the turbines nor the laying and operation of the cabling within the park nor the laying and operation of the grid connection will have any significant negative impacts on marine mammals that fulfil the killing and injury requirements of sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act.

5.2.2 Sec. 44 para. 1 no. 2 BNatSchG (prohibition of disturbance)

Pursuant to sec. 44 para. 1, 2 of the Federal Nature Conservation Act, it is also prohibited to significantly disturb wild animals of strictly protected species during the breeding, rearing, moulting, hibernation and migration periods, with significant disturbance occurring if the disturbance worsens the conservation status of the local population of a species. A local population comprises those (partial) habitats and activity areas of the individuals of a species that are spatially and functionally connected in a way that is sufficient for the habitat (space) requirements of the species. A deterioration of the conservation status is to be assumed in particular if the chances of survival, breeding success or reproductive capacity are reduced, whereby this must be examined and assessed on a species-specific basis for each individual case (cf. legal justification for the BNatSchG amendment 2007, BT-Drs. 11).

The harbour porpoise is a strictly protected species according to Annex IV of the Habitats Directive and thus within the meaning of sec. 44 para. 1 no. 2 in conjunction with sec. 7 para. 1 no. 14 BNatSchG. 7 para. 1 no. 14 BNatSchG, so that a species protection assessment must also be carried out in this regard.

The species protection assessment pursuant to sec. 44 para. 1 no. 2 BNatSchG refers to population-relevant disturbances of the local population, the occurrence of which varies in the German EEZ of the Baltic Sea.

In its statements in the context of planning approval and enforcement procedures, the Federal Agency for Nature Conservation (BfN) regularly examines the existence of disturbance under species protection law within the meaning of sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act (BNatSchG). It comes to the conclusion that the occurrence of a significant disturbance due to construction-related underwater noise can be avoided with regard to the harbour porpoise as a protected species, provided that the sound event level of 160 dB or the peak level of 190 dB is not exceeded in each case at a distance of 750 m from the emission point and sufficient alternative areas are available in the German North Sea. According to the BfN, the latter should be ensured by coordinating the noise-intensive activities of different project developers with the aim of ensuring that no more than 10 % of the area of the German North Sea EEZ is affected by noise causing disturbance (BMU 2013).

<u>Construction-related impacts of wind energy generation</u>

The temporary execution of the pile driving work is not expected to cause any significant disturbance to harbour porpoises within the meaning of sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act.

According to the current state of knowledge, it is not to be assumed that disturbances that may occur due to sound-intensive construction measures, and provided that preventive and mitigation measures are implemented, would worsen the conservation status of the local population.

Through effective noise abatement management, in particular through the application of suitable noise abatement systems in accordance with the principles and objectives in the update of the plan as well as subsequent orders in the individual approval procedure of the BSH and taking into account the specifications from the noise abatement concept of the BMU (2013), negative impacts of the pile driving work on harbour porpoises are not to be expected.

The BSH's planning approval decisions will contain concrete orders that ensure effective noise protection management through appropriate measures. The protection of the highly endangered population of harbour porpoises in the central Baltic Sea will always be given the highest priority.

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 compliance with the requirements of species protection will be coordinated with the BfN in the course of implementation and adjusted if necessary. The following noise-reducing and environmental protection measures are regularly ordered as part of the planning approval procedures:

- Preparation of a sound prognosis taking into account the site- and plant-specific properties (basic design) before the start of construction,
- Selection of the erection method with the lowest noise level according to the state of the art and the existing conditions,
- Preparation of a concretised soundproofing concept adapted to the selected foundation structures and erection processes for the execution of pile driving works in principle two years before the start of construction, in any case before the conclusion of contracts regarding the sound-relevant components,
- Use of sound-reducing accompanying measures, individually or in combination, away from the pile (bubble curtain system) and, if necessary, also close to the pile, according to 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 sound insulation concept,
- Concept for the removal of animals from the hazard area (at least within a radius of 750 m around the pile driving site),
- Concept for verifying the efficiency of the deterrence and sound-reducing measures,
- Operating noise-reducing system design according to the state of the art.

As outlined above, deterrence measures and a soft-start procedure must be applied to ensure that animals in the vicinity of the pile-driving work have the opportunity to move away or escape in time.

A measure ordered to avoid the risk of killing pursuant to sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act, such as the scaring away of a species, may in principle also fulfil the prohibition of disturbance if it takes place during the protected periods and is significant (BVerwG, judgment of 27.11.2018 - 9 A 8/17, cited in juris).

Until 2016, a combination of pingers as a pre-warning system, followed by the use of the so-called Seal Scarer as a warning system, was used to deter harbour porpoises in construction projects in the German Baltic Sea. All results from monitoring by acoustic detection of harbour porpoise 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, the use of seal scarers is associated with a large loss of habitat caused by the animals' escape 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 the deterrence of animals from the endangered area of construction sites, the so-called Fauna Guard System, has been used since 2017 in construction projects in the German EEZ of the Baltic Sea and since 2018 also in the EEZ of the North Sea. The development of new deterrence systems such as the Fauna Guard System opens up the possibility for the first time to adapt the deterrence of harbour porpoises and seals in such a way that the realisation of the killing and realisation elements within the meaning of sec. 44 para. 1 no. 1 BNatSchG can be excluded with certainty without a simultaneous realisation of the disturbance elements within the meaning of sec. 44 para. 1 no. 2 BNatSchG.

The use of the Fauna Guard System is accompanied by monitoring measures. The effects of the Fauna Guard System 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 (FaunaGuard study, in preparation).

The selection of noise-reducing measures by the subsequent executing agencies of the individual projects must be based on the state of the art in science and technology and on experience already gained in the context of other offshore projects. Practical findings on the application of technical sound-reducing systems and experience with the control of the pile driving process in connection with the characteristics of the impulse hammer were gained in particular during foundation work from projects in the German EEZ of the North Sea and Baltic Sea, such as "Butendiek", "Borkum Riffgrund I", "Sandbank", Gode Wind 01/02", "NordseeOne", "Veja Mate", "Merkur Offshore", "EnBWHoheSee" and especially "Arkona Basin Southeast". A current study commissioned by the BMU (BELLMANN, 2020) provides a cross-project evaluation and presentation of the results from all technical noise reduction measures used in German projects to date.

The results from the very extensive monitoring of the construction phase of 20 wind farms have confirmed that the measures to avoid and reduce disturbance of harbour porpoises by pile driving noise are being implemented effectively and that the specifications from the BMU noise protection concept (2013) are being reliably complied with. The current state of knowledge takes into account construction sites in water depths of 22 m to 41 m, in soils with homogeneous sandy to heterogeneous and difficult-to-penetrate profiles, and piles with diameters of up to 8.1 m. The results of this study show that the impact of pile driving on the harbour porpoise can be prevented effectively and reliably. It has been shown that the industry has found solutions in the various procedures to effectively reconcile installation processes and noise protection.

According to current knowledge and based on the development of technical noise protection to date, it can be assumed that significant disturbance to harbour porpoises can be ruled out from the foundation works within the areas covered by the plan, even assuming the use of piles with a diameter of more than 10 metres.

In addition, in the downstream approval procedures of the BSH, concrete monitoring measures and noise measurements will be ordered in order to record 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 sound input through the use of technical sound mitigation systems clearly reduces disturbance effects on harbour porpoises. The minimisation of effects relates to both the spatial and temporal extent of disturbance (DÄHNE et al., 2017; BRANDT ET AL. 2016; DIEDERICHS ET AL., 2019).

In order to avoid cumulative impacts due to parallel pile driving at different projects, a temporal coordination of pile driving is ordered within the framework of subordinate planning approval procedures and enforcement. Following the BMU noise protection concept (2013) for the North Sea, the area approach is also pursued with the aim of always maintaining sufficient high-quality alternative habitats for the harbour porpoise population in the German EEZ of the Baltic Sea, free of disturbance-triggering noise inputs.

Cumulative impacts on marine mammals, especially harbour porpoises, can occur mainly due to noise exposure during the installation of foundations using pulse pile driving. Thus, marine mammals can be significantly affected if pile driving is carried out simultaneously at different locations within the EEZ without equivalent alternative habitats being available.

So far, the realisation of offshore wind farms and platforms has been relatively slow and gradual. In the period from 2013 to 2017 inclusive, pile driving was carried out in three wind farms in the German EEZ of the Baltic Sea. Since 2013, all pile driving has been carried out using technical noise mitigation measures. Since 2014, the noise protection values have been reliably complied with and even undercut through the successful use of noise reduction systems (Bellmann, 2020 in preparation).

Due to the small number of construction projects in the Baltic Sea, there was no overlap of noise-intensive work.

The evaluation of the sound results with regard to sound propagation and the possibly resulting accumulation has shown that the propagation of impulsive sound is strongly restricted when effective sound minimising measures are applied (DÄHNE et al., 2017).

Current findings on possible cumulative effects of pile driving on the occurrence of harbour porpoise in the German EEZ of the North Sea are provided by two studies from 2016 and 2019 commissioned by the German Offshore Wind Energy Association (BWO). The two studies evaluated and assessed the extensive data from monitoring the construction phases of offshore wind farms by means of acoustic and visual/digital recording of harbour porpoise across projects (Brandt et al., 2016, Brandt et al., 2018, Diederichs et al., 2019). Effects were assessed in both studies based on the range and duration of harbour porpoise displacement from the vicinity of pile driving sites before, during and after pile driving activities.

The study from 2019, which deals with the evaluation of the data from the period 2014 to 2018 inclusive, comes to the conclusion that the optimised use of technical noise abatement measures since 2014 and the resulting reliable compliance with the limit value has not led to any further reduction in the displacement effects on harbour porpoises compared to the phase from 2011 to 2013 with sound abatement systems that had not yet been optimised. The displacement radius determined in both studies is approx. 7.5 km and thus confirms the assumptions from the BMU noise protection concept (2013) for the North Sea. However, the most recent study also showed that no reduction in displacement effects could be detected above a sound level of 165 dB (SEL05 re 1µPa2 s at 750 m distance) (Diederichs et al., 2019). The authors of the study put forward various hypotheses for the interpretation of the results, including psychoacoustic reactions of the animals, differences in food availability, effects of displacement using SealScarer and the activity of the respective construction site, but also differences in data quality. The study also assessed data from the construction of a wind farm in the EEZ of a neighbouring state without the use of sound mitigation measures. This showed that displacement and thus disturbance is significantly lower in construction sites with the use of sound mitigation systems than in construction sites without sound mitigation (Diederichs et la. 2019).

According to the current state of knowledge, preventive and mitigation measures, as already described, are required during pile driving in order to exclude with certainty any significant disturbance of the local population of harbour porpoise.

As a result, applying the above-mentioned strict noise protection and noise reduction measures in accordance with the principles and objectives of the plan and the orders in the planning approval decisions, there is no reason to fear significant disturbance within the meaning of sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act (BNatSchG) if the limit value of 160 dB SEL5 at a distance of 750 m is complied with. Furthermore, the requirement cited by the BfN that noise-intensive construction phases of various project developers in the German North Sea EEZ be coordinated in terms of time in accordance with the BfN's demand is ordered.

<u>Operational effects of wind energy generation</u>

According to current knowledge, the <u>operation of</u> offshore wind turbines is not expected to cause disturbance pursuant to sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act. Based on the current state of knowledge, no negative long-term effects on harbour porpoises due to noise emissions from the turbines are to be expected given the regular construction of the turbines. Any effects are limited to the immediate vicinity of the turbine and depend on the 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 operational noise from offshore wind turbines (LUCKE et al. 2007b): Masking effects were registered at simulated operating noise levels 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 noise levels of 115 dB re 1 µPa. The initial results thus indicate that masking effects due to operating noise can only be expected in the immediate vicinity of the respective installation, whereby the intensity again depends on the type of installation.

Standardised measurements during the operational phase of offshore wind farms in the German EEZ of the North Sea have confirmed that, from an acoustic point of view, the underwater sound outside the wind farm areas is not clearly distinguishable from the permanently present background sound. At a distance of 100 m from the respective wind turbine, only low-frequency noise can be measured. With increasing distance to the turbine, however, the noise of the turbine is only insignificantly differentiated from the ambient sound. Even at a distance of 1 km from the wind farm, higher sound levels are always measured than in the centre 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. Even the wind farm-related ship traffic could hardly be differentiated from the general ambient sound introduced by diverse sound sources, such as other ship traffic, wind and waves, rain and other uses (MATUSCHEK et al. 2018). Results from current investigations of underwater noise in the operational phase of offshore wind farms are presented in detail in chapter 3.2.3.

Results of a study on the habitat use of offshore wind farms by harbour porpoises in operation from the Dutch offshore wind farm "Egmont aan Zee" confirm this assumption. With the help of acoustic recording, the use of the area of the wind farm or of two reference areas by harbour porpoises was considered before the construction of the turbines (baseline recording) and in two consecutive years of the operational phase. 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 operational 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 connection between the presence of the turbines and the increased use by harbour porpoises. They suspect the causes to be factors such as an enrichment of the food supply through a so-called "reef effect" or a calming of the area through the absence of fishing and shipping, or possibly a positive combination of these factors.

The results from the investigations in 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 occurrence that are comparable - and in some cases higher - than those from the 2008 baseline survey.

The results from the monitoring of the operational phase of offshore wind farms in the EEZ have so far not yielded clear results. The survey according to the StUK4 by means of aircraft-based recording has so far resulted in fewer sightings of harbour porpoises inside the wind farm areas than outside. However, acoustic recording of habitat use by means of special underwater measuring devices, the so-called CPODs, shows that harbour porpoises use the wind farm areas (Butendiek, 2017; Nördlich Helgoland, 2019; Krumpel et al., 2017, 2018, 2019). The two methods - visual/digital detection from aircraft and acoustic detection are complementary, i.e. the results from both methods are to be used to identify and evaluate possible effects. The joint evaluation of the data, the development of suitable evaluation criteria and the description of the biological relevance will be the subject of a research programme.

In order to ensure with sufficient certainty that the disturbance requirement pursuant to sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act (BNatSchG) does not come into effect, an operational noise-reducing system design in accordance with the state of the art will be used in line with the corresponding requirement of the subordinate suitability determination and the orders in the individual planning 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 record 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 does not fulfil the prohibition criteria of sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act.

<u>Cumulative view</u>

In Chapter 4.10.3, cumulative effects of offshore wind energy production on harbour porpoises were presented and preventive and mitigation measures were described at the same time. However, the harbour porpoise is exposed to the effects of various anthropogenic uses as well as natural and climate-related changes. A differentiation or even weighting of the share of the effects of a single use on the status of the population is hardly possible scientifically.

Spatial planning and the provisions of the plan, including the principles and objectives, are among the central instruments for mitigating or even avoiding cumulative impacts on the harbour porpoise population through the equalisation of spatial conflicts between uses and the designation of priority and reservation areas for nature conservation.

The designation of priority areas for wind energy exclusively outside nature conservation areas is a measure to ensure the protection of harbour porpoises in the German EEZ. In addition, spatial planning paves the way for downstream planning levels and procedures. Finally, the principles of the plan form the backbone for the specifications in the subordinate procedures and for the orders for the protection of harbour porpoises in the context of individual approval procedures.

In addition, the BSH's planning approval decision includes a number of requirements due to the habitat approach pursued, which ensure effective prevention and reduction of cumulative impacts from pile driving noise, especially on the highly endangered population of harbour porpoise in the central Baltic Sea and on the populations in the nature conservation areas. In the period from 01.11. to 31.03., no sound-intensive work without full noise protection is permitted for all construction projects in areas EO1 and EO2, such as reference and test measurements for the further development and optimisation of technical noise reduction systems.

In conclusion, it can be stated with regard to the harbour porpoise that the implementation of the plan does not fulfil the prohibition criteria of sec. 44 para. 1 no. 1 and no. 2 BNatSchG, also with regard to cumulative impacts.

Other marine mammals

In addition to the harbour porpoise, animal species listed as such in a legal ordinance under sec. 54 para 1 are considered to be specially protected under sec. 7 para. 1 no. 13c of the Federal Nature Conservation Act. In the Federal Ordinance on Species of Wild Fauna and Flora (BArtSchV) issued on the basis of sec. 54 para. 1 no. 1 BNatSchG, native mammals are listed as specially protected and thus also fall under the species protection provisions of sec. 44 para. 1 no. 1 BNatSchG. In principle, the considerations listed in detail for harbour porpoises apply to the sound impact of construction and operation activities of offshore wind turbines in areas EO1 to EO3 and their surrounding marine mammals. However, among marine mammals, species-specific hearing thresholds, sensitivity and behavioural responses vary considerably. The differences in the perception and evaluation of sound events among marine mammals are based on two components: First, the sensory systems are morphoanatomically as well as functionally species-specific. As a result, marine mammal species hear and react to sound differently. Secondly, both perception and response behaviour depend on the respective habitat (KETTEN, 2004).

The areas in the plan are of low to medium importance for harbour seals and grey seals.

Seals are generally considered tolerant of sonic activity, especially in the case of an abundant food supply. However, escape reactions during seismic activities have been detected by telemetric studies (RICHARDSON, 2004). According to all previous findings, harbour seals can still perceive pile-driving sounds at a distance of more than 100 km. Operating noise from 1.5 - 2 MW wind turbines can still be perceived by harbour seals at a distance of 5 to 10 km (LUCKE K., J. SUNDERMEYER & U. SIEBERT, 2006; MINOSplus Status Seminar, Stralsund, Sept. 2006, presentation).

Overall, it can be assumed that the requirements of species protection can be met due to the large distances to casting and mooring sites as well as the specified measures.

With regard to the harbour seal and grey seal, the preventive and mitigation measures already listed for the harbour porpoise apply.

In conclusion, it can be stated with regard to the common seal and grey seal that the implementation of the plan does not fulfil the prohibition criteria of sec. 44 para. 1 no. 1 and no. 2 of the Federal Nature Conservation Act, also with regard to other marine mammals.

5.3 Avifauna (seabirds, resting birds and migratory birds)

The plan is to be evaluated on the basis of species protection requirements according to sec. 44 para. 1 BNatSchG for avifauna (resting and migratory birds).

In the areas covered by the plan, protected bird species according to Annex I of the Birds Directive (in particular red-throated divers, black-throated divers, lesser black-backed gulls and eared grebes) and regularly occurring migratory bird species (long-tailed duck, common scoter, velvet scoter, guillemot and razorbill), which also occur as resting species, occur in varying densities. Against this background, the compatibility of the plans with sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act (prohibition of killing and injury) and sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act (prohibition of disturbance) must be examined and ensured.

The individual areas for offshore wind energy in the Baltic Sea EEZ have different importance for seabirds and resting birds. Overall, site EO1 is of medium importance for seabirds. The area touches the southern and south-eastern margins of the extensive resting habitats of the Pomeranian Bay and the Adlergrund. Overall, the area has a medium seabird occurrence and a medium occurrence of endangered species and species in need of special protection. According to current knowledge, areas EO2 and EO3 are of low importance as feeding and resting habitats for seabirds. Both areas have a low occurrence 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.

In addition, the EEZ has an average to above-average importance for bird migration. Up to one billion birds migrate across the Baltic Sea every year. For sea ducks and geese from northern Europe and Russia (as far as western Siberia), the Baltic Sea is an important passage area, with much of the migration in autumn taking place in an east-west direction near the coast. Thermal swifts (and other diurnal land birds such as woodpigeons) prefer to migrate along the "bird flight line" (islands of Fehmarn, Falster, Møn and Zealand, Falsterbo). East of this main route, these birds migrate in much lower densities. For crane migration, the western Baltic Sea is of above-average importance, as the majority of the biographic population must inevitably cross the Baltic Sea on their way south. In addition, the western Baltic Sea is overflown by several species requiring special protection (e.g. white-cheeked goose, whooper swan, eider, mourning duck and velvet scoter), sometimes at 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 procedures. In recent years, the monitoring of the operational phase of offshore wind farms in the German EEZ has increased the knowledge of impacts relevant to species protection.

5.3.1 sec. 44 para. 1 no. 1 BNatSchG (prohibition of killing and injury)

According to sec. 44 para. 1 no. 1 BNatSchG, it is prohibited to hunt, capture, injure or kill wild animals of specially protected species. Species under special protection include European bird species, i.e. species listed in Annex I of the Birds Directive, species whose habitats are protected in nature conservation areas, as well as characteristic species and regularly occurring migratory bird species. Accordingly, injury to or killing of birds as a result of collisions with wind turbines must be excluded. The risk of collision depends on the behaviour of the individual animals and is directly related to the species concerned and the environmental conditions encountered. For example, a collision of divers is not to be expected due to their distinct avoidance behaviour towards vertical obstacles (GARTHE et al., 2018; Mendel et al., 2019; BIOCONSULT SH ET AL., 2020).

As already explained, according to sec. 44 para. 5 sentence 2 no. 1 of the Federal Nature Conservation Act (BNatSchG), there is no violation of the prohibition of killing and injury "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 Federal Nature Conservation Act on the basis of corresponding supreme court rulings, since in the planning and approval of public infrastructure and private construction projects it must be regularly assumed that unavoidable operational killing or injury of individual birds (e.g. through collision of birds with wind turbines) may occur, which, however, as the realisation of socially adequate risks, should not fall under the prohibition (BT-Drs. 16/5100, p. 11 and 16/12274, p. 70 f.). Attribution only occurs if the risk of success is significantly increased by the project due to special circumstances, such as the construction of the installations, the topographical conditions or the biology of the species. In this context, measures for risk avoidance and reduction are to be included in the assessment (cf. LÜTKES/EWER/HEUGEL, SEC. 44 BNATSCHG, MARGINAL NO. 8, 2011; BVERWG, JUDGEMENT OF 12 MARCH 2008; REF. 9 A3.06; BVERWG, JUDGEMENT OF 9 July 2008, ref. 9 A14.07; FRENZ/MÜGGENBORG/LAU, sec. 44 BNATSCHG, MARGINAL NO. 14, 2011).

In its statements, the BfN regularly states that the changes in the technical size parameters of the wind turbines in current offshore wind farm projects generally result in an increase in vertical obstacles in the airspace compared to the implementation from 2011 to 2014. However, according to the current state of knowledge, an increased risk of bird strikes cannot be quantified due to the simultaneous reduction in the number of turbines. It is true that collision-related individual losses due to the erection of a fixed installation in previously obstacle-free areas cannot be completely ruled out. However, the measures ordered, such as minimising light emissions, ensure that collisions with offshore wind turbines are avoided as far as possible or that this risk is at least minimised. In addition, effect monitoring will be carried out during the operational phase in order to verify the current nature conservation assessment of the actual bird strike risk posed by the turbines and to be able to adjust it if necessary.

According to previous findings, there is an increased risk potential for cranes to collide with wind turbines based on their flight behaviour and flight altitude distribution. During previous bird migration observations in the vicinity of site O-1.3, higher numbers of cranes were observed, especially under crosswind conditions from a westerly direction (BioConsult SH, 2019; IfAÖ et al., 2020). For the suitability assessment of site O-1.3, a requirement was included in sec. 43 of the draft suitability determination for the protection of the crane, taking into account the available findings, in order to comprehensively observe the migratory activity and in this way to identify situations with an increased migratory activity in good time so that effective measures can be taken to reduce the collision risk of cranes in these situations. Due to the strict assessment standard under species protection law, it was also considered necessary to include other species or species groups of bird migration in the requirement for area O-1.3 in order to be able to exclude a significantly increased risk of death and injury with the necessary certainty.

The MSP takes account of the bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" (cf. MSP Principle (5) Chap. 2.4 Nature conservation). In principle, the corridors can be used by wind energy if they are designated as priority or reservation areas for wind energy. During periods of mass migration events, wind turbines shall not be operated in bird migration corridors if other measures are not sufficient to exclude a proven significantly increased collision risk of birds with wind turbines. Under the same conditions, construction and maintenance work shall not take place.

The need for preventive and mitigation measures - this could be, for example, the shutdown during mass migration events - in the "bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" supports MSFD environmental objective 3 "Seas not affected by the impact of human activities on marine species and habitats" and contributes to the implementation of operational objective UZ3-02 "Measures to protect migratory species in the marine environment".

Clear and operational specifications are needed for measuring and shutdown systems and for the presence of a mass migration event during spring and autumn migration. Insofar as mass migration passes the area of offshore wind turbines according to these measuring systems and specifications, measures for the protection of bird migration must be initiated immediately, in particular those that exclude a collision of birds with wind turbines if there is an increased risk of collision.

Against this background, there is no reason to fear a significant increase in the risk of killing or injuring avifauna. The realisation of offshore wind turbines together with ancillary facilities, such as transformer stations and cabling within the park, therefore does not violate the prohibition of killing and injury pursuant to sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act (BNatSchG).

If the requirements of the suitability assessment are implemented, it cannot be assumed that the prohibition of injury and killing under sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act will be realised in the context of offshore wind energy use in the areas covered by the plan.

5.3.2 Sec. 44 para. 1 no. 2 BNatSchG (prohibition of disturbance)

According to sec. 44 para. 1 no. 2 BNatSchG, it is prohibited to significantly disturb wild animals of strictly protected species during the breeding, rearing, moulting, hibernation and migration periods, with significant disturbance occurring if the disturbance worsens the conservation status of the local population of a species. For this reason, it is necessary to consider possible disturbance to local populations in German waters, especially in the German EEZ, caused by wind energy use in the areas covered by the Plan.

A cross-area and cross-surface species protection assessment with regard to the prohibition of disturbance in the sense of a deterioration of the conservation status of local populations of protected species was carried out as part of the SEA for the site development plan (FEP, Environmental Report 2019). The result of the assessment in the context of the preparation of the FEP (BSH 2019) can be confirmed on the basis of the available data and information on the areas.

As already explained, protected species occur in areas EO1 to EO3. These include species listed in Annex I of the Birds Directive, species whose habitats are protected in the nature conservation areas, as well as characteristic species and regularly occurring migratory bird species.

The area of sites EO1 to EO3 is used by divers mainly as a passage area during migration periods and in winter. According to the current state of knowledge, this area and its surroundings are located outside focal points of occurrence in the Pomeranian Bay. Based on the available information, the BSH concludes that the areas EO1 to EO3 are not of high importance for the common 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 Lesser Black-backed Gulls in areas EO1 to EO3 and the temporally limited coupling to the species-specific main migration periods, only a low significance for Lesser Black-backed Gulls can be assumed for areas EO1 to EO3. With regard to Lesser Black-backed Gulls, a wind farm project in areas EO1 to EO3 is, according to current knowledge, not expected to fulfil the requirements for disturbance under sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act.

Slavonian Grebes prefer shallow grounds with water depths of up to 10 m. Due to the water depths of areas EO1 to EO3, this part of the EEZ is not particularly important for Slavonian Grebes. This is confirmed by only isolated sightings from the seabird surveys of the cluster "Westlich Adlergrund", which also cover the area EO1. In this respect, no disturbance of the local eared grebe population can be assumed.

Diving sea ducks, such as ice ducks, velvet scoters and scoters, also prefer the nutrient-rich shallow grounds in the Baltic Sea. Therefore, the areas EO1 to EO3 and their surroundings are not considered to be of special importance for them.

With regard to diving sea ducks, a wind farm project in areas EO1 to EO3 does not, according to the current state of knowledge, meet the criteria for disturbance under sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act.

Common guillemots and razorbills show a large-scale distribution in winter in the areas of the plan. Based on existing studies and knowledge of the distribution in the entire Baltic Sea, no focal points of occurrence can be identified for the areas EO1 to EO3. Area EO1 only borders on the southern fringes of the distribution range of alcids. According to current knowledge, no significant impacts of a wind farm project in the areas covered by the plan can be assumed for alcids, in particular guillemots and razorbills. Therefore, according to the current state of knowledge, the BSH does not assume that the disturbance requirement under sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act is fulfilled.

The gull species occurring in the areas covered by the plan are known to be prominent ship followers. Furthermore, findings from research projects and wind farm monitoring indicate an attraction effect of offshore wind farms. According to current knowledge, significant impacts on the populations of the occurring gull species in the form of disturbances are not to be expected from an offshore wind farm in the areas for wind energy production.

In conclusion, the construction and operation of offshore wind turbines including ancillary facilities (transformer station, cabling within the park) in the areas covered by the plan are not expected to fulfil the disturbance requirement under sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act (BNatSchG), according to the current state of knowledge.

Within the framework of the individual approval procedures, however, an update of the examination of the fulfilment of the disturbance requirement according to sec. 44 para. 1 no. 2 BNatSchG is necessary, if necessary taking into account further preventive and mitigation measures, but in any case taking into account the specific technical designs.

5.4 Bats

The areas of the plan for offshore wind energy use are to be assessed on the basis of species protection requirements pursuant to sec. 44 BNatSchG in conjunction with Art. 12 FFH-D for bats. Art. 12 Habitats Directive for bats.

5.4.1 Sec. 44 para. 1 no. 1 and no. 2 BNatSchG

In terms of species protection law, the same considerations apply in principle as those already mentioned in the context of the avifauna assessment. According to Art. 12 para. 1 no. 1 a) Habitats Directive, all intentional forms of capture or killing of individuals of species listed in Annex IV of the Habitats Directive, i.e. all bat species, taken from the wild are prohibited. With regard to collisions with offshore structures, reference can be made to the Guidance on the strict system of protection for animal species of Community interest under the Habitats Directive, which assumes in II.3.6 para. 83 that the killing of bats through collisions with wind turbines is an unintentional killing that must be continuously monitored pursuant to Art. 12 para. 4 Habitats Directive. There are no indications for the examination of further facts according to Art. 12 para. 1 of the Habitats Directive.

Migratory movements of bats over the Baltic Sea have been documented in various ways, but so far there is a lack of concrete information on migratory species, migration corridors, migration heights and migration concentrations. Previous findings only confirm that bats, especially long-distance migratory species, migrate over the Baltic Sea. There is currently no reliable data available to indicate significant impacts on bats and to question the suitability of the areas for wind energy production.

Furthermore, it can be assumed that any negative impacts of wind turbines on bats will be avoided by the same preventive and mitigation measures provided for the protection of bird migration.

Experiences and results from research projects or from wind farms that are already in operation will also be given appropriate consideration in further procedures.

In its statements, the BfN regularly assumes that, according to current knowledge, killing or injuring (sec. 44 para. 1 no. 1 BNatSchG) of other specially protected species, such as bats, by offshore wind farms can be ruled out. According to the Federal Agency for Nature Conservation (BfN), the prohibition of significant disturbance (sec. 44 para. 1 no. 2 BNatSchG) of other strictly protected species is also not to be expected according to the current state of knowledge. The BSH concurs with the opinion of the BfN.

6 Impact assessment / territorial protection assessment

6.1 Legal basis

Insofar as a site of Community importance or a European bird sanctuary may be significantly impaired in terms of its components relevant to the conservation objectives or the purpose of protection, sec. 7 para. 6 in conjunction with para. 7 of the ROG, the provisions of the Federal Nature Conservation Act on the admissibility and implementation of such interventions, including obtaining the opinion of the European Commission, must be applied when amending and supplementing maritime spatial plans.

The Natura2000 network comprises the Sites of Community Importance (SCIs) under the Habitats Directive and the Special Protection Areas (SPAs) under the Birds Directive, which have since been designated as protected areas in Germany (e.g. BVerwG, decision of 13 March 2008 - 9 VR 9/07). It therefore does not replace the assessment at the level of the concrete project in knowledge of the concrete project parameters, which is carried out within the framework of approval procedures. In this respect, further preventive and mitigation measures are to be expected if they are deemed necessary by the impact assessment within the framework of approval procedures in order to exclude any impairment of the conservation objectives of Natura2000 sites or the conservation purposes of protected areas by the use within or outside a nature conservation area. At the same time, it must be taken into account that for some uses - especially wind energy - the MSP traces the projects already in operation and the designations of the FEP sectoral planning, for which impact assessments have already been carried out.

In the German EEZ of the Baltic Sea, there are the nature conservation areas "Pommersche Bucht - Rönnebank" (Ordinance on the Establishment of the Nature Conservation Area "Pommersche Bucht - Rönnebank" of 22 September 2017, NSGPBRV,BGBl. I p. 3415), "Fehmarnbelt" (Ordinance on the Establishment of the Nature Conservation Area "Fehmarnbelt" of 22 September 2017, NSGFmbV, BGBl. I p. 3405) and "Kadetrinne"(Ordinance on the Establishment of the Nature Conservation Area "Kadetrinne" of 22 September 2017, BGBl. I p. 3410, NSGKdrV).

The total area of the three nature reserves is 2,472 km², the nature reserve "Pomeranian Bay - Rönnebank" covers an area of 2,092km², the nature reserve "Fehmarnbelt" contains an area of 280 km2 and the nature reserve "Kadetrinne" of 100 km2.

Protected species are the habitat types "reefs" and "sandbanks" according to Annex I of the Habitats Directive, certain fish species (sturgeon, fin) and marine mammals according to Annex II of the Habitats Directive (harbour porpoise, grey seal, seal) as well as various seabird species according to Annex I of the Habitats Directive (red-throated diver, black-throated diver, horned grebe) and regularly occurring migratory bird species (red-necked grebe, yellow-billed grebe, long-tailed duck, common scoter, velvet scoter, common gull, guillemot, razorbill, black guillemot).

The impact assessment carried out here takes place at the higher level of spatial planning and sets a framework for subordinate planning levels, if these exist. It therefore does not replace the assessment at the level of the specific project. Depending on the designations of the MSP 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 assessments of the downstream planning levels are taken into account within the framework of this MSP. Insofar as no assessment has yet been carried out within the framework of subordinate planning levels, the assessment is carried out within the framework of this SEA for the MSP on the basis of existing data and knowledge.

There is also a staged planning and approval process for raw material extraction. Where data and knowledge are available, an impact assessment is carried out within the framework of this SEA; otherwise, the assessments are reserved for the downstream planning levels.

The MSP contains designations relevant to the impact assessment on priority and reservation areas for wind energy, reservation areas for pipelines and reservation areas for hydrocarbons and sand and gravel extraction. The same applies to pipelines.

Scientific determinations can only be examined as far as information is available.

A differentiation must be made for the impact assessment:

Wind energy

Since, according to sec. 5 para. 3 sentence 2 no. 5 a) WindSeeG, areas and sites for wind energy plants may not be designated in the FEP within a protected area designated pursuant to sec. 57 BNatSchG, the MSP does not contain any area designations for the use of wind energy within the protected areas designated by ordinance.

In the following, the impact assessment therefore refers exclusively to area designations at or in the vicinity of protected areas established by ordinance.

For areas EO1, EO2 and EO3, please refer to the impact assessment of the FEP 2019/Draft FEP 2020.

6.2 Assessment of the compatibility of the MSP with regard to habitat types

The conservation or, where necessary, the restoration of a favourable conservation status of the reef habitat type (EU Code 1170) is the purpose of protection in the Kadetrinne nature reserve (sec. 3 para. 3 no. 1 NSGKdrV) and in the "Pommersche Bucht - Rönnebank" nature reserve (sec. 4 para. 1 no. 1 NSGPBRV). The habitat type "sandbank" is a protected property in the nature reserve "Pommersche Bucht - Rönnebank" (sec. 5 para.1 no.1 NSGPBRV) and in the nature reserve "Fehmarnbelt" (sec. 3 para.3 no.1 NSGFmbV).

Due to the shortest distance between areas EO1 to EO3 and the nature conservation areas, construction, installation and operational impacts on the FFH habitat types "reef" and "sandbank" with their characteristic and endangered biotic communities and species can be excluded. The areas are located far outside the drift distances discussed in the literature, so that no release of turbidity, nutrients and pollutants is to be expected that could impair the nature conservation and FFH areas in their components relevant to the conservation objectives or the conservation purpose.

6.3 Assessment of the compatibility of the MSP with regard to protected species

6.3.1 Compatibility assessment in accordance with the Ordinance on the Establishment of the Nature Reserve "Pomeranian Bay - Rönnebank

Pursuant to sec. 9 para. 1 no. 3 NSGPBRV, the impairment of the conservation objectives or protective purposes of the nature conservation areas by the implementation of the plan must be examined.

The assessment of the impacts of the plan is based on the conservation purpose of the "Pomeranian Bay - Rönnebank" protected area. According to sec. 3 para. 1 NSGPbrV, the overarching conservation purpose is to achieve the conservation objectives of the Natura 2000 sites 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 Oder Bank, the Adlergrund, the Rönnebank and the slope areas of the Arkona Basin.

According to sec. 3 para. 2 no. 3 NSGPbrV, 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.

Protected marine mammal species

Finally, under sec. 4 - 6 para. NSGPbrV, the Ordinance of 22.09.2017 sets out objectives to ensure the survival and reproduction of the marine mammal species listed in sec. 3 para. 2 NSGPbrV of Annex II of the Habitats Directive harbour porpoise and grey seal and to conserve and restore their habitats.

Pursuant to sec. 4 para 3, the protection of harbour porpoises in Area I shall require in particular the conservation or, where necessary, the restoration of

- the natural population densities of this species with the aim of achieving a favourable conservation status, its natural spatial and temporal distribution, health status and reproductive fitness, taking into account natural population dynamics, natural genetic diversity within the range population and genetic exchange opportunities with populations outside the range,
- of the area as a harbour porpoise habitat largely free of disturbance and unaffected by local pollution,
- unfragmented habitats and the possibility of migration of the harbour porpoise - within the central Baltic Sea and into the western Baltic Sea and Belt Sea as well as
- the essential food resources of harbour porpoises, in particular the natural population densities, age class distributions and distribution patterns of organisms serving as food resources for harbour porpoises.

The same is regulated in sec. 6 para. 3 NSGPbrV for the harbour porpoise in Area III of the protected area and in sec. 5 para. 3 NSGPbrV.

According to sec. 5 para. 1 NSGPbrV, the purpose of protection in Area II is to maintain or restore a favourable conservation status of the harbour porpoise and to maintain or restore a favourable conservation status of the grey seal.

Reference is made to the results of the impact assessment on the FEP 2019/Draft FEP 2020.

Possible impairments of the conservation purposes of the nature reserve "Pommersche Bucht- Rönnebank" through the realisation of projects in areas EO1, EO2 and EO3 of the present plan can be excluded with certainty if the orders in the subordinate individual approval procedures are complied with.

Protected seabird species

Pursuant to sec. 34 para. 1 BNatSchG and sec. 9 para. 1 no. 3 NSGPBRV, the impairment of the conservation objectives of sub-area IV of the nature reserve by the implementation of the plan must be examined.

The assessment of compatibility is based on the protection purpose of Area IV according to sec. 7 of the NSGPBRV.

According to sec. 7 para. 1 NSGPBRV, the conservation objectives pursued in Area IV include the maintenance or, where necessary, the restoration of a favourable conservation status

- according to No.1, of the species listed in Annex I to Directive 2009/147/EC occurring in this area: red-throated diver (*Gavia stellata*), black-throated diver (*Gavia arctica),* horned grebe (*Podiceps auritus*),
- according to no. 2, of the migratory bird 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
- according to No. 3 of the function of this area as a feeding, wintering, moulting, transit and resting area for the species mentioned.

According to sec. 7 para. 2 NSGPBRV, in order to protect the habitats and to ensure the survival and reproduction of the bird species listed in para. 1 and of the area in its functions listed in para. 1, it is necessary in particular to maintain or, where necessary, to restore

- according to No. 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,
- according to No. 2, the essential food resources of the bird species, in particular the population densities, age class distributions and distribution patterns of the organisms serving as food resources for the bird species,
- according to No. 3, the characteristic features of the area, in particular with regard to salinity, freedom from ice even in severe winters, and geo- and hydromorphological conditions with their species-specific ecological functions and effects, as well as
- according to No. 4, the natural quality of the habitats with their respective species-specific ecological functions, their unfragmented nature and spatial interrelationships, as well as unimpeded access to adjacent and neighbouring marine areas.

Reference is made to the results of the impact assessment on the FEP 2019/Draft FEP 2020.

Possible impairments of the conservation purposes of the nature reserve "Pommersche Bucht- Rönnebank" through the realisation of projects in areas EO1, EO2 and EO3 of the present plan can be excluded with certainty if the orders in the subordinate individual approval procedures are complied with.

6.3.2 Impact assessment in accordance with the Ordinance on the Establishment of the "Fehmarnbelt" Nature Conservation Area

According to sec. 3 NSGFmbV, the compatibility of the implementation of the plan with the conservation purposes of the nature reserve must be examined.

The overarching conservation purpose of the "Fehmarnbelt" nature reserve is, according to sec. 3 para. 1 NSGFmbV, the realisation of the conservation objectives of the Natura2000 area through the permanent preservation of the marine area, the diversity of its habitats, biotic communities and species relevant to this area, as well as the special character of the sandbank in the form of megaripples.

Pursuant to para. 2, the protection shall include

the preservation or, where necessary, the restoration

- the specific ecological values and functions of the area, in particular, its characteristic morphodynamics as well as the hydrodynamics shaped by the water exchange between the North Sea and the Baltic Sea, a natural or near-natural expression of the marine macrophyte stocks and the species-rich gravel, coarse sand and shingle beds,

- the stocks 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;

Pursuant to sec. 3 para. 3 no. 2 NSGFmbV, the conservation objectives pursued include in particular the conservation or, where necessary, the restoration of a favourable conservation status of the harbour porpoise and harbour seal species.

In order to protect harbour porpoises and harbour seals, sec. 3 para. 5 NSGFmbV requires 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, their health status and their reproductive fitness, taking into account natural population dynamics, natural genetic diversity within the population and genetic exchange opportunities with populations outside the area,
- of the area as a feeding and migration habitat for harbour porpoises and harbour seals, and as a breeding and nursery habitat for harbour porpoises, with as little disturbance as possible and largely unaffected by local pollution,
- unfragmented 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-Vorpommern and to the moorings along the Danish (especially Rødsand) and German coasts, as well as
- the essential food resources of harbour porpoises and harbour seals, in particular the natural population densities, age class distributions and distribution patterns of organisms serving as food resources for harbour porpoises and harbour seals.

Reference is made to the results of the impact assessment on the FEP 2019/Draft FEP 2020.

Possible impairments of the conservation purposes of the "Fehmarnbelt" nature conservation area through the realisation of projects in areas EO1, EO2 and EO3 of the plan in question can be ruled out with certainty if the orders in the subordinate individual approval procedures **are** complied with.

6.3.3 Impact assessment in accordance with the Ordinance on the Establishment of the "Kadetrinne" Nature Conservation Area

According to sec. 3 NSGKdrV, the compatibility of the implementation of the plan with the conservation purposes of the nature reserve must be examined.

According to sec. 3 para. 1 NSGKdrV, the overriding protective purpose of the "Kadetrinne" nature reserve is to achieve the conservation objectives of the Natura2000 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 conservation or, where necessary, the restoration of the specific ecological values and functions of the area, in particular its characteristic morphodynamics

and the hydrodynamics shaped by the exchange of water between the North Sea and the Baltic Sea,
- the stocks of harbour porpoises, including their habitat and natural population dynamics, and
- - its connecting and stepping stone function for the ecosystems of the western and central Baltic Sea.

Pursuant to sec. 3 para. 3 no. 2 NSGKdrV, the conservation objectives pursued include the preservation or restoration of a favourable conservation status of the harbour porpoise.

- 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 population and genetic exchange opportunities with populations outside the area,
- of the area as a feeding, migration, breeding and nursery habitat for harbour porpoises with as little disturbance as possible and largely unaffected by local pollution,
- unfragmented habitats and the possibility of migration of marine mammals within the central Baltic Sea and into the western Baltic Sea as well as
- the main foraging organisms of harbour porpoises, in particular the natural population densities, age class distributions and distribution patterns.

Reference is made to the results of the impact assessment on the FEP 2019/Draft FEP 2020.

Possible impairments of the conservation purposes of the "Fehmarnbelt" nature conservation area through the realisation of projects in areas EO1, EO2 and EO3 of the plan in question can be ruled out with certainty if the orders in the subordinate individual approval procedures **are** complied with.

6.3.4 Natura2000 areas outside the German EEZ

The impact assessment also takes into account the long-distance effects of the plan on the protected areas in the adjacent 12-mile zone and in the adjacent waters of the neighbouring states. This also concerns the assessment and consideration of functional relationships between the individual protected areas or the coherence of the network of protected areas pursuant to sec. 56 para. 2 BNatSchG, since the habitat of some target species (e.g. avifauna, marine mammals) may extend over several protected areas due to their large radius of action.

In detail, the bird sanctuary "Westliche Pommersche Bucht", the FFH and bird sanctuary "Plantagenetgrund", the FFH area "Darßer Schwelle", the bird sanctuary "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 considered. 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" were considered.

The protection and conservation objectives for the Natura 2000 sites outside the EEZ were taken from the following documents:

- Bird sanctuary "Westliche Pommersche Bucht" (coastal sea M-V, DE1649 401): EUNIS factsheet (https://eunis.eea.europa.eu/sites/DE1649401)
- FFH and bird sanctuary "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 sanctuary 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 sanctuary "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 und Teile der Pommerschen Bucht" (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 Habitats Directive 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 of the FEP 2020.

Possible impairments of the conservation purposes of the Natura 2000 sites through the realisation of projects in areas EO1, EO2 and EO3 of the plan in question can be ruled out with certainty if the orders in the subordinate individual approval procedures are complied with.

The results of the impact assessment in the context of the designations in the update of the plan pursuant to sec. 34 of the Federal Nature Conservation Act in connection with the conservation purposes of the above-mentioned Natura2000 areas with regard to protected species and habitats are also transferable to the Natura2000 areas in the territorial sea. The assessment of possible impairments of the conservation purposes and conservation objectives of the Natura2000 sites in the German EEZ came to the conclusion that, taking into account the principles and objectives of the maritime spatial plan as well as preventive and mitigation measures ordered in the context of subordinate approval procedures, such impairments can be excluded with the necessary certainty. This conclusion is also transferable to the protection purposes and conservation objectives of Natura2000 in the coastal sea. The Natura2000 network is structured in German waters in such a way that the connectivity of important habitat types but also functions, such as migration routes in particular, is guaranteed. Appropriate measures for the prevention and mitigation of significant impacts in the context of subordinate approval procedures in the German EEZ always ensure that no long-distance impacts, including indirect significant impairments of the conservation objectives of the Natura2000 sites in the coastal sea, are to be expected.

6.4 Result of the impact assessment

As a result, a significant impairment of the conservation purposes of the nature conservation areas "Pommersche Bucht - Rönnebank", "Fehmarnbelt", and "Kadetrinne" can be ruled out with the necessary certainty by updating the plan, taking into account preventive and mitigation measures for FHH habitat types, marine mammals, avifauna and other protected animal groups.

It should be noted that the Habitats Directive impact assessment carried out here was not able to examine project-specific characteristics that are only concretised and defined by the developers of projects within the framework of planning approval procedures.

The impact assessment is therefore carried out within the framework of the planning approval procedure for the respective project, with the aim of deriving and defining the necessary preventive and mitigation measures at project level.

According to the current state of knowledge, a significant impairment of the Habitats Directive habitat types "reefs" and "sandbanks with only slight permanent overtopping by seawater" can be ruled out even when cumulatively considering the plan and already existing projects for the nature conservation areas "Pommersche Bucht - Rönnebank", "Fehmarnbelt", and "Kadetrinne" as well as for Natura2000 sites in the coastal sea due to the small-scale impacts on the one hand and the distances to the sites on the other hand.

7 Overall plan assessment

In summary, with regard to the provisions of the MSP, the effects on the marine environment are minimised as far as possible through orderly, co-ordinated overall planning. The protection of the nature conservation areas designated by ordinance as priority areas for nature conservation serves to safeguard the conservation purposes and open space. By strictly adhering to preventive and mitigation measures, in particular for noise reduction during the construction phase, significant impacts can be avoided, especially through the implementation of the designations for offshore wind energy and power lines. No priority or reservation areas for wind energy are designated in the priority areas for nature conservation. The reservation areas for power lines also run predominantly outside ecologically important areas.

On the basis of the above descriptions and assessments, as well as the assessment of species and site protection, it must be concluded for the Strategic Environmental Assessment, also with regard to any interactions, that, according to current knowledge and at the comparatively abstract level of spatial planning, no significant impacts on the marine environment within the study area are to be expected as a result of the planned designations.

Many environmental impacts, for example from shipping or fishing, occur independently 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, since it is not evident 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 fundamentally "neutral" with regard to their effects on the environment. Although it is possible in principle that, due to the concentration/bundling of individual uses on certain areas, some of the provisions of the plan may well have negative environmental impacts in the area of this specific area, an overall balance of the environmental impacts would tend to be positive due to the bundling effects, as the remaining areas are relieved and risks to the marine environment (e.g. collision risk) are reduced.

For wind energy use, the potential impacts are often small-scale and mostly short-term, as they are limited to the construction phase. To date, there is a lack of sufficient scientific knowledge and uniform assessment methods for the cumulative assessment of impacts on individual protected goods such as bat migration. Therefore, the potential impacts cannot be conclusively assessed within the framework of this SEA or are subject to uncertainties and require more detailed examination in the context of subsequent planning stages.

8 Measures to avoid, reduce and compensate for significant negative impacts of the spatial plan on the marine environment

8.1 Introduction

Pursuant to No. 2 c) Annex 1 to sec. 8 para.1 ROG, the environmental report shall contain a description of the measures planned to prevent, reduce and, as far as possible, compensate for significant adverse environmental effects resulting from the implementation of the plan.

In principle, the MSP takes better account of the needs of the marine environment. The provisions of the MSP avoid 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 and the corresponding connection lines exists in any case and the corresponding infrastructure would have to be created even without the MSP (cf. Chap. 3.2). However, if the plan were not implemented, the uses would develop without the land-saving and resource-saving control and coordination effect of the MSP.

In addition, the provisions of the MSP are subject to a continuous optimisation process, as the insights gained on an ongoing basis during the SEA and consultation process are taken into account in the preparation of the plan.

While individual prevention, mitigation and compensation measures can already be implemented at the planning level, others only come into effect during concrete implementation and are regulated there in the individual approval procedure on a project- and site-specific basis.

8.2 Measures at plan level

With regard to planning preventive and mitigation measures, the MSP makes spatial and textual designations which, in accordance with the environmental protection objectives set out in Chapter 1.4serve to avoid or reduce significant negative impacts of the implementation of the MSP on the marine environment. This essentially concerns

- the designation of all nature conservation areas in the EEZ established by ordinance as priority areas for nature conservation,
- the designation of the bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen",
- refraining from designating priority or reservation areas for wind energy in priority areas for nature conservation,
- the designation of reservation areas for transmission lines predominantly outside priority areas for nature conservation,
- the principle that consideration should be given to existing nature conservation areas when planning, laying and operating pipelines,
- the principle of noise reduction in the construction of wind turbines,
- the principle of overall coordination of construction work on energy generation plants and the laying of pipelines,
- the principle of choosing the gentlest possible installation method when laying pipes,
- the principle of taking into account best environmental practice according to the Helsinki Convention and the respective state of the art in science and technology,
- and the lowest possible land consumption, ensured by the following principles
    - Economic uses should be as space-saving as possible.

- After the end of use, fixed installations must be dismantled.
- When laying pipelines, the aim should be to achieve the greatest possible bundling in the sense of parallel routing. In addition, the routing should be as parallel as possible to existing structures and buildings.

8.3 Measures at the concrete implementation level

In addition to the measures mentioned in Chapter 8.2 at plan level, there are measures for the prevention and mitigation of insignificant and significant negative impacts in the actual implementation of the MSP for certain designations or associated uses, such as offshore wind energy, pipelines and sand and gravel extraction. These mitigation and preventive measures are specified and ordered by the respective competent approval authority at project level for the planning, construction and operational phases.

With regard to the specific preventive and mitigation measures for offshore wind energy and power lines, at least the power cables, reference is made to the statements in the Baltic Sea Environmental Report on the FEP 2019/ Draft FEP 2020. These measures, such as noise protection for offshore wind turbines, are described in detail in Chapter 8.

Concrete preventive and mitigation measures for pipelines include, for example, restrictions on construction times when laying within protected areas, a reduction in light emissions during construction work, the avoidance of riprap as far as possible, and measures to protect cultural and material assets.

For sand and gravel extraction, the concrete preventive and mitigation measures are derived from the main operating plans. These measures include, for example, a restriction of extraction trips during times that are sensitive for certain species, the stipulation to only use vessels with a certain sound spectrum, the order to exclude certain stone fields or reef types from extraction as well as from impairment through screening, and strict supervision through appropriate monitoring (cf. Chap. 10).

9 Alternative assessment

9.1 Principles of the alternatives assessment

9.1.1 General

A graduated alternatives assessment is carried out for the maritime spatial plan. Depending on the increasingly concrete planning, the alternatives to be examined are reduced in the course of the planning process and become increasingly (spatially) concrete.

In general, according to sec. 5 para. 1 sentence 1 SEA Directive in conjunction with the criteria in Annex I SEA Directive and sec. 40 para. 2 no. 8 UVPG, the environmental report contains a brief description of the reasons for the choice of reasonable alternatives examined.

In describing and assessing the environmental effects determined in accordance with sec. 8 para. 1 ROG, the report shall contain, pursuant to No. 2c Annex 1 to sec. 8 para. 1 ROG, information on the alternative planning options that may be considered, taking into account the objectives and spatial scope of the maritime spatial plan. The prerequisite is always that these take account of the objectives and spatial scope of the MSP.

At the same time, it also applies to the identification and examination of the planning options or alternative plans to be considered that these can only relate to what can reasonably be required according to the content and level of detail of the maritime spatial plan. The following applies: The greater the expected environmental impacts and thus the requirement for conflict management in planning, the more extensive or detailed investigations are required.

Annex 4 No. 2 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. At the plan level, therefore, it is primarily the conceptual/strategic design and spatial alternatives that play a role.

In principle, it should be noted that a preliminary assessment of possible and conceivable planning options is already inherent in all designations in the form of objectives and principles. As can be seen from the justification of the individual objectives and principles, especially those with environmental relevance, the respective determination is already based on a consideration of possible affected public concerns and legal positions, so that a "preliminary examination" of planning options or alternatives has already taken place.

In addition to the zero alternative, the environmental report examines in particular spatial planning options and alternatives as far as they are relevant for the individual uses.

The SEA and thus also the alternatives assessment for the maritime spatial plan are characterised by a greater scope of investigation and a lower level of detail compared to environmental assessments at subsequent planning and approval levels.

9.1.2 Alternatives assessment process

The overarching guidelines initially serve as a framework for the selection and evaluation of the alternatives. In the early stage of the planning process, three planning options were initially developed as overall spatial planning solutions. From these, various sectoral and subspatial planning options were then developed and examined in parallel to the preparation of the draft plans, in accordance with the planning that was taking shape (cf Figure 55).

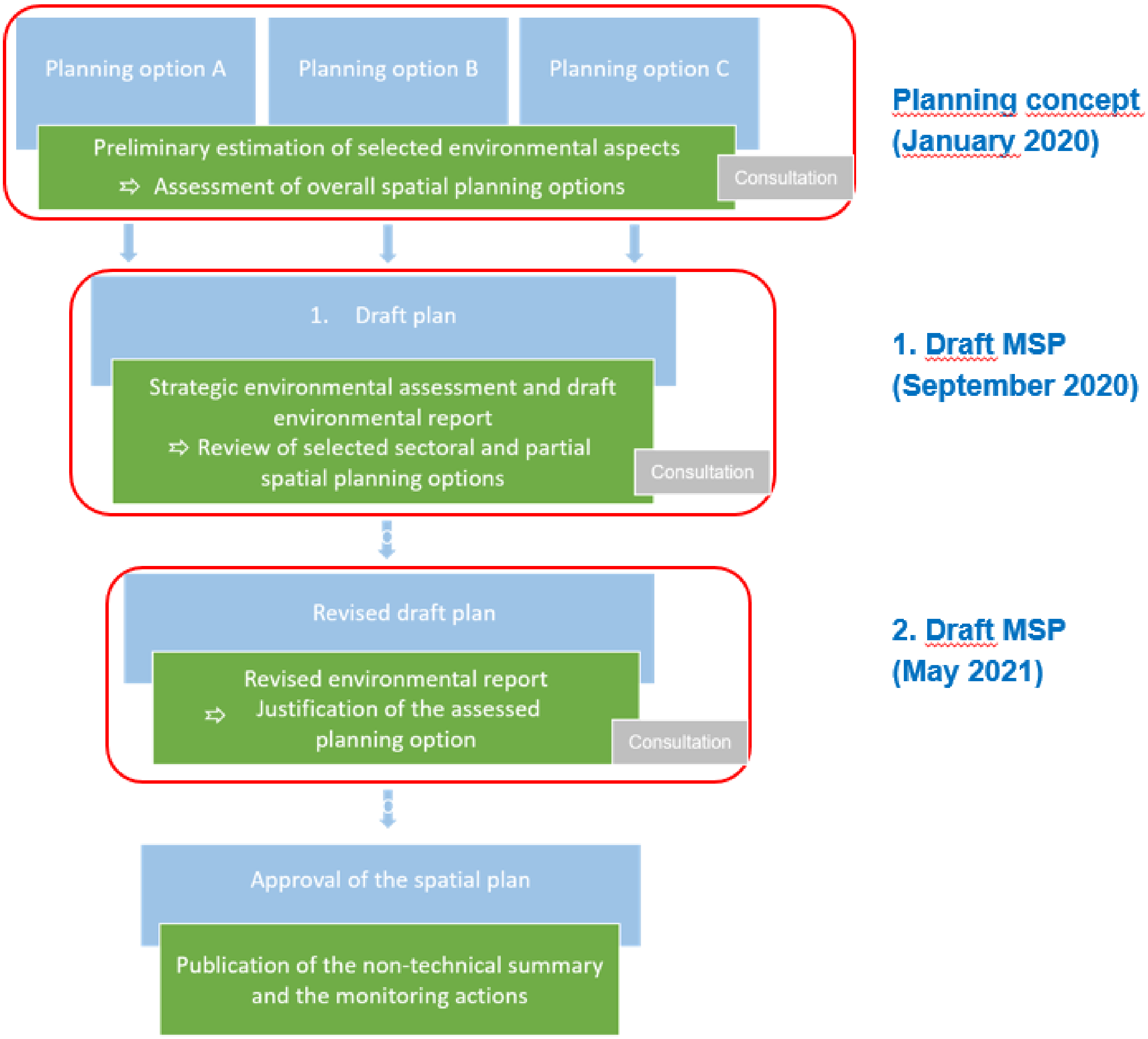

Figure 55. Tiered approach to alternatives assessment.

A guiding principle was developed for the maritime spatial plan and MSP guidelines formulated on how the sea can be used and preserved in its diversity. The following overarching objectives can be derived from this, against which the planning alternatives considered below are measured.

The maritime spatial plan shall:

- Support coherent international marine spatial planning and territorial cooperation with other countries and at the regional seas level,
- take into account land-sea relations and planning in the territorial sea,
- lay the foundation for a sustainable marine economy in the spirit of Blue Growth,
- contribute to the protection and enhancement of the state 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 demands, with

- the identification of appropriate areas, in particular for economic and scientific uses, but also for marine environmental and other concerns,
- a prioritisation of sea-specific uses and functions,
- the balancing of ecological, economic and social concerns,
- the economical and optimised use of areas allocated to uses, especially areas for fixed infrastructure, which also includes reversibility of fixed installations,
- the holistic view of the different activities in the sea,
- with their effects and interactions as well as cumulative effects, and under
- and applying the ecosystem approach and the precautionary principle.

9.2 Examination of alternatives within the framework of the planning concept

The planning concept was prepared as a first informal planning step. At an early stage in the process of updating the maritime spatial plans, the concept for updating the maritime spatial plans in the German EEZ of the North Sea and Baltic Sea comprised three planning options (A-C) as overall spatial plan variants. The early and comprehensive consideration of several planning options represents an essential planning and testing step in the updating of maritime spatial plans.

The concept for the update presents the utilisation demands of different sectors from three different perspectives - in the sense of overall planning alternatives, which are all oriented towards 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 interdependencies and interactions as well as corresponding planning principles were taken into account and illustrated which maximum demands of individual sectors are thereby limited.

For this concept for the update, a preliminary assessment of selected environmental aspects was already carried out before the preparation of this environmental report. This environmental assessment in the sense of an early examination of variants and alternatives was intended to support the comparison of the three planning options from an environmental perspective.

The planning options at a glance:

(A) Planning option A focuses on traditional uses of the sea, with particular attention to the interests of shipping, resource extraction and fishing.

(B) Planning option B shows a climate protection perspective in which a lot of space is given to future use by offshore wind energy.

(C) Planning option C focuses in particular on the wide-ranging and extensive protection of areas for marine nature conservation. In addition to the initially predominantly spatial designations, there are some supplementary textual designations.

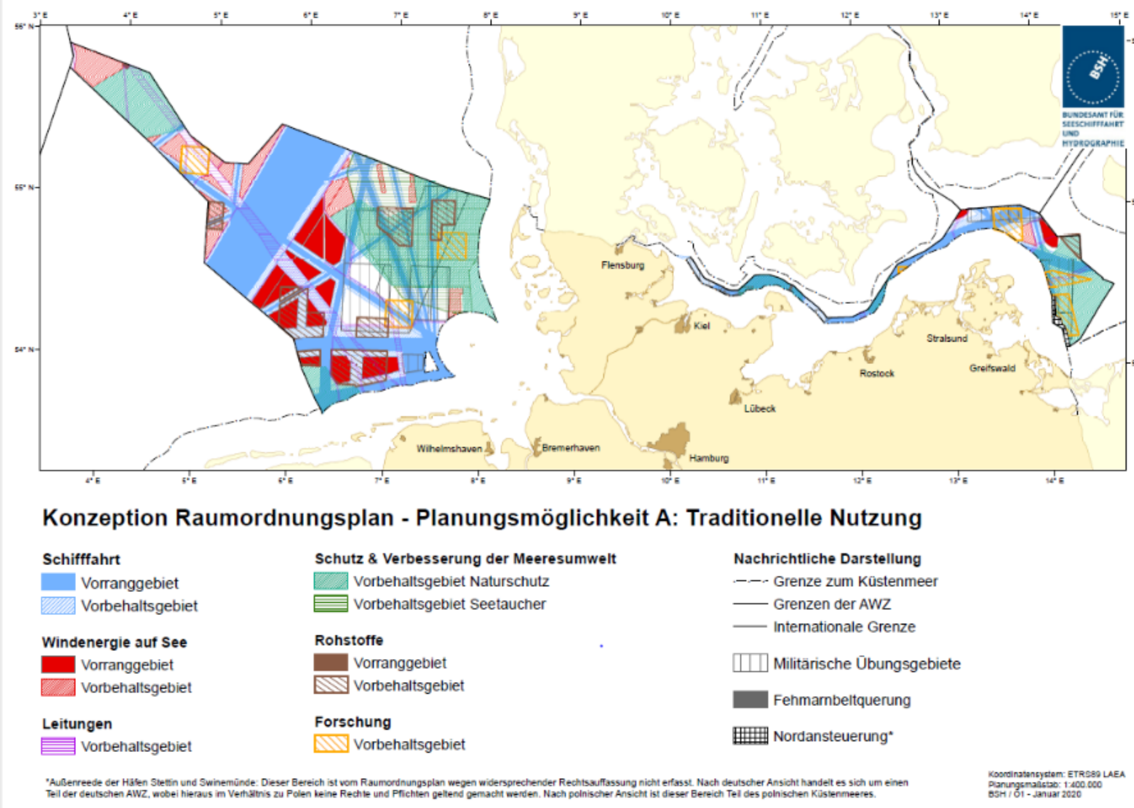

Figure 56: Maritime Spatial Plan Concept - Planning Option A "Traditional Use" .

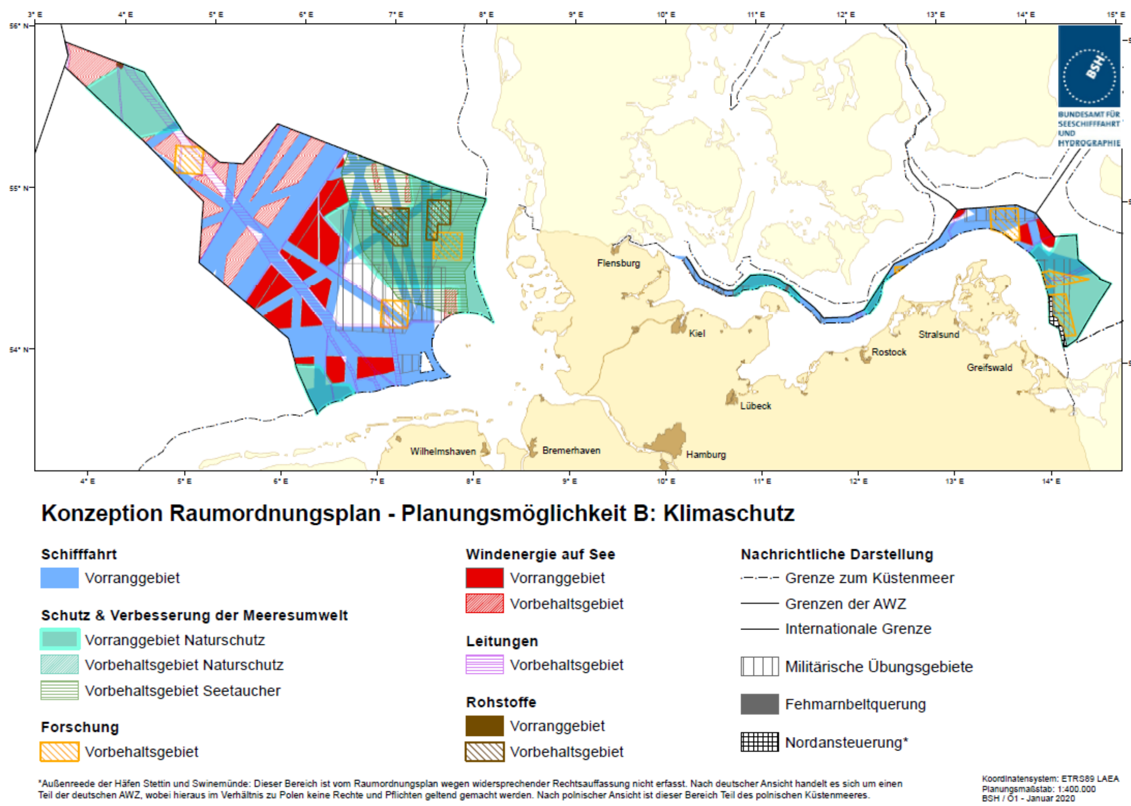

Figure 57: Maritime Spatial Plan Concept - Planning Option B "Climate protection" .

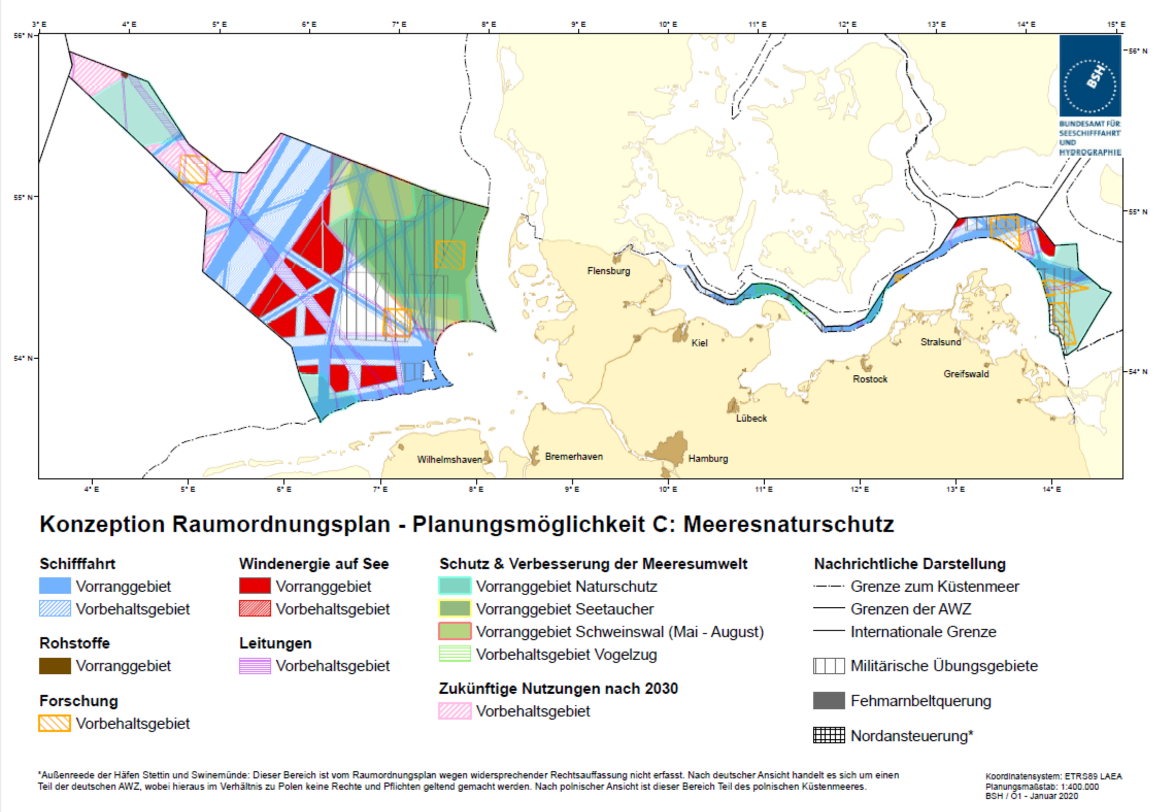

Figure 58: Maritime Spatial Plan Concept - Planning Option C "Marine nature conservation" .

In addition to general basic assumptions and overarching objectives that applied to all three planning options (cf. Concept), the individual planning options were based on the following additional objectives.

Planning option A

Shipping

- Barrier effects must be avoided, especially with regard to the possible establishment of future VTGe, and sufficient space must be secured for this in the long term, especially in Route SN10.

Raw material extraction

- Raw material extraction should also be made possible in combination with other uses and in nature conservation areas, and should be given special weight in the balancing process. Permit areas according to the BBergG are defined as reservation areas.

Fishing

- For fisheries, opportunities are to be created to limit restrictive effects of uses, especially through further wind energy expansion at sea, and to generate income opportunities through joint use in wind farm areas - this is stated in the text.

Planning option B

Wind energy at sea

- Comprehensive areas are to be secured for the further expansion of offshore wind energy, also beyond 2030, with the largest possible installed capacity for energy generation. For this purpose, area designations for shipping in the course of Route 10 in the North Sea are only

planned for the areas of the main traffic flows.
- The future extraction of hydrocarbons, which could affect the expansion of wind energy depending on the location of the extraction facilities, is not supported by the designation of reservation areas, but permit areas for sand and gravel extraction are taken into account.

Planning option C

Protection and enhancement of the marine environment

- Economic uses in areas for the protection and enhancement of the marine environment which are incompatible with the conservation purpose shall be excluded as far as possible.
- Raw material extraction of sand and gravel, but also of hydrocarbons, should not be privileged, by refraining from spatial designations for all raw materials.
- For bird migration in the Baltic Sea, a reservation area is defined in the area of the Fehmarn-Lolland route.

9.2.1 Environmental assessment of the planning options

In the following table, only those planning topics are listed for which alternative planning solutions have been presented in the planning options. In the assessment of the environmental aspects, impacts are primarily named that relate to the spatial definitions, and here in particular to the differences between the three planning options.

In general, it can be stated that from an environmental perspective, no clear preference for a planning option can be identified. For shipping, differences between the three planning options in terms of environmental impacts cannot be determined at such a coarse 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 wider priority areas are defined within the 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 specifications between the planning options. Here, the extent of the area designations varies greatly. From a climate protection point of view, this leads to different levels of CO2 savings potential. In a relative comparison based on the assumed installed capacity, planning option B offers significantly greater CO2 savings potential compared to A and C. On the other hand, the three planning options lead to higher CO2 emissions. On the other hand, the three planning options lead to different land use; it is 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. However, less than 1 % of the designated areas is actually sealed. Nature conservation areas make up a large part of the EEZ area. Over a third of the North Sea EEZ and over 50 % of the Baltic Sea EEZ are protected. These are relatively large proportions of land; however, they do not necessarily mean zero use in these areas. The priority areas for nature conservation contribute to safeguarding open space, as uses incompatible with nature conservation are excluded in them. The quantitative differences between the three planning options with regard to the designation of areas for the protection and improvement of the marine environment are rather small. The decisive factor is rather the protection purpose of the designations; for example, the main distribution areas of divers and harbour porpoises are designated as priority areas in individual plan variants. In this respect, from the pure perspective of nature conservation and the precautionary principle, planning option C is to be given preference. However, the climate protection aspect must also be considered here, which is given much less consideration in planning option C.

The differences in the area designations and the assessment of selected environmental aspects are presented in detail below.

	Area definitions	Selected environmental aspects
Shipping		
A	Shipping routes as priority areas with accompanying reservation areas	• Certain displacement and bundling effects are to be expected.
B	All shipping routes in full width priority areas; fanning out of SN10 into three busy main shipping routes, thus leaving intermediate spaces that are shown as reservation areas for offshore wind energy	• Possible increased collision risk with corresponding environmental risks compared to planning options A and C due to reservation areas for wind energy within route SN10, and the concentration of traffic in the remaining corridors, without additional navigation areas.
C	Shipping routes as priority areas with accompanying reservation areas; SN10 along the main traffic flows as a priority area for shipping, with remaining intermediate spaces as a temporary priority area until 2035.	• The temporary priority area does not result in any additional environmental impacts in the medium term compared to planning option A.
Wind energy at sea / Future uses		
A	Designation of areas as priority and reservation areas for offshore wind energy for approx. 35 - 40 GW of installed capacity; Designation of areas EN1 to EN3, and EN6 to EN12 as well as EO1 and EO3 as priority areas for offshore wind energy.	• Land use approx. 5,000 km², approx. 15 % share of North Sea and Baltic Sea EEZ.
B	Area designations with more extensive priority and reservation areas for wind energy, also within SN10 for approx. 40 - 50 GW; Designation of areas EN1 to EN3, and EN6 to EN13 as well as EO1 to EO3 as priority areas for offshore wind energy.	• Land use approx. 6,400 km², approx. 20 % share of North Sea and Baltic Sea EEZ, significantly larger than in planning option A. • CO2 savings potential under climate protection aspects: In relation to planning options A and C, the CO2 savings potentials are significantly greater when capacities for installed power are taken into account.

		• It is possible that a higher collision risk may result from the location of wind energy areas within the main shipping route 10.
C	Designation of areas with a smaller extent of priority and reservation areas for wind energy for approx. 25 -28 GW of installed capacity; Designation of areas EN1 to EN3, and EN6 to EN12 as well as EO1 and EO3 as priority areas for offshore wind energy. In the North-western region of the German EEZ, reservation areas are designated for future uses, with wind energy as only one possible use; No designation of areas for wind energy in the reservation areas for divers and harbour porpoises.	• In relation to planning options A and B, the CO2 savings potentials already secured for wind energy by the specifications are significantly lower. • At approx. 3,000 km², the land take for wind energy, approx. 9 % share of the North Sea and Baltic Sea EEZs, is significantly lower than in planning options A and B. • On an area of around 1,600 km² or approx. 6% of the North Sea EEZ, future use is kept open, but no prioritisation is made for offshore wind energy, for example, thus maintaining the option for uses with lower environmental impacts in the long term. • Subsequent use by wind energy at the wind farm sites in the main distribution areas of divers and harbour porpoises is ruled out, so that a positive environmental impact can be expected in the long term compared to the status quo. • Overall, compared to planning options A and B, a significantly stronger weighting of marine nature conservation concerns and thus a potentially lower impact on the marine environment can be expected.
Raw materials		
A	Reservation areas for all permits and for hydrocarbons, and areas for sand and gravel extraction	• Possible disturbance may occur through avoidance effects and potential physical disturbance/injury from underwater sound during seismic surveys. In addition, there would be possible impacts from the construction and operation of production platforms, among others. • Mining in the reservation areas for sand and gravel, all of which are located in nature conservation areas, may result in the following impacts: impairment of the seabed through physical disturbance, impairment and avoidance ef-

		fects through turbidity plumes, alteration of habitats through removal of substrates.and habitat and area losses.
B	Reservation areas only for sand and gravel extraction	• Fewer impairments than in planning option A are to be expected because only designations for sand and gravel extraction are envisaged and no prioritisation of the extraction of hydrocarbons is made by spatial planning.
C	No designations for raw material extraction	• By foregoing designations for the extraction of raw materials as a whole, including the protected areas, a lower burden can occur compared to planning options A and B, as spatial planning does not specify any prioritisation over other uses here. The use is then based solely on the operational plans according to mining law approval. 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 extent of the existing nature conservation areas. In addition, the main concentration area of divers in the North Sea is designated as a reservation area.	• The reservation for nature conservation in the nature conservation areas includes the general exclusion of offshore wind energy and thus supports the protective purpose of these areas. In the context of further land development for offshore wind energy and a subsequent update of the sectoral planning, nature conservation would only be accorded the weight of a reservation by the regional planning authorities when weighing up the interests. • The reservation for the area of the divers leads to the fact that a subsequent use or the expansion of wind energy - is placed under reservation here.
B	Priority areas for nature conservation are defined in the extent of the existing nature conservation areas, with the exception of the areas that overlap with the reservation areas for sand and gravel extraction. The main concentration area for divers in the North Sea is designated as a	• The designations as priority areas for nature conservation support the conservation purposes of the nature conservation areas. However, where the designations for sand and gravel extraction overlap with the nature conservation area, nature conservation is only assigned a reservation.

	reservation area - as in planning option A.	• Wind energy use in the priority area and in the reservation area for nature conservation remains excluded. • The reservation for the diver area means that a subsequent use is conditional here. • 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 extent of all nature conservation areas, as well as for the main concentration area of divers 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 reservation area for bird migration is defined.	• The designation of nature conservation areas, as well as the main concentration areas of divers and harbour porpoises, as priority areas for nature conservation supports the conservation purposes of the nature conservation areas and other areas of outstanding nature conservation importance. This gives nature conservation greater weight in the balancing process against other uses within these areas. • The priority of the main concentration area of the common divers leads here to the exclusion of a subsequent use of the existing wind farm areas within the area. In the long term, this could mitigate or compensate for the observed avoidance effects and habitat losses of the common divers. Likewise, wind energy development in the priority area for harbour porpoises is excluded. • The Fehmarn-Lolland bird migration reserve in the Baltic Sea serves as an additional designation to support the MSFD measure for the protection of migratory species.

9.3 Examination of alternatives as part of the planning process

The first draft of the plan was prepared on the basis of the planning concept, the comments received on it and further findings and requirements from informal expert and departmental discussions. The draft plan was revised on the basis of the comments received and coordinated in departmental discussions.

The environmental report was prepared in parallel to the drafting of the plan. The selection of the alternatives examined was mainly based on the planning options presented and the assessment of the environmental impacts (cf. also Chapter 5 of the concept). The designations were taken from the respective planning options, but were also spatially adapted in part due to further considerations, or further developed as a combination of various aspects of individual planning solutions.

In the course of the planning process, the alternatives to be examined were reduced during the revision of the draft plan and became increasingly (spatially) concrete. Thus, the presentation of different alternatives could help to better compare and discuss them in case of conflicting requirements.

It remains the case that the plan must be considered in the overall context so that, in addition to taking nature conservation concerns and the prevention or reduction of possible negative environmental impacts into account, the choice of plan solutions also aims to achieve the greatest possible overall balance with other economic, scientific and safety concerns. The decisive factor is that, based on current knowledge, the SEA concludes at the level of the designations made in the MSP maritime spatial plan that no significant impacts on the marine environment are to be expected.

9.3.1 Zero alternative

The zero option, i.e. not updating the MSP, is not a reasonable alternative.

The overarching and forward-looking planning and coordination, taking into account a large number of spatial claims, is expected to lead to a comparatively lower overall land use and thus to lower environmental impacts than if the plan were not implemented (cf. Chapter 3).

Compared to the MSP 2009 and the FEP 2019, the draft plan contains a designation of reservation areas for wind energy for the long-term expansion of offshore wind energy and thus fulfils a precautionary control of the expansion of offshore wind energy. The inclusion of these areas enables spatially ordered and land-saving planning, taking into account environmental concerns and the interests of other uses. This also applies to the designation of reservation areas for pipelines. Whereas in the 2009 MSP only existing pipelines are defined as reservation areas, the current reservation areas for pipelines also include routes for future connection lines and interconnectors. These reservation areas are predominantly located outside protected areas and thus have a steering effect for the most concentrated routing possible outside sensitive areas.

9.3.2 Spatial alternatives

The following overall or partial spatial alternatives were considered in the preparation of the draft plan:

9.3.2.1 Shipping

For navigation, the approach of planning option B is adopted: All shipping routes are defined as priority areas. In contrast to planning option C, the general designation of reservation areas for shipping along all shipping routes is dispensed with (cf. further justifications in the draft MSP).

The shipping routes are also defined as priority areas within the nature conservation areas. The designation reflects the existing traffic flows and serves to keep the routes clear.

The renunciation of the differentiation into priority and reservation areas for shipping has no influence on potential environmental impacts, because shipping traffic does not change de facto as a result of the priority areas for shipping. The designation of priority areas for shipping serves primarily to keep important shipping routes free of fixed installations and is therefore complementary to the priority areas for nature conservation in its regulatory purpose of avoiding accidents.

Navigation also enjoys priority in the nature conservation priority areas in the Pomeranian Bay - Rönnebank, Kadet Trench and Fehmarn Belt nature conservation areas. It must be taken into account that the shipping routes in the north of the Pomeranian Bay - Rönnebank NSG (SO3, in the course of the Adlergrund VTG), as well as in the area of the Kadet Trench and in the Fehmarn Belt (SO1), are important and very busy routes. The number of ship movements in the southern part of the Pomeranian Bay-Rönnebank National Park is much lower - however, the northern approach to the ports of Swinoujscie and Szczecin (SO2) runs here.

Alternative: Shipping	
Brief description	• The areas for navigation are designated as reservation areas in the entire width of the nature conservation areas.
Presentation of the alternative in comparison to the draft plan	• In the draft plan, all routes are designated as priority areas, including in the nature conservation areas.
Points of conflict with other uses	• According to the provisions of UNCLOS applicable under sec. 1 para. 4 of the ROG, restrictions on shipping in the EEZ are only possible under the conditions laid down therein, so that there can already be no legal conflict of considerations. Furthermore, sec. 57 para. 3 no. 1 BNatSchG stipulates that restrictions on shipping are not permissible in nature conservation areas. • In the Pomeranian Bay - Rönnebank NSG in particular, the international shipping route would not be adequately secured by spatial planning in the VTG Adlergrund
Environmental assessment	• There would presumably be no changes to the environmental impacts from shipping, as there would continue to be freedom of navigation or, in the VTG, the obligation to use it for the large vessels in the approach to the seaports. • No regulations can be made via spatial planning to avoid certain areas, or to change the routing in nature conservation areas. However, the number of ship movements outside the VTG is rather small. • The priority areas for shipping primarily serve to keep important shipping routes free of fixed installations and are therefore complementary to the priority areas for nature conservation in their regulatory purpose of avoiding accidents.

9.3.2.2 Wind energy at sea

For offshore wind energy in the Baltic Sea, the spatial designations from planning options A and C are used.

The definition of priority areas is not only based on the legally stipulated 20 GW of offshore wind energy expansion, but all areas expected to be required for the expansion of offshore wind energy by 2035 (approx. 30 GW) - the medium-term planning horizon of the maritime spatial plan - are designated as priority areas for wind energy. For the Baltic Sea, these are the areas EO1 to EO3.

Since there are no spatial alternatives for the use of wind energy in the Baltic Sea, it was additionally determined that the areas of the bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" can in principle be used by wind energy, provided they are designated as priority or reservation areas for wind energy. During periods of mass migration events, wind turbines shall not be operated in the bird migration corridors if other measures are not sufficient to exclude a proven significantly increased collision risk of birds with wind turbines. Under the same conditions, construction and maintenance work shall not take place

9.3.2.3 Lines

The reservation areas for pipelines correspond to those already shown in the concept in all three planning options. Only those corridors were defined in which at least two pipelines exist or are planned, or which are reserved for future pipelines.

These are required for the cable systems for the transmission of electricity from the areas for the generation of offshore wind energy, based on the designations of the site development plan. The reservation areas secure the course of existing interconnectors and pipelines, as well as routes for future cables and pipelines.

The nature conservation areas are excluded as far as possible from the designations. The only exception is the corridor along the route of the (existing) Nord Stream 1 and 2 pipelines, which cross the Pomeranian Bay - Rönnebank nature conservation area. Due to the distance that remains between the pipelines, further cable systems (especially interconnectors) can be planned here in the future.

Compared to the planning concept, border corridors at the transition of the transmission lines into the coastal sea have been added, similar to the designations of the MSP 2009 and based on the designations of the FEP.

The reservation areas for pipelines can be an instrument, e.g. in approval procedures for transit pipelines and cross-border submarine cables, to demand routing, where possible, in these corridors that are suitable for the whole area, and thus to avoid routing through nature conservation areas and the associated impairments. Where individual cables or other pipelines are currently routed through nature conservation areas, it is not possible to refer to a reservation from spatial planning in the case of changes or new project planning, but if necessary to work towards a more nature-compatible routing and, where possible, the use of the defined corridors.

9.3.2.4 Raw material extraction

For the designations for raw material extraction in the Baltic Sea EEZ, the draft includes - in addition to the assumptions on which all planning options are based - the approach of planning option A:

The permit area for sand and gravel extraction within the Pomeranian Bay - Rönnebank NSG is designated as a reservation area analogous to planning option A.

The alternative of not designating any areas, as envisaged in planning options B and C, would probably not de facto result in any reduction of environmental impacts, since sand and gravel extraction is generally permitted as a privileged use in the nature conservation area and, if approved, is subject to corresponding conditions to mitigate and avoid impairments of the protected goods and objectives.

9.3.2.5 Protection and enhancement of the marine environment

With the spatial designations for the protection and improvement of the marine environment in the Baltic Sea EEZ, the nature conservation areas Pomeranian Bay - Rönnebank, Kadet Trench and Fehmarn Belt, which have been designated by ordinance, are also secured in spatial planning and their protection purposes are supported.

In the Pomeranian Bay - Rönnebank nature conservation area, the priority for nature conservation is not downgraded to a reservation in the area for sand and gravel extraction (planning option B).

For the priority areas for navigation through these areas, the nature conservation determinations have no restrictive effect. Sand and gravel extraction continues to be permitted in the Adlergrund, but in the case of authorisations and permits, in addition to the requirements of the nature conservation area ordinances, it can support the consideration of the interests to be protected.

The designation of the bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" in the maritime spatial plan takes into account the special importance of bird migration across the Fehmarn Belt, the so-called bird flight line, and across Rügen to Sweden.

The areas of the bird migration corridors can in principle be used for wind energy if they are designated as priority or reservation areas for wind energy. During periods of mass migration events, wind turbines shall not be operated in bird migration corridors if other measures are not sufficient to exclude a proven significantly increased collision risk of birds with wind turbines. Under the same conditions, construction and maintenance work shall not take place.

The spatial consideration of bird migration corridors in connection with the requirement for preventive and mitigation measures ensures targeted protection of bird migration as an essential component of the marine environment by resolving the conflict with the use of wind energy in an appropriate manner. It thus follows the precautionary approach and the ecosystem approach.

The need for preventive and mitigation measures - this could be, for example, the shutdown during mass migration events - in the "bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" supports MSFD environmental objective 3 "Seas not affected by the impact of human activities on marine species and habitats" and contributes to the implementation of operational objective UZ3-02 "Measures to protect migratory species in the marine environment".

Clear and operational specifications are needed for measuring and shutdown systems and for the presence of a mass migration event during spring and autumn migration. Insofar as mass migration passes the area of offshore wind turbines according to these measuring systems and specifications, measures for the protection of bird migration must be initiated immediately, in particular those that exclude a collision of birds with wind turbines if there is an increased risk of collision.

9.4 Justification for the choice of alternatives examined

The alternatives assessment at the spatial planning level compares conceptual/strategic planning options and spatial alternatives in the plan design.

The alternatives assessment took place in parallel with the preparation of the plan, and a preliminary assessment of possible and conceivable planning options is already inherent in all designations in the form of objectives and principles. As can be seen from the justification of the individual objectives and principles, especially those with environmental relevance, the respective determination is already based on a consideration of possible affected public concerns and legal positions, so that a "preliminary examination" of planning options or alternatives has already taken place.

When selecting the alternatives examined, the objectives and the spatial scope of the maritime spatial plan were always taken into account. At the same time, it applied to the identification and examination of the planning options or plan alternatives under consideration that these can only relate to what can reasonably be required according to the content and level of detail of the maritime spatial plan.

Alternative spatial determinations have been considered for almost every use, whereby other locations are not always possible or sensible in the limited dimensions of the EEZ. For example, the extraction of raw materials is bound to fixed locations and shipping also requires spatial designations on the main traffic routes. Likewise, the priority areas for nature conservation trace the protected areas and thus the occurrence of protected species or biotopes.

For each use, it was therefore examined whether an alternative design was possible via textual designations, especially if spatial alternatives could not be considered as reasonable alternatives. In this way, the type of use in the areas could be specified in such a way that the extent of the impact is reduced. This environmental precaution applies to shipping as well as to economic and scientific uses. These include the seasonal limitation of activities to protect sensitive bird species and marine mammals or the reference to mitigation measures and best environmental practice.

Since the spatial definition in many cases only traces the use and had little design scope for locating the use at this point, the search for alternative design and consideration for the marine environment was an essential step in the alternatives assessment. This mitigates conflicts between protection needs and use claims and improves them in terms of environmental compatibility.

10 Planned measures for monitoring the effects of the implementation of the maritime spatial plan on the environment

10.1 Introduction

According to No. 3 b) Annex 1 to sec. 8 para. 1 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.

With regard to the planned monitoring measures, it should be noted that the actual monitoring of potential impacts on the marine environment can only begin at the moment when the maritime spatial plan is implemented, i.e. the designations made within the framework of the plan are realised. Nevertheless, the natural development of the marine environment, including climate change, must not be disregarded when assessing the results of monitoring measures. However, general research cannot be carried out within the framework of monitoring. Therefore, project-related monitoring of the impacts of the uses regulated in the plan is of particular importance. This mainly concerns designations for offshore wind energy, pipelines and areas for raw material extraction.

The essential task of monitoring the Plan is to bring together and assess the results from 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 the unforeseen significant effects of the implementation of the Plan on the marine environment as well as the review of the projections of the environmental report.

In addition - also to avoid duplication of work - results from existing national and international monitoring programmes are to be taken into account. The monitoring of the conservation status of certain species and habitats required under sec. 11 of the Habitats Directive must also be included. There will also be links to the measures provided for in the MSFD.

10.2 Planned measures in detail

In summary, the planned measures for monitoring the potential impacts of the Plan are as follows:

- Bringing together data and information that can be used for describing and assessing the status of areas, protected assets,
- Development of expert information networks for assessing the potential impacts from the development of individual projects as well as the cumulative impacts on the marine ecosystem,
    - MarinEARS (Marine Explorer and Registry of Sound) and National Sound Registry,
    - MARLIN (Marine Life Investigator),
- Develop appropriate procedures and criteria for evaluating the results of effect monitoring of individual projects,
- Development of procedures and criteria for the assessment of cumulative effects,
- Develop procedures and criteria for forecasting potential impacts of the plan in spatial and temporal context,
- Develop procedures and criteria for the evaluation of the plan and adapt or optimise as necessary in the context of the update,
- Evaluation of measures to avoid and reduce significant impacts on the marine environment,
- Development of norms and standards.

The following data and information are required for the assessment of the potential effects of the plan:

1. Data and information available to the BSH within the scope of its competence:
   - Data from previous EIAs and monitoring of offshore projects that are available to the BSH for review (according to See-AnlV),
   - Data files from the right of entry (according to WindSeeG),
   - Data sets from the preliminary investigations (according to WindSeeG),
   - Data sets from construction and operation 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 areas of responsibility of other federal and state authorities (on request):
   - Data from the national monitoring of the North Sea and Baltic Sea (formerly BLMP),
   - Data from monitoring measures within the framework of the implementation of the MSFD,
   - Data from the monitoring of Natura 2000 sites,
   - Country data from monitoring in the territorial sea,
   - Data from other authorities responsible for permitting uses at sea under other legal bases, e.g. under 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 within the framework of international bodies and conventions:
   - HELCOM
   - ASCOBANS
   - AEWA
   - BirdLife International

For reasons of practicability and the appropriate implementation of requirements from the SEA, the BSH will pursue an ecosystem-oriented approach as far as possible when monitoring the possible impacts of the plan, which focuses on the interdisciplinary consolidation 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 monitoring (e.g. specialist 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 the project level and from other national and international monitoring programmes, as well as from the accompanying research, it will be necessary to review the gaps in knowledge set out in the environmental report or the forecasts that are subject to uncertainties. This applies in particular to forecasts regarding the assessment of significant impacts of the uses regulated in the MSP on the marine environment. Cumulative effects of defined uses are to be assessed both regionally and supraregionally.

The investigation of potential environmental impacts of areas for wind energy has to be carried out at the downstream project level following the standard "Investigation of impacts of offshore wind turbines (StUK4)" and in coordination with the BSH. Monitoring during the construction of foundations by means of pile driving includes, among other things, measurements of underwater sound and acoustic recordings of the effects of pile driving on marine mammals using POD measuring devices.

With regard to the specific measures for monitoring the potential impacts of wind energy use, including impacts from power cables, reference is made to the detailed explanations in the Environmental Report on the FEP 2019/ Draft FEP 2020.

For the approval of areas for sand and gravel extraction, for example, it must be demonstrated by suitable monitoring that the maximum permitted extraction depth is not exceeded and that the original substrate is demonstrably preserved before the next main operating plan approval. Furthermore, it must be demonstrated that sufficient unmined areas remain between the excavation tracks so that the recolonisation potential is given.

For pipelines, a project-specific monitoring concept for the construction and operational phases must be submitted prior to construction. Monitoring measures during the construction phase include the documentation of turbidity plumes, hydro-sound measurements and the recording of marine mammals and seabirds and resting birds. Essential monitoring measures during the operational phase of pipelines include annual documentation of the positional stability of the pipeline and the cover 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 use new findings from the environmental impact studies and from the joint evaluation of research and EIS data. A joint evaluation of the research and EIS data will also produce products that provide a better overview of the distribution of biological protected goods in the EEZ. The pooling of information leads to an increasingly solid basis for impact prediction.

In general, the intention is to keep data from research, projects and monitoring uniform and to make it available in a competently evaluated form. In particular, the creation of joint overview products for reviewing impacts of the plan is to be aimed for here. The geodata infrastructure already available at the BSH with data from physics, chemistry, geology and biology as well as uses of the sea will be used as a basis for the consolidation and evaluation of 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 also consolidate and archive in the long term data collected in the course of accompanying ecological research at the BSH. The data on biological assets from the baseline surveys of offshore wind energy projects and from the monitoring of the construction and operation phases are already collected and archived at the BSH in a specialist 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 federal government under the Spatial Planning Act (ROG)[8]. Pursuant to sec. 17 para. 1 ROG, the competent Federal Ministry, the Federal Ministry of the Interior, for Building and the Home Affairs (BMI), draws up a spatial plan for the German EEZ as a statutory instrument in agreement with the federal ministries concerned. Pursuant to sec. 17 para. 1 sentence 3 of the ROG, the BSH, with the approval of the BMI, carries out the preparatory procedural steps for the preparation of the maritime spatial plan. During the preparation of the MSP, an environmental assessment is carried out in accordance with the provisions of the ROG and, where applicable, those of the Environmental Impact Assessment Act (UVPG)[9], the so-called Strategic Environmental Assessment (SEA).

According to Art. 1 of the SEA Directive 2001/42/EC, the aim of SEA is to ensure a high level of environmental protection in order to promote sustainable development and to help ensure that environmental considerations are adequately taken into account in the preparation and adoption of plans well before the actual planning of the project.

The main content document of the SEA is this Environmental Report. It identifies, describes and assesses the likely significant effects that the implementation of the MSP will have on the environment, as well as possible and alternative planning options, taking into account the main purposes of the plan and the spatial scope.

According to sec. 17 para. 1 ROG, the maritime spatial plan for the German EEZ shall, taking into account any interactions between land and sea and taking into account safety aspects, determine

1. to ensure the safety and ease of shipping traffic,
2. to other economic uses,
3. scientific uses and
4. to protect and enhance the marine environment.

Pursuant to sec. 7 para. 1 of the ROG, spatial plans must define **objectives and principles of** spatial planning for the development, organisation and protection of the area, in particular the uses and functions of the area, for a specific planning area and for a regular medium-term period.

Pursuant to sec. 7 para. 3 ROG, these designations may also designate areas, such as priority and reservation areas.

For the area of the German EEZ, a multi-stage planning and approval process is envisaged for some uses, such as offshore wind energy and power cables. The instrument of maritime spatial planning is at the highest and superordinate level in this context. The maritime spatial plan is the forward-looking planning instrument that coordinates the most diverse use interests of the economy, science and research as well as protection claims.

The SEA for the maritime spatial plan is related to various downstream environmental assessments, in particular the SEA for the site development plan (FEP), which is directly downstream.

The FEP is the technical plan for the orderly expansion of offshore wind energy. In the next step, the areas defined in the FEP for offshore

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

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

wind turbines are pre-screened. If the suitability of an area for the use of offshore wind energy is determined, the area is put out to tender and the winning bidder can submit an application for permission to erect and operate wind turbines on the area. In view of the character of the maritime spatial plan as a controlling planning instrument, the depth of the assessment of likely significant environmental impacts is characterised by a greater breadth of investigation and, in principle, a lesser depth of investigation. The focus of the assessment is on the evaluation of cumulative effects and the examination of alternatives.

The preparation or updating of the maritime spatial plan and the implementation of the SEA are carried out taking into account environmental protection objectives. These provide information on the environmental status to be aimed for in the future (environmental quality objectives). The environmental protection objectives can be derived from an overall view of the international, Community and national conventions and regulations that deal with marine environmental protection and on the basis of which the Federal Republic of Germany has committed itself to certain principles and objectives.

11.2 Methodology of the Strategic Environmental Assessment

The present environmental report builds on the existing methodology of the SEA of the site development plan and develops it further with a view to the additional designations made in the maritime spatial plan.

The methodology depends primarily on the provisions of the plan to be assessed. Within the framework of this SEA, it is determined, described and assessed for the individual designations whether the designations are likely to have significant effects on the objects of protection concerned. The subject of the environmental report corresponds to the provisions of the maritime spatial plan as listed in sec. 17 para. 1 ROG. The effects of the spatial designations are particularly relevant here. Although textual objectives and principles without direct spatial definition often also serve to avoid and reduce environmental impacts, they can in turn also lead to impacts, so that an assessment is required.

The assessment of the likely significant environmental effects of the implementation of the maritime spatial plan includes secondary, cumulative, synergetic, short-, medium- and long-term, permanent and temporary, positive and negative effects related to the protected assets. The basis for the assessment of possible impacts is a detailed description and assessment of the state of the environment. The SEA has been carried out with regard to the following protected goods:

- Area
- Floor
- Water
- Plankton
- Biotope types
- Benthos
- Fish
- Marine mammals
- Avifauna
- Bats
- Biodiversity
- Air
- Climate
- Landscape
- Cultural assets and other material assets
- People, especially human health
- Interactions between protected goods

The description and assessment of the likely significant environmental impacts is carried out for the individual designations in the drawings and texts on the use and protection of the EEZ in relation to the protected species, taking into account the assessment of the status quo.

All plan contents that can 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 interactions, a consideration of possible cumulative effects and potential transboundary impacts.

An assessment of the effects of the provisions of the plan is carried out on the basis of the status description and status assessment and the function and significance of the respective designated areas for the individual objects of protection on the one hand and the effects and resulting potential effects of these provisions on the other. A forecast of the project-related effects during implementation of the maritime spatial plan is made depending on the criteria of intensity, scope and duration of the effects.

Within the framework of the impact forecast, specific framework parameters are used as a basis for assessment, depending on the designations for the respective use.

With regard to the priority and reservation areas for offshore wind energy, certain parameters in the form of bandwidths are assumed for a consideration of the protected goods. In detail, these include power 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. For the assessment of the environmental impacts of shipping, it is necessary to examine which additional impacts are attributable to the stipulations in the MSP.

11.3 Summary of the tests related to the protected goods

11.3.1 Area

The German EEZ in the North Sea and Baltic Sea is of great importance for many uses and for the marine environment. At the same time, its area is limited, so land-saving use is imperative. Sparing use of land is therefore also reflected in the guidelines and principles of the maritime spatial plan.

The basis for sustainable development of the limited resource of land in the EEZ of the North Sea and Baltic Sea is the most efficient and sparing use of land, especially in the case of competing uses. This can lead to a situation where the MSP does not always define the desirable area for uses, but the sufficient area.

Another aspect of sustainable and economical use of land resources is the obligation to dismantle structures, submarine cables, etc. after the end of their operating life, so that these areas are available for subsequent use.

Due to the following points, an assessment of the extent to which the provisions of the MSP have an impact on the protected resource land is only possible in a synopsis of all uses:

- Temporally and spatially overlapping uses possible
- Mostly no 100% permanent land consumption of a use
- Not all uses actually consume land in the sense of seabed.

This summary consideration with regard to the protected resource of land was carried out within the framework of the designations for the individual uses in the MSP itself.

11.3.2 Floor

The Baltic Sea is a secondary sea of the Atlantic Ocean and is connected to the North Sea via the

Great Belt, the Little Belt and the Øresund. The bottom relief is characterised by its basin and sill structure. The Baltic Sea basins take over the function of sedimentation areas with the 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 via the Darss Sill (Kadet Channel).

Based on the basin and sill structure of the Baltic Sea, eight sub-areas were delineated using geological, geomorphological and oceanographic criteria.

The Bay of Kiel lies at the southern end of the Little and Great Belts in the western Baltic Sea. Its eastern border is formed by the Fehmarn Belt and the Fehmarn Sound. It is a typical fjord coast with narrow, deep bays. The water depths range from 5 m on the Stoller Grund to 42 m in the Vinds Grav channel 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 found especially in the vicinity of the Great Belt Channel, where sufficiently strong currents form megaripples, on the relatively flat seabed at depths of 15 to 18 m. The sandy areas are found especially in the vicinity of the Great Belt Channel, where sufficiently strong currents form megaripples. Silty sands are common west of Fehmarn, among other places. Mixed sediments occur in the deep channels of the Great Belt and the Fehmarn Belt. Late glacial sands and ribbon clays underlie this Holocene sedimentary layer. Beneath this, in large parts of the Kiel Bay, lie Saale Age boulder clay and meltwater sands, which in turn mostly overlie older glacial or Tertiary clays and sands.

The 18 to 24 km wide Fehmarn Belt occupies a special position for the exchange of water between the Belts and the neighbouring Baltic Sea basins to the east, in that the exchange between North Sea and Baltic Sea water takes place predominantly via the Great Belt - Fehmarn Belt system. Several mega- or giant ripple fields in the western Fehmarn Belt are an expression of these striking hydrodynamic conditions. The giant ripples lie on a continuous layer of residual sediments consisting of stones of varying density that reach the size of a fist.

To the east of the Fehmarn Belt lies the Mecklenburg Bay, which is delimited roughly along the 20 m depth line to the Darss Sill and the Fehmarn Belt. The 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 contour, which gradually becomes sandier towards the edge of the basin. The thickness of the silt is between 5 and 10 m in the centre of the basin. Towards the edge of the basin, medium to coarse sands are found. 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 deposits of the different Baltic Sea stages, which overlie the boulder clay from the last ice age.

The Darß Sill is the name given to the sea area between the Fischland - Darß peninsula and the Danish islands of Falster and Møn. The characteristic element is a submarine ridge of boulder clay, which runs from the steep shore between Wustrow and Ahrenshoop in a north-westerly direction to Gedser Rev. The furrow system of the Kadet Trench is cut into this ridge to a depth of 32 metres. Here, boulder clay ribs of 1 to 2 m height alternate with flat fine sand and mud flats in irregular succession. On the Kadetrinne, and especially on its flanks, there is a varying density of stone and boulder cover. Giant or megaripples with crest intervals of about 400 m are observed in the channels. The northeast bordering Falster-Rügen plateau is much poorer in relief and, with the exception of the Plantagenet bed, which rises to a water depth of less than 8 m, and a channel structure to the north of it into the Arkona Basin, it has hardly any morphological structure. It is predominantly covered by fine sands. The thicknesses of the sands range from 10 m to 50 m. The geological structure of this subarea essentially consists of three boulder clay horizons. West of a line Darßer Ort - Møn its surface dips into the Arkona Basin. Above this follow sandy to silty sediments of the different Baltic Sea stages.

The Arkona Basin is bounded to the Falster-Rügen plateau by the 40 m depth line. In the west, the Kriegers Flak elevation juts into the basin. To the northeast, the Arkona Basin is connected to the Bornholm Basin via Bornholmsgat; to the east, it borders the shoal of Rønne Bank with Adlergrund as its western spur. The maximum water depth is over 50 m. The sediment distribution on the seabed consists almost exclusively of silty sediments. The geological structure consists of two boulder-gel horizons overlain by late and post-glacial clays and silts.

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 area to 40 m on the German side. Morphologically, the area appears as a knoll that dips into the Arkona Basin to the east and south. The distribution of surface sediments on the seabed is very heterogeneous and shows the typical sill character. In the German EEZ, the boulder clay is widespread in the northwestern corner, which is directly on the seabed, especially on the flanks down to the 25 m depth contour in the south or down to the 40 m depth contour in the east. In the shallower water depths, it is strikingly covered with stones and boulders (erratic blocks), which form wall-like structures in places. To the south, the boulder clay is followed by a band of coarse sand and gravel, which is replaced by sands and clays as the water depth increases. In the east, the spottily distributed, low-density sand blankets and clays directly adjoin the overlying boulder clay. In the area of the stone and boulder deposits, a pronounced mussel growth (Mytilus) is characteristic.

The Adlergrund is the western spur of the Rønnebank, which extends as a shoal from Bornholm towards the southwest. The seabed has a very uneven relief due to its glacial formation history and postglacial overprinting. The water depths range between 5 and 25 m. In large parts, residual sediments (coarse sand, fine gravel and stones) dominate the overlying boulder clay. The stones are fist- to head-sized and occur sporadically to extensively in these areas. In addition, blocks (erratic blocks) several metres long are common, which are covered with mussels (Mytilus) of varying density. The low-density marine sands occur in patches between the residual sediments or as elongated bands. On the north-western edge, the sands merge into the mud of the Arkona Basin. To the south, there is a continuous transition to the sandy areas of the Pomeranian Bay and Oder Bank. The geological structure of the Adlergrund is essentially determined by boulder clay uplifts, meltwater deposits in the form of sands and gravels, as well as the Chalk till close to the seabed, which has fault zones and intermediate layers of sands, gravels or stones due to its glacial-tectonic stress.

The adjacent sub-area of the Oderbank to the south is an elevation with water depths ranging from 7 to approx. 20 m. The largely structureless seabed consists mainly of fine sands. Residual sediments in the form of isolated stone deposits occur especially to the north and north-east of the Oderbank in the Adlergrund channel. In the northwestern area of the Oderbank, in addition to isolated stones with a diameter of up to 1 m, there are also mussel fields ranging in size from a fist to several square metres, as well as smaller ripple fields of coarse sand. The geological structure of the Oderbank has boulder clay and glacial sands at its core.

The status assessment was carried out for the aspects "rarity/threat", "diversity/indigenous species" and "preloading". As the sediment types and bottom forms are found throughout the Baltic Sea, but are in part characteristic of the south-western Baltic Sea, the aspect of "rarity/hazard" is assessed as medium to low. In the EEZ of the Baltic Sea, one encounters a medium to high "diversity/property", which is reflected in the form of a heterogeneous sediment distribution in combination of distinct morphological conditions as well as heterogeneous sediment distribution and lack of bottom forms or homogeneous sediment distribution and distinct bottom forms. Due to the anthropogenic changes, which, however, did not lead to a loss of ecological functions, a medium "pre-stress" is assumed.

The pollutants emitted by shipping and entering the seabed, such as oil, occur regardless of whether or not the plan is implemented.

Wind turbines have a locally limited environmental impact on soil. The sediment is only permanently affected in the immediate vicinity by the insertion of the foundation elements, including any scour protection, and the resulting land use.

During the construction of wind turbines, sediments are briefly stirred up and turbulence plumes form. The extent of the resuspension essentially depends on the fine grain content in the soil. In areas with a low proportion of fines, most of the released sediment will settle relatively quickly directly in the area of the intervention or in its immediate vicinity. The suspension content quickly decreases to the natural background values due to dilution effects and sedimentation of the stirred-up sediment particles. However, the expected impairments in areas with a higher proportion of fine grains and the associated increased turbidity remain limited on a small scale due to the low flow near the bottom.

The interaction of the foundation and hydrodynamics in the immediate vicinity of the wind turbine can lead to the permanent stirring up and redistribution of sediments. According to previous experience in the North Sea, permanent sediment redistribution due to currents is only to be expected in the immediate vicinity of the wind turbines. Such experience is not yet available for the Baltic Sea. However, due to the low near-bottom current velocities in the vicinity of the turbines, only local scour is to be expected here as well. Due to the predicted spatially narrow scope of the scouring, no significant substrate changes are to be expected.

When laying the park's internal cabling or pipelines, the turbidity of the water column increases due to sediment resuspension. The extent of resuspension depends mainly on the chosen installation method and the fine grain content in the soil. In areas with a lower proportion of fines, most of the released sediment will settle relatively quickly directly at the construction site or in its immediate vicinity. In the process, the suspension content decreases again to the natural background levels 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 the areas with soft sediments and correspondingly high fine grain contents, the released sediment will settle much more slowly. However, since the near-bottom currents are relatively low, it can be assumed that the turbulence plumes that occur here will also have a rather localised character and that the sediment will settle again relatively in 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 heavy metal concentrations. In the area of silty and clayey seabeds, 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, are hardly drifted over larger distances and remain in their native environment. In the medium term, this remobilised material is deposited again in the silty basins.

Impacts in the form of mechanical stress on the soil due to displacement, compaction and vibrations that are to be expected in the course of the construction phase are assessed as low due to their small-scale nature.

The impacts described due to offshore wind energy and power lines are spatially limited and, with the exception of land sealing due to the installation of foundation structures, temporary. The impacts occur independently of the implementation or non-implementation of the plan.

Generally, gravel sands and sands are extracted over a large area using a suction trailer hopper dredger. This usually creates 2 to 4 m wide furrows between which unstressed seabed remains. 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. The extent of the turbidity plumes produced during material recirculation depends on the grain size and quantity of the recirculated material as well as the current and its directional stability. Due to the low current velocities in the Baltic Sea, a locally limited expansion of the turbidity plumes is to be expected.

Selective extraction can lead to a change in the substrate; depending on the recycled fraction, a refinement or coarsening of the original sediment type takes place, which can have an impact on the physicochemical parameters and thus lead to a mobilisation of pollutants. Due to the rather low pollutant load of the sediments and the low impact on the physicochemical parameters, no significant release of pollutants from the sediment can be assumed overall.

Hydrocarbon extraction does not currently take place in the Baltic Sea EEZ. In general, the following impacts on the protected resource soil are to be expected:

Construction-related discharge of cuttings/drilling fluid can lead to turbidity plumes or material changes in the sediments. Sealing and/or compaction of the seabed may occur as a result of foundation structures. Operationally, there may be pollutant inputs from anti-corrosion coatings or discharges of production water or other wastewater that could impact the seabed.

The effects described with regard to raw material extraction would exist both if the plan were implemented and if it were not implemented. However, by designating priority and reservation areas, the use of raw material extraction will be assigned greater importance in future spatial planning considerations. An impact on soil as a protected resource in the priority and reservation areas is therefore more likely with implementation of the plan than with non-implementation.

Trawls and bottom-set gillnets are used for fishing purposes in the Baltic Sea EEZ. The otter boards of bottom trawls usually penetrate the sandy to silty seabed of the Baltic Sea to a depth of a few millimetres to centimetres. In sandy seabeds and with corresponding sediment dynamics, a relatively rapid regeneration can be assumed within days or a few weeks. In greater water depths, especially in the Baltic Sea basin, the drag marks remain for longer periods of time due to the low sediment dynamics.

The near-bottom formation of turbidity plumes and possible release of pollutants from the sandy sediments is negligible in areas with relatively low fine grain content and low heavy metal concentrations. In seabeds with a higher proportion of fines, such as the Baltic Sea basins, there may be a significant release of pollutants from the sediment into the bottom water. The pollutants usually adhere to sinking particles which, due to the low currents in the Baltic Sea basins, hardly drift over large distances and remain in their native environment.

The impacts of fisheries on soil as a protected resource are independent of the non-implementation or implementation of the plan.

Overall, the designations presented in the MSP do not have any significant impacts on soil as a protected resource.

11.3.3 Benthos and biotopes

The species inventory of the Baltic Sea EEZ can be considered average with its approx. 250 macrozoobenthos species. The benthic communities are also typical for the Baltic EEZ and for the most part do not show any special features. According to the currently available studies, the macrozoobenthos of the Baltic EEZ is also considered average due to the number of Red List species detected. Studies of the macrozoobenthos in the context of the approval 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.

The deep foundations of the wind turbines and platforms cause small-scale and short-term disturbance of the seabed, sediment resuspension and the formation of turbidity plumes. The resuspension of sediment and the subsequent sedimentation can lead to impairment or damage to the benthos and the use of biotopes in the immediate vicinity of the foundations for the duration of the construction activities. However, these impairments will probably only have a small-scale effect and are limited in time. Changes in the species composition may occur in the immediate vicinity of the structure due to the local sealing of surfaces and the introduction of hard substrates. Since the colonisation of the artificial hard substrates is associated with an accumulation of organic material, oxygen deficiency may occur locally due to the biological degradation process.

The laying of the submarine cable systems is also expected to cause only small-scale disturbances to the benthos and biotopes due to sediment turbulence and turbidity plumes in the area of the cable route. Possible impacts on the benthos and biotopes depend on the laying methods used and the geological and hydrographical conditions. Only minor disturbances in the area of the cable route are to be expected with the comparatively gentle installation using the flushing-in method. For the duration of the laying of the submarine cable systems, local sediment shifting and turbidity plumes are to be expected. In cohesive soils, the cable systems are milled or laid with a heavy plough. These methods are also associated with disturbance of the sediment and benthic fauna as well as sediment turbulence.

In areas with a lower fine grain content, most of the released sediment will settle relatively quickly in the immediate vicinity of the cable route. In the areas with soft sediments and correspondingly high fine grain contents, the near-bottom currents are relatively low, so that only temporary, local effects are to be expected for these areas as well. In the short term, pollutants and nutrients can be released from the sediment into the bottom water. The possible release of pollutants from the sandy sediment is negligible. In the area of silty and clayey seabeds, there may be a significant release of pollutants from the sediment into the bottom water. The pollutants generally adhere to sinking particles which, due to the low currents in the Baltic Sea basins, are hardly drifted over larger distances and remain in their native environment. In the medium term, this remobilised material is deposited again in the silty basins.

Benthic habitats are directly overbuilt in the area of required rockfill for cable crossings or in the event that it is locally necessary to lay cable sections on the seabed. The resulting habitat loss is permanent but small-scale. An off-site hard substrate is created, which can cause small-scale changes in species composition. Significant impacts by these small-scale areas on benthos and biotopes are not to be expected. In addition, the risk of a negative impact on the benthic soft-bottom community by species untypical of the area is low, as the recruitment of species will most likely occur from the natural hard substrate habitats.

The top sediment layer of the seabed can heat up directly above the cable system due to operational factors, which can lead to adverse effects on benthic communities. The MSP establishes a planning principle to minimise adverse effects as far as possible; special consideration is to be given to the interests of marine environmental protection when selecting the cover and the necessary laying depth of power and data cables. At the level of sectoral planning (FEP), the planning principle on sediment heating specifies that the 2 K criterion must be complied with. According to the BfN's assessment, this precautionary value ensures with sufficient probability that significant negative impacts of cable heating on the marine environment are avoided.

According to the current status, the planned submarine cable routes are not expected to have any significant impacts on benthos and biotopes, provided that the 2C criterion is met. Only very small areas outside protected areas will be affected. Due to the mostly fast regenerative capacity of the occurring populations of benthic organisms with short generation cycles and their wide distribution in the German Baltic Sea, a fast recolonisation is very likely.

With regard to the designation of area SKO1 as a reservation area for sand and gravel extraction, its location within the nature conservation area "Pomeranian Bay - Rönnebank" must be taken into account.

No concrete information is available 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 previous extraction activities have led to a fundamental change in the sediment structure or composition in the extraction area. Overall, the investigations show that the original substrate in the area could be preserved and that there is a regenerative capacity especially for species-rich gravel, coarse sand and shingle beds. Under similar conditions, it can be assumed that significant impairments of benthic habitats and their communities can be ruled out by the designation of the SKO1 area according to the current state of knowledge.

With regard to the general definition of aquaculture, the fulfilment of conditions for the exclusion of possible significant adverse effects on the marine environment must be examined in downstream plans or at project level.

With regard to the uses of shipping, marine research, national and allied defence and other uses, no significant effects on benthos and biotopes are to be expected due to the designations of the MSP, which would go beyond the general effects of the uses without designation.

The designation of the designated nature conservation areas of the Baltic Sea EEZ as priority areas for nature conservation supports the positive effects on benthic communities and biotopes that can be expected on the basis of appropriate management measures of the nature conservation areas.

11.3.4 Fish

According to previous findings, the habitat-typical fish communities occur in the German EEZ. The pelagic fish community, represented by herring, sprat, salmon and sea trout, has been identified as well as 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 in terms of distinctiveness. In the eastern part of the EEZ, a total of 45 fish species have been identified in various surveys, 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. Consequently, the fish population in the planning area is not ecologically significant compared to adjacent marine areas. According to the current state of knowledge, the planned construction of wind farms and the associated platforms and submarine cable routes are not - expected to have a significant adverse effect on fish. The impacts of the construction of the wind farms, platforms and submarine cable systems on fish fauna are limited in space and time. During the construction phase of the foundations, the platforms and the laying of the submarine cable systems, sediment turbulence and the formation of turbidity plumes may - temporarily affect fish fauna on a small scale. Due to the prevailing sediment and current conditions, the turbidity of the water is expected to decrease again quickly. Thus, according to the current state of knowledge, the impairments will remain small-scale and temporary. Overall, small-scale impairments can be assumed for adult fish. In addition, the fish fauna is adapted to the natural sediment turbulence caused by storms. Furthermore, during the construction phase, noise and vibrations may temporarily displace fish. Noise from the construction phase must be mitigated by appropriate measures. Further local impacts on fish fauna may result from the additionally introduced hard substrates due to a possible change in the benthos.

According to current knowledge, the designation of nature conservation priority areas 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 designation of other uses in the MSP, such as raw material extraction, land and alliance defence or shipping, will not have a significant impact on fish fauna.

11.3.5 Marine mammals

The German Baltic Sea EEZ, 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 identified in the plan are used by harbour porpoises as migration and feeding areas. There is currently no evidence that these areas have any special functions as nursery areas for harbour porpoises. Seals and grey seals use the three areas EO1 to EO3 only sporadically as passage areas. Based on the findings from the monitoring of Natura2000 sites and from studies for offshore wind farms, a medium to seasonally high importance of areas EO1 and EO2 for harbour porpoises can currently be derived. The seasonal high importance of the area results from the possible use by individuals of the separate and highly endangered Baltic Sea subpopulation of harbour porpoise in the winter months. These areas are of no particular importance for harbour seals and grey seals.

Marine mammals may be endangered by noise emissions during the installation of the foundations of transformer or collection platforms. Without the use of noise abatement measures, significant impacts on marine mammals during pile driving cannot be ruled out in individual sub-areas. The driving of piles for the transformer and collection platforms will therefore only be permitted in the specific approval procedure if effective noise reduction measures are used. The plan defines principles and objectives in this regard.

These state that the installation of the foundations is only to be carried out in compliance with strict noise reduction measures. In the actual approval procedure, extensive noise reduction measures and monitoring measures are ordered to ensure compliance with applicable noise protection values (sound event level (SEL) of 160 dB re 1µPa²s and peak level of 190 dB re 1µPa at a distance of 750 m around the pile driving or installation site). Appropriate measures shall be taken to ensure that no marine mammals are present in the vicinity of the pile driving site. Significant impacts on marine mammals due to the operation of the transformer or collection platforms can be ruled out according to current knowledge.

The designation of priority areas for wind energy production outside nature conservation areas contributes to a reduction of the threat to harbour porpoises in important feeding and nursery areas. The construction and operation of wind turbines and platforms is currently not expected to have any significant adverse impacts on marine mammals after implementation of the mitigation measures to be ordered in the individual procedure in accordance with the planning principle and corresponding compliance with applicable noise protection values. The laying and operation of submarine cable systems is also not expected to have any significant impacts on marine mammals.

As a result, significant impacts of the MSP designations on marine mammals can be excluded with the necessary certainty.

11.3.6 Seabirds and resting birds

The EEZ of the Baltic Sea can be divided into different sub-areas, each of which has a seabird occurrence expected for the respective prevailing hydrographic conditions, distances to the coast, existing pre-existing pressures and species-specific habitat requirements.

The uses considered in the MSP have various impacts on seabirds and resting birds, most of which are both spatially and temporally limited to the area or for the duration of the activity. For species sensitive to disturbance, such as red-throated divers and black-throated divers, offshore wind farm projects have disturbance effects that lead to avoidance behaviour. There are no findings on habituation effects to date.

By safeguarding open space or not designating areas for wind energy in marine nature conservation areas, impacts such as habitat loss in these important habitats are reduced. The MSP also designates nature conservation areas as priority areas for nature conservation. Principles of the MSP also provide for temporal and spatial coordination in the construction of offshore wind farm projects.

The spatial designation of further uses, such as shipping, national and alliance defence and raw material extraction (especially sand and gravel mining) is not automatically accompanied by increased intensities of use. Rather, these spatial designations are a tracing of previous activities.

As a result, no significant impacts of the designations in the MSP on the protected species of seabirds and resting birds can be ruled out with the necessary certainty.

11.3.7 Migratory birds

The Baltic Sea EEZ is of average to above-average importance for bird migration. Up to one billion birds migrate across the Baltic Sea every year. For sea ducks and geese from northern Europe and Russia (as far as western Siberia), the Baltic Sea is an important migration area, with a large part of the migration occurring in autumn in an east-west direction near the coast. The western Baltic Sea is overflown by several species requiring special protection (e.g. white-cheeked goose, whooper swan, eider, mourning duck and velvet scoter), sometimes at high intensities. Thermal swifts and other diurnal landbirds prefer to migrate along the "bird flight line" (islands of Fehmarn, Falster, Møn and Zealand, Falsterbo). East of this main route, these birds migrate in much lower densities. The western Baltic Sea is of above-average importance for crane migration.

Possible impacts of offshore wind energy on migratory birds may be that they constitute a barrier or collision risk. Open space protection in nature reserves reduces collision and barrier effects in important habitats.

The MSP takes account of the bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" (cf. MSP Principle (5) Chap. 2.4 Nature conservation). In principle, the corridors can be used by wind energy if they are designated as priority or reservation areas for wind energy. During periods of mass migration events, wind turbines shall not be operated in bird migration corridors if other measures are not sufficient to exclude a proven significantly increased collision risk of birds with wind turbines. Under the same conditions, construction and maintenance work shall not take place.

The need for preventive and mitigation measures - this could be, for example, the shutdown during mass migration events - in the "bird migration corridors "Fehmarn-Lolland" and "Rügen-Schonen" supports MSFD environmental objective 3 "Seas not affected by the impact of human activities on marine species and habitats" and contributes to the implementation of operational objective UZ3-02 "Measures to protect migratory species in the marine environment".

Clear and operational specifications are needed for measuring and shutdown systems and for the presence of a mass migration event during spring and autumn migration. Insofar as mass migration passes the area of offshore wind turbines according to these measuring systems and specifications, measures for the protection of bird migration must be initiated immediately, in particular those that exclude a collision of birds with wind turbines if there is an increased risk of collision.

The other uses considered in the MSP do not constitute vertical barriers in space.

Against the background of the current state of knowledge and taking into account MSP 2.4 (5), significant impacts on migratory birds can be excluded with the necessary certainty.

11.3.8 Bats

Migratory movements of bats across the Baltic Sea have been documented in various ways, but so far there is a lack of concrete information on migratory species, migration corridors, migration heights and migration concentrations. Previous findings only confirm that bats, especially long-distance migratory species, migrate across the Baltic Sea.

Due to the verticality in 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 bat migration over the North Sea EEZ. Other uses considered in the MSP do not pose comparable obstacles in the airspace.

According to the findings to date, the spatial designations of the maritime spatial plan do not have any significant impacts on bats.

11.3.9 Air

The provisions in the MSP and their implementation do not result in any measurable impacts on air quality. Pollutant emissions from shipping occur independently of the implementation of the plan.

11.3.10 Climate

The CO2 savings associated with the provisions on offshore wind energy can be expected to have a positive impact on the climate in the long term.

11.3.11 Landscape

The impact of the planned wind turbines in the German EEZ on the coastal landscape can be classified as low. Through coordinated and harmonised overall planning, the provisions of the MSP can minimise the land required for the expansion of offshore wind energy and thus - compared to non-implementation of the plan - also reduce the impacts on the landscape as a protected resource.

Negative impacts on the landscape can be ruled out for the pipelines because they are laid in or on the seabed.

11.3.12 Cultural assets and other material assets

With the further expansion of wind energy in the German EEZ, known as well as previously undiscovered cultural assets and traces of settlements may be endangered to a greater extent. However, this risk can be reduced through comprehensive coordination and agreement measures with the specialist authorities, and at the same time a great gain in knowledge can be expected for underwater archaeology with regard to underwater cultural assets and other cultural traces.

11.3.13 Biodiversity

Biodiversity comprises the diversity of habitats and biotic communities, the diversity of species and the genetic diversity within species (Art. 2 Convention on Biological Diversity, 1992). Biodiversity is the focus of public attention.

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 assemblages 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 control and warning function in this context, as they show the state 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 goods. In summary, it can be stated that, according to current knowledge, no significant impacts on biodiversity are to be expected as a result of the MSP designations.

11.3.14 Interactions

In general, impacts on a protected good lead to various consequences and interactions between the protected goods. The main interdependency of the biotic protected goods exists via the food chains. Possible interactions during the construction phase result from sediment relocation and turbidity plumes as well as noise emissions. However, these interactions only occur for a very short time and are limited to a few days or weeks.

Plant-related interactions, e.g. through the introduction of hard substrate, are expected to be permanent but only local. This could lead to a small-scale change in the food supply.

Due to the variability of the habitat, interactions can only be described very imprecisely. Basically, 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.

11.3.15 Cumulative effects

Soil, benthos and biotopes

A significant part of the environmental impacts of the areas for offshore wind energy and reserved areas for transmission lines on soil, benthos and biotopes will occur exclusively during the construction period (formation of turbidity plumes, sediment relocation, etc.) and in a spatially limited area. Due to the gradual implementation of the construction projects, construction-related cumulative environmental impacts are unlikely. Possible cumulative impacts on the seabed, which could also have a direct impact on the benthos and specially protected biotopes, result from the permanent direct land use for the foundations of the facilities and the installed pipelines. The individual impacts are generally small-scale and local.

In the area where pipelines are laid, the impairment of sediment and benthic organisms will essentially be temporary. In the case of crossing particularly sensitive biotope types such as reefs or species-rich gravel, coarse sand and shingle beds, permanent impairment would have to be assumed.

With regard to a balance of land use, reference is made to the environmental report on the FEP 2019 or FEP draft 2020. There, the direct land use by wind energy and power cables is estimated on the basis of model assumptions.

Due to the lack of a reliable scientific basis, no statement can be made on the use of specially protected biotopes according to sec. 30 BNatSchG. An area-wide sediment and biotope mapping of the EEZ, which is currently being carried out, will provide a more reliable assessment basis in the future.

In addition to the direct use of the seabed and thus the habitat of the organisms settled there, plant foundations, overlying pipelines and necessary crossing structures lead to an additional supply of hard substrate. This can lead to the settlement of non-native hard substrate-loving species and change the species composition. This effect can lead to cumulative effects through the construction of several offshore structures, pipelines or riprap in crossing areas of pipelines. The hard substrate introduced also results in a loss of habitat for benthic fauna adapted to soft bottoms. However, as the land use for both the grid infrastructure and the wind farms will be within the ‰ range, no significant impacts are to be expected, even in the cumulative effect, which would lead to a threat to the marine environment in relation to the seabed and the benthos.

Fish

The impacts on fish fauna due to the designations are probably most strongly influenced by the realisation of initially 20 GW of wind energy in the reservation areas of the North Sea and Baltic Sea. Here, the impacts of the OWPs are concentrated on the one hand on the regularly ordered closure of the area to fishing, and on the other hand on the change in habitat and its interaction.

The anticipated fishery-free zones within the wind farm areas could have a positive impact on the fish fauna by eliminating negative fishing effects, such as disturbance or destruction of the seabed and catch and bycatch of many species. Due to the lack of fishing pressure, the age structure of the fish fauna could return to a more natural distribution, so that the number of older individuals increases. The OWP could develop into an aggregation site for fish, although it has not yet been conclusively clarified whether wind farms attract fish.

In addition to the absence of fisheries, an improved food base for fish species with a wide variety of diets would also be conceivable. The vegetation of the wind turbines with sessile invertebrates could favour benthophagous species and make a larger and more diverse food source accessible to the fish (Glarou et al. 2020). This could improve the condition of the fish, which in turn would have a positive impact on fitness. Currently, research is needed to translate such cumulative effects to the population level of fish.

Furthermore, species composition could be directly altered by species with different habitat preferences than established species, e.g. reef dwellers, finding more favourable living conditions and becoming more abundant. Cumulative effects resulting from large-scale offshore wind development could include

- an increase in the number of older individuals,
- better conditions for the fish due to a larger and more diverse food base,
- 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.

In addition to predation, the natural mechanism for limiting populations is intra- and interspecific competition, which is also called density limitation. It cannot be ruled out that within individual wind farms local density limitation sets in before the favourable effects of the wind farms propagate spatially, e.g. through the migration of "surplus" individuals. In this case, the effects would be local and not cumulative. What effects changes in fish fauna might have on other elements of the food web, both below and above their trophic level, cannot be predicted at the current state of knowledge.

Together with the designation of nature conservation areas, wind farm areas could contribute to positive stock developments and thus to the recovery of fish stocks in the Baltic Sea.

Marine mammals

Cumulative impacts on marine mammals, in particular harbour porpoises, may occur primarily due to noise exposure during the installation of deep foundations. Thus, marine mammals can be significantly affected by the fact that - if pile driving is carried out simultaneously at different locations within the EEZ - not enough equivalent habitat is available to avoid and retreat to.

The realisation of offshore wind farms and platforms so far has been relatively slow and gradual. To date, pile driving has been carried out in three wind farms in the German EEZ of the Baltic Sea. Since 2011, all pile driving work has been carried out using technical noise reduction measures. Since 2014, the noise protection values have been reliably complied with and even undercut through the successful use of noise reduction systems. There was no temporal overlap of the three construction sites so far, so that there was no overlapping of noise-intensive pile driving works that 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 the deterrence measures, due to the installation with two erection ships.

The evaluation of the sound results with regard to sound propagation and the possibly resulting accumulation has shown that the propagation of impulsive sound is strongly restricted when effective sound minimising measures are applied (BRANDT et al. 2018, DÄHNE et al., 2017).

In order to avoid and reduce cumulative impacts on the harbour porpoise population in the German EEZ, a restriction of sound emissions from habitats to maximum permissible proportions of the EEZ and nature conservation areas is specified in the orders of the downstream approval procedure. Accordingly, the propagation of sound emissions may not exceed defined areas of the German EEZ and nature conservation areas. This ensures that sufficient high-quality habitats are available to animals for escape at all times. The order primarily serves to protect marine habitats by avoiding and minimising disturbances caused by impulsive sound emissions. The order of preventive and mitigation measures in areas EO1 and EO2 will also focus in particular on the protection of animals of the highly endangered population of the central Baltic Sea.

In conclusion, the implementation of the plan will lead to prevention and mitigation of cumulative impacts. This assessment also applies with regard to cumulative impacts of the various uses on marine mammals.

Seabirds and resting birds

The uses considered in the MSP can have different effects on seabirds and resting birds, in particular from the use of offshore wind energy through the vertical structures such as platforms or offshore wind turbines, such as habitat loss, an increased collision risk or a scaring and disturbing effect. These effects are considered on a site- and project-specific basis as part of the environmental impact assessment and monitored as part of the subsequent monitoring of the construction and operation phases of offshore wind farm projects. For seabirds and resting birds, habitat loss due to cumulative impacts of several structures or offshore wind farms can be particularly significant. By safeguarding open space in marine nature reserves, the impacts on seabirds and resting birds in these important habitats associated with OWPs are reduced. Although the MSP also specifies other uses within the nature conservation areas, no increases in intensity are expected as a result of the spatial planning designations. Rather, these are redrawings of already existing uses or intensities of use.

As a result of the SEA, significant cumulative impacts of the spatial planning designations on the protected species of seabirds and resting birds are not to be expected according to the current state of knowledge.

Migratory birds

Of the uses considered in the MSP, especially the use of offshore wind energy can have different effects on migratory birds, such as barrier effects and collision risk, due to the vertical structures of the offshore wind turbines. These effects are considered on a site-specific basis as part of the environmental impact assessment and monitored as part of the subsequent monitoring of the construction and operation phases of offshore wind farm projects.

The designation of priority areas, including the conditional reservation area EO2-West, in a spatial context to each other reduces barrier effects and collision risks in important feeding and resting habitats.

The provisions of the MSP under 2.4 (5) are expressly referred to at this point. This environmental report refers to these provisions in Chapter 4.7.6

Against the background of the current state of knowledge and taking into account MSP 2.4 (5), significant cumulative impacts on migratory birds can be excluded with the necessary certainty.

11.3.16 Cross-border effects

The present SEA concludes that, as things stand at present, no significant impacts on the areas of neighbouring states adjacent to the German Baltic Sea EEZ are discernible as a result of the stipulations made in the MSP.

For the protected goods soil and water, plankton, benthos, biotope types, landscape, cultural heritage and other material goods and humans, including human health, significant transboundary impacts can generally be excluded. Possible significant transboundary impacts could only result from a cumulative assessment 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.

For the protected resource fish, the SEA concludes that, according to current knowledge, no significant transboundary impacts on the protected resource are to be expected from the implementation of the MSP, as the identifiable and predictable effects are of a small-scale and temporary nature.

This also applies to marine mammals and seabirds and resting birds. These use the areas predominantly as migration areas. No significant loss of habitat for strictly protected species of seabirds and resting birds is to be expected. Based on current knowledge and taking into account impact minimisation and damage limitation measures, significant transboundary impacts can be excluded. For example, the installation of the foundations of wind turbines and platforms will only be permitted in the specific approval procedure if effective noise reduction measures are applied. Against the background of the particular threat to the separate Baltic Sea population of harbour porpoises, intensive monitoring measures are to be carried out as part of the enforcement process and, if necessary, the noise mitigation measures are to be adapted or the construction work coordinated in order to exclude any cumulative effects.

For migratory birds, erected wind turbines in particular can represent a barrier or collision risk. By safeguarding open space in the marine nature conservation areas, these impacts are reduced in important resting areas for some migratory bird species. Furthermore, the area EO2 is only designated as a reservation area for offshore wind energy, in particular due to the conflict with bird migration. The other uses considered in the MSP do not have any comparable spatial impacts. According to the current state of knowledge, no significant cross-border impacts on migratory birds are to be expected from the designations in the maritime spatial plan.

11.4 Species protection law assessment

The present species protection assessment examines whether the plan meets the requirements of sec. 44 para. 1 no. 1 and no. 2 BNatSchG for specially and strictly protected animal species. In particular, it is examined whether the plan violates species protection prohibitions.

According to sec. 44 para. 1 no. 1 BNatSchG, killing or injuring wild animals of specially protected species, i.e. animals listed in Annex IV of the Habitats Directive and Annex I of the V Directive, is prohibited. The species protection assessment pursuant to sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act always refers to the killing and injury of individuals.

Pursuant to sec. 44 para. 1 no. 2 BNatSchG, it is also prohibited to significantly disturb wild animals of strictly protected species during the breeding, rearing, moulting, hibernation and migration periods, whereby significant disturbance exists if the disturbance worsens the conservation status of the local population of a species.

According to current knowledge, two separate subpopulations of harbour porpoise occur in the German waters of the Baltic Sea: the Belt Sea subpopulation in the western Baltic Sea - Kattegat, Belt Sea, Sund - up to the area north of Rügen, and the central Baltic Sea subpopulation from the area north of Rügen.

The limit of the subpopulation of the harbour porpoise in the central Baltic Sea, which is classified as endangered, is 13°30' E, taking into account the results of acoustic, morphological, genetic and satellite-based surveys. (SVEEGARD et al. 2015).

The abundance of the separate population in the central Baltic Sea was estimated to be 447 individuals based on the acoustic data.

The separate subpopulation of the central Baltic Sea has been classified as threatened with extinction by the IUCN and HELCOM, among others, due to the very small number of individuals and the spatially restricted genetic exchange.

In the Baltic Sea EEZ, three nature conservation areas, "Pommersche Bucht - Rönnebank" (NSGPBRV), "Fehmarnbelt" (NSGFmbV), and "Kadetrinne" (NSGKdrV) were designated in 2017 with the conservation objective of maintaining and, where necessary, restoring the favourable conservation status of the species listed in Annex II of Directive 92/43/EEC harbour porpoise, harbour seal and grey seal. The nature reserve "Pomeranian Bay - Rönnebank" is of great importance for harbour porpoises in winter. During this period, the nature reserve and its surroundings as far as Rügen are also frequented by animals of the highly endangered population of the harbour porpoise of the central Baltic Sea. No animals of the central Baltic Sea population occur west of a longitude of 13° 30'. The nature reserve "Kadetrinne" shows the border area of the population of the harbour porpoise from Skagerrak, Kattegat and Belt Sea with higher densities of the harbour porpoise west of the NSG and strongly decreasing densities in eastern direction with decreasing densities. The protected area "Fehmarnbelt" and its surroundings have the highest density of harbour porpoise in the German waters of the Baltic Sea.

Areas EO1 and EO2 are regularly used by harbour porpoises, but to a very low extent. The occurrence of harbour porpoise in both areas is low compared to the occurrence west of the Darss Sill. According to current knowledge, there is no evidence that the two areas are used as breeding grounds. Areas EO1 and EO2 are of medium importance for harbour porpoises. In the winter months, however, a high significance can be assumed due to the possible use by animals of the endangered subpopulation of the central Baltic Sea. For grey seals and harbour seals, these areas are of low importance.

Area EO3 is used by harbour porpoises irregularly and to a very low extent. Overall, the occurrence of harbour porpoise in area EO3 is low compared to the occurrence in the Kadet Trench and further west. According to current knowledge, the area is not used as a nursery area. Area EO3 is of low importance for harbour porpoises. For grey seals and harbour seals, this area is on the edge of their range.

The main threats to harbour porpoise mortality in the ASCOBANS Agreement Area, which includes the German EEZ in the North Sea, include bycatch in bottom-set nets but also in trawl nets, 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. In contrast, collisions with ships are not known for small cetaceans such as the harbour porpoise.

According to the current state of knowledge, killing or injury of individual animals as a result of the uses defined in the plan is possible due to the input of impulse sound during pile driving for the foundation of facilities.

For marine mammals and in particular for the strictly protected species harbour porpoise, injuries or even kills could be expected from pile driving for the foundations of offshore wind turbines, transformer stations or other platforms if no preventive and mitigation measures were taken.

If the limit values of 160 dB for the sound event level (SEL05) and 190 dB for the peak level at a distance of 750 m from the point of emission, as specified in the subordinate approval procedures, are complied with in relation to the harbour porpoise, it is not possible for the killing and injury provisions of sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act (BNatSchG) to come into effect.

Appropriate means, such as scaring and soft-start procedures, will be used to ensure that no harbour porpoises are present within the 750 m radius around the pile driving site.

The plan lists objectives and principles that provide a framework for downstream planning levels and individual approval procedures. In the downstream procedures, designations, orders and requirements are made with regard to the necessary noise abatement measures and other preventive and mitigation measures, by means of which the realisation of the prohibition can be excluded. The measures are strictly monitored in order to ensure with the necessary certainty that the killing and injury provisions of sec. 44 para. 1 no. 1 of the Federal Nature Conservation Act do not come into effect.

The temporary execution of the pile driving work is not expected to cause significant disturbance to harbour porpoises within the meaning of sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act.

According to the current state of knowledge, it is not to be assumed that disturbances that may occur due to sound-intensive construction measures, and provided that preventive and mitigation measures are implemented, would worsen the conservation status of the local population.

Through effective noise abatement management, in particular through the application of suitable noise abatement systems in accordance with the principles and objectives in the update of the plan as well as subsequent orders in the individual approval procedure of the BSH and taking into account the specifications from the noise abatement concept of the BMU (2013), negative impacts of the pile driving work on harbour porpoises are not to be expected.

The BSH's planning approval decisions will contain specific orders that ensure effective noise protection management through appropriate 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 compliance with the requirements of species protection will be coordinated with the BfN in the course of implementation and adjusted if necessary. The following noise-reducing and environmental protection measures are regularly ordered as part of the planning approval procedures:

- Preparation of a sound prognosis taking into account the site- and plant-specific properties (basic design) before the start of construction,
- Selection of the erection method with the lowest noise level according to the state of the art and the existing conditions,
- Preparation of a concretised soundproofing concept adapted to the selected foundation structures and erection processes for the execution of pile driving works in principle two years before the start of construction, in any case before the conclusion of contracts regarding the sound-relevant components,
- Use of sound-reducing accompanying measures, individually or in combination, away from the pile (bubble curtain system) and, if necessary, also close to the pile, according to 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 sound insulation concept,
- Concept for the removal of animals from the hazard area (at least within a radius of 750 m around the pile driving site),
- Concept for verifying the efficiency of the deterrence and sound-reducing measures,
- Operating noise-reducing system design according to the state of the art.

As outlined above, deterrence measures and a soft-start procedure must be applied to ensure that animals in the vicinity of the pile-driving work have the opportunity to move away or escape in time.

As already explained, protected species occur in areas EO1 to EO3. These include species listed in Annex I of the Birds Directive, species whose habitats are protected in the nature conservation areas, as well as characteristic species and regularly occurring migratory bird species.

The area of sites EO1 to EO3 is used by divers mainly as a passage area during migration periods and in winter. According to the current state of knowledge, this area and its surroundings are outside of occurrence foci in the Pomeranian Bay.

Areas EO1 to EO3 are also of low to medium importance for other bird species.

In conclusion, the construction and operation of offshore wind turbines including ancillary facilities (transformer station, cabling within the park) in the areas covered by the plan are not expected to fulfil the disturbance requirement under sec. 44 para. 1 no. 2 of the Federal Nature Conservation Act (BNatSchG), according to the current state of knowledge.

Within the framework of the individual approval procedures, however, an update of the examination of the fulfilment of the disturbance requirement according to sec. 44 para. 1 no. 2 BNatSchG is necessary, if necessary taking into account further preventive and mitigation measures, but in any case taking into account the specific technical designs.

In principle, the same considerations apply to bats in terms of species protection law that were already explained in the context of the avifauna assessment.

Furthermore, it can be assumed that any negative impacts of wind turbines on bats will be avoided by the same preventive and mitigation measures provided for the protection of bird migration.

Experiences and results from research projects or from wind farms that are already in operation will also be given appropriate consideration in further procedures.

According to current knowledge, offshore wind farms are not expected to kill or injure (sec. 44 para. 1 no. 1 BNatSchG) other specially protected species, such as bats. The prohibition of significant disturbance (sec. 44 para. 1 no. 2 BNatSchG) of other strictly protected species, such as bats, is also not to be expected.

11.5 Impact assessment

Insofar as a site of Community importance or a European bird sanctuary may be significantly impaired in terms of its components relevant to the conservation objectives or the purpose of protection, sec. 7 para. 6 in conjunction with sec. 7 para. 7 of the ROG, the provisions of the Federal Nature Conservation Act on the admissibility and implementation of such interventions, including obtaining the opinion of the European Commission, must be applied when amending and supplementing maritime spatial plans.

In the German EEZ of the Baltic Sea, there are the nature conservation areas "Pommersche Bucht - Rönnebank" (Ordinance on the Establishment of the Nature Conservation Area "Pommersche Bucht - Rönnebank" of 22 September 2017, NSGPBRV,BGBl. I p. 3415), "Fehmarnbelt" (Ordinance on the Establishment of the Nature Conservation Area "Fehmarnbelt" of 22 September 2017, NSGFmbV, BGBl. I p. 3405) and "Kadetrinne"(Ordinance on the Establishment of the Nature Conservation Area "Kadetrinne" of 22 September 2017, BGBl. I p. 3410, NSGKdrV).

The total area of the three nature reserves is 2,472 km², the nature reserve "Pomeranian Bay - Rönnebank" covers an area of 2,092km², the nature reserve "Fehmarnbelt" contains an area of 280 km2 and the nature reserve "Kadetrinne" of 100 km2.

Protected species are the habitat types "reefs" and "sandbanks" according to Annex I of the Habitats Directive, certain fish species (sturgeon, fin) and marine mammals according to Annex II of the Habitats Directive (harbour porpoise, grey seal, seal) as well as various seabird species according to Annex I of the Habitats Directive (red-throated diver, black-throated diver, horned grebe) and regularly occurring migratory bird species (red-necked grebe, yellow-billed grebe, long-tailed duck, common scoter, velvet scoter, common gull, guillemot, razorbill, black guillemot).

The impact assessment carried out here takes place at the higher level of spatial planning and sets a framework for subordinate planning levels, if these exist. It therefore does not replace the assessment at the level of the specific project. Depending on the designations of the MSP 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 assessments of the downstream planning levels are taken into account within the framework of this MSP. Insofar as no assessment has yet been carried out within the framework of subordinate planning levels, the assessment is carried out within the framework of this SEA for the MSP on the basis of existing data and knowledge.

There is also a staged planning and approval process for raw material extraction. Where data and knowledge are available, an impact assessment is carried out within the framework of this SEA; otherwise, the assessments are reserved for the downstream planning levels.

The MSP contains designations relevant to the impact assessment on priority and reservation areas for wind energy, reservation areas for pipelines and reservation areas for hydrocarbons and sand and gravel extraction. The same applies to pipelines.

With regard to wind energy generation, reference is made to the results of the impact assessment on the FEP 2019/Draft FEP 2020.

The assessment has shown that possible impairments of the conservation purposes of the nature conservation areas "Pommersche Bucht-Rönnebank", "Kadetrinne" and "Fehmarnbelt" can be ruled out with certainty by implementing the plan in question and by complying with the orders in the subordinate individual approval procedures.

11.6 Measures to avoid, reduce and compensate for significant negative impacts of the maritime spatial plan on the marine environment

Pursuant to No. 2 c) Annex 1 to sec. 8 para. 1 ROG, the environmental report shall contain a description of the measures planned to prevent, reduce and, as far as possible, compensate for significant adverse environmental effects resulting from the implementation of the plan.

In principle, the MSP takes better account of the needs of the marine environment. The provisions of the MSP avoid 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 and the corresponding connection lines exists in any case and the corresponding infrastructure would have to be created even without the MSP. However, if the plan were not implemented, the uses would develop without the land-saving and resource-saving control and coordination effect of the MSP.

In addition, the provisions of the MSP are subject to a continuous optimisation process, as the insights gained on an ongoing basis during the SEA and consultation process are taken into account in the preparation of the plan.

While individual prevention, mitigation and compensation measures can already be implemented at the planning level, others only come into effect during concrete implementation and are regulated there in the individual approval procedure on a project- and site-specific basis.

With regard to planning preventive and mitigation measures, the MSP makes spatial and textual designations which, in accordance with the environmental protection objectives, serve to avoid or reduce significant negative impacts of the implementation of the MSP on the marine environment. This concerns, among other things, spatial designations for priority areas for nature conservation and the reservation 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 turbines, and the principle of taking into account best environmental practice in accordance with the Helsinki Convention and the respective state of the art in science and technology in economic and scientific uses.

Minimising land consumption is ensured by the following principles:

- Economic uses should be as space-saving as possible.
- After the end of use, fixed installations must be dismantled.
- When laying pipelines, the aim should be to achieve the greatest possible bundling in the sense of parallel routing. In addition, the routing should be as parallel as possible to existing structures and buildings.

In addition to the aforementioned measures at the plan level, there are measures for the prevention and mitigation of insignificant and significant negative impacts in the concrete implementation of the MSP for certain designations or associated uses, such as offshore wind energy, pipelines and sand and gravel extraction. These mitigation and preventive measures are specified and ordered by the respective competent approval authority at project level for the planning, construction and operational phases.

11.7 Alternative assessment

Pursuant to Art. 5 para. 1 sentence 1 SEA Directive in conjunction with the criteria in Annex I SEA Directive and sec. 40 para. 2 No. 8 UVPG, the environmental report contains a brief description of the reasons for the choice 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 role.

In principle, it should be noted that a preliminary assessment of possible and conceivable planning options is already inherent in all designations in the form of spatial planning objectives and principles. As can be seen from the justification of the individual objectives and principles, especially those with environmental relevance, the respective determination is already based on a consideration of possible affected public concerns and legal positions, so that a "preliminary examination" of possible planning options or alternatives has already taken place.

In detail, in addition to the zero alternative, spatial planning options or alternatives in particular are examined within the framework of the environmental assessment, insofar as they are relevant for the individual uses.

The planning concept and the planning guidelines (MSP, Chapter 1) form the basis for the planning solutions to be examined and for the examination of alternatives. Whereas initially three overall plan alternatives were examined in the context of the preparation of the planning concept on the basis of selected environmental aspects, in particular individual area designations, further (partial) spatial alternatives or different spatial planning areas (such as priority areas, reservation areas) were considered and assessed from an environmental perspective for the preparation of the first draft plan. Area designations for wind energy in the outer EEZ are subject to a detailed environmental assessment at subordinate planning levels.

The zero alternative is not assessed as a reasonable alternative for the update of the maritime spatial plan, as requirements and spatial claims have changed considerably since the MSP 2009 came into force, and the need for more far-reaching designations has become clear, particularly for nature conservation. The draft plan is expected to lead to a comparatively lower overall land use and thus to lower environmental impacts due to more comprehensive and forward-looking planning and coordination, taking into account a large number of spatial claims.

The preferred planning solution from an environmental point of view was not included in the draft plan in all cases. Rather, the overall context of the plan had to be considered, and in the choice of planning solutions, in addition to taking nature conservation concerns and the prevention or reduction of possible negative environmental impacts into account, a balance with other economic, scientific and safety concerns had to be sought as far as possible in the overall view. The decisive factor is that, at the level of this SEA, no significant impacts on the marine environment are to be expected for the designations made in the MSP according to the current state of knowledge.

11.8 Planned measures for monitoring the effects of the implementation of the maritime spatial plan on the environment

According to No. 3 b) Annex 1 to sec. 8 para. 1 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.

The monitoring also serves to verify the gaps in knowledge set out in the environmental report and the forecasts that are subject to uncertainties. The results of the monitoring are to be taken into account in the updating of the MSP in accordance with sec. 45 para. 4 UVPG.

The actual monitoring of potential impacts on the marine environment can only begin when the uses regulated under the plan are realised. Therefore, project-related monitoring of the impacts of offshore wind farms, pipelines and resource extraction is of particular importance. The main task of monitoring is to bring together and evaluate the findings from 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 must be carried out at the downstream project level in accordance with the standard "Investigation of impacts of offshore wind turbines (StUK4)" and in consultation with the BSH.

With regard to the specific measures for monitoring the potential impacts of wind energy use, including impacts from power cables, reference is made to the detailed explanations in the Environmental Report on the FEP 2019/ Draft FEP 2020.

For the approval of areas for sand and gravel extraction, for example, it applies that, before the next main operating plan approval, it must be demonstrated by suitable monitoring that the maximum permitted extraction depth is not exceeded, the original substrate is preserved and sufficient unmined areas remain so that the recolonisation potential is given.

For pipelines, monitoring measures during the construction phase include documentation of turbidity plumes, hydro-sound measurements and surveys of marine mammals and seabirds and resting birds. Essential monitoring measures during the operational phase of pipelines include annual documentation of the positional stability of the pipeline and the cover heights as well as annual documentation of the epifauna on the overlying pipeline for a period of five years after commissioning.

The BSH is conducting a whole range of projects as part of the accompanying research into the possible impacts 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 "Assessment approaches for underwater sound monitoring in the context of offshore licensing procedures, spatial planning and MSFD", and various sub-projects within the NavES R&D network "Nature-compatible developments at sea". The results from the ongoing BSH projects will flow directly into the further development of standards and norms, such as the development of the 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-checked basis of marine environmental information for the assessment of possible impacts of offshore installations and form an important basis for the updating of the MSP.

11.9 Overall plan assessment

In summary, with regard to the designations of the maritime spatial plan, the effects on the marine environment are minimised as far as possible through orderly, coordinated overall planning. The safeguarding of the nature conservation areas designated by ordinance as priority areas for nature conservation serves to protect the conservation purposes and safeguard open space. The reservation areas for pipelines run predominantly outside ecologically significant areas. By strictly adhering to preventive and mitigation measures, significant impacts can be avoided, particularly through the implementation of the designations for offshore wind energy and power lines.

On the basis of the above descriptions and assessments, as well as the assessment of species and site protection, it must be concluded for the Strategic Environmental Assessment, also with regard to any interactions, that, according to current knowledge and at the comparatively abstract level of spatial planning, no significant impacts on the marine environment within the study area are to be expected as a result of the planned designations.

Most of the environmental impacts of the individual uses for which designations are made would also occur - based on the same medium-term time horizon - if the plan were not implemented, since it is not evident 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 fundamentally "neutral" with regard to their effects on the environment. Although it is possible in principle that, due to the concentration/bundling of individual uses on certain areas/territories, some of the provisions of the plan may well have negative environmental impacts in the area of this specific area, an overall balance of the environmental impacts would tend to be positive due to the bundling effects, as the remaining areas/territories are relieved and hazards to the marine environment (e.g. collision risk) are reduced.

12 References

Abt K (2004) Robbenzählungen im schleswig-holsteinischen Wattenmeer. Bericht an das Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer. Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer. Tönning, Germany. 34 Seiten.

Abt KF, Hoyer N, Koch L & Adelung D (2002) The dynamics of grey seals (*Halichoerus grypus*) off Amrum in the south-eastern North Sea - evidence of an open population. Journal of Sea Research 47: 55−67.

Abt KF, Tougaard S, Brasseur SMJM, Reijnders PJH, Siebert U & Stede M (2005) Counting harbour seals in the wadden sea in 2004 and 2005 - expected and unexpected results. Waddensea Newsletter 31: 26−27.

Adams J., Van Holk, A. F., Maarleveld, T. , (1990): Dredgers and Archaeology. Shipfinds from the Slufter. Alphen aan den Rijn.

AK Seehunde (2005) Protokoll Arbeitskreis Seehunde vom 27.10.2005. Arbeitskreis Seehunde, Hotel Fernsicht, Tönning, 27.10.2005. Landesamt für den Nationalpark Schleswig-Holsteinisches Wattenmeer. Tönning. 6 Seiten.

Anderwald, P., Brandecker, A., Coleman, M., Collins, C., Denniston, H., Haberlin, M. D., . . . Walshe, L. (2013). Displacement responses of a mysticete, an adontocete, and a phacid seal to construction- related vessel traffic. Endangered Species Research, 21(3), 231-240.

Almqvist G, Strandmark AK & Appelberg M (2010) Has the invasive round goby caused new links in Baltic food webs? Environmental Biology of Fishes 89: 79–93.

Altvater, S. (2019). EBA in MSP – a SEA inclusive handbook. Projektbericht Pan Baltic Scope. Retrieved from http://www.panbalticscope.eu/wp-content/uploads/2019/12/EBAinMSP_FINAL-1.pdf

Andersin A-B, Lassig J, Parkkonen L & Sandler H (1978) The decline of macrofauna in the deeper parts of the Baltic proper and the Golf of Finland. Kieler Meeresforschungen, Sonderheft 4: 23–52.

Andren, T. and E. Andren, (2001): Did the Second Storegga Slide Affect the Baltic Sea? Baltica, 14, 115-122.

Andrulewicz, E., Napierska, D. and Z. Otembra, (2003): The Environmental Effects of the Installation and Functioning of the Submarine SwePol Link HVDC Transmission Line: a Case Study of the Polish Marine Area of the Baltic Sea. Journal of Sea Research, 49, 337-345.

Anton, C., Belasus, M., Bernecker, R., Breuer, C., Jöns, H., Schorlemer, S. von, (2020): Spuren unter Wasser: Das kulturelle Erbe in Nord- und Ostsee erforschen und schützen. Halle: Nationale Akademie der Wissenschaften Leopoldina.

Armonies W (1999) Drifting benthos and long-term research: why community monitoring must cover a wide spatial scale. Senckenbergiana Maritima 29: 13−18.

Armonies W (2000) What an introduced species can tell us about the spatial extension of benthic populations. Marine Ecology Progress Series 209: 289−294.

Armonies W, Herre E & Sturm M (2001) Effects of the severe winter 1995/96 on the benthic macrofauna of the Wadden Sea and the coastal North Sea near the island of Sylt. Helgoland Marine Research 55: 170−175.

Armonies W & Asmus H (2002) Fachgutachten Makrozoobenthos im Rahmen der UVS und FFH-VP für den Offshore-Bürgerwindpark „Butendiek“ westlich von Sylt. Im Auftrag der OSB-Offshore Bürgerwindpark „Butendiek“ GmbH und Co. KG.

Arntz WE & Rumohr H (1986) Fluctuations of Benthic Macrofauna during Succession and in an Established Community. Meeresforschung 31: 97−114.

Arntz, W. and W. Weber, (1970): Cyprina islandica L. (Molluska, Bivalvia) als Nahrung für Dorsch und Kliesche in der Kieler Bucht. Berichte der Deutschen Wissenschaftlichen Kommission für Meeresforschung, 21, 193-209.

Arntz WE (1970) Das Makrobenthos der Kieler Bucht im Jahre 1968 und seine Ausnutzung durch die Kliesche (*Limanda limanda* L.). Dissertation Universität Kiel. 167 Seiten.

Arntz WE (1971) Biomasse und Produktion des Makrobenthos in den tieferen Teilen der Kieler Bucht im Jahr 1968. Kieler Meeresforschung 27: 36−72.

Arntz WE, Brunswig D & Sarnthein M (1976) Zonierung von Mollusken und Schill im Rinnensystem der Kieler Bucht (Westliche Ostsee). Senckenbergiana maritima 8: 189−269.

Arntz WE (1978) Zielsetzung und Probleme struktureller Benthosuntersuchungen in der Marinen Ökosystemforschung. Verhandlungen der Gesellschaft für Ökologie: 35−51.

Arveson, P. T., & Vendittis, D. J. (2000). Radiated noise characteristics of a modern cargo ship. The Journal of the Acoustical Society of America, 107(1), 118-129. https://doi.org/10.1121/1.428344

Ascobans (2005) Workshop on the Recovery Plan for the North Sea Harbour Porpoise, 6.−8. Dezember 2004, Hamburg, Report released on 31.01.2005, 73 Seiten.

Ascobans, (2010). The Harbour porpoise in the Baltic Sea - Jastarnia Plan .

Ascobans (2012) ASCOBANS conservation plan for the Harbour porpoise population in the western Baltic, the Belt Sea and the Kattegat.

Ascobans (2019). ASCOBANS/JG16/Inf.3.3. Outcome of the OSPAR-HELCOM workshop to examine possibilities for developing indicators for incidental by-catch of birds and marine mammals

ASCOBANS (2020) THE BALTIC PROPER HARBOUR PORPOISE, UNEP/ASCOBANS/Res.9.2

Atkinson, C. M., (2012): Impacts of Bottom Trawling on Underwater Cultural Heritage (Masters Thesis), Texas A&M University.

Atzler, R., (1995): Der pleistozäne Untergrund der Kieler Bucht und angrenzender Gebiete nach reflexionsseismischen Messungen. Berichte – Reports, Geologisch-Paläontologisches Institut der Universität Kiel, 70, 116 S.

Auer, J., (2004): Fregatten Mynden: a 17th-century Danish Frigate Found in Northern Germany. The International Journal of Nautical Archaeology, 33.2, 264–280.

Auer, J., (2010): Fieldwork Report: Princessan Hedvig Sophia 2010. Esbjerg Maritime Archaeology Reports 3. Esbjerg

Auer, J., Jantzen, D., Heumüller, M., Klooß, S., (2020): Kulturerbe unter Wasser: Leitfaden für Baumaßnahmen im Küstenmeer. Schleswig.

Azzellino, A., C. Lanfredi, A. D'Amico, G. Pavan, M. Podestà, J. Haun (2011). Risk mapping for sensitive species to underwater anthropogenic sound emissions: Model development and validation in two Mediterranean areas. Marine Pollution Bulletin 63:56–70

Baerens, C. und P. Hupfer, (1999): Extremwasserstände and der deutschen Ostseeküste nach Beobachtungen und in einem Treibhausgasszenario. Die Küste, 61, 47-72.

Balla, S., K. W.-J. (2009, April). Leitfaden zur Strategischen Umweltprüfung (SUP). *Texte 08/09*. Dessau-Roßlau, Sachsen-Anhalt, Deutschland: Umweltbundesamt.

Ballin, T. (2017). Rising waters and processes of diversification and unification in material culture: the flooding of Doggerland and its effect on north-west European prehistoric populations between ca. 13 000 and 1500 cal BC

Barz K & Zimmermann C (Hrsg.) Fischbestände online. Thünen-Institut für Ostseefischerei. Elektronische Veröffentlichung auf www.fischbestaende-online.de, Zugriff am 12.03.2018.

Beaugrand G (2009) Decadal changes in climate and ecosystems in the North Atlantic Ocean and adjacent seas. Deep Sea Research II 56: 656–673.

Behre K.-E., (2003): Eine neue Meeresspiegelkurve für die südliche Nordsee, Probleme der Küststenforschung in südlichen Nordseegebiet 28, 9-63.

Bell, C. (2015). Nephrops norvegicus. The IUCN Red List of Threatened Species 2015: e.T169967A85697412

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

Benke H., S. Bräger, M. Dähne, A. Gallus, S. Hansen, C. G. Honnef, M. Jabbusch, J. C. Koblitz, K. Krügel, A. Liebschner3, I. Narberhaus3, U. K. Verfuß (2014). Baltic Sea harbour porpoise populations: status and conservation needs derived from recent survey results. Mar.Ecol.Progr. Ser., Vol. 495: 275–290

Bernem, K.-H. van, (2003): Einfluss von Ölen auf marine Organismen und Lebensräume. In: Lozan, J.L., Rachor, E., Reise, K., Sündermann, J. und H. von Westernhagen. Warnsignale aus Nordsee & Wattenmeer – Eine aktuelle Umweltbilanz. Wissenschaftliche Auswertungen, Hamburg 2003. 229-233.

Betke K & Matuschek R (2011) Messungen von Unterwasserschall beim Bau der Windenergieanlagen im Offshore-Testfeld „alpha ventus“. Abschlussbericht zum Monitoring nach StUK3 in der Bauphase.

Betke (2012) Messungen von Unterwasserschall beim Betrieb der Windenergieanlagen im Offshore-Windpark alpha ventus.

Beukema JJ (1992) Expected changes in the Wadden Sea benthos in a warmer world: lessons from periods with mild winters. Netherlands Journal of Sea Research 30: 73−79.

BFAFi Bundesforschungsanstalt für Fischerei, Institut für Ostseefischerei Rostock (2007) Dorsch/Kabeljau-Fänge durch die deutsche Freizeitfischerei der Nord- und Ostsee 2004-2006. Bericht einer Pilotstudie im Rahmen des Nationalen Fischerei-Datenerhebungsprogrammes gemäß der Verordnung der Kommission. No 1581/2004, 7. Appendix XI (Section E), para. 3.

BfN, Bundesamt für Naturschutz (2006) Naturschutzfachlicher Planungsbeitrag des Bundesamtes für Naturschutz zur Aufstellung von Zielen und Grundsätzen der Raumordnung für die deutsche Ausschließliche Wirtschaftszone der Nord- und Ostsee, Februar 2006.

BfN, Bundesamt für Naturschutz (2012a) Mariner Biotoptyp „Seegraswiesen und sonstige marine Makrophytenbestände“. (http://www.bfn.de/habitatmare/de/marine-biotoptypen.php, Stand: 14.05.2013).

BfN, Bundesamt für Naturschutz (2012b) Kartieranleitung „Artenreiche Kies-, Grobsand- und Schillgründe im Küsten- und Meeresbereich“.

BfN. (2017). Die Meeresschutzgebiete in der deutschen ausschließlichen Wirtschaftszone der Nordsee - Beschreibung und Zustandsbewertung

BfN, Bundesamt für Naturschutz (2018) BfN-Kartieranleitung für „Riffe“ in der deutschen ausschließlichen Wirtschaftszone (AWZ). Geschütztes Biotop nach § 30 Abs. 2 S. 1 Nr. 6 BNatSchG, FFH – Anhang I – Lebensraumtyp (Code 1170). 70 Seiten.

BfN, Bundesamt für Naturschutz (2020) Die Meeresschutzgebiete in der deutschen ausschließlichen Wirtschaftszone der Ostsee – Beschreibung und Zustandsbewertung – 498 Seiten.

BfN (2020) Naturschutzfachlicher Planungsbeitrag des Bundesamtes für Naturschutz zur Fortschreibung der Raumordnungspläne für die deutsche Ausschließliche Wirtschaftszone in der Nord- und Ostsee, August 2020.

BIO/CONSULT AS (2004) Hard bottom substrate monitoring, Horns Rev offshore wind farm - Annual Status Report 2003. - (Gutachten i. A. von Elsam Engineering) 40 S. + Anhang.

BioConsult SH & Co.KG (2018) Umweltmonitoring im Cluster „Westlich Adlergrund“. Fachgutachten Rastvögel. 3. Untersuchungsjahr März 2016 – Februar 2017. Unveröffentlichtes Gutachten im Auftrag der Iberdrola Renovables Offshore Deutschland GmbH und E.ON Climate & Renewables GmbH, Husum, Oktober 2018.

BioConsult SH & Co.KG (2019) Umweltmonitoring im Cluster „Westlich Adlergrund“. Fachgutachten Rastvögel. 4. Untersuchungsjahr März 2017 – Februar 2018. Unveröffentlichtes Gutachten im Auftrag der Iberdrola Renovables Offshore Deutschland GmbH und E.ON Climate & Renewables GmbH, Husum, Februar 2019.

Bijkerk R (1988) Ontsnappen of begraven blijven. De effecten op bodemdieren van een verhoogte sedimentatie als gevolg van baggerwerkzaamheden. Literatuuronderzoek – NIOZ Rapport 2005−6,18 Seiten.

Björdal, C. G., Manders, M., Al-Hamdani, Z., Appelqvist, C., Haverhand, J. Dencker, J., (2012): Strategies for Protection of Wooden Underwater Cultural Heritage in the Baltic Sea Against Marine Borers. The EU Project ‚WreckProtect‘. In: Conservation and Management of Archaeological Sites 14.1-4, 201–214.

Blundell, G. M., & Pendleton, G. W. (2015). Factors Affecting Haul-Out Behavior of Harbor Seals (Phoca vitulina) in Tidewater Glacier Inlets in Alaska: Can Tourism Vessels and Seals Coexist? PLoS One, 10(5), e0125486. https://doi.org/10.1371/journal.pone.0125486

BMU, Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (2013) Konzept für den Schutz der Schweinswale vor Schallbelastungen bei der Errichtung von Offshore-Windparks in der deutschen Nordsee (Schallschutzkonzept).

BMU Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (2018) Zustand der deutschen Ostseegewässer 2018. Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, Referat WR I 5, Meeresumweltschutz, Internationales Recht des Schutzes der marinen Gewässer. 194 Seiten.

BMU. (2019). Projektionsbericht 2019 für Deutschland gemäß Verordnung (EU) Nr. 525/2013

BMU. (2020). Seeverkehr. Retrieved from https://www.bmu.de/themen/luft-laerm-verkehr/verkehr/seeverkehr

BMUB. (2016). MSRL-Maßnahmenprogramm zum Meereschutz der deutschen Nord- und Ostsee. Bonn

Bobertz, B., Harff, J., Kramarska, R., Lemke, W., Przezdziecki, P., Uscinowicz, S. and J. Zachowicz, (2004): Map of Surface Sediments of the Pomeranian Bight. International Borders Geoenvironmental Concerns, 7-8.

Bobsien IC & Brendelberger H (2006) Comparison of an enclosure drop trap and a visual diving census technique to estimate fish populations in eelgrass habitats. Limnology and Oceanography: Methods 4(5): 130–141.

Bochert R & Zettler ML (2004) Long-term exposure of several marine benthic animals to static magnetic fields. Bioelectromagnetics 25:498−502.

Bock, G. M., (2003): Quantifizierung und Lokalisierung der entnommenen Hartsubstrate vor der Ostseeküste Schleswig-Holsteins. Eine historische Aufarbeitung der Steinfischerei. Studie im Auftrag des Landesamtes für Natur und Umwelt Schleswig-Holstein (LANU), 52 S.

Bock, G. M., Thiermann, F., Rumohr, H. und R. Karez, (2004): Ausmaß der Steinfischerei an der schleswig-holsteinischen Ostseeküste, Jahresbericht Landesamt für Natur und Umwelt Schleswig-Holstein (LANU) 2003, 111-116.

Borkenhagen K, Guse N, Markones N, Mendel B, Schwemmer H, Garthe S (2017) Monitoring von Seevögeln in der deutschen Nord- und Ostsee 2016. Im Auftrag des Bundesamts für Naturschutz (BfN).

Borkenhagen K, Guse N, Markones N, Schwemmer H, Garthe S (2018) Monitoring von Seevögeln in der deutschen Nord- und Ostsee 2017. Im Auftrag des Bundesamts für Naturschutz (BfN).

Borkenhagen K, Guse N, Markones N, Schwemmer H, Garthe S (2019) Monitoring von Seevögeln in der deutschen Nord- und Ostsee 2018. Im Auftrag des Bundesamts für Naturschutz (BfN)

Borrmann, R., Rehfeldt, D. K., Wallasch, A.-K., & Lüers, S. (2018). Approaches and standards for the determination of the capacity density of offshore wind farms. in Veröffentlichung

Bosselmann A (1989) Entwicklung benthischer Tiergemeinschaften im Sublitoral der Deutschen Bucht. Dissertation Universität Bremen, 200 Seiten.

Brandt MJ, Höschle C, Diederichs A, Betke K, Matuschek R & Nehls G (2013) Seal Scarers as a tool to deter harbour porpoises from offshore construction sites. Marine Ecology Progress Series 421: 205−216.

Brandt M, Dragon AC, Diederichs A, Schubert A, Kosarev V, Nehls G, Wahl V, Michalik A, Braasch A, Hinz C, Ketzer C, Todeskino D, Gauger M, Laczny M & Piper W (2016) Effects of offshore pile driving on harbour porpoise abundance in the German Bight. Study prepared for Offshore Forum Windenergie. Husum, June 2016, 246 Seiten.

Brandt MJ,Dragon AC, Diederichs A, Bellmann M, Wahl V, Piper W, Nabe-Nielsen J & Nehls G (2018) Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. Marine Ecology Progress Series 596: 213−232.

Breuer, G. and W. Schramm, (1988): Changes in Macroalgal Vegetation of Kiel Bight (Western Baltic Sea) During the Past 20 Years. Kieler Meeresforschungen, Sonderheft 6, 241-255.

Brey T (1984) Gemeinschaftsstrukturen, Abundanz, Biomasse und Produktion des Makrobenthos sandiger Böden der Kieler Bucht in 5-15 m Wassertiefe. Berichte aus dem Institut für Meereskunde an der Christian-Albrechts-Universität Kiel Nr. 186: 248 Seiten.

Brockmann, U., D. Topcu, M. Schütt & W. Leujak (2017) Eutrophication assessment in the transit area German Bight (North Sea) 2006–2014 – Stagnation and limitations. Marine Pollution Bulletin 136:68-78.

BSH, Bundesamt für Seeschifffahrt und Hydrographie / IOW, Institut für Ostseeforschung Warnemünde, (2012): Digitaler Kartensatz zur Sedimentverteilung für das deutsche Ostseegebiet.

BSH, Bundesamt für Seeschifffahrt und Hydrographie (2019a), Flächenentwicklungsplan 2019 für die deutsche Nord- und Ostsee

BSH, Bundesamt für Seeschifffahrt und Hydrographie (2019b) Umweltbericht Ostsee zum Flächenentwicklungsplan 2019. Hamburg/ Rostock.

BSH. Bundesamt für Seeschifffahrt und Hydrographie (2020a). Konzeption zur Fortschreibung der Raumordnungspläne für die deutsche ausschließliche Wirtschaftszone in der Nord- und Ostsee.

BSH, Bundesamt für Seeschifffahrt und Hydrographie (2020b) Entwurf Umweltbericht Ostsee zum Flächenentwicklungsplan 2020. Hamburg/ Rostock.

Buhl-Mortensen, Lene & Neat, Francis & Koen-Alonso, Mariano & Hvingel, Carsten & Holte, Borge. (2015). Fishing impacts on benthic ecosystems: An introduction to the 2014 ICES symposium special issue. ICES Journal of Marine Science. 73. 10.1093/icesjms/fsv237.

Bundesamt für Naturschutz (Hrsg.) (2020) Die Meeresschutzgebiete in der deutschen ausschließlichen Wirtschaftszone der Ostsee - Beschreibung und Zustandsbewertung – BfN-Skript 553; 498 S.

Burchard, H. und H. U. Lass, (2004): Einschätzung einiger Risiken durch Offshore-Windkraftanlagen im Bereich Kriegers Flak und Adlergrund auf das marine Ökosystem der Ostsee. Schreiben des IOW an das BSH vom 2.1.2004.

Burchard, H., Lass, H. U., Mohrholz, V., Umlauf, L., Sellschopp, J., Fiekas, V., Bolding, K. and L. Arneborg, (2005): Dynamics of medium-intensity dens water plumes in the ArkonaBasin, Western Baltic Sea. Ocean Dynamics, 55, 391-402 (DOI: 10.1007/s10236-005-0025-2).

Bureau Waardenburg (1999) Falls of migrant birds − An analysis of current knowledge. Report prepared for the Directoraat-Generaal Rijksluchtvaartdienst, Postbus 90771, 2509 LT Den Haag, Programmadirectie Ontwikkeling Nationale Luchthaven, Ministerie van Verkeer en Waterstaat.

Castellote, M., Clark, C. W., & Lammers, M. O. (2012). Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise. Biological Conservation, 147(1), 115-122

Carlen I., L. Thomas, J. Carlström, M. Amundin, J. Teilmann, N. Tregenza, J. Tougaard, J. Koblitz, S. Sveegard, D. Wenneberg, O. Loisa, M. Dähne, K. Brundiers, M. Cosecka, L.Kyhn, C. Ljungqvist, I. Pawliczka, R. Koza, B. Arciszewski, A. Galatius, M. Jobbusch, J. Laaksonlaita, J. Nemmi, S. Lyytinen, A. Galllus, H. Benke, P. Blankett, K. Skora, A. Acevedo-Gitierrez, 2018. Basin-scale distribution of harbour porpoises in the Baltic Sea provides basisfor effective conservation actions. Biological Conservetion, 226:42-53

Carlén, I., L. Nunny and M. P. Simmonds (2021).Out of Sight, Out of Mind: How Conservation Is Failing European PorpoisesFront. Mar. Sci., 04 February 2021 | https://doi.org/10.3389/fmars.2021.617478Carstensen D., Froese R., Opitz S. & Otto T. (2014) Ökologischer und ökonomischer Nutzen fischereilicher Regulierungen in Meeresschutzgebieten. GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel. Im Auftrag des Bundesamtes für Naturschutz.

Cederwall H & Elmgren R (1980) Biomass increase of benthic macrofauna demonstrates eutrophication of the Baltic Sea. In Proceedings of the 6th Symposium of the Baltic Marine Biologists: relationship and exchange between the pelagic and benthic biota.

Chen F.,G.I.Shapiro, K.A.Bennetta, S.N.Ingram, D.Thompson, C.Vincent, D.J.F.Russell, C.B.Embling (2017): Shipping noise in a dynamic sea: a case study of grey seals in the Celtic Sea. Mar. Poll. Bull. Volume 114, Issue 1, https://www.sciencedirect.com/science/article/abs/pii/S0025326X16307925

Chion, C, D. Lagrois, J. Dupras, 2019. A Meta-Analysis to Understand the Variability in Reported Source Levels of Noise Radiated by Ships From Opportunistic Studies. Front. Mar. Sci., 26 November 2019 | https://doi.org/10.3389/fmars.2019.00714

Clark, C. W., Ellison, W. T., Southall, B. L., Hatch, L., Van Parijs, S. M., Frankel, A., & Ponirakis, D. (2009). Acoustic masking in marine ecosystems: intuitions, analysis, and implication. Marine Ecology Progress Series, 395, 201-222.

Couperus AS, Winter HV, van Keeken OA, van Kooten T, Tribuhl SV & Burggraaf D (2010) Use of high resolution sonar for near-turbine fish observations (didson)-we@ sea 2007-002 IMARES Report No. C0138/10, Wageningen, 29 Seiten.

Cosens, S., & Dueck, L. (1993). Icebreaker Noise in Lancaster Sound, N.W.T., Canada: Implications for Marine Mammal Behavior. Marine Mammal Science, 9(3), 285-300. https://doi.org/10.1111/j.1748-7692.1993.tb00456.x

Culloch, R. M., Anderwald, P., Brandecker, A., Haberlin, D., McGovern, B., Pinfield, R., Cronin, M. (2016). Effect of construction-related activities and vessel traffic on marine mammals. Marine Ecology Progress Series, 549, 231-242.

Cushing DH (1990) Plankton Production and Year-class Strength in Fish Populations: an Update of the Match/Mismatch Hypothesis. Advances in Marine Biology 26: 249–293.

Crumlin-Pedersen, O., (1996): Viking-Age Ships and Shipbuilding in Hedeby/Haithabu and Schleswig. Roskilde: Vikingeskibsmuseet.

Crumlin-Pedersen, O. & Olsen O., (2002): The Skuldelev Ships I: Topography, Archaeology, History, Conservation and Display. Roskilde: Vikingeskibsmuseet.

Daan N, Bromley PJ, Hislop JRG & Nielsen NA (1990) Ecology of North Sea fish. Netherlands Journal of Sea Research 26 (2−4): 343–386.

Dähne M, Tougaard J, Carstensen J, Rose A & Nabe-Nielsen J (2017) Bubble curtains attenuate noise levels from offshore wind farm construction and reduce temporary habitat loss for harbour porpoises. Marine Ecology Progress Series 580: 221−237.

Dähnhardt A & Becker PH (2011) Herring and sprat abundance indices predict chick growth and reproduc-tive performance of Common Terns breeding in the Wadden Sea. Ecosystems 14: 791–803.

Danish Energy Agency. (2017). Master data register for wind turbines at end of December 2017. Retrieved from https://ens.dk/en/our-services/statistics-data-key-figures-and-energy-maps/overview-energy-sector

Davis N, van Blaricom G & Dayton PK (1982) Man-made structures: effects on adjacent benthic communities. Marine Biology 70: 295−303.

De Backer A, Debusschere E, Ranson J & Hostens K (2017) Swim bladder barotrauma in Atlantic cod when in situ exposed to pile driving. In: DEGRAER S, BRABANT R, RUMES B & VIGIN L (Hrsg.) (2017) Environmental impacts of offshore wind farms in the Belgian part of the North Sea: A continued move towards integration and quantification. Brussels: Royal Belgian Institute of Natural Sciences, OD Natural Environment, Marine Ecology and Management Section.

de Jong K., Forland T.N., Amorim M.C.P., Rieucau G., Slabbekoorn H. & Siyle L.D. (2020) Predicting the effects of anthropogenic noise on fish reproduction. Rev Fish Biol Fisheries. https://doi.org/10.1007/s11160-020-09598-9.

Dekeling, R.P.A., Tasker, M.L., Van der Graaf, A.J., Ainslie, M.A, Andersson, M.H., André, M., Borsani, J.F., Brensing, K.,Castellote, M., Cronin, D., Dalen, J., Folegot, T., Leaper, R., Pajala, J., Redman, P., Robinson, S.P., Sigray, P., Sutton, G.,Thomsen, F., Werner, S., Wittekind, D., Young, J.V., Monitoring Guidance for Underwater Noise in European Seas, Part II:Monitoring Guidance Specifications, JRC Scientific and Policy Report EUR 26555 EN, Publications Office of the European Union, Luxembourg, 2014, doi: 10.2788/27158

De Robertis, A., Wilson, C. D., Furnish, S. R., & Dahl, P. H. (2013). Underwater radiated noise measurements of a noise-reduced fisheries research vessel. Ices Journal of Marine Science, 70(2), 480-484. https://doi.org/10.1093/icesjms/fss172

De Robertis A. & Handegard N. O. (2013) Fish avoidance of research vessels and the efficacy of noise-reduced vessels: a review. – ICES Journal of Marine Science, 70: 34–45.

Denkmalschutzbehörden der Küstenbundesländer Mecklenburg-Vorpommern, Niedersachsen und Schleswig-Holstein (2020) Beitrag zum kulturellen Erbe für den Umweltbericht des BSH-Raumordnungsplanes in der Ausschließlichen Wirtschaftszone der Nord- und Ostsee, Gemeinsame fachliche Empfehlung der für die Archäologie zuständigen Denkmalschutzbehörden der Küstenbundesländer Mecklenburg-Vorpommern, Niedersachsen und Schleswig-Holstein

Dickey-Collas M, Heessen H & Ellis J (2015) 20. Shads, herring, pilchard, sprat (Clupeidae) In: Heessen H, Daan N, Ellis JR (Hrsg.) Fish atlas of the Celtic Sea, North Sea, and Baltic Sea: based on international research-vessel surveys. Academic Publishers, Wageningen, Seite 139−151.

Diesing, M. und K. Schwarzer, (2003): Erforschung der FFH-Lebensraumtypen Sandbank und Riff in der AWZ der deutschen Nord- und Ostsee. 2. Zwischenbericht, Institut für Geowissenschaften, Christian-Albrechts-Universität, Kiel, 62 S. mit Anhang.

Durant JM, Hjermann DØ, Ottersen G & Stenseth NC (2007) Climate and the match or mismatch between predator requirements and resource availability. Climate Research 33: 271–283.

Durinck J, Skov H, Danielsen F, Christensen KD (1994) Vinterføden hos Rødstrubet Lom *Gavia stellata* i Skagerak. Dansk Ornitologisk Forenings Tidsakrift 88: 39–41.

Dyndo M., D. M. Wiśniewska, L. Rojano-Doñate1 & P. T. Madsen (2015). Harbour porpoises react to low levels of high frequency vessel noise, Scientific Reports, Nature.

EEA European Environment Agency (2015) State of the Europe’s seas. EEA Report No 2/2015. European Environment Agency. Publications Office of the European Union, Luxembourg (Webseite der European Environment Agency).

Ehlers, P. (2016). Kommentar zu § 1 . In P. Ehlers, Kommentar zum Seeaufgabengesetz (p. § 1). Baden-Baden: Nomos.

Ehrich S., Adlerstein S., Götz S., Mergardt N. & Temming A. (1998) Variation in meso-scale fish distribution in the North Sea. ICES C.M. 1998/J, S.25 ff.

Ehrich S. & Stransky C. (1999) Fishing effects in northeast Atlantic shelf seas: patterns in fishing effort, diversity and community structure. VI. Gale effects on vertical distribution and structure of a fish assemblage in the North Sea. Fisheries Research 40: 185−193.

Ehrich S, Kloppmann MHF, Sell AF & Böttcher U (2006) Distribution and Assemblages of Fish Species in the German Waters of North and Baltic Seas and Potential Impact of Wind Parks. In: Köller W, Köppel J & Peters W (Hrsg.) Offshore Wind Energy. Research on Environmental Impacts. 372 Seiten.

Ehrich S, Adlerstein S, Brockmann U, Floeter JU, Garthe S, Hinz H, Kröncke I, Neumann H, Reiss H, Sell AF, Stein M, Stelzenmüller V, Stransky C, Temming A,Wegner G & Zauke GP (2007) 20 years of the German Small-scale Bottom Trawl Survey (GSBTS): a review. Senckenbergiana Maritima 37: 13–82.

EIGAARD,O., BASTARDIE, F.,BREEN, M., DINESEN, G., HINTZEN, N., LAFFARGUE, P., NIELSEN, J. R., et al. (2016) Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES Journal of Marine Science, 73(Suppl. 1): i27–i43.

Elmer K-H, Betke K & Neumann T (2007) Standardverfahren zur Ermittlung und Bewertung der Belastung der Meeresumwelt durch die Schallimmission von Offshore-Windenergieanlagen. „Schall II“, Leibniz Universität Hannover.

Emeis, K.-C., Struck, U., Leipe, T., Pollehne, F., Kunzendorf, H. and C. Christiansen, (2000): Changes in the C, N, P burial rates in some Baltic Sea sediments over the last 150 years – relevance to P regeneration rates and the phosphorus cycle. Marine Geology, 167, 43-59.

EMEP (2016) European monitoring and evaluation programme. Unpublished modelling results on the pro-jected effect of Baltic Sea and North Sea NECA designations to deposition of nitrogen to the Baltic Sea area. Available at the HELCOM Secretariat.

Englert, A. & Trakadas, A., (2009): Wulfstan’s Voyage. The Baltic Sea region in the early Viking Age as seen from shipboard. Maritime Culture of the North, Band 2. Roskilde: Vikingeskibsmuseet.

ENTSO-E AISBL. (2018). European Power System 2040, Completing the map, The Ten-Year Network Development Plan 2018 System Needs Analysis. Brüssel.

Erbe, C., & Farmer, D. M. (2000). Zones of impact around icebreakers affecting beluga whales in the Beaufort Sea. The Journal of the Acoustical Society of America, 108(3 Pt 1), 1332-1340.

Erbe, C. (2003). Assessment of Bioacoustic Impact of Ships on Humpback Whales in Glacier Bay, Alaska. https://www.nps.gov/glba/learn/nature/loader.cfm?csModule=security/getfile&PageID=846005

Erbe, C., MacGillivray, A., & Williams, R. (2012). Mapping cumulative noise from shipping to inform marine spatial planning. The Journal of the Acoustical Society of America, 132(5), EL423-EL428. https://doi.org/10.1121/1.4758779

Erbe, C., A.A. Marley, R.P.Schoeman, J.N. Smith, L.E. Trigg & C.B. Embling (2019). The Effects of Ship Noise on Marine Mammals – A Review. Frontiers in Marine science, doi:10.3389/fmars.2019.0060

Erbe C., M. Dähne, J. Gordon, H. Herata, D. S. Houser, S. Koschinski, R. Leaper, R. McCauley, B. Miller, M. Müller, A. Murray, J. N. Oswald, A. R. Scholik-Schlomer, M. Schuster, I. C. Van Opzeeland and V. M. Janik (2020). Managing the Effects of Noise From Ship Traffic, Seismic Surveying and Construction on Marine Mammals in Antarctica. Fronters in Marine Science

Eriksson N. & Rönnby, J., (2012): The ‚Ghost Ship‘. An Intact Fluyt from c. 1650 in the Middle oft he Baltic Sea. In: The International Journal of Nautical Archaeology 41.2, 350–361.

EuGH, Kommission./.Vereinigtes Königreich, C-6/04 (EuGH Oktober 20., 2005).

Evans, P. (2020) European Whales, Dolphins, and Porpoises: Marine Mammal Conservation in Practice, ASCOBANS. Academic Press, ISBN: 978-0-12-819053-1

Fabi G, Grati F, Puletti M & Scarcella G (2004) Effects on fish community induced by installation of two gas platforms in the Adriatic Sea. Marine Ecology Progress Series 273: 187−197.

Fauchald P (2010) Predator-prey reversal: a possible mechanism for ecosystem hysteresis in the North Sea. Ecology 91: 2191–2197.

Fennel W & Seifert T (2008) Oceanographic processes in the Baltic Sea. Die Küste 74: 77–91.

Finck P, Heinze S, Raths U, Riecken U & Ssymank A (2017) Rote Liste der gefährdeten Biotoptypen Deutschlands: dritte fortgeschriebene Fassung 2017. Naturschutz und Biologische Vielfalt 156.

Finneran, J. J. (2015). Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015. The Journal of the Acoustical Society of America, 138(3), 1702- 1726.

Firth, A., Mcaleese, L., Anderson R, R., Smith, R. & Woodcock, T., (2013): Fishing and the historic environment. (EH6204. Prepared for English Heritage). Wessex Archaeology, Salisbury.

Fließbach KL, Borkenhagen K, Guse N, Markones N, Schwemmer P & Garthe S (2019) A Ship Traffic Disturbance Vulnerability Index for Northwest European Seabirds as a Tool for Marine Spatial Planning. Frontiers in Marine Science 6: 192.

Fluit, C. C. J. M. and S. J. M. H. Hulscher, (2002): Morphological Response to a North Sea Bed Depression Induced by Gas Mining. Journal of Geophysical Research, 107, C3, 8-1 – 8-10.

Frankel, A. S., & Gabriele, C. M. (2017). Predicting the acoustic exposure of humpback whales from cruise and tour vessel noise in Glacier Bay, Alaska, under different management strategies. Endangered Species Research, 34, 397-415.

Frazão Santos, C. A. (2020). Integrating climate change in ocean planning. *Nat Sustain 3*, pp. 505-516. doi:https://doi.org/10.1038/s41893-020-0513-x

Freyhof J (2009) Rote Liste der im Süßwasser reproduzierenden Neunaugen und Fische (Cyclostomata & Pisces). In: Haupt H, Ludwig G, Gruttke H, Binot-Hafke M, Otto C & Pauly A (Red.) Rote Liste gefährdeter Tiere, Pflanzen und Pilze Deutschlands, Band 1: Wirbeltiere. Naturschutz und Biologische Vielfalt 70 (1): 291–316.

Fricke R, Rechlin O, Winkler H, Bast H-D & Hahlbeck E (1996) Rote Liste und Artenliste der Rundmäuler und Meeresfische des deutschen Meeres- und Küstenbereichs der Ostsee. *In*: Nordheim H von & Merck T (Hrsg.) Rote Listen und Artenlisten der Tiere und Pflanzen des deutschen Meeres- und Küstenbereichs der Ostsee. Landwirtschaftsverlag Münster, Schriftenreihe für Landschaftspflege und Naturschutz 48: 83–90.

Schriftenreihe für Landschaftspflege und Naturschutz 48: 83–90.

Frisk, G. V. (2012). Noiseonomics: the relationship between ambient noise levels in the sea and global economic trends. Scientific Reports, 2, 437. https://doi.org/10.1038/srep00437

Froese R & Pauly D (HRSG) (2000) FishBase 2000: concepts, design and data sources. ICLARM, Los Baños, Laguna, Philippines. 344 Seiten. www.fishbase.org, Zugriff am 14.03.2018.

Garrett, J. K., Blondel, P., Godley, B. J., Pikesley, S. K., Witt, M. J., & Johanning, L. (2016). Long-term underwater sound measurements in the shipping noise indicator bands 63Hz and 125Hz from the port of Falmouth Bay, UK. Marine Pollution Bulletin, 110(1), 438-448. https://doi.org/10.1016/j.marpolbul.2016.06.021

Gassmann, M., Wiggins, S. M., & Hildebrand, J. A. (2017). Deep-water measurements of container ship radiated noise signatures and directionality. The Journal of the Acoustical Society of America, 142(3), 1563. https://doi.org/10.1121/1.5001063

Gill A.B. & Bartlett M. (2010) Literature review on the potential effects of electromagnetic fields and subsea noise from marine renewable energy developments on Atlantic salmon, sea trout and European eel. Scottish Natural Heritage Commissioned Report No.401

Gilles A et al. (2006) MINOSplus – Zwischenbericht 2005, Teilprojekt 2, Seiten 30−45.

Gilles A, Viquerat S & Siebert U (2014a) Monitoring von marinen Säugetieren 2013 in der deutschen Nord- und Ostsee, itaw im Auftrag des Bundesamtes für Naturschutz.

Gilles, A, Dähne M, Ronnenberg K, Viquerat S, Adler S, Meyer-Klaeden O, Peschko V & Siebert U (2014b) Ergänzende Untersuchungen zum Effekt der Bau- und Betriebsphase im Offshore-Testfeld „alpha ventus“ auf marine Säugetiere. Schlussbericht zum Projekt Ökologische Begleitforschung am Offshore-Testfeldvorhaben alpha ventus zur Evaluierung des Standarduntersuchungskonzeptes des BSH StUKplus.

Gilles A, Viquerat S, Becker EA, Forney KA, Geelhoed SCV, Haelters J, Nabenielsen J, Scheidat M, Siebert U, Sveegaard S, van Beest FM, van Bemmelen R & Aarts G (2016) Seasonal habitat-based density models for a marine top predator, the harbor porpoise, in a dynamic environment. Ecosphere 7(6): e01367. 10.1002/ecs2.1367.

Glarou M., Zrust M. & Svendsen J.C. (2020) Using Artificial-Reef Knowledge to Enhance the Ecological Function of Offshore Wind Turbine Foundations: Implications for Fish Abundance and Diversity

Glockzin M & Zettler ML (2008) Spatial macrozoobenthic distribution patterns and responsible major environmental factors - a case study from the Pomeranian Bay (southern Baltic Sea), Journal of Sea Research 59 (3): 144−161.

Gogina M, Nygard H, Blomqvist M, Daunys D, Josefson AB, Kotta J, Maximov A, Warzocha J, Yermakov V, Gräwe U & Zettler ML (2016) The Baltic Sea scale inventory of benthic faunal communities. ICES Journal of Marine Science 73(4): 1196−1213.

Gollasch S (2003) Einschleppung exotischer Arten mit Schiffen. In: Lozan JL, Rachor E, Reise K, Sündermann J & von Westernhagen H (Hrsg.): Warnsignale aus Nordsee & Wattenmeer – Eine aktuelle Umweltbilanz. Wissenschaftliche Auswertungen, Hamburg 2003. 309-312.

Gomez. C. A, Lawson J.W., A.J Wright, A.D. Buren, D. Tollit, V. Lesage (2016). A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. Can. J. Zoology. Vol. 94: 801-819. https://doi.org/10.1139/cjz-2016-0098

Götz, T., Hastie, G., Hatch, L. T., Raustein, O., Southall, B. L., Tasker, M., . . . Fredheim, B. (2009). Overview of the impacts of anthropogenic underwater sound in the marine environment. In OSPAR Biodiversity Series (Vol. 441). https://www.ospar.org/documents?v=7147

Gosselck F & Georgi F (1984) Benthic recolonization of the Lübeck Bight (Western Baltic) in 1980/1981. Limnologica 15: 407−414.

Gosselck F, Doerschel F & Doerschel T (1987) Further developments of macrozoobenthos in Lübeck Bay, following recolonisation in 1980/81. Internationale Revue der gesamten Hydrobiologie 72: 631−638.

Gosselck F (1992) Zwischen Artenreichtum und Tod. Die Tiere des Meeresbodens der Lübecker Bucht als Maßstab ihrer Umwelt. Ber. Ver. Natur Heimat Kulturhist. Mus. Lübeck 23/24: 41−61.

Gosselck F, Arlt G, Bich A, Bönsch R, Kube J, Schroeren V & Voss J (1996) Rote Liste und Artenliste der benthischen wirbellosen Tiere des deutschen Meeres- und Küstenbereichs der Ostsee.In: Nordheim H von & Merck T (Hrsg) (1996): Rote Listen und Artenlisten der Tiere und Pflanzen des deutschen Meeres- und Küstenbereichs der Ostsee. – Schriftenreihe für Landschaftspflege und Naturschutz 48: 41−51.

Gosselck, F., Lange, D. und N. Michelchen, (1996): Auswirkungen auf das Ökosystem Ostsee durch den Abbau von Kies und Kiessanden vor der Küste Mecklenburg-Vorpommerns. Gutachten im Auftrag des Landesamtes für Umwelt und Natur M-V.

Hagmeier A (1925) Vorläufiger Bericht über die vorbereitenden Untersuchungen der Bodenfauna der Deutschen Bucht mit dem Petersen-Bodengreifer. – Berichte der Deutschen Wissenschaftlichen Kommission Meeresforschung, Band 1: 247−272.

Halliday, W. D., Insley, S. J., Hilliard, R. C., de Jong, T., & Pine, M. K. (2017). Potential impacts of shipping noise on marine mammals in the western Canadian Arctic. Marine Pollution Bulletin. https://doi.org/10.1016/j.marpolbul.2017.09.027.

Hammond PS, Berggren P, Benke H, Borchers DL, Collet A, Heide-Jorgensen MP, Heimlich-Boran, S, Hiby AR, Leopold MF & Oien N (2002) Abundance of harbour porpoise and other small cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology 39: 361−376.

Hammond PS & Macleod K (2006) Progress report on the SCANS-II project, Paper prepared for ASCOBANS Advisory Committee, Finland, April 2006.

Hammond PS, Lacey C, Gilles A, Viquerat S (2017) Estimates of cetacean abundance in European Atlantic Waters in summer 2016 from the SCANS-III aerial and shipboard surveys. https://synergy .st-andrews.ac.uk/scans3/files/2017/04/SACANS-III-design-based-estimates-2017-0428-final.pdf.

Hartz, S., Jöns, H., Lübke, H., Schmölcke, U., Von Carnap-Bornheim, C., Heinrich, D. Klooß, S., Lüth F., Wolters, S., (2014): Prehistoric settlements in the southwestern Baltic Sea area and development of the regional Stone Age economy. Bericht der Römisch-Germanischen Kommission 92, 77–210

Hatch, L., Clark, C., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., . . . Wiley, D. (2008). Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. Environ Manage, 42(5), 735-752. https://doi.org/10.1007/s00267-008-9169-4

Heessen HJL (2015) 56. Goatfishes (Mullidae). In: Heessen H, Daan N, Ellis JR (Hrsg.) Fish atlas of the Celtic Sea, North Sea, and Baltic Sea: based on international research-vessel surveys. Academic Publishers, Wageningen, Seite 344–348.

HELCOM (2009) Eutrophication in the Baltic Sea – An integrated thematic assessment of the effects of nutrient enrichment and eutrophication in the Baltic Sea region. Helsinki Commission. Balt. Sea Environ. Proc. No.115B.

HELCOM (2013a) Red List of Baltic Sea underwater biotopes, habitats and biotope complexes. Baltic Sea Environment Proceedings No. 138.

HELCOM (2013b) HELCOM Red List of Baltic Sea species in danger of becoming extinct. Baltic Sea Environment Proceedings No. 140.

HELCOM (2013c) Red List Species, Species information Sheet Mammals – Harbour Porpoise, IUCN, 2016-2. Phocoena phocoena (Baltic Sea Population).

HELCOM/VASAB. (2016). Guideline for the implementation of ecosystem-based approach in Maritime Spatial Planning (MSP) in the Baltic Sea area.

HELCOM (2018a): HELCOM Thematic assessment of biodiversity 2011-2016. Available at: http://www.helcom.fi/baltic-seatrends/holistic-assessments/state-of-the-baltic-sea-2018/reports-and-materials/

HELCOM (2018b): HELCOM Thematic assessment of biodiversity 2011-2016. Baltic Sea Environment Proceedings No. 158." Available at: http://www.helcom.fi/baltic-sea-trends/holistic-assessments/state-of-the-balticsea- 2018/reports-and-materials/

Hermann C. & Krause J.C. (2000) Ökologische Auswirkungen der marinen Sand- und Kiesgewinnung. In: H. von Nordheim und D. Boedeker. Umweltvorsorge bei der marinen Sand- und Kiesgewinnung. BLANO-Workshop 1998. BfN-Skripten 23. Bundesamt für Naturschutz (Hrsg.). Bonn Bad Godesberg, 2000. 20−33.

Hermannsen, L., Beedholm, K., Tougaard, J., & Madsen, P. T. (2014). High frequency components of ship noise in shallow water with a discussion of implications for harbor porpoises (Phocoena phocoena). The Journal of the Acoustical Society of America, 136(4), 1640-1653.

Hermannsen, L., Mikkelsen, L., Tougaard, J., Beedholm, K., Johnson, M. Madsen, P.T. (2019) Recreational vessels without Automatic Identification System (AIS) dominate anthropogenic noise contributions to a shallow water soundscape. Sci. Rep. 9:15477 https://doi.org/10.1038/s41598-019-51222-9

Hiddink JG, Jennings S, Kaiser MJ, Queirós AM, Duplisea DE & Piet GJ (2006) Cumulative impacts of sea-bed trawl disturbance on benthic biomass, production, and species richness in different habitats. Canadian Journal of Fisheries and Aquatic Sciences 63(4), 721−736.

HIDDINK, JG, JENNINGS, S, SCIBERRAS, M, et al. (2019) Assessing bottom trawling impacts based on the longevity of benthic invertebrates. *J Appl Ecol*. 2019; 56: 1075– 1084. https://doi.org/10.1111/1365-2664.13278

Hirth, L., & Müller, S. (2016). System-friendly wind power – How ad-vanced wind turbine design can increase the economic value of electricity generated through wind power. *Energy Economics 56*.

Hislop J, Bergstad OA, Jakobsen T, Sparholt H, Blasdale T, Wright P, Kloppmann MHF, Hillgruber N & Heessen H (2015) 32. Cod fishes (Gadidae). In: Heessen H, Daan N, Ellis JR (Hrsg.) Fish atlas of the Celtic Sea, North Sea, and Baltic Sea: based on international research-vessel surveys. Academic Publishers, Wageningen, S 186–194.

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), Bundesamt für Seeschifffahrt und Hydrographie.

Höft, D., Richter, P., Valerius, J., Schwarzer, K. Meier, F., Thiesen, M., Mulckau, A., in prep.: Map of boulder distribution in the German EEZ, Bundesamt für Seeschifffahrt und Hydrographie.

Hollowed AB, Barange M, Beamish RJ, Brander K, Cochrane K, Drinkwater K, Foreman MGG, Hare JA, Holt J, Ito S, Kim S, KIng JR, Loeng H, Mackenzie BR, Muetre FJ, Okey TA, Peck MA, Radchenko VI, Rice JC, Schirippa MJ, Yatsu A & Yamanaka Y (2013) Projected impacts of climate change on marine fish and fisheries. ICES Journal of Marine Science 70:1023–1037.

Houde ED (1987) Fish early life dynamics and recruitment variability. American Fisheries Society Symposium 2: 17–29.

Houde ED (2008) Emerging from Hjort's Shadow. Journal of Northwest Atlantic Fishery Science 41: 53–70.

Huber, F., Knepel, G., (2015): Wrackplünderer in der Nordsee. Schutz für archäologische Fundstücke unter Wasser. In: Sporttaucher 6, 18.

Huber, F., Witt, J. M., (2018): Das Seegefecht bei Helgoland. Schiffswracks in Gefahr. In: Leinen Los 1-2, 48–50.

Hubold, G., Klepper, R. (2013) Die Bedeutung von Fischerei und Aquakultur für die globale Ernährungssicherheit. Thünen Working Paper 3. Thünen-Institut für Marktanalyse. 105 pp.

Hüppop, O., Michalik, B., Bach, L., Hill, R., Pelletier, S. K. (2018): Migrating birds and bats – barriers and collisions. In Perrow MR (ed.): Wildlife and Wind Farms, Conflicts and Solutions. Vol. 3 Offshore: Potential Effects. Pelagic Publishing, Exeter, UK: in press.

Hyder, K., Weltersbach, M. S., Armstrong, M., Ferter, K., Townhill, B., Ahvonen, A., ... & Borch, T. (2018) Recreational sea fishing in Europe in a global context—Participation rates, fishing effort, expenditure, and implications for monitoring and assessment. *Fish and Fisheries*, *19*(2), 225-243.

Hygum, B., 1993: Miljoparvirkninger ved ral og sandsugning. Et litteraturstudie om de biologiske effekter ved rastofindvining i havet. (Environmental effects of gravel and sand suction. A literature study on the biological effects of raw material extraction in marine environments.)

DMU-Report no. 81 (The Danish Environmental Investigation Agency and the Danish National Forest and Nature Agency).

IBL Umweltplanung GmbH (2016b) Cluster „Nördlich Helgoland“, Jahresbericht 2015. Ergebnisse der ökologischen Untersuchungen. Unveröffentlichtes Gutachten im Auftrag der E.on Climate & Renewable GmbH, RWE International SE und WindMW GmbH, 30.06.2016. 847 Seiten.

ICES, Internationaler Rat für Meeresforschung (1992) Effects of Extraction of Marine Sediments on Fisheries. ICES Cooperative Reserach Report No. 182, Kopenhagen.

ICES, Internationaler Rat für Meeresforschung WGEXT (1998) Cooperative Research Report, Final Draft, April 24, 1998.

ICES, (2001) Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES Cooperative Research Report, No. 247, 80 S.

ICES (2016) Effects of extraction of marine sediments on the marine environment 2005-2011.

ICES, Internationaler Rat für Meeresforschung (2019) Fisheries overview – Baltic Sea Ecoregion. 29 Seiten ICES, Internationaler Rat für Meeresforschung (2020) Working Group on Recreational Fisheries Surveys (WGRFS). ICES Scientific Reports. 2:102. 57 pp. http://doi.org/10.17895/ices.pub.7563

ICES, Internationaler Rat für Meeresforschung (2019) Baltic Sea Ecoregion – Fisheries overview. 29 Seiten, DOI: https://doi.org/10.17895/ices.advice.5566

ICES, Internationaler Rat für Meeresforschung 2020: EU request an emergency measures to prevent bycatch of common dolphin (Delphin-us delphis) and Baltic Proper harbour porpoise (Phocoena phocoena) in the Nor-theast Atlantic. In Report of the ICES Advisory Committee, 2020. ICES Advice 2020

Ickerodt, U., (2014): Was ist ein Denkmal wert? Was ist der Denkmalwert? Archäologische Denkmalpflege zwischen Öffentlichkeit, denkmalrechtlichen Anforderungen und wissenschaftlichem Selbstanspruch. Österreichische Zeitschrift für Kunst und Denkmalpflege 68, Heft 3/ 4, 294–309.

IfAÖ Institut für Angewandte Ökosystemforschung GmbH (2005b) BENTHOS – Bestandsaufnahme und Monitoring benthischer Lebensgemeinschaften des Sublitorals vor der Außenküste Mecklenburg-Vorpommerns – Teilvorhaben „Monitoring Makrozoobenthos“, Bericht für das Jahr 2004. Unveröffentlichtes Gutachten des Instituts für Angewandte Ökologie im Auftrag des LUNG M-V, 192 S. (zitiert in SORDYL et al., 2010).

IFAÖ, (2009): Wirkungen durch erhöhte Trübungen, Resuspension und Sedimentation bei submarinen Baggerungen, Pflug-Trenchen sowie Verklappungen. Literaturstudie. Anhang 8 der Umweltverträglichkeitsstudie zur Nord Stream Pipeline.

IfAÖ Institut für Angewandte Ökosystemforschung GmbH (2015) Spezielle biotopschutzrechtliche Prüfung (BRP) für das 1. und 2. Untersuchungsjahr der Basisaufnahme zum Bau und Betrieb des Offshore-Windparks „Windanker“. Unveröffentlichtes Gutachten im Auftrag von Iberdrola Renovables Deutschland GmbH. Stand 27.11.2015. 15 Seiten.

IfAÖ Institut für Angewandte Ökosystemforschung GmbH (2015a) Fachgutachten „Benthos“ für das Offshore-Windparkprojekt „EnBW Baltic 2“. Baubegleitendes Monitoring. Betrachtungszeitraum: Herbst 2014.

IfAÖ (2019) FFH-Verträglichkeitsuntersuchung (FFH-VU) zur Entnahme von Kies und Sand aus dem Feld „OAM III“, Antragsfläche 2019-2023. Unveröfftl. Gutachten im Auftrag der OAM-DEME Mineralien GmbH, Großhansdorf, 22.02.2019.

IPCC, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2001) Third Assessment Report. Climate Change 2001.

IPCC, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2007) Fourth Assessment Report. Climate Change 2007.

IPCC. (2019). Summary for Policymakers. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Retrieved from https://www.ipcc.ch/srocc/download-report

ISO 17208-1:2016. Underwater acoustics — Quantities and procedures for description and measurement of underwater sound from ships — Part 1: Requirements for precision measurements in deep water used for comparison purposes

ISO 17208-2:2019. Underwater acoustics — Quantities and procedures for description and measurement of underwater sound from ships — Part 2: Determination of source levels from deep water measurements

IUCN, International Union for the Conservation of Nature (2014) IUCN Red List of Threatened Species. Version 2014.1. (www.iucnredlist.org).

Janssen F., Schrumm, C. and J. O. Backhaus, 1999: A Climatological Data Set of Temperature and Salinity for the Baltic Sea and the North Sea, German Journal of Hydrographic, Supplement 9, 245pp

Jensen, J. & SH. Müller-Navarra, (2008): Storm surges on the German Coast. Die Küste 74: 92–124.

Karez, R. und D. Schories, (2005): Die Steinfischerei und ihre Bedeutung für die Wiederansiedlung von Fucus vesiculosus in der Tiefe. Rostocker Meeresbiologische Mitteilungen, 14, 95-107.

Karlson AML, Almqvist G, Skora KE & Appelberg M (2007) Indications of competition between non-indigenous round goby and native flounder in the Baltic Sea. ICES Journal of Marine Science 64: 479–486.

Katzung, G., (2004): Geologie von Mecklenburg-Vorpommern. E. Schweitzerbart’sche Verlagsbuchhandlung, 580 S.

Kenny, A. J. and H. L. Rees, (1996): The Effects of Marine Gravel Extraction on the Macrobenthos: Results 2 Years Post-Dredging, Mar. Pollut. Bull. 32, 615-622.

Ketten DR (2004) Marine mammal auditory systems: a summary of audiometric and anatomical data and implications for underwater acoustic impacts. Polarforschung 72: S. 79−92.

Kinda, G. B., Le Courtois, F., & Stephan, Y. (2017). Ambient noise dynamics in a heavy shipping area. Marine Pollution Bulletin, 124(1), 535-546.

Kloppmann MHF, Böttcher, U, Damm U, Ehrich S, Mieske B, Schultz N & Zumholz K (2003) Erfassung von FFH-Anhang-II-Fischarten in der deutschen AWZ der Nord- und Ostsee. Studie im Auftrag des BfN, Bundes-forschungsanstalt für Fischerei. Endbericht, Hamburg, 82 Seiten.

Knorr, K., Horst, D., Bofinger, S., & Hochloff, P. (2017). Energiewirtschaftliche Bedeutung der Offshore-Windenergie für die Energiewende. Varel: Fraunhofer-Institut für Windenergie und Energiesystemtechnik

Knust R., Dalhoff P., Gabriel J., Heuers J., Hüppop O. & Wendeln H. (2003) Untersuchungen zur Vermeidung und Verminderung von Belastungen der Meeresumwelt durch Offshore-Windenergieanlagen im küstenfernen Bereich der Nord- und Ostsee („offshore WEA“). Abschlussbericht des Forschungs- und Entwicklungsvorhabens Nr. 200 97 106 des Umweltbundesamts, 454 Seiten mit Anhängen.

Kock M (2001) Untersuchungen des Makrozoobenthos im Fehmarnbelt, einem hydrographisch besonders instabilen Übergangsbereich zwischen zentraler und westlicher Ostsee. Dissertation zur Erlangung des Doktorgrades der Mathematisch-Naturwissenschaftlichen Fakultät der Christian-Albrechts-Universität zu Kiel. 103 S. und Anhang.

Kölmel R (1979) The annual cycle of macrozoobenthos: its community structures under the influence of oxygen deficiency in the Western Baltic. In Cyclic phenomena in marine plants and animals, Seite 19–28. Pergamon.

Kolp, O., (1965): Paläogeographische Ergebnisse der Kartierung des Meeresgrundes der westlichen Ostsee zwischen Fehmarn und Arkona. Beiträge zur Meereskunde, 12-14, 19-65.

Kolp, O., (1966): Die Sedimente der westlichen und südlichen Ostsee und ihre Darstellung. Beiträge zur Meereskunde, 17/18, 9-60.

Kolp, O., (1976): Die submarinen Uferterrassen der südlichen Ostsee und Nordsee und ihre Beziehung zum eustatischen Meeresspiegelanstieg. Beiträge zur Meereskunde, 35, 6-47.

Koop, B. (2004): Vogelzug über Schleswig-Holstein. Der Fehmarn-Belt – Ein „bottle neck“ im europäischen Vogelzugsystem. Ornithologische Arbeitsgemeinschaft für Schleswig-Holstein und Hamburg e.V.: 7.

Krägefsky S. (2014) Effects of the alpha ventus offshore test site on pelagic fish. In: Beiersdorf A, Radecke A (Hrsg) Ecological research at the offshore windfarm alpha ventus − challenges, results and perspectives. Bundesamt für Seeschifffahrt und Hydrographie (BSH), Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (BMU). Springer Spektrum, 201 Seiten.

Kramarska, R., (1998): Origin and Development of the Odra Bank in the Light of the Geologic Structure and Radiocarbon Dating. Geological Quarterly, 42, 277-288.

Kratzer I.M.F., I. Schäfer, A.Stoltenberg, J. C. Chladek, L. Kindt-Larsen, F. Larsen and D. Stepputtis (2020).Determination of Optimal Acoustic Passive Reflectors to Reduce Bycatch of Odontocetes in Gillnets. Front. Mar. Sci., 03 July 2020https://doi.org/10.3389/fmars.2020.00539

Kraus S., M. W. Brown, H. Caswell, C. W.Clark, M. Fujiwara, P. K. Hamilton, R. D.Kenney, A. R.Knowlton, S. Landry, C. A.Mayo, W. A. McLellan, M. J.Moore, D. P.Nowacek, D.A. Pabst, A. J. Read, R. M. Rolland (2005). North Atlantic Right Whales in Crisis. SCIENCE, VOL 309

Kröncke I (1995) Long-term changes in North Sea benthos. Senckenbergiana maritima 26 (1/2): 73−80.

Krost, P., Bernhard, M., Werner, W. and W. Hukriede, (1990): Otter Trawl Tracks in Kiel Bay (Western Baltic) Mapped by Side-Scan Sonar. Meeresforschung, 32, 344-353.

Kühlmorgen-Hille G (1963) Quantitative Untersuchungen der Bodenfauna in der Kieler Bucht und ihrer jahreszeitlichen Veränderungen. Kieler Meeresforschung 19: 42−103.

Kühlmorgen-Hille G (1965) Qualitative und quantitative Veränderungen der Bodenfauna der Kieler Bucht in den Jahren 1953-1965. Kieler Meeresforschung 21: 167−191.

Kunc H, McLaughlin K, & Schmidt R. (2016) Aquatic noise pollution: implications for individuals, populations, and ecosystems. Proc. Royal Soc. B: Biological Sciences 283:20160839. DOI: 10.1098/rspb.2016.0839.

Lacoste, E., McKindsey, C. W., Archambault, P. (2020) Biodiversity–Ecosystem Functioning (BEF) ap-proach to further understanding aquaculture–environment interactions with application to bivalve culture and benthic ecosystems. Reviews in Aquaculture 12, Issue 4, 2027-2041

Ladich F. (2013) Effects of noise on sound detection and acoustic communication in fishes. In Animal communication and noise (pp. 65-90). Springer, Berlin, Heidelberg.

Landmann/Rohmer. (2018). Umweltrecht Band I - Kommentar zum UVPG. München: C.H. Beck.

Landmann/Rohmer Umweltrecht Band I - Kommentar zum BNatSchG, §. 4. (2018). München: C.H. Beck

Lang T., Kotwicki L., Czub M., Grzelak K., Weirup L. & Straumer K. (2017) The health status of fish and Benthos communities in chemical munitions dumpsites in the Baltic Sea. In: Beldowski J, Been R, Turmus EK (eds) Towards the monitoring of dumped munitions threat (MODUM). Dordrecht: Springer Netherlands, pp 129-152.

Lange, W., Mittelstaedt, E. und H. Klein, (1991): Strömungsdaten aus der westlichen Ostsee.Deutsche Hydrographische Zeitschrift, Reihe B, Nr. 24, 129pp.

Lass, H. U.: (2003): Über mögliche Auswirkungen von Windparks auf den Wasseraustausch zwischen Nord- und Ostsee. In: Meeresumwelt-Symposium 2002. Hrsg.: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit und Bundesamt für Seeschifffahrt und Hydrographie. S. 121-130.

LBEG (2019) Erlaubnis- und Bewilligungsfelder in der dt. AWZ der Ostsee (Stand September 2019)

Leaper, R. C., & Renilson, M. R. (2012). A review of practical methods for reducing underwater noise pollution from large commercial vessels. International Journal of Maritime Engineering, 154, A79-A88.

Leaper, R. C., Renilson, M. R., & Ryan, C. (2014). Reducing underwater noise from large commercial ships: current status and future directions. The Journal of Ocean Technology, 9(1), 50-69.

Leaper R. (2020). The Role of Slower Vessel Speeds in Reducing Greenhouse Gas Emissions, Underwater Noise and Collision Risk to Whales. Fronters in Marine Science.

Lemke, W., Kuijpers, A., Hoffmann, G., Milkert, D. and R. Atzler, (1994): The Darss Sill, Hydrographic Threshold in the Southwestern Baltic: Late Quarternary Geology and Recent Sediment Dynamics. Continental Shelf Research, 14, 847-870.

Lemke, W. und F. Tauber, (1997): Bericht zur Auswertung von Sidescan-Sonar.Aufzeichnungen von bathymetrischen Daten von Munitionsverdachtsflächen in der Pommerschen Bucht. Interner Bericht, Institut für Ostseeforschung Warnemünde, 19 S.

Lemke, W., (1998): Sedimentation und paläogeographische Entwicklung im westlichen Ostseeraum (Mecklenburger Bucht bis Arkona-Becken) vom Ende der Weichselvereisung bis zur Litorinatransgression. Meereswissenschaftliche Berichte, Warnemünde, 31, 156 S. mit Anhang.

Leonhard SB, Stenberg C & Støttrup J (2011) Effect of the Horns Rev 1 Offshore Wind Farm on Fish Communities Follow-up Seven Years after Construction DTU Aqua Report No 246-2011 ISBN 978-87-7481-142-8 ISSN 1395−8216.

Lester S.E. & Halpern B.S. (2008) Biological responses in marine no-take reserves versus partially protected areas.In Mar Ecol Prog Ser Vol. 367: 49 – 56.

Lippert, H., Weigelt, R., Bastrop, R., Bugenhagen, M., Karsten, U., (2013): Schiffsbohrmuscheln auf dem Vormarsch? In: Biologie in unserer Zeit 43.1, 46–53.

LLUR Landesamt für Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein (2014). Neobiota in deutschen Küstengewässern. Eingeschleppte und kryptogene Tier- und Pflanzenarten an der deutschen Nord- und Ostseeküste. 216 Seiten.

Løkkeborg S, Humborstad OB, Jørgensen T & Soldal AV (2002) Spatio-temporal variations in gillnet catch rates in the vicinity of North Sea oil platforms. ICES Journal of Marine Science 59 (Suppl): 294−S299.

Lucke K, Sundermeyer J & Siebert U (2006) MINOSplus Status Seminar, Stralsund, Sept. 2006, Präsentation.

Lucke K, Lepper P, Hoeve B, Everaarts E, Elk N & Siebert U (2007) Perception of low-frequency acoustic signals by harbour porpoise *Phocoena phocoena* in the presence of simulated wind turbine noise. Aquatic mammals 33:55−68.

Lucke K, Lepper PA, Blanchet M-A & Siebert U (2009) Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. Journal of the Acoustical Society of America 125(6): 4060−4070.

MacDonald A., Heath M.R., Greenstreet S.P.R. & Speirs D.C. (2019) Timing of Sandeel Spawning and Hatching Off the East Coast of Scotland. In Front. Mar. Sc. https://doi.org/10.3389/fmars.2019.00070.

McKenna, M. F., Ross, D., Wiggins, S. M., & Hildebrand, J. A. (2012). Underwater radiated noise from modern commercial ships. The Journal of the Acoustical Society of America, 131(1), 92-103.

McKenna, M. F., Wiggins, S. M., & Hildebrand, J. A. (2013). Relationship between container ship underwater noise levels and ship design, operational and oceanographic conditions. Scientific Reports, 3, https://doi.org/10.1038/srep01760

Madsen PT, Wahlberg M, Tougaard J, Lucke K & Tyack P (2006) Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs, Marine Ecology Progress Series 309: 279−295.

Margetts, A.R. & Bridger, C.M. (1971) The effect of a beam trawl on the sea bed. ICES CM, 1971.

MARILIM (2016) Umweltmonitoring im Cluster „Westlich Adlergrund“. Fachgutachten Benthos, 1. Untersuchungsjahr März 2014 bis Februar 2015, 147 Seiten.

Matuschek R, Gündert S, Bellmann MA (2018) Messung des beim Betrieb der Windparks Meerwind Süd/Ost, Nordsee Ost und Amrumbank West entstehenden Unterwasserschalls. Im Auftrag der IBL Umweltplanung GmbH. Version 5. P. 55. itap – Institut für technische und angewandte Physik GmbH.

Meinig, H.; Boye, P.; Dähne, M.; Hutterer, R. & Lang, J. (2020): Rote Liste und Gesamtartenliste der Säugetiere (Mammalia) Deutschlands. – Naturschutz und Biologische Vielfalt 170 (2): 73 S.

Mendel B, Schwemmer P, Peschko V, Müller S, Schwemmer H, Mercker M & Garthe S (2019) Operational offshore wind farms and associated ship traffic cause profound changes in distribution patterns of Loons (Gavia spp.). Journal of environmental management 231: 429-438.

Merchant, N. D., Pirotta, E., Barton, T. R., & Thompson, P. M. (2014). Monitoring ship noise to assess the impact of coastal developments on marine mammals. Marine Pollution Bulletin, 78(1-2), 85- 95

Mes, M. J., (1990): Ekofisk Reservoir Voidage and Seabed Subsidence. Journal of Petroleum Technology, 42, 1434-1439.

Methratta ET & Dardick WR (2019) Meta-Analysis of Finfish Abundance at Offshore Wind Farms. Reviews in Fisheries Science & Aquaculture 27(2): 242-260.

Meyerle, R. & C. Winter, (2002): Hydrografische Untersuchungen zum Offshore-Windpark SKY 2000. Im Auftrag der 1. SHOW VG.

Mikhalevsky, P. N., Sagen, H., Worcester, P. F., Baggeroer, A. B., Orcutt, J., Moore, S. E., . . . Yuen, M. Y. (2015). Multipurpose Acoustic Networks in the Integrated Arctic Ocean Observing System. Arctic, 68(5).

Mikkelsen et al. 2019: Long-term sound and movement recording tags to study natural behavior and reaction to ship noise of seals. https://doi.org/10.1002/ece3.4923

Möbius K (1873) Die wirbellosen Tiere der Ostsee. Jahresbericht der Commission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel für das Jahr 1871, 1: 97–144.

Möllmann C, Diekmann R, Müller-Karulis B, Kornilovs G, Plikshs M & Axe P (2009) Reorganization of a large marine ecosystem due to atmospheric and anthropogenic pressure: a discontinuous regime shift in the central Baltic Sea. Global Change Biology 15: 1377–1393.

Munk P, Fox CJ, Bolle LJ, van Damme CJ, Fossum P & Kraus G (2009) Spawning of North Sea fishes linked to hydrographic features. Fisheries Oceanography 18(6): 458–469.

Nachtsheim, D. A., S. Viquerat, N. C. Ramírez-Martínez, B. Unger, U. Siebert1 and A. Gilles (2021). Small Cetacean in a Human High-Use Area: Trends in Harbor Porpoise Abundance in the

North Sea Over Two Decades. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2020.606609

Neo YY., Hubert J, Bolle L, Winter HV, Ten Cate C & Slabbekoorn, H (2016) Sound exposure changes European seabass behaviour in a large outdoor floating pen: effects of temporal structure and a ramp-up procedure. Environ. Poll. 214: 26-34.

Nissling A, Kryvi H, & Vallin L (1994) Variation in egg buoyancy of Baltic cod *Gadus morhua* and its impli-cations for egg survival in prevailing conditions in the Baltic Sea. Marine Ecology Progress Series 110: 67–74.

Nord Stream (2014) Results of Environmental and Socio-economic Monitoring 2013, Document-No. GPE-PER-MON-100-080400EN.

Norden Andersen, O. G. Nielsen, P. E. and J. Leth, (1992): Effects on sea bed, benthic fauna and hydrography of sand dredging in Koge Bay, Denmark. Proceedings of the 12th Baltic Marine Biologists Symposium, Fredensborg 1992.

Ogawa S, Takeuchi R. & Hattori H. (1977) An estimate for the optimum size of artificial reefs. Bulletin of the Japanese. Society of Fisheries and Oceanography, 30: 39–45.

Ojaveer H (2006) The round goby *Neogobius melanostomus* is colonizing the NE Baltic Sea. Aquatic Inva-sions 1: 44–45. OSPAR commission (2010) Assessment of the environmental impacts of cables.

Omeyer, L.C.M., P. D. Doherty, S. Dolman, R. Enever, A. Reese, N. Tregenza, R. Williams and B. J. Godley (2020). Assessing the Effects of Banana Pingers as a Bycatch Mitigation Device for Harbour Porpoises (Phocoena phocoena). Front. Mar. Sci., 13 May 2020 | https://doi.org/10.3389/fmars.2020.00285

Oppelt I., (2019): Wracktauchen – Die schönsten Tauchplätze der Ostsee. Wetnotes.

Ossowski, W., (2008): The General Carleton Shipwreck, 1785. Gdańsk, Polish Maritime Museum.

Österblom H, Hansson S, Larsson U, Hjerne O, Wulff F, Elmgren R & Folke C (2007) Human-induced trophic cascades and ecological regime shifts in the Baltic Sea. Ecosystems 10 (6): 877–889.

Papenmeier, S., Valerius, J., Thiesen, M., Mulckau, A., in prep.: Map of sediment distribution in the German EEZ (1:10.000). Bundesamt für Seeschifffahrt und Hydrographie.

Paschen, M., Richter, U. and W. Köpnick, (2000): TRAPESE – Trawl Penetration in the Seabed. Abschlussbericht, Universität Rostock, Fachbereich Maschinenbau und Schiffstechnik, Institut für Maritime Systeme und Strömungstechnik, 150 S. mit Anhang.

Perry AL, Low PJ, Ellis JR & Reynolds JD (2005) Climate change and distribution shifts in marine fishes. Science 308: 1912–1915.

Petersen CGJ (1918) The sea bottom and its production of fish-food. A survey of work done in connection with the valuation of the Danish waters from 1883-1917. Reports of the Danish Biological Station 25.

PGU, Planungsgemeinschaft Umweltplanung Offshore Windpark (2012a) Konverterstation und Netzanbindungen im Cluster DolWin. Projekt DolWin1. Genehmigungsantrag. Gefährdung der Meeresumwelt / Natura2000-Gebietsschutz / Artenschutz / Biotopschutz/ Landschaftspflegerischer Begleitplan (Eingriffsregelung) / Untersuchungen.

PGU, Planungsgemeinschaft Umweltplanung Offshore Windpark (2012b) Konverterstationen und Netzanbindungen im Cluster DolWin. Projekt DolWin 2. Planfeststellungsantrag. Gefährdung der Meeresumwelt / Natura2000-Gebietsschutz / Artenschutz / Biotopschutz/ Landschaftspflegerischer Begleitplan (Eingriffsregelung) / Untersuchungen. Umweltfachliche Stellungnahme, August 2012.

Pine, M. K., Jeffs, A. G., Wang, D., & Radford, C. A. (2016). The potential for vessel noise to mask biologically important sounds within ecologically significant embayments. Ocean & Coastal Management, 127, 63-73.

Pine M.K., K. Nicolich, B. Martin, C. Morris, F. Suaves (2020). Assessing auditory masking for management of underwater anthropogenic noise. The Journal of the Acoustical Society of America 147, 3408 (2020)

Platis, A., Siedersleben, S. K., Bange, J., Lampert, A., Bärfuss, K., Hankers, R., Emeis, S. (2018, Februar 01). First in situ evidence of wakes in the far field behind offshore wind farms. Nature Scientific Reports.

Popper A.N. & Hastings M.C. (2009) The effects of anthropogenic sources of sound on fishes. Journal of Fish Biology, 75, 455–489.

Popper A.N. & Hawkins A.D. (2019) An overview of fish bioacoustics and the impacts of anthropogenic sounds on fishes. Journal of Fishbiology. 22 Seiten. DOI: 10.1111/jfb.13948.

Prena J, Gosselck F, Schroeren V & Voss J (1997) Periodic and episodic benthos recruitment in southwest Mecklenburg Bay (western Baltic Sea). Helgoländer Meeresuntersuchungen 51: 1–21.

Rachor E (1990) Veränderungen der Bodenfauna. In: Lozan JL, Lenz W, Rachor E, Watermann B & von Westernhagen H (Hrsg): Warnsignale aus der Nordsee. Paul Parey 432 Seiten.

Rachor E, Arlt G, Bick A, Bönsch R, Gosselck F, Harms J, Heiber W, Kröncke I, Kube J, Michaelis H, Reise K, Schroeren V, van Bernem K-H & Voss J (1998) Rote Liste der bodenlebenden wirbellosen Meerestiere. – In: Binot M, Bless R, Boye P, Gruttke H & Pretscher P (Bearb.), 1998: Rote Liste gefährdeter Tiere Deutschlands. - Schr.-R. Landschaftspfl. Natursch. 55: 290–300.

Rachor E, Bönsch R, Boos K, Gosselck F, Grotjahn M, Günther C-P, Gusky M, Gutow L, Heiber W, Jantschik P, Krieg H-J, Krone R, Nehmer P, Reichert K, Reiss H, Schröder A, Witt J & Zettler ML (2013) Rote Liste und Artenlisten der bodenlebenden wirbellosen Meerestiere. In: BfN (Hrsg.) (2013) Rote Liste gefährdeter Tiere, Pflanzen und Pilze Deutschlands. Band 2: Meeresorganismen, Bonn

Read AJ (1999) Handbook of marine mammals. Academic Press.

Read AJ & Westgate AJ (1997) Monitoring the movements of harbour porpoise with satellite telemetry. Marine Biology 130: 315−322.

Remane A (1934) Die Brackwasserfauna. Zoolischer Anzeiger (Suppl) 7: 34–74.

Reubens JT, Degraer S, & Vincx M (2014) The ecology of benthopelagic fishes at offshore wind farms: a synthesis of 4 years research. Hydrobiologia 727: 121-136.

Richardson JW (2004) Marine mammals versus seismic and other acoustic surveys: Introduction to the noise issue. Polarforschung 72 (2/3), S. 63−67.

Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., . . . Kraus, S. D. (2012). Evidence that ship noise increases stress in right whales. Proceedings of the Royal Society B: Biological *Sciences, 279*(1737), 2363-2368

Rose A, Diederichs A, Nehls G, Brandt MJ, Witte S, Höschle C, Dorsch M, Liesenjohann T, Schubert A, Kosarev V, Laczny M, Hill A & Piper W (2014) OffshoreTest Site Alpha Ventus; Expert Report: Marine Mammals. Final Report: From baseline to wind farm operation. Im Auftrag des Bundesamts für Seeschifffahrt und Hydrographie.

Ruck, K.-W., (1969): Voruntersuchungen und Baugrundverhältnisse für eine Brücke über den Fehmarn-Belt. Der Bauingenieur, 44, 175-180.

Rudkowski, S., (1979): The Quaternary History of Baltic Poland. In: Gudelis, V. and L.-K. Königsson, Hrsg.: The Quaternary History of the Baltic. Acta Universitatis Upsaliensis. Symposia Universitatis Upsaliensis Annum Quingentesimum Celebrantis, 1, 175-183.

Rumohr H (1995) 6.3.2 Zoobenthos. In: Rheinheimer G (Hrsg.): Meereskunde der Ostsee. 2. Auflage. –Berlin; Heidelberg; Mailand; Paris; Tokyo: Springer Verlag, 1995. 173–181.

Rumohr H (1996) Veränderungen des Lebens am Meeresboden. In: Lozan JL, Lampe R, Matthäus W, Rachor E, Rumohr H & von Westernhagen H (Hrsg) Warnsignale aus der Ostsee. Paul Parey, 385 Seiten.

Rumohr, H., (2003): Am Boden zerstört... Auswirkungen der Fischerei auf Lebewesen am Meeresboden des Nordost-Atlantiks. WWF Deutschland, 26 S.

Ruth, J., ,D. Tollit, J. Wood, A. MacGillivray, Z. Li, K. Trounce and O. Robinson, 2019. Potential Benefits of Vessel Slowdowns on Endangered Southern Resident Killer Whales. Front. Mar. Sci., 26 June 2019 | https://doi.org/10.3389/fmars.2019.00344

Sapota, M.R. (2004): The round goby (*Neogobius melanostomus*) in the Gulf of Gdansk – a species introduction into the Baltic Sea. Hydrobiologia 514: 219-224.

Sapota MR & Skora KE (2005) Spread of alien (non-indigenous) fish species *Neogobius melanostomus* in the Gulf of Gdánsk (south Baltic). Biological Invasions 7: 157–164.

Schade N, H.-K. S.-D. (2020). Klimaänderungen und Klimafolgenbetrachtung für das Bundesverkehrssystem im Küstenbereich - Schlussbericht des Schwerpunktthemas Fokusgebiete Küsten (SP-108) im Themenfeld 1 des BMVI-Expertennetzwerks. doi:10.5675/ExpNSN2020.2020.09

Scheidat M, Gilles A & Siebert U (2004) Erfassung der Dichte und Verteilungsmuster von Schweinswalen (*Phocoena phocoena*) in der deutschen Nord- und Ostsee. MINOS - Teilprojekt 2, Abschlussbericht, S. 77−114.

Scheidat M,Tougaard J,Brasseur S, Carstensen J,van Polanen-Petel T,Teilmann J & Reijnders P (2011) Harbour porpoises (*Phocoena phocoena*) and windfarms: a case study in the Dutch North Sea. Environmental Research Letters 6 (2): 025102.

Schiele KS, Darr A, Zettler ML, Friedland R, Tauber F, von Weber M & Voss J (2015) Biotope map of the German Baltic Sea. Marine Pollution Bulletin 96(1–2): 127–135.

Schmälter, A. (2017). Kommentar zur Seeanlagenverordnung. In Danner/Theobald, Energierecht (p. § 7 SeeAnlV). München: C.H.Beck.

Schmölcke, U., Endtmann, E., Klooß, S., Meyer, M., Michaelis, D., Rickert, B.-H., Rößler, D, (2006): Changes of sea level, landscape and culture: A review of the south-western Baltic area between 8800 and 4000BC. Palaeogeography, Palaeoclimatology, Palaeoecology 240, 423–438.

Schomerus T, Runge K, Nehls G, Busse J, Nommel J & Poszig D (2006) Strategische Umweltprüfung für die Offshore-Windenergienutzung. Grundlagen ökologischer Planung beim Ausbau der Offshore-Windenergie in der deutschen Ausschließlichen Wirtschaftszone. Schriftenreihe Umweltrecht in Forschung und Praxis, Band 28, Verlag Dr. Kovac, Hamburg 2006. 551 Seiten.

Schuchardt B (2010) Marine Landschaftstypen der deutschen Nord- und Ostsee. F&E-Vorhaben im Auftrag des Bundesamtes für Naturschutz (BfN). 58 S. + Anhänge.

Schulz S (1968) Rückgang des Benthos in der Lübecker Bucht. Monatsbericht. Dt. akad. Wissensch. Berlin 10: 748–754.

Schulz S (1969a) Benthos und Sediment in der Mecklenburger Bucht. Beiträge zur Meereskunde 24/25: 15–55.

Schulz S (1969b) Das Makrobenthos der südlichen Beltsee (Mecklenburger Bucht und angrenzende Seegebiete). Beiträge zur Meereskunde 25: 21–46.

Schulz-Ohlberg, J., Lemke, W. and F. Tauber, (2002): Tracing Dumped Chemical Munitions in Pomeranian Bay (Baltic Sea) at Former Transport Routes to the Dumping Areas off Bornholm Island. In: Missiaen, T. and J.-P. Henriet, Hrsg.: Chemical Munition Dump Sites in Coastal Environments. Belgian Ministry of Social Affairs, Public Health and Environment, 43-51.

Schwarz J & Heidemann G (1994) Zum Status der Bestände der Seehund- und Kegelrobbenpopulationen im Wattenmeer. Veröffentlicht in: Warnsignale aus dem Wattenmeer, Blackwell, Berlin.

Sciberas, M., Jenkins, S.R., Kaiser, M.J., Hawkins, S.J. & Pullin, A.S. (2013). Evaluating the biological effectiveness of fully and partially protected marine areas. Environmental Evidence 2013 2:4.

Segschneider M., (2014): Verbrannt und versunken – Das Wrack Lindormen im Fehmarnbelt. In: Archäologische Nachrichten aus Schleswig-Holstein 20, 2014, 88–93.

Serigstad B (1987) Oxygen uptake of developing fish eggs and larvae. Sarsia 72(3-4): 369–371.SHD (SEEHYDROGRAPHISCHER DIENST DER DDR), 1987: Kadetrinne.

Siegel, H., Gerth, M. and A. Mutzke, 1999: Dynamics of the Oder river plume in the Southern Baltic Sea: saltellite data and numerical modelling. Continental Shelf Research, 19, 1143-1159.

Skov H, Vaitkus G, Flensted KN, Grishanov G, Kalamees A, Kondratyev A, Leivo M, Luigujoe L, Mayr C, Rasmussen JF, Raudonikis L, Scheller W, Sidlo PO, Stipniece A, Struwe-Juhl B, Welander B (2000) Inventory of coastal and marine Important Bird Areas in the Baltic Sea. BirdLife International, Cambridge.

Skov H, Heinänen S, Žydelis R, Bellebaum J, Bzoma S, Dagys M, Durinck J, Garthe S, Grishanov G, Hario M, Kieckbusch JJ, Kube J, Kuresoo A, Larsson K, Luigujoe L, Meissner W, Nehls HW, Nilsson L, Petersen IK., Roos MM, Pihl S, Sonntag N, Stock A, Stipniece A (2011): Waterbird populations and pressures in the Baltic Sea. TemaNord 2011:550. Nordic Council of Ministers, Copenhagen.

Sordyl H, Gosselck F, Shaqiri A & Fürst R (2010) Einige Aspekte zu makrozoobenthischen Lebensräumen und raumordnerischen Sachverhalten in marinen Gebieten der deutschen Ostsee. In: Kannen A Et Al. (Hrsg) Forschung für ein integriertes Küstenzonenmanagement: Fallbeispiele Odermündung und Offshore-Windkraft in der Nordsee. Coastline Reports 15 (2010), Seite 185–196.

Southall BL, Bowles AE, Ellison WT, Finneran JJ, Gentry RL, Greene CR Jr, Kastak D, Ketten DR, Miller JH, Nachtigall PE, Richardson WJ, Thomas JA & Tyack PL (2007) Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33: 411 – 521

Southall Brandon L., James J. Finneran, Colleen Reichmuth, Paul E. Nachtigall, Darlene R. Ketten, Ann E. Bowles, William T. Ellison, Douglas P. Nowacek, and Peter L. Tyack, (2019). Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Vol. 45, 2

Spence, J. H., & Fischer, R. W. (2017). Requirements for Reducing Underwater Noise From Ships. IEEE Journal of Oceanic Engineering, 42(2), 388-398

Stobart B., Warwick R., Gonzaléz C., Mallol S., Diaz D., Reñones O. & Goñi R. (2009) Long-term and spillover effects of a marine protected area on an exploited fish community. In Mar Ecol Prog Ser. Vol. 384: 47–60. doi: 10.3354/meps08007.

Tardent P (1993) Meeresbiologie. Eine Einführung. 2. neubearbeitete und erweiterte Auflage. Georg Thieme Verlag, Stuttgart, New York, 305 Seiten.

Tauber, F. und W. Lemke, (1995): Meeresbodensedimente in der westlichen Ostsee – Blatt Darß. Deutsche Hydrographische Zeitschrift, 47,171-178.

Tauber, F., Lemke, W. and R. Endler, (1999): Map of Sediment Distribution in the Western Baltic Sea (1 : 100,000), Sheet Falster-Møn. Deutsche Hydrographische Zeitschrift, 51, 5-32.

Tauber, F., (2014): Search for palaeo landscapes in the southwestern Baltic Sea with sidescan sonar. Bericht der Römisch-Germanischen Kommission 92, 2014, 325–350.

Tauber, F., (2018): Beobachtungen bei zwei Anomalien im Fehmarnbelt (Unveröffentlichter Bericht).

Thiel R, Winkler H, Böttcher U, Dänhardt A, Fricke R, George M, Kloppmann M, Schaarschmidt T, Ubl C, & Vorberg, R (2013) Rote Liste und Gesamtartenliste der etablierten Fische und Neunaugen (Elasmobranchii, Actinopterygii & Petromyzontida) der marinen Gewässer Deutschlands. Naturschutz und Biologische Vielfalt 70 (2): 11–76.

Thorson G (1957) Bottom communities (sublittoral or shallow shelf). Treatise on Marine Ecology and Palaeoecology Vol I, Ecology, ed. J.W. Hedgpeth. Memoirs of the Geological Society of America 67: 461–534.

Thünen. Institut für Fischereiökologie. (2020) Meeresmüll – Müll Zusammensetzung. https://www.thuenen.de/de/fi/arbeitsbereiche/meeresumwelt/meeresmuell/muell-zusammensetzung/, zuletzt aufgerufen am 19.08.2020.

Tillit DJ, Thompson PM & Mackay A (1998) Variations in harbour seal *Phoca vitulina* diet and dive-depths in relation to foraging habitat. Journal of Zoology 244: 209−222.

Tischler W (1993) Einführung in die Ökologie. (4. Aufl.) Fischer Stuttgart.

Todd VLG, Pearse WD, Tregenza NC, Lepper PA & Todd IB (2009) Diel echolocation activity of harbour porpoises (*Phocoena phocoena*) around North Sea offshore gas installations. ICES Journal of Marine Science 66: 734–745.

Trippel E.A., Kjesbu O.S. & Solemdal P. (1997) Effects of adult age and size structure on reproductive output in marine fishes. In Early life history and recruitment in fish populations (pp. 31-62). Springer, Dordrecht.

UBA. (2019). Emissionsbilanz erneuerbarer Energieträger, Bestimmung der vermiedenen Emissionen im Jahr 2018. Climate Change 37/2019.

UBA. (in Vorbereitung). Klimawirkungs- und Vulnerabilitätsanalyse 2021 (KWVA 2021), Berichtskapitel für das Handlungsfeld Küsten- und Meeresschutz.

Uscinowicz, S., Kramarska, R. and P. Przedziecki, (1988): The Quarternary of the South-West Region of the Polish Baltic. In: Winterhalter, B., Hrsg.: The Baltic Sea. Geological Survey of Finland, Special Paper, 6, 31-37.

Valdemarsen JW (1979) Behavioural aspects of fish in relation to oil platforms in the North Sea. Int Counc Explor Sea CM 1979/B:27.

van Bernem K.H. (2003) Einfluss von Ölen auf marine Organismen und Lebensräume = Effects of oil on marine organisms and habitats, in: Lozán, J.L. et al. (Ed.) Warnsignale aus Nordsee & Wattenmeer: eine aktuelle Umweltbilanz. pp. 229-234

Van Beusekom JEE, Thiel R, Bobsien I. Boersma M, Buschbaum C, Dänhardt A, Darr A, Friedland R, Kloppmann MHF, Kröncke I, Rick J & Wetzel M (2018) Aquatische Ökosysteme: Nordsee, Wattenmeer, Elbeästuar und Ostsee. In: Van Storch H, Meinke I & Claußen M (Hrsg.) Hamburger Klimabericht – Wissen über Klima, Klimawandel und Auswirkungen in Hamburg und Norddeutschland. Springer Spektrum, Berlin, Heidelberg.

Varanesi, U. [Hrsg.], (1989): Metabolism of polycyclic aromatic hydrocarbons in the aquatic environment. CRC Press Inc. Boca Raton. Florida.

Velasco F, Heessen HJL, Rijnsdorf A & De Boois I (2015) 73. Turbots (Scophthalmidae). In: Heessen H, Daan N, Ellis JR (Hrsg) Fish atlas of the Celtic Sea, North Sea, and Baltic Sea: based on international re-search-vessel surveys. Academic Publishers, Wageningen, Seite 429–446.

von Nordheim H & Merck T (1995): Rote Liste der Biotoptypen, Tier- und Pflanzenarten des deutschen Wattenmeer- und Nordseebereichs. - Bundesamt für Naturschutz (BfN) (Hrsg.), Bonn-Bad Godesberg, 139 Seiten.

Wales, S. C., & Heitmeyer, R. M. (2002). An ensemble source spectra model for merchant ship-radiated noise. The Journal of the Acoustical Society of America, 111(3), 1211-1231

Wasmund, N, (2012): Faktenblatt zur Auswirkung der Eutrophierung auf das Phytoplankton der zentralen Ostsee.

Wasmund N, Dutz J, Pollehne F, Siegel H, Zettler ML (2016a) Biological Assessment of the Baltic Sea 2015. Meereswissenschaftliche Berichte Warnemünde 102 DOI: 10.12754/msr-2016-0102.

Wasmund N, Dutz J, Pollehne F, Siegel H, Zettler ML (2017) Biological Assessment of the Baltic Sea 2016. Meereswissenschaftliche Berichte Warnemünde 105 DOI: 10.12754/msr-2017-0105.

Watermann, B., Schulte-Oehlmann, U. und J. Oehlmann, (2003): Endokrine Effekte durch Trbutylzinn (TBT). In: Lozan, J.L., Rachor, E., Reise, K., Sündermann, J. und H. von Westernhagen. Warnsignale aus Nordsee & Wattenmeer – Eine aktuelle Umweltbilanz. Wissenschaftliche Auswertungen, Hamburg 2003. 239-244.

Walter, U., Buck, B. H. und H. Rosenthal, (2003): Marikultur im Nordseeraum: Status quo, Probleme und Tendenzen. In: Lozan, J.L., Rachor, E., Reise, K., Sündermann, J. und H. von Westernhagen. Warnsignale aus Nordsee & Wattenmeer – Eine aktuelle Umweltbilanz. Wissenschaftliche Auswertungen, Hamburg 2003. 122-131.

Watling L & Norse EA (1998). Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting. Conservation Biology 12(6), 1180−1197.

Weber, W., Ehrich, S. und E. Dahm, (1990): Beeinflussung des Ökosystems Nordsee durch die Fischerei. In: In Lozán, J.L., Rachor, E., Reise, K., Sündermann, J. & Westernhagen, H. v. (Hrsg.): Warnsignale aus Nordsee & Wattenmeer. Eine aktuelle Umweltbilanz. Wissenschaftliche Auswertungen, Hamburg 2003. 252-267.

Weber, W. und O. Bagge, (1996): Belastungen durch die Fischerei, S. 88-92. In: Wahrsignale aus der Ostsee, Lozan, J.L., R. Lampe, W. Matthäus, E. Rachor, H. Rumohr und H. von Westernhagen, Hrsg.

Weigel, S., (2003): Belastung der Nordsee mit organischen Schadstoffen. In: Lozan, J.L., Rachor, E., Reise, K., Sündermann, J. und H. von Westernhagen. Warnsignale aus Nordsee & Wattenmeer – Eine aktuelle Umweltbilanz. Wissenschaftliche Auswertungen, Hamburg 2003. 83-90.

Weigelt M (1985) Auswirkungen des Sauerstoffmangels 1981 auf Makrozoobenthos und Bodenfische in der Kieler Bucht. Berichte aus dem Institut für Meereskunde an der Christian-Albrechts-Universität Kiel 138: 122 Seiten.

Weigelt M (1987) Auswirkungen von Sauerstoffmangel auf die Bodenfauna der Kieler Bucht. Berichte aus dem Institut für Meereskunde Kiel, 176: 1–297.

Weilgart L. (2018) The impact of ocean noise pollution on fish and invertebrates. Report for Oceancare, Switzerland. 34 pp.

Werner, F., Hoffmann, G., Bernhard, M., Milkert, D. und K. Vkgren, (1990): Sedimentologische Auswirkungen der Grundfischerei in der Kieler Bucht (Westliche Ostsee). Meyniana, 42, 123-151.

Westerberg H. und Lagenfelt I. (2008) Sub-sea power cables and the migration behaviour of the European eel. Fisheries Management and Ecology 15(5-6):369 – 375. DOI: 10.1111/j.1365-2400.2008.00630.x.

Westphal, T., Heußner; K.-U., Tauber, F., (2014): Results of dendrochronological investigations on wood samples from the SINCOS Project, Bericht der Römisch-Germanischen Kommission 92, 351–364.

Williams, R., Ashe, E., Blight, L., Jasny, M., & Nowlan, L. (2014). Marine mammals and ocean noise: future directions and information needs with respect to science, policy and law in Canada. Marine Pollution Bulletin, 86(1-2), 29-38

Williams, R., Erbe, C., Ashe, E., Beerman, A., & Smith, J. (2014). Severity of killer whale behavioral responses to ship noise: a dose-response study. Marine Pollution Bulletin, 79(1-2), 254-260. https://doi.org/10.1016/j.marpolbul.2013.12.004

Wilson, S. C., Trukhanova, I., Dmitrieva, L., Dolgova, E., Crawford, I., Baimukanov, M., . . . Goodman, S. J. (2017). Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal. Biological Conservation, 214, 213-222

Winkler HM (2006) Die Fischfauna der südlichen Ostsee. Meeresangler-Magazin 16: 17–18.

Wittekind, D. K. (2014). A Simple Model for the Underwater Noise Source Level of Ships. Journal of Ship Production and Design, 30(1), 7-14.

Wolf, R. (2004). Rechtsprobleme bei der Anbindung von Offshore-Windenergieparks in der AWZ an das Netz. ZUR, 65-74.

Wolfson A, van Blaricom G, Davis N & Lewbel GS (1979) The marine life of an offshore oil platform. Marine Ecology Progress Series 1: 81–89.

Wright, A. J. (2014). Reducing Impacts of Human Ocean Noise on Cetaceans: Knowledge Gap Analysis and Recommendations. https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/Report-Reducing-Impacts-of-Noise-from-Human-Activities-on-Cetaceans.pdf

Zander, C. D., (1991): Die biologische Bedeutung der Lebensgemeinschaft „Miesmuschelgürtel“ in der Ostsee. Seevögel, 12, Sonderheft 1, 127-131.

Zeiler, M., Figge, K., Griewatsch, K., Diesing, M. und K. Schwarzer, (2004): Regenerierung von Materialentnahmestelle in Nord- und Ostsee. Die Küste, 68, 67-98.

Zettler M, Bönsch R & Gosselck F (2001) Distribution, abundance, and some population characteristics of the Ocean Quahog, Arctica islandica (Linnaeus, 1767), in the Mecklenburg Bight (Baltic Sea). Journal of Shellfish Research 20 (2):161–169.

Zettler ML, Bönsch R & Gosselck F (2000) Verbreitung des Makrozoobenthos in der Mecklenburger Bucht (südliche Ostsee) – rezent und im historischen Vergleich. Institut für Ostseeforschung Warnemünde. Meereswissenschaftliche Berichte No. 42: 144 Seiten.

Zettler ML, Röhner M, Frankowski J, Becher H & Glockzin I (2003) F+E-Vorhaben, FKZ: 802 85 210, Benthologische Arbeiten zur ökologischen Bewertung von Windenergie- Anlagen-Eignungsgebieten in der Ostsee. Endbericht für die Areale Kriegers Flak (KF) und Westlicher Adlergrund (WAG), Bundesamt für Naturschutz, 54 Seiten.

Zettler ML, Karlsson A, Kontula T, Gruszka P, Laine AO, Herkül K, Schiele KS, Maximov A & Haldin J (2014) Biodiversity gradient in the Baltic Sea: a comprehensive inventory of macrozoobenthos data. Helgoland Marine Research 68(1): 49–57.

Zirbel, K., P. Balint, E.C.M. Parsons (2011). Navy sonar, cetaceans and the US Supreme Court: A review of cetacean mitigation and litigation in the US. Marine Pollution Bulletin 63: 40–48