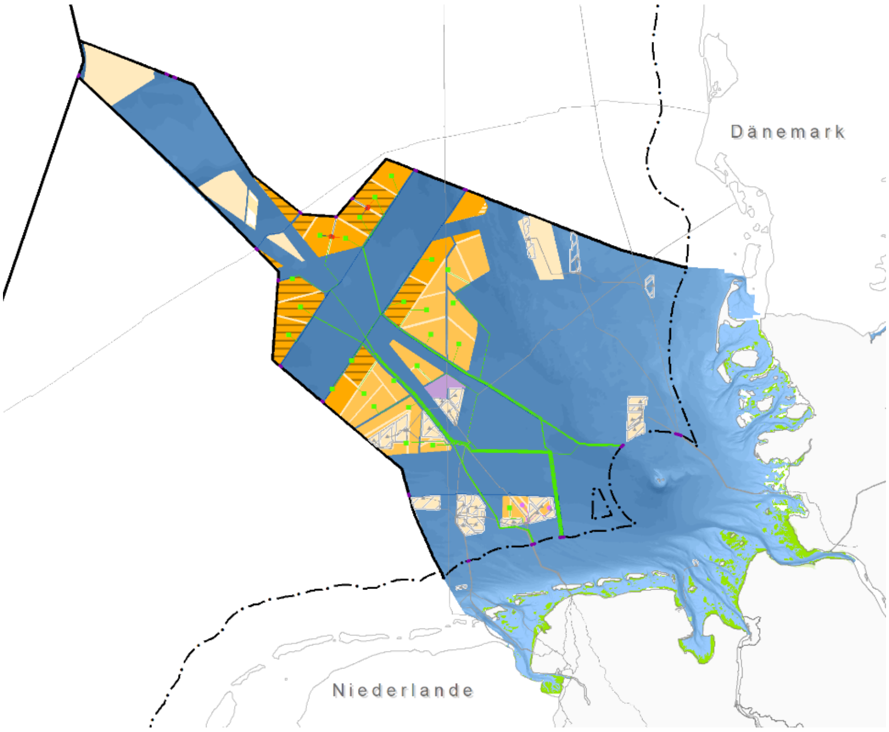
BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Environmental Report: North Sea Site Development Plan



Hamburg, 7th June 2024

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1. Introduction

A Strategic Environmental Assessment (SEA) was carried out as part of the revision and update of the SDP. This environmental report documents the result of the SEA for the EEZ of the North Sea.

1.1. Legal basis and tasks of environmental assessment

In addition to the Act on the Assessment of Environmental Impacts (UVPG), the Offshore Wind Energy Act (WindSeeG) is the central legal basis for this environmental report on the draft site development plan (SDP). The WindSeeG is currently being amended (Resolution of the Federal Government on an "Act to implement the EU Renewable Energy Directive in the area of offshore wind energy and power grids to update the Offshore Wind Energy Act and other provisions", Bundestag printed paper dated 29 April 2024), hereinafter referred to as Draft WindSeeG, for the provisions of the EnWG amended by the aforementioned draft bill: Draft EnWG.

According to Sections 4 et seq. Draft WindSeeG, the BSH prepares a site development plan (SDP) in agreement with the Federal Network Agency (BNetzA) and in coordination with the Federal Agency for Nature Conservation (BfN), the Directorate-General for Waterways and Shipping (GDWS) and the coastal states. The SDP was last updated in 2023. The renewed revision was initiated on 1 September 2023.

During the last amendment and update of the SDP, a detailed environmental assessment within the meaning of Sections 33 et seq. of the Environmental Impact Assessment Act (UVPG), the Strategic Environmental Assessment (SEA), was carried out. The environmental reports were published together with the SDP on 20 January 2023. The need to carry out an SEA with the preparation of an environmental report arises from Section 6, para. 4, sentence 2 WindSeeG in conjunction with Section 35, part. 1, No. 1 UVPG in conjunction with No. 1.17 of Appendix 5 because the SDP is subject to the SEA obligation according to Section 5 WindSeeG [1]. In principle, this also applies if the SDP is updated or amended.

As part of the revision initiated on 1 September 2023, areas and sites that go beyond SDP 2023 and are therefore not covered by the SEA carried out in this procedure will be designation for the implementation of the expansion targets according to Section 1, para. 2, sentence 1 WindSeeG.

With the completion of the revision procedure for maritime spatial planning, a maritime spatial plan (ROP 2021) for the German EEZ of the North Sea and Baltic Sea is now available; this came into force on 1 September 2021. The intention is not only to plan in areas that are designated as priority or reservation area for wind energy in the ROP 2021. A deviation procedure

[1] WindSeeG of 13 October 2016 (Federal Law Gazette I p. 2258, 2310), which was last amended by Article 10 of the Act of 20 December 2022 (Federal Law Gazette I p. 2512), hereinafter also taking into consideration the planned amendment to the draft bill of the Federal Government Bundesrat Drs. 157/24 "Draft Act on the Implementation of the EU Renewable Energy Directive in the Areas of Offshore Wind Energy and Power Grids and on the Amendment of the Federal Requirements Plan Act" (WindSeeG-E).

must therefore be carried out in favour of wind energy within SN10, SN15, SN16, SN17 and possibly SN8, which are designated for shipping as well as with regard to the priority area for divers.

The SEA for the revision of the SDP will continue to be based on the results of the maritime spatial planning revision procedure and the SEA carried out for previous site development plans: According to Section 5, para. 3, sentence 4 WindSeeG (cf also Section 39, para. 3, sentence 3 UVPG), the SEA pending in the procedure for the update and revision of the SDP is limited to additional or other significant environmental impacts compared with the SEA for the ROP and previous site development plans as well as to necessary updates and in-depth analyses.

In accordance with Section 72, para. 1, sentence 1 WindSeeG, the assessment of the environmental impact of offshore wind turbines or installations for other forms of energy generation according to the provisions of the UVPG based on an SEA already carried out according to Sections 5 to 12 for the site development plan or the site investigation shall be limited to additional or other significant impacts on the environment as well as to any necessary updates and elaborations.

The SEA for the revision of the SDP is also based on the environmental reports for the preparation and revision of the SDP from 2019, 2020, and 2023 and ROP 2021. Insofar as new knowledge on existing designations is available and relevant, this will also be taken into consideration.

In the following, the scope of the assessment is therefore limited to additional or other significant environmental impacts as well as to necessary updates and in-depth analyses resulting from updated findings, the updated area map, and planned changes to the legal framework.

For the designation of acceleration sites according to Section 5, para. 2b Draft WindSeeG, this environmental assessment constitutes the required strategic environmental assessment in accordance with Section 6, para. 4, sentence 2 WindSeeG in conjunction with Section 35, para. 1, No. 1 in conjunction with No. 1.17 Annex 5 UVPG as well as the assessment in accordance with Section 34, para. 1 to 5 in conjunction with Section 36, sentence 1, No. 2 BNatschG, whereby the requirements of Article 15c, para. 1 of Directive (EU) 2018/2001 are fulfilled.

The objective of the strategic environmental assessment according to Art. 1 of Directive 2001/42/EC on the assessment of the impacts on the environment of certain plans and programmes on the environment (SEA Directive) 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 consideration in the preparation and adoption of plans well in advance of actual project planning.

The SEA has the task of identifying the likely significant impacts on the environment of implementing the plan, describing them at an early stage in an environmental report, and assessing them. It serves as an effective environmental precaution according to the applicable laws and is implemented according to consistent principles, and with public participation. In accordance with Section 2, para. 1 UVPG, the following protected assets are to be considered:

- Humans, in particular human health
- Fauna, flora, and biodiversity

- space, seabed, water, air, climate, and seascape
- Cultural heritage and other material assets
- the interactions between the aforementioned protected assets

The main content document of the Strategic Environmental Assessment is the Environmental Report to be elaborated. It identifies, describes, and assesses the likely significant effects that the implementation of the SDP will have on the environment and possible alternative planning options, taking into consideration the essential purposes of the plan, Section 40, para. 1, sentences 1 and 2 UVPG.

For the selection of acceleration sites, a further review is integrated into this environmental report; which assesses the requirements of Section 5, para. 2b Draft WindSeeG and determines the factual basis required for the exercise of discretion according to Section 5, para. 2b, sentence 3 Draft WindSeeG.

Further details can be found in the designation of the scope of the investigation.

1.2. Brief description of the content and most important objectives of the Site Development Plan

According to Section 4, para. 1 WindSeeG, the purpose of the SDP is to make offshore grid planning designations for the exclusive economic zone (EEZ) of the Federal Republic of Germany.

Section 4, para. 2 WindSeeG stipulates that for the expansion of offshore wind turbines and the offshore connection cables required for this purpose, the SDP shall make designations with the objective of

- achieving the expansion targets according to Section 1, para. 2, sentence 1 WindSeeG
- expanding power generation from offshore wind turbines in a spatially ordered and space-saving manner
- ensuring an orderly and efficient use and utilisation of offshore connection cables and planning, constructing, commissioning, and using offshore connection cables in synchronisation with the expansion of electricity generation from offshore wind turbines
- establishing acceleration sites

According to the legal mandate of Sec. 5, para. 1 WindSeeG-E, the SDP contains designations for the period from 2026 for the German EEZ and, subject to the following provisions, for the territorial sea:

- areas; in the territorial sea, areas may be designated only if the competent country has designated the areas as a possible subject of the Site Development Plan
- sites, including acceleration sites in the areas designated according to Number 1; in the territorial sea, sites can be designated only if the competent state has identified the sites as a possible subject of the site development plan
- the chronological order in which the designated sites, including acceleration sites, are to be put out to tender according to Part 3, Section 2, 4, and 5, including the

designation of the respective calendar years, and whether the area is to be centrally pre-screened

- the calendar years including the quarter in the respective calendar year in which the subsidised offshore wind turbines and the corresponding offshore grid connection cable are to be commissioned on the designated sites and acceleration sites as well as the quarters in the respective calendar year in which the cable of the in-farm cabling of the subsidised offshore wind turbines is to be connected to the converter or transformer platform
- the expected generation capacity of offshore wind turbines to be installed in the designated areas as well as on the designated sites and acceleration sites
- locations of converter platforms, collector platforms and, where possible, substations
- routes or route corridors for offshore connection cables,
- locations at which the offshore connection cables cross the boundary between the exclusive economic zone and the territorial sea
- Routes or route corridors for interconnectors,
- routes or route corridors for possible cross connections between the installations, routes, or route corridors mentioned in Numbers 1, 2, 6, 7, and 9
- Standardised technology principles and planning principles

For areas in the German EEZ and in the territorial sea, the SDP may designate available grid connection capacities on existing offshore connection cables or on offshore connection cables to be completed in the following years; these may be allocated to pilot offshore wind turbines according to Section 95, para. 2 WindSeeG. The SDP may make spatial requirements for the construction of pilot offshore wind turbines in areas and designate the technical conditions of the offshore grid connection cable and resulting technical requirements for the grid connection of pilot offshore wind turbines.

In accordance with Section 5, para. 2a WindSeeG, the SDP may designate areas for other forms of energy generation outside of areas.

In accordance with Section 3, No. 8 WindSeeG, an area for other energy generation is an area outside of areas on which offshore wind turbines and installations for other forms of energy generation, each of which is not connected to the grid, can be constructed in spatial coherence and which is subject to the approval procedure according to Section 2 of the Maritime Facilities Act. According to Section 4, para. 3, sentence 1 WindSeeG, the objective of these designations is to enable the practical testing and implementation of innovative concepts for energy generation not connected to the grid in a spatially ordered and land-saving manner.

In the context of the SEA, a “classic” offshore wind farm is assumed based on the findings to date with regard to electricity generation within the areas for other forms of energy generation. Impacts on the environment going beyond this are highly dependent on the respective type of use and should therefore be comprehensively examined at the approval level. In this respect, the SEA for the areas for other forms of energy generation is carried out analogously to the testing of sites for offshore wind energy.

As part of forward-looking planning, the Draft WindSeeG already takes into consideration that approval procedures for renewable energy projects should be accelerated. The SDP will accordingly define "acceleration sites" for wind energy as well as mitigation measures and rules for mitigation measures. The acceleration sites are to be subject to a simplified licensing procedure in which, as a rule, no environmental impact assessment according to the UVPG will take place.

In addition, an infrastructure area plan will be drawn up to define infrastructure areas for the grid and storage infrastructure required for the integration of renewable energies into the electricity system. According to Section 12j, para. 6, sentence 2 Draft EnWG, a separate strategic environmental assessment is not required for the infrastructure area plan for the EEZ because the strategic environmental assessment carried out for this SDP also takes into consideration the environmental impacts of the infrastructure areas of the draft SDP in the EEZ. In accordance with Section 5, para. 2c, sentence 1 Draft WindSeeG, the SDP also defines effective and proportionate mitigation measures or rules for mitigation measures for infrastructure areas within the meaning of Section 12j EnWG-E in order to prevent possible negative environmental impacts or, if this is not possible, to significantly reduce them where necessary.

In the following, the term "sites" includes both sites within the meaning of Section 3, para. 1, sentence 1, No. 4 Draft WindSeeG and acceleration sites within the meaning of Section 3, para. 1, sentence 1, No. 2 Draft WindSeeG.

1.3. Relationship with other relevant plans, programmes and projects

The SDP is related to other plans and programmes within the Exclusive Economic Zone (EEZ) and adjacent areas – in particular in the territorial sea – as well as to plans and projects at upstream and downstream planning and licensing levels. Detailed information can be found in the scope for the current SEA dated 5 June 2024 to which reference is made here.

1.4. Presentation and consideration of the environmental conservation objectives

The update and revision of the SDP and the implementation of the SEA will be carried out taking into consideration the environmental conservation objectives. These provide information on the environmental status to be aimed for (environmental quality objectives). The environmental conservation objectives can be seen in an overall view of the international, union-based, and national conventions and provisions that deal with marine environmental protection, among other things, and based on which the Federal Republic of Germany has committed itself to certain principles and objectives.

These are explained in detail in the scope for the current SEA. Please refer to the statements in Chapter 3 of the scope of 5 June 2024.

The environmental reports on SDP 2020 contain a description of how compliance with the aforementioned relevant international, EU, and national regulations and recommendations listed in the scope of the study is checked and implemented and which designations are made or which measures are taken.

The following additions to the statements in the environmental reports on the SDP 2020 with regard to environmental and nature conservation requirements at the EU level are necessary:

- Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC with regard to the promotion of energy from renewable sources and repealing Council Directive (EU) 2015/652 (OJ L, 2023/2413, 31 October 2023, p. 1) amending Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 238, 21 December 2018, p. 82)

The RED III Directive authorises and obliges the Member States to introduce acceleration sites, which are to be subject to a simplified licensing procedure in which, as a rule, no environmental impact assessment is carried out according to the Environmental Impact Assessment Act (UVPG) and to designate an infrastructure area plan. Accordingly, the SDP defines acceleration sites and mitigation measures as well as rules for mitigation measures.

With regard to the national level, the following requirements are supplemented compared with the statements in the environmental reports for SDP 2020:

- General ruling on the temporary securing of part of the nature and seascape in the German exclusive economic zone of the North Sea (in and adjacent to the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area) dated 8 March 2021.
- General ruling on the extension of temporary securing of part of the nature and seascape in the German exclusive economic zone of the North Sea (in and adjacent to the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area), General ruling of the BfN dated 21 December 2022.

The general injunctions temporarily safeguard an area in the southern North Sea, which includes parts of the outer grounds around Sylt and Amrum as well as the moraine ridge of the Elbe Glacial Valley north of the island of Heligoland. This serves to maintain the coherence of the “Natura 2000” network and to provisionally secure an area to prepare an offset of the adverse effects on the species red-throated diver and black-throated diver. The temporarily secured area and the prohibitions applicable there will be observed as part of the planning of the SDP.

1.5. Methodology of the Strategic Environmental Assessment

When implementing the Strategic Environmental Assessment, various approaches to the planning status can be considered within the framework of the methodology. This environmental report is based on the methodology already used for the strategic environmental assessment of the Federal Offshore Grid Plan and the site development plan, which was also used for the strategic environmental assessment of the ROP with regard to the size of offshore wind energy and subsea cables and pipelines.

The methodology is based primarily on the designations of the plan to be examined. Within the framework of this SEA, it is determined, described, and evaluated for each of the designations whether the designations have likely significant impacts on the protected assets concerned.

According to Section 1, para. 4 UVPG in conjunction with Section 40, para. 3 UVPG, in the environmental report, the competent authority provisionally assesses the environmental impacts of the designations with regard to effective environmental precaution according to the applicable laws. According to the special legal standard of Section 5, para. 3 WindSeeG, the designations may not pose a threat to the marine environment. In this context, the nature conservation requirements under nature conservation law (in particular the BNatSchG) must also be examined.

The subject matter of the environmental report comprises the description and assessment of likely significant effects of the implementation of the SDP on the marine environment for the designations of the SDP as listed in Section 5, para. 1 WindSeeG (see 1.2).

The methodology of the Strategic Environmental Assessment is comprehensively explained in the scope for the current SEA. Reference is made at this point to the designated scope of 5 June 2024.

1.5.1. Area of investigation

The SUP area of investigation covers the German EEZ of the North Sea (Figure 1). It should be noted that the data availability within the EEZ of the North Sea for the region up to Shipping Route SN 10 is considerably better than for the area north-west of Shipping Route SN 10 because of the available project-related monitoring data.

Also for the area north-west of the SN 10 shipping route, the SDP designates areas, sites, and locations for converter platforms, transmission lines, and gates for interconnectors. Based on the available sediment data and findings from the biodiversity monitoring of the BfN, a description and assessment of the environmental status and an evaluation of the potential environmental impacts is possible for this area in accordance with the explanations in Chapters 2 and 4.

The adjacent territorial sea and the adjacent areas of the littoral states are not directly the subject of this plan; however, they are considered as part of the cumulative and transboundary consideration of this SEA where necessary.

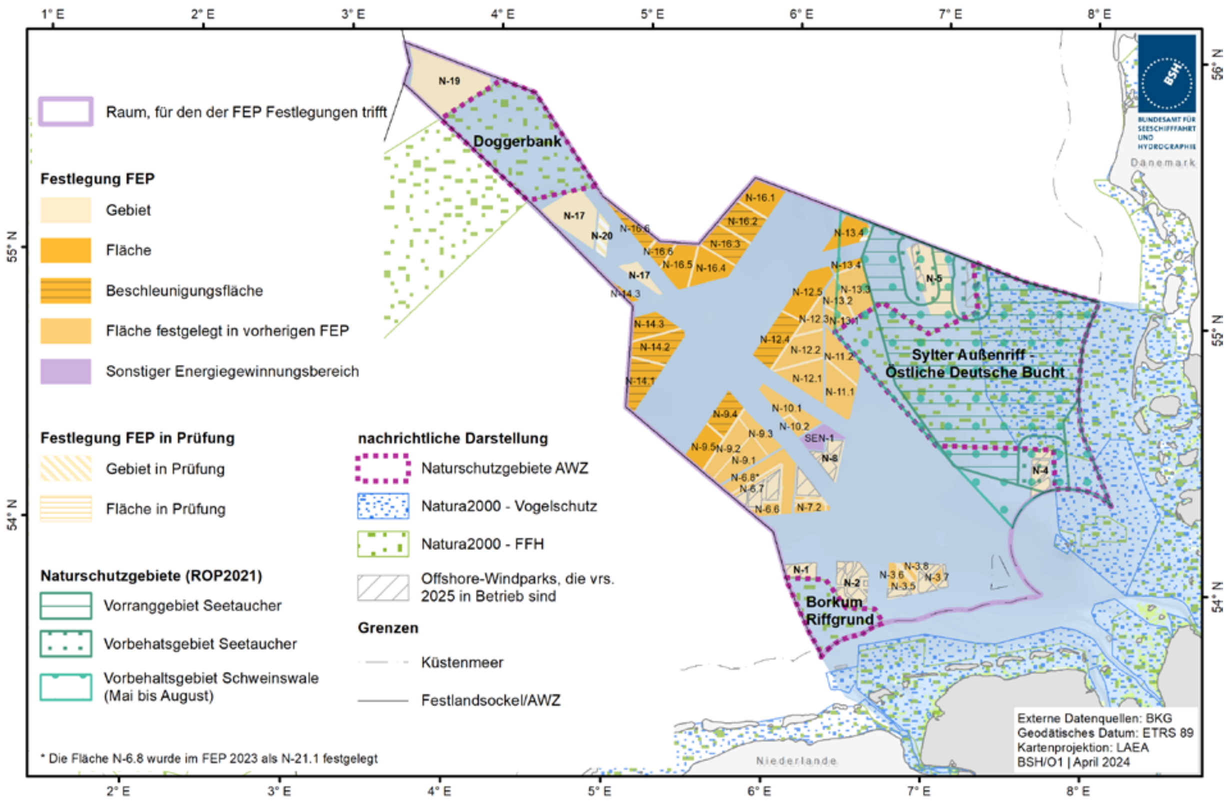

Figure 1: Delimitation of the area of investigation for the SEA of the site development plan – in this case, the EEZ of the North Sea.

1.5.2. Assumptions for the description and assessment of likely significant effects

The description and assessment of likely significant effects of the implementation of the SDP on the marine environment are carried out separately for areas and sites, platforms, subsea cables, and areas for other energy generation, taking into consideration the status assessment. For each of these aspects, it is examined individually whether additional or different significant environmental impacts arise compared with the SEA for the existing SDP or the SEA for ROP 2021 and whether updates and elaborations of the descriptions and assessments are required. The following table sets out the potential environmental impacts based on essential factors that may be caused by the respective use and which form the basis for the assessment of the expected significant environmental impacts. For the assessment, effects are differentiated according to whether they are construction-, deconstruction-, or operation-related or are caused by the installation itself.

Table 1: Overview of potentially significant effects if the SDP is implemented.

Use	Effect	Potential Effect	Benthos	Fish	Seabirds and resting	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biological diversity	Seabed	Site	Water	Air	Climate	Humans/health	Cultural and material	Scenery
			Protected assets																
Areas, sites, and platform locations, areas for other energy generation	Introduction of hard substrate (foundations)	Change of habitats	x	x			x		x	x	x	x							
		Habitat and area 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				x				x	
	Scouring/sediment relocation	Change of habitats	x	x					x	x		x	x					x	
	Sediment turbulence and turbidity plumes (construction phase)	Adverse effect	x t	x t	x t				x t			x		x t					
		Physiological effects and deterrent effects		x t			x												
	Resuspension of sediment and sedimentation (construction phase)	Adverse effect	x t	x t					x t			x		x t					
	Noise emissions during pile driving (construction phase)	Adverse effect/deterrent effect		x t			x												
		Potential disturbance/damage		x t			x												
	Visual disturbance as a result of construction activity	Local deterrence and barrier effects		x t	x t														
	Obstacle in airspace	Deterrent effects, habitat loss			x														
		Barrier effect, collision			x	x		x											x
	Light emissions (construction	Attraction effects, collision			x	x		x											x

Use	Effect	Potential Effect	Protected assets																
			Benthos	Fish	Seabirds and resting	Migratory birds	Marine mammals	Bats	Plankton	Biotope types	Biological diversity	Seabed	Site	Water	Air	Climate	Humans/health	Cultural and material	Scenery
	and operating phase)																		
	Wind farm-related maritime traffic (maintenance, construction traffic)	Adverse effect/deterrent effects Collision		x	x	x	x	x	x		x	x	x t	x	x	x	x	x	
	Material emissions (construction and operating phase)	Potential disturbance/damage										x		x					
Subsea cables	Cable laying, cable trench, and working strip	Disturbance of near-surface sediments	x							x		x	x					x	
		Adverse effect	x							x		x							
	Introduction of hard substrate (rock-fill)	Change of habitats	x	x					x	x		x						x	
		Habitat and area loss	x	x						x		x	x					x	
	Heat emissions	Adverse effects on/displacement of cold-water loving species	x								x	x							
	Magnetic fields	Adverse effect	x																
		Adverse effect on the orientation behaviour of individual migratory species		x															
	Turbidity plumes (construction phase)	Adverse effect	x t	x t	x t				x t			X t		x t					
		Physiological effects and deterrent effects		x t															

Cumulative effects and interactions between protected assets are also assessed in addition to the effects on the individual protected assets.

1.5.3. Cumulative assessment

Section 40, para. 2, sentence 1 UVPG lists the information that the environmental report must contain. As an implementation of Directive 2001/42/EC, the cumulative nature of the effects should also be considered as criteria for the significance of effects with regard to the areas according to Annex II of Directive 2001/42/EC.

The temporally and/or spatially related, cumulative effects can be considered for a single use or for the interaction of several uses. The effect of different uses or different effects of a use can have a synergistic, antagonistic, or additive effect on the state of the ecosystem (Foden et al. 2010, Brown, et al. 2013, Stelzenmüller et al. 2018). Cumulative effects are therefore not necessarily the sum of all individual effects but rather can also be less or greater than their sum.

The focus of the environmental report on the SDP is on the cumulative consideration of similar uses, namely those for which the SDP makes designations. A cumulative assessment of different uses (i.e. intersectoral) is carried out within the framework of the SEA at the higher level of the ROP for the EEZ.

The cumulative effects of offshore wind energy on the marine environment as a whole needs to be better understood in view of the accelerated expansion.

This is necessary in order to rule out any threat to the marine environment, to comply with species protection and site protection legislation, and to order mitigation and preventive measures for the realisation of future projects or to accompany compensatory measures for existing offshore wind energy.

An assessment of the designations is carried out on the basis of the current state of knowledge within the meaning of Section 39, para. 2, sentence 2 UVPG. An important basis for assessing the effects of habitat loss and underwater noise is provided by the position paper on the cumulative assessment of the loss of diver habitat in the German North Sea (BMU, 2009) as well as the noise protection concept of the BMU (2013).

1.5.4. Interactions

In general, effects on any one protected asset lead to various consequences and interactions between the protected assets and other components of the ecosystem. The essential interconnection of the biotic protected assets exists via the food chains. Because of the variability of the factors that naturally affect the individual protected assets and the different temporal and spatial resolution of the data available for analysing the individual protected assets, interactions between the individual ecosystem components can be identified and related to the effects of the plan only to a limited extent. The description has therefore so far been mainly verbal and argumentative based on findings from the literature.

1.5.5. Specific assumptions for assessment of likely significant environmental effects (model parameters)

In detail, the analysis and assessment of the respective designations is carried out as follows:

Areas and sites, including the expected capacity to be installed:

When designating areas, there have been changes in the spatial outline of the shipping route SN10 compared with SDP 2023; these are included accordingly in the scope of the SEA. Within the areas, the SDP will define sites and for these the expected generation capacity of offshore wind turbines to be installed.

For a consideration of the protected assets in the SEA, certain parameters for the development of the sites are assumed. In detail, these include the number of installations, output per installation [MW], hub height [m], height of the lower rotor tip [m], rotor diameter [m], total height [m] of the installations, diameter of foundation types [m], and diameter of the scour protection [m].

In particular, the present SEA takes into consideration the following input parameters:

- Installations already in operation or in the approval procedure (as reference and existing pressure)
- Forecast of certain technical developments and assumptions of bandwidths for various parameters for the consideration of the designated areas and sites.

Table 2 provides an overview of the parameters to be used with the respective bandwidths. In order to depict the range of possible developments, the assessment is largely conducted based on two scenarios. In a first scenario, many small installations are assumed, and in contrast, in a second scenario, a few large installations. Because of the bandwidth covered, a highly comprehensive description and assessment of the protected asset is enabled.

The parameters of the scenarios reflect the expected advancing state of the art and because of this, differ in the different zones that are expected to be established for the development of offshore wind energy.

In Areas N-1 to N-8, the use of marine space was calculated both on the basis of existing data (planning data where applicable) and on the model parameters of the U-frame. The results of these calculations were compared in order to check whether the basic assumptions of the model wind farm are correct or need to be corrected.

Table 2: Model parameters for the consideration of the areas and sites (for the allocation of zones, see Figure 10: Overview of SDP zones; Update for diameter of foundation and scour protection in accordance with Hoffmann, Quiroz & Widerspan, 2022).

Parameter*	Zones 1 and 2		Zones 3 to 5	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Power per installation [MW]	5	15	15	30
Hub Height [m]	100	150	150	210
Rotor diameter [m]	140	240	240	350
Total height [m]	170	270	270	385

Diameter of foundation, monopile (m)**	6.7	10.6	11.3	14-18
Diameter of scour protection, monopile [m]	30	48	51	63-81

* For wind farms in Zone 2 that go into operation after 2029, the parameters of Tones 3 to 5 apply.

** There are currently no empirical values available regarding the effectiveness of state-of-the-art noise mitigation measures for foundation diameters that are assumed for both scenarios for Zones 3 to 5. The applicable threshold values for noise protection must be complied with in any case (cf also the explanations in Chapter 4.7.1).

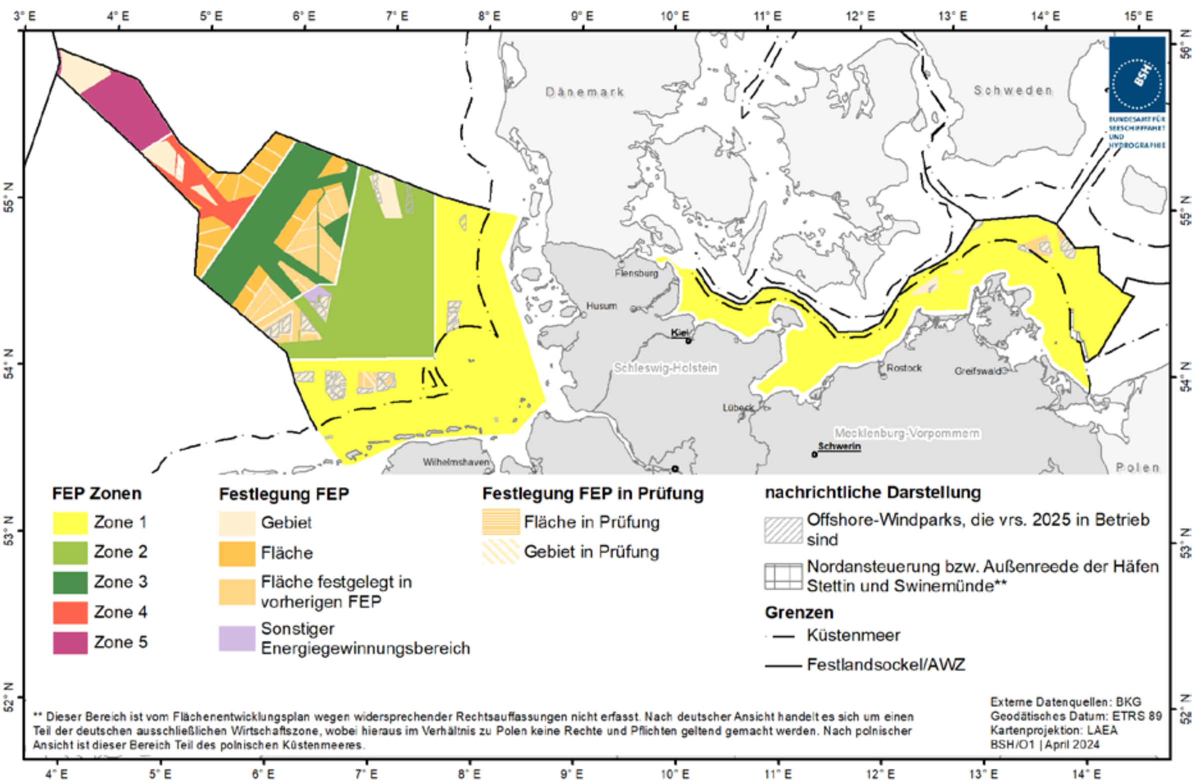

Figure 2: Overview of SDP zones

Locations for platforms (transformer or accommodation platforms)

Also for the assessment of locations for platforms (transformer, converter, or accommodation platforms), certain parameters are assumed as a basis for the assessment. These include the number of platforms, the length of in-farm cabling [km], the diameter of one or several foundations [m], and the area for foundations (including scour protection) [m²].

Table 3: Parameters for the consideration of grid connections and platforms

Grid connection	320 kV		525 kV		220 kV
converter platforms transformer/accommodation platforms*	66 kV	155 kV	66 kV	132 kV	

Specific Length of in-farm cabling [km/MW]	approx. 0.12	approx. 0.12	approx. 0.12	approx. 0.09	approx. 0.12
Number of converter platforms	1	1	1	1	0
Site foundation of converter platform, including scour protection [m²]	approx. 11,500 (Platform area approx. 105 m + 56 m)	approx. 11,500	approx. 11,500	approx. 11,500	
Number of transformer platforms	0	2	0	0	1
Number of accommodation platforms	2	0	2	2	0
Diameter of foundation [m]**	approx. 2 × 10	approx. 2 × 10	approx. 2 × 10	approx. 2 × 10	approx. 10
Diameter of scour protection [m]	approx. 2 × 50	approx. 2 × 50	approx. 2 × 50	approx. 2 × 50	approx. 50

* The figures for transformer/accommodation platforms refer to the number of transformer/accommodation platforms per grid connection (only for completions from 2026) for the different connection concepts. Only the length of the in-farm cabling depends on the expected generation capacity of the respective site and was determined on the basis of existing plans.

** The calculation of the use of marine space is based on the assumption of a monopile foundation. It is assumed that monopile and Jacket each have approximately the same total use of marine space on the seafloor.

Routing and route corridors for subsea cables

When designating routes and route corridors for subsea cables (grid connection cables, interconnectors, and cross connections), certain widths of the cable trench [m] and a certain area of the crossing constructions [m^2] are assumed. In particular, the environmental impacts of construction, operation, and repair are considered.

Table 4: Parameters for the consideration of subsea cables

Subsea cables		
Width of cable trench [m]		approx. 1.5
Area of the crossing construction in the North Sea (m^2)		approx. 900
Area of crossing constructions in Baltic Sea (m²)		approx. 750

Areas for other energy generation

For the designation of “separate energy generation areas”, the Strategic Environmental Assessment is based on the assumption of a “conventional” offshore wind farm on the basis of existing knowledge of electricity production. Impacts on the environment beyond this are highly dependent on the respective use variant and should therefore be comprehensively examined at the approval level. In this respect, the SEA for areas for other forms of energy generation is carried out in the same way as for the assessment of sites for offshore wind energy and is based on the same model parameters.

Relevant planning and technical principles

By regulating planning and engineering principles in the SDP, the space requirements can be minimised, and the potential environmental impacts reduced to a minimum. The predominant number of planning principles serve to prevent or reduce environmental impacts and do not lead to significant effects.

The SDP also contains some planning principles that do not relate to the reduction of environmental impacts. If these are based on objectives of maritime spatial planning, they are to be observed to a lesser extent than the binding nature of the spatial planning objectives. Remaining planning principles are examined for probable significant environmental impacts on protected assets.

With regard to the technical principles, a DC system as a self-commutated high-voltage DC transmission with a voltage level of ± 320 kV was already designated within the framework of the Federal Offshore Grid Plan (BFO) North Sea and was thus also the subject of the environmental assessment of the BFO. Changes in the standard transmission capacity will be examined in the environmental report.

1.6. Data sources and indications of difficulties in compiling the documents

With regard to the data and knowledge bases for the SEA, reference is made to Chapter 5 of the scope for the current SEA dated 5 June 2024.

Indications of difficulties in compiling the documents

Indications of difficulties arising when compiling the data (e.g. as technical gaps or lack of knowledge) are to be presented according to Section 40, para. 2, sentence 1, No. 7 UVPG. There are still gaps in knowledge in places, especially with regard to the following points:

- Long-term effects from the operation of offshore wind farms and associated installations such as converter platforms
- Data for assessing the environmental status of the various protected assets for the area of the outer EEZ.

In principle, forecasts on the development of the living marine environment after implementation of the SDP 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.

The BfN has been mapping the benthic biotope types in the exclusive economic zone of the North Sea and Baltic Sea since 2012. The project has largely been completed in the nature conservation areas. High-resolution biotope maps covering the entire area are thus now available. For the areas outside the protected areas, the map represents an interim status. Here, the biotope type map is based primarily on interpolated sediment information (LAURER et al.

2013) and modelled distributions of benthic biocoenoses. Gaps in knowledge regarding the occurrence of legally protected biotope types cannot be ruled out in these areas.

Furthermore, there are no scientific assessment criteria for some protected assets, 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, to allow cumulative effects to be considered in both temporal and spatial terms.

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-checked basis of marine environmental information for the assessment of potential effects of offshore installations.

2. Description and assessment of the environmental status

According to Section 40, para. 2, sentence 1, No. 3 UVPG, the environmental report includes a description of the characteristics of the environment and the current environmental status in the area of investigation of the SEA. Compared with the existing strategic environmental assessments for the SDP and the ROP, this should be limited to additional or other significant environmental impacts as well as necessary updates and in-depth analyses.

The description of the current environmental status is basically required in order to be able to forecast its change upon implementation of the plan. The subject of the inventory are the protected assets listed in Section 2, para. 1, Nos. 1 to 4 UVPG as well as interactions between them according to Section 2, para. 1, No. 5 UVPG. The information is presented in a problem-oriented fashion. 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. Depending on the type of effect and the protected asset in question, these will have differing extents and may go beyond the limits of the plan

2.1. Site

2.1.1. Data availability

In order to calculate the use of marine space of existing offshore wind farms, those under construction and those for which applications have been submitted as well as the grid connection systems, information from the design approval documents, the as-built and as-lay documentation, information from databases (e.g. MarinEars, CONTIS, and Mariplan), and information from application documents were included.

The model parameters of the investigation framework were used to calculate the use of marine space for offshore wind energy in the areas and sites defined in this plan.

2.1.2. Presentation of the calculations

The effects of the construction and operation of offshore wind farms are taken into consideration when calculating the use of marine space. Use of marine space includes both the actual loss of area (e.g. through sealing) and the loss or disturbance of the original seabed function (e.g. loss of biotope).

Sites are sealed by the foundation structures of wind turbines and platforms, by crossing constructions, and by scour protection measures. More than 90% of the wind turbines erected in the EEZ of the North Sea are based on monopiles. The monopile including scour protection is therefore used as the basis for the modelled calculation of the use of marine space by foundation structures. All wind turbines in the North Sea based on monopiles are fitted with scour protection, the diameter of which can be up to five times the diameter of the monopile. On average, it is around 4.5-fold the diameter of the monopile (Hoffmann et al, 2022). The actual diameter of the scour protection is used to calculate the use of marine space by installations and platforms based on monopiles in the case of existing data. For the modelled calculation of the use of marine space by monopile foundations, 4.5 times the diameter of a monopile is assumed as the diameter of the scour protection (including monopile).

Other foundation structures are disintegrated structures such as jackets, tripods, and tripiles. Transformer and converter platforms are predominantly based on jacket structures and rarely on monopiles. The jacket foundations of converter platforms in particular are often provided with scour protection. In the case of wind turbines, foundations with disintegrated foundation structures are planned in the previous procedures without scour protection. Tripods and tripiles as foundation structures have so far been used only for wind turbines in the North Sea and were also planned without scour protection. This will be attached subsequently if necessary.

In the case of disintegrated structures, the use of marine space includes loss of area and disturbance of the site and is illustrated below using a jacket foundation as an example (Figure 3). The orange-coloured areas in the following figure show the sealing of the sea floor by the driven piles (single pile diameter). The area adjacent to the driven pile (orange) (dark grey) represents the area in which the original biotope is lost. Because there is still no reliable information on the actual extent of the biotope loss, an initial approximation of five times the diameter of the driven pile was assumed (based on the maximum diameter of a scour protection on the monopiles).

The light grey area in the following figure represents the area surrounded by the driven piles on the seabed in which the area may be disturbed because of the near-bottom components of the foundation structures. Loss of area and disturbance of the area because of the disintegrated foundation structure together result in the use of marine space by the foundation.

For the modelled calculation of the use of marine space of disintegrated structures, it is assumed that this roughly corresponds to the use of marine space of the monopiles.

A comparison of the use of marine space by monopiles and disintegrated structures in the inventory data shows that, with roughly the same nominal output of the wind turbines, the disintegrated foundation structures generally have a lower use of marine space than installations founded on monopiles.

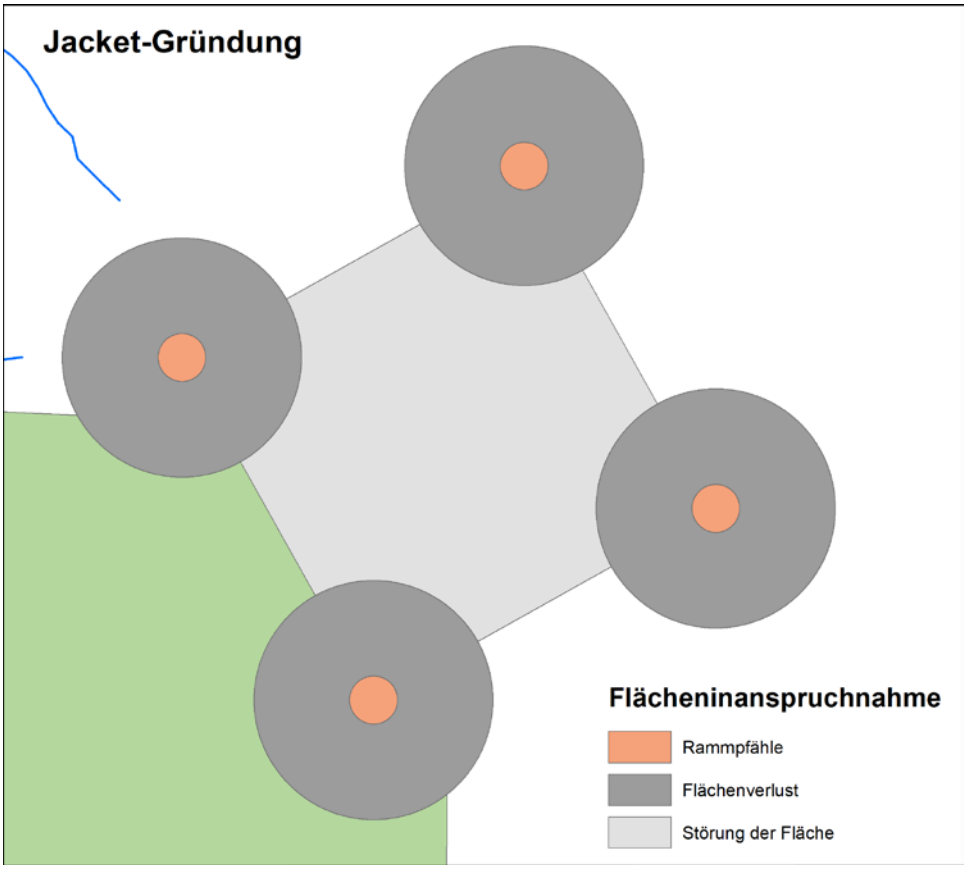

Figure 3: Exemplary illustration of the use of marine space of a disintegrated structure (here: 4-legged jacket).

In order to determine the use of marine space caused by the jetting of the in-farm cabling, grid connections and interconnectors, a 1 m wide cable trench is assumed, which is recognised as a 100% calculated loss in the encroachment assessment. The width of the cable trench is determined by the width of the jetting blade of the respective laying device; this creates a cable trench between half a metre and one metre wide during jetting. For the DC connections of the 2 GW platforms, three cables must be bundled to transmit the electricity produced (previously only two cables were bundled). Because laying equipment with a wider jetting blade may have to be used for this purpose, a cable trench width of 1.5 m was assumed for all DC connections of the 2 GW converter platforms as a precautionary measure when calculating the use of marine space.

A value of 0.12 km per MW of installed capacity is assumed for calculating the length of the in-farm cabling. The analysis of the population and planning data for SDP Sites N-1 to N-8 shows that this is also the most frequently occurring value. The evaluation of the existing data also shows that the number of installations and, in particular, the layout and position of the converter platform have a major influence on the length of the in-farm cabling. The smaller the number of installations, the more compact the OWF area (small perimeter compared to the area), and the closer the position of the converter platform, the shorter the in-farm cabling. The previous population and planning data show values between 0.1 and 0.58 km/MW. The high value of

0.58 km/MW results not only from the unfavourable area layout but above all from the location of the converter platform far from the OWF. The average value is 0.19 km/MW.

For the use of marine space of transformer and accommodation platforms, the model parameters of the investigation framework provide for a monopile of 10 m diameter with a scour protection of 50 m diameter (including monopile). This corresponds to an area of 1964 m^2 per platform. Transformer platforms are predominantly erected on jacket foundations. The use of marine space is between 751 m^2 and 2,369 m^2. On average, it is 1,309 m^2 and thus considerably below the model value of the scope of 1,964 m^2. The same applies for accommodation platforms.

Converter platforms are predominantly based on multi-legged jacket constructions and are often equipped with scour protection. In some cases, scour protection was also retrofitted. The use of marine space ranges from 1,826 m^2 to 19,314 m^2. On average, it is 8,667 m^2 and thus significantly below the model assumption of 11,500 m^2.

A comparison between the results on the use of marine space based on the model parameters of the scope for Zones 1 to 5 and the use of marine space taking into consideration the inventory and planning data for Areas N-1 through N-8 shows only a minimal difference in the total use of marine space in relation to the EEZ. The results based on the model parameters of the investigation framework show a land consumption of 2,857 ha (Scenario 1) to 3,037 ha (Scenario 2). This corresponds to 0.1–0.106% of the area of the EEZ of the North Sea. The results, taking into consideration the existing and planning data, show only a slightly higher use of marine space of 2906 ha for Scenario 1 to 3115 ha for Scenario 2. This corresponds to 0.102–0.109% of the area of the EEZ of the North Sea. In relation to the respective SDP areas, this results in use of marine space of between 0.2% and 0.4%. This applies to both the model calculations and the inventory data For existing data, the maximum values of a use of marine space are 0.35% for Area N-8 and 0.62% (model calculation for scenario 2) for Area N-9. This means that the use of marine space remains well below 1% of the respective wind farm site.

2.2. Seabed

2.2.1. Data availability

An important basis for the description of the surface sediments is the map of sediment distribution in the German North Sea at a scale of 1:250,000 (Laurer et. al, 2014; Project GPDN – Geopotential German North Sea, Figure 5). The mapping is based on grain size distributions from surface soil samples, which were categorised according to the sediment classification system of Figge (1981) and interpolated into the site (Figure 3: Map A). As part of the project “Area-wide sediment mapping of the Exclusive Economic Zone”, area-wide sediment mapping has been carried out for several years using hydroacoustic methods (e.g. side-scan sonar measurements). In addition to the larger scale of 1:10,000, the applied methodology offers the advantage that spatial interpolation of samples distributed at specific points is no longer necessary. The resulting detailed maps significantly improve our state of knowledge of small-scale structural and sediment changes at the seabead surface (Figure 5: Figure B. In particular, existing gaps in knowledge regarding the distribution of coarse sand-fine gravel surfaces, stony residual sediments, and blocks (Figure 5: Figure C) can thus be closed. They therefore also form a valuable data basis for detailed biotope mapping. The maps as shown in Figure 3 (A and B) are not yet available for the entire EEZ of the North Sea. The current mapping status is available in the “GeoSeaPortal” data access portal of the BSH [(www.geoseaportal.de)](http://www.geoseaportal.de) and shown in Figure 4.

The general descriptions of the structure of the near-surface sub-surface are essentially based on boreholes, pressure soundings, and subsoil exploration reports from projects such as “Shelf Geo-Explorer Baugrund” (SGE-Baugrund), the GPDN project, and the literature as well as the investigations and analyses of the BSH. Since 2018, a geophysical data and knowledge base has been created within the SEBAMO (I & II) project through which specific subsoil characteristics can be placed in an overall geological context across regions (www.pinta.bsh.de/SEBAMO-I).

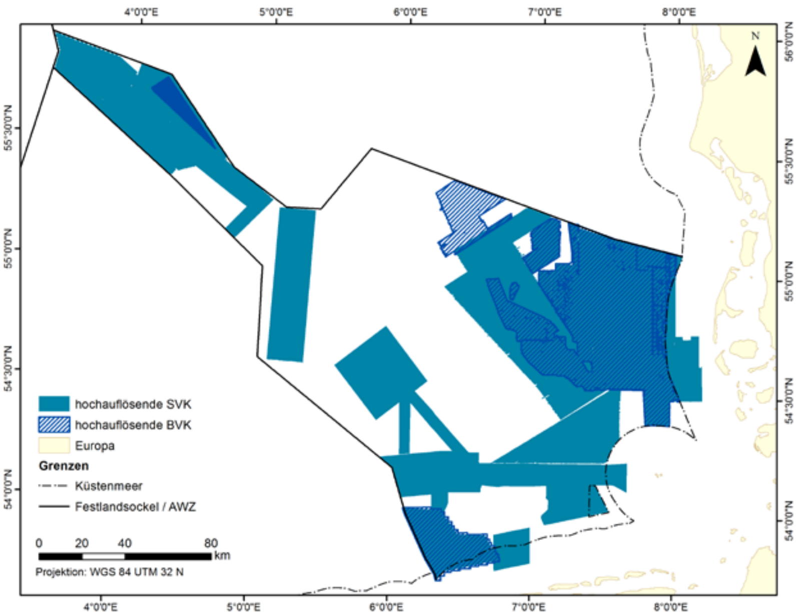

Figure 4: Overview of the detailed sediment distribution maps (SVK, scale 1: 10,000) and boulder distribution maps (BVK, based on a spatial resolution of the backscatter mosaics of 25 cm), current data availability: last revised spring 2024.

The data and information used to describe the distribution of pollutants in the sediment are based on the annual monitoring tours of the BSH (long-term monitoring). The current MSFD status assessment (2024) was used for further information and status assessment (BLANO 2024).

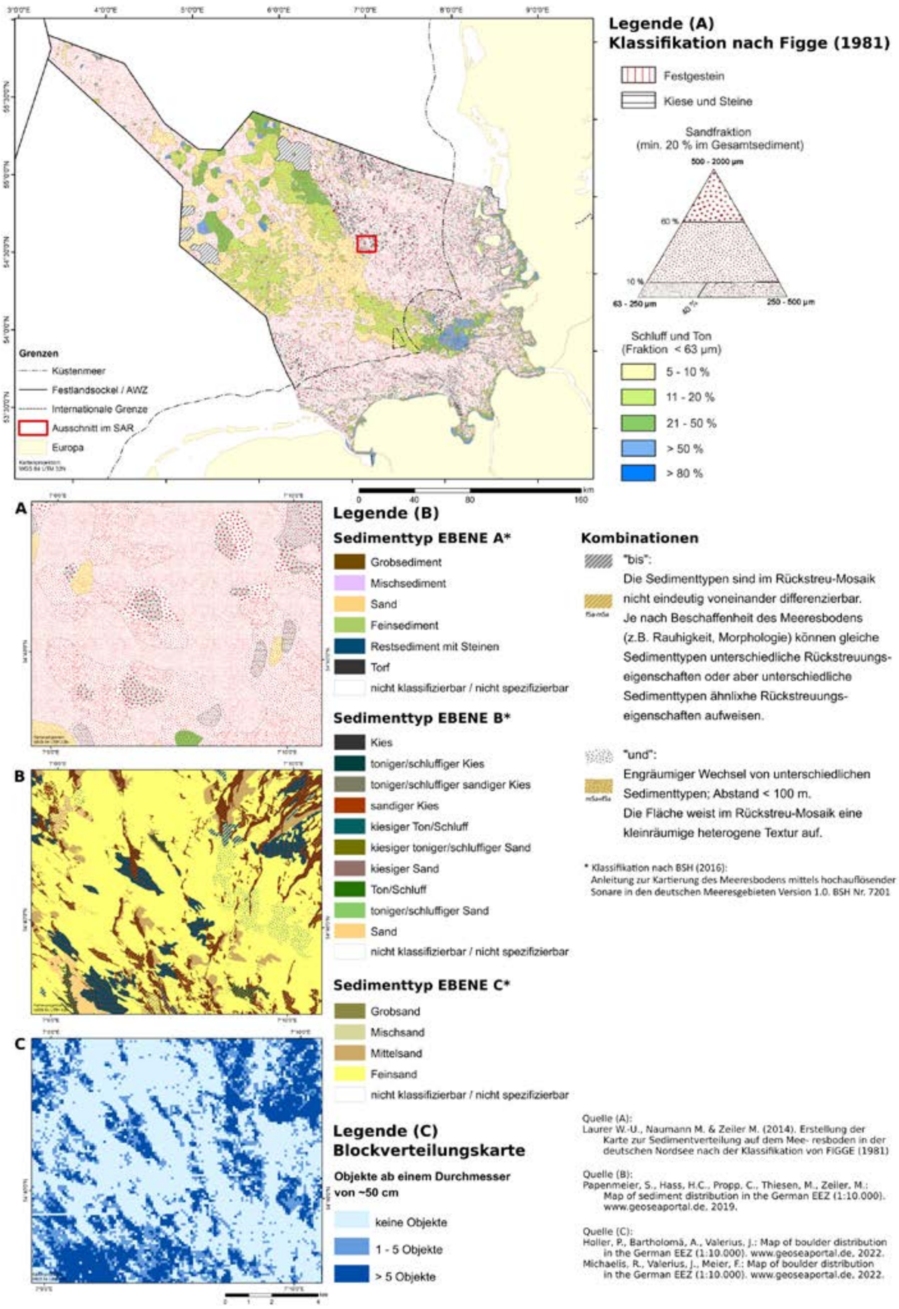

Figure 5: Overview of various sediment distribution maps based on different data sources. Image A: Sediment distribution map generated from interpolated data (grab samples). Image B and C: d Areal sediment and boulder distribution map based on analyses of side-scan sonar data, grab samples, and video recordings.

2.2.2. Status description

Structure of the upper seabed, geomorphology, and sedimentology in the German EEZ of the North Sea

The former Elbe Glacial Valley divides the EEZ of the North Sea into a western and an eastern sub-area, thereby resulting in a regional geological division into four regions (Figure 6, including bathymetry):

- Borkum und Norderneyer Riffgrund (1)
- Nördlich Helgoland (2)
- Elbe Glacial Valley and western plains (3)
- Doggerbank and Northern Shillbank (4).

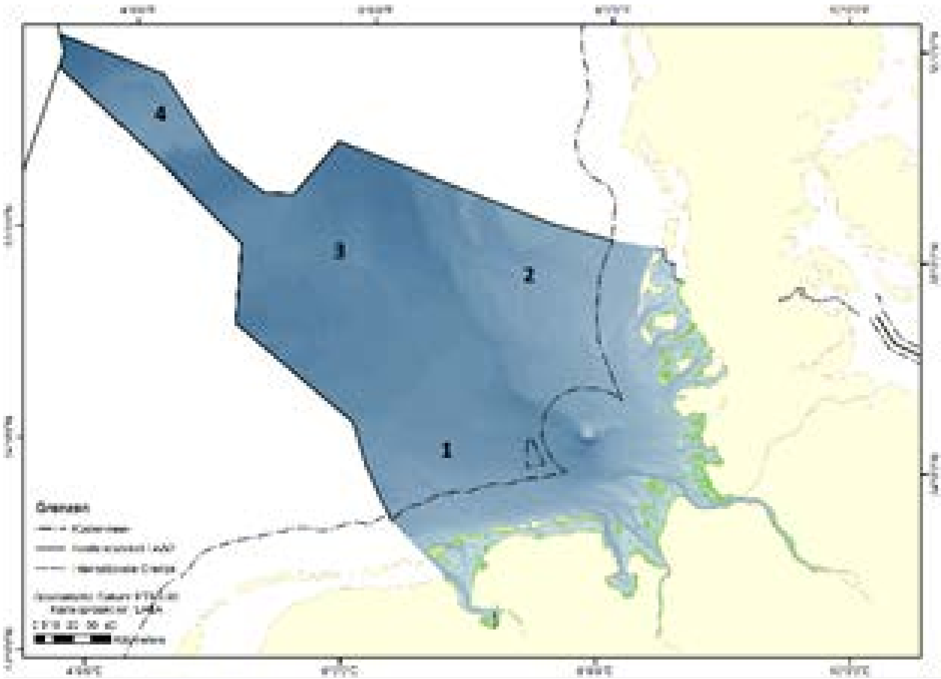

Figure 6: Overview of the regional geological sub-areas in the EEZ of the North Sea.

Borkum and Norderneyer Riffgrund

This sub-area comprises the area of the Borkum and Norderneyer Riffgrund between the two traffic separation zones “German Bight Western Approach” and “Terschelling German Bight” and borders on the 12 nautical mile limit off Heligoland in the east.

The seabed drops evenly from 18 m in the South-west to 42 m in the North and 36 m in the East. Along the 12-nautical-mile limit with the territorial sea of Lower Saxony, the extensions of the shoreface connected sand ridges as defined by REINECK (1984) extend into the EEZ. They run in a northwest-southeast direction and are subject to pronounced sediment dynamics. Its core remains largely stable whilst its surface layer is subject to horizontal positional changes of 100–200 m per year (Antia, 1996). On a small scale, ripple fields in varying degrees are observed on the sandy areas, which indicate recent sediment transport or sand relocation.

The sediment distribution on the seabed in the area of the Borkum and Norderney Riffgrund is predominantly heterogeneous. Medium to coarse sandy sediments are mainly found here with gravel also occurring to a lesser extent. Rocks can occur throughout the reef area. The new findings from the comprehensive sediment mapping show a widespread occurrence of stones, blocks, and boulders in the Borkum Riffgrund. Towards the North-east and East and with increasing water depth, the sediments change to medium to fine sands, the proportion of silt and clay of which reaches up to 10% in places and can rise to 20% in the area of the former Elbe Glacial Valley (Laurer et al. 2014).

Holocene and Pleistocene sediment layers can be identified in the near-surface sub-surface. Beneath a 0.5 to 2.5 m thick surface layer of North Sea sands (Nieuw Zeelandgronden Formation) lie periglacial fine sands of the late Weichselian period, which in places contain clay layers and stones (Twente Formation) and can reach thicknesses of up to 16 m. In the area of the reef grounds, both formations wedge out; there are reworked moraine deposits from the Saale glacial period under a coarse sandy to gravelly residual sediment cover on the seabed. The sandy-clayey moraine clay, which can locally contain erratic boulders or stones, lies on Eemian marine sands, which consist of a sandy sedimentary sequence from the late Elster and early Holstein periods and can reach a thickness of several metres. Former gullies or depressions are encountered in the respective horizons; the fill material of these can have a heterogeneous sediment composition ranging from silt and clay to gravel. Peat can also be expected in some places. The gullies meander in the sub-surface but, according to previous findings, are narrowly confined.

Nördlich Helgoland

This sub-area extends from the 12 nautical mile limit off North Friesland seawards to the eastern shore of the former Elbe Glacial Valley and ends in the North at the EEZ border with Denmark.

The water depths range from 9 m at the western edge of the Amrumbank to 50 m in the north-west of the sub-area. Morphologically, the western part in particular is characterised by an uneven relief by the standards of the German Bight. Particularly noteworthy are the striking submarine Geest edge along the Elbe Glacial Valley, the western edge of the Amrumbank and the ridges in the northern area, which extend from the Danish base into the German EEZ. Characteristic form inventories are large or megaripple fields, coarse sand strips, and erosion furrows, the formation of which is closely related to the sediment supply, grain size composition, and hydrodynamic forces (Diesing et al. 2006). In addition, biogenic structures such as mussel fields are observed in sonograms (side-scan sonar recordings) (Werner, 2004).

The sub-area is characterised by a pronounced heterogeneous sediment distribution on the seabed. In addition to fine and medium sands, coarse sands and gravels are common. The proportion of fines is rarely more than 5% (Laurer et al, 2014). Pleistocene elevations were reworked and partially levelled during sea-level rise. They show the characteristic covering of residual or relict sediments (coarse sands, gravel, blocks, and boulders). Between these residual sediment deposits, fine to medium sand areas occur; these are generally 0.5 to 2 metres thick but may be absent in places. In exceptional cases, the moraine clay within these residual sediment fields lies directly on the seabed. Compared to the Borkum and Norderney Riffgrund, a higher density of stones can be observed on the seabed in this maritime area; these are concentrated in structures orientated northwest-southeast (Schwarzer und Diesing 2003).

The current results of the area-wide sediment mapping show extensive areas of stony residual sediments and blocks on the seabed surface, especially to the east of the former Elbe Glacial Valley (cf Figure 5 A–C).

The structure of the upper seabed is essentially characterised by the glacial advance of the Saale period (Warthe stage). The sub-surface is criss-crossed to varying degrees by infilled meltwater gullies and depressions. According to the data basis to date, it can be assumed that the main drainage of this glacial gully system is directed NW to W. In addition to clastic sediments such as sands, clays, silts, and gravels, these structures contain organogenic sediments such as peat.

Elbe Glacial Valley and western plains
This sub-area extends northwest of Heligoland to the German-Danish or German-Dutch EEZ border, but excludes the area of the north-western region of the German EEZ. To the east, the eastern bank of the former Elbe Glacial Valley, which appears as a striking Geest edge on the seabed, forms the boundary to the sub-area “Nördlich Helgoland”. This area north of the traffic separation zones has water depths of around 30–50 m and slopes gently from the south-east to the west and north. In the centre of the sub-area is the White Bank, which rises about 3 m from the surrounding seabed. The seabed in this sub-area has a even relief and is largely flat. Occasionally, side scan sonar images reveal depression-like formations in which the content of finer-grained material usually increases. Ripple fields occur in places; this is probably due to ground currents. The seabed surface consists of fine sands with considerable contents of silt and clay. In the area of the Elbe Glacial Valley, the recent surface sediment shows an increase in clay and silt content of up to 50% that correlates with the water depth. The fine sands have good to very good grading. Occasional small-scale gravel deposits may occur locally. In the plains to the west of the former Elbe Glacial Valley, a small amount of stone deposits can also be expected.

The defining element in the sub-surface is the Elbe Glacial Valley located in the eastern part of the area, which runs along the submarine edge of the Geest-edge to the north-west and north. In the course of the Holocene marine transgression, this formerly approx. 30 km wide valley was initially filled with an alternating layer of fine sandy and silty-clayey sediments and later predominantly with sandy sediments. The thickness of the sediment fill reaches approx. 20 m. However, in the area of the adjacent plains to the west, thicknesses of 1 m are exceeded only in exceptional cases. This is usually followed by densely bedded fine to medium sand with coarse sand intercalations. They can contain gravel and layers of shale as well as occasionally clays, silts, and peats.

Doggerbank and nördliche Schillbank
This area comprises the area of the north-western region of the German EEZ, the elongated extension in the extreme north-west of the EEZ, which lies in the area of the central North Sea and extends to the EEZ borders of Denmark, Great Britain, and the Netherlands.

The seabed morphology is determined by Doggerbank, the northeastern foothills of which, the Tail's End, crosses the area as a submarine ridge. The shallowest water depths of 29 m are found on Doggerbank whilst the greatest depths of 69 m are measured on its north-western flank. Distinctive seabed forms such as sand waves or large or mega ripple fields (as found on the British side) have not been observed in this sub-area. The seabed is relatively poor in structure.

Sedimentologically, the seabed surface consists mainly of a well-sorted layer of fine sand, which is interrupted by the patchy occurrence of silt and clay or coarse sandy sediments.

Doggerbank contains a Pleistocene core of Weichselian sediments (Dogger Bank Formation), which lies beneath Holocene North Sea sands up to approx. 15 m thick. The Dogger Bank Formation consists of stiff to very stiff silty clay, which locally carries gravels and stones and can reach a thickness of several tens of metres. The sediments of the Doggerbank Formation probably extend to the south-eastern boundary of the North-western region of the German EEZ. Late Weichselian gullies filled with soft, silty clays occur in this area. In the north-western slope area of the Doggerbank, the Holocene sand layer thins out or is completely missing in places. Between the Doggerbank and the northern Schillbank, the 2–16 m thick periglacial fine sands occur; locally, these can contain clay layers and stones. These are deposited on the fine marine sands from the Eemian interglacial period; these can be traced through the entire sub-area with thicknesses of 2–16 m.

SDP sites and areas

The sites and areas identified in the current SDP are located in three of the four regions described above. Sites N-9.4/9.5 and N-12.4/N-12.5 as well as Areas N-14, N-16, N-17 and N-20 are assigned to the "Elbe Glacial Valley and western plains" region. To the north-west of the Doggerbank nature conservation area is Area N-19 in the area of the deep northern Schillbank. Areas N-4 and N-5 as well as Site N-13.4 designated for subsequent use are located in the morphologically and sedimentologically heterogeneous region "Nördlich Helgoland". The sites are characterised in more detail below, primarily in terms of sedimentology.

Area N-4

From a sedimentological point of view, Area N-4, which is designated for subsequent use, is characterised by the predominant fine sand. Silt and clay contents of over 5% are only rarely reached. In addition to the fine sand fraction, medium sand is also strongly represented throughout the area and dominates the surface sediments in some areas, mostly with coarse sand fractions. These coarser medium sand to coarse sand areas can be found in particular in the area of the Amrumbank West OWF, where some blocks were also recorded. Some blocks and stones have also been mapped in the Meerwind SüdOst OWF area as well as a coarse sand/gravel area in the north of the wind farm.

Area N-5

The composition of the surface sediments of area N-5 is quite heterogeneous. With the exception of very fine-grained sediments, all grain sizes are represented here – from sands, gravels, and stones to blocks and boulders. The heterogeneous picture already drawn by the map of

Laurer et al. (2014) is confirmed and refined by the new sediment distribution maps (Figure 7).

Larger contiguous areas of fine sand with a predominantly low proportion of fines (< 5%) can be found only in the central area and on the southern edge of the area. In the East, North-east, North, and North-west as well as on the western edge of the area, coarse sands, gravels, stony residual sediment, and medium and fine sands occur in an often small-scale alternation. The largest contiguous area of coarse sediments (sandy gravel, gravel to stony residual sediments) is located in the East and North-east of the area and is most likely due to superficial boulder clay ridges (see also N-13.4). Boulder deposits and erratic boulders are particularly abundant in the east and north-west (parts of the Sylter Außenriff).

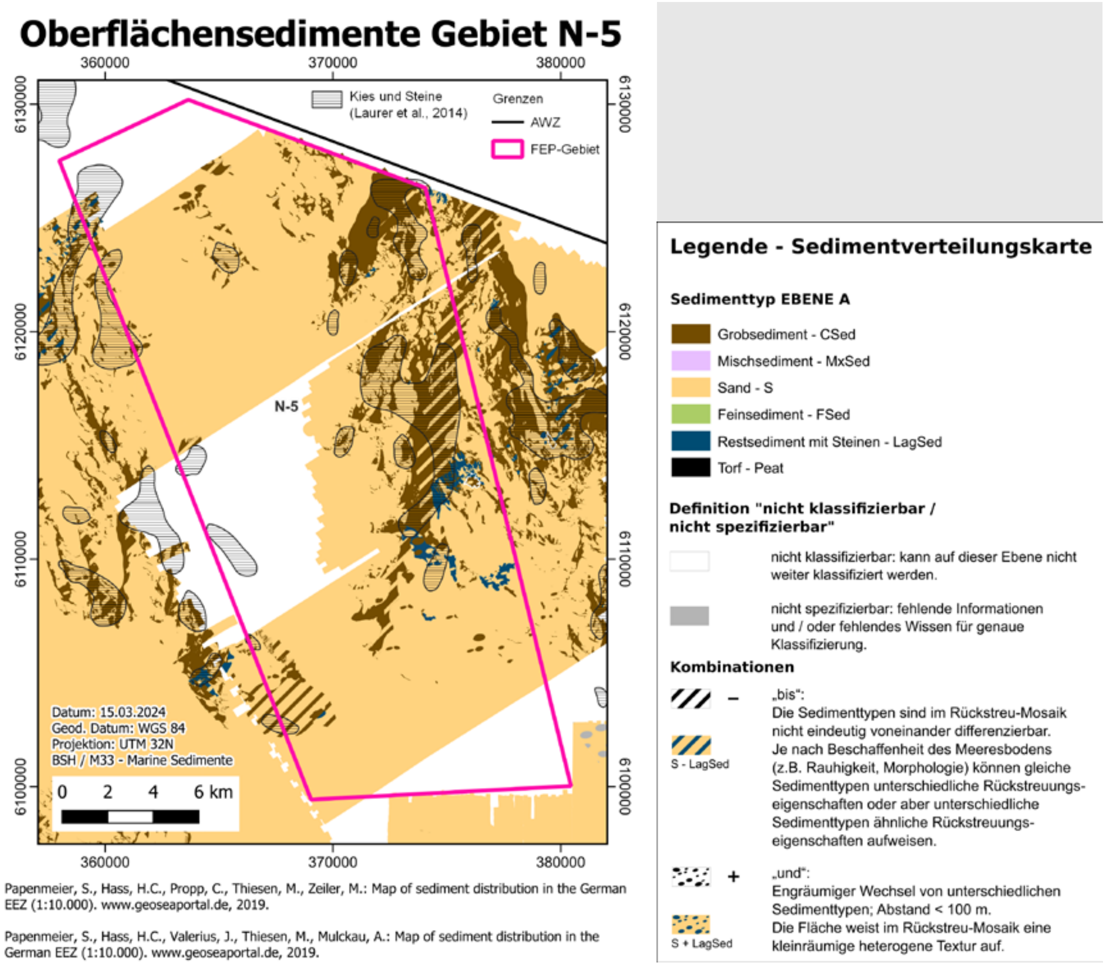

Figure 7: Sediment distribution map in Area N-5

The hard substrates described here (coarse sediments such as gravel, residual sediments, boulder deposits) are an indication of the occurrence of biotopes protected according to Section 30 BNatSchG such as reefs and species-rich gravel, coarse sand and shell layers (see also Chapters 2.5.3 and 5.1)

Site N-9.4 and N-9.5

Like the previously analysed Sites N-9.1–9.3, Sites N-9.4 and N-9.5 are dominated by fine sand. Silt and clay contents of up to 20% occur in both sites. An area with medium and coarse sand deposits is known in Site N-9.4. Morphologically, both sites are characterised by a calm seabed relief. There is currently no knowledge of stone and boulder deposits in this area.

Sites N-12.4 and N-12.5

Fine sand is also the predominant sediment fraction within these two sites. The admixtures of silt and clay vary greatly. Site N-12.4 predominantly contains > 5% fines; within Site N-12.5, clay and silt predominantly occur at 11–12%. Both sites also contain areas with 21–50% fines. Medium to coarse sand was recorded in a small area within Site N-12.5. No evidence of blocks or stone deposits is known to date.

Site N-13.4

The eastern part of the two-part Site N-13.4 consists of the homogeneous sediments of the Elbe Glacial Valley with its almost flat seabed relief and the morphologically and sedimentologically heterogeneous sediments of the region “Nördlich Helgoland”. The west is therefore characterised by extensive fine sediments (fine sand with a fine grain content of over 10%). The central and eastern areas of the southern sub-site as well as large areas in the centre of the northern area of N-13.4 are characterised by boulder fields with erratic boulders running NNW–SSO (cf Figure 8). They are – alternating with sands (medium to coarse sand) – surrounded by stony and/or gravelly coarse sediments. This is due to the surface erosion of boulder clay ridges, which were processed by hydrodynamic processes, whereby the finer parts were washed out (residual sediments). In the EEZ, interconnected structures of this size (Figure 8) are otherwise found only in the Sylter Außenriff and Borkum Riffgrund protected areas. SDP Sites N-13.4 and N-13.3 take up approx. 55% of the total area of this large contiguous stone and boulder deposit (including gravel, residual sediment). In addition to these areas, initial analyses indicate that the moraine clay is covered by only a small mobile sediment layer (< 1–2 m) over a large part of Site N-13.4. This is most likely the case in almost the entire eastern section of the northern sub-site; the thin sediment layer here consists mostly of fairly homogeneous fine and medium sands. Near-surface moraine clay is also suspected under the sands in the southern sub-area, which adjoin the boulder fields and the coarse sediments. The identical picture can also be seen in the entire North-east of Site N-13.3. Residual stony sediments with blocks and boulders can be found on the surface alternating with thin gravels and coarse and medium sands under which moraine clay is presumed. These new findings are based on the latest data evaluations from 2023.

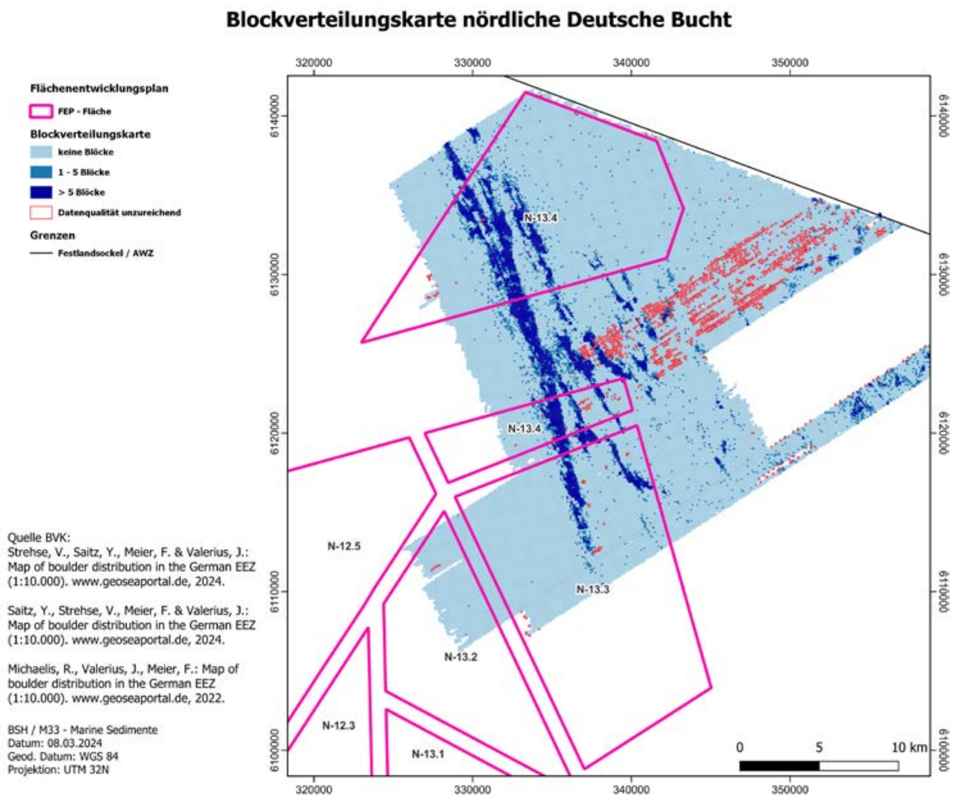

Figure 8: Block distribution map in the area of Sites N-13.3 and N-13.4

Area N-14

Area N-14 is characterised primarily by fine sand with a low proportion of fines up to a maximum of 10%. However, all sites also contain small-scale marginal areas with fine grain fractions of up to 50% or more. N-14.2 also contains a medium to coarse sandy area. The composition of the surface sediments has not yet been mapped in parts of Sites N-14.1. and N-14.2 (data gap in Laurer et al. 2014). Stones and blocks have not yet been recorded.

Area N-16

The elongated Area N-16 along the shoulder of the German EEZ is dominated by fine sand. The proportion of clay and silt is highly variable and varies between < 5 and 50% in almost all N-16 sites. Many sub-areas of the sites also have fine grain contents of over 50%. N-16.1 and N-16.5 contain the largest areas with a high proportion of fines. So far, no blocks or stones have been detected within this area, which is completely characterised by fine sediments. Only one small-scale exception has been recorded as part of new data surveys: a very small area with coarse and residual sediments (< 200 m in extent) within the clayey-silty area in Site N-16.6.

Area N-17

Fine sand dominates the surface sediments within the two-part Area N-17. The south-eastern fine sand areas contain up to 50% fines in some areas whilst the north-western sub-site predominantly contains only up to 10% clay and silt. According to Laurer et al. 2014, smaller areas of medium to coarse sand also occur in the extreme north-west of the area.

Area N-19

Area N-19 can generally be described as a fine sand area with predominantly very low fine grain fractions < 5%. However, n the revised Figge map (Laurer et al. 2014), however, some medium and coarse sand areas as well as clay and silt areas have already been mapped. Using hydroacoustic methods, it has been possible to draw a far more heterogeneous picture of this remote EEZ area in recent years. Numerous small-scale coarse sediment areas were recorded in the centre, west, and north (gravelly sands to sandy gravels according to Folk (1954); which occur in a spatially heterogeneous alternation with the dominant fine sands, particularly in the north. The bathymetry of the area with water depths of approx. 41 m to approx. 67 m represents a special feature within the designated areas.

Area N-20

Area N-20 is almost exclusively characterised by fine sand with low clay and silt content (< 5 to 10%). In the south-east, however, there is a small area in which clay and silt dominate the surface sediments with over 80%. There are no known deposits of coarser sediments or stones.

Subsea cables

The subsea cables defined in the SDP largely run through extensive areas of fine sand with fine grain fractions of 0–20%. The cables running within the areas between Areas N-9 and N-14 as well as the cable systems along Area N-16 are expected to cross some areas with high levels of fines (up to 50% and more). Clays and silts (> 80%) are to be expected near Site N-16.1 and between Area N-12 and Site N-10.1. Coarser sediments may occur along the cable routes of NOR-7-2, NOR-11-1, NOR-12-2/-3/-4, and NOR-16-1 northwest of Heligoland (in the EEZ and territorial sea). Because of a nearby block field in the north, blocks along the cable routes cannot be ruled out, especially in this area.

Pollutant distribution in the sediment

Metals

Metals are an essential natural component of sediments and the (bio)geochemical cycle. However, anthropogenic activities can lead to an accumulation of certain metals in the sediment.

Sediment pollution in the North Sea is strongly determined by the input of river sediment contaminated with metals. In the general spatial distribution, the sediments near the coast show increased metal contents, which are less pronounced along the East Frisian islands than along the North Frisian coast. In contrast, the central North Sea has lower concentrations (BSH 2016). These clear gradients indicate the dominant role of river inputs as a source of metal pollution. There are also additional inputs from the atmosphere (e.g. from industrial emissions) as well as from offshore activities and maritime shipping (e.g. from corrosion protection measures) through the water column into the sediment. In addition, there may also be selective inputs from dumping (e.g. dredged material). The absolute metal content in the sediment is also strongly dependent on the regional grain size distribution. Higher metal contents are observed in regions with a high proportion of fine grains than in sandy regions. The reason for this is the higher affinity of the adsorption of metals on fine sediment particles. The different particle reactivity of individual metals or the organic content (e.g. through accumulation in organisms) also determine the degree of enrichment in the sediment. The seabed is generally an important sink for metals; however, metals can also be released from the sediment into the seawater during resuspension and remineralisation processes, and the sediment can act as a source of pollution.

Specifically, lead and nickel concentrations in the fine-grain fraction of the sediment in the central North Sea are also considerably higher than the OSPAR background concentrations (https://dome.ices.dk/OHAT/?assessmentperiod). On the other hand, metals such as copper, cadmium, and zinc currently show little to no increase in most regions of the German EEZ compared with the OSPAR background concentrations. In contrast, elevated concentrations of mercury are found further into the EEZ.

Organic pollutants

Most of the organic pollutants are of anthropogenic origin. Many of them are considered environmentally relevant because they are toxic and/or persistent in the environment and/or can accumulate in the food chain (bioaccumulative). These pollutants include already banned industrial chemicals such as dichlorodiphenyltrichloroethane (DDT) and polychlorinated biphenyls (PCBs) as well as new, only partially regulated components such as perfluorinated and polyfluorinated alkyl compounds (PFAS).

In principle, the tributaries of the North Sea are the main source of input. Atmospheric input is also relevant for polycyclic aromatic hydrocarbons (PAHs) resulting from combustion processes. The main factors that determine the distribution of pollutants in the sediment are the sediment properties (especially organic content), the physico-chemical properties of the pollutants themselves, and their input pathways and sources. Non-polar substances with low water solubility and low vapour pressure (e.g. PCBs and dioxins) adsorb preferentially on particles (preferably organic material). This can lead to accumulation in the sediment. On the other hand, polar compounds tend to accumulate in the water phase because of their hydrophilicity (Fent, 2013). Particle-bound organic pollutants (non-polar substances) can be taken up by benthic organisms in particular via food. Also this can lead to an accumulation of pollutants in the organisms.

Marine sediments can not only serve as a sink but can also help remobilise bound pollutants (e.g. through physical disturbances such as offshore construction activities and bottom-disturbing fishery). This means that already regulated or banned organic pollutants previously bound in the sediment can be released again.

Overall, the monitoring data of the North Sea sediment show that the concentration of non-polar pollutants is increased in areas with high TOC and fine grain content because of their hydrophobic properties. Localised increases as a result of anthropogenic activities can also be detected.

Old munitions

In 2011, a federal–state working group published a basic report on the munition contamination of German marine waters, which is updated annually. According to official estimates, the seabed of the North Sea and Baltic Sea holds 1.6 million tonnes of old ammunition and explosive ordnance of various types. A considerable proportion of these old munitions are from the Second World War. Even after the end of the war, large quantities of ammunition were sunk in the North Sea and Baltic Sea to disarm Germany. According to the current state of knowledge, the explosive ordnance load in the German North Sea, especially the territorial sea, is estimated at up to 1.3 million t. The overall data availability is insufficient. It can thus be assumed that explosive ordnance deposits are also to be expected in the area of the German EEZ (e.g. remnants of mine barriers and combat operations). For the only known munitions dumping area in the EEZ of the North Sea (approx. 15 nautical miles west of Sylt), there is little and unclear information about the type and quantity of conventional munitions dumped.

The location of the known ammunition dump area can be found on the official nautical charts and in the 2011 report (which also includes suspected areas for ammunition-contaminated areas). The reports of the Federal-State Working Group are available at www.munition-im-meer.de Information on munitions finds, including the EEZ, is also provided by the OSPAR Commission at https://odims.ospar.org/.

The ammunition remnants can basically silt up or be exposed on the seabed if the sediment properties are suitable. In addition, storm events or strong currents can lead to ammunition bodies in the sediment being exposed. This allows ammunition bodies to represent artificial hard substrates.

If the corrosion of the ammunition bodies has progressed, compounds typical of explosives (e.g. TNT and degradation products) can be released into the marine environment. Current studies therefore detect these compounds in the various environmental compartments (e.g. Beck et al. 2019; Koske et al. 2020; Strehse et al. 2023).

The diverse research work and knowledge gained on the topic of old munitions in the North Sea and Baltic Sea led to a new overall assessment in 2020 (Bach et al. 2023). With regard to the environmental aspects, it states, among other things: “From the research results now available, it can be deduced that an increased hazard potential for the marine environment can be assumed in the vicinity of maritime areas contaminated by munitions. Taking into consideration the significant quantities of munitions, adverse effects on the marine environment, including the marine food web, can no longer be ruled out and must be investigated further”.

2.2.3. Status assessment

Because the assessment and evaluation of the status of an area under consideration also defines its supraregional importance for the respective protected asset, the status of the protected asset seabed (area-specific) assessed in Chapter 2.2.4. The criteria “rarity and endangerment”, “uniqueness and diversity”, and “existing pressures” are considered. With respect to the protected asset seabed, the aspect “rarity and endangerment” takes into consideration the portion of the sediments on the seabed and the distribution of the morphological form inventory throughout the North Sea. The “diversity and uniqueness” of the surface sediments are assessed on the basis of their heterogeneity and the characteristics of the morphological inventory of forms. These two criteria are assessed on the basis of the status assessments given above.

The “existing pressure” considers the extent of the existing anthropogenic pressure of the seabed sediments and their morphology (also “naturalness”). The following factors are taken into consideration: bottom-disturbing fishery, pollution, existing infrastructure.

Existing pressure from fishery: In the North Sea, bottom trawling uses otter boards and beam trawls. Otter trawls are used mainly in the northern North Sea and are pulled diagonally across the seabed. In contrast, beam trawls have primarily been used in the south of the North Sea since the 1930s. The skids of the beam trawls leave tracks of 30 to 50 cm in width. In particular, their tickler chains or chain nets have a greater impact on the seabed than otter trawls. The bottom trawls create specific furrows in the sediment that can range from a few millimetres to 8 cm deep on moraine clay and sandy seabed and up to 30 cm deep in soft silt. The results from the EU project TRAPESE show that at most the upper 10 cm of the seabed are regularly scoured and stirred up (Paschen et al. 2000). In this way, the natural sediment dynamics (sedimentation/erosion) and the mass transfer between sediment and seabed water and biogenic structures in the sediment are influenced. The basic grain size composition is hardly changed. A map showing the spatial extent of pressure from bottom-disturbing fishery in the German North Sea can be found in the current MSFD status report (BLANO 2024, Figure II.5.2.2-2).

Existing pressure from pollutants: According to the current state of knowledge, the observed concentrations of most pollutants in the sediment of the German EEZ do not pose any immediate threat to the marine ecosystem. The concentrations of PAHs are below the OSPAR threshold values in the German EEZ of the North Sea. The input and metal contamination in the surface sediment of the EEZ has generally tended to decline in recent years for some metals (cadmium, mercury, lead); however others (nickel, copper, zinc) show no clear trend. According to the MSFD (BLANO 2024), good environmental status with regard to pollution (descriptor 8 pollutants) is not achieved for the North Sea. Among other things, this is due to the exceeding of the assessment thresholds for mercury and lead in the sediment of the territorial sea and EEZ. Even though the concentrations of tributyltin compounds (TBT) are generally decreasing because of the prohibition in the North Sea, the sediments of the southern North Sea generally continue to show concentrations above the assessment thresholds (BLANO 2024).

Existing pressure from existing infrastructure: In those areas where offshore wind farms have already been built and cable systems laid, the seabed has already been strongly influenced – usually on a small scale – by erosion, mixing, resuspension, material sorting, displacement, and compaction as well as the introduction of hard substrate. A detailed description of these effects can be found in Chapter 4.1.

2.2.4. Importance of areas and sites for the protected asset

The importance of Sites N-9.4/9.5 and N-12.4/12.5 and Areas N-14, N-16, N-17, and N-20 for the protected asset seabed is assessed as low. On one hand, this is because of the low rarity and endangerment of the in-situ sediments, which are characterised by the fine sand – dominant in the German North Sea – and varying clay and silt contents of < 5 to 50%. The diversity and uniqueness of the sediments of the sites and areas can be assessed as predominantly medium. A certain heterogeneity of the sediment distribution is present because of strongly fluctuating fine grain contents within the sites/areas as well as smaller medium and coarse sand areas; for example in Site N-16.1 in which even a small area with > 80% clay and silt was mapped. The diversity and uniqueness of the protected asset seabed is assessed as low within Sites N-9.5, N-12.4, 14.3, and 16.3.

There is an existing pressure in all areas as a result of the bottom-disturbing fishery. As a result, the naturalness of the sediments is assessed as low. Taking into consideration the current MSFD status report (BMUV 2023), a strong (because permanent) influence on the sediments can be assumed, especially in Sites N-9.4, N-9.5, N-12.5, and N-16.1. This applies in particular to the habitat function of the sediments.

The importance of Area N-4 is categorised as “medium”, especially because numerous sediment fractions are represented in the area. Although the fine sand fraction is quite dominant, the fine grain content rarely exceeds 5%. However, there are also numerous areas in which medium sand and medium-coarse sand as well as coarse sand and gravel dominate. Some stones and blocks were also recorded. The “rarity and endangerment” as well as the “diversity and uniqueness” of the sediments in this area are therefore categorised as medium. Because of the four OWFs in operation, the seabed is already affected by construction, installation, and operation-related impacts (e.g. loss of area and introduction of hard substrate (see Chapter 4.1.1). On the other hand, the sediments of Area N-4 have been comparatively undisturbed for years because of the exclusion of bottom-disturbing fishery. The extent of existing anthropogenic pressure is therefore assessed as medium.

Area N-19 is also of medium importance for the protected asset seabed. Because new data have shown a small-scale heterogeneity of the sediment distribution in large parts of the area, the diversity and uniqueness can be rated as medium. Because these small-scale sediment changes contain coarse sediments, the rarity and endangerment of the sediments can also be categorised as medium. The detection of fine-grained sediments (> 80% clay and silt) in Laurer et al. (2014) also supports this categorisation. In addition, the morphology of the area is special because the deepest areas of the German EEZ are located in the north-western region of the German EEZ (approx. 41 to 67 m within N-19). For about half of the area, the (bottom-disturbing) fishing pressure was categorised as comparatively low. The naturalness here can thus be described as medium.

Area N-5 and Site N-13.4 each have a high importance for the protected asset seabed. Because of their very heterogeneous and small-scale variable sediment distributions and especially because of the widespread coarse sand, gravel, stone, and boulder deposits, both the rarity and endangerment as well as the diversity and uniqueness are classified as high. In addition, bottom-disturbing fishery is almost non-existent in the centre and east of Site N-13.4 (and N-13.3) as well as in Area N-5 because of the uneven seabed relief. In Area N-5, this is also the case in the Sandbank OWF, where construction-, installation, and operation-related factors have also had and continue to have an impact on the seabed (e.g. loss of area). Because of the small-scale nature of the permanent impact of the Sandbank OWF in comparison with the overall Area N-5, the existing pressure is considered to be low to medium, and the naturalness of the area is considered to be medium to high. For Site N-13.4, the existing pressure is categorised as medium because the west of the area – the area within the Elbe Glacial Valley – is heavily fished.

2.3. Water

2.3.1. Data availability

The data and information used to describe the distribution of nutrients and pollutants in the seawater are based on the annual monitoring tours of the BSH (long-term monitoring). The current MSFD status assessment (2024) was used for further information and status assessment (BLANO 2024).

2.3.2. Status description

The North Sea is a relatively shallow shelf sea with a wide opening to the North Atlantic Ocean in the north. The oceanic climate of the North Sea - characterised by salinity and temperature - is largely determined by this northern opening to the Atlantic. In the south west, the Atlantic has less influence on the North Sea because the shallow English Channel and the narrow Dover Strait.

Currents

The currents in the North Sea consist of a superposition of the semi-diurnal tidal currents with the wind and density-driven currents. In general, the North Sea is characterised by large-scale cyclonic (i.e. counterclockwise) circulation with a strong inflow of Atlantic water at the north-western edge and an outflow into the Atlantic Ocean via the Norwegian Gully. The strength of the North Sea circulation depends on the prevailing air pressure distribution over the North Atlantic, which is parametrised by the North Atlantic Oscillation Index (NAO), the standardised air pressure difference between Iceland and the Azores.

Swell

In the case of swell, a distinction is made between the waves generated by the local wind (the wind sea) and the groundswell. Groundswell are waves that have left their area of origin and enter the maritime area under consideration. The groundswell entering the southern North Sea is generated by storms in the North Atlantic or the northern North Sea. The groundswell has a longer period than the wind sea. The height of the wind sea depends on the wind speed and the time over which the wind acts on the water surface (duration of action) and on the length of the swell (fetch) (i.e. the distance over which the wind acts). For example, the strike length in the German Bight is considerably smaller for easterly and southerly winds than for northerly and westerly winds. The significant or characteristic wave height (i.e. the mean wave height of the upper third of the wave height distribution) is given as a measure of the wind sea.

In the climatological annual cycle (1950–1986), the highest wind speeds (about 9 m/s) in the inner German Bight occur in November and then drop to 7 m/s by February. In March, the speed reaches a local maximum of 8 m/s, after which it drops rapidly and remains at a flat level of around 6 m/s between May and August, before rising just as rapidly from mid-August to the maximum in late autumn (BSH, 1994). This annual trend, based on monthly averages, is transferable to the height of the swell. For the inner German Bight, the directional distribution of the swell for the unmanned lightship UFS German Bight (formerly UFS Deutsche Bucht) shows –

analogous to the distribution of the wind direction – a distribution with a maximum for swell from the west/south west and a second maximum from the east/south east (Loewe et al. 2003).

Temperature, salinity and seasonal stratification

Water temperature and salinity in the German EEZ are determined by the large-scale atmospheric and oceanographic circulation patterns, the freshwater inputs from the rivers Weser and Elbe, and the energy exchange with the atmosphere. The latter applies in particular to sea surface temperature (Loewe et al. 2003). The seasonal minimum temperature in the German Bight usually occurs at the end of February/beginning of March, seasonal warming begins between the end of March and the beginning of May, and the temperature maximum is reached in August. Based on spatial mean temperatures for the German Bight, Schmelzer et al. (2015) find extreme values of 3.5°C in February and 17.8°C in August for the period 1968–2015. This corresponds to a mean amplitude of 14.3 K with the annual difference between maximum and minimum varying between 10 and 20 K. With the onset of seasonal warming and increased irradiation, thermal stratification sets in between the end of March and the beginning of May in the northwestern German Bight at water depths of over 25–30 m. With pronounced stratification, vertical gradients of up to 3 K/m are measured in the temperature jump layer (thermocline) between the warm surface layer and the colder seabed layer; the temperature difference between the layers can be up to 10 K (Loewe et al. 2013). Flatter areas are generally mixed, even in summer, as a result of turbulent tidal currents and wind-induced turbulence. With the beginning of the first autumn storms, the German Bight is again thermally vertically mixed.

The time series of the annual mean of the spatial mean temperature of the entire North Sea, which is based on the weekly temperature charts that have been published by the BSH since 1968, shows that the course of the SST is not characterised by a linear trend but rather by regime changes between warmer and colder phases. The extreme warm regime of the first decade of the new millennium – in which the annual mean North Sea SST fluctuated around a mean level of 10.8°C – ended with the cold winter of 2010. After four considerably cooler years, the North Sea SST reached its highest annual mean of 11.4°C in 2014.

With regard to climate-related changes, Quante et al. (2016) expect an increase in SST of 1–3 K by the end of the century. Despite significant differences in the model simulations with regard to set-up, stimulus from the global climate model, and bias corrections, the different projections arrive at consistent results (Klein et al. 2018).

In contrast to the temperature, the salt content does not have a clearly pronounced annual cycle. Stable salinity stratifications occur in the North Sea in the estuaries of the major rivers and in the area of the Baltic outflow. Because of tidal turbulence, the fresh water discharge of the major rivers within the estuaries mixes with the coastal water at shallow depths, but at greater depths it stratifies over the North Sea water in the German Bight. The intensity of stratification varies depending on the annual course of river discharges, which in turn exhibit significant inter-annual variability (e.g. as a result of high meltwater run-off in spring after heavy snow winters). For example, the salinity at Heligoland Reede is negatively correlated with the discharge volumes of the Elbe. This shows that freshwater inputs cause a considerably reduced salinity near the surface near the coast (Loewe et al. 2013), whereby the Elbe, with a discharge of 21.9 km³/year, has the strongest influence on salinity in the German Bight.

Since 1873 the salinity measurements of Heligoland Reede have been available, since about 1980 also the data at the positions of the former lightships, which were at least partly replaced by automated measuring systems later. The relocation of lightship positions and methodological problems, also in the measurements at Heligoland, led to breaks and uncertainties in the long time series and made reliable trend estimates difficult (Heyen & Dippner 1998). No long-term trend in the annual mean surface salinity at Heligoland is apparent for the years 1950-2014. This also applies to the annual discharge rates of the Elbe. The projections for the future development of salinity in the German EEZ currently still differ greatly in terms of temporal development and spatial patterns. Recent projections indicate a decrease in salinity of between 0.2 and 0.7 PSU by the end of the century (Klein et al. 2018).

Ice conditions

In the open German Bight, the heat reserve of the relatively salty North Sea water in early winter is often so large that ice can form only rarely. The open maritime area off the North and East Frisian islands is ice-free in two thirds of all winters. On average over many years, the ice edge extends right behind the islands and into the outer estuaries of the Elbe and Weser. In normal winters, ice occurs on 17 to 23 days in the protected inner fairways in the North Frisian Wadden area, and only on 2 to 5 days in the open fairways - similar to the East Frisian Wadden area.

In ice-rich and ice-rich winters, on the other hand, ice occurs on average on 54 to 64 days in the protected inner fairways in the North Frisian Wadden area, and on 31 to 42 days in the open fairways similar to the East Frisian Wadden area. In the inner tidal flats, mainly solid ice forms. In the outer tidal flats, mainly floe ice and ice slurry form; these are kept in motion by wind and tidal effects. Further information can be found in the Climatological Ice Atlas 1991–2010 for the German Bight (Schmelzer et al. 2015).

Fronts

Fronts in the sea are high-energy meso-scale structures (of the order of a few tens of kilometres to a few hundred kilometres) which have major effects on the local movement dynamics of the water, biology, ecology, and – because of their ability to bring CO_2 to greater depths – the climate. In the coastal areas of the North Sea, especially off the German, Dutch and English coasts, the river plume fronts with strong horizontal salinity and suspended matter gradients are located between the freshwater input area of the major continental rivers and the continental coastal waters of the North Sea. These fronts are not static formations but consist of a system of smaller fronts and eddies with typical spatial scales between 5 and 20 km. This system is subject to great temporal variability with time scales from 1 to about 10 days. Depending on the meteorological conditions, the discharge rates of the Elbe and Weser rivers and the circulation conditions in the German Bight, frontal structures continuously dissolve and form. Only under extremely calm weather conditions can discrete frontal structures be observed over longer periods of time. During the period of seasonal stratification (approx. from the end of March to September), the tidal mixing fronts, which mark the transition area between the thermally stratified deep water of the open North Sea and the shallower, vertically mixed area as a result of wind and tidal friction, are located approximately in the area of the 30 m depth

line. Because of the dependence on topography, these fronts are relatively stationary (Otto et al., 1990). Kirches et al. (2013a-c) analysed satellite-based remote sensing data from 1990 to 2011 and constructed a climatology for SST, chlorophyll, yellow, and suspended sediment fronts in the North Sea. This shows that fronts occur year-round in the North Sea. The strength of the spatial gradient generally increases towards the coast.
Fronts are characterised by considerably increased biological activity; adjacent areas play a key role in the marine ecosystem. They influence ecosystem components at all stages – either directly or as a cascading process through the food chain (ICES 2006). Vertical transport at fronts brings nutrients into the euphotic zone and thus increases biological productivity. The increased biological activity on fronts resulting from the high availability and effective use of nutrients, results in increased atmospheric CO_2 binding and transport to deeper layers. The outflow of these CO_2-enriched water masses into the open ocean is referred to as “shelf sea pumping” and is an essential process for the uptake of atmospheric CO_2 by the world ocean. The North Sea is a CO_2 sink in large parts all year round except for the southern areas in the summer months. Over 90% of the CO_2 absorbed from the atmosphere is exported to the North Sea.

Suspended solids and turbidity

The term “suspended matter” refers to all particles with a diameter >0.4 µm suspended in sea-water. Suspended matter consists of mineral and/or organic material. The proportion of organic suspended matter is strongly dependent on the season. The highest values occur during plankton blooms in early summer. During stormy weather conditions and the resulting high swell, the suspended matter content in the entire water column increases strongly because of the resuspension of silty-sandy bottom sediments. This is where the groundswell has the greatest effect. When storm lows pass through the German Bight, increases in the suspended matter content of up to ten times the normal values are easily possible. As water samples cannot be taken during extreme storm conditions, corresponding estimates are derived from the records of anchored turbidimeters. If the temporal variability of the suspended sediment content at a fixed position is considered, there is always a distinct half-day tidal signal. Ebb and flood currents transport the water in the German Bight on average about 10 nautical miles from or towards the coast. Accordingly, the high suspended particulate matter (SPM) content near the coast is also transported ‘back and forth’ and causes the strong local fluctuations. Further variability in the SPM is caused by material transport (advection) from rivers such as the Elbe and Weser and from the English south-east coast.

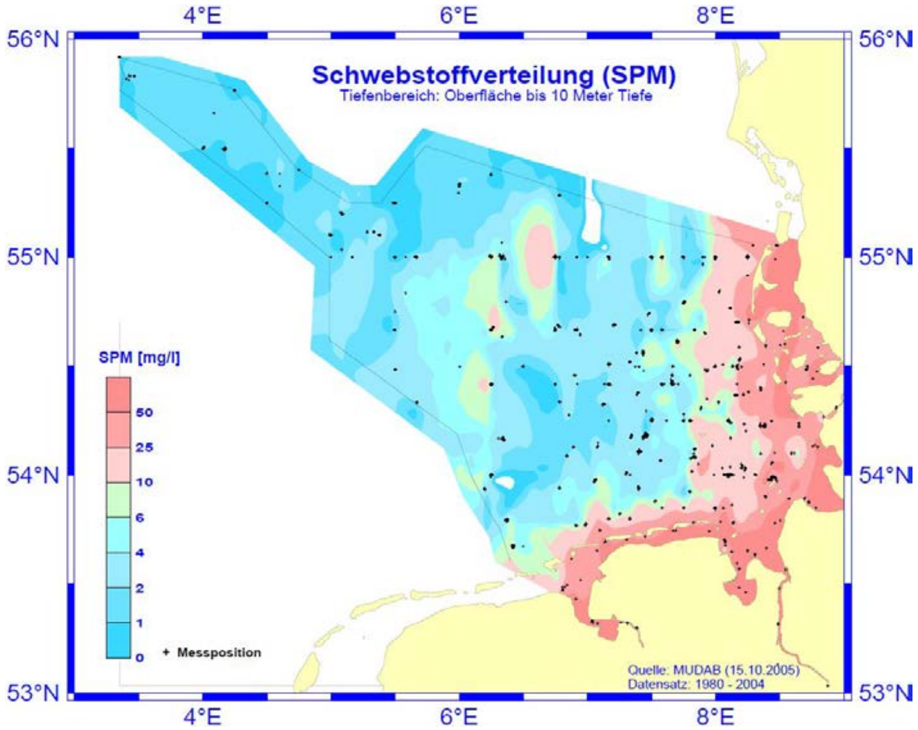

Figure 9: Suspended particulate matter (SPM) for the German North Sea.

In Figure 9, a mean suspended sediment distribution for the German Bight is shown. The basis for the presentation are all SPM values stored in the Marine Environmental Database (MUDAB) as of 15 October 2005. The data set was reduced to the range “surface to 10 metres depth” and to values ≤ 150 mg/l. The underlying values measured were only obtained in weather conditions in which research vessels are still operational. Difficult weather conditions are therefore not reflected in the average figures shown here. In Figure 9, mean values of around 50 mg/l and extreme values of > 150 mg/l are measured in the mudflat areas landward of the East and North Frisian Islands and in the large estuaries. Further seawards, the figures quickly decrease to a range between 1 and 4 mg/l. Slightly east of 6° E, there is an area of increased suspended sediment. The lowest SPM mean values around 1.5 mg/l are found in the north-western fringe of the EEZ and over the sandy areas between Borkum Riffgrund and the Elbe Glacial Valley.

Nutrients

Nutrients such as phosphate and inorganic nitrogen compounds (nitrate, nitrite, ammonium) as well as silicate are essential for marine life. They are vital substances for the formation of phytoplankton (the microscopic single-celled algae floating in the sea) on the biomass production of which the entire marine food chain is based and which is estimated to produce 50–70% of atmospheric oxygen worldwide.

The anthropogenic input of nutrients into the marine environment occurs mainly via direct discharges (industry and wastewater treatment plants), rivers, and the atmosphere as well as naturally through inputs from other maritime areas such as the Atlantic (BLANO 2024). In the

German EEZ, all nutrient concentrations show similar spatial distribution structures. A gradual decrease in concentration can be observed from the coastal area to the open sea. This is due mainly to river input and the associated supply of nutrients through anthropogenic activities. The highest concentrations are measured in the Elbe inflow area and in the coastal regions. This is clearly recognisable in the example of soluble inorganic nitrogen compounds (DIN) in Figure 10. Nutrient concentrations show a typical annual cycle with higher concentrations in winter (remineralisation) and lower concentrations in the summer months (biological growth).

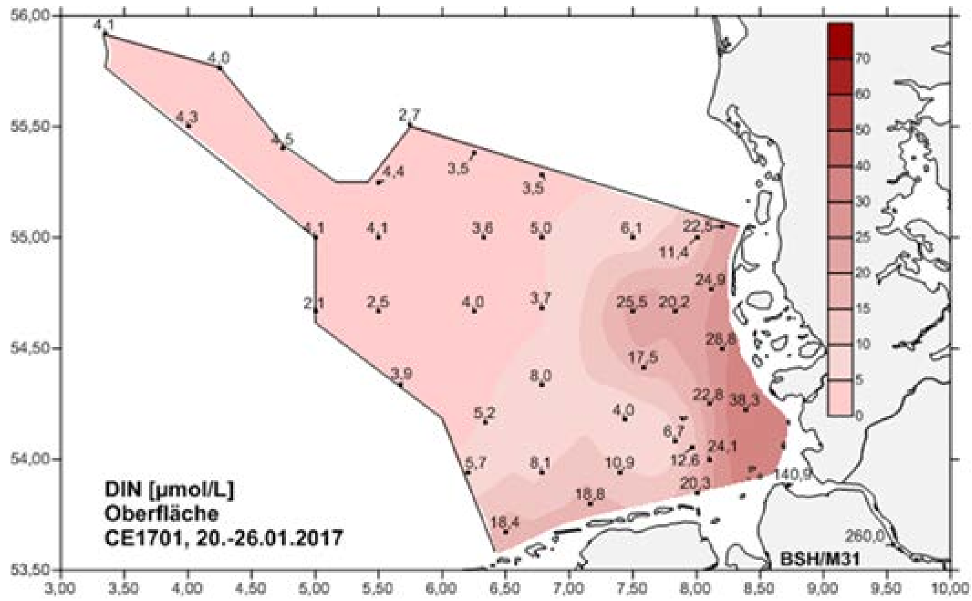

Figure 10: Distribution pattern of soluble inorganic nitrogen compounds (DIN)

Pollutants

Metals

Because metals are a natural component of the marine environment, the detection of these does not necessarily constitute pollution. In addition to the naturally occurring metal contents, human activities sometimes introduce significant additional quantities of individual metals into the marine environment. The main sources of metal inputs are inflows from the North Sea, interaction with the sediment, and atmospheric inputs. Other inputs are caused by maritime shipping and offshore activities (e.g. corrosion protection measures) as well as discharges (e.g. dredged material).

In general, the metal content of seawater is determined by the swelling and sinking processes and the large-scale circulation of the marine water masses. The predominantly dissolved elements (copper, nickel, cadmium) in particular but also mercury form a gradual decrease in concentrations in seawater from the coast to the open sea. In contrast, for more particle-bound metals such as lead, a rapid and strong decrease in concentrations from the coast to the open sea can generally be observed. Similar to nutrients, some metals show seasonal concentration fluctuations in the dissolved fraction. These roughly correspond to the biological growth and remineralisation cycle, which is also decisive for the nutrient content dissolved in seawater, partly because some metals are also essential micronutrients. However, increased concentrations of these metals (e.g. copper, zinc) can also have a toxic effect on marine organisms.

Organic substances

Because the Elbe is the main source of most pollutants in the German Bight, the highest pollutant concentrations are found in the Elbe plume off the North Frisian coast, which generally decreases in the open sea. Polar compounds are particularly relevant for the protected asset water because they are found mainly in the water phase because of their hydrophilic properties.

The concentration gradients for non-polar substances from the coast to the open sea are particularly strong in the German Bight because these substances are predominantly adsorbed (accumulated) on suspended matter and are removed from the water phase by sedimentation. Non-polar volatile substances can also be released into the atmosphere because of their high vapour pressure and low water solubility (Fent, 2013). Outside the coastal regions rich in suspended matter, the concentrations of non-polar pollutants are therefore usually quite low. In recent years, new analytical methods have detected many “new” pollutants (emergning pollutants) with polar properties in the environment (e.g. PFAS, pharmaceuticals). Many of these substances occur in much higher concentrations than the “banned pollutants” (e.g. the herbicides isoproturon, diuron and atrazine). The effects of typical explosive compounds (e.g. TNT and its degradation products) from ammunition bodies on the marine environment are also the subject of current research (see section on old munitions).

2.3.3. Status assessment

Nutrients

An excess of nutrients, which occurred because of extremely high inputs from agriculture, industry, and traffic in the 1970s and 1980s, led to over-fertilisation (eutrophication) of the North Sea. Because of various measures, nutrient inputs into the North Sea have been reduced by around 50% since 1983 (UBA 2017). However, nutrient inputs via the German North Sea tributaries are currently still too high for the most part (in accordance with the Surface Waters Ordinance for the 2016–2020 assessment period). This means that 87% of the German North Sea is currently classified as eutrophic despite declining inputs. Only parts of the outer German Bight (north-western region of the German EEZ) are not considered eutrophic (assessment period 2015–2020) (BLANO 2024, OSPAR Thematic Assessment Eutrophication 2023). As a result of eutrophication, there may be an increased occurrence of (harmful) algal blooms (phytoplankton and green algae), a decrease of visibility depths, a decline in seagrass meadows, and shifts in the species composition as well as oxygen deficiencies near the seabed. In accordance with the MSFD, the good environmental status of the German North Sea with regard to eutrophication (Descriptor 5) is still not achieved (BLANO 2024).

Pollutants

According to the current state of knowledge, the observed concentrations of most pollutants in seawater do not pose any immediate threat to the marine ecosystem. In ecotoxicological assessment, it is not sufficient to consider the toxicity of individual pollutants; rather, the cumulative effect of the large number of pollutants present, which may be amplified by synergistic effects, must be considered. The status assessment is therefore based on threshold values for individual pollutants. In addition, there is a lack of knowledge and assessment of the potential harmful effects of the new chemicals produced and commercialised each year that can enter the marine environment.

In accordance with the MSFD, good environmental status with regard to pollution (descriptor 8 pollutants) is not achieved for the North Sea. This is due, among other things, to the exceeding of the assessment thresholds for organotin compounds (TBT), polycyclic aromatic hydrocarbons (benzo[g,h,i]-perylene), and perfluorooctane sulfonic acid (PFOS) in the coastal seawater (BLANO 2024).

The radioactive contamination of the North Sea by artificial radionuclides was dominated by direct discharges from European nuclear fuel reprocessing plants. Because these discharges have declined sharply in recent decades, the proportion of radionuclides released from marine sediment now greatly exceeds the former. The activity concentrations of the lead nuclide caesium-137 in the North Sea decreased and reached a historic low of 1.5 Bq/m^3 ± 0.5 Bq/m^3 in the central North Sea (BLANO 2024). According to the current state of knowledge, radioactive contamination of the North Sea from artificial sources poses no danger to humans or nature.

2.4. Plankton

Plankton includes all organisms with little or no movement of their own that float in the water and cannot swim against the water current but rather are dependent on the water current for their direction of movement. These mostly very small organisms form a fundamental component of the marine ecosystem. Plankton includes plant organisms (phytoplankton), small animals, and developmental stages of the life cycle of marine animals such as eggs and larvae of fish and benthic organisms (zooplankton) as well as bacteria (bacterioplankton) and fungi.

2.4.1. Data availability

There are only a few monitoring programmes for plankton in the German EEZ of the North Sea. Previous findings on the spatial and temporal variability of phyto- and zooplankton come from research programmes, a few long-term studies, and ecosystem modelling. In recent years, remote sensing has also made a major contribution to improving the data situation with regard to estimating phytoplankton biomass via chlorophyll a concentration. Since 1932, a valuable long-term series has been provided by the Continuous Plankton Recorder (CPR) from the area of the Northeast Atlantic and the North Sea (REID et al. 1990, BEAUGRAND et al. 2003). Approximately 450 different phyto- and zooplankton taxa have been identified through the CPR surveys, and more than 100 phytoplankton species have been identified in the North Sea (EDWARDS et al. 2005). The most important data source for the German Bight is the long-term data series Helgoland Reede, which has been continuously collected by the Biological Institute Heligoland (BAH in the AWI Foundation) since 1962 (WILTSHIRE & MANLY 2004). At the Heligoland Reede station, investigations of nutrient concentrations with simultaneous recording of temperature, salinity and oxygen are carried out every working day. Since 1967, the phytoplankton biomass has been determined. Since 1975, the zooplankton of the Heligoland Reede has also been continually and systematically investigated (GREVE et al. 2004). There is a lack of such long-term series in the German EEZ. Only in the years 2008 to 2011 was the plankton (phytoplankton and mesozooplankton) investigated at 12 selected stations in the German EEZ by the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) on behalf of the BSH as part of biological monitoring. Sampling took place five times a year in parallel with nutrient sampling (WASMUND et al. 2012). For this reason, the description of the current status will be limited to the investigations at the Helgoland Reede station and to information from the four-year investigations of the IOW. It should be noted that Heligoland is not representative of the EEZ in terms of hydrography and the phytoplankton community. In addition, zooplankton samples were collected and analysed from the FINO1 research platform in the area of the EEZ between March 2003 and December 2004 (OREJAS et al. 2005). The hydrographic conditions in this area of the EEZ vary greatly, particularly because of the depth of the water and the prevailing currents, and differ significantly from those in the Helgoland Reede. However, a pronounced variability in succession, as observed at the Helgoland roadstead, was also documented in this area. Recently, further plankton investigations (phytoplankton and mesozooplankton) were carried out in the German EEZ of the North Sea as part of a UBA project (R&D project commissioned by the UBA and carried out by the BSH) “Pilot test of an innovative monitoring of the aspects of eutrophication and pelagic habitats” (iMonEP). The investigations were carried out from March 2021 to March 2023 at 17 stations with two to four samples per year (Figure 11). Twelve of these stations were identical to the positions that the IOW had also sampled until 2011 (Figure 12). Plankton sampling for classic plankton count analyses took place at all stations. Additional samples for DNA meta-barcoding were taken at eight stations in order to test the suitability of this method for surveying plankton (Figure 11). No conclusive results from the investigations are yet available. These are expected to be available by the end of 2024. In the follow-up project KliMHaP (“Innovatives **M**onitoring **p**elagischer **Ha**bitate zur Einschätzung ihrer Ökosystemfunktion im sich wandelnden **Kli**ma“) [“Innovative monitoring of pelagic habitats to assess their ecosystem function in a changing climate”], also commissioned by the UBA and implemented by the BSH, the investigations are to be continued with an identical sampling strategy until September 2026.

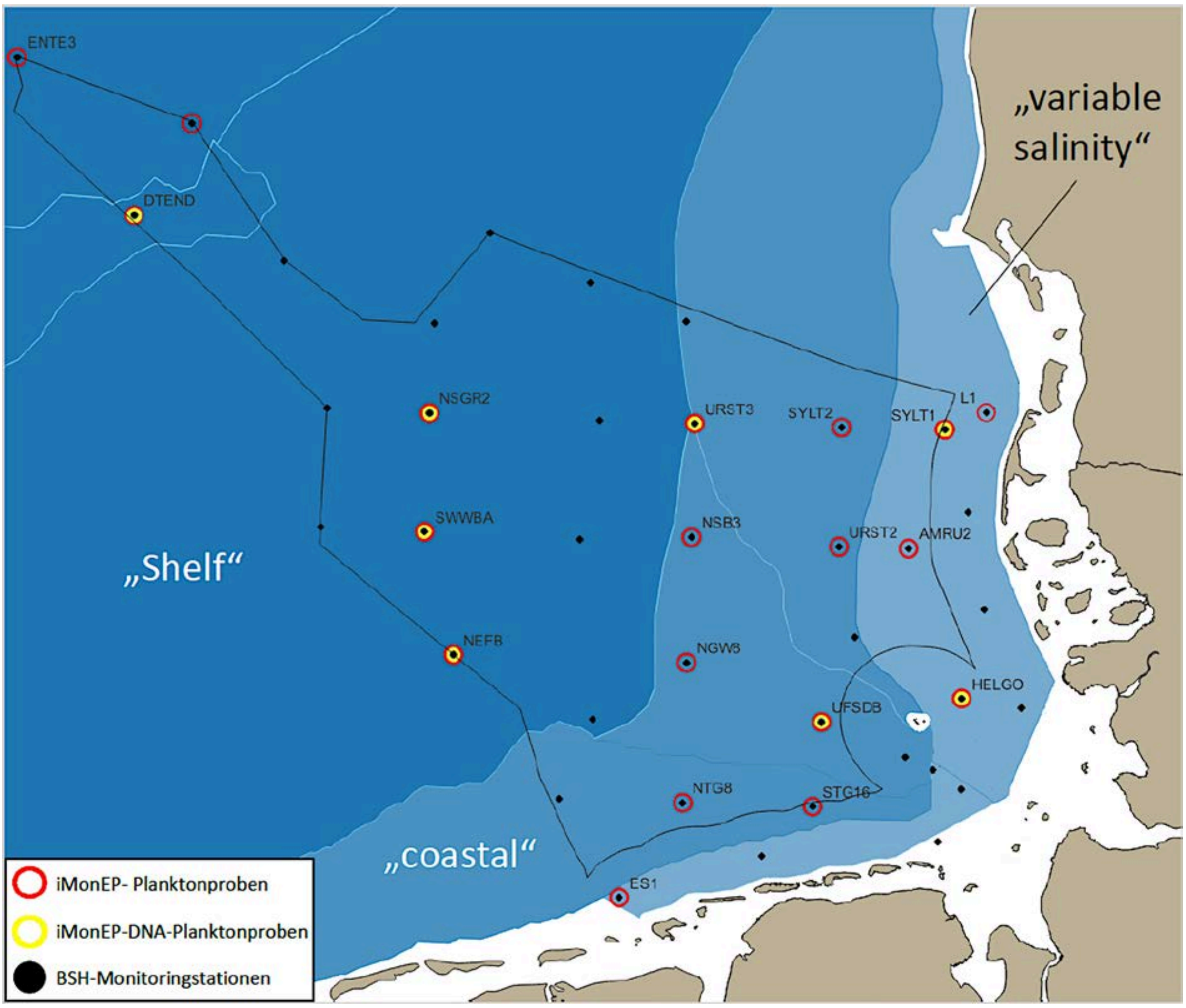

Figure 11: Project stations iMonEP and KliMHaP. The three differently coloured blue areas represent the OSPAR assessment areas for the pelagic habitats

2.4.2. Status description

2.4.2.1. Spatial distribution and temporal variability of phytoplankton

Phytoplankton is the lowest living component of marine food chains and comprises small organisms, which are usually up to 200 µm in size and are taxonomically categorised as plants. These are microalgae that usually consist of a single cell or which 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 micro-organisms that can feed heterotrophically (i.e. on other micro-organisms). There are also mixotrophic organisms that can feed either autotrophically or heterotrophically depending on the situation. Many microalgae, for example, are able to change their type of nutrition in the course of their life cycle. Bacteria and fungi also form separate groups phylogenetically (evolutionary history). When considering the phytoplankton, bacteria, fungi, and such organisms that are closer to the animal kingdom because of their physiological characteristics are also taken into account. In this report, the term phytoplankton is used in this extended sense. Important taxonomic groups of the phytoplankton of the southern North Sea and the German Bight are diatoms or diatoms (Bacillariophyta), dinoflagellates, and flagellate algae (Dinophyceae) as well as microalgae or microflagellates of various taxonomic groups. Phytoplankton serves as the food base for organisms that specialise in filtering water for food. The most important primary consumers of phytoplankton include zooplanktic organisms such as copepods (Copepoda) and water fleas (Cladocera). Phytoplankton growth in the German Bight exhibits fixed annual patterns of occurrence. In spatial terms, the spring growth and thus the algal bloom (algal mass propagation) begins only in the areas far from the coast (i.e. in the outer area of the German EEZ). Different diatom species are responsible for the spring algae bloom from year to year. *Thalassiosira rotula* forms spring algal flowers particularly frequently (VAN BEUSEKOM et al. 2003). In summer, the phytoplankton has a low biomass and is dominated by dinoflagellates and other small flagellates. Another diatom bloom usually follows in autumn (HESSE 1988; REID et al. 1990).

The spatial distribution of phytoplankton depends primarily on the physical processes in the pelagic zone. Hydrographic conditions – in particular temperature, salinity, light, current, wind, turbidity, fronts, and tide – influence the occurrence and species diversity of phytoplankton. The North Sea can be roughly divided into two fundamentally different areas for the occurrence of plankton: The area with a year-round mixed water body and the area with strong stratification (vertical stratification) of the water body. These usually also have different nutrient concentrations. The encounter of mixed and stratified water masses is referred to as oceanographic fronts (cf Chapter 2.3.2). These largely determine the occurrence of phytoplankton. Phytoplankton occurs in high abundance in stratified water bodies near the thermocline (layer boundary between overlying water masses with different temperatures). In the German Bight, the geographical positions of fronts change depending on the weather conditions, the amount of freshwater input from rivers, the tides, and wind-induced currents. However, they prefer to occur in the inner areas of the German Bight. In general, the nutrient levels in the area of the German territorial sea off the coast of Lower Saxony and in the southern part of the Schleswig-Holstein coast in the area of the Elbe water plume are twice as high as in the northern part of the Schleswig-Holstein territorial sea off Sylt. This is also reflected in phytoplankton growth and chlorophyll a concentrations (VAN BEUSEKOM et al. 2005). A spatially precise delineation of habitat types is therefore possible only to a limited extent for phytoplankton (unlike for benthos, for example).

The spatial and temporal distribution of microplankton in the Deutschen Bucht was specified by HESSE (1988). Large-scale investigations identified three water masses in the German Bight with which the occurrence of phytoplankton is associated. The displacement of these main water masses can influence the temporal and spatial development of phytoplankton. During biological monitoring, 144 taxa were identified in 2010, and 140 taxa were identified in 2011 (WASMUND et al. 2011, WASMUND et al. 2012). Most species were diatoms. In the course of the surveys from 2008 to 2011, new species were found each year whilst some species from the first years of investigation were no longer found. In total, 193 phytoplankton taxa were found during the four years of the study (WASMUND et al. 2012). In 2011, the species *Cyclotella choctawhatcheeana* was probably spotted for the first time, while the otherwise often frequent species *Thalassiosira pacifica*, *Proboscia indica*, *Planktolyngbya limnetica*, *Coscinodiscus granii*, and *Prorocentrum minimum* were no longer spotted in 2011 (WASMUND et al. 2012).

2.4.2.2. Spatial distribution and temporal variability of zooplankton

Zooplankton includes all marine animals floating or migrating in the water column. In the marine ecosystem, zooplankton plays a central role: on 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, the zooplankton has a special significance as the primary consumer (grazer) of the phytoplankton. Eating away or grazing can stop the algal bloom and regulate the degradation processes of the microbial cycle by consuming the cells. The succession of zooplankton in the German Bight shows pronounced seasonal patterns of occurrence. Maximum abundances are generally reached in the summer months. The succession of zooplankton 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 staggered occurrence of succession and abundance of species leads to the disruption of food chains. In particular, temporal displacement, or trophic mismatch, results in food shortages at different developmental stages of organisms, with effects at the population level. Zooplankton is categorised according to the life strategies of the organisms:

Holozooplankton: The entire life cycle of the organisms takes place exclusively in the water column. The best-known holoplanktonic groups of importance for the southern North Sea include Crustacea (crustaceans, crabs) such as Copepoda (copepods) and Cladocera (water fleas).

Merozooplankton: Only certain stages of the life cycle of the organism – mostly the early life stages such as eggs and larvae – are planktonic. The adult individuals then move to benthic habitats or join the nekton. These include early life stages of bristle worms, mussels, snails, crabs, and fish. Pelagic fish eggs and fish are abundant in the merozooplankton during the reproductive period.

The transport and distribution of larvae are particularly important for the spatial occurrence and population development of both nektonic and benthic species. The distribution of larvae is determined by both the movements of the water masses themselves and the endogenous or species-specific characteristics of the zooplankton. Environmental factors that can influence larval dispersal, metamorphosis, and settlement are: Sediment type and structure, meteorological and hydrographical conditions, light, and chemical solutes released into the water by adult individuals of the species. Characterising habitat types based on the presence of zooplankton is difficult. As already explained for phytoplankton, water masses actually form the habitat of zooplankton. In 2010, a 157 zooplankton taxa were identified as part of the biological monitoring programme. Arthropoda was the most common group with 80 taxa, followed by Cnidaria with 27 taxa, Polychaeta with 15 taxa and Echinodermata larvae with nine taxa. The total exceeded that of 2009 by 14 taxa and that of 2008 by 40 taxa. A lower diversity was observed throughout the region off the North Frisian Islands (stations HELGO, AMRU2 and SYLT1, Figure 12). This observation goes hand in hand with the large-scale transport of water off the coast towards Jutland. In 2008, this zone was characterised by an “estuarine plume” with lower salinity and higher chlorophyll values (WASMUND et al., 2009). The spatial distribution of taxa in accordance with the Margalef species richness index shows a pattern typical of estuaries. The values increase with increasing distance from the station near Heligoland, which is closest to the Elbe estuary, towards the central North Sea. This experience was already made in the first reporting year, 2008. The result was supported by the changing copepod composition at the time. According to this, the proportion of marine genera increased from 20% to over 80% with increasing distance from the coast (WASMUND et al. 2009 and 2011). In 2011, 139 zooplankton taxa were recorded; arthropods were the most common group (WASMUND et al. 2012).

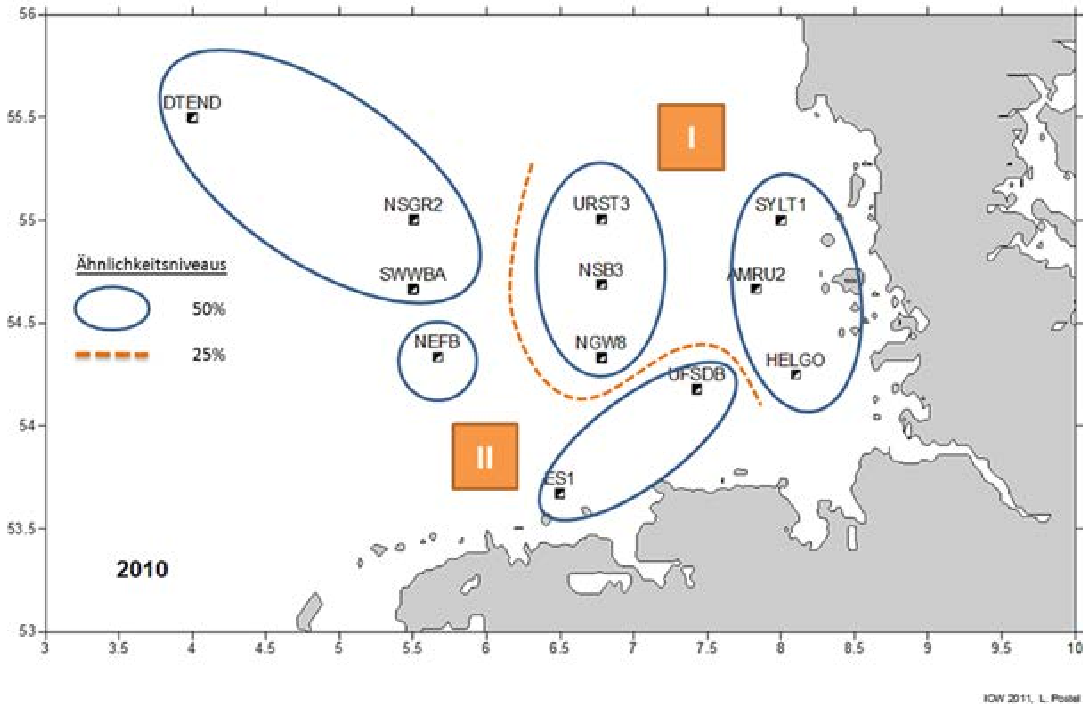

Figure 12: Spatial distribution of mesozooplankton communities according to cluster analysis based on the abundances of all taxa and their developmental stages in the German EEZ 2010 (Wasmund et al. 2011).

2.4.3. Status assessment

Overall, taking into consideration all available long-term data (CPR, Helgoland Reede), changes in both phytoplankton and zooplankton in the North Sea have been observed since the late 1980s and 1990s. The slowly progressing changes affect species composition as well as abundance and biomass (ALHEIT et al. 2005, WILTSHIRE & MANLY 2004, BEAUGRAND 2009, REID et al. 1990). The evaluation of the phytoplankton data from Helgoland Reede shows a significant increase in biomass since records began. This increasing trend in biomass appears to be related to the development of flagellates. For the area of the German Bight, a decline of diatoms in favour of small flagellates has been observed since the early 1970s (HAGMEIER & BAUERNFEIND 1990, VON WESTERNHAGEN & DETHLEFSEN, 2003). The changes in the phytoplankton also affect a weakening of the late summer diatom bloom, an extension of the growth phase, and the occurrence of algal blooms of non-native species. In addition to natural variability, these changes may be related to anthropogenic influences such as eutrophication and, not least, the North Atlantic Oscillation (NAO) and the increase in water temperature observed in the North Sea. However, because plankton is influenced by a wide range of natural and anthropogenic factors and because very few investigations have been carried out in this area, it remains unclear to what extent eutrophication, climate change, or simply natural variability contribute to changes in phytoplankton (EDWARDS & RICHARDSON 2004). Non-native species are also having an increasing impact on succession. The number of non-indigenous species spreading in the North Sea as a result of anthropogenic factors has increased considerably during the period under review. Non-indigenous species are introduced via the ballast water of vessels and mussel aquaculture. Effects of non-native plankton species on the species composition of native species through displacement, changes in biomass, and primary production cannot be ruled out. Throughout the North Sea, 17 non-indigenous phytoplankton species have been detected in samples (GOLLASCH & TUENTE 2004). Some of the non-native phytoplankton species are now developing pronounced algal blooms in German coastal waters and the EEZ of the North Sea. The non-native thermophilic diatom species *Coscinodiscus wailesii* has slowly established itself in the German Bight since 1982 and even formed a spring bloom in 2000. Fifteen non-native species have been found in the zooplankton of the North Sea since 1990 (**Gollasch** 2003). Based on evaluations of the long-term series from the Helgoland Reede, WILTSHIRE & MANLY (2004) have, for the first time, established a direct link between the increase in water temperature and the shift in phytoplankton abundance in the North Sea. The authors correlated the 1.13°C increase in water temperature observed between 1962 and 2002 with the mean diatom day (MDD), a calculated parameter of diatom abundance. It was shown that the aforementioned increase in temperature over the 40-year period has caused a shift in the occurrence of phytoplankton. Following a relatively warm winter quarter, the MDD shifts more towards the end of spring. In such cases, diatoms reach a high abundance.

Based on these results and other studies, the authors point out that although the living conditions of marine organisms have not yet reached limiting ranges, the control mechanisms of seasonal and spatial events have changed considerably (BEAUGRAND et al. 2003). It can be assumed that this also applies to the German EEZ. In addition to the aforementioned temporal shift or delay in phytoplankton succession (WILTSHIRE & MANLY 2004), a possible species shift could also have consequences for the primary and secondary consumers of the food chains. Changes in the species composition, abundance, and biomass of plankton have consequences for both the primary production of water bodies and the occurrence and populations of fish, marine mammals, and seabirds. Thus, the reduced abundance of diatoms in favour of small flagellates could have a negative impact on the food chain (VON WESTERNHAGEN & DETHLEFSEN 2003) because *C. wailesii*, which is now highly abundant in the German Bight, is not eaten by primary consumers. Changes in the seasonal pattern of phytoplankton growth can also lead to trophic mismatch within marine food chains: a delay in diatom growth can affect the growth of primary consumers. Under certain conditions, phytoplankton can pose a threat to the marine environment. In particular, toxic algal blooms pose a major threat to secondary consumers of the marine ecosystem and to humans. According to REID et al. (1990), a number of phytoplankton taxa are known to be toxic or potentially toxic in the North Sea.

There is also evidence of a gradual change in zooplankton since the early 1990s. For example, the species composition and dominance ratios have changed. Whilst the number of non-native species has increased, many species typical of the area, including those that are part of the natural food resources of the ecosystem, have decreased. In general, the abundance of native cold-water species in holoplankton has declined sharply. In contrast, meroplankton has increased (LINDLEY & BATTEN 2002). The proportion of echinoderm larvae has increased noticeably. This is mainly associated with the distribution of the opportunistic species *Amphiura filiformis* (KRÖNCKE et al. 1998).

The seasonal development and succession of zooplankton in the German Bight correlates predominantly with changes in water temperature. However, the changes in seasonal development vary from species to species. Overall, in warm years, abundance maxima of various key species occur up to 11 weeks earlier than usual in the long-term trend (GREVE 2001). The growth phase of many species has been extended overall. According to HAYS et al. (2005), climate changes have particularly affected distribution limits of species and groups of the North Sea marine ecosystem. For example, zooplankton associations of warm-water species have shifted their distribution almost 1,000 km northwards in the north-east Atlantic. In contrast, the areas of cold water associations have decreased. In addition, climate changes have effects on the seasonal occurrence of abundance maxima of different groups. For example, the copepod *Calanus finmarchicus* reaches its maximum abundance 11 days earlier whilst its main food, the diatom *Rhizosolenia alata*, reaches its maximum concentration 33 days earlier and the dinoflagellate *Ceratium tripos* 27 days earlier. This delayed population development can have consequences for the entire marine food chain. EDWARDS & RICHARDSON (2004) even suggest a particular threat to temperate marine ecosystems because of changes or temporal offsets in the development of different groups. The threat arises from the direct dependence of the reproductive success of secondary consumers (fish, marine mammals, seabirds) on plankton (food source). 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 reactions vary greatly in terms of association or group and seasonality.

2.5. Biotope types

According to POTT (1996), a biotope type is an abstracted type from the totality of similar biotopes with largely uniform conditions for the biocoenoses. In the terrestrial realm, these are habitats characterised predominantly by specific plant communities. The typification includes abiotic (in the marine environment mainly sediment composition and depth zone) and biotic features (occurrence of certain species and communities). The currently valid national biotope type classification (FINCK et al. 2017) primarily takes into consideration the biocoenoses according to SALZWEDEL et al. (1985), adapted and adjusted by RACHOR & NEHMER (2003), in the typification for the North Sea.

In addition, some marine biotopes are subject to direct federal protection according to Section 30 BNatSchG. Section 30, para. 2 BNatSchG generally prohibits actions that may cause destruction or other significant adverse effects on the biotopes listed. According to Section 72, para. 2 WindSeeG, Section 30, para. 2, sentence 1 BNatSchG shall be applied to projects with the proviso that a significant adverse effect on biotopes within the meaning of Section 30, para. 2, sentence 1 BNatSchG shall be avoided as far as possible. This protection was extended to the EEZ with the amendment of the BNatSchG in 2010. However, Section 30, para. 2, sentence 1 BNatSchG shall be applied to projects under the WindSeeG with the proviso that a significant adverse effect on biotopes shall be avoided as far as possible. The selection of

legally protected biotopes took into consideration the national or regional endangerment classification as well as the list of natural habitat types of the Habitats Directive (Annex 1, Directive 92/43/EEC). The legally protected biotope types are mainly “biotope complexes”, which can comprise several different biotope types in a mosaic.
In the EEZ of the North Sea, the following biotopes, which are legally protected according to Section 30, para. 2, No. 6 BNatSchG, are potentially present: Reefs (also FFH habitat type), sublittoral sandbanks (also FFH habitat type), species-rich gravel, coarse sand and shell layers as well as silt beds with burrowing mega-fauna communities. Seagrass meadows and other marine macrophytes are not to be expected because of the prevailing turbidity and water depth.

2.5.1. Data availability

The basis for the population description is the current status of the biotope type map provided by the BfN (as of February 2024). The BfN has been mapping the benthic biotope types in the exclusive economic zone of the North Sea and Baltic Sea since 2012. The BSH supports this process, particularly with sediment mapping. The project has largely been completed in the nature conservation areas. High-resolution biotope maps covering the entire area are thus now available. For the areas outside the protected areas, the map represents an interim status (Figure 13). Here, the biotope type map is based primarily on interpolated sediment information (LAURER et al. 2013) and modelled distributions of benthic biocoenoses. In particular for the maritime areas with heterogeneous sediment structure, the possibility of further, previously unknown occurrences of legally protected biotopes in areas with an interpolated sediment map cannot be completely ruled out.

Further indications of small-scale biotope changes and the selective occurrence of legally protected biotopes (especially marine boulders as defined by BfN 2018) are provided by the information available at the BSH from various planning permission and plan approval procedures.

2.5.2. Standard biotope types of Germany (FINCK et al. 2017)

The revised standard biotope type list of the BfN (FINCK et al. 2017) has a predominantly hierarchical structure for the marine area and comprises six classification levels. The maritime region (North Sea, Baltic Sea) as well as the abiotic parameters depth zone (Eu- and Sublittoral) and sediment form the fundamental basis for the marine area. A finer subdivision of the biotope types takes place with the inclusion of biological components from level 4. At this level, a rough distinction is first made between structure-forming ecological groups (plants and algae, epifauna, infauna). At Level 5, the biological biocoenoses in the sublittoral zone of the North Sea are introduced into the classification system according to RACHOR & NEHMER (2003), which can be further specified at the finest level 6 by taking into consideration dominant taxa.

The Red List of endangered biotope types in Germany contains 278 natural biotope types for the marine area (North Sea and Baltic Sea); of these, slightly more than 50% have been categorised as endangered. Of these, 13 biotope types are classified as completely destroyed (category 0), seven as threatened with complete destruction (category 1), and 43 biotope types as endangered (category 2). The completely destroyed biotope types in the North Sea include various bio- and geogenic reef types, which are characterised by the European oyster *Ostrea edulis* or the sand coral *Sabellaria* spp (FINCK et al. 2017). The main reasons for the disappearance of these biotopes are various human factors such as heavy use and nutrient/pollutant inputs.

Of the 278 marine biotope types, fewer than 100 biotope types potentially occur in the German EEZ of the North Sea. The distribution of most of these biotope types is limited to the heterogeneous substrate structures of the Sylter Außenriff and Borkum Riffgrund. Because of their homogeneity, the large areas of sand and mud below a water depth of 35 m offer a considerably lower diversity of habitats.

The following description of the distribution of benthic biotope types in the German EEZ of the North Sea is based primarily on the biotope map compiled by the Federal Agency for Nature Conservation (BfN). It is generally not possible to map and visualise the biotopes of classification level 6 (taking into consideration the dominant taxa) at the selected scale level. The species (groups) relevant for the endangerment classification are therefore taken into consideration in the protected asset benthos (cf Chapter 2.6.2). Furthermore, those biotopes that have an almost complete spatial overlap with legally protected biotopes because of their sedimentological and, in some cases, biological features are not shown here. This includes the types 02.02.01 (Sublittal rocky and stony bottom of the North Sea) and 02.02.06 (Sublittal mixed substrate of the North Sea), which are dominated by rocks, blocks, and stones as well as the types 02.02.02 and 02.02.03, which are characterised by moraine clay and are largely absorbed into the FFH habitat type reefs in the EEZ. Sublittoral coarse sediment banks (02.02.07) and sublittoral sandbanks (02.02.09) together form the “sandbank complex”, which is also legally protected as an FFH habitat type according to Section 30 BNatSchG. Sublittoral shell layers (02.02.04) are potentially assigned to the legally protected biotope “species-rich gravel, coarse sand and shell layers” but cannot be surveys at the selected mapping scale because of their small-scale distrubution. The latter also applies to sublittoral peat beds (02.02.05) so that the following description focusses on the sublittoral, flat coarse sediments (02.02.08), the sublittoral, flat sand beds (02.02.10), and the sublittoral silt beds (02.02.11).

Sublittoral, level coarse sediment of the North Sea (02.02.08)

Level coarse sediment areas are closely interlocked with glacial deposits and therefore often form complex structures with reefs. In the sublittoral zone of the North Sea, the biotope is usually colonised by the *Goniadella spisula* community (Biotope code 02.02.08.02.01) or dominated by epifauna (02.02.08.01). In their species-rich character, they correspond to the legally protected biotope “species-rich gravel, coarse sand and shell layers” (cf Chapter 2.5.3.3). The coarse sediments in the “Sylter Außenriff – Östliche Deutsche Bucht” and “Borkum Riffgrund” nature conservation areas as well as individual neighbouring areas have been mapped.

Coarse sediments are widespread in areas N-5 and N-19 as well as in Site N-13.4*. Local evidence is available from Area N-4 (especially the northern part of this area). However, a biological characterisation for a more detailed breakdown of this biotope type in these sites is still pending. The sediment information available does not indicate the occurrence of coarse sediments in the other sites and areas. However, small-scale occurrences of coarse sediments, especially on slopes exposed to currents (e.g. south-eastern slope of Doggerbank) as well as on flat grounds (e.g. Weiße Bank) cannot be completely ruled out.

Sublitoral even sandy bottom of the North Sea (02.02.11) and sub-types

Sublittoral sand beds make up by far the largest area of all Level 3 biotope types in the German EEZ of the North Sea. In the silt-poor fine sands up to 30–35 m water depth, this biotope type occurs in the form “sublittoral, even sandy bottom of the North Sea with *Tellina-fabula* community” (code 02.02.10.02.03). This biotope type can be found in Areas N-4 and N-5 as well as in the eastern parts of Area N-13. The medium and coarse sands in the same maritime areas are colonised by a *Goniadella-Spisula* community. The corresponding biotope has the code 02.02.10.02.04. In the areas below 30–35 m, the proportion of silt in the sand beds increases. This habitat is colonised by either an *Amphiura filiformis* or a *Nucula nitidosa* community with the latter occurring mainly in the areas closer to the coast (PESCH et al. 2008). Because of a strongly overlapping species inventory and a high interannual fluctuation (FIORENTINO et al. 2017), the two communities cannot be reliably separated in the modelling of their distribution and are therefore shown together in the BfN map (biotope codes 02.02.10.02.01 and 02.02.10.02.05). The sites of Areas N-12 and N-9 lie within the spatial transition zone between these two biotope types. On the other hand, according to the current state of knowledge, Sites N-14.1 through N-14.3 and N-16.2 throguh N-16.6 as well as Areas N-17 and N-20 located to the north-west of this are currently known to be colonised by an *Amphiura filiformis* community and can therefore be assigned primarily to biotope code 02.02.10.02.01. In the transition to Doggerbank, the benthic community changes to the *Bathyporeia tellina* community and thus also the corresponding biotope type (code 02.02.10.02.02). According to the BfN biotope map, N-17 in the northern sub-site of the area is classified as this biotope type. Area N-19 lies entirely within a sandbank and therefore requires no further classification as a biotope type according to FINCK et al. (2017).

In the northern section of the Elbe Glacial Valley, the BfN identifies the sub-site with a dominance of *Callianassa*, *Upogebia*, and *Nephrops* (“burrowing mega-fauna”, Figure 13) for a section of the sublittoral even sandy bottom of the North Sea with an *Amphiura filiformis* community. FINCK et al. (2017) classify this habitat type as vulnerable to endangered (RL Cat. 2–3), in particular because of the high fishing pressure on the eponymous species *Nephrops norvegicus* (Norway lobster). The study on which the designation of this biotope was based was not available to the BSH at the time this report was prepared. However, the designated sites show a high degree of overlap with a main fishing area for Norway lobster in the German fishing fleet (LETSCHERT et al. 2021). The joint data set from the BSH and BfN also shows an increased occurrence of the crab genus *Upogebia* in this area (cf Chapter 2.6.2.2). The occurrence of this more endangered biotope type can therefore not be ruled out *a priori* and will be taken into consideration below as part of the precautionary approach subject to an assessment that may need to be adjusted when an updated data basis is available.

Sublitoral silt bottom of the North Sea (02.02.11) and sub-types

According to FINCK et al. (2017), sublittoral sediments with a silt content of at least 20% are referred to as silt beds. Such substrates are found in the German EEZ of the North Sea – mainly along the Elbe glacial valley – as well as in the outer EEZ in the area of the eastern oyster bed and other smaller areas. Analogous to the surrounding silty sands, they are colonised by an *Amphiura filiformis* or a *Nucula nitidosa* community. Such biotopes can be foundin the western areas of Site N-13.4*, in large parts of Site N-16.1, and to a lesser extent in other areas of Area N-16 (especially N-16.5). They can also occur in other areas provided that the silt content in the sediment is above 20%.

The BfN also identifies the subtype “dominated by *Callianassa*, *Upogebia*, *Nephrops*” (Figure 13) for this biotope type, analogous to the flat sand beds in the northern area of the Elbe Glacial Valley. This habitat type is also assessed as vulnerable to endangered in FINCK et al. (2017) (RL Cat. 2–3). With regard to the data situation and the procedure for consideration of this biotope type, the statements made for the comparable biotope type of flat sand beds apply.

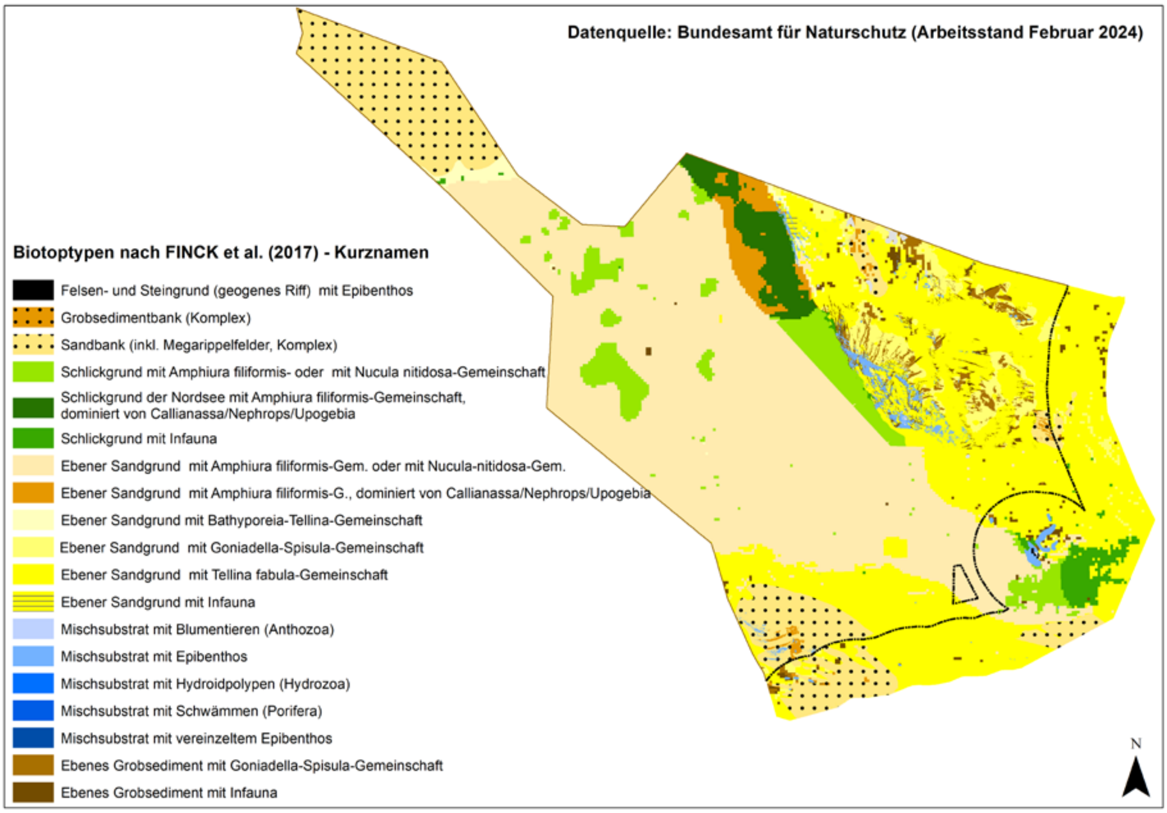

Figure 13: Illustration of the distribution of North Sea sublittoral biotope types (short names) according to Finck et al. (2017) in the German sector of the North Sea, data bases: Biotope type map of the BfN, working status February 2024

2.5.3. Legally protected marine biotopes in accordance with Section 30 BNatSchG and FFH habitat types

2.5.3.1. Reefs

Reefs are habitats characterised by hard substrates, which can be of either biogenic or geogenic origin. They are colonised by a biocoenosis that differs considerably from the surrounding soft substrates and is often richer in species. Geogenic hard substrates are found in the German EEZ of the North Sea, particularly where glacial debris is not permanently covered by a sediment layer and thus penetrates the surface of the seabed. This is particularly, but not exclusively, the case in the area of the Sylter Außenriff and its western slopes in the transition to the Elbe Glacial Valley and in the area of the Borkum Riffgrund. Depending on the composition of the debris and the local sediment dynamics, the sites are characterised by more or less coarse residual sediments with or without stones, blocks, or marine boulders. Accordingly, the mapping guidelines (BFN 2018) categorise the geogenic reefs in the North Sea into “stone/block fields” and “residual sediment with scattered stones and/or blocks”. The “marine boulders” are a special type. These are solitary erratic blocks with a length of at least 2 m; according to BFN (2018), these are also to be assessed as a protected biotope. Such marine boulder have not yet been systematically recorded in the German EEZ of the North Sea and therefore cannot be considered in the SEA. However, data from planning approval and planning permission procedures show that marine boulders can occur throughout the entire EEZ.

Biogenic reefs are composed of biogenic materials (e.g. mussel shells, calcareous skeletons) and therefore occur independently of available geogenic hard bottoms (e.g. bed-stable mussel banks, sand coral banks). There is currently no information on the occurrence of biogenic reefs in the German EEZ of the North Sea.

Current investigations confirm the occurrence of geogenic reefs in Site N-13.4* and in Area N-5. Furthermore, there are suspected areas for smaller reef occurrences on the first 10–15 km of the route within the EEZ of the connection systems coming from the Gate N-V as well Interconnector I_NOR-6. In addition, the corridor variant for the SEN-1 hydrogen pipeline in the direction of Gate N-I runs through at least one designated reef area within the “Borkum Riffgrund” nature conservation area. A smaller reef area is also crossed on the alternative corridor in the direction of Gate N-III.

The reefs are analysed in more detail in the biotope conservation assessment (Chapter 5.1).

2.5.3.2. Sandbanks

Habitats Directive habitat type 1110 refers to “Sandbanks with only slight permanent overtopping by seawater”. Sandbanks are identified and characterised mainly by their topography (elevation relative to the surrounding seabed) and their sediments. Depending on their geological genesis, they consist of homogeneous sands or mosaics of different sands and gravels. Residual sediments and boulder field embedded in these mosaics are to be assigned to the Habitats Directive habitat type “Reefs” provided they comply with the mapping instructions (BFN 2018). Important ecological functions of sandbanks include foraging and nursery areas for fish species, foraging habitats for resting and wintering seabirds, and a stepping stone function for the distribution of bottom-dwelling organisms throughout the North Sea (NARBERHAUS et al. 2012).

Submarine sandbanks were identified by KLEIN (2006) and examined, supplemented, and reported to the European Union as FFH habitat type “sublittoral sandbank” by the BfN. According to the current state of knowledge, no further sandbanks are expected to be designated in the EEZ. In the German EEZ of the North Sea, four sites have been designated as legally protected sandbanks: Amrumbank, Borkum Riffgrund, Doggerbank, and Sandbank 24.

Doggerbank extends from the protected area of the same name to the north-west to the tip of the North-western region of the German EEZ and thus also includes the entire Area N-19. Area

N-5, which is earmarked for subsequent use, partially overlaps with “Sandbank 24” to the west of Sylter Außenriff.

Furthermore, the corridor variant for the hydrogen pipeline SEN-1 leads in the direction of the border corridor N-I over a distance of approx. 21 km through the sandbank within the “Borkum Riffgrund” nature conservation area over a distance of approx. 21 km as well as a further 7 km through the same sandbank outside the aforementioned protected area.

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

This biotope includes species-rich sublittoral pure or mixed deposits of gravel, coarse sand, and shell sediments of the seabed, which are colonised by a specific macrozoobenthos community, the composition of which depends not only on the substrates but also on the natural environment. This community is often richer in species than the biocoenosis in the surrounding middle sands. 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 as well as from the mostly small-scale alternation of different grain sizes, which offers different ecological niches. In the sublittoral zone of the North Sea, the biotope is usually colonised by the *Goniadella spisula* community. This can be identified by the occurrence of various typical macrozoobenthos species such as *Spisula elliptica, Branchiostoma lanceolatum, and Aonides paucibranchiata*.

Species-rich gravel, coarse sand and shell layers can be associated with stones or mixed substrates and locally with blue mussel beds and thus occur in direct spatial proximity to the FFH habitat type “Reefs”. Reefs and species-rich gravel, coarse sand and shell layers form closely interlocked mosaics, especially on subtidal shelves, current-exposed slopes, and shallow bottoms. Coarser substrates within the “sublittoral sandbanks” FFH habitat type often correspond to the characteristics of species-rich gravel, coarse sand and shell layers and represent more valuable areas of the sandbank from a nature conservation perspective.

The biotope “species-rich gravel, coarse sand and shell layers in marine and coastal areas” can be surveyed only by means of comprehensive, high-resolution sediment mapping in conjunction with biological verification (BFN 2011a). Such high-resolution mapping has so far been carried out only for the nature conservation areas and individual directly neighbouring areas. For this reason, confirmed evidence of this biotope, which is legally protected under Section 30 BNatSchG, is available only from Area N-5 and the surrounding areas intended for subsequent use for the sites and areas under consideration here Coarse substrates are also widespread in Site N-13.4 and in Area N-19 (cf Chapter 2.5.2). Furthermore, there are suspected areas for smaller coarse sediment areas in the northern part of Area N-4 on the first 10–15 km of the route within the EEZ of the connection systems coming from Gate N-V as well as Interconnector I_NOR-6. In addition, the corridor variant for the SEN-1 hydrogen pipeline in the direction of the Gate N-I runs for approx. 7 km through coarse substrates on the sandbank within the “Borkum Riffgrund” nature conservation area.

Such substrates form the basis for the occurrence of this legally protected biotope. However, biological verification according to BFN (2011a) is not available for these sites and areas. For precautionary reasons, however, these areas are regarded as suspected areas for species-rich gravel, coarse sand and shell layers and are treated analogously to confirmed occurrences in the following.

The sediment information available does not provide any further indications of larger areas of coarse sediment in the other sites and areas. Small-scale occurrences of coarse sediments and thus potentially of legally protected biotope sites, especially on slopes exposed to currents (e.g. south-eastern slope of Doggerbank) and on flat grounds (e.g. Weiße Bank) cannot be completely ruled out.

2.5.3.4. Silt beds and burrowing mega-fauna communities

The legally protected biotope “Silt beds with burrowing mega-fauna communities” is determined by the occurrence of sea pens (Pennatularia) of which some species are particularly sensitive to mechanical disturbances and damage. In addition to the obligatory sea pens, the biotope can be characterised by the occurrence of burrowing crab species (according to the mapping instructions, this includes *Nephrops norvegicus, Calocaris macandreae, Upogebia deltaura, Upogebia stellata*, and *Callianassa subterranea*).

While most crab species mentioned in the mapping instructions are widespread in the silt-rich sediments of the German EEZ of the North Sea, there is no recent evidence of sea pens from the relevant substrates. Without the occurrence of this obligatory character species, there is also no evidence of the occurrence of the legally protected biotope silt beds with burrowing mega-fauna in the German EEZ.

2.5.4. Status assessment

The importance of the biotope types occurring in the German maritime area is assessed on the basis of the national protection status and the endangerment classification in the Red List of endangered biotope types in Germany FINCK et al. 2017). The legally protected biotopes are of major importance in this context.

Almost all sublittoral biotopes far from the coast are categorised as vulnerable (Cat. 3-V) in FINCK et al. (2017). For most biotopes, FINCK et al. (2017) and BMUV (2023) cite degradation caused by current or past nutrient and pollutant inputs (including wastewater discharges, oil spills, dumping, waste, and rubble dumping) and physical disturbance (especially from bottom-disturbing fishery and possibly from the effects of construction activities) as causes of endangerment. There is currently only a risk of loss for small-scale biotopes such as biogenic reefs.

In addition to the degree of endangerment of the respective biotope type, the biotope diversity is taken into consideration when assessing the importance of the respective site/area. Heterogeneous areas that harbour several biotope types provide a habitat for different biocoenoses. They are therefore of greater importance for the preservation of biodiversity, among other things.

2.5.5. Importance of areas and sites for the protected asset biotopes

Area N-4

Area N-4, which is intended for subsequent use, has a largely homogeneous sediment structure of fine sands. However, coarser sediments also occur, especially in the northern area (e.g. IFAÖ 2004). Because of the homogeneous biotope structure, Area N-4 is of low to medium importance whilst areas with coarse sediments are of medium to high importance for the protected asset biotopes.

Area N-5

Area N-5 is located in a sedimentologically heterogeneous area on the edge of the Sylter Außenriff. In parts of the area, various sand, coarse sediment and mixed substrates form extensive mosaics (e.g. AQUA TECH 2003 in BIOCONSULT 2006), some of which can be assigned to the definitions of the legally protected biotopes “reefs” and “species-rich gravel, coarse sand and shell layers”. More than half of Sandbank 24 designated by the BfN is also located within Area N-5. On the other hand, the south-eastern part of Area N-5 is largely characterised by more homogeneous sands.

Because of the great diversity of biotopes and the possible or confirmed occurrence of three different legally protected biotopes, Area N-5 is of medium to high importance in terms of biotope conservation.

Areas N-9 and N-12

Homogeneous sublittoral sand beds characterised by an *Amphiura filiformis* or a *Nucula nitidosa community* (biotope code 02.02.10.02.01/02.02.10.02.05) prevail in all sites under consideration in Areas N-9 and N-12. Particularly in the northern area of Site N-12.5, the silt-rich fine sands transition to the biotope type sublittoral silt beds because of the higher silt content; however these are colonised by the same communities (code 02.02.11.02.01/02.02.11.02.02). Because of the wide distribution and the comparatively low endangerment classification of the biotopes present, Sites N-9.4, N-9.5, N-12.4, and N-12.5 are of low to medium importance for the protected asset biotopes.

According to the BfN, there are indications of a possible special character because of special occurrences of long-lived and functionally important species (here mainly species of deep-digging mega-fauna) for parts of Site N-12.5 (Figure 13, cf also Chapter 2.6.2.2). If the occurrence of this endangered biotope is confirmed by further investigations, such areas would be of medium to high importance for the protected asset biotopes.

Area N-13(Site N-13.4*)

Site N-13.4* in Area N-13 is located at the transition from the Sylter Außenriff to the Elbe Glacial Valley. This is accompanied by a change from coarse and sandy substrates in the North-east of the area to silt-rich substrates in the South-west. This change of substrate is interrupted by a band of residual sediment and stone blocks that runs from north to south through both subsites. These areas are assigned to the legally protected biotope “reefs” and, according to current knowledge, make up approx. 10.5% of the site. In addition to the reefs, the species-rich gravel, coarse sand, and shell layers may constitute a second legally protected biotope. However, biological verification of the identified coarse sediment areas is still pending. According to the BfN, there are also indications of special characteristics of the flat sand and silt beds in the west of the site because of special occurrences of long-lived and functionally important species (here mainly species of deep-digging mega-fauna). As a result, Site N-13.4 offers a high overall diversity of biotopes. The importance of the area for the protected asset biotopes is therefore to be rated as high overall.

Areas N-14, N-16, N-17, and N-20

Similar to Areas N-9 and N-12, Areas N-14, N-16, N-17, and N-20 are dominated by homogeneous sublittoral sand beds characterised by an *Amphiura filiformis* or a *Nucula nitidosa* community (biotope codes 02.02.10.0201/02.02.10.02.05). In parts of the areas, the silt-rich fine sands turn into silt beds, which are colonised by the same communities (02.02.11.02.01/02.02.11.02.02). Because of the wide distribution and the comparatively low threat classification of the biotopes present, the importance of areas N14, N-16, N-17, and N-20 is classified as low to medium.

Deviating from this, according to the BfN, for Site N-16.1, there are indications of special characteristics of the flat sand and silt beds because of the occurrence of particular densities of species of burrowing mega-fauna (here mainly the Norway lobster *Nephrops norvegicus*). For areas that correspond to the corresponding biotope type, a medium to high importance for the protected asset biotopes would be assumed.

The northern part of Area N-17 is located in the transition area to the Doggerbank and has a different colonisation structure than the deeper and more silt-rich substrates and is therefore classified as the biotope type “Sublittoral flat sand bed of the North Sea with *Bathyporeia-Tellina* community” (code 02.02.10.02.02). Because of the geographical restriction and the higher endangerment classification of this biotope, this part of Area N-17 would be assigned medium importance.

Area N-19

Area N-19 is located entirely within the “Doggerbank” sandbank designated by the BfN and thus entirely within a legally protected biotope. The sandbank in Area N-19 occurs locally in the form of a coarse sediment bank or as suspected areas for the species-rich gravel, coarse sand and shell layers, which is also a legally protected biotope. Area N-19 is considered to be of high importance for the protected asset biotopes because of the extensive legally protected biotope “Sandbank”.

2.5.6. Importance of the routes for the grid connection systems, interconnectors, and corridors for hydrogen pipelines for the protected asset biotope types

Grid connection systems from Gate N-II (NOR 6-4)

Starting from Gate N-II, Grid connection system NOR 6-4 initially runs in a northerly direction and later bypasses Area N-2 in a north-westerly direction through flat fine sand beds with a *Tellina fabula* community. This involves crossing the sandbank at Borkum Riffgrund outside the nature conservation area of the same name over a length of approx. 8–9 km. Because of the protection status of the sandbank as a Section 30 biotope, the importance of this section of the lake connection system is rated as high.

The importance of the flat sand bed with *Tellina fabula* community is rated as low because of the widespread distribution of this biotope type and the generally rapid regenerative capacity of the biocoenosis. As the route progresses, the depth and silt content of the sediment increase and the *Tellina fabula* community is initially replaced by a *Nucula nitidosa* and then by an *Amphiura filiformis* community as it continues to the converter site (Biotope code 02.02.10.02.01/02.02.10.02.05). Special features with regard to the characteristics of the aforementioned biotope types are not to be considered in the course of Grid connection NOR 6-4. The importance of this section for the protected asset biotope types is thus assessed as low to medium.

Grid connection systems from Gate N-III (NOR 9-4, 9-5, 14-1, 14-2, 14-3, 16-3, 16-4, 16-5)

All grid connection systems coming from Gate N-III cross an area with flat fine sands with a Tellina-fabula community in a north-north-westerly direction. This section of the route is of minor importance for the protected asset biotope types.

To the south-east of Area N-3, a reef area to the east of the corridor was identified as part of the procedure for the NeuConnect interconnector. The occurrence of further reef areas as well as coarse sediments and thus of potentially protected biotopes, cannot be completely ruled out in this section. The importance of these biotope types is generally assessed as high.

As the route progresses, the depth and silt content of the sediment increase, and the *Tellina fabula* community is initially replaced by a *Nucula nitidosa* and then by an *Amphiura filiformis* community as it continues to the converter sites (Biotope code 02.02.10.02.01/02.02.10.02.05). With regard to the importance of the areas for the protected asset biotope types, the assessments for the areas and sites passed apply so that according to the current state of knowledge, no special characteristics need to be taken into consideration. This results in an assessment of low to medium for Grid connection systems NOR 9-4 and NOR 9-5 as well as NOR 14-1, NOR 14-2, and NOR 14.3 and NOR 16-3, NOR 16-4, and NOR 16-5.

Grid connection systems from gate N-V (NOR 12-3, 12-4, 16-1, 16-2)

The grid connection systems coming from the Gate N-V enter the EEZ in a westerly direction between Heligoland and Area N-4 and initially cross a short section of flat sandy bottom with a *Tellina fabula community* (low importance). Based on the information available, small-scale occurrences with coarse sediments and stone and boulder fields, which would be legally protected biotopes, are also likely in this area. Depending on their colonisation structure and the resulting possible demarcation as legally protected biotopes, such areas would be of medium to high importance as species-rich gravel, coarse sand and shell layers or reefs.

Most of the rest of the route is dominated by silt-rich, flat fine sand beds with *Nucula nitidosa* and *Amphiura filiformis* communities (Biotope code 02.02.10.02.01/02.02.10.02.05). Locally, the sediments are classified as silt beds because of a silt content of over 20%. There are no indications of special characteristics of the corresponding biotope types for the entire course of Grid connection systems NOR 12-3 and NOR 12-4 so that the importance of this route section is assessed as low to medium.

The same assessments apply also to Grid connection systems N-16.1 and N-16.2 from the entry into the EEZ to the bundling point south-west of Site N-12.4 and in the further course until reaching Site N-16.1 (aggregated assessment low to medium). For the last route section up to the planned converter site, the same statements apply for Grid connection system NOR 16-1 as for Site N-16.1 (cf Chapter 2.5.5). The importance of this last section of the route for the protected asset biotope is therefore rated as medium to high.

Interconnectors

Five interconnector routes are to be considered. These will either connect individual OWF in the German EEZ of the North Sea with the grids of neighbouring countries or connect the power grids of Germany with those of the neighbouring countries.

The shortest interconnector (I-NOR-12) connects Site N-14.3 with the systems of the Netherlands and leaves the German EEZ after a distance of less than 8 km, which runs along the northern edge of the Site N-14.3. Therefore, the same statements apply to the importance of the route area as for Site N-14.3 (overall low to medium).

A further interconnector (I-NOR-11) connects Site N-16.5 with the Danish grid system and initially runs along Site N-16.5 to the north-west and then turns to the north-east between the two sub-sites of Site N-16.6 and follows the route of the VikingLink interconnector. Interconnector I-NOR-10 runs parallel to the VikingLink route and therefore partly also parallel to Interconnector I-NOR-11. This maritime area is dominated by silt beds and silt-rich sand beds with an *Amphiura filiformis* community. Individual blocks were identified on the route to the VikingLink interconnector; however, these did not meet the criteria of the legally protected reef biotope. Because of the homogeneity of the habitat without enhancing features, the importance of the routes for these interconnectors is rated as low to medium. Should reefs be identified in the route area, these areas would be of high importance.

To the north-west of Shipping route SN10, two further interconnectors (I-NOR-8 and I-NOR-9) run along the south-eastern edges of Areas N-14 and N-16 from the Dutch EEZ to the Danish EEZ. For the entire route, reference should therefore be made to the descriptions and assessments for the areas mentioned. The importance of the route area is therefore to be assessed as low to medium in terms of the protected asset biotope types. An exception to this is the section along Site N-16.1; this is of medium to high importance because of the likely higher value of the biotope North Sea silt beds with *Amphiura filiformis* community dominated by *Callianassa/Upogebia/Nephrops*.

Another interconnector (I-NOR-7) runs almost parallel to this to the south-east of Shipping route SN10 along the north-western edges of Sites N-9.4, N-9.5, N-12.4, N-12.5, and N-13.4. For the route section from the entry of the interconnector from the Dutch into the German EEZ to the boundary of Site N-12.5, the importance of the route for the protected asset biotope types to be protected is assessed as low to medium according to the comments on the sites mentioned. For the section of the route along Sites N-12.5 and N-13.4 – and here in particular for the reef to be crossed – the importance is assessed as medium to high (cf Chapter 2.5.5.).

The same applies to the fifth interconnector (I-NOR-6), which is to connect the German power grid with Denmark and runs parallel to the interconnector described above from Site N-12.4. This interconnector runs parallel to the grid connection systems coming from the Gate N-V along the southern edges of Areas N-11 and N-12. Accordingly, the statements and assessments made there are transferable to this section of the interconnector.

Corridors for hydrogen pipes for the grid connection of Site SEN-1

The corridor variant for the hydrogen pipeline SEN-1 in the direction of the Gate N-I crosses the sandbank within the “Borkum Riffgrund” nature conservation area over a distance of approx. 21 km as well as a further 7 km through the same sandbank outside the aforementioned protected area. It also crosses around 7 km of coarse substrates within the nature conservation area and crosses at least one designated reef area. The importance of the route corridor for this route section is therefore rated as high for the protected asset biotopes. In the further course of the corridor up to Site SEN-1, predominantly widespread biotope types are crossed. The importance of these route sections for the protected asset biotope is rated as medium.

A smaller reef area is also crossed on the alternative corridor in the direction of Gate N-III. However, according to the current state of knowledge, this high-quality section of the route covers only a few hundred metres. In the further course of the route to the Site SEN-1, predominantly widespread biotope types are crossed. The importance of these route sections for the protected asset biotope is rated as medium.

2.6. Benthos

Benthos refers to all organisms living on or in seabed substrates. According to RACHOR (1990a), the benthos includes micro-organisms such as bacteria and fungi, unicellular animals (protozoa), and plants as well as inconspicuous multicellular organisms and large algae and animals up to bottom-dwelling fish. The protected asset benthos focusses on larger invertebrates (i.e. the macrozoobenthos). Whilst benthic fish species are taken into consideration in the protected asset fish (Chapter 2.7), plants (including macroalgae) do not occur in the North Sea because of the great water depth and the high turbidity of the water body in the German EEZ in the North Sea. For smaller benthic organisms (meiobenthos, microbenthos), there is a lack of comprehensive data for an area-wide population assessment as well as clear findings and indicators for assessing the effects of the pressures under consideration. The macrozoobenthos (animals > 1 mm) is therefore investigated internationally as a proxy for the entire zoobenthos (ARMONIES & ASMUS, 2002). Benthic organisms are an important component of the North 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).

2.6.1. Data availability

The primary basis for the status description and assessment of the macrozoobenthos is data collected or compiled as part of various environmental impact assessments of offshore wind farm projects and accompanying ecological research as well as data and publications collected or compiled as part of biodiversity monitoring and various mapping projects (as of October 2023) commissioned by the Federal Agency for Nature Conservation (BfN) (hereinafter referred to as the joint BSH and BfN dataset). The analysis of the data focussed on an evaluation of the distribution of long-lived and vulnerable species, which are therefore classified as potentially sensitive species. The species were selected on the basis of the endangerment classification according to RACHOR et al. (2013) as well as on the basis of auto-ecological information from the relevant specialist information systems (e.g. Marine Life Information Network, marlin.ac.uk and Critterbase, TESCHKE et al. 2022, https://critterbase.awi.de/). Modelled distribution maps based on OLDELAND (2024) were created for some of these species.

The data analysed are supplemented by information from scientific publications and research reports describing the spatial distribution, variability, and functional and taxonomic characteristics of benthic biocoenoses.

The basis for the description of the composition and spatial distribution of the benthic communities is the work by RACHOR & NEHMER (2003), which builds on the publication by SALZWEDEL et al. (1985), among others. The spatial representation was updated using various modelling techniques by PESCH et al. (2008) as well as in unpublished reports as a basis for the creation of the current BfN biotope map (working status February 2024, Figure 13). Further information on the characterisation of endo- and epibenthic communities throughout the EEZ of the North Sea can be found in DANNHEIM et al. (2014a) and NEUMANN et al. (2017).

Studies on individual biocoenoses and regional characteristics in the German EEZ of the North Sea are mainly available from the Alfred Wegener Institute for Polar and Marine Research (IOW & AWI 2019, MICHAELIS et al. 2019, GUTOW et al. 2020, SHOJAEI et al. 2021, GUTOW et al. 2022, BEERMANN et al. 2023) as well as from other working groups (e.g. SINGER et al. 2023).

2.6.2. Spatial distribution and temporal variability

The variability of the distribution of macrozoobenthos over longer periods of time (years, decades) is controlled primarily by climatic factors and secondarily by anthropogenic influences. An important climatic factor is the winter temperature, which can cause high mortality, especially in shallower maritime areas (BEUKEMA 1992, ARMONIES et al. 2001). The analysis of a long-term data set from 1981 to 2011 by SHOJAEI et al. (2016) showed that the winter temperatures and the North Atlantic Oscillation (NAO) are the environmental factors that have the greatest influence on the temporal variability of macrozoobenthos in the German Bight. Regional oscillations of temperature, salinity, and near-surface currents caused by the NAO have a strong structuring character on benthic biocoenoses, especially seasonally but also in the medium term (KRÖNCKE et al. 1998, TUNBERG & NELSON 1998). A spatial distribution of benthic organisms projected to the year 2099 because of expected climate change suggests a northward shift and a high degree of habitat loss for a number of key species, especially for the southern North Sea, with potential effects on ecosystem function (WEINERT et al. 2016).

Wind-induced currents are responsible for the dispersal of planktonic larvae as well as (in flatter areas) for a redistribution of bottom-dwelling stages through current-induced sediment relocations (ARMONIES 1999, 2000a, 2000b). Among anthropogenic effects, in addition to nutrient and pollutant discharges, disturbance of the seabed surface by fishery is particularly important (BMUV 2023). Fishery with bottom trawls can adversely affect the structure and trophic function of benthic biocoenoses (DANNHEIM et al. 2014b), even in sites that have already been heavily damaged (REISS et al. 2009).

The following natural classification of the German EEZ of the North Sea according to benthological criteria differs from the natural classification according to sedimentological criteria. Although the macrozoobenthos shows a strong link to sediment structure (KNUST et al. 2003), water temperature and the hydrodynamic system (currents, wind, water depth) are among the natural factors in the German Bight responsible for the composition of the macrozoobenthos. RACHOR & NEHMER (2003) therefore subdivide the area into seven natural units (abbreviations A–G), which are listed in Table 5 and graphically depicted in Figure 14, taking into consideration the hydro- and topography.

The Elbe Glacial Valley and the Doggerbank form the central guiding structures in the German EEZ of the North Sea. These are important for the networking of habitats, as stepping stones, and as retreat areas. The Doggerbank is also a biogeographical divide between the central and southern North Sea.

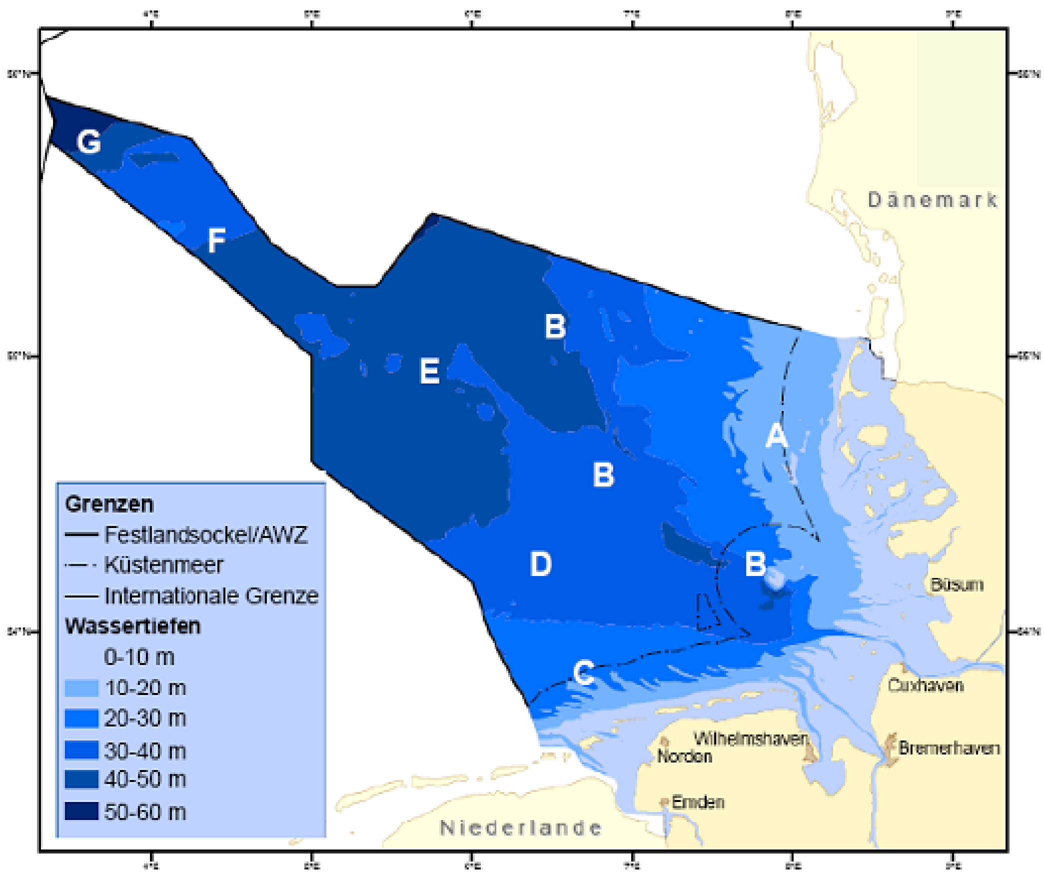

Figure 14: Natural area classification of the German EEZ of the North Sea according to Rachor & Nehmer (2003), final report for the BfN.

Table 5: Natural units of the German EEZ of the North Sea (according to RACHOR & NEHMER 2003).

ABBRE-VIATON cf Figure 14	DESIGNATION	HYDROGRAPHY	TOPOGRA-PHY	SEDIMENT*	BENTHOS
A	Östliche Deutsche Bucht (North Frisian EEZ) with Sylter Außenriff	changing salinity with frontal systems between North Sea water and freshwater input from the large rivers; high nutrient concentration, higher pollutant concentration than in the rest of the EEZ; northward residual current (CCC)	from −10 to −43 m	Heterogeneous sediment distribution of fine to coarse sands, scattered gravel, and stone surfaces	primarily **Tellina fabula community** (dominant species: ribbed flat clam and spionid annelids), adaptable; shoreward the sublittoral variant of the Macoma balthica community; **Gonia della spisula community** high species diversity in biotope mosaics with often lower colonisation densities
B	Elbe Glacial Valley	Water bodies seasonally stratified at times, regionally with oxygen depletion; low-salinity coastal water can lie above higher-salinity water	elongated, on the eastern slope steeper hollow form up to 50 m	Fine sands with silt components that increase with water depth	**Amphiura filiformis community** (dominant species: brittle star); burrowing mega-fauna possible in parts; Nucula nitidosa communits in the nearshore silt and silty sand areas
C	Southwestern German Bight (coastal East Frisian EEZ with Borkum Riffgrund)	Inflow of Atlantic water from the channel and the western North Sea; easterly current	from −20 to −36 m	heterogeneous sediment distribution of fine to coarse sands, scattered gravel and individual stone deposits	primarily **Tellina fabula community** (dominant species: ribbed flat mussel and spionids), adaptable; as well as **Goniadella spisula community** high species diversity in biotope mosaics with often lower colonisation densities
D	Northwestern German Bight (offshore East Frisian EEZ)	under North Sea water influence; slight easterly current	from −30 to −40 m	Silty fine sand	**Amphiura filiformis community** (dominant species: Brittle star); burrowing mega-fauna possible in sub-areas
E	Transition zone between the German Bight and the Doggerbank.	low tidal dynamics with low amplitude; stratified water body in summer; high salinity with low variability; oxygen deficiency possible	Depths from −38 (shallow ground Weiße Bank) to −50 m	Silty fine sand	**Amphiura filiformis community** (dominant species: Brittle star); burrowing mega-fauna possible in sub-areas

F	Doggerbank	on the slopes, formation of eddies and fronts; strong vertical mixing on the bank, water bodies rarely stratified	Depths from −29 to −40 m, shallowing to the W	Fine to medium sand	Far-shore fine sand community **Bathyporeia-Tellina community**
G	Central North Sea north of the Doggerbank	Water regularly stratified in the summer months	Depths over −40 m	Fine sands, in places moraine clay or marine clay	Benthic community of the central North Sea, Myriochele

*modified BSH

2.6.2.1. Biocoenoses

In the offshore areas of the German Bight, water depth and sediment composition are the most important factors determining the distribution of infauna on the mid-scale. The distribution pattern of seabed animal communities described by SALZWEDEL et al. (1985) and in principle by HAGMEIER (1925) has been repeatedly confirmed, although there are differences in dominance ratios and spatial distribution of the communities depending on the investigation and time. The last complete review of the communities according to SALZWEDEL et al. (1985) was carried out by RACHOR & NEHMER (2003) in 2000 using bottom grabbers in the south-eastern North Sea. PEHLKE (2005, published in PESCH et al. 2008) modelled the distribution of the communities using statistical methods and largely confirmed the rough spatial classification of RACHOR & NEHMER (Figure 15). DANNHEIM et al. (2014a) were also able to confirm the infauna communities described by RACHOR & NEHMER (2003) with the associated character species. In addition to the established biocoenoses, seven other communities were described in DANNHELM et al. (2014a); however, these are essentially gradual transitional communities between the established associations. In contrast to the epifauna (see below), no clear gradients are recognisable for the infauna depending on the distance to the coast. Rather, according to DANNHEIM et al. (2014a), sediment properties have the greatest influence on the composition of the infauna. This, in turn, causes a high degree of small-scale variability in the faunal structure, especially in sedimentologically heterogeneous areas such as the Borkum Riffgrund and the Sylter Außenriff.

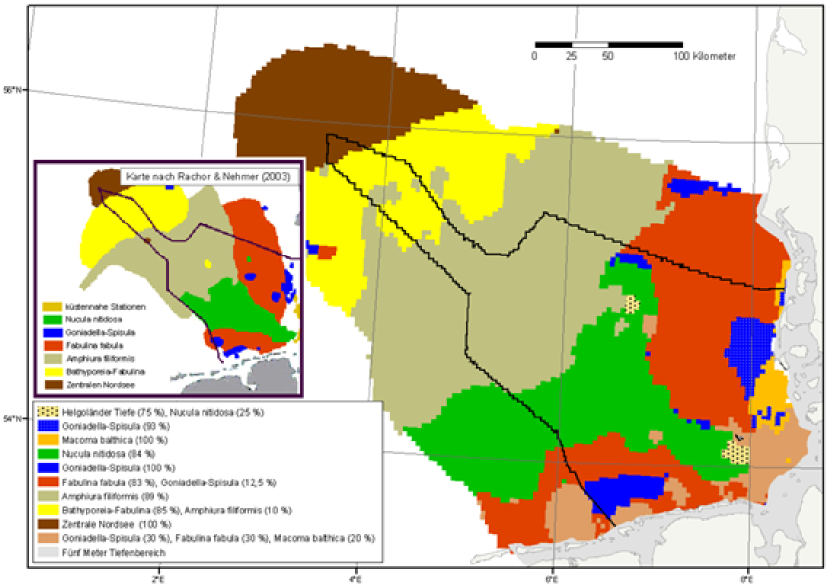

Figure 15: Modelled distribution of the most important infauna biocoenoses in the German EEZ of the North Sea and adjacent areas (from Pehlke 2005, Appendix)

For the epifauna, DANNHEIM et al. (2014a) identified six significantly different communities on both a large-scale and a regional scale. However, the associations identified are not spatially clearly delimitable units but rather reflect gradual changes in abundance ratios between the stations near and far from the coast in an essentially constant structural species composition. Dominant and regularly occurring character species in the entire EEZ are *Asterias rubens* (common starfish), *Astropecten irregularis* (sand star), *Crangon* spp. (North Sea shrimp), *Liocarcinus holsatus* (flying crab), *Ophiura ophiura* (brittle star), *Ophiura albida* (little serpent star) and *Pagurus bernhardus* (common hermit crab). The communities close to the coast in particular are characterised by a few dominant species (e.g. *Crangon crangon* and *Ophiura albida*) whilst the dominance ratios in the regions far from the coast are more balanced. The more productive regions near the coast also have higher abundances and biomass values than the regions far from the coast. NEUMANN et al. (2013) break down the epifauna into considerably fewer associations but find zonations in the colonisation structures comparable to those of DANNHEIM et al. (2014a).

2.6.2.2. Species composition with a focus on vulnerable species

Around 1,600 macrozoobenthos species are currently known from the German area of the North Sea (ZETTLER et al. 2018); of these, slightly fewer than 100 are non-native species (Neobiota, ZETTLER et al. 2018, LACKSCHEWITZ et al. 2022). Because of natural and climatically induced changes in the distribution of species, active and passive introductions through human activities as well as changes in taxonomy, the number is subject to constant fluctuations. Therefore, the entire species composition is not considered below. Instead, the description focuses on long-lived vulnerable species, the occurrence of which could indicate a sensitivity of the benthos to the predicted effects and which could be relevant with regard to a higher-resolution typologisation of the biotopes in accordance with FINCK et al. (2017) (cf Chapter 2.5.2).

The currently valid Red List of bottom-dwelling marine invertebrates is presented by RACHOR et al. (2013). A revision is currently underway but has not yet been published. According to RACHOR et al. (2013), 11.7% of all 1,244 species considered there are vulnerable, and a further 16.5% of species are near-threatened species that are probably stable over large areas but extremely rare. If the 3.9% extinct or lost species are taken into consideration, 32.2% of all species assessed are assigned to a Red List category.

According to DANNHEIM et al. (2016), the benthic species on the Red List are not homogeneously distributed in the German EEZ. The number of Red List species increases with increasing distance from the coast and reaches its highest values in the area of Doggerbank with up to 15 Red List species per station. Local hotspots in terms of the number and abundance of Red List species are located primarily in the Doggerbank, the heterogeneous areas of the Sylter Außenriff, and the “shoulder areas” of the German EEZ north-west of the Elbe Glacial Valley Figure 16). According to Dannheim et al. (2016), the distribution of Red List species in the German EEZ of the North Sea is largely determined by water depth, the temperature, and the sediment properties in addition to distance from the coast and thus does not differ considerably from the factors determining the distribution patterns of the remaining benthic fauna.

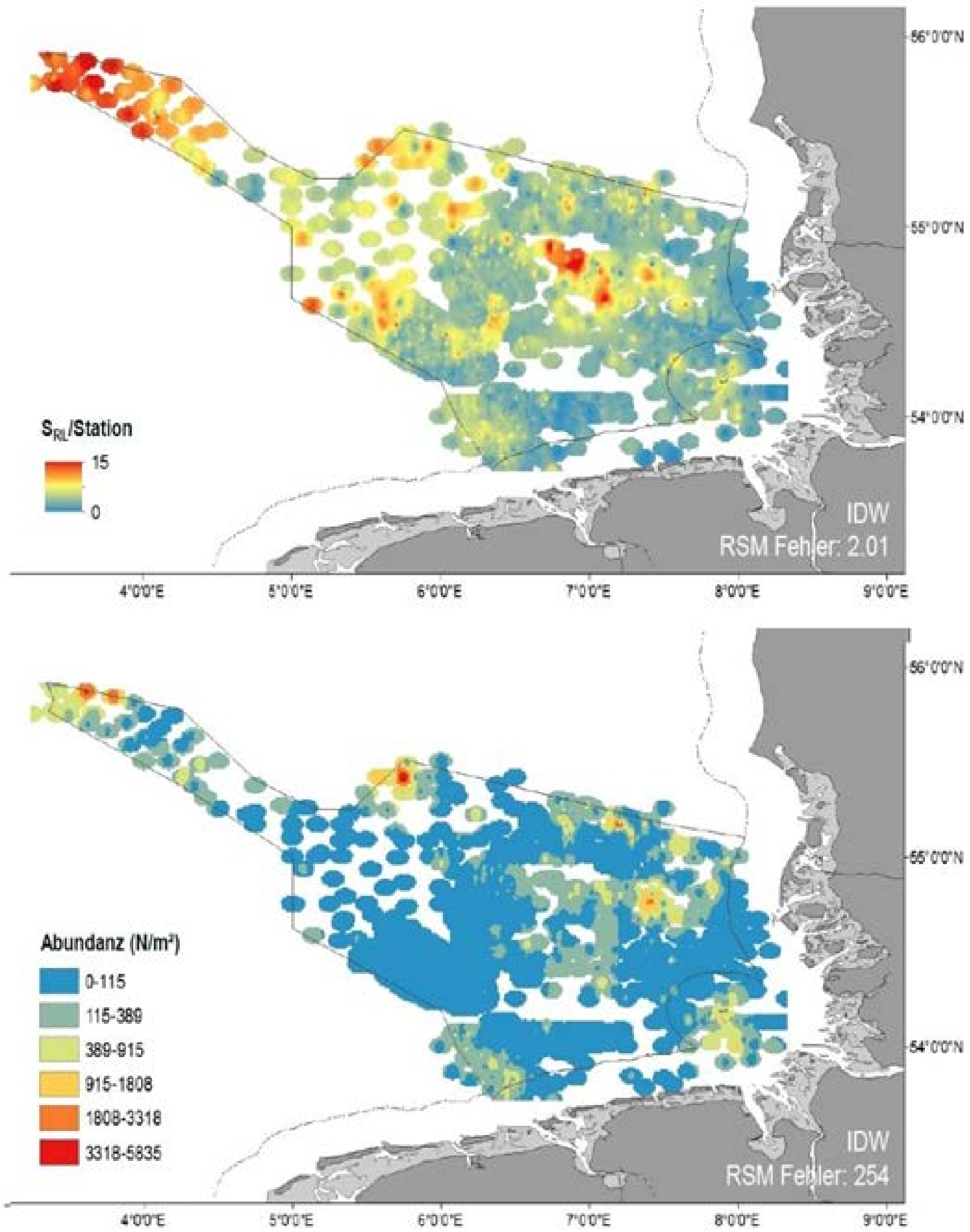

Figure 16: Number of species (top) and abundance (bottom) of Red List benthic species in the German EEZ (from Dannheim et al. 2016).

According to RACHOR et al. (2013), 57 species are considered extinct or lost or critically endangered (categories 0 and 1). However, around 50 of these species occur or occurred exclusively in the maritime area around Heligoland or in the Baltic Sea.

The European oyster *Ostrea edulis* has largely disappeared from the areas it once colonised in the German EEZ of the North Sea. Research and development projects are currently underway to actively reintroduce this species in the “Borkum Riffgrund” nature conservation area (POGODA et al. 2020). The mussel species *Heteroanomia squamula*, which was thought to be lost, is a sessile hard-bottom species now regularly detected in the course of operational monitoring of OWF (IFAÖ 2022a). Previously lacking evidence and the associated endangerment classification are therefore probably also related to the lack of investigations in the natural habitats of this species (hard bottoms). *Nucula nucleus* (RL category 1) is an extremely rare species of which there are few (< 20) records from the silt-rich sands in the *Nucula nitidosa* or *Amphiura filiformis* communities. Little is currently known about their distribution in the offshore areas of the EEZ. The BSH currently has no recent records of the other species from the EEZ listed in categories 0 and 1.

In RACHOR et al. (2013), a further 21 species are classified as endangered (category 2) based on the assessment of their population situation or population trends at that time. Of the endangered species occurring in the EEZ of the North Sea, three species - the dead man's fingers (*Alcyonium glomeratum),* the horse mussel *(Modiolus modiolus),* and the European lobster (*Homarus gammarus*) – are dependent on the presence of hard-bottom structures. Whilst the European lobster in the EEZ has so far been found mainly on wrecks and other artificial hard bottoms (e.g. KRONE & Schröder 2011, BSH 2024), the dead man's fingers is an integral part of the reef community in the area of the Sylter Außenriff (e.g. according to BIOCONSULT 2006 also in the area of area N-5) as well as less frequently in the area of the Borkum Riffgrund. According to the current state of knowledge, there is no recent evidence of stable populations of the horse mussel within the German EEZ of the North Sea.

The endangered whelk *Buccinum undatum* is also dependent on hard bottoms for spawning but is otherwise highly mobile and sediment-unspecific. Accordingly, there are records of the species from the entire German North Sea – from Heligoland to Sylter Außenriff to Doggerbank. However, the species has become rare because of its exposure to active bottom-disturbing fishing gear and its sensitivity to various pollutants (HALLERS-TJABBES et al. 1996).

In contrast, the polychaete species *Sabellaria spinulosa*, which belongs to the sand coral group, is potentially reef-building. Their reef-like structures of sediment tubes used to be widespread in the Wadden Sea. However, since the early 1990s, there has been no recent evidence of this biotope in the German Wadden Sea (VORBERG et al. 2017 and citations therein). However, there is no knowledge of historical occurrences of such reef structures in the German part of the North Sea far from the coast. Recently, this species has regularly, but not frequently, been recorded on secondary hard bottoms (especially on snail shells inhabited by hermit crabs) in the Sylter Außenriff, on the Borkum Riffgrund, and in neighbouring maritime areas. Because of this mode of life, there is no obligatory sediment binding of this species and it can be found in the entire EEZ.

The spoon worm *Echiurus echiurus* is a comparatively large species (10–15 cm long) that burrows in sandy and muddy sediments. Because of its ability to penetrate deeper into the sediment, it is often not surveyed using standard sampling techniques. In the joint data set of the BSH and BfN, the main area of distribution of this, which is assessed as endangered, is on the south-eastern slope of the Doggerbank, which can also be seen in the modelled distribution map of OLDELAND (2024) (Figure 17). Evidence from other areas of the EEZ is rare.

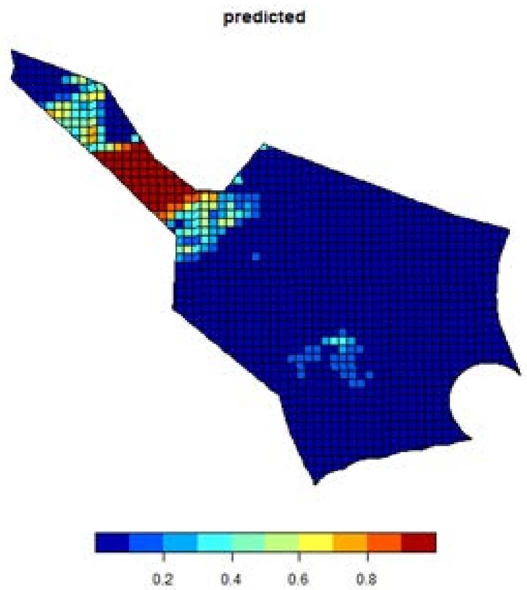

Figure 17: Probability of occurrence of the spoon worm *Echiurus echiurus* in the German EEZ of the North Sea (Oldeland 2024, data basis: joint dataset of the BSH and BfN, modelling technique: GBM)

Another endangered and deep-digging species is *Upogebia stellata*, which is related to the mud lobster. Members of the genus *Upogebia* usually build U-shaped tunnels at sediment depths of up to 20 cm, where they ensure an oxygen supply to deeper sediment layers and an increased exchange of substances between water and sediment through their permanent respiratory and food flow (Howe et al. 2004). *Upogebia stellata* is much rarer than the closely related species *Upogebia deltaura* but colonises almost the same habitats. The main areas of distribution of both species are the deeper areas of the Elbe Glacial Valley up to the northern shoulder of the German EEZ of the North Sea as well as the south-western areas of the outer German Bight. A modelling the distribution of the endangered species *Upogebia stellata* was not possible with the required model quality because of the low number of records.

All other endangered or vulnerable species considered here (RL category 3) belong to the group of bivalves. Because of their size and their largely immobile lifestyle as adults, mussels are often particularly characteristic of certain habitats, and because of their long lifespan, they are often particularly sensitive to disturbance. Like its related species of the genus *Spisula*, the elliptical trough shell *Spisula elliptica* (RL category 2) is one of the characteristic species (in the broader sense) of the *Goniadella Spisula* community and is therefore predominantly found on medium and coarse sands (cf Rachor & Nehmer 2003, Gutow et al. 2022). The joint dataset of the BSH and BfN clearly shows main areas of distribution in the three areas under the Habitats Directive: Sylter Außenriff, Borkum Riffgrund, and Doggerbank (Figure 18). Stability and abundance of the species in the neighbouring sandy areas are considerably lower. In the silt-rich areas with *Nucula nitidosa* or *Amphiura filiformis* communities, the species occurs only rarely.

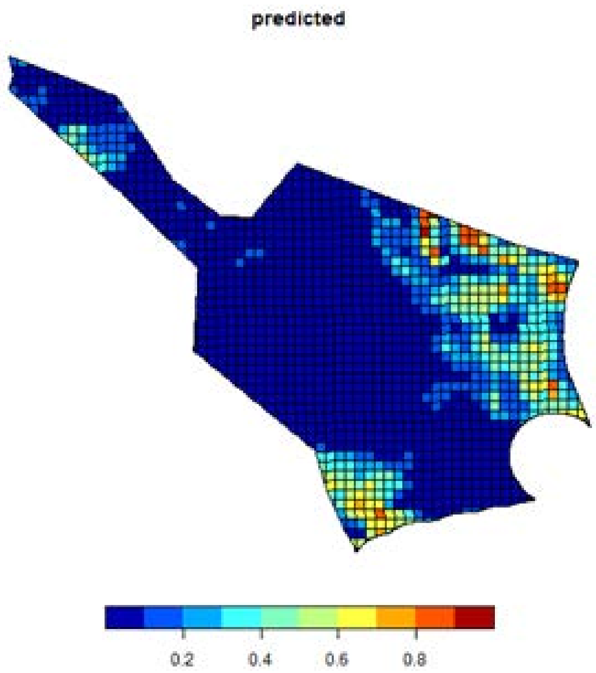

Figure 18: Probability of occurrence of the elliptical surfclam *Spisula elliptica* in the German EEZ (Oldeland 2024, data basis: joint dataset of the BSH and BfN, modelling technique: GBM)

The native representatives of the genus *Ensis* (razor clams) have similar main areas of distribution in the German Bight, although unlike the species of the genus *Spisula*, these prefer mainly finer sands. The endangered sword razor (*Ensis ensis,* RL category 2) is widespread in the fine sands of all three protected areas, whereas the vulnerable species (RL category 3) razor shell (*Ensis magnus*) is much rarer in the area of the Doggerbank than in the two coastal protected areas Sylter Außenriff and Borkum Riffgrund (Figure 19). All *Ensis* species avoid silty sediments. In the areas with *Nucula nitidosa* or *Amphiura filiformis* communities, the genus is therefore only found only in exceptional cases.

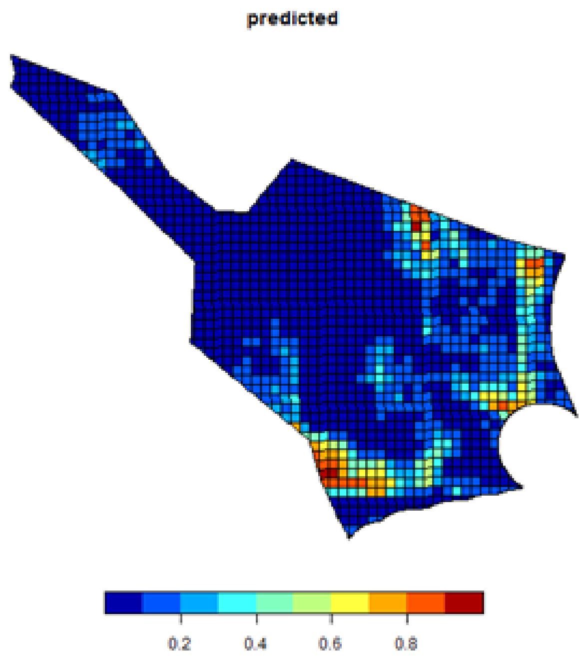

Figure 19: Probability of occurrence of the sword razor *Ensis ensis* in the German EEZ (Oldeland 2024, data basis: joint dataset of the BSH and BfN, modelling technique: GBM)

Another long-lived and endangered species is the truncated softshell clam *Mya truncata* (RL category 2). The number of records in the joint BSH and BfN dataset is so low that a clear sediment link is not recognisable. The few records are distributed over mudflats and sands in the Helgoländer Tiefen Rinne, the Sylter Außenriff, and the Elbe Glacial Valley. Evidence from the south-western German Bight and the transition to the North-western region of the German EEZ is rare. The species does not appear to occur recently in the north-western region of the German EEZ.

The black clam *Arctica islandica* is categorised as vulnerable in RACHOR et al. (2013). However, their populations in the North Sea have declined considerably more than in the Baltic Sea. Stable populations of this species can hardly be found in the German part of the North Sea. However, in addition to widespread evidence of young mussels, old and large individuals of this species are also occasionally found. The detection of numerous juvenile individuals of this species in an area of the Elbe Glacial Valley in 2013 (IOW & AWI 2019) confirms the remaining potential for reproduction in this maritime area. However, subsequent investigations have not yet confirmed the permanent establishment of the species in the area. Beyond this maritime area, there are individual records of different age classes from various areas (e.g. around Hel-igoland, in the Sylter Außenriff, and in various areas of the outer German Bight. The only area with regular records in the joint dataset of the BSH and BfN is the north-western slope of the Doggerbank and the adjoining transition to the Central North Sea, which largely confirms the data in IOW & AWI (2019).

2.6.3. Status assessment

The status assessment for the benthos is based on the joint data set of the BSH and BfN taking into consideration the relevant literature (cf Chapter 2.6.1). The estimation is made verbally and argumentatively on the basis of the three criteria “rarity and endangerment”, “uniqueness and diversity”, and “existing pressures”. Overall, the data situation for the assessment of this protected asset has improved considerably compared with previous assessments; however, there are still considerable gaps in knowledge at the regional level. For such areas, the data from the respective site/area is supplemented by analogue conclusions from surrounding maritime areas.

Criterion rarity and endangerment

This criterion assesses the occurrence of vulnerable, endangered, and critically endangered species. This is based on the Red List according to RACHOR et al. (2013). Because of the widely varying data situation between the individual areas/sites and the direct dependence of the detection of rare species on the scope of the investigations, a systematic classification based solely on the number of Red List species is not meaningful. In addition to the descriptions in DANNHEIM et al. (2016) on the large-scale distribution of Red List species, the assessment therefore primarily takes into consideration the potential of the respective site/area as a habitat for the endangered and endangered species described in Chapter 2.6.2.

Criteria uniqueness and diversity

This criterion refers to the number of species and the composition of the species communities. The extent to which species or biocoenoses characteristic of the habitat occur and whether special features are present is assessed. The starting point for the assessment is the assumption that a homogeneous occurrence of only one biocoenosis with a typical composition that is widespread in the EEZ means that the site is of low importance for the protected asset. *A* higher initial assessment (medium) is made *a priori* for the *Goniadella-Spisula* community, the *Bathyporeia-Tellina* community of the Doggerbank, and the transition community to the Central North Sea because of their faunistic characteristics and geographical restrictions in the German EEZ of the North Sea (GUTOW et al. 2022, BEERMANN et al. 2023). For this criterion, a site/area is considered to be of greater importance if the presence of different communities (heterogeneity of the habitat) or other reasons result in increased species diversity or if special functional aspects have been described for the area in the literature.

Existing pressure criterion

For this criterion, the intensity of current anthropogenic pressures on benthic communities is assessed. The most effective direct disturbance variable is fishery with active bottom-disturbing fishing gear (e.g. HIDDINK et al. 2019, EIGAARD et al. 2016, BUHL-MORTENSEN et al. 2015 and literature cited therein). Furthermore, eutrophication can change or adversely affect benthic biocoenoses.

The assessment is based primarily on the information on pollution and the state of the seabed in the draft “2024 report on the state of the German North Sea waters” (BMUV 2023), whereby pollution from existing installations and structures (loss of area) is generally not relevant for the sites and areas under consideration here.

Overall, the benthos in large parts of the German EEZ of the North Sea has deviated from its original state primarily because of existing pressures (fishery, eutrophication, and pollutant inputs). Of particular note here is the direct disturbance of the surface of the seabed by intensive fishing activity, which causes a shift from long-lived species (mussels) to short-lived, rapidly reproducing species. Therefore, neither the species composition nor the biomass of the zoobenthos corresponds to the status that would be expected without the influence of human uses (ARMONIES & ASMUS 2002). Despite a generally high level of pressure, a closer look reveals a spatially differentiated picture (BMUV 2023, Figure 20).

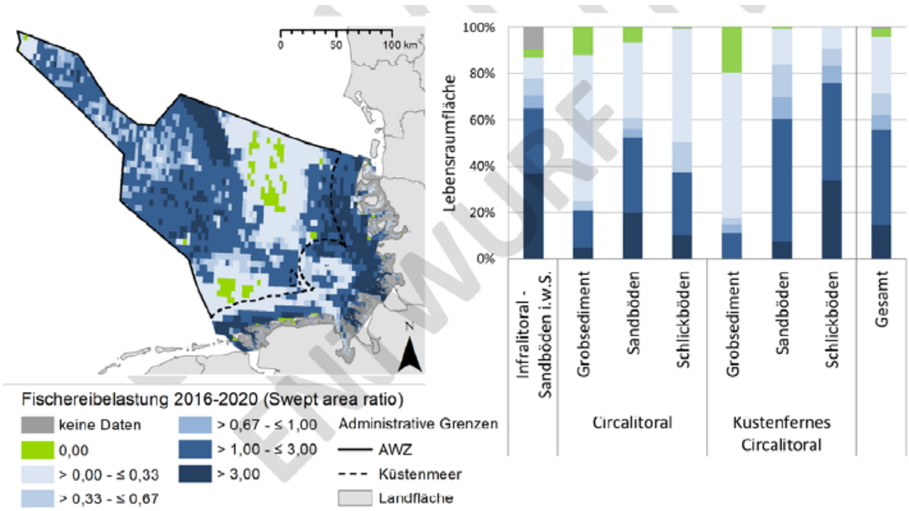

Figure 20: Spatial extent of pressure from bottom-disturbing fishery in the German North Sea in the period 2016-2020 (left) and percentags of pressure for the benthic biotope classes within the meaning of MSFD (right from BMUV 2023)

This means that the Elbe Glacial Valley, large parts of the territorial sea and areas of the Doggerbank and the outer German Bight are particularly exposed to existing pressure from the bottom-disturbing fishery. There is a considerably lower impact in parts of the Borkum Riffgrund and the Sylter Außenriff as well as in the existing offshore wind farms because of the restrictions on bottom-disturbing fishery associated with the current navigation regulations.

With regard to eutrophication, there is a clear spatial trend in the form of decreasing pressure with increasing distance from the coast (BMUV 2023). Direct and indirect effects of eutrophication on the benthos were not assessed in BMUV (2023). However, it can be assumed that it is low in areas far from the coast compared with the pressure caused by bottom-disturbing fishery. The existing pressure from non-indigenous species (neobiota) also plays a subordinate role outside the estuaries and individual areas of the infralittoral (e.g. Pacific oyster beds).

For other disturbance variables (e.g. maritime traffic, pollutants), there are currently no suitable indicators to be able to take these into consideration in the assessment.

2.6.4. Importance of areas and sites for the protected asset benthos

Area N-4

Only a small number of vulnerable species were identified for the Area N-4 in DANNHEIM et al. (2016). The long-lived and vulnerable representatives of the mussel genera *Ensis* and *Spisula* are widespread in the area; however, their densities are considered average. The investigations carried out prior to the construction and during the operation of the wind farms currently located in this area also indicate that the area is of low to medium importance with regard to the criterion of rarity and endangerment.

In Area N-4, the *Tellina fabula community* dominates the structure of the benthic colonisation; only in medium to coarse sandy areas is the *Goniadella spisula* community to be found on a small scale. There is no evidence of particularly high species diversity or special functional aspects. The importance of the area is therefore to be rated as low to medium with regard to the criterion of diversity and uniqueness.

Because of the wind turbines already installed in the area and their ancillary installations, Area N-4 is subject to existing pressure with a loss of area for the benthic communities amounting to < 0.5% of the area. Furthermore, the benthic community in the vicinity of the piles is slightly altered on a small scale by sediment changes and the introduction of dead and living material from the communities of the artificial hard substrates. On the other hand, because of the exclusion of bottom-disturbing fishery, a partial recovery of the benthic cenosis in Area N-4 can be assumed. Overall, the existing pressure does not lead to an upgrading or downgrading of the importance of the area for the protected asset benthos; this is therefore assessed as low to medium overall in the aggregation.

Area N-5

In DANNHEIM et al. (2016, Figure 16) Area N-5 is characterised with a slightly increased diversity of Red List species. The joint BSH and BfN dataset shows regular occurrences of the endangered mussel species *Ensis ensis* and *Spisula elliptica*. Vulnerable hard-bottom-associated species such as the dead man’s fingers and the whelk have been found in the reefs (BioConsult 2006). Because of the potential importance of the area as a habitat for several endangered species, the rarity and endangerment criterion is assessed as medium to high.

Because of the sedimentological heterogeneity, Area N-5 is colonised by different communities. The predominant fine sands form the habitat for the *Tellina fabula* community, whereas the coarser substrates are inhabited by the *Goniadella spisula* community. The hard bottoms in turn provide a habitat for a diverse, as yet unclassified cenosis. Because of the different communities present, Area N-5 is comparatively species-rich and is thus rates as medium to high in terms of the criterion of uniqueness and diversity.

Because of the wind turbines already installed in parts of the area and their ancillary installations, Area N-5 is subjected to existing pressure by a loss of area for the benthic communities, amounting to < 0.3% of the area. Furthermore, the benthic community in the vicinity of the piles is slightly altered on a small scale by sediment changes and the introduction of dead and living material from the communities of the artificial hard substrates. On the other hand, because of the exclusion of bottom-disturbing fishery in parts of Area N-5, a partial recovery of the benthic cenosis can be assumed. But even outside the safety zone of the existing wind farm, the fishing effort is comparatively low. Overall, the importance of Area N-5 for the protected asset benthos is rated as medium to high.

Area N-9 (Sites N-9.4 and N-9.5)

With regard to the criterion of rarity and endangerment, the importance of both sites in Area N-9 is rated as medium to probably high in places. Although DANNHEIM et al. (2016) found an above-average number of Red List species in this maritime area, the overall abundance of endangered species remains low. The importance of the area for the conservation of regional populations of vulnerable species is thus not overly high. An exception to this could be the deep-digging crayfish species *Upogebia stellata* (RL category 2, endangered), which is regularly found in the area but so far only in low densities (IFAÖ 2023).

The area is colonised by a typical *Amphiura filiformis* community but is comparatively species-rich compared with other maritime areas (IfAÖ 2023). GUTOW et al. (2020) describe a special importance for the maritime area because of the occurrence of deep-digging mega-fauna (especially the crab genera *Callianassa* and *Upogebia*), which are said to ensure increased mass exchange between water and sediment through bioturbation because of their burrowing activity. However, in the analyses by WREDE et al. (2017), the two genera are shown not to be the most important representatives of bioturbation potential. Whilst *Callianassa subterranea* has only a temporary active influence on the exchange of substances because of its long phases of low activity and its feeding behaviour (Forster & Graf 1995, Howe et al. 2004) and even lives under suboxic conditions (FORSTER & GRAF 1995, POWILLEIT & GRAF 1996), the density of the larger and filtering genus *Upogebia* is often too low in order to be able to provide a considerable proportion of the bioturbation potential. The importance of the area is therefore classified as medium overall for the criterion of uniqueness and diversity.

According to the BMUV (2023), the maritime area is one of the areas within the German EEZ of the North Sea with a high level of pressure from bottom-disturbing fishery. However, there are no indications of a particularly strong change in the benthic community compared with other lake areas. The overall importance of both sites of Area N-9 for the protected asset benthos is thus assessed as medium. In areas with a higher colonisation density of *Upogebia stellata*, a medium to high importance cannot be ruled out.

Area N-12 (Sites N-12.4 and N-12.5)

Similar to Area N-9, DANNHEIM et al. (2016) also found an above-average number of Red List species in Area N-12 although their overall colonisation density remains low. However, there are frequent records of the endangered crab species *Upogebia stellata* from the muddier areas in the north-east of Site N-12.5. Based on this evidence, the rarity and endangerment criterion for Site N-12.5 is assessed as “medium to high” and for Site N-12.4 as “medium”.

Area N-12 is also comparable to Area N-9 with regard to the criterion “uniqueness and diversity”. GUTOW et al. (2020) identified a special importance for both sites because of the deep-digging mega-fauna. This argument is only partially followed here (cf reasoning for Area N-9). However, the north-eastern area of Site N-12.5 is part of the main habitat of the Norway lobster *Nephrops norvegicus*, which probably also has important occurrences there from an ecological point of view. Because of its size and burrowing activity, the Norway lobster is considered an important structure former in the muddy areas of the North Sea (JOHNSON et al. 2013 and citations therein). The criterion “Uniqueness and diversity” is therefore assessed as medium to high for Site N-12.5 but as low to medium for Site N-12.4.

In the area of both sites, BMUV (2023) identifies a high level of pollution from bottom-disturbing fishery. However, this has been affecting the fauna living there for decades and has already been taken into consideration in the assessment of the other two criteria.

Overall, the importance of Site N-12.4 is assessed as medium and that of Site N-12.5 as medium to high because of the potentially important occurrences of *Nephrops norvegicus* and *Upogebia stellata*.

Site N-13.4*

The eastern parts of Site N-13.4* have similar sedimentological and thus also faunistic characteristics to Area N-5. In addition, the western area with its silty substrates provides a habitat for another biocoenosis.

Because of the presence of several endangered species (e.g. *Upogebia stellata* in the muddy area, the European lobster (*Homarus gammarus)* in the reef areas and the mussel species *Ensis ensis* and *Spisula elliptica* in the eastern, sandy areas), the importance of the area is assessed as medium to high with regard to the criterion of rarity and endangerment.

The sedimentological heterogeneity of Site N-13.4* leads to a high diversity of benthic biocoenoses. The fine sands form the habitat for the *Tellina fabula* community, whereas the coarser substrates are inhabited by the *Goniadella spisula* community. In contrast, the muddy areas of the Elbe Glacial Valley in the west of the area are colonised by the *Amphiura filiformis* community. The hard bottoms, in turn, provide a habitat for a diverse, as yet unclassified cenosis. This close spatial integration of different communities in combination with the probably significant occurrence of the Norway lobster in the western part of the site lead to a medium to high importance with regard to the criterion of uniqueness and diversity.

Whilst the reef areas and the adjoining coarse sediment areas to the east are largely spared the effects of bottom-disturbing fishery, the muddy areas in the west of the site are among the most heavily fished maritime areas in the German EEZ of the North Sea.

In aggregate, this results in a medium to high importance for the protected asset benthos for Site N-13.4.

Area N-14 (Sites N-14.1, N-14.2, N-14.3)

DANNHEIM et al. (2016) found an average number of Red List species for Area N-14 but also an above-average number locally. However, the joint dataset of the BSH and BfN does not indicate that the area is of particular importance for any of the vulnerable species under consideration. The rarity and endangerment criterion is therefore assessed as low to medium for all three sites in Area N-14.

Area N-14 is colonised by a typical *Amphiura filiformis* community. There is no evidence of high species diversity or special functional aspects that would indicate a high importance of the maritime area. With regard to the criterion of uniqueness and diversity, the sites in Area N-14 are therefore assessed as "low".

Because the existing pressure, particularly from bottom-disturbing fishery, does not allow for any upgrading, the importance of Sites N-14.1, N-14.2, and N-14.3 is assessed as low to medium.

Area N-16 (Sites N-16.1 to N-16.6)

Area N-16 extends in the northern part of the German EEZ from the border with the Danish EEZ and partially extends into the North-western region of the German EEZ to the south-west. This results in gradual differences in the benthic colonisation, which lead to a different assessment of the importance of the individual sites for the protected asset benthos.

DANNHEIM et al. (2016) found an above-average number of Red List species in the northernmost part of Area N-16 with high abundances in some cases. Furthermore, the joint dataset of the BSH and BfN from this area contains evidence of the endangered crab species *Upogebia stellata* and the Norway lobster *Nephrops norvegicus*. The importance of Site N-16.1 can thus be classified as medium to high in terms of the rarity and endangerment criteria. Evidence of these or other endangered or critically endangered species from the other sites of the area is sporadic or non-existent. The other Red List species (DANNHEIM et al. 2016) are also only average in Sites N-16.2, N-16.3, and N-16.4 (medium assessment) and rather below average in Sites N-16.5 and N-16.6 (low to medium assessment).

All six sites are colonised by the *Amphiura filiformis* community. For Sites N-16.3 through N-16.6, the literature references and the evaluation of the data did not provide any indications of particularly significant aspects of the biocoenosis. The criterion of uniqueness and diversity is thus assessed as low for these four areas. Deviating from this, Sites N-16.1 and N-16.2 are assessed as “medium to high” and “medium”, respectively for this criterion. For parts of the two sites, GUTOW et al. (2020) describe a special importance because of the deep-digging mega-fauna (cf comments on Area N-9). However, the potentially important occurrence of populations of the Norway lobster *Nephrops norvegicus* in Site N-16.1 is essential for the assessment.

According to the BMUV (2023), the silty areas in Site N-16.1 are among the most intensively fished areas in the German EEZ of the North Sea. However, the other sites in Area N-16 are also heavily fished.

The aggregation of the individual criteria results in the following overall assessment of the importance of the six sites in Area N-16 for the protected asset benthos:

- <u>N-16.1: medium to high</u>
- <u>N-16.2: medium</u> (probably locally medium to high for important occurrences of *Upogebia stellata*)
- <u>N-16.3 und N-16.4: medium</u>
- <u>N-16.5 and N-16.6: low to medium</u>

Area N-17

Area N-17 is distributed over the basal area of the north-western region of the German EEZ up to the south-eastern slope of the Doggerbank and therefore shows gradual changes in the benthic colonisation similar to the sites in Area N-16.

According to DANNHEIM et al. (2016), the area harbours an average number and density of Red List species. The northern part of Area N-17 is located in the main distribution area of the spoon worm *Echiurus echiurus* within the German EEZ of the North Sea and is therefore of high regional importance for this species, which is classified nationally as endangered. The importance of the northern sub-site of Area N-17 is therefore assessed as “medium to high” for the rarity and endangerment criterion as a precautionary measure. Because there were only a few records of this species at the time the Red List was compiled in 2013 because of the insufficient availability of data and the difficulty of recording this species, it cannot be ruled out that the endangerment status will change as part of the ongoing Red List update. The southern parts of Area N-17 are rated as “medium” for this criterion.

Area N-17 is colonised predominantly by a typical *Amphiura filiformis* community. However, radiating from the Doggerbank, the *Bathyporeia-Tellina* community extends into the northern part of Area N-17. This community is considered to be richer in species and has a species inventory that differs greatly from most other communities in the German Bight (e.g. BEERMANN et al. 2023). The northern part of Area N-17 is therefore assigned medium importance with regard to the criterion of uniqueness and diversity. In contrast, the southern sub-sites of Area N-17 are of minor importance for this criterion.

Existing pressures from bottom-disturbing fishery and other stressors are of medium intensity in the area.

In aggregate, this results in a low to medium importance for the protected asset benthos for the southern sub-sites and a medium importance for the northern sub-site in N-17. If the endangerment status of the burbot *Echiurus echiurus* is confirmed in the Red List update, the importance of the northern sub-site in N-17 could be assessed as medium to high.

Area N-19

Because of its location north-west of the Doggerbank as a separate natural unit in the transition to the Central North Sea with a species inventory that differs from the communities of the German Bight, the area represents a certain speciality for the German EEZ of the North Sea; however, this is somewhat relativised with regard to the entire North Sea.

For example, DANNHEIM et al. (2016) show that the number of Red List species is particularly high in this area. This is mainly, but not exclusively, due to the geographical restriction of many species that occur only in this area. However, the data from the joint dataset of the BSH and BfN also show that Area N-19 is the only area of the German EEZ in which the black clam *Arctica islandica* is regularly detected. With regard to the criterion of rarity and endangerment, the importance of Area N-19 is therefore assessed as “medium to high”.

Area N-19 is predominantly colonised by the *Bathyporeia-Tellina* community or Doggerbank community, which merges into the Central North Sea community with increasing water depth, whereby BEERMANN et al. (2023) no longer distinguish the latter from the Doggerbank community. Both communities are relatively species-rich and have special faunistic characteristics because of their geographical restriction to the German EEZ of the North Sea. In all three sub-sites in Area N-19, there are also coarse substrates that have not yet been sufficiently investigated faunistically but which potentially provide a habitat for a small-scale variation of the Doggerbank community. Overall, for precautionary reasons, all three sub-sites are therefore of medium to high importance for the criterion of diversity and uniqueness.

According to the BMUV (2023), fishery pressure in this area is somewhat lower than in the other offshore areas of the German EEZ of the North Sea. This may favour the conservation of long-lived species.

Overall, Area N-19 is of medium to high importance for the protected asset benthos.

Area N-20

According to DANNHEIM et al. (2016), the number of Red List species detected in Area N-20 can be categorised as below average to average. The joint data set of the BSH and BfN provides no further indications of important occurrences of vulnerable species in Area N-20. The rarity and endangerment criterion is thus assessed as “low to medium”.

Area N-20 is colonised by a typical *Amphiura filiformis* community. There is no evidence of high species diversity or special functional aspects that would indicate high importance. With regard to the criterion of uniqueness and diversity, area N-20 is therefore assessed as “low”.

Because the existing pressures, particularly from bottom-disturbing fishery, do not permit any upgrading, the overall importance of Area N-20 is assessed as low to medium.

The estimation of the importance of the individual sites for the protected asset benthos is summarised in the following Table 6.

Table 6: Summary of the assessment of the importance of the areas and sites for the protected asset benthos. Assessments in brackets represent local deviations or assessments that may change as the data situation changes. Further details can be found in the site and area-specific texts

Site/area	Rarity and threat	Uniqueness and diversity	Existing pressure	Total assessment
N-4	low to medium	low to medium	medium to high	low to medium
N-5	medium to high	medium to high	medium	medium to high
N-9.4	medium (higher locally)	medium	High	medium (to high)
N-9.5	medium (higher locally)	medium	High	medium (to high)
N-12.4	medium	low to medium	High	Medium
N-12.5	medium to high	medium to high	High	medium to high
N-13.4	medium to high	medium to high	medium to high	medium to high
N-14.1	low to medium	Low	medium	low to medium
N-14.2	low to medium	Low	medium	low to medium
N-14.3	low to medium	Low	medium	low to medium

N-16.1	medium to high	medium to high	High	medium to high
N-16.2	Medium	medium	High	Medium (locally possibly medium to high)
N-16.3	medium	Low	medium	Medium
N-16.4	medium	Low	medium	Medium
N-16.5	low to medium	Low	medium	low to medium
N-16.6	low to medium	Low	medium	low to medium
N-17	medium (medium to high – northern sub-site)	Low Medium (northern sub-site)	medium	low to medium (medium to high – northern sub-site)
N-19	medium to high	medium to high	medium to high	medium to high
N-20	low to medium	Low	Medium	low to medium

2.6.5. Importance of the routes for the grid connection systems and interconnectors for the protected asset benthos

Grid connection systems from Gate N-II (NOR 6-4)

There are no areas along the route of Grid connection system NOR 6-4 that have an increased number of vulnerable species according to DANNHEIM et al. (2014a) or that are of particular importance as a habitat for one of the (highly) endangered species under consideration according to the joint dataset of the BSH and BfN. The importance with regard to the criterion of rarity and endangerment can therefore be assessed as low to medium for the entire route.

The grid connection system crosses several widespread communities in the German EEZ of the North Sea along the route from the transition to the territorial sea to the converter site. There are no indications of route sections with increased biodiversity or special importance. With regard to the criterion uniqueness and diversity, the importance is therefore to be categorised as low to medium. If coarse sediments with a *Goniadella-Spisula community* are identified along the route (e.g. in the area of the sandbank), these areas would be assessed as medium to high with regard to this criterion.

There are no specific indications of existing pressures that requires special consideration.

In the aggregation, the importance of the sites planned for the NOR 6-4 cable connection system is therefore rated as low to medium. If coarse sediments with a *Goniadella-Spisula community* are identified along the route (e.g. in the area of the sandbank), these areas would be rated as medium to high.

Grid connection systems from Gate N-III (NOR 9-4, 9-5, 14-1, 14-2, 14-3, 16-3, 16-4, 16-5)

The corridors of these grid connection systems cross areas that, according to DANNHEIM et al. (2014), have an increased number of vulnerable species in Areas N-7 and N-9. The areas coincide with frequent detections of the endangered crab species *Upogebia stellata* in the joint dataset of the BSH and BfN. The importance of this section is therefore medium to locally high. However, the occurrence of endangered species there is not of particular importance because of the low density. Coarser sediments to the east and south-east of Area N-3 may be of particular importance for the endangered species *Spisula elliptica.* This area would also be of medium to high importance in terms of the rarity and endangerment criteria, and important occurrences of endangered species cannot be completely ruled out. For all other route sections, on the other hand, it is assessed as low to medium.

Several communities are widespread in the German EEZ of the North Sea along the route of the grid connection systems from the transition to the territorial sea to the converter sites. There are no indications of route sections with increased biodiversity or special functional importance. With regard to the criterion uniqueness and diversity, the importance is therefore to be categorised as low to medium. If coarse sediments with a *Goniadella-Spisula community* are identified along the route, these areas would be assessed as medium to high with regard to this criterion.

There are no specific indications of existing pressures that requires special consideration.

In aggregate, the importance of the routes planned for the aforementioned cable connection systems for the protected asset benthos is therefore to be assessed as low to medium according to the current state of knowledge. On a small scale, coarse sediments with a *Goniadella spisula community* or areas with particularly high densities of the crab species *Upogebia stellata* may occur. The importance of these would be assessed as medium to high in deviation from the above assessment.

Grid connection systems from gate N-V (NOR 12-3, 12-4, 16-1, 16-2)

For the route of Grid connection systems NOR 12-3 and NOR 12-4, there are no indications of important habitats of vulnerable, endangered, or critically endangered species based on the benthos data from the transition to the territorial sea to the planned converter site. According to DANNHEIM et al. (2014), an accumulation of vulnerable species appears to occur only in the direct transition area between the territorial sea and the EEZ (Figure 16). This accumulation is probably due mainly to the reef areas in the area of the territorial sea, which are bypassed by the route to the north. Further suspected areas were identified in the direct course of the route (cf Chapters 2.5.6 and 5.1). A significant occurrence of endangered species cannot be ruled out for these areas. The importance of the reef area for the protected asset benthos is rated as medium to high. The other sections of the route in this area are of low to medium importance with regard to the rarity and endangerment criteria.

The grid connection systems cross several widespread communities in the German EEZ of the North Sea in the further course of the route from the transition to the territorial sea to the converter sites. There are no indications of route sections with increased biodiversity or special functional importance. With regard to the criterion uniqueness and diversity, the importance is therefore to be categorised as low to medium. If coarse sediments with a *Goniadella-Spisula community* are identified along the route, these areas would be assessed as medium to high with regard to this criterion.

There are no specific indications of existing pressures that requires special consideration.

In aggregate, the importance of the routes planned for Cable connection systems NOR 12-3 and NOR 12-4 for the protected asset benthos is therefore to be assessed as low to medium according to the current state of knowledge. Small-scale occurrences of reef communities, coarse sediments with a *Goniadella spisula* community, or areas with particularly high densities of the crab species *Upogebia stellata* cannot be completely ruled out. This would lead to an assessment of medium to high in deviation from the above assessment.

The same assessments apply also to Grid connection systems N-16.1 and N-16.2 from the entry into the EEZ to the bundling point south-west of Site N-12.4 and in the further course until reaching Site N-16.2 (aggregated assessment low to medium with the exceptions listed above). However, for the last route section up to the planned converter site, the same statements apply for Grid connection systems NOR 16-1 and NOR 16.2 as for the Sites N-16.1 and N-16.2, respectively (cf Chapter 2.6.4). The occurrence of endangered *(Upogebia stellata*) or functionally important species *(Nephrops norvegicus*) is to be expected here. The importance of this last section of the route for the protected asset benthos is therefore rated as medium (Site N-16.2) or medium to high (in the area of Site N.16.1).

Interconnectors

Five interconnector routes are to be considered. These will either connect individual OWF in the German EEZ of the North Sea with the grids of neighbouring countries or fundamentally connect the power grids of Germany with those of the neighbouring countries.

The shortest interconnector (I-NOR-12) connects Site N-14.3 with the systems of the Netherlands and leaves the German EEZ after a distance of less than 8 km, which runs along the northern edge of the Site N-14.3. Therefore, the same statements apply to the importance of the route area as for Site N-14.3 (overall low to medium).

A further interconnector (I-NOR-11) connects Site N-16.5 with the Danish grid system and initially runs along Site N-16.5 to the north-west and then turns to the north-east between the two sub-sites of Site N-16.6 and follows the route of the VikingLink interconnector. Interconnector I-NOR-10 runs parallel to the VikingLink route and therefore partly also parallel to Interconnector I-NOR-11. The statements and assessments for Sites N-16.6. and N-16.5 (low to medium) apply to the route of these interconnectors. The mere presence of individual blocks (cf Chapter 2.5.6.) does not result in a higher importance for the protected asset benthos.

To the north-west of Shipping route SN10, two interconnectors (I-NOR-8 and I-NOR-9) run along the south-eastern edges of Areas N-14 and N-16 from the Dutch EEZ to the Danish EEZ. The route sections between the aforementioned sites show no special features or fundamental differences from the other route sections in terms of benthic colonisation. Reference should therefore be made to the descriptions and assessments for Site N-14.1 as well as Sites N-16.1 through N-16.5 for the entire route.

Another interconnector (I-NOR-7) runs almost parallel to this to the south-east of Shipping route SN10 along the north-western edges of Sites N-9.4, N-9.5, N-12.4, N-12.5, and N-13.4. For the route section from the entry of the interconnector from the Dutch EEZ into the German EEZ to the boundary of Site N-12.5, the importance of the route for the protected asset benthos is to be assessed as medium accoring to the comments on the sites mentioned and as medium to high if important populations of the endangered crab species *Upogeba stellata* occur. For the section of the route along Sites N-12.5 and N-13.4 – and here in particular for the reef to be crossed – the importance is assessed as medium to high.

The same applies to the fifth interconnector (I-NOR-6), which is to connect the German power grid with Denmark and runs parallel to the interconnector described above from Site N-12.4. This interconnector runs parallel to the grid connection systems coming from the Gate N-V along the southern edges of Areas N-11 and N-12. Accordingly, the statements and assessments made there are transferable to this section of the interconnector.

2.7. Fish

As the most species-rich of all vertebrate groups living today, fish are equally important in marine ecosystems as predators and prey. Bottom-dwelling fish feed primarily on invertebrate fauna living in and on the seabed, 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 for seabirds and marine mammals.

An initial categorisation of the fish fauna can be based on the mode of life of the adults. Terrestrial (demersal) species can be distinguished from those that live in open water (pelagic). Mixed forms of these (benthopelagic) are also widely used. However, this separation is not strict: demersal fish regularly ascend into the water column, while pelagic fish occasionally stay near the bottom. Demersal fish make up the largest proportion in the North Sea (at almost 60%) ahead of pelagic (20%) and benthopelagic (15%) species. Only about 5% cannot be assigned to any of the three lifestyles because of a close habitat connection (FROESE & PAULY 2024). The individual life stages of the species often differ more from each other in form and behaviour than the same stages of different species. Pelagic herring lay their eggs in thick mats on sandy-gravelly bottoms or stick them to suitable substrate such as algae or stones (DICKEY-COLLAS et al. 2015); all flatfish have pelagic larvae that transition to bottom life when they metamorphose into their characteristic body shape (VELASCO et al. 2015), and benthopelagic fish such as Atlantic cod have pelagic eggs and larvae (HISLOP et al. 2015). The vast majority of fish species recorded in the North Sea complete their entire life cycle – from egg to mature adult – there and are therefore described as *permanent residents* (LOZAN 1990). They include commercially fished species (e.g. sand eel, mackerel, and sole) as well as economically insignificant species (e.g. eelpout or yellow sole). Other marine species occur regularly in the North Sea as “summer visitors” mainly in summer but without clear signs of reproduction. Examples are the red gurnard and the striped red mullet. However, very small young of these two species have been recorded recently, thereby suggesting reproduction in the area (HEESSEN 2015, DÄNHARDT 2017). Some species occur irregularly in the North Sea regardless of the season; these include sculpin, bream, dogtooth, and halibut. Of these and other “misguided” species, only single specimens are usually caught. Unlike the marine fish of the three categories mentioned above, the life cycle of diadromous species spans the sea and freshwater. As the only catadromous species found in the German EEZ, the eel spawns in the sea and spends most of its adult life in fresh or brackish water. Much more common are anadromous species that spawn in freshwater and otherwise live in the sea. In the EEZ, smelt, twaite shad, and sea lamprey are examples of this.

The most important influences on fish populations are fishery and climate change (HOLLOWED et al. 2013, HEESSEN et al. 2015). The current warming of the North Sea can lead to a weakening of the synchronicity between the temperature-controlled zooplankton development and the day-length-controlled phytoplankton development. Because of this “mismatch” (CUSHING 1990, BEAUGRAND et al. 2003), fish larvae may find a reduced density of zooplankton when they rely on external food after consuming their yolk sac. The importance of this phenomenon stems from the fact that, across species, survival rates of early life stages have a disproportionate effect on population dynamics (HOUDE 1987, 2008). This variability can propagate to the predators at the top of the food web (DURANT et al. 2007, DÄNHARDT & BECKER 2011) and have implications for the management of fish populations. The effects of fishery and climate change interact and can hardly be distinguished in their relative effect on fish population dynamics (DAAN et al. 1990, VAN BEUSEKOM et al. 2018). Although the dominance ratios within a fish species community can follow long-term, periodic climate fluctuations (PERRY et al. 2005,BEAUGRAND 2009,GRÖGER et al. 2010,HISLOP et al. 2015), these cannot be explained without taking fishery into consideration (FAUCHALD 2010). Added to this are the hydrographic conditions and the influences of diverse human activities. Despite their complexity, a holistic view of the effects of various stressors on the fish fauna offers the possibility of recognising negative effects at an early stage and, if necessary, initiating targeted measures.

2.7.1. Data availability

Because data are available almost exclusively from bottom trawling and not from pelagic sampling, the following assessment can be made for demersal fish only. For pelagic fish, there are no data that fully represent the species composition and which were collected in connection with offshore wind farms. A reliable assessment of the pelagic fish community is therefore not possible. The basis for the status assessment of the protected asset (bottom-dwelling) fish are the analyses of the R&D project “Assessment approaches for maritime spatial planning and licensing procedure with regard to the benthic system and habitat structures” (DANNHEIM et al., 2014) as well as results from the environmental impact assessments for the consideration of the criteria of *rarity and endangerment* as well as *diversity and uniqueness* (from 2015). For a historical reference, EHRICH et al. (2006) and KLOPPMANN et al. (2003) were considered. The classification in the North Sea-wide context was done with the help of HEESSEN et al. (2015). For the current assessment (2022/2023) of the exploited populations, the internet portal “Fish populations online” (BARZ & ZIMMERMANN 2018, accessed on 1 February 2024) was used; this clearly 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 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 on different spatial and temporal scales. Hydrographic and, in a broader sencse, climatic factors such as swell, tides, and wind-induced currents as well as the large-scale circulation of the North Sea have a large-scale effect. On medium (regional) to small (local) space-time scales, water temperature and other hydrophysical and hydrochemical parameters as well as food availability, intra- and interspecific competition, and predation, which includes fishery, have an impact. Another crucial factor for the distribution of fish in time and space is habitat. In a broader sense, this means not only physical structures and the nature of the seabed 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 migration routes of migratory species and fishery to structures in the sea. Newly introduced structures can serve as spawning substrate (sheet piling for herring spawn) or food source (fouling on artificial structures) for some fish species (EEA 2015). Some fish species (e.g. Atlantic 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 ships), a general prohibition of navigation and use is regularly envisaged within the OWF sites with the consequence that no fishery takes place in the area. There is a need for research on whether the fishery-free area is used. Further information on the effects of newly introduced structures is described in Chapter 4.6 (Description and assessment of likely significant effects of implementing the site development plan on the marine environment).

2.7.2.1. Red List species in the German North Sea area

For the 107 fish and lamprey species established in the North Sea, the threat 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). Accordingly, 23.4% (25 species) of the marine fish and lampreys established in the North Sea are categorised as extinct or endangered. Taking into consideration the extremely rare species, the proportion of Red List species increases to 27.1% (29 species). Five of these species (allis shad, twaite shad, houting, river lamprey, and sea lamprey) are additionally listed in Appendix II of the Habitats Directive.

As part of a research and development project, DANNHEIM et al. (2014) derived “assessment approaches for maritime spatial planning and licensing procedure with regard to the benthic system and habitat structures” from data from 30 wind farm projects and nine research projects of the Alfred Wegener Institute for Polar and Marine Research. According to this, 15 of the 89 fish species analysed (16.9%) had a Red List endangerment status: Allis shad, thornback ray, and spiny dogfish are critically endangered (Category 1), European eel, dogfish, and haddock are considered european eel (Category 2), whilst twaite shad, starry ray, river lamprey, greater petrale, and poor cod are vulnerable (Category 3). The authors identified an indeterminate threat (category G) for the ocean pipefish, ling, common pipefish, and the ballan wrasse is extremely rare (category R).

2.7.2.2. Typical regional fish communities in the EEZ

During a one-off investigation in May 2002 to survey fish species of Appendix II Habitats Directive in the German EEZ KLOPPMANN et al. (2003) detected 39 fish species in the areas of

Borkum-Riffgrund, Amrum-Außengrund, Osthang Elbe Glacial Valley, and Doggerbank. This investigation identified a gradual change in the species composition of the fish communities from the inshore to the offshore areas because of hydrographic conditions. These changes were confirmed by DANNHEIM et al. (2014), who were able to geographically distinguish four fish communities in the German EEZ using effort-corrected catch figures: The largest formed the central community (ZG), which were demarcated in the north by the two communities of the duckbill (ES I and ES II) and along the coast by a coastal community (KG) (Figure 21 and Figure 22). Areas with less than six stations were not assigned to any fish community (grey symbols in Figure 21).

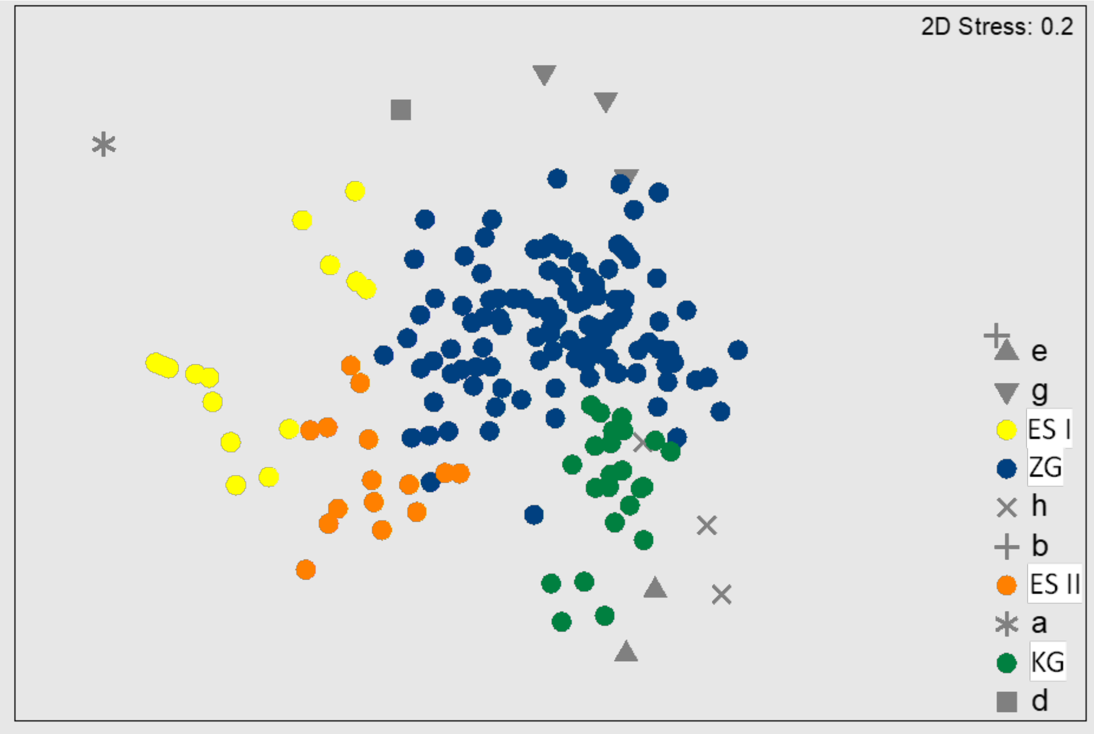

Figure 21: Relative similarity of species composition and species-specific abundances of bottom-dwelling fish in the German EEZ of the North Sea. The central community (ZG, blue dots), the coastal community (KG, green dots) and two communities of the north-western region of the German EEZ (ES I and II, yellow and orange dots) can be clearly distinguished from each other. Areas with less than six stations were not assigned to any fish community (grey symbols e, g, h, b, and d). Non-metric multi-dimensional scaling based on √-transformed and effort-standardised abundance data from catches with a 2 m beam trawl; N = 173 stations). From DANNHEIM et al. (2014).

The species number of community ES I was clearly lower (ES I: 2 ± 1 · Hol−1) than that of the other communities with a mean species number of 6 ± 2 Hol−1 (ES II) and 7 ± 2 · Hol−1 (KG). Like species numbers, demersal fish abundance increased with proximity to the coast – from 4,454 ± 3,598 individuals/km^{-2} in the offshore ES I to 95,128 ± 44,582 individuals/km^{-2} in the coastal community (Figure 23 (a)). On the other hand, biomass did not show a geographic trend, and the lowest biomass was found in ES I (108 ± 112 kg · km^{-2}). The largest biomass was found in ES II with 801 ± 513 kg · km^{-2} (Figure 23b). Based on high-resolution data from environmental impact studies for individual offshore wind farms, the demersal fish community was investigated on a smaller scale (DANNHEIM et al. 2014). For this purpose, the data for the community analyses were grouped according to wind farm clusters as defined in the Federal

Offshore Grid Plan (BSH 2017). In the following, these wind farm areas are designated numerically as OWF Areas 1-12 according to the SDP (Figure 22).

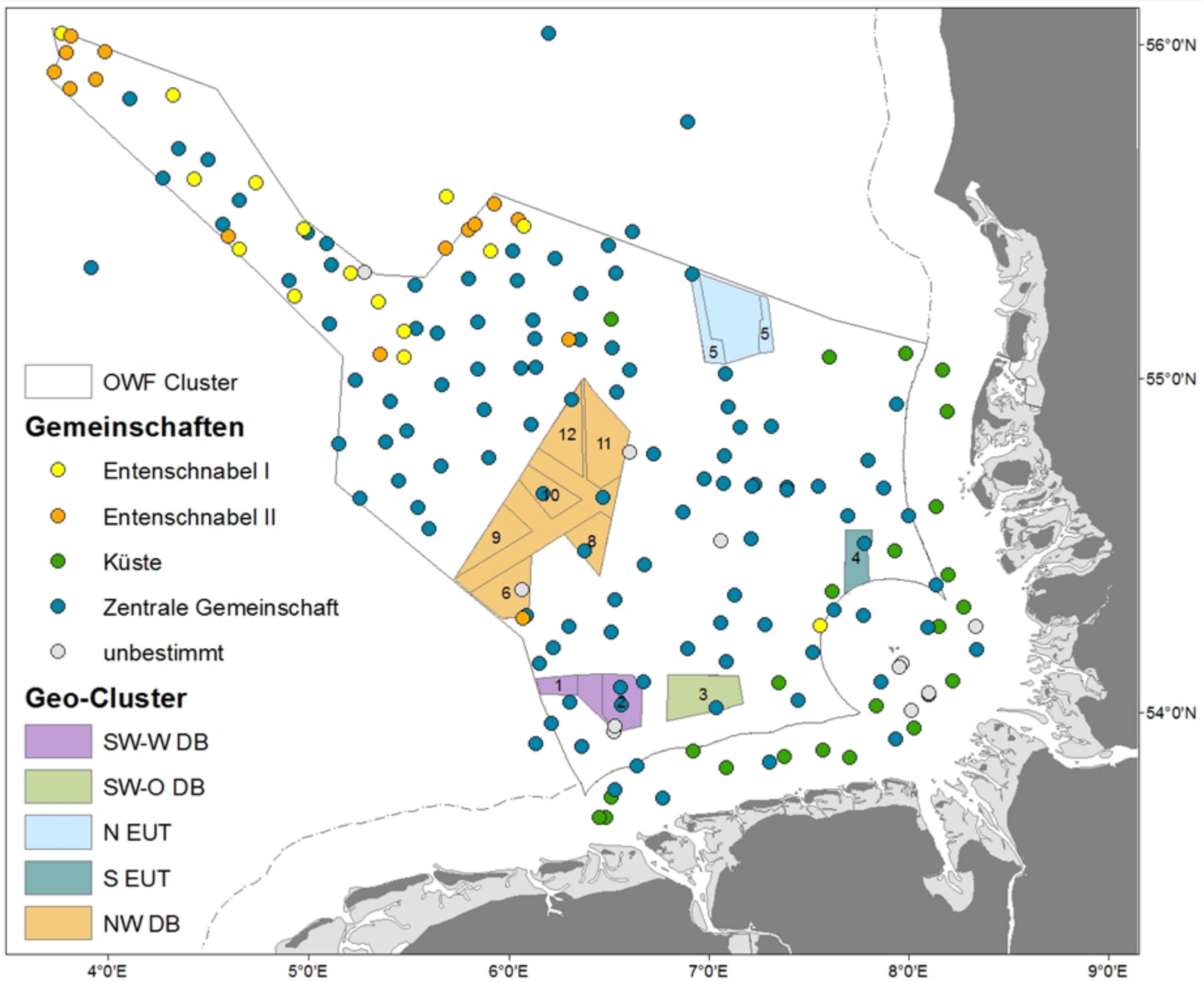

Figure 22: Map of the spatial variability of the identified fish communities in the German EEZ of the North Sea based on effort-corrected abundance data and the location of the geo-clusters determined from the R-values (single-factorial ANOSIM). SW-W DB = Western Südwestliche Deutsche Bucht, SW-O DB = Eastern Südwestliche Deutsche Bucht, N EUT = Northern Elbe Glacial Valley, S EUT = Southern Elbe Glacial Valley, NW DB = Northwestern Deutsche Bucht. methods of analysis, colour coding, and sample size as in Figure 1F. From DANNHEIM et al. (2014).

In order to exclude temporal effects on the spatial analyses, data from all OWF areas were analysed in pairs separately by year and season (Figure 24). The individual OWF areas were compared pairwise using one-factorial similarity analyses (ANOSIM), whereby the mean R-value was calculated as a measure of the mean dissimilarity between predefined groups (here: the OWF areas). R-values close to 0 indicate an absence of differences, R-values close to 0.25 indicate that groups are almost inseparable, R-values close to 0.50 indicate that separation of groups is possible, R-values close to 0.75 indicate good separability of groups, and R-values close to 1.00 indicate complete separation of groups (CLARKE & GORLEY 2001). Without the influence of temporal effects, the western OWF areas 1 and 2 (SW-W DB) were separated from the eastern OWF area 3 (SW-O DB) in the Südwestlichen Deutschen Bucht off the East Frisian coast (Figure 24). Furthermore, the analyses showed a separation of the coastal OWF areas

4 (S EUT) and 5 (N EUT) along the edge of the Elbe Glacial Valley. The greatest similarity (indicated by low R-values) in terms of species-specific fish abundance was between OWF areas 6 to 12 in the Nordwestliche Deutsche Bucht (NW DB).

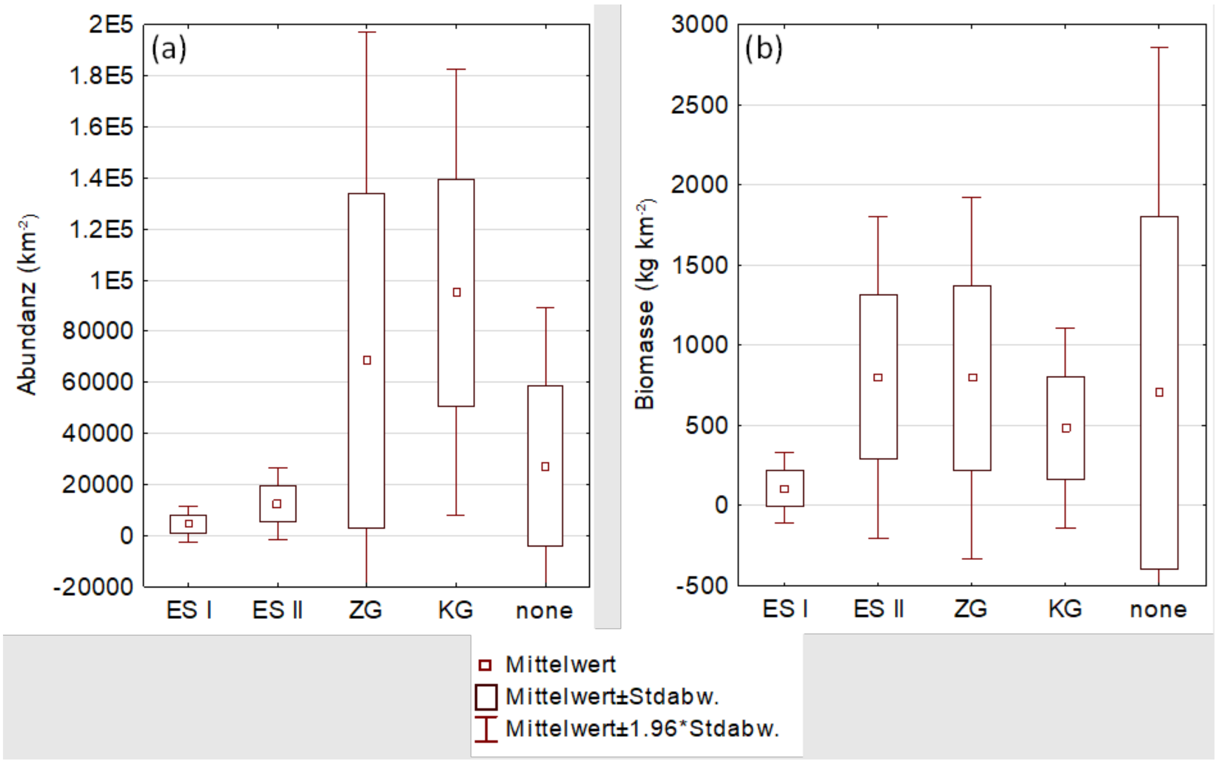

Figure 23: Box-whisker plots of (a) abundance (km^{-2}) and (b) biomass (kg · km^{-2}) of the fish communities identified in the German EEZ of the North Sea. Abbreviations, analytical methods, and sample sizes as in Figure 21. From DANNHEIM et al. (2014).

The differences between the five geo-clusters identified using ANOSIM (SW-W DB, SW-O DB, N EUT, S EUT, NW DB (Figure 24) stood out clearly; the degree of dissimilarity sometimes varied greatly even between neighbouring geo-clusters. Whilst OWF areas 5 and 6 were quite similar (mean R-value = 0.42), the fish community of OWF area 12 differed significantly from that of OWF area 10 within the NW DB geocluster (R = 0.84) (Figure 24 left). The separation of geo-clusters based on species-specific abundance should therefore be understood as a spatial gradient in community characteristics rather than a sharp demarcation of different demersal communities. The number of demersal fish species was generally quite similar between the geo-clusters: The most fish species per haul on average (13 ± 3) were caught in the geo-cluster SW-W DB whilst the fewest fish species (11 ± 3) were caught in the geo-cluster N EUT. Furthermore, the geo-clusters showed no clear geographical differences in the total abundance and total biomass of all species. The highest abundance was recorded in the geo-cluster SW-O DB (82,040 ± 70,335 individuals · km^{-2}), the lowest in the geo-cluster NW DB (20,010 ± 22,847 individuals · km^{-2}). The average biomass varied between 750 ± 447 kg · km^{-2} (NW DB) and 1563 ± 657 kg · km^{-2} (SW-O DB). Also the species composition hardly differed between the geo-clusters: Over 60% of the species were found across different areas. Only five species were relevant for the dissimilarity between the geo-clusters. Yellow sole, dab, and plaice occurred in all geo-clusters but contributed to the similarity to varying degrees. Scaldfish were characteristic of the western geo-clusters (SW-W DB, SW-O DB, NW DB) whilst gobies characterised the geo-clusters along the Elbe Glacial Valley and eastern areas (N EUT, S EUT). There are hardly any structural differences in species composition between the geo-clusters. Differences are based solely on the different abundances of the species.

Cluster	1	2	3	4	5	6	8	9	10	11	12
1		0,43	**0,60**	**0,77**	**0,67**		**0,80**				
2			**0,67**	**0,77**	**0,60**	**0,78**	**0,79**	**0,96**	**0,93**	**0,85**	**1,00**
3				**0,69**	**0,68**	**0,76**	**0,71**	**0,97**	**0,95**	**0,89**	
4					**0,54**		**0,70**				
5						0,42	**0,55**				
6							0,24	0,17	0,22	0,21	
8								0,47	0,17	0,10	0,37
9									0,34	0,49	
10										0,21	**0,84**
11											0,01
12											

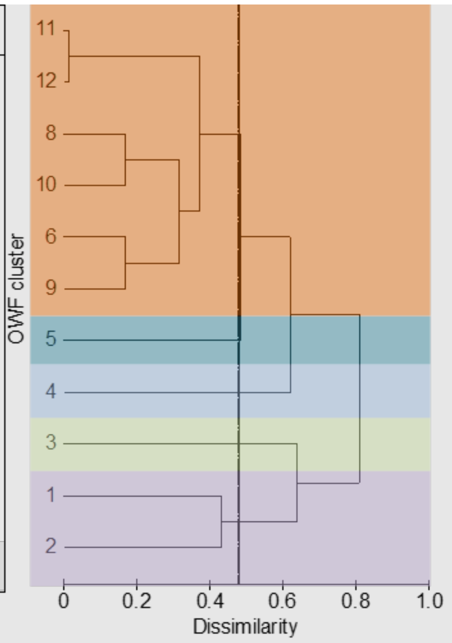

Figure 24: R-values for the diversity of OWF areas (one-factorial ANOSIM) based on abundance data of the demersal fish community. The R-values correspond to the mean R-value of the individual pairwise tests between the OWF areas. Differences between the identified geo-clusters in different colours. From DANNHEIM et al. (2014).

2.7.3. Status assessment

The status assessment of the demersal fish community of the EEZ of the German North Sea is based on i) rarity and endangerment, ii) diversity and uniqueness, and iii) existing pressure. These three criteria are defined below and applied separately for Areas N-9, N-12, and N-13. The status of Areas N-14 to N-16 and Areas N-17 to N-20 is assessed on the basis of the information available in the literature.

2.7.3.1. Rarity and endangerment

The rarity and endangerment of the fish community is assessed on the basis of the proportion of species that are considered vulnerable 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 2023) and have been assigned to one of the following Red List categories: Extinct or lost (0), critically endangered (1), endangered (2), vulnerable (3), indeterminate (G), extremely rare (R), threatened (V), data insufficient (D) or least concern (*) (THIEL et al. 2013). Special attention is paid to the endangerment situation of species listed in Appendix II of the Habitats Directive. They are the focus of Europe-wide conservation efforts and require special protective measures (e.g. of their habitats).

Because of similar geological and hydrographic environmental conditions, the results from the environmental investigations of Area N-6 for Area N-9, Area N-8 for Area N-12, and Area N-5 for Area N-13 are used as a basis in the following.

During the environmental impact assessments in the period under consideration (Chapter 2.7.1), 46 fish species were identified in the maritime area in which Sites **N-9.4 and N-9.5** are located. Of these, according to THIEL et al. (2013), no species is considered extinct or lost (0); the thornback ray (one species, 2.2%) is critically endangered (1), and haddock, an endangered species (2), was detected (2.2%). The poor cod is considered vulnerable (3) (one species, 2.2%). The greater pipefish is considered to be indeterminate (G) (one species, 2.2%). With the spotted ray, one extremely rare species (R) was detected in the maritime area of Area N-9 (2.2%). The four species Atlantic cod, turbot, sole, and bib are near threatened (8.7%). For seven of the species analysed (15.2%), the data situation is considered insufficient for an assessment (D). Of the 46 species surveyed, 30 (65.2%) are considered least concern (*) (Table 7).

During the environmental impact assessments in the period under consideration (Chapter 2.7.1), 41 fish species were identified in the maritime area in which Sites **N-12.4 and N-12.5** are located. Of these, according to THIEL et al. (2013), no species is considered extinct or lost (0); the thornback ray (one species, 2.4%) is critically endangered (1), and haddock, an endangered species (2), was detected (2.4%). The poor cod is considered vulnerable (3) (one species, 2.4%). The greater pipefish is considered to be indeterminate (G) (one species, 2.4%). With the spotted ray, one extremely rare species (R) was detected in the maritime area of Area N-12 (2.4%). The three species Atlantic cod, turbot, and sole are near threatened (7.3%). For five of the species analysed (12.2%), the data situation is considered insufficient for an assessment (D). Of the 41 species surveyed, 28 (68.3%) are considered least concern (*) (Table 7).

During the environmental impact assessments in the period under consideration (Chapter 2.7.1), 33 fish species were identified in the maritime area in which Sites **N-13.4 and N-13.5** are located. Of these, according to THIEL et al. (2013), no species is considered extinct or lost (0). No species is considered to be critically endangered (1), endangered (2), or vulnerable (3). The ocean pipefish is considered to be indeterminate (G) (one species, 3%). No extremely rare species (R) were detected in the lake area of Area N-13. The three species Atlantic cod, turbot, and sole are near threatened (9.1%). For six of the species analysed (18.2%), the data situation is considered insufficient for an assessment (D). Of the 33 species surveyed, 23 (69.7%) are considered least concern (*) (Table 7).

In the Red List of Marine Fishes, 27.1% of the species assessed are assigned to an endangerment category (0, 1, 2, 3, G, or R); 6.5% are near-threatened, and 22.4% cannot be assessed because of a lack of data. 43.9% of the species are considered to be least concern (THIEL et al. 2013) (Table 7). In comparison, significantly fewer species with an endangerment status were detected in all maritime area considered (9: 10.9%, 12: 12.2%, 13: 3%), whilst there were always more species of least concern than those listed in the Red List (9: 65.2%, 12: 68.3%, 13: 69.7%).

Table 7: Relative proportion of Red List categories in fish species detected in Areas N-9, N-12, and N-13. Extinct or lost (0), critically endangered (1), endangered (2), vulnerable (3), indeterminate (G), extremely rare (R), threatened (V), data insufficient (D) or least concern (*) (THIEL et al. 2013) (EIS data

from 2015, see Chapter 2.7.1). For comparison, the relative proportions of the assessment categories of the Red List North Sea (THIEL et al. 2013) are shown.

Area	Red List Category								
	0	1	2	3	G	R	V	D	*
9	0.0	2.2	2.2	2.2	2.2	2.2	8.7	15.2	65.2
12	0.0	2.4	2.4	2.4	2.4	2.4	7.3	12.2	68.3
13	0.0	0.0	0.0	0.0	3.0	0.0	9.1	18.2	69.7
North Sea (Thiel et al. 2013)	**2.8**	**7.5**	**6.5**	**1.9**	**4.7**	**3.7**	**6.5**	**22.4**	**43.9**

No extinct or lost species (category 0) were found in any of the maritime area. For critically endangered (1) and endangered (2) species (thornback ray and haddock), the importance of the areas is below average whilst vulnerable species (3) (poor cod) occur in the areas in roughly equal numbers compared with the Red List. For these species, the areas have an average importance. In all the areas analysed, the proportions of species in category G (indeterminate, greater pipefish and ocean pipefish) and category R (extremely rare, spotted ray) were lower than in the Red List. For these species, the areas have an below-average importance. Relatively more species in categories V (near threatened) and * (least concern) were found in all areas. The proportion of species that could not be assessed because of lack of data (D) was below the proportion of this category in the Red List (Table 1F) in nearly all areas. Against this background, the rarity and endangerment of the fish fauna in the areas under consideration is rated as **medium**.

2.7.3.2. Diversity and uniqueness

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

Over 200 species of fish have been recorded in the North Sea so far (DAAN et al. 1990: 224, LOZAN 1990: >200, FRICKE et al. 1994, 1995, 1996: 216, Froese & Pauly 2024: 209). The vast majority of these are rare individual records. Less than half of them reproduce regularly in the German EEZ or are encountered as larvae, young, or adults. According to these criteria, only 107 species are considered established in the North Sea (THIEL et al. 2013). In the German EEZ, represented here by the area-related fish data from environmental impact assessments (from 2015), 56 species were identified. The number of species in the individual areas was between 33 and 47 (see “Rarity and endangerment”). Most species were found in Area N-9, but this may be partly due to the increased survey effort in this area. The lowest number of species was recorded in Area N-13 (Table 8).

The most important representatives of demersal flatfish and roundfish species were recorded across all areas. In general, dab, plaice, yellow sole, scaldfish, and common dragonet were among the character species in all areas. Furthermore, whiting, grey gurnard, turbot, fourbeard rockling, hooknose, sole, and sand goby were among the most important fish species. Striped red mullet, reticulated dragonet, greater sand eel, and lesser weever were also strongly represented in some cases. Although the bottom trawls used are unsuitable for recording pelagic fish, the species typical of the pelagic part of the fish community, namely herring, sprat, and horse mackerel were recorded in all areas (Table 8). The ocean pipefish (indeterminate) occurred in one area. Thornback ray (critically endangered) and haddock (endanged) as well as poor cod (vulnerable) and greater pipefish (indeterminate) were detected in two of the areas surveyed. The two ray species blonde ray and spotted ray (extremely rare) were also recorded in two areas. No fish species in accordance with Appendix II-IV of the Habitats Directive were detected during the investigations.
Of the 56 species detected in the German EEZ during the period under review, 26 species occurred in all areas. 15 species occurred only in one area each. The fish species composition obviously differs between the areas with regard to individual, rare species, while there are great similarities in the characteristic, more common species (Table 8). Further differences between the areas are due mainly to different abundance distributions of the dominant species.

The demersal fish community of sandy seabeds in the southern North Sea is dominated by flatfish (dab, plaice, yellow sole, and seabed) with species such as hooknose, dab, grey gurnard, and whiting also regularly occurring (DAAN et al. 1990, ROGERS et al. 1998, EHRICH et al. 2006). An increase in abundance and stability has been observed for the smaller species yellow sole, scaldfish, and dragonet; this is due mainly to fishery and climatic changes (VAN HAL et al. 2010). Sand gobies play an important role in the food web of the demersal fish community in large parts of the North Sea as prey species for larger demersal fish species and predators of benthic invertebrates (SCHÜCKEL et al. 2012). Alongside Atlantic cod, whiting is one of the most common cod species in the North Sea. In earlier times, the thornback ray was considered the most common and most widespread ray in the German North Sea (ZIDOWITZ et al. 2017). Today, there are only isolated recent records from the German EEZ and the Wadden Sea. The other two ray species, spotted ray and blonde ray, are extremely rare in German waters (THIEL et al. 2013). They prefer sandy habitats; however, their occurrence is not limited to this type of habitat (Heessen et al. 2015).

Overall, the diversity and uniqueness of all the areas analysed are assessed as **medium**. The results of the investigations provide a representative overview of the fish community occurring in this North Sea region. Overall, the area has a stable species and dominance structure. The typical and characteristic species of both the pelagic and demersal components of the fish communities under consideration were represented in all areas.

Table 8: Total species list of fish species detected in Areas N-9, N-12 and N-13 (EIS data from 2015, see Chapter 2.7.1).

		Area		
Species name	**Trivial name**	**9**	**12**	**13**
Agonus cataphractus	Hooknose	■	■	■
Ammodytes marinus	Lesser sand eel	■		■

Aphia minuta	Transparent goby	■		
Arnoglossus laterna	Scaldfish	■	■	■
Belone belone	Garpike	■	■	
Buglossidium luteum	Yellow sole	■	■	■
Callionymus lyra	Common dragonet	■	■	■
Callionymus maculatus	Spotted dragonet	■		
Callionymus reticulatus	Reticulated dragonet	■	■	■
Chelidonichthys lucerna	Tub gurnard	■	■	■
Ciliata mustela	Fivebeard rockling	■	■	■
Clupea harengus	Herring	■	■	■
Ctenolabrus rupestris	Goldsinny wrasse	■		
Echiichthys vipera	Lesser weever	■	■	■
Enchelyopus cimbrius	Fourbeard rockling	■	■	
Engraulis encrasicolus	European anchovy	■	■	
Entelurus aequoreus	Ocean pipefish			■
Eutrigla gurnardus	Grey gurnard	■	■	■
Gadus morhua	Atlantic cod	■	■	■
Gasterosteus aculeatus	Three-spined stickleback	■	■	■
Gobius niger	Black goby	■		
Hippocampus hippocampus	Short-snouted seahorse	■		
Hippoglossoides platessoides	American plaice		■	
Hyperoplus lanceolatus	Greater sand eel			■
Limanda limanda	Common dab	■	■	■
Liparis liparis	Common seasnail			■
Lophius piscatorius	Sea-devil	■	■	
Melanogrammus aeglefinus	Haddock	■	■	
Merlangius merlangus	Whiting	■	■	■
Microstomus kitt	Lemon sole	■	■	■
Mullus surmuletus	Striped red mullet	■	■	■
Myoxocephalus scorpius	Bullhead	■	■	■
Pholis gunnellus	Butterfish		■	■
Phrynorhombus norvegicus	Norwegian topknot	■		
Platichthys flesus	Flounder	■	■	■
Pleuronectes platessa	Plaice	■	■	■
Pollachius virens	Saithe	■		
Pomatoschistus lozanoi	Lozano's goby		■	
Pomatoschistus minutus	Sand goby	■	■	■
Pomatoschistus norvegicus	Norwegian goby	■	■	
Pomatoschistus pictus	Painted goby		■	■
Raja brachyura	Blonde ray	■	■	
Raja clavata	Thornback ray	■	■	
Raja montagui	Spotted ray	■	■	

Scophthalmus maximus	Turbot	■	■	■
Scophthalmus rhombus	Brill	■	■	■
Scyliorhinus canicula	Small-spotted catshark	■	■	
Solea solea	Sole	■	■	■
Sprattus sprattus	Sprat	■	■	■
Syngnathus acus	Greater pipefish	■	■	
Syngnathus rostellatus	Lesser pipefish	■	■	■
Taurulus bubalis	Longspined bullhead			■
Trachurus trachurus	Horse mackerel	■	■	■
Trisopterus luscus	Bib	■		
Trisopterus minutus	Poor cod	■	■	
Number of species		**47**	**42**	**33**
Average number of species per investigation		**26**	**23**	**25**

2.7.3.3. Existing pressure

The southern North Sea has been intensively used for centuries. Fishery probably has the greatest adverse affect on the natural habitat and the fish community; however, nutrient pollution can also adversely affect the natural habitat. In addition, fish are under other direct or indirect human influences such as maritime traffic, pollutants, and sand and gravel extraction. However, these indirect influences and their effects on the fish fauna are difficult to prove. In principle, it is not possible to reliably separate the relative effects of individual anthropogenic factors on the fish community and their interactions with natural biotic (predators, prey, competitors, reproduction) and abiotic (hydrography, meteorology, sediment dynamics) influential variables of the German EEZ.

As a result of the removal of indicator species and bycatch as well as the adverse effect on the seabed in the case of bottom-disturbing fishing methods, fishery is considered the most effective existing pressure to the fish community. There is no assessment of populations on a smaller spatial scale such as the German Bight. Consequently, the assessment of this criterion cannot be carried out at the area level but rather only for the entire North Sea. Of the 107 species considered established in the North Sea, 21 are fished commercially (THIEL et al. 2013). The fishing impact assessment is based on the “Fisheries overview - Greater North Sea Ecoregion” of the International Council for the Exploration of the Sea (ICES 2022a). Fishery has two main effects on the ecosystem: the disturbance or destruction of benthic habitats by bottom-disturbing nets and the removal of indicator species and by-catch species. The latter often include protected, vulnerable, or threatened species including not only fish but also birds and mammals (ICES 2022b). About 6600 fishing vessels from nine nations fish in the North Sea. The largest quantities were landed in the early 1970s and catches have been declining since then. However, a reduction in fishing effort has only been observed since 2003. The intensity of bottom-disturbing fishery is concentrated in the southern North Sea and is by far the predominant form of fishery in the German EEZ (ICES 2022a). Flatfish trawling in the German EEZ targets plaice and sole; it uses not only heavy bottom gears but also relatively small meshes. As a result, the bycatch rates of small fish and other marine animals can be quite high.

Commercial fishery and spawning population sizes are assessed against maximum sustainable yield (MSY), taking into consideration the precautionary approach. 118 populations throughout the North Sea were considered in terms of fishing intensity; of these, 45 are the subject of a scientific stock assessment (Figure 25). Of the 45 populations assessed, 30 are managed sustainably. 52 of the 118 stocks were assessed for their reproductive capacity (spawning biomass); 33 stocks are able to use their full reproductive capacity (Figure 25). The biomass proportion of the total catch (4,426,000 t in 2022) managed at too high a fishing intensity outweighs the proportions of sustainably caught and unassessed fish populations in the North Sea (3,261,000 t Figure 25). Fish from populations for which the reproductive capacity is above the reference level account for most of the biomass in the catch (3,946,000 t, Figure 25).

Overall, the fishing mortality of demersal and pelagic fish has decreased considerably since the late 1990s. For most of these populations, spawning biomass has been increasing since 2000 and is now above or close to individually set reference points. Nevertheless, fishing mortality for many populations is also above the established reference measures (e.g. for Atlantic cod, whiting, or mackerel). Moreover, for the vast majority of the populations exploited, no reference levels are defined, which makes it impossible to carry out scientific population assessments.

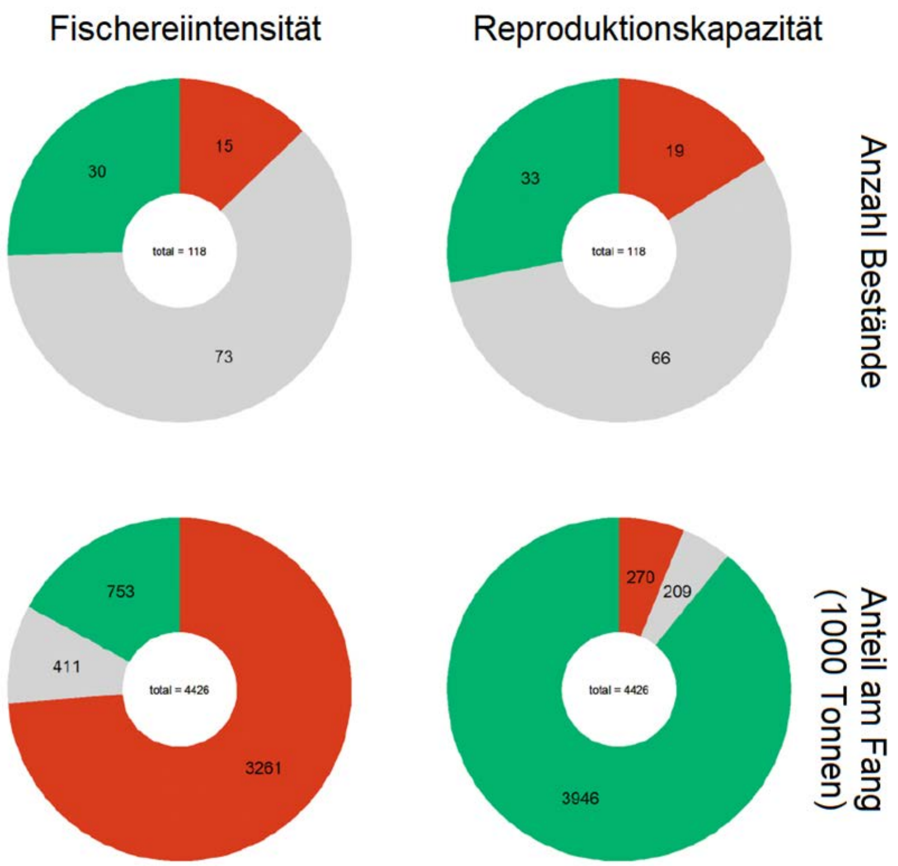

Figure 25: Summary of the status of fish populations throughout the North Sea in 2022, focusing on fishing intensity and reproductive capacity. Left: The fishing intensity indicates the number of populations (top) and the biomass proportion of the catch (bottom; in 1,000 tonnes) that is below (green) or above

(red) the reference value (fishing intensity for sustainable long-term yield, FMSY). Right: The reproductive capacity indicates the number of populations (top) and the proportion of biomass in the catch (bottom) that is above (green) or below (red) the reference value (spawning biomass, MSY Btrigger). Grey indicates the number or biomass proportion of the catch of populations for which no reference points are defined and for which no population assessment is therefore possible. Consideration of 118 populations in total. Modified according to ICES 2022a.

In addition to fishery, eutrophication is one of the greatest ecological problems for the marine environment in the North Sea (BMU 2018). Despite reduced nutrient inputs and lower nutrient concentrations, the southern North Sea is subject to a high eutrophication load in the period 2006 - 2014. Nitrates and phosphates are carried in predominantly via rivers; this leads to a pronounced gradient in nutrient concentration from the coast to the open sea (BROCKMANN et al. 2018). Major direct effects of eutrophication are increased chlorophyll-a concentrations, reduced depths of visibility, local decline in seagrass areas, and density with associated mass proliferation of green algae. Above all, the seagrass meadows of the Wadden Sea have an important protective function for the fish spawn and offer numerous juvenile fish a protected feeding area between the stalks. As seagrass meadows decline as a result of eutrophication, there are fewer retreat areas and potentially higher predation rates. The indirect effects of nutrient enrichment (e.g. oxygen deficiency and a changed species composition of macrozoobenthos) may also have impacts on the fish fauna. In many species, the survival and development of fish eggs and larvae depends on oxygen concentration (SERIGSTAD 1987). Depending on how much oxygen is required, a lack of oxygen can lead to the death of the fish spawn and larvae. Furthermore, the altered species composition of the benthos can also influence the biodiversity of the fish community, especially that of the specialists.

Based on the fact that, according to ICES, fish species richness in the North Sea has not declined for 40 years (number of species per 300 hauls; catch data from the International Bottom Trawl Survey, IBTS), and that commercially exploited populations are also subject to strong natural fluctuations, the existing pressure of the fish fauna in the German EEZ was assessed as **medium**. This assessment is supported by the summary of fishery metrics and the ecosystem effects of bottom-disturbing fishery (WATLING & NORSE 1998, HIDDINK et al. 2006).

Areas N-4 and N-5

According to the current state of knowledge, there is no new situation for Areas N-4 and N-5 compared with SDP 2020. The importance of these areas for the protected asset fish according to the above criteria is to be regarded as average regardless of the subsequent use scenario.

Sites N-14 through N-16 and Areas N-17 through N-20

For Areas N-14 to N-16 and Areas N-17 to N-20, there is currently no data from the environmental impact assessments. An assessment is therefore possible only on the basis of the literature. The subdivision of fish communities in the North Sea generally corresponds to changes in abiotic parameters such as water depth, salinity, and water temperature as well as the nature of the seabed (DAAN et al. 1990, ROGERS et al. 1998, EHRICH et al. 2009). KLOPMANN et al. (2003) determined a gradual change in the species composition of the fish communities in the German EEZ from the inshore to the offshore areas because of the hydrographic conditions.

According to DANNHEIM et al. (2004), the areas under consideration (N-14 to N-20) are characterised by a transition from the central community to the two communities of the north-western region of the German EEZ. In the course of this transition, the number and abundance of species is expected to gradually decrease with distance from the coast (cf Chapter 2.7.2.2). A study by RAMBO et al. (2017) shows not only the spatial distribution of different diversity measures (Hill's N0, species richness and N1, spatial variation of species richness) in relation to the demersal fish communities but also a sensitivity measure (Community Sensitivity Index, CSI), which shows the vulnerability of the demersal fish fauna to fishery. Hotspots in the EEZ are therefore found in particular near the Elbe Glacial Valley and north-west of the Doggerbank whilst less diverse areas can be found on the Doggerbank and in the southern north-western region of the German EEZ (transition zone between the Doggerbank and the German Bight) (Figure 26). Because the overlap of the hotspots with the designated sites for wind energy is minimal (parts of N-16.1 and N-19), these areas are also not considered to be of particular importance for the fish community.

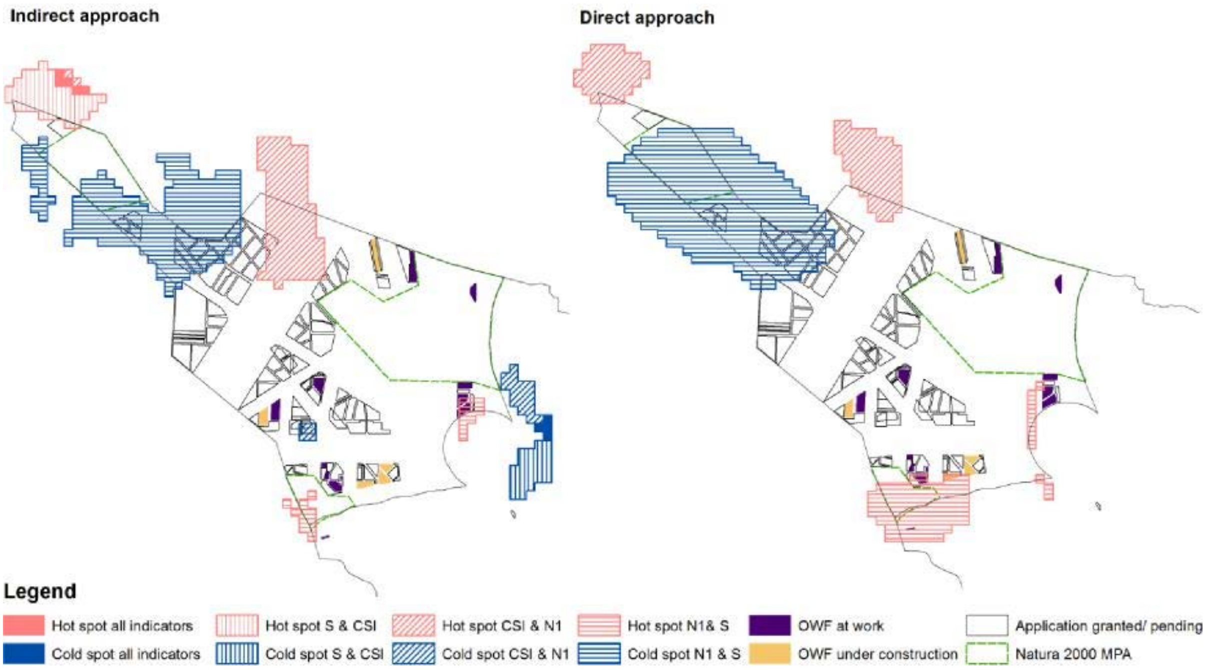

Figure 26: Statistically significant hotspots and coldspots of all indirectly and directly mapped indicators (solid colour) and indicator pairs (dashed lines) in the German EEZ (indicators Hill's N0, species richness and N1, spatial variation of species richness as well as Community Sensitivity Index, CSI). From RAMBO et al. (2017).

2.7.4. Importance of areas and sites for the protected asset

The overarching criterion for the importance of the area for fish is its relation to the life cycle within which different stations with stage-specific habitat requirements (nursery area, foraging ground, and potential spawning grounds) are linked by more or less long migrations in between. The overview of species records by area did not show any particular importance of a special area (Table 8) for the constant, frequent character species. The areas under consideration are characterised by a predominantly homogeneous sediment and depth structure, and the sand beds are used as a habitat by many species such as flounder, sand eel, and goby. There are no clear trends in the distribution of coastal and non-coastal species. This is plausible because the areas under consideration are equally remote from the coast. Although more species were found in Area N-9 and N-12, this is partly due to the increased survey effort in these areas. The proportion of vulnerable species (Red List categories 0-R) was also higher in Areas N-9 and N-12 than in area N-13. Several species of rays were also found in these two areas. These areas could therefore be of above-average importance for these species.

2.8. Marine mammals

Three species of marine mammals regularly occur in the German EEZ of the North Sea: Harbour porpoises (*Phocoena phocoena*), grey seals (*Halichoerus grypus*), and harbour seals (*Phoca vitulina*). All three species are characterised by a high mobility. Migrations (especially in search of food) are not limited to the EEZ but rather also include the territorial sea and large areas of the North Sea across borders.

Harbour porpoises occur year-round in the German EEZ of the North Sea but show seasonal variability in their occurrence and spatial distribution. Abundance and distribution patterns also vary between years. In the summer months, mother-calf pairs are common, especially in the waters off the North Frisian Islands and west of Sylt.

The two seal species have their resting and haul-out places mainly on islands and sandbanks in the area of the territorial sea but also on places further from the coast such as the island of Heligoland. For foraging, they undertake extensive migrations in the open sea from their resting places. Because of the high mobility of the marine mammals and the use of extensive areas, it is necessary to consider their occurrence not only in the German EEZ but also in the entire area of the southern North Sea.

Occasionally, other marine mammals are also observed in the German EEZ of the North Sea. These include white-sided dolphins (*Lagenorhynchus acutus*), white-beaked dolphins (*Lagenorhynchus albirostris*), bottlenose dolphins (*Tursiops truncatus*) and minke whales (*Balaenoptera acutorostrata*).

Marine mammals are among the top predators of marine food webs. This makes them dependent on the lower components of the marine ecosystem: On one hand, from their direct food organisms (predominantly fish and zooplankton). On the other hand, indirectly from phytoplankton. As consumers at the top of the food web, marine mammals simultaneously influence the occurrence of food organisms.

2.8.1. Data availability

The occurrence of the harbour porpoise in the North Sea and in particular in German waters has largely been well investigated over the last 25 years.

The large-scale investigations include the four SCANS (Small Cetacean Abundance in the North Sea and adjacent waters) investigations, which cover the entire area of the North Sea, Skagerrak, Kattegat, the western Baltic Sea/Belt Sea, and the Celtic Sea as well as other parts of the north-eastern Atlantic.

The German waters currently belong to the areas of the North Sea, which have been systematically and intensively investigated for the occurrence of marine mammals since 2000. Most of the data are provided by the investigations, which are carried out as part of environmental impact studies and construction and operational monitoring for offshore wind farms. In addition, regular investigations are carried out for the monitoring of nature conservation areas on behalf of the BfN. Finally, data are also collected as part of research projects that investigate specific issues.

The data situation can currently be described as good to very good for Areas N-1 up to and including N-13 (Zone 3) in the German EEZ whilst the data from Areas N-14 to N-19 (Zone 4 and Zone 5) is limited to BfN monitoring data and individual fly-overs as part of research projects. The data from the construction and operational monitoring of the BSH are also systematically quality-assured and used for studies. The current state of knowledge on the occurrence of marine mammals in German waters can thus be considered sufficient. Current findings are obtained from the monitoring of offshore projects and the preliminary site investigation in Area N-4 (Nördlich Helgoland investigation cluster) as well as from individual projects in Areas N-6 through N-8 and partly Area N-9. The results from the construction and operational monitoring of offshore wind farms as well as the preliminary investigation of sites thus provide extensive spatially and temporally highly resolved data on the occurrence of marine mammals in Zones 1 through 3.

The current findings relate to different spatial levels:

- entire North Sea and neighbouring waters: Investigations as part of SCANS I, II III, and IV from 1994, 2005, 2016, and 2022
- Research projects in the German EEZ and in the territorial sea (including MINOS, MINOSplus (2002–2006), and StUKplus (2008–2012)),
- Investigations to fulfil the requirements of the UVPG within the framework of permission and planning approval procedures of the BSH as well as from the construction and operational monitoring of offshore wind farms since 2001 and ongoing.
- Monitoring of the nature conservation area on behalf of BfN since 2008 and ongoing,

For the German EEZ, the most comprehensive data are collected as part of environmental impact studies as well as in the context of the construction and operational monitoring of offshore wind farms. The marine mammals are surveyed from the aircraft. With the introduction of the StUK4, flight-based recording is carried out using high-resolution digital photo and video technology.

In addition, since 2009, acoustic data on the habitat use by harbour porpoises have been surveyed using underwater measurement systems such as C-PODs. Since 2009 (with some interruptions since 2019), a network of CPOD stations has been maintained in the German EEZ by the operators of offshore wind farms as well as by the preliminary site investigation. The station network provides the most comprehensive and valuable data on harbour porpoise habitat use in the areas of the German EEZ of the North Sea to date.

Information on the occurrence of marine mammals is also provided by observations within the framework of the ship-based survey of resting and seabirds according to StUK. The large-scale distribution and abundance in the German EEZ is surveyed as part of the monitoring of Natura 2000 sites on behalf of the BfN (monitoring reports on behalf of the BfN 2019, 2020, 2021).

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 of their occurrence. Both the distribution and the abundance of the animals vary over the course of the seasons. In order to be able to draw conclusions about seasonal distribution patterns and the use of areas as well as the effects of seasonal and interannual variability, large-scale long-term investigations are necessary.

2.8.2.1. Harbour porpoise

The harbour porpoise (*Phocoena phocoena*) is the most common and widespread whale species in the temperate waters of the North Atlantic and North Pacific as well as in some secondary seas such as the North Sea (EVANS, 2020). The distribution of harbour porpoises is restricted to continental shelf seas with water depths predominantly between 20 m and 200 m because of their hunting and diving behaviour (READ 1999, EVANS, 2020). The animals are extremely mobile and can cover long distances in a short time. Satellite telemetry has shown that harbour porpoises can travel up to 58 km in one day. The marked animals have behaved individually in their migration. Between the individually chosen places of inhabitation, there were migrations of a few hours to a few days (READ & WESTGATE 1997).

In the North Sea, the harbour porpoise is the most widespread species of cetacean. In general, harbour porpoises occurring in German and neighbouring waters of the southern North Sea are assigned to a single population, the North Sea population including the Skagerrak, northern Kattegat, and eastern part of the English Channel (ASCOBANS 2005, EVANS 2020).

The best overview of the occurrence of harbour porpoises throughout the North Sea is provided by the large-scale surveys of small cetaceans in northern European waters conducted in 1994, 2005, 2016, and 2022 as part of the SCANS surveys (HAMMOND et al. 2002, HAMMOND et al., 2013, HAMMOND et al. 2021, GILLES et al, 2023). The large-scale SCANS surveys make it possible to estimate population size and population trends in the entire area of the North Sea, which is part of the habitat of highly mobile animals, without the need for the detailed mapping of marine mammals in sub-areas (seasonal, regional, small-scale). The abundance of harbour porpoises in the North Sea in 1994 was estimated at 341,366 animals based on the SCANS-I survey. In 2005, a larger area was covered by the SCANS II survey and, as a result, a larger number of 385,617 animals was estimated. However, the abundance calculated on a site of the same size as in 1994 was approximately 335,000 individuals of fauna. The survey in 2016 showed a mean abundance of 345,373 (minimum abundance: 246,526; maximum abundance: 495,752) animals in the North Sea. The latest survey in 2022 showed a mean abundance of 338,918 (min. 243,063, max. 476,203). Results from SCANS I, II, III, and IV indicate no decreasing trend in harbour porpoise abundance between 1994, 2005, 2016, and 2022 (Gilles et al 2023). However, the regional distribution in 2005 and 2016 differs from the distribution in 1994 in that more animals were counted in the south-west than the north-west in 2005 (LIFE04NAT/GB/000245, Final Report, 2006) and high occurrence was recorded across the

English Channel in 2016. The shift of the population towards the English Channel has also been confirmed in the current SCANS IV investigation.

The abundance calculated in SCANS I, II, and III is also comparable to the statistical value of 361 (CV 0.20) from modelling data from study conducted from 2005 to 2013 (GILLES et al. 2016). The study by GILLES et al. (2016) provides a good overview of the seasonal distribution patterns of harbour porpoise in the North Sea. Data from the UK, Belgium, the Netherlands, Germany and Denmark for the years 2005 to 2013 inclusive was considered together in the study. Data from large-scale and cross-border visual surveys (e.g. those collected in the SCANS-II and Doggerbank projects) as well as extensive data from smaller-scale national surveys (monitoring, EIS), were validated, and seasonal and habitat distribution patterns were predicted (GILLES et al. 2016). During the investigation, the results of the habitat modelling were verified and confirmed using data from acoustic surveys. This study is one of the first to take into consideration dynamic hydrographic variables such as surface temperature, salinity, and chlorophyll as well as food availability, especially of sand eels. Food availability was modelled by the distance of the animals to known sandeel habitats in the North Sea. The habitat modelling showed significantly high densities in the area west of Doggerbank, especially in spring and summer. The study concludes that the distribution patterns of harbour porpoise in the North Sea indicate the high spatial and temporal variability of hydrographic conditions, the formation of fronts, and the associated food availability.

Occurrence of the harbour porpoise in the German North Sea

The German EEZ is part of the habitat of the harbour porpoise in the North Sea. The north-eastern area of the German EEZ is part of a larger area with high sighting rates of harbour porpoises (REID et al. 2003). In comparison, the remaining areas of the German EEZ have lower sighting rates.

Especially in the summer months, the area of the territorial sea and the German EEZ off the North Frisian Islands, especially north of Amrum and near the Danish border, are intensively used by harbour porpoises (SIEBERT et al. 2006). In addition, the occurrence of calves is always confirmed there during the summer months.

The large-scale investigations on the distribution and abundance of harbour porpoises and other marine mammals carried out in the framework of the MINOS and MINOSplus projects from 2002 to 2006 (SCHEIDAT et al. 2004, GILLES et al. 2006) provide an overview for the German waters of the North Sea.

A recent evaluation of data from the monitoring of Natura 2000 sites and from research projects has confirmed the indications from the SCANS-III study and shown that the population of harbour porpoise in the German EEZ of the North Sea has changed in recent years. The changes in the population are more pronounced in the area of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area than in the southern part of the German EEZ (GILLES et al., 2019).

In addition, the long-term monitoring data from basic, construction, and operational monitoring of offshore wind farms provide a good overview of the distribution in the EEZ area up to Shipping route SN10.

The southern part of the German EEZ of the North Sea is largely covered by the “North of Borkum” cluster. The most recent data are from 2019 with densities between 0.59 ind/km² (autumn) and 0.02 ind/km² (summer). The area is characterised by interannual fluctuations and, as in previous years, the western part of the importance, in which the “Borkum Riffgrund” FFH area is also located, is of particular importance because higher densities occur there.

The central to north-western part of the German Bight was investigated as part of the cluster investigations of Cluster 6 and the Östlich Austerngrund cluster as well as in the context of the preliminary site investigation of a Area N-9. The latest data from the site investigation of Area N-9 show higher occurrences in spring (March) and in the summer months (especially June) 2021. The density varied from 0.02 ind./km^2 to 1.43 ind./km^2. Sightings were made throughout the investigation area with no conspicuous focus. The data from previous years, which were collected as part of the investigations in Cluster 6 and the Östlich Austerngrund cluster, also show similar values (BSH 2024).

The eastern German Bight and most of the Elbe-Urstromtal were analysed as part of the clusters Nördlich Helgoland, Westlich Sylt, and Butendiek. In addition, monitoring on behalf of the BfN takes place regularly in this area of the EEZ because affects a large part of the Sylter Außenriff nature conservation area.

Since 2008, the abundance of the harbour porpoise has been determined as part of the monitoring of Natura 2000 sites. Although abundance varies from year to year, it remains at high levels, especially in the summer and spring months. The last fly-over of the entire EEZ as part of Natura 2000 monitoring took place in 2019 (Nachtsheim et al, 2020). The abundance was estimated at 27,752 (95% CI: 20,151–39,690) animals. The distribution corresponded to the known distribution patterns; the abundance was comparable to the values of the last complete survey in 2012. An increased occurrence was recorded mainly in the south-western part of the North Sea (i.e. in the Natura 2000 site “Borkum Riffgund”); as expected, mother–calf pairs were sighted in the Natura2000 area “Sylter Außenriff” (Figure 27).

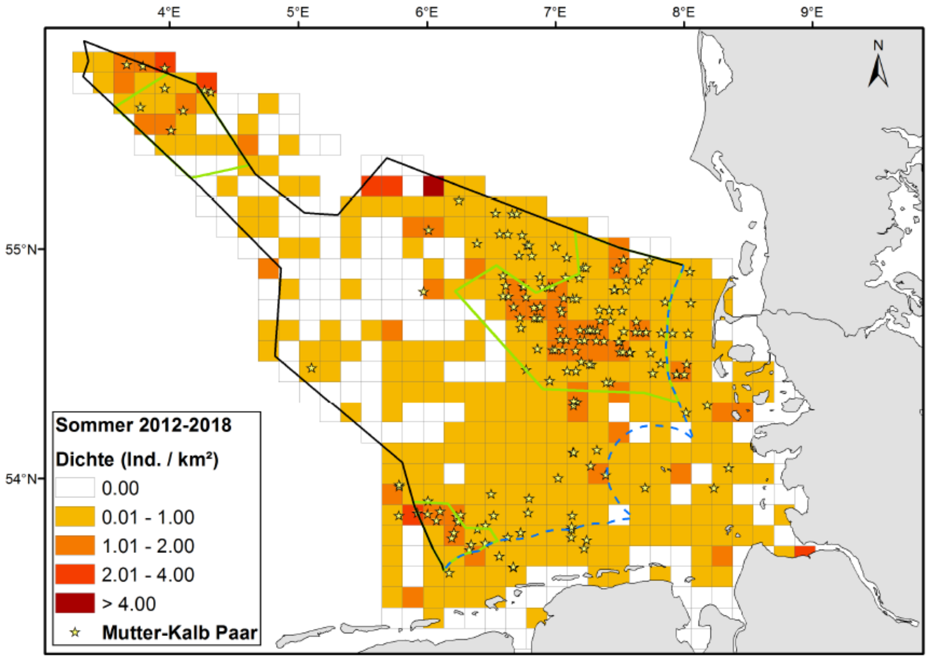

Figure 27: Occurrence of harbour porpoise in the German EEZ of the North Sea based on data from the monitoring of nature conservation areas and scientific research projects from 2012 to 2018 inclusive (GILLES et al., 2019).

Overall, there has been a change in the distribution and abundance of the harbour porpoise population in the German EEZ, thereby indicating a shift from the "Sylt Outer Reef – Eastern German Bight nature conservation area" nature conservation area to the "Borkum Riffgrund" nature conservation area (NACHTSHEIM et al. 2021a). This change is consistent with the findings from SCANS III and IV, which have already confirmed a shift in the population of harbour porpoise in the south-west of the North Sea (HAMMOND et al. 2021, Gilles et al, 2023). The reasons for the change are not yet clear.

Occurrence in nature conservation areas

Based on the results of the MINOS and EMSON investigations (surveys of marine mammals and seabirds in the German EEZ of the North Sea and Baltic Sea), three areas were defined in the German EEZ that are of particular importance for harbour porpoises. These were notified to the EU as offshore protected areas in accordance with the Habitats Directive and recognised by the EU as Site of Community Importance (SCI) in November 2007: Doggerbank (DE 1003-301), Borkum Riffgrund (DE 2104-301), and especially the Sylter Außenriff (DE 1209-301). Since 2017, the three fauna-flora habitat areas in the German EEZ of the North Sea have been given the status of nature conservation areas:

- Ordinance on the Designation of the "Borkum Riffgrund" nature conservation area (NSGBRgV), Federal Law Gazette I, I p. 3395 dated 22 September 2017
- Ordinance on the Designation of the "Doggerbank" nature conservation area (NSGDgbV), Federal Law Gazette I, I p. 3400 dated 22 September 2017
- Ordinance on the Designation of the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area (NSGSylV), Federal Law Gazette I, I p. 3423 dated 22 September 2017.

The “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area is the main distribution area for harbour porpoises in the EEZ. The highest densities are often found here in the summer months. The nature conservation area “Sylter Außenriff – Östliche Deutsche Bucht” has the function of a breeding area. In the period from 1 May until the end of August, high calf percentages are surveyed in the protected area “Sylter Außenriff – Östliche Deutsche Bucht”. Results from the monitoring of Natura 2000 sites as well as from the monitoring of offshore wind farms have shown a high occurrence of harbour porpoise in protected areas until 2013, especially in the area of the Sylter Außenriff (GILLES et al. 2014a). In the BfN monitoring for 2019 (NACHTSHEIM et al, 2020), a decrease in the harbour porpoise population in the Sylter Außenriff was recorded in favour of the population in the Borkum Riffgrund protected area.

The “Borkum Riffgrund” nature conservation area highly important for harbour porpoises in spring and partially in the early summer months. This is also reflected in the data collected as part of the cluster investigations of the “Nördlich Borkum” cluster. There, a gradient was observed in survey years 2013–2019, decreasing from west to east and showing increased densities especially in the southwestern area, which includes the area included in the Natura 2000 site “Borkum Riffgrund”. This gradient is reflected in both the aerial data and the acoustic data (IfAÖ et al, 2021). The cluster survey also shows a regularly recurring pattern in the proportion of calves (i.e. a peak is discernible approximately every four years with a calf proportion of up to 13.4%) (2014; IfAÖ et al. 2021).

However, current findings from the monitoring of Natura 2000 sites show a change in populations in the German EEZ, which also particularly affects the nature conservation area “Sylter Außenriff – Östliche Deutsche Bucht”. The change in abundance and distribution in the Natura 2000 site indicates a shift of the population from the “Sylter Außenriff” to the Natura 2000 sites “Borkum Riffgrund”; nevertheless, the Sylter Außenriff plays an important role as a protected area for harbour porpoises (NACHTSHEIM et al. 2020, 2021b, 2022, GILLES et al. 2019). Neither the BfN monitoring report nor Nachtsheim et al. (2021a) gives concrete reasons for the shift in the population and indicates the need to investigate causes as well as cumulative effects that could explain the changes.

The BMU has highlighted the importance of the area of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area in the noise protection concept for harbour porpoises based on findings and defined a main concentration area for the harbour porpoise in the summer months (BMU 2013).

Occurrence in the areas

Occurrence in Areas N-4 and N-5

Areas N-4 and N-5, which are to be designated for subsequent use, were investigated over many years as part of the construction and operational monitoring. In addition, these areas are located in an area of the EEZ that is regularly surveyed as part of the BfN monitoring programme. As part of the construction and operational monitoring of the clusters located in the wind farm, average densities of 0.1 (winter) to 0.5 ind./km² (spring) were determined for the Nördlich Helgoland cluster in 2019 and up to 1.5 ind/km² in summer 2018 (BioConsult et al. 2020). In the Butendiek cluster, 1.26 ind./km² were recorded in spring 2020 (BioConsult SH, 2020). Adjacent to this, in the Westlich Sylt cluster, densities of between 0.3 ind./km² (winter) and 1.3 ind./km² (summer) were recorded in 2019/2020 (IfAÖ & BioConsult SH 2020). This roughly corresponds to the values of the BfN monitoring programme (Nachtsheim et al, 2020) and the trends of the monitoring programme in recent years (Nachtsheim et al, 2019).

Based on the findings, Areas N-4 and N-5 (near the nature conservation area) are of medium importance for harbour porpoises (and even of high importance in summer) and are part of the main concentration area identified for harbour porpoises in the German North Sea (BMU, 2013). The sub-sites of Area N-5 are regularly used by harbour porpoises for crossing and inhabitation as well as as a foraging ground and breeding area. All investigations in the area of Cluster 5 from research projects such as the MINOS, MINOSplus, and SCANS surveys, from EIS, and the monitoring of offshore wind farm projects as well as from the monitoring of Natura 2000 sites always confirm a high calf occurrence in the summer months. The waters to the west of Sylt are considered a breeding area of the harbour porpoise because of the high proportion of sighted calves. Area N-5 is therefore part of a large area that is used as a foraging and breeding ground for harbour porpoises.

Occurrence in Area N-9 (Sub-area N-9.4 and N-9.5)

Area N-9 is located on the border between Zones 3 and 4. The southern part of the area has been well investigated as part of the preliminary site investigation as well as the cluster investigations of Cluster 6. Cluster 6 was investigated over many years as part of the operational monitoring of the “BARD Offshore 1”, “Veja Mate”, “Deutsche Bucht”, “EnBW HoheSee”, and “Albatros” OWFs. The annual mean absolute abundances in survey years 2008 to 2013 ranged from 0.34 ind./km² to 0.98 ind./km²; this was slightly to considerably higher than the values recorded in 2004–2006. The preliminary site investigation of Sites N-9.1 through N-9.3 showed 265 harbour porpoises in the first year of investigation (2019/2020) using video-based surveys (including two calves in March). In the second survey year (2020/2021), 656 harbour porpoises were recorded; out of these, 56 calves were mostly recorded in June. The phenology of occurrence varied between the two survey years and is subject to seasonal fluctuations. Higher occurrences were recorded in spring (March) and in the summer months (predominantly in June) of 2021. The density varied from 0.02 ind./km² to 1.43 ind./km². Sightings were made throughout the investigation area with no conspicuous focus (IfAÖ et al. 2022). The irregular and low calf numbers observed in this area of the German EEZ in 2008–2020 still do not indicate a particular importance of the area for the reproduction of the species. In comparison with the BfN monitoring data, it can be assumed that the distribution pattern and individual densities will also continue in the extension of Area N-9.

Occurrence in Area N-12 (Sub-area N-12.4 and N-12.5)

The expansion of Area N-12 borders Zone 3. To the south and east of the Sites N-12.4 and N-12.5, data are available from the preliminary site investigation of the sites in Area N-9 as well as from the cluster monitoring in Östlich Austerngrund. The most recent data between 2019 and 2022 showed average densities of 0.51–0.68 ind/km² across the entire investigation area with a maximum of 1.3 ind/km² in the summer months. The northern part of the investigation area (adjacent to N-12 and close to the Sylter Außenriff nature conservation areas and the main concentration area of the harbour porpoise) is used primarily in spring and summer and partly in autumn. This is consistent with the large-scale distribution observed. The area to the south and east of Sites N-12.4 and N-12.5 was also investigated from 2018 to 2020 as part of the preliminary site investigation of Sites N-9.1 to N-9.3. The highest mean density was recorded in summer 2020 at 0.65 ind/km² whilst low densities were always recorded in autumn. There were no distribution centres. In 2019, the BfN monitoring data showed increased densities in sub-sites N-12.4 and N-12.5. Sub-site N-12.5 is located in the catchment area of the main concentration area of the harbour porpoise, which plays a central role in reproduction and breeding, especially in the summer months (May - August). In addition, the sites border on the transition zone between the German Bight and Doggerbank, where calf sightings occur in accordance with BfN monitoring.

Occurrence in Area N-13 (Sub-area N-13.4*)

The extension of Area N-13 is located on the border between Zones 3 and 4 and within the main concentration area of the harbour porpoise. In accordance with BfN monitoring, high densities and calf sightings are recorded here, particularly in the summer months. The area is adjacent to the west of the Westlich Sylt cluster, where high densities were also recorded in summer as a result of operational monitoring (0.3 ind./km² (winter) and 1.3 ind./km² (summer) in 2019/2020).

Occurrence in Area N-14

Area N-14 is located in Zone 4 and thus outside of current monitoring areas within the framework of basic, construction, and operational monitoring of OWFs and, to date, outside of monitoring within the framework of the centralised preliminary site investigation. The data in this area are based on the large-scale SCANS surveys as well as the monitoring of the BfN. This area of the EEZ is used regularly but not with the same intensity as Areas N-12 and N-13 or the nature conservation areas. In summer of 2019, the density during the last BfN monitoring was 0.16 ind/km².

Occurrence in Area N-16

Area N-16 is located in Zone 4 and thus outside of current monitoring areas within the framework of basic, construction, and operational monitoring of OWFs and, to date, outside of monitoring within the framework of the centralised preliminary site investigation. The data in this area are based on the large-scale SCANS surveys as well as BfN monitoring and individual research projects. This area of the EEZ is regularly and relatively intensively used by harbour porpoises to pass through and stay, and there are regular sightings of calves. In spring 2020, the density during BfN monitoring was 2.29 ind/km². Area N-16 is in the transition area to the Doggerbank. There may thus be a transition between the Sylter Außenriff and Doggerbank FFH areas.

Occurrence in Area N-17 and Area N-19

Areas N-17 and N-19 are located in Zones 4 and 5 (North-western region of the German EEZ) and thus far outside of current monitoring areas within the framework of basic, construction, and operational monitoring of OWFs and, to date, outside of monitoring within the framework of the centralised preliminary site investigation. The data in this area are based on the large-scale SCANS surveys as well as BfN monitoring and individual research projects.

The occurrence of the harbour porpoise in Areas N-17 and N-19 can be deduced from habitat modelling based on data from 2006 to 2013 and from the connected habitat of the harbour porpoise in the North Sea (Gilles et al., 2016). Investigations conducted in 2009, 2013, and 2015, including as part of research projects, show that Area N-19 tends to be on the edge of the main distribution area of the harbour porpoise from the western coast of the UK to Doggerbank (Geelhoed et al. 2014, Cucknell et al. 2017).

Habitat modelling, taking into consideration all data available up to and including 2013, shows that Area N-19 is located at the edge of the large contiguous distribution area of the harbour porpoise with high densities east of the British Isles. This extends as far as the Doggerbank (Gilles et al., 2016).

The distribution of harbour porpoises in the German EEZ of the North Sea based on current data from 2012 to 2020 from the monitoring of nature conservation areas as well as from research projects confirms a regular occurrence in N-17 and a high occurrence in the "Doggerbank" nature conservation area as well as in Area N-19 (Gilles et al., 2019, Nachtsheim et al., 2020). The density in Area A of the BfN monitoring programme, which includes Area N-19, the Doggerbank nature conservation area, and Area N-17, was 2.02 ind/km² in spring 2020.

2.8.2.2. Harbour seals and grey seals

The harbour seal *(Phoca vitulina*) is the most widespread seal species in the North Atlantic and is found along coastal regions throughout the North Sea. Suitable undisturbed resting places are crucial for the occurrence of harbour seals. In the German North Sea, sandbanks in particular are used for this purpose (SCHWARZ & HEIDEMANN 1994). Telemetric investigations show that adult harbour seals in particular rarely move more than 50 km from their original resting places (TOLLIT et al. 1998; Jones et al. 2015). Harbour seals can spend days at sea on foraging trips, which cover several hundred kilometres (VANCE et al. 2021). In the 2017 Intermediate Assessment of OSPAR, which covers the years 1992 to 2014 and the area of the wider North Sea, the latest count in 2014 indicates an abundance of over 64,000 individuals (OSPAR 2017). This value refers to counts of fauna that are out of the water at the time of the change of coat (primarily August). This survey thus represents a minimum value. The entire Wadden Sea is an important habitat for the harbour seal and accounts for about 40% of the population of the extended North Sea. The temporal analysis of the harbour seal from 1992 to 2014 shows increasing populations for most coastal areas of the extended North Sea, with the harbour seal population tripling in the entire Wadden Sea between 1992 and 2014. However, in some other coastal areas such as the coast of Northern Ireland, a decreasing population trend is reported for this period.

Grey seals can sometimes undertake long migrations between different resting places throughout the North Sea region (McCONNELL et al. 1999). THOMPSON et al. (1996) report migrations between resting places in the range 125-356 km. Hunting trips are reported to be up to 145 km. A recent example shows the extensive migrations of grey seals already in the pup stage (Peschko et al., 2020). Population estimates for the extended North Sea are difficult: Migrations of grey seals from the British coast to the Wadden Sea as well as counts that take place only in some areas of the extended North Sea at the time of the change of coat (end of March/beginning of April) are reasons for this. A population estimate from 2008 for the entire area of the extended North Sea (excluding Norway) is given in the OSPAR Intermediate Assessment (2017): About 100,000 animals. However, this estimate is based on counts in summer during the change of coat of harbour seals in which grey seals were also counted. The trend for the grey seal as well as the number of colonies established in the area of the extended North Sea is described as stable or positive in the course of the OSPAR report.

Regular counts of both harbour seals and grey seals take place trilaterally (Denmark, Germany, Netherlands) in the Wadden Sea and on Heligoland during the respective change of coat periods. For the harbour seal, the following figures are given for 2023 (GALATIUS et al., 2023): 9,334 young. This corresponds to an increase of 10% compared with the previous year but is below the peak of 9,945 young in 2021. The number of adult harbour seals is given as 22,621 animals. This is roughly the same as in 2010 AND represents a decrease of 4% compared with the previous year. Analogously, the following figures are given for the grey seal (SCHOP et al., 2023): 2,515 pups, which corresponds to an increase of 10% of the value from the previous year. The number of adult grey seals is given as 10,544. This corresponds to an increase of 18% of the value from the previous year. However, the authors note that this includes migratory animals from the UK coast or does not take into consideration animals that are at sea. An orientation and comparison with previous years is nevertheless possible.

Variations in the counts at the respective locations are explained by fluctuations between the individual survey areas or by day-dependent fluctuations (e.g. because of weather and disturbance effects) on the respective survey days.

Occurrence of seals in the German North Sea

For the German part of the Wadden Sea in particular, corresponding data on the population of the harbour seal and grey seal can be taken from the monitoring reports of the Wadden Sea (GALATIUS et al. 2023, SCHOP et al. 2023): In the Wadden Sea of Schleswig-Holstein, 4,305 harbour seal pups were counted in 2023 (+12% compared with 2022). With 2,059 young, Lower Saxony and Hamburg together recorded a slight decrease compared to the previous year (−5% compared with 2022). Adult harbour seals were reported at 7,936 individuals in Schleswig-Holstein in 2023 (−5% compared with 2022) and 5,639 in Lower Saxony and Hamburg as a whole (+17% compared with 2022). Overall, the numbers of harbour seals in Lower Saxony and Hamburg are below the maximum of 7,553 from 2019. Compared with the numbers along the coast of Schleswig-Holstein, the current figures (7,936 individuals) are also below the maximum of 10,746 from 2020. Grey seal pups were recorded in Lower Saxony with 393 individuals and on Heligoland with 684 individuals (decrease in 2022/2023 by almost 9% and increase by 12% compared with 2021/2022). One pup was recorded on the coast of Schleswig-Holstein. The number of adult grey seals on the coast of Lower Saxony increased by almost 26% to 1,190 sighted animals. The current number of grey seals recorded on Heligoland is 1,420. In the Wadden Sea of Schleswig-Holstein, 176 animals were recorded. This means that all coastal areas in Germany where grey seals have their resting places have seen increases compared to the previous year 2021/2022. Fluctuations in the numbers of animals sighted are attributed to fluctuations between the resting places along the coast or to varying conditions on the respective survey day (weather, disturbances, different numbers of animals in the water). Formally speaking, the resting places along the East Frisian Islands are outside the EEZ (with the exception of Heligoland). Nevertheless, the population records should nevertheless be cited here because both the harbour seal and the grey seal go in search of food beyond the East Frisian Islands in their radius of action. The occurrence of seals in the German EEZ is highlighted in the final report of the 2nd Subproject presented by MINOS and MINOSplus (GILLES et al. 2006). In total, 249 seals were recorded in the German EEZ between 2002 and 2006. The modelling based on this results in the highest densities for the nearshore area and decreasing densities with increasing distance from the coast. Similarly, the study by HERR et al. (2009) describes a decreasing density of seals with increasing distance from the coast. However, the study also shows that seals do visit the German EEZ. Several studies show that seals migrate from the Wadden Sea to the open North Sea in search of food (RIES 1993; ADELUNG et al. 2006; LIEBSCH et al. 2006) and stay there for a certain period of time (TOUGAARD et al., 2008). The fact that seals explore areas within the EEZ is confirmed by the cluster investigations of the clusters “Cluster 6” and “Nördlich Borkum”.

Occurrence of seals in nature conservation areas

Based on the results of the MINOS and EMSON investigations (surveys of marine mammals and seabirds in the German EEZ of the North Sea and Baltic Sea), three areas were defined in the German EEZ that are of particular importance for harbour porpoises but also appear to be important for seals (HERR et al. 2009).

These areas are listed in Chapter 2.7.2.1.2 with additional information.

The aforementioned study by HERR et al. (2009) provides an overview of sighting data from aerial surveys in 2002–2007 (Figure 1). This overview shows the use by seals within the designated nature conservation areas. This can be seen most clearly in the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area. In the respective nature conservation area ordinances, the harbour seal and grey seal are listed as the protective purpose in Section 3 and Section 4, respectively. Only the harbour porpoise is mentioned as an additional marine mammal species in addition to the harbour seal solely in the nature conservation area ordinance for the “Doggerbank” nature conservation area.

Results from monitoring by Federal Agency for Nature Conservation also provide information on the occurrence of seals in the nature conservation areas:

Federal Agency for Nature Conservation monitoring in ‘Stratum D’ counted total 203 seals between 2009 and 2015 (IFAÖ et al., 2020). However, the area investigated is larger than the “Borkum Riffgrund” nature conservation area. How many of these seals actually stayed within the nature conservation area is not evident in the report. In the more recent reports of the Federal Agency for Nature Conservation on the survey of marine mammals in the North Sea and Baltic Sea, seals are no longer listed. In addition to the data from the monitoring by the Federal Agency for Nature Conservation, the report on the cluster investigation “North of Borkum” also provides an insight into the stay of seals in the nature conservation area “Borkum Riffgrund” via the own data (IFAÖ et al., 2020):

The cluster report presents a south–north gradient starting from the East Frisian Islands for the years 2014–2019. Increased densities are shown for the nature conservation area in the winter months of 2014-2019. For 2019 alone, the annual mean shows increased densities directly in the nature conservation area. As part of the StUK plus monitoring in the testing ground ‘alpha ventus’, 355 seals were sighted during aerial surveys between 2008 and 2013 (242 harbour seals, 64 grey seals, and 49 undetermined seals; BIOCONSULT SH & IFAÖ 2014). Here, too, the area investigated is larger than the nature conservation area "Borkum Riffgrund". How many of the total 355 animals were recorded in the flight surveys within the nature conservation area is not shown in the report. However, it is made clear that some of the site in and around the nature conservation area is used by seals.

Occurrence in the areas

There is no current data on the occurrence of harbour seal and grey seal in the sites of Zones 4 and 5 because the surveys are carried out mostly at the resting places of these two species. The occurrence at sea is addressed in some studies (GILLES et al. 2006, HERR et al. 2009). From these studies, it can be deduced that the occurrence of harbour seal and grey seal decreases with increasing distance from the coast. Figure 1 from HERR et al. (2009) shows that no seal sightings were recorded in large areas in which the sites of Zones 4 and 5 considered here are located. At the places where sightings were made, only a few individuals were spotted. In total, there were only five sightings in Zones 4 and 5. The importance of the individual sites for seals is considered low to medium.

Other marine mammals

Other marine mammals such as white-beaked dolphins and minke whales also occur sporadically in the sites of Zones 4 and 5. No other marine mammals were sighted in the German EEZ during the SCANS-IV investigations. However, other marine mammals are occasionally sighted in the course of BfN monitoring. For example, in the summer of 2021, there were four sightings of white-beaked dolphins in the area of the Doggerbank nature conservation area. In the BfN monitoring report from 2020, eight white-beaked dolphins and a minke whale were sighted in the area of Doggerbank. The BfN is also currently conducting a research project to record minke whales in the Doggerbank. The BSH does not currently have any results from this project.

2.8.3. Status assessment

The data availability from monitoring since 2002 to the present allows a good assessment of the importance and status in Zone 3 and a sufficient assessment in Zones 4 to 5.

2.8.3.1. Harbour porpoise

The harbour porpoise is the key species in the German waters of the North Sea that is used in the noise protection concept of the BSH (2013) to assess the potential effects of impulsive noise inputs. Furthermore, within the framework of the implementation of the MSFD, the harbour porpoise is the indicator species for assessing cumulative effects of uses and, finally, for assessing the good environmental status in the OSPAR area.

Protection status

Harbour porpoises are protected under several international conservation agreements. They fall under the conservation mandate of the European Habitats Directive (Directive 92/43/EEC) on the conservation of natural habitats and of wild fauna and flora, under which special areas are designated to protect the species. The harbour porpoise is listed in both Appendix II and

Appendix IV of the Habitats Directive. As an Appendix IV species, it enjoys strict species protection in accordance with Article 12 and 16 of the Habitats Directive.

The harbour porpoise is also listed in Appendix II to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention, CMS) or the population of the central Baltic Sea in Appendix I. The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) was also adopted under the auspices of CMS. In addition, the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), in Appendix II of which the harbour porpoise is listed, should also be mentioned.

In Germany, the harbour porpoise is listed in the Red List of Endangered Animals (MEINIG et al., 2020). Here it is classified in threat category 2 (endangered). The authors point out that the endangerment classification for Germany results from the joint consideration of threats in the North Sea and the Baltic Sea. The occurrence in the North Sea is recorded by ship- and aircraft-based investigations and is described as stable. In the Borkum-Riffgrund nature conservation area, there has been a slight increase in abundance (PESCHKO et al. 2016, cited in MEINING et al., 2020). However, because of an ongoing threat from bycatch in gillnets, environmental toxins, and noise, the authors have come to the conclusion that the status should be classified as “threatened” despite the overall stable short-term population trend (MEINIG et al., 2020).

Based on the results of the research projects MINOS and EMSON, three areas of particular importance for harbour porpoises in the German EEZ were defined. These were notified to the EU as offshore protected areas in accordance with the Habitats Directive and recognised by the EU as Site of Community Importance (SCI) in November 2007: Doggerbank (DE 1003-301), Borkum Riffgrund (DE 2104-301), and especially Sylter Außenriff (DE 1209-301). Since 2017, the three areas in the German EEZ of the North Sea under the Habitats Directive have been given the status of nature conservation areas:

The protective purposes of the nature conservation areas in the German EEZ of the North Sea include maintaining and restoring a favourable conservation status of the species from Appendix II of the Habitats Directive, in particular the harbour porpoise, the grey seal, and the harbour seal as well as the conservation of their habitats (NSGBRgV, 2017. Federal Law Gazette, Part I, No. 63, 3395).

Assessment of the occurrence

The population of harbour porpoises in the North Sea has decreased over the last few centuries. The general situation of the harbour porpoise had already deteriorated in earlier times. In the North Sea, the population has declined mainly because of bycatch, pollution, noise, overfishing, and food restrictions (ASCOBANS 2005, EVANS 2020). However, there is a lack of concrete data in order to be able to forecast a trend development. The best overview of the distribution of harbour porpoises in the North Sea is provided by the compilation from the “Atlas of the Cetacean Distribution in North-West European Waters” (REID et al. 2003). However, when making abundance or population calculations based on aerial surveys or even field trips, the authors caution that the occasional sighting of a large aggregation (group) of fauna within an area recorded in a short period of time can lead to the assumption of unrealistically high relative densities (REID et al. 2003). The recognition of distribution patterns or the calculation of populations is made more difficult in particular by the high mobility of the fauna.

Data from the large-scale surveys carried out as part of research projects and, since 2008, as part of the monitoring of Natura 2000 sites on behalf of the Federal Agency for Nature Conservation (BfN) indicate a significant increase in harbour porpoise densities in the southern German North Sea between 2002 and 2012 (GILLES et al., 2014). In the area of the Sylt Outer Reef, the trend analysis also indicates stable population in summer over the years 2002-2012 (GILLES et al. 2014). The western area in particular shows a positive trend for spring and summer, whilst no clear trend can be detected in autumn. Harbour porpoise densities in the eastern area have remained largely constant over the years and significant differences between the hotspots in the west and lower density in the south-eastern German Bight have been found.

Current findings from the large-scale cluster investigations of offshore wind farms do not provide any indication of a decreasing trend in the abundance of harbour porpoise or of changes in seasonal distribution patterns in the German EEZ of the North Sea from 2001 to the present. However, these data sets only ever represent a sub-area of the German EEZ. The multi-year data from the CPOD station network confirm continuous habitat use by harbour porpoises (ROSE et al. 2019).

An EEZ-wide analysis is carried out in Nachtsheim et al (2021): A current assessment of the population trend in the German waters of the North Sea based on data from the monitoring of nature conservation areas and from research projects from 2012 to 2018 has shown a population shift. For the entire EEZ, declining trends (−1,79%/year) were described in the “Sylter Außenriff – Östliche Deutsche Bucht” and “Doggerbank” nature conservation areas as well as in the central area of the German Bight. A positive trend has developed in the area of the “Borkum Riffgrund” nature conservation area as well as in areas N-1, N-2, and N-3. The causes of the population shift are not yet known and could be related to both the effects of human activities and shifts in the fish populations (NACHTSHEIM et al., 2021, GILLES et al., 2019). The aspect of population displacement is also consistent with the findings from the SCANS I, II, III, and IV surveys, which also describe a population displacement towards the south-eastern coast of Great Britain and the English Channel. There thus appears to be a more extensive phenomenon, which is only partially surveyed by the observation of the German EEZ. The large-scale SCANS I, II, III, and IV investigations do not allow any conclusions to be drawn about a declining harbour porpoise population. The abundance of harbour porpoises in the entire North Sea has not changed significantly since 1994; however, their spatial distribution has.

Assessment of spatial units

The northern and eastern parts of Tone 3 (Areas N-4 and N-5) are located in the main concentration area of the harbour porpoise. These areas are used intensively during the summer months for foraging and the rearing of calves. Outside the summer months, these are also important areas for inhabitation, migration, and feeding.

Zones 4 and 5 are used to varying degrees by harbour porpoises for migration, inhabitation, and, in some cases, breeding. The western part of Zone 4 (Areas N-9 and N-14) is used to a lesser extent, mainly for migration and foraging. The eastern part of Zone 4 (Areas N-12 and N-13) is located near the main concentration area of the harbour porpoise and in the transition area to Doggerbank. This area is used more intensively, especially during the summer months.

Zone 5 south of the Doggerbank FFH area is regularly used for migration, inhabitation, and foraging, and the FFH area itself is also used for rearing calves. The area north of the Doggerbank FFH area site is heavily frequented by harbour porpoises because of it is part of a continuous area north of it up to the western border of Great Britain.

Existing pressure

Existing pressures on the North Sea harbour porpoise population include various anthropogenic activities, changes in the marine ecosystem, diseases, and climate change.

Existing pressures on marine mammals result from fishery, attacks by dolphin-like creatures, physiological effects on reproduction, diseases possibly related to high levels of pollution, and underwater noise. The greatest threat to harbour porpoise populations in the North Sea comes from fishery – through bycatch in set and bottom trawls, the depletion of prey fish populations through overfishing, and the associated reduction in food availability (EVANS 2020). An analysis of dead and stranded fish from the British Isles from 1991 to 2010 has identified the causes as follows: 23% infectious diseases, 19% attacks by dolphins, 17% bycatch, 15% starvation, 4% stranded alive; in 22%, the cause of death cannot be determined (EVANS 2020). A similar study on PCB values in dead and stranded fish from 1990 to 2017 concluded the following similar result: 31% bacterial or other infections, 23% bycatch, 0.01% complications at birth, 0.05% trauma, 15% attacks by other marine mammals (WILLIAMS et al. 2020).

In addition to pollution caused by the discharge of organic and inorganic pollutants or oil spills, the population is also threatened by diseases (of bacterial or viral origin) and climate change (in particular the impact on the marine food web).

In addition to maritime traffic, current anthropogenic uses in the German EEZ of the North Sea with high sound impacts include seismic explorations as well as military uses or blasting of non-transportable munitions. Threats to marine mammals may be caused during the construction of wind farms and platforms with deep foundation, especially because of noise emissions during the installation of the foundations if no mitigation or preventive measures are taken.

2.8.3.2. Harbour seals and grey seals

Protection status

Grey seal and harbour seal are listed in Appendix II and V of the Habitats Directive (Directive 92/43/EEC). Appendix II includes species for which special protected areas must be designated.

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

The harbour seal is classified in category G (indeterminate). The authors confirm that the populations in the German North Sea and Baltic Sea should be considered separately. Because of the positive population development of the harbour seal in the North Sea, it is to be classified as “least concern” when considered separately.

In addition, the two seal species are listed in Appendix III (protected animal species that may be caught or used under restrictions) of the Bern Convention (CoE 2002). The harbour seal is also listed in Appendix II (animal species in an unfavourable conservation status and which, without internationally coordinated protective measures, could soon be among the critically endangered species) of the Bonn Convention (CMS SECRETARIAT 2015).

For Germany, the classification according to the Red List of Endangered Animals, Plants and Fungi of Germany (MEINIG et al. 2020) of the Federal Agency for Nature Conservation is decisive.

Both seal species are also listed in the nature conservation area ordinances of the three nature conservation areas in the North Sea. They are reflected in Section 3 and Section 4, respectively, as the protective purpose. Only the harbour porpoise is mentioned as an additional marine mammal species in addition to the harbour seal solely in the nature conservation area ordinance for the “Doggerbank” nature conservation area.

Assessment of the occurrence

The harbour seal population shows a positive trend for most coastal areas of the extended North Sea (OSPAR, 2017). Positive trends can also be observed at a smaller scale (Wadden Sea) from the beginning of the surveys in 1975 until 2020 (GALATIUS et al. 2020). From 2021, until the current survey in 2023, the numbers are declining (GALATIUS et al. 2023). The current population figure for the Wadden Sea is roughly the same as in 2010 and represents a decrease of 4% compared with the previous year. As in 2021, the percentage of juveniles is at its highest level since young were recorded in 2000. Analogously, the following figures are given for the grey seal (SCHOP et al., 2023): 2,515 pups, which corresponds to an increase of 10% of the value from the previous year. The number of adult grey seals is given as 10,544. This corresponds to an increase of 18% of the value from the previous year. Both adults and pups have reached a peak. For the occurrence of the harbour seal in the wider North Sea in general as well as along the coasts of the Wadden Sea, the population still appears to be at a high level (compared with survey year 1975) despite the decline in the Wadden Sea over the last three years.

The trend in grey seal abundance as well as the number of colonies established in the area of the extended North Sea is described as stable or positive in the course of the OSPAR report (OSPAR, 2017). In the Wadden Sea on the coasts of the Netherlands, Germany, and Denmark, this trend is confirmed on a smaller spatial scale (SCHOP et al., 2023): For the coastal areas of the Wadden Sea, the population can thus be assessed as positive. However, the total numbers are considerably lower compared with those for the harbour seal in the German Wadden Sea.

Assessment of spatial units

The Sites in Zones 4 and 5 are located in the natural units “Elbe-Ursprungtal”, “Transition areas between the German Bight and Doggerbank”, “Doggerbank”, and “Central North Sea north of the Doggerbank” with water depths of over 40 m. Compared with the areas around the sandbanks of the North Frisian and East Frisian islands, the area is of comparatively less importance for seals. Like the entire EEZ, this area is also used to a small extent by seals for foraging or as a migration area.

Existing pressure

Intensive hunting of seals, as was common until the beginning of the last century, is now meaningless. Today, fishery is considered to be an existing pressure because it has a limiting effect on food resources (but also from the point of view of bycatch of marine mammals in fishing gear). The ICES Expert Group indicates 15 grey seals as bycatch for the reporting year 2018 for the extended North Sea (ICES, 2020). However, the report assumes an underestimation of the bycatch quantity because the transmission of data is patchy. In stark contrast, a report on the Danish gillnet fishery indicates an average, extrapolated bycatch of 411 seals per year in the North Sea (LARSEN et al., 2021). As already mentioned, this figure refers only to the Danish gillnet fishery and not to the fishing fleets of other states. The calculations are based on the survey of bycatch on selected fishing vessels. It can thus be assumed that the actual bycatch of seals in the North Sea is likely to be much higher than indicated in the ICES report. A comprehensive and robust quantification of bycatch as an existing pressure on seals is not possible at this point. The same is true of other existing pressure, which can only be listed here in qualitative terms. Another existing pressure to be mentioned here is pollutants such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT) but also heavy metals such as mercury, which accumulates in seals as upper predators via prey fish. A reduced immune defence against pathogens because of pollutants is described (KAKUSCHKE & PRANGE 2007). Negative effects of various heavy metals on the immune system have been shown in harbour seals from the North Sea (KAKUSCHKE et al. 2009). Harbour seals were affected by distemper epidemics (*Phocine distemper virus*) in 1988 and 2002. Immunotoxic pollutants may also have played a role (HALL et al. 2006).

In addition, the vessel traffic in traffic separation zones was well as service traffic within existing wind farms can be taken into account as an existing pressure. In their study, JONES et al. (2017) present the overlap of ship noise with the distribution of grey seals. According to the modelling, the animals should be exposed to cumulative sound exposure levels (SEL) over a corresponding period of time, which can lead to a temporary threshold shift (TTS). In contrast, a more recent study in grey seals shows that the fauna in the study were never exposed to ship noise exceeding the threshold value for a TTS (TRIGG et al. 2020). Similarly, MIKKELSEN et al. (2019) shows how grey seals fitted with hydrophones and sensors for three-dimensional motion recording changed their diving behaviour in the presence of ship noise. Whether such changes in behaviour have any negative impact on the individual fauna is unknown (TRIGG et al. 2020). It is not possible to quantify this potential existing pressure.

Investigations also show that an adverse effect from pile driving is possible (THOMPSON et al. 2013, HASTIE et al. 2015). Both studies were conducted in UK waters; noise mitigation measures were not used. However, such an existing pressure can be avoided by means of suitable noise mitigation measures during the pile driving. Noise mitigation measures are used in the German EEZ during pile driving. It is not possible to quantify the extent to which highly mobile marine mammals are pre-stressed by sound inputs from territorial waters without noise mitigation.

Further existing pressures are caused by seismic exploration, military use, or blasting of non-transportable ammunition as well as climate change (especially affecting the marine food web). Overall, it can be assumed that there is a medium existing pressure for both the harbour seal and the grey seal.

2.8.4. Importance of areas and sites for the protected asset

2.8.4.1. Importance of areas and sites for harbour porpoises

According to the current state of knowledge, it can be assumed that the German EEZ is used by harbour porpoises for traversing, inhabitation, and as a food and area-specific breeding area. Based on the knowledge available, it can be concluded that the EEZ is of medium to high importance for harbour porpoises in certain areas. Habitat use varies in different areas of the EEZ. Marine mammals and, of course, harbour porpoises are highly mobile species that use large areas variably in search of food, depending on hydrographic conditions and food supply. It therefore makes little sense to consider the importance of individual sites such as the sites of the plan or individual wind farm sites. In the following, the importance of areas belonging to a natural unit is assessed separately.

Areas N-4 and Sub-area N-13, Sub-area N-12

According to the current state of knowledge, Areas N-4 and the northern sub-area N-13 are of medium importance for harbour porpoises (and even of high importance in summer) and are part of the main concentration area identified for harbour porpoises in the German North Sea (BMU, 2013).

- The areas are used by harbour porpoises all year round for crossing and inhabitation and probably as a foraging ground.
- The occurrence of harbour porpoises in the vicinity of Areas N-4 and N-13 is relatively high but lower than the high occurrence in the waters west of Sylt (Area N-5)
- Regular sightings of calves in these areas, albeit in comparatively small numbers, allow the assumption that these areas are to be seen as peripheral areas of the large breeding area in the German EEZ of the North Sea.
- Because of their function as foraging ground and occasionally breeding areas, Areas N-4 and N-13 are of medium to seasonally high importance for harbour porpoises.

This assessment applies also to the extended Area N-12. The extended sites are directly adjacent to the sites already described and have comparable water depths, seabed characteristics, and hydrographic properties. It can therefore be assumed that these are also of medium to high seasonal importance for the harbour porpoise in summer.

Area N-5

The sites of Area N-5 are regularly used by harbour porpoises for crossing and inhabitation as well as as a foraging ground and breeding area.

According to the current state of knowledge, the environment in which the sites of Area N-5 are located is of high importance for harbour porpoises and represents the core area of the main concentration area for harbour porpoises identified in the German North Sea (BMU 2013):

- The sites are used by harbour porpoises all year round for crossing and inhabitation and as a foraging ground.
- Harbour porpoises use the sites of Area N-5 intensively, especially in summer.

- All sites of Area N-5 are used by harbour porpoises as breeding grounds during the summer months.
- The density of harbour porpoises in this area is high compared with other areas of the EEZ.
- The sites of Area N-5 are of major importance for harbour porpoises, especially in their function as foraging and breeding grounds.

Area N-14

Area N-14 is regularly used by harbour porpoises for crossing, inhabitation, and foraging. Overall, the use is low compared with other areas of the EEZ. According to the current state of knowledge, the area can be assigned medium importance for harbour porpoises.

Areas N-16 and N-17

The sites of Areas N-16 and N-17 are located in the transition zone between the German Bight and the Doggerbank. They are used intensively in parts but, in any case, regularly for crossing, inhabitation, and foraging.

- The areas are used by harbour porpoises all year round for crossing and inhabitation and as a foraging ground.
- Mother-calf pairs are sighted in this area. The transition area represents the connectivity of the two FFH areas, Sylter Außenriff, and Doggerbank, both of which are used for the rearing of harbour porpoise calves. It is possible that migration routes (BfN, 2020) run here; however, these cannot be clearly demarcated because of the high mobility of the animals (Janssen et al., 2022)
- The areas are of medium importance for harbour porpoises; in some parts, they are of high importance in the spring and summer months

Area N-19

The sites of Area N-19 are regularly used by harbour porpoises for crossing and inhabitation, and the directly adjacent “Doggerbank” FFH area is used as a foraging ground and breeding area. It can be assumed that the edge of the area is also used as a breeding area.

- The areas are used by harbour porpoises all year round for crossing and inhabitation and as a foraging ground.
- The areas are used intensively with high densities (in parts comparable to the area around the Sylter Außenriff)
- According to the current state of knowledge, the environment in which the sites of Area N-19 are located is of medium importance for harbour porpoises and of high importance in spring and summer

2.8.4.2. Importance of areas and sites for seals

A number of investigations refer to the decreasing importance of areas located at increasing distances from resting sites along the coast (THOMPSON et al. 1996, McCONNELL et al. 1999, DIETZ et al. 2003, GILLES et al. 2006, HERR et al. 2009; VANCE et al., 2021). An increased occurrence of seals along the coastal areas of the German EEZ can be seen, for example, in figure 1 from HERR et al. (2009). However, studies also show the importance of offshore areas for foraging (e.g. fauna swimming from the Wadden Sea into the open North Sea; RIES 1993;

ADELUNG et al. 2006; LIEBSCH et al. 2006). There is even evidence that foraging takes place almost exclusively in areas further offshore (LIEBSCH et al. 2006, TOUGAARD et al. 2006). A number of authors indicate a preferred foraging radius of 50-60 km around the resting places (THOMPSON & MILLER 1990, THOMPSON et al. 1998). However, it is also known from such experiments that both harbour seals and grey seals can move well over 100 km from their resting places during their forays (THOMPSON et al. 1996, LOWRY et al. 2001) and that certain distant areas are even regularly visited during foraging trips. Shallow areas and submarine sandbanks in particular are known to be such places (THOMPSON & MILLER 1990). Occasional use of the sites in Zones 4 and 5 for foraging can thus not be ruled out. Likewise, the sites can be crossed during a longer hike. For example, it is known from a telemetry study that harbour seals swim from the North Frisian coast to Doggerbank (ADELUNG et al., 2004). Another example is young grey seals after weaning; with increasing hunting experience, they can travel long distances such as from Heligoland to the British coast (PESCHKO et al., 2020). In summary, the sites in Zones 4 and 5 are used to a certain extent by seals but only to a small extent or very small extent by the grey seal. It therefore seems plausible that the sites in Zones 4 and 5 are of only minor importance for seals.

2.9. Seabirds and resting birds

According to the "Qualitätsstandards für den Gebrauch vogelkundlicher Daten in raumbedeutsamen Planungen" (DEUTSCHE ORNITHOLOGEN-GESELLSCHAFT 1995), resting birds are "birds that stay in an area outside their breeding territory, usually for a longer period of time (e.g. for moulting, feeding, resting, and wintering)". Feeding birds are defined as birds "that regularly seek food in the investigated area and do not breed there but which breed or might breed in the wider region".

Seabirds are species of birds that are mainly bound to the sea with their mode of life and only come ashore for breeding for a short time. These include, for example, fulmar, gannet, and auks (guillemot, razorbill). Terns and gulls, on the other hand, have a distribution that is mostly closer to the coast than seabirds.

2.9.1. Data availability

In order to be able to draw conclusions about seasonal distribution patterns and the use of different maritime areas (sub-areas), a good data basis is necessary. In particular, large-scale long-term studies and extensive analyses of existing data are required in order to be able to identify correlations in distribution patterns as well as the effects of intra- and interannual variability.

The findings on the spatial and temporal variability of the occurrence of seabirds in the southern North Sea are based on surveys by ESAS (European Seabirds at Sea) as well as on several spatially and temporally limited research projects (e.g. MINOS, MINOSplus, EMSON, StUKplus, HELBIRD, DIVER I + II, TOPMarine). In recent years, the database has expanded significantly because of many new investigation programmes for monitoring Natura 2000 sites as part of environmental impact studies and the construction and operational monitoring of offshore wind farms as well as research projects and studies focusing on scientific evaluations of existing data in the German EEZ of the North Sea. The available data basis can therefore be considered very good for Zones 1 and 2 (BSH 2021).

For Zones 3 to 5 of the ROP 2021 (BSH 2021) in which the draft SDP24 sites and areas for offshore wind energy are defined, only limited data from environmental impact studies or preliminary site investigations/benchmark assessments are available because the neighbouring SDP23 areas will not be put out to tender or developed until this year. Also data from the "Marine Biodiversity Monitoring of Vertebrates" programme funded by the Federal Agency for Nature Conservation (BfN) are available The digital flight data from all the aforementioned sources from the September 2013 to August 2021 was used for the distribution maps in this chapter. In general, data for the SDP24 draft sites and areas are mostly available only from the calendar spring and summer, which has a different effect on the distribution maps based on the species-specific seasons (see BSH 2013 & Chapter 6.2.1) and only allows limited statements to be made on the distribution of the species and the importance of the SDP24 draft sites and areas. The available data sources for Zones 3 to 5 can be considered sufficient.

2.9.2. Spatial distribution and temporal variability

Seabirds are highly mobile and therefore able to cross large areas during foraging or to track species-specific prey organisms such as fish over long distances. This high mobility – depending on the specific conditions of the marine environment – leads to a high degree of spatial and temporal variability in the occurrence of seabirds. The distribution and abundance of birds vary over the course of the seasons.

The distribution of seabirds in the German Bight is determined in particular by the distance to the coast or the breeding grounds, the hydrographic conditions, the water depth, the nature of the seabed, and the food supply. In addition, the occurrence of seabirds is influenced by strong natural events (e.g. storms) and anthropogenic factors such as nutrient and pollutant inputs, shipping, and fishery. Seabirds, as consumers in the upper part of the food webs, feed on species-specific fish, macrozooplankton, and benthic organisms. They are thus directly dependent on the occurrence and quality of benthos, zooplankton and fish.

Some areas of the German territorial sea and parts of the EEZ of the North Sea have a high importance for seabirds and waterbirds (not only nationally but also internationally as a number of studies have shown) and were identified very early on as areas of particular importance for seabirds, "Important Bird Areas - IBA" (e.g. SKOV et al. 1995, HEATH & EVANS 2000). Particular mention should be made here of sub-area II of the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area established by an ordinance of 22 September 2017, which was designated as a Special Protected Area (SPA) by an ordinance of 15 September 2005 in accordance with the EU Birds Directive (79/409/EEC). Current plans foresee a new sub-area III to the west adjacent to it within the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area for the protection of the star and black-throated diver (BMUV 2022). With regard to the species group divers, a main concentration area harbour was identified in spring in the German Bight, west of Sylt, within the framework of an overarching evaluation and assessment of existing data sets. The delimitation of the main concentration area harbour was chosen to include all important and known regular occurrences (BMU 2009).

2.9.2.1. Abundance of seabirds and resting birds in the German North Sea

There are 18 species of seabirds in the German EEZ of the North Sea; these are regularly recorded as resting birds in larger populations. Table 9 contains population estimates for the most important seabird species in the EEZ and the entire German North Sea for 1993–2003 and 2011–2016. As indicated, the figures for these periods are based on data sets of varying scope and therefore cannot be directly related. Population calculations for the German EEZ for 2011 to 2016 as well as for the current reference period for reporting to the EU (2017 to 2022) are not (yet) available. Cells marked in grey highlight the season with the highest occurrence for each species in the respective reference period.

Table 9: Populations of the most important resting bird species in the entire German North Sea and the EEZ. Shaded in grey: the seasons with the highest occurrence in the respective reference period. *Figures based on aircraft transect counts from 2002 to 2006; **spring populations of red-throated divers according to SCHWEMMER et al. (2019; reference period 2002–2017, vessel and flight surveys), ***Spring populations of black-throated divers according to GARTHE et al. (2015; reference period 2000–2013, vessel and flight surveys); I = 1–5, II = 6–10, III = 11–50 individuals.

		Mendel et al. (2008)		https://geodienste.bfn.de	
		Schiffserfassungen		Schiffs- und Flugerfassungen	
		Bezugszeitraum 1993 bis 2003		Bezugszeitraum 2011 bis 2016	12-Jahrestrend gemäß EU V-RL 79/409/EWG 2004 bis 2016
Art (wissenschaftlicher Name)	Jahreszeit	Bestand dt. AWZ	Bestand dt. Nordsee	Bestand dt. Nordsee	Trendwerte als durchschnittliche Änderung pro Jahr in %
Sterntaucher	Frühjahr	**16.500	**22.000	22.000	2,88
(*Gavia stella*)	Sommer	*0	*0	140	nicht signifikant
	Herbst	*0	*200	1.000	keine Aussage möglich
	Winter	*1.900	*3.600	6.000	
Prachttaucher	Frühjahr	***1.200	***1.600	700	-0,31
(*Gavia arctica*)	Sommer	*0	*0	8	nicht signifikant
	Herbst	*0	*III	30	keine Aussage möglich
	Winter	*170	*300	210	
Eissturmvogel	Frühjahr	11.500	11.500	30.000	2,79
(*Fulmaris glacialis*)	Sommer	40.000	40.000	25.000	nicht signifikant
	Herbst	24.000	24.000	7.500	keine Aussage möglich
	Winter	10.500	10.500	3.700	
Basstölpel	Frühjahr	600	800	4.900	9,66
(*Morus bassanus*)	Sommer	1.200	1.400	7.000	p ≤ 0.01
	Herbst	2.600	2.700	6.500	moderate Zunahme
	Winter	190	230	3.200	
Tordalk	Frühjahr	800	850	3.400	-7,04
(*Alca torda*)	Sommer	II	II	700	p ≤ 0.05
	Herbst	0	I	550	moderate Abnahme
	Winter	4.500	7.500	15.000	
Trottellumme	Frühjahr	15.500	18.500	35.000	-12,35
(*Uria aalge*)	Sommer	3.400	7.000	13.000	p ≤ 0.001
	Herbst	21.000	21.000	89.000	starke Abnahme
	Winter	27.000	30.000	27.000	
Dreizehenmöwe	Frühjahr	6.500	13.500	11.000	-2,54
(*Rissa tridactyla*)	Sommer	8.500	20.000	7.000	nicht signifikant
	Herbst	11.000	16.500	3.800	keine Aussage möglich
	Winter	11.000	14.000	20.000	
Zwergmöwe	Frühjahr	III	4.600	19.500	5,13
(*Hydrocoloeus minutus*)	Sommer	0	III	340	nicht signifikant
	Herbst	III	400	1.900	keine Aussage möglich
	Winter	450	1.100	4.400	
Sturmmöwe	Frühjahr	1.900	30.000	19.500	-2.95
(*Larus canus*)	Sommer	70	30.000	3.000	nicht signifikant
	Herbst	550	65.000	5.500	keine Aussage möglich
	Winter	10.000	50.000	25.000	
Mantelmöwe	Frühjahr	1.200	2.600	2.200	-1,15
(*Larus marinus*)	Sommer	500	2.500	490	nicht signifikant
	Herbst	9.500	16.500	1.100	keine Aussage möglich
	Winter	9.000	15.500	9.500	
Silbermöwe	Frühjahr	1.200	74.000	14.500	-0,61
(Larus argentatus)	Sommer	1.800	115.000	9.500	nicht signifikant
	Herbst	4.100	98.000	15.500	keine Aussage möglich
	Winter	15.000	62.000	22.000	
Heringsmöwe	Frühjahr	14.500	41.000	37.000	7,07
(*Larus fuscus*)	Sommer	29.000	76.000	68.000	p ≤ 0.05
	Herbst	14.500	33.000	57.000	keine Aussage möglich
	Winter	550	1.200	4.600	
Brandseeschwalbe	Frühjahr	430	12.500	7.000	-4.22
(*Thalasseus sandvicensis*)	Sommer	130	21.000	4.100	p ≤ 0.05
	Herbst	110	3.500	6.500	keine Aussage möglich
	Winter	0	0	3	
Flussseeschwalbe	Frühjahr	150	10.000	k.A.	k.A.
(*Sterna hirundo*)	Sommer	0	19.500	k.A.	k.A.
	Herbst	800	5.800	k.A.	k.A.
	Winter	0	0	k.A.	
Küstenseeschwalbe	Frühjahr	120	7.500	k.A.	k.A.
(*Sterna paradisaea*)	Sommer	210	15.500	k.A.	k.A.
	Herbst	1.700	3.100	k.A.	k.A.
	Winter	0	0	k.A.	
Trauerente	Frühjahr	III	56.000	82.000	14,42
(*Melanitta nigra*)	Sommer	III	66.000	333.000	p ≤ 0.001
	Herbst	110	18.500	200.000	starke Zunahme
	Winter	III	135.000	670.000	
Skua (*Stercorarius skua*)		k.A.	k.A.	k.A.	k.A.
Spatelraubmöwe (*Stercorarius pomarinus*)		k.A.	k.A.	k.A.	k.A.

2.9.2.2. Frequently occurring species in the area of the SDP24 draft sites/areas

The occurrence of seabirds shows a high spatial and temporal variability. Long-term observations and systematic counts provide information on recurring seasonal distribution patterns of the most common species in German waters of the North Sea. In the following, the most common and particularly protected species in the area of the SDP24 draft sites/areas are considered individually because of the species-specific differences in spatial and temporal distribution.

Divers (red-throated diver *(Gavia stellata*) and black-throated diver *(Gavia arctica*)

The two species cannot always be reliably distinguished from each other when counted. For this reason, both species are presented together in this case as the diver species group. According to all previous findings, the proportion of black-throated divers is approx. 8–11%.

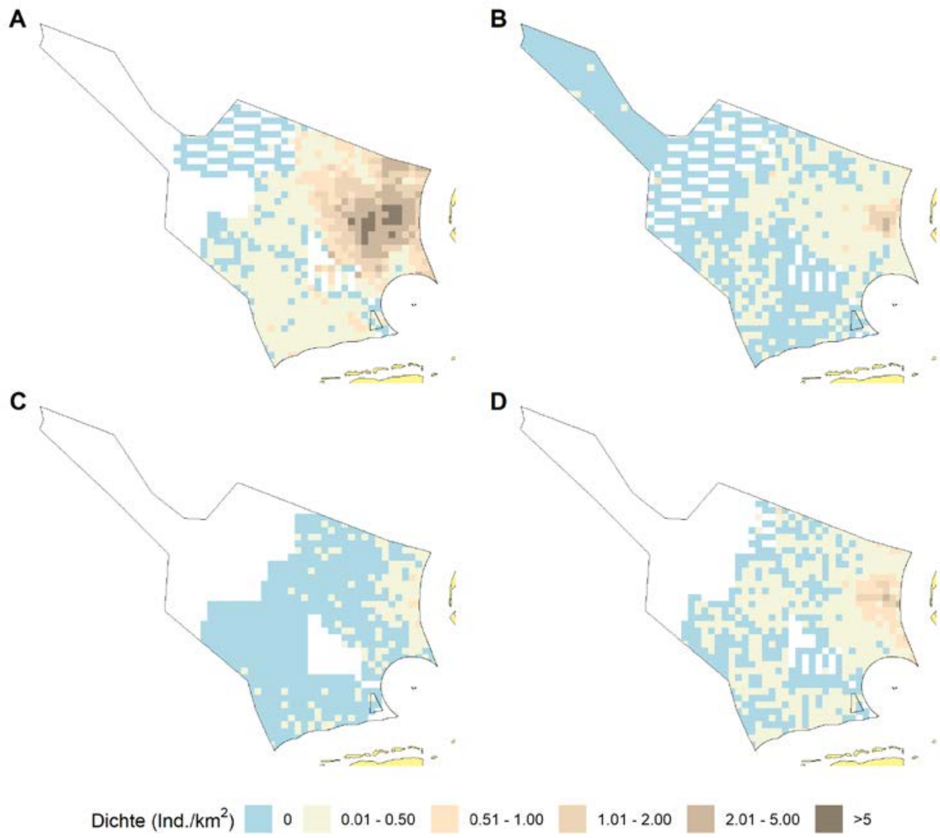

Figure 28: Temporally aggregated densities (September 2013 to August 2021) of the divers species group in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 30 April), B - summer (1 May – 15 September), C - autumn (16 September – 31 October) and D - winter (1 November – 29 February). White areas represent grid cells without data.

Divers are regularly found along the coast of the south-eastern North Sea in winter. Towards spring, the centre of occurrence shifts further north, especially in the area west of Sylt. At this time of year, the distribution reaches almost 100 km into the EEZ (MENDEL et al. 2008). Based on many years of data collection in the German EEZ, a main distribution area (main concentration area) for divers in spring was identified and defined off the North Frisian Islands (BMU 2009). An evaluation of the data from research projects, environmental impact studies, and monitoring of offshore wind farm projects from 2000 to 2013 before the construction of the wind farms showed that the seasonal main areas of distribution of divers in the German Bight had remained largely constant over a long period of time. At the same time, there was a clear expansion of the occurrence of divers in a westerly direction, thereby confirming the importance of the main concentration area (GARTHE et al. 2015). A study by the FTZ commissioned by the BSH and the BfN, which, in addition to the data basis of the 2015 study, takes into consideration data from the construction and operating phase of the offshore wind farm projects in the years 2014–2017, shows a shift of the diver occurrence to the central area of the main concentration area after construction of the wind farms; this is the furthest away from the projects realised (GARTHE et al. 2018, 2019, 2023; Figure 29). Recent studies commissioned by the Bundesverband der Windparkbetreiber Offshore e.V. (BWO) confirm this observation (BIOCONSULT SH et al. 2020, 2022).

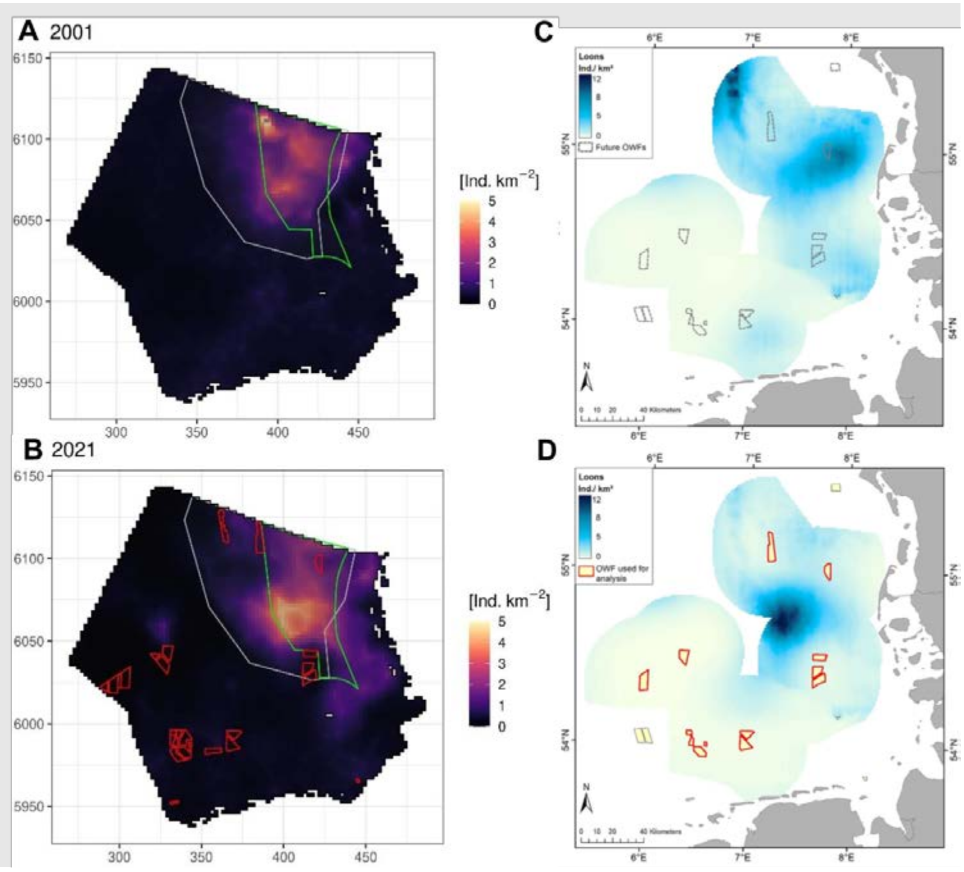

Figure 29: Modelled diver densities for the spring (1 May - 15 May) in 2001 (A), in 2021 (B; source: Bioconsult SH 2022); for the spring (1 March - 30 April) before (C) and after (D) construction of the OWF in the respective cluster (source: Garthe et al. 2023). All details on the data sources and modelling can be found in the sources listed.

Fulmar (*Fulmarus glacialis*)

Fulmars occur in the German North Sea all year round and almost everywhere in the offshore areas. They occur in higher densities in areas far from the coast than in areas close to the coast (MARKONES et al. 2015). The long-term data of the FTZ indicate a year-round occurrence in the German Bight. However, the highest numbers are encountered in summer in areas with saline and temperature-stratified North Sea water (MENDEL et al. 2008). In the course of baseline surveys for offshore wind farm projects, it was also determined that the fulmar occurs in higher densities beyond the 40-m depth line. The breeding colony on Heligoland is still too small to have a significant impact on the populations at sea. In 2022, 23 breeding pairs were counted there, in 2023 25 (personal communication Jochen Dierschke/Heligoland Bird Observatory). In 2005, the maximum of 121 breeding pairs was reached (DIERSCHKE et al. 2023). Fulmars are found regularly and in high densities at a distance of over 70 km from the coast, especially in summer (Figure 30).

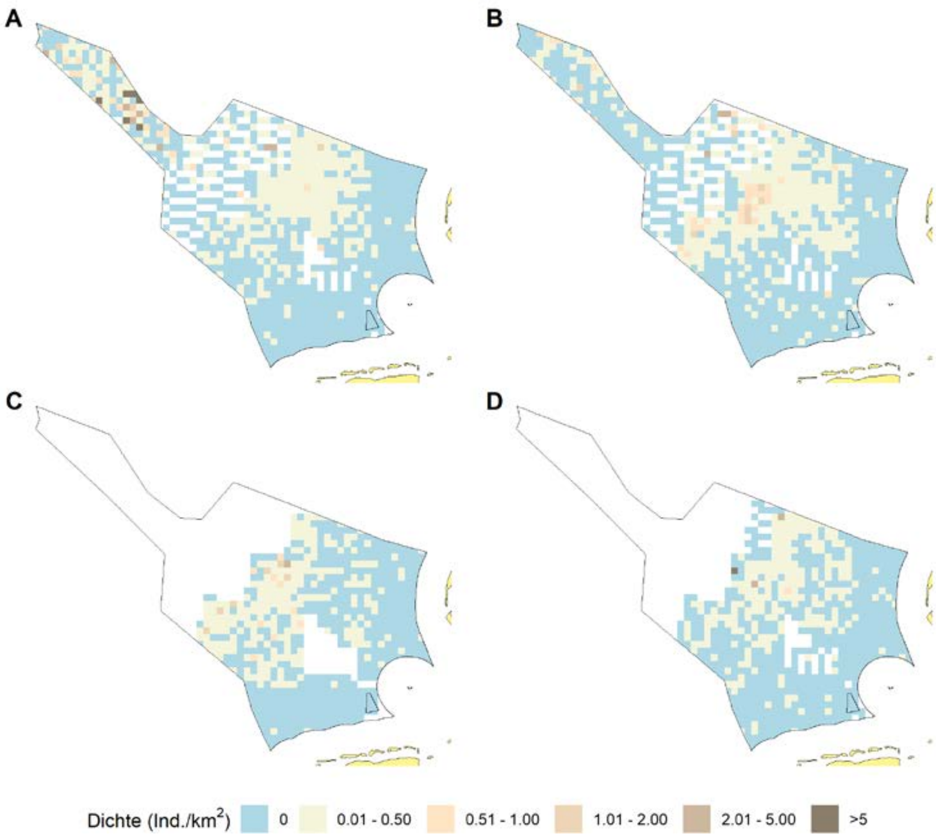

Figure 30: Temporally aggregated densities (September 2013 to August 2021) of the fulmar in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (16 March – 15 May), B - summer (16 May – 31 August), C - autumn (1 September – 30 November) and D - winter (1 December – 15 March). White areas represent grid cells without data.

Gannet (Morus bassanus)

The gannet occurs in low densities in large parts of the German North Sea (MENDEL et al. 2008, MARKONES et al. 2014, MARKONES et al. 2015). Current distribution maps show an almost site-wide distribution south-east of Shipping route SN10 with locally higher densities in spring and summer as well as a more irregular occurrence in autumn and winter (Figure 31). A moderate increase of 9.66% average change per year was calculated for the population figures from 2004 to 2016 (Table 9). According to Gerlach et al. (2019), the autumn grazing population has doubled over the years and is estimated at 6,000 individuals. The gannet is an important breeding bird on Heligoland and has shown a continuously increasing breeding population since the first breeding pairs settled there in 1991 (DIERSCHKE et al. 2011, DIERSCHKE et al. 2023). Most recently, the number of breeding pairs decreased by almost half from 1,485 in 2022 to 887 in 2023 (personal communication Jochen Dierschke/Heligoland Bird Observatory). This coincides with the outbreak of avian influenza in the gannet breeding colony on Heligoland (June 2022) (LANE et al. 2023, DIERSCHKE & DIERSCHKE 2023).

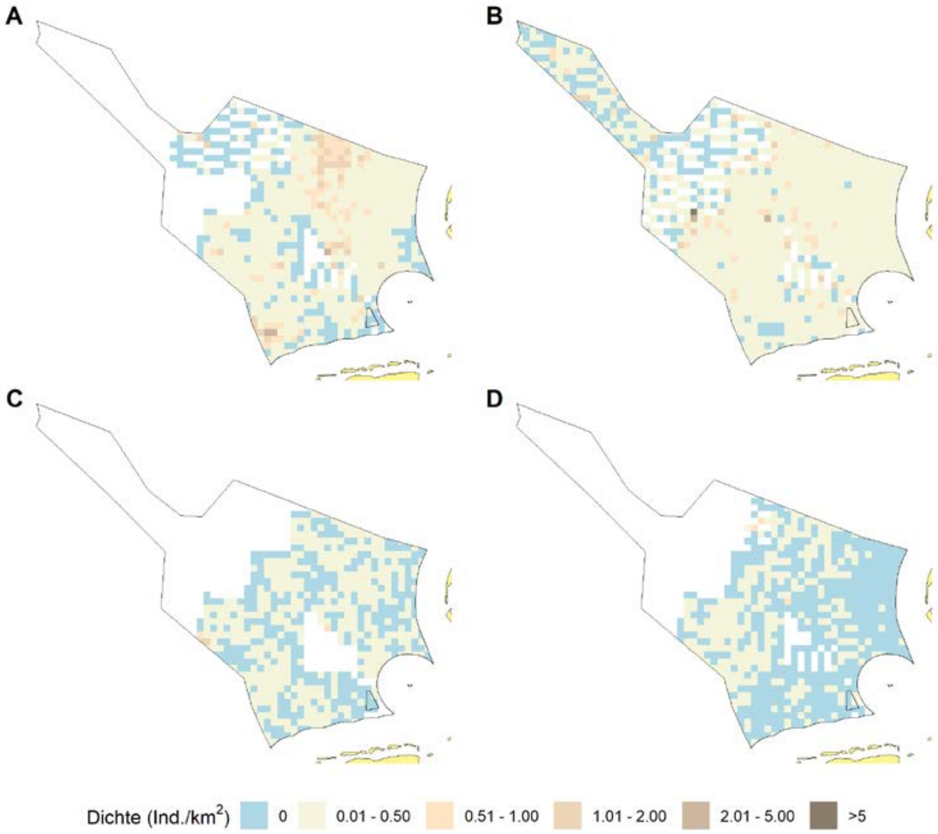

Figure 31: Temporally aggregated densities (September 2013 to August 2021) of the gannet in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 30 April), B - summer (1 May – 31 August), C - autumn (1 September – 31 October) and D - winter (1 November – 29 February). White areas represent grid cells without data.

Razorbill (Alca torda)

Razorbills are relatively evenly distributed in the coastal waters of the EEZ in winter. There is a clear concentration off the East Frisian Islands. At other times of the year, the occurrence in German waters remains low (MENDEL et al. 2008). The long-term data series of the FTZ and BfN confirm the main occurrence of razorbills in the winter months (cf Table 9). The highest concentrations occur north of Borkum and Norderney and extend into the offshore area (MENDEL et al. 2008) as well as to the northern part of the Elbe Glacial Valley. Figure 32 also shows higher densities in spring in the north-western and central parts of the German Bight. The BfN determined a "moderate decrease" in populations in 2004–2016 (7.04% average change per year) (Table 9). In contrast, the breeding colony on Heligoland reached a new high in 2023 with 114 breeding pairs after the count of 74 breeding pairs in the previous year (personal communication Jochen Dierschke/Heligoland Bird Observatory, DIERSCHKE & DIERSCHKE 2023).

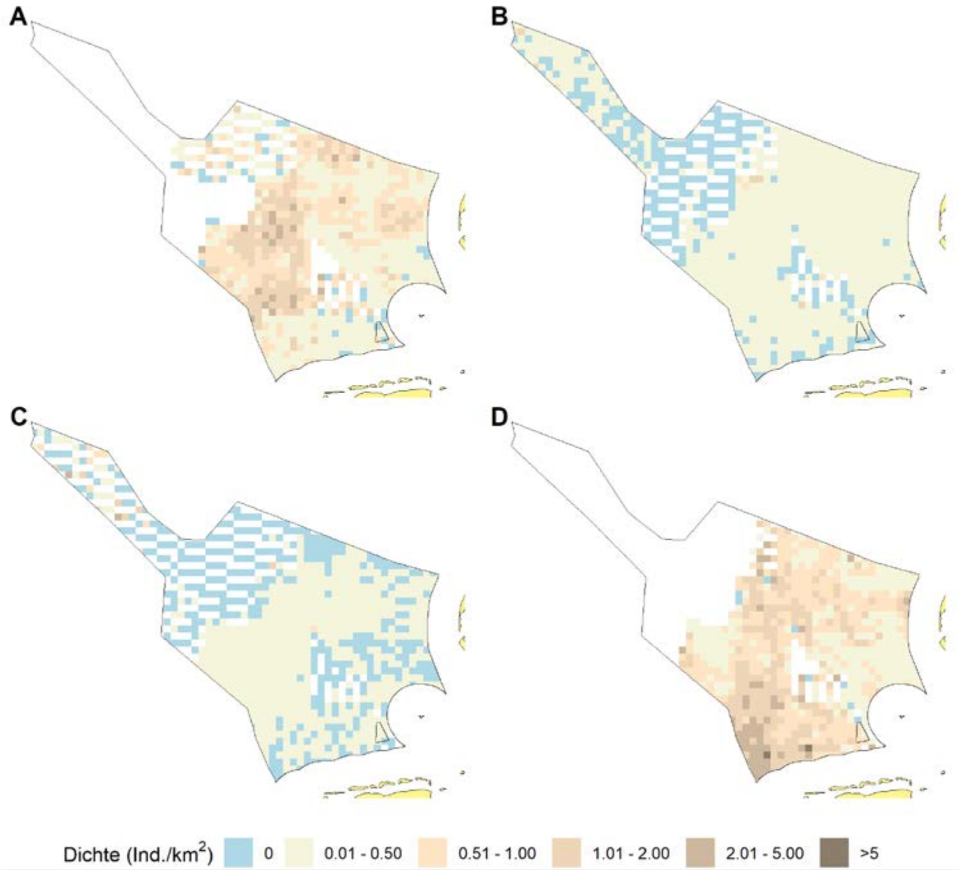

Figure 32: Temporally aggregated densities (September 2013 to August 2021) of the razorbill in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 15 April), B - summer (16 April – 30 June), C - autumn (1 July – 30 September) and D - winter (1 October – 29 February). White areas represent grid cells without data.

Guillemot (Uria aalge)

The guillemot is a typical seabird that spends time on land only during the breeding season. It is one of the most common seabird species in the northern hemisphere and has a breeding population of around 2.46–3.17 million individuals in Europe. The most important breeding areas are located on the rocky coasts of Iceland and the British Isles, the latter with about 1.4 million individuals (BirdLife International 2017). The north-western European population, which includes the breeding birds of Heligoland, is estimated at around 471,000 individuals (Nagy & Langendoen 2018). Studies on ringed guillemots have shown that individuals from these large colonies migrate to the southern and eastern North Sea in the post-breeding season for the purpose of foraging (Tasker et al. 1987). The only breeding colony in German waters is on Heligoland. Most recently, 4,007 (2022) and 4,435 (2023) breeding pairs were counted there (personal communication Jochen Dierschke/Heligoland Bird Observatory). The Heligoland breeding colony was hit by an outbreak of avian influenza in spring 2023; this "…[caused] hundreds of dead young birds on Heligoland and many washed up adult birds on the beaches of the East Frisian Islands, some of which had been fitted rings from Heligoland. The effects on the breeding population cannot yet be estimated. …“ (DIERSCHKE & DIERSCHKE 2023).

During the breeding season, the birds only leave the colony to forage within a maximum radius of 30 km. The occurrence of guillemots is therefore concentrated in the vicinity of the breeding colony on Heligoland during the breeding season (MENDEL et al. 2008). Medium to high densities are observed at this time in the Elbe Glacial Valley as well as in the North-western region of the German EEZ (*Figure 33*).

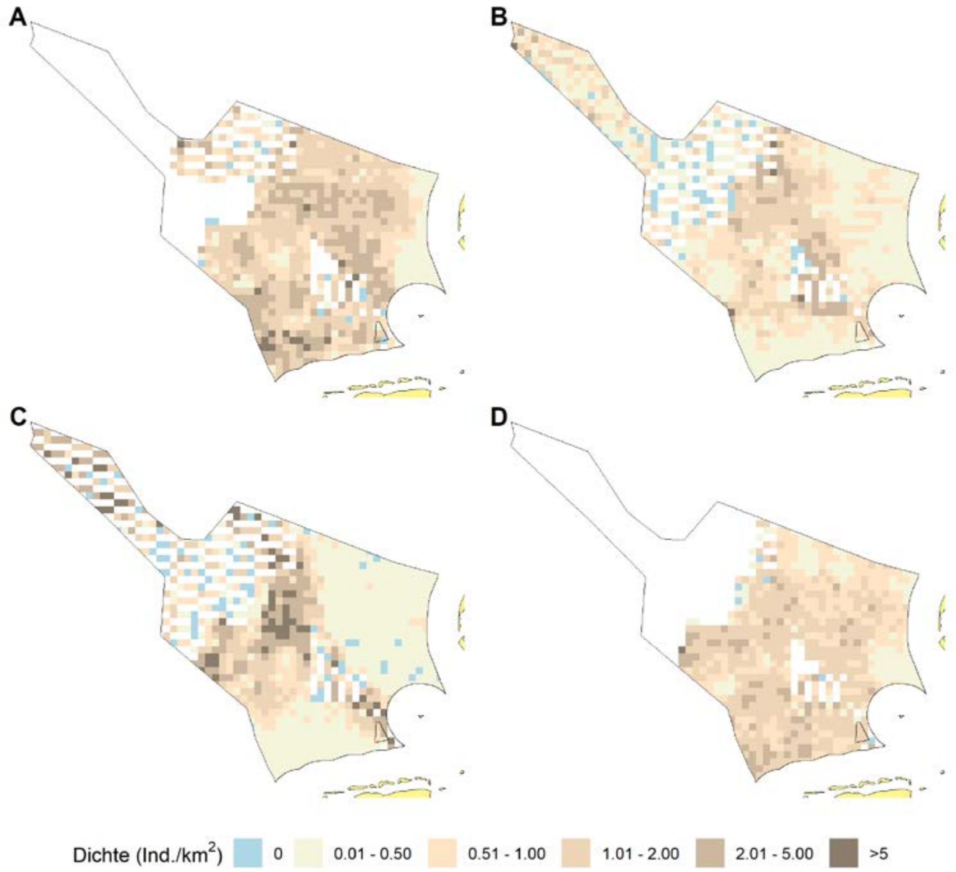

Figure 33: Temporally aggregated densities (September 2013 to August 2021) of the guillemot in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 15 April), B - summer (16 April – 15 July), C - autumn (17 July – 30 September) and D - winter (1 October – 29 February). White areas represent grid cells without data.

In autumn, the occurrence of guillemots shifts to offshore areas with water depths of 40–50 m. During this time, adults are often observed with their young, which most likely originate from British breeding colonies (Markones & Garthe 2011; BUCKINGHAM et al. 2023). Whilst winter was the season with the highest population numbers in the reference period 1993 to 2003 (MENDEL et al. 2008), it has been autumn since the reference period 2011 to 2016 (cf Table 9, Peschko et al. 2024). High to locally very high densities are concentrated in autumn in the area of the north-western region of the German EEZ and the central area of the German Bight with areas of high density to the south and north-west of it (Figure 33). By modelling data from 2011 to 2016, Peschko et al. (2024) identified an area of very high densities in autumn that partially coincides with the previously mentioned areas of high densities based on temporally aggregated data (2013 to 2021) (Figure 34). The BfN determined a “strong decrease” in populations in 2004–2016 (12.35% average change per year) (Table 9). The winter population of the common guillemot (with a most recently recorded average size of 31,000 individuals) shows a decline of around 75% from 2003/2004 to 2015/2016 (Gerlach et al. 2019).

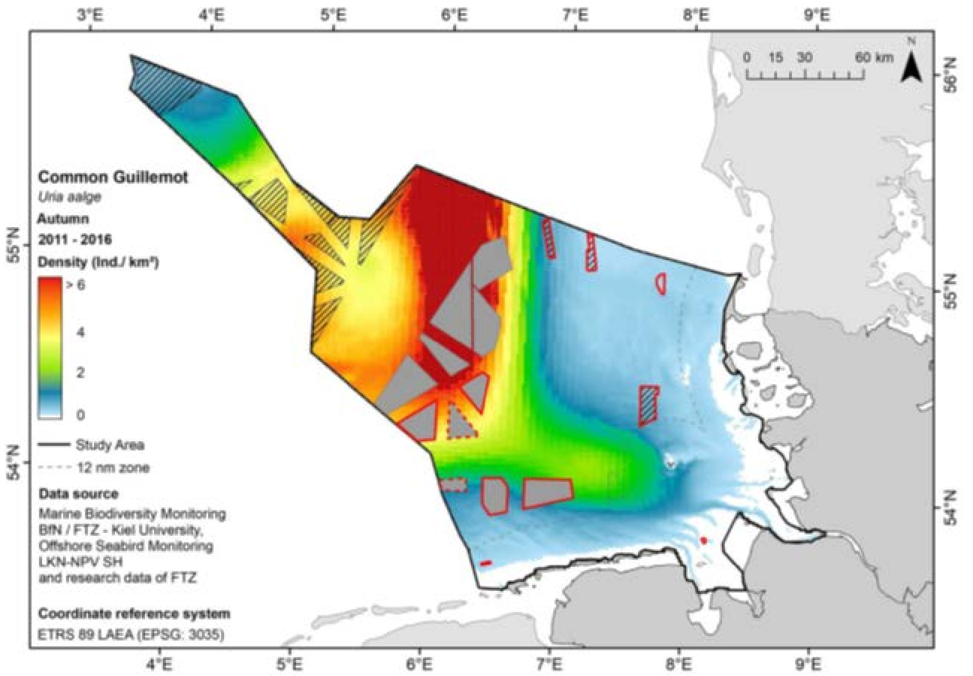

Figure 34: Modelled distribution of guillemots in autumn in the German North Sea (area: German EEZ and coastal waters as shown). Priority areas for offshore wind energy defined up to 2030 (including OWF under construction or in operation) are shown in grey; hatched sites are for wind energy projects up to 2035/2040 (BSH 2021a, BSH 2021b); a solid red line = OWF in operation; a dashed red line = an approved OWF (source: Peschko et al. 2024)

Kittiwake (Rissa tridactyla)

After the lesser black-backed gull and the guillemot, the kittiwake is one of the most common species in the German EEZ of the North Sea and occurs all year round. The long-term data series of the FTZ show a clearly concentrated occurrence around Heligoland in spring and summer and in summer also in a north-westerly direction along the Elbe Glacial Valley. In Figure 35, this is reflected only in spring and identifies the north-western region of the German EEZ as an area of medium to high densities. According to Table 9 and Figure 35, winter seems to be the season with the highest occurrence, and it seems plausible that the north-western region of the German EEZ also has medium to high densities over a wide area.

The breeding population initially declined slowly from 8,600 breeding pairs in 2001 then increasingly rapidly (Dierschke et al. 2023). Most recently, 2,463 breeding pairs were counted in 2022 and 2,215 breeding pairs in 2023 (personal communication Jochen Dierschke/Heligoland Bird Observatory).

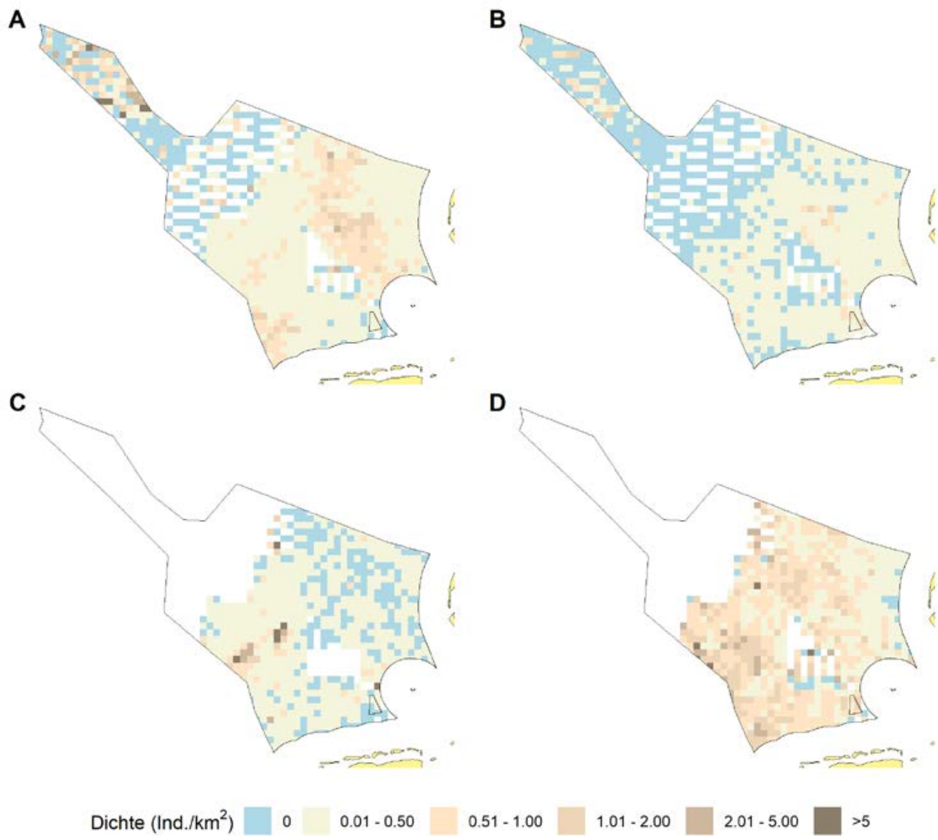

Figure 35: Temporally aggregated densities (September 2013 to August 2021) of the kittiwake in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 15 May), B - summer (16 May – 31 July), C - autumn (1 August – 31 October) and D - winter (1 November – 29 February). White areas represent grid cells without data.

Little gull (Larus minutus)

The German Bight, where the little gull reaches only low population densities, is located at the north-eastern edge of the winter distribution of European little gull (GLUTZ von BLOTZHEIM & BAUER 1982). In general, a considerable proportion of the north-west European population flies over the coastal areas of the German North Sea coast during migration as long-term observations from research projects and EIS consistently show. High densities can then be observed especially in the area of the Elbe estuary (MARKONES et al. 2015). During the breeding season and in summer, only isolated individuals remain in the German EEZ (MENDEL et al. 2008). The large number of individuals during migration is then followed by a lower, constant winter occurrence in the German North Sea, which is predominantly restricted to the territorial sea and the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area. The area around the “Borkum Riffgrund” nature conservation area seems to be of particular importance in spring (Figure 36). In general, their occurrence depends heavily on the prevailing weather.

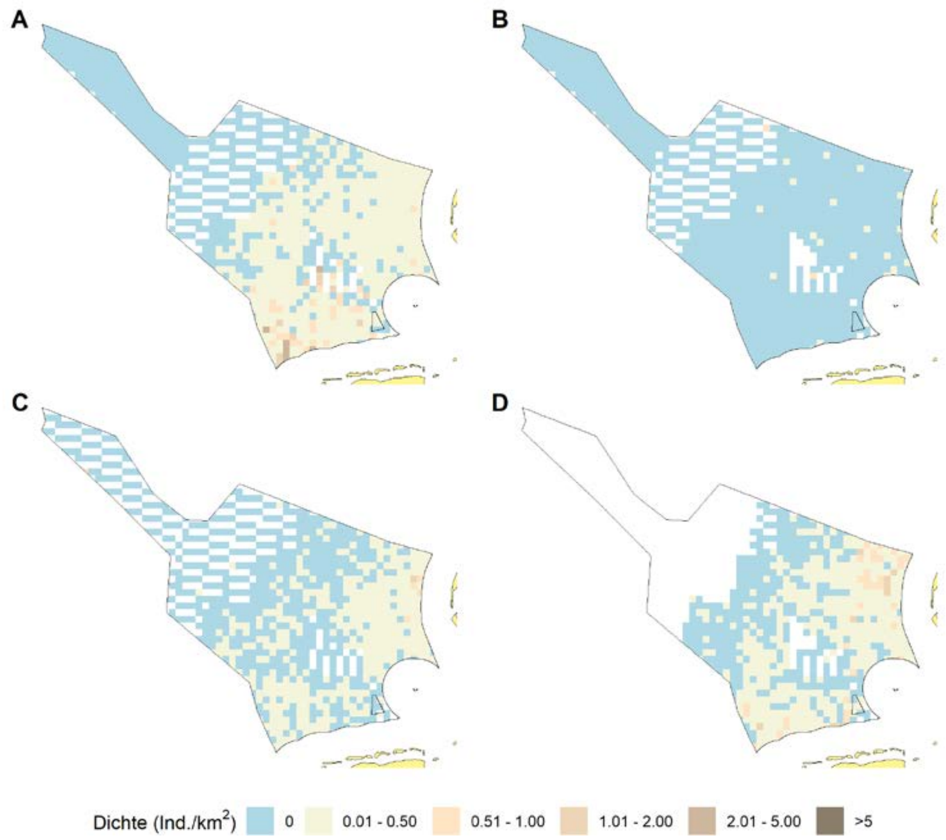

Figure 36: Temporally aggregated densities (September 2013 to August 2021) of the little gull in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 31 May), B - summer (1 June – 15 July), C - autumn (16 July – 31 October) and D - winter (1 November – 29 February). White areas represent grid cells without data.

Common gull (Larus canus)

Common gulls are widespread in the eastern and southern part of the German Bight near the coast in winter. The highest densities are reached in the Elbe-Weser estuary, in the area of the Ems estuary, and off the North Frisian islands. The long-term data series of the FTZ indicate that common gulls are present in the German North Sea all year round, but the largest populations in the offshore area are reached in winter. The winter occurrence extends with high densities over the entire coastal area down to the 20 m depth contour. In areas far from the coast, common gulls still occur regularly but in significantly lower numbers (MENDEL et al. 2008). In the other seasons, common gulls stay closer to the coasts, where their breeding grounds are also located (Figure 37). The occurrence of common gulls is also highly dependent on the weather.

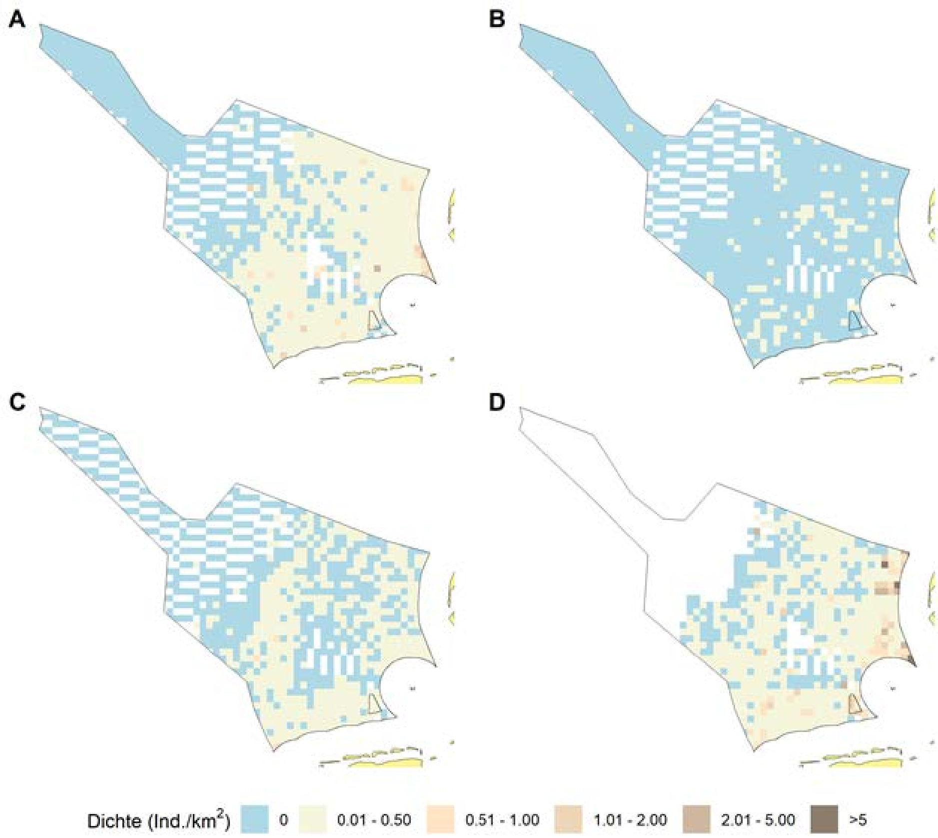

Figure 37: Temporally aggregated densities (September 2013 to August 2021) of the common gull in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 15 May), B - summer (16 May – 15 July), C - autumn (16 July – 31 October) and D - winter (1 November – 29 February). White areas represent grid cells without data.

Greater black-backed gull (Larus marinus)

Great black-backed gulls are present in the German North Sea all year round (Figure 38). They occur in low densities in spring and summer both near the coast and in the offshore area 80 km from the coast. In autumn, the occurrence then steadily increases and leads to a large winter population in the Elbe estuary and along the East Frisian coast. In the offshore area, only isolated greater black-backed gulls occur (Mendel et al. 2008). The winter population of the greater black-backed gull (with a most recently recorded average size of 18,500 individuals) shows a decrease of over 30% from 2003/2004 to 2015/2016 (Gerlach et al. 2019).

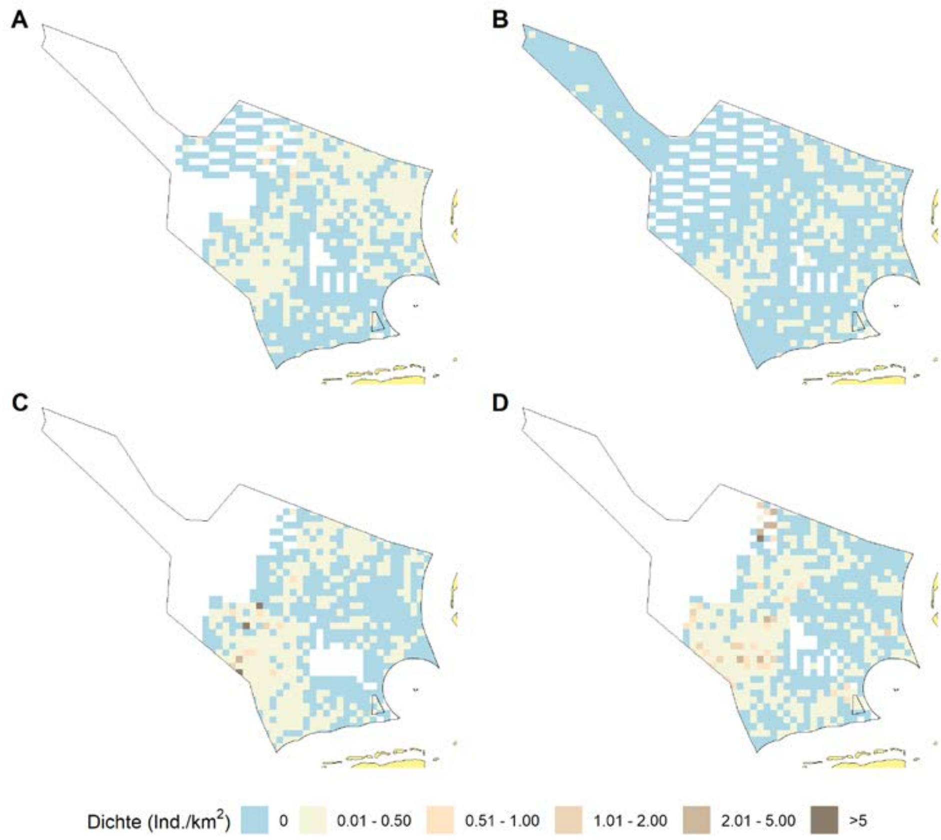

Figure 38: Temporally aggregated densities (September 2013 to August 2021) of the greater black-backed gull in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 30 April), B - summer (1 May – 31 July), C - autumn (1 August – 31 October) and D - winter (1 November – 29 February). White areas represent grid cells without data.

Herring gull (Larus argentatus)

Herring gulls occur widely but irregularly in the interior of the German Bight in spring and autumn. They can be observed occasionally in summer. In winter, the season with the highest population numbers, the occurrence is irregular but with locally increased densities, especially in the north-western German Bight as well as on the north-eastern edge of Shipping route SN10 (Figure 39). The winter population of the herring gull (with a most recently recorded average size of 155,000 individuals) shows a decline of around 30% from 2003/2004 to 2015/2016 (Gerlach et al. 2019).

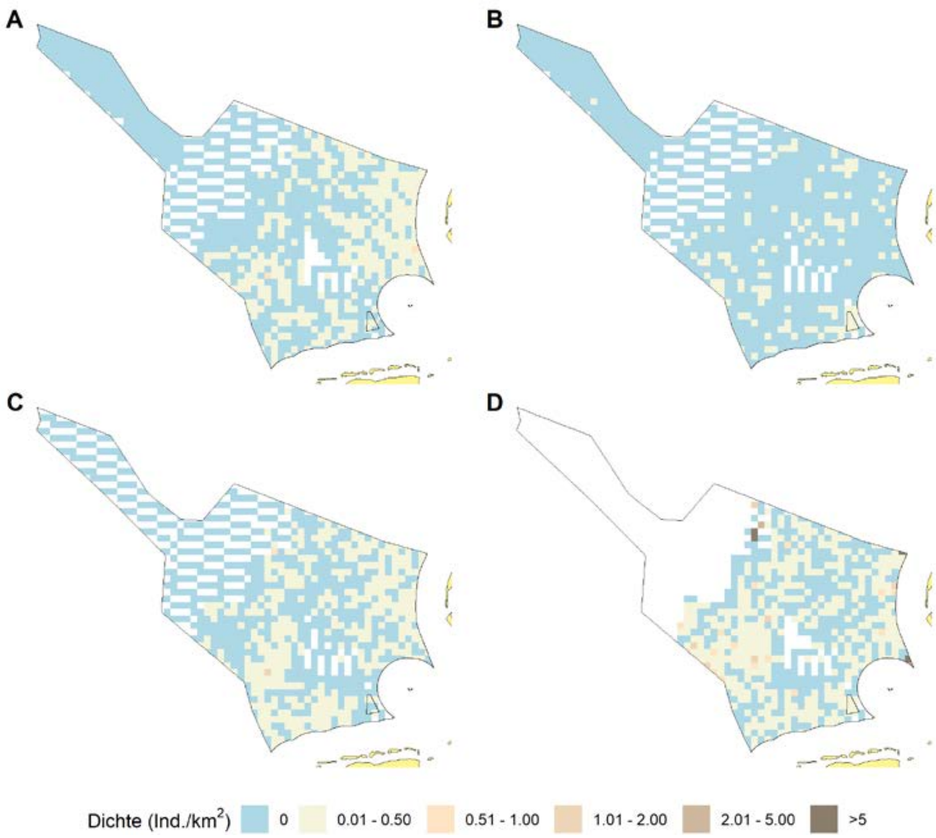

Figure 39: Temporally aggregated densities (September 2013 to August 2021) of the herring gull in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 15 May), B - summer (16 May – 15 July), C - autumn (16 July – 31 October) and D - winter (1 November – 29 February). White areas represent grid cells without data.

Lesser black-backed gull (Larus fuscus)

During the migration home and in the pre-breeding period, the distribution of the lesser black-backed gull is concentrated around 60 km off the coast. Both during and after the breeding season, the lesser black-backed gull is a widespread species in the German Bight (Figure 40). The focus is on the territorial sea off Schleswig-Holstein and Lower Saxony as well as the neighbouring areas of the EEZ, especially west of the island of Heligoland. The lesser black-backed gull is a well-known ship follower. Their sometimes highly concentrated occurrence can therefore often be observed in connection with fishing activity. In the area around the island of Heligoland, the lesser black-backed gull is the only seabird species to occur in high densities during the summer months and is the most common seabird species in the German North Sea during this time. Recent investigations show, as for the greater black-backed gull, a decrease in the summer occurrence of the lesser black-backed gull in the German North Sea. However, this is not due to a decline in the breeding population but rather a shift in occurrence to terrestrial areas (MARKONES et al. 2015).

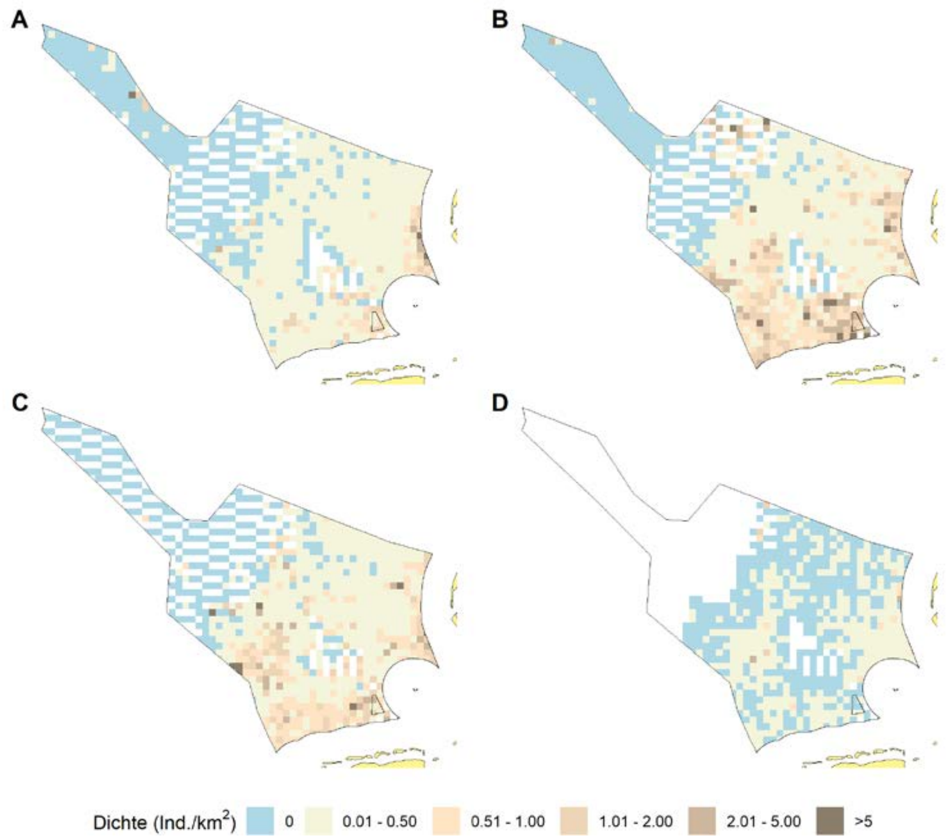

Figure 40: Temporally aggregated densities (September 2013 to August 2021) of the lesser black-backed gull in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (16 March – 15 May), B - summer (16 May – 15 July), C - autumn (16 July – 31 October) and D - winter (1 November – 15 March). White areas represent grid cells without data.

Sandwich tern (Thalasseus sandvicensis)

The distribution area of the Sandwich tern in the pre-breeding season, during the breeding season, and during migration runs along the coast of the North Sea – with most birds in a 20 to 30 km wide strip and concentrations near known breeding colonies on Norderoog, Trischen, and Wangerooge.

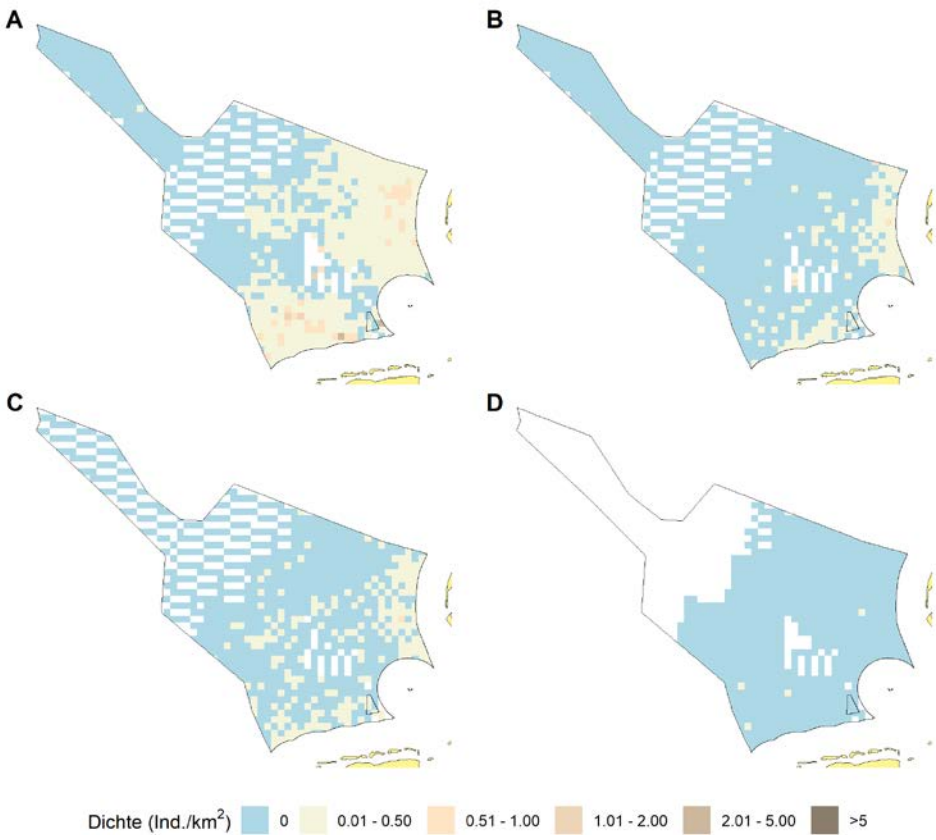

Figure 41: Temporally aggregated densities (September 2013 to August 2021) of the sandwich tern in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (16 March – 15 May), B - summer (16 May – 15 July), C - autumn (16 July – 15 October) and D - winter (16 October – 15 March). White areas represent grid cells without data.

The long-term data series of the FTZ show that the Sandwich tern is most common in the German North Sea in the summer months. Sandwich terns then occur in large areas of the entire territorial sea. In the area outside the territorial sea, Sandwich terns occur only sporadically (MENDEL et al. 2008; Figure 41). In areas with a water depth of more than 20 m, there are hardly any foraging Sandwich terns.

Common tern (Sterna hirundo) and Arctic tern (S. paradisaea)

Common and Arctic terns cannot always be reliably distinguished from each other under unfavourable observation conditions and are therefore treated together. During the breeding season, both common and Arctic terns stay in a strip off the coast, which protrudes only slightly into the EEZ in the northern part. The highest densities are found near the breeding sites on the islands off the coast. The distribution of the two tern species after the breeding season is quite similar to that during the breeding season. However, local focal points are less clearly located near the breeding sites, which are no longer occupied at this time. The EEZ gains some importance after the breeding season, especially the area off the North Frisian Islands (MENDEL et al. 2008).

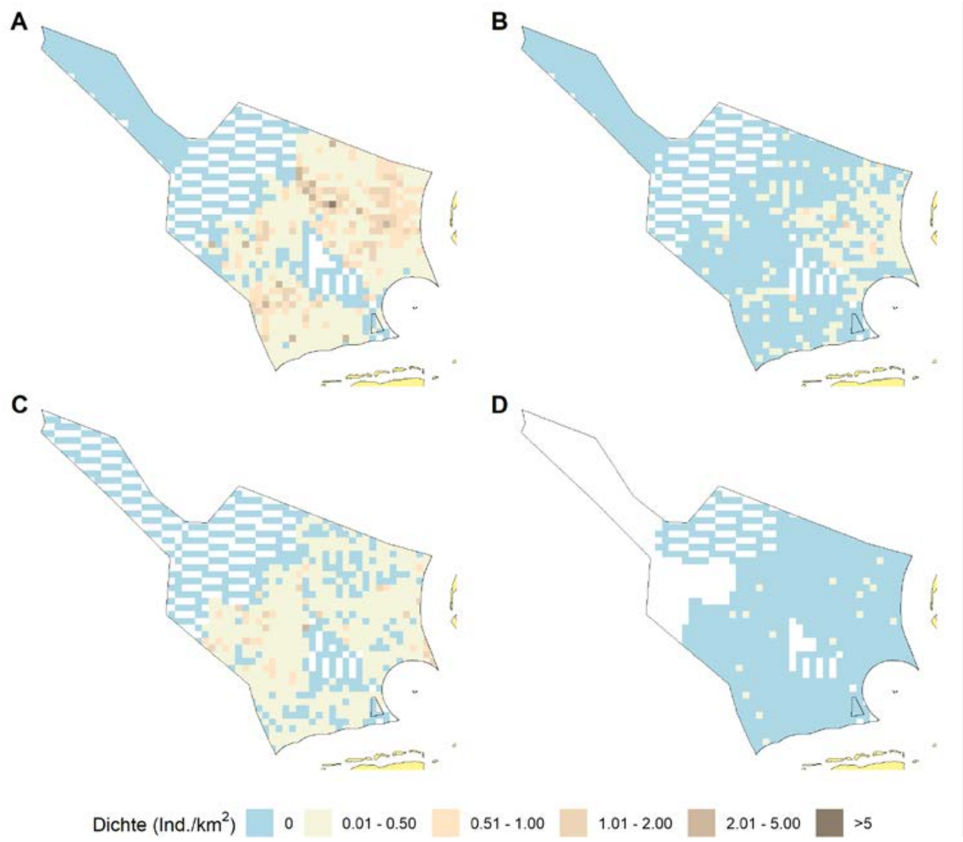

Figure 42: Temporally aggregated densities (09/13 to 08/21) of the common and Arctic tern species group in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 April – 15 May), B - summer (16 May – 15 July), C - autumn (16 July – 15 October) and D - winter (16 October – 31 March). White areas represent grid cells without data.

Black scoter (Melanitta nigra)

Black scoters can be found in the German North Sea all year round; however, their occurrence is concentrated in areas close to the coast and shallower offshore areas (Figure 43). In spring and autumn, the occurrence of black scoters is determined by migration. In winter, the coastal areas serve as important resting habitats, and in summer, a moult migration can be observed. The offshore bird conservation area "Östliche Deutsche Bucht" records very low populations only in summer and autumn compared with the entire German North Sea (MENDEL et al. 2008).

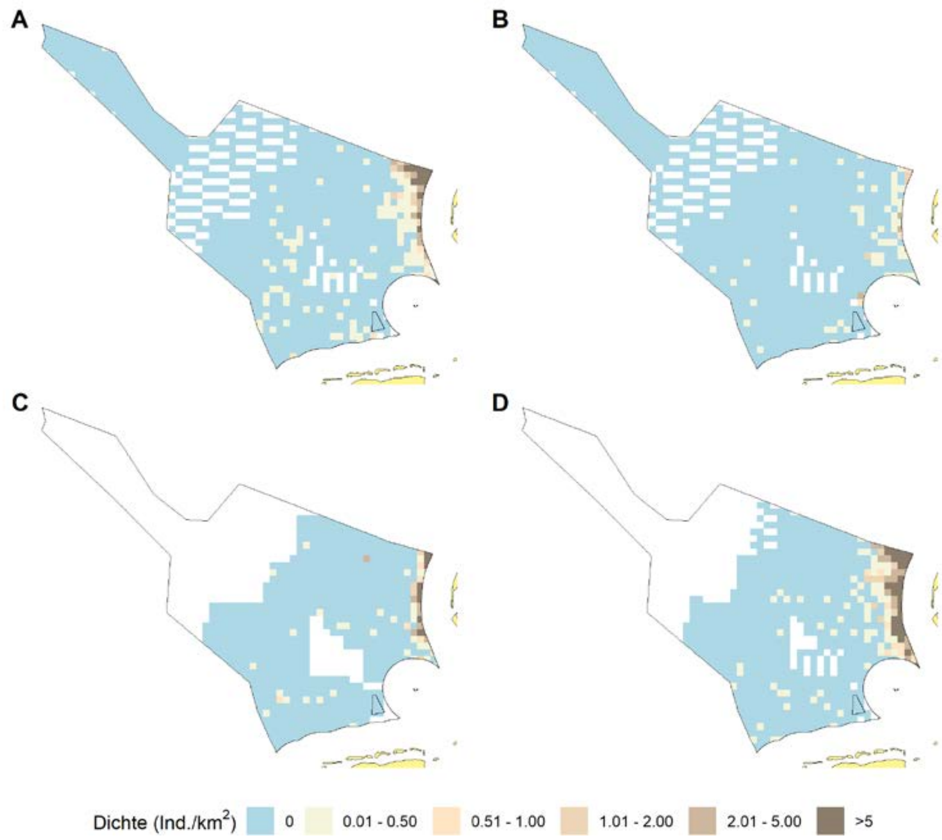

Figure 43: Temporally aggregated densities (September 2013 to August 2021) of the black scoter in the German EEZ of the North Sea based on a 5 × 5 km grid, mapped for the species-specific A - spring (1 March – 31 May), B - summer (1 June – 30 September), C - autumn (1 October – 30 November) and D - winter (1 December – 29 February). White areas represent grid cells without data.

Skua (Stercorarius skua)

Skuas are very rarely observed in the German Bight. Occasional occurrences are possible all year round, but a focal point can be recognised above all during migration from the end of June to November. In the eastern part of the German Bight, the occurrence is often observed in connection with strong westerly winds (DIERSCHKE et al. 2011).

Pomarine skua (Stercorarius pomarinus)

Pomarine skuas occur mainly during the autumn migration in the German North Sea. The occurrence is subject to strong annual fluctuations and is therefore extremely variable (PFEIFER 2003).

2.9.2.3. Occurrence of seabirds and resting birds in the areas for wind energy

Area N-4

The data from the vicinity of Area N-4 show a medium and occasionally high occurrence of seabirds. The entire area of the eastern German Bight, which includes Area N-4, is of high importance for six species (groups). This applies to red-throated and black-throated divers, little gulls, common gulls, black scoters, and terns (common, Arctic, and sandwich terns).

However, the black scoters is rarely or never observed in the Area N-4 because of the water depth of more than 20 m. In recent investigations, dense occurrences of black scoters have only been observed in the extreme north-eastern edge of the area of investigation of N-4 (IBL UMWELTPLANUNG et al. 2016a, IBL UMWELTPLANUNG et al. 2017a, IBL UMWELTPLANUNG et al. 2018a). Common gulls occur in and around Area N-4 mainly in autumn and winter and mostly over large areas. Little gulls can occur all year round in Area N-4 but are most common in spring and winter. Terns occur mainly during migration periods. In recent investigations, occurrence was concentrated in the north of Area N-4 (IBL UMWELTPLANUNG et al. 2017a, IBL UMWELTPLANUNG et al. 2018). Area N-4 is located in the southern part of the main concentration area for divers in spring (BMU 2009). In the species-specific spring, from March to May, divers are regularly observed in higher densities in the vicinity of the area, especially north-west and east of N-4 (IBL UMWELTPLANUNG et al. 2017a, IBL UMWELTPLANUNG et al. 2018a, IBL UMWELTPLANUNG et al. 2019a).

The most frequently represented species are lesser black-backed gulls, kittiwakes) especially in association with fishing activities), common gulls (independent of fishing activities, especially in high densities in autumn and winter), and auks. The latter, mainly common guillemot and razorbill, occur only on average in the area around Area N-4 compared with the offshore areas of the EEZ. In summer, the immediate vicinity of Area N-4 is partly used as a foraging ground by breeding birds from the breeding colonies of Heligoland. Investigations with gannets tagged during the breeding season showed a significantly reduced exploration of wind farm sites compared with surrounding areas (PESCHKO et al. 2021). Fulmars occur rather sporadically. The area is of no particular importance for diving sea ducks. Other bird species listed in Appendix I of the Birds Directive occur only in average numbers.

Area N-5

The surroundings of area N-5 are characterised by a high occurrence of seabirds. All previous results show a gradient in the composition of the bird community: The area to the east of Area N-5 marks the transition between nearshore areas with water depths of less than 20 m and areas with increasing water depth and distance from the coast. The vicinity of N-5 thus has a mixed bird community with a high proportion of shorebirds in nearshore areas; this transitions westwards into an upland bird community with increasing water depth (BIOCONSULT SH 2015). In investigations, the black scoter was the most common species in the investigation area in the coastal area east of the Area N-5 in both vessel-based and digital aerial surveys (BIOCONSULT SH 2017, BIOCONSULT SH 2018, BIOCONSULT SH 2019, BIOCONSULT SH 2020, BIOCONSULT SH 2022a). In Area N-5, open sea species such as kittiwake, Larus gulls and auks are increasingly dominant. To the west of Area N-5, the fulmar also occurs in late winter and summer (IFAÖ 2016, IFAÖ 2017). During wind farm-related investigations in the vicinity of N-5, gannets were found only in small numbers during migration periods or in summer (IFAÖ 2017, BIOCONSULT SH 2018, BIOCONSULT SH 2019, BIOCONSULT SH 2020, , BIOCONSULT SH 2022a). Figure 31 shows medium densities in the area of N-5 in the species-specific spring.

Species listed in Annex I of the Birds Directive (V-RL) regularly occur. Area N-5 is located in the north-western corner of the main concentration area of divers in the German Bight in spring (BMU 2009). From March to mid-May (species-specific spring), high densities with marked intra- and interannual variability are recorded in the area around Area N-5 (GARTHE et al. 2015, GARTHE et al. 2018, BIOCONSULT SH et al. 2020). According to current investigations, the divers population is concentrated south-east of Area N-5 within the Special Protection Area. In the other seasons, divers are observed only sporadically (BIOCONSULT SH 2017, IFAÖ 2017, BIOCONSULT SH 2018, IFAÖ 2018, BIOCONSULT SH 2019, IFAÖ 2019, BIOCONSULT SH 2020, BIOCONSULT SH 2022a). Little gull occur mainly in low densities in Area N-5 during migration periods and in winter. The densities increase from west to east. Terns have been observed east of Area N-5 during migration periods and occasionally in summer (BIOCONSULT SH 2017, IFAÖ 2017, BIOCONSULT SH 2018, IFAÖ 2018, BIOCONSULT SH 2019, IFAÖ 2019, BIOCONSULT SH 2020, BIOCONSULT SH 2022a).

Expansions of Areas N-9, N-12, N-13 (Zone 3) as well as Areas N-14 and N-16 (Zone 4)

The areas to the south-east and north-west of the Shipping route SN10 to the north of the traffic separation zones have a medium to high seasonal occurrence of seabirds. The species composition and, above all, the abundance ratios indicate that these areas are typical habitats for the deep-sea bird community. The most common species are the guillemot, kittiwake, razorbill, and lesser black-backed gull. Gulls are observed here mainly hunting for fishing waste. However, common gulls occur in small numbers in autumn and winter regardless of fishing activities. The fulmar and the Northern gannet are observed all year round in this area of the EEZ. However, the occurrences show strong intra- and interannual fluctuations (PGU 2015, IBL UMWELTPLANUNG et al. 2016b, IBL UMWELTPLANUNG et al. 2017b).

Species listed in Appendix I of the Birds Directive may occur sporadically in the area during migration periods and in winter. The occurrence of little gulls, terns, and divers does not indicate any focal points. This area of the EEZ serves as a migration area for them (IBL UMWELTPLANUNG et al. 2017b). Compared with the diver distribution area, only low diver densities have been recorded in the adjacent areas in spring so far (IFAÖ 2016; Figure 29).

Because of the depth of the water, these areas are of no importance as resting and foraging habitats for diving sea ducks that seek their food on the seabed. Many of the exclusively piscivorous seabird species found here forage by diving in the water column. These species are attracted by the concentrated occurrence of fish and macrozooplankton.

Because of their nature, these areas are part of the large-scale habitat of the common guillemot in the North Sea. The investigations carried out as part of environmental impact studies and monitoring have shown the occurrence of guillemots carrying young birds in this area of the EEZ in the post-breeding period (MARKONES & GARTHE 2011, MARKONES et al. 2014, PLANUNGSGEMEINSCHAFT UMWELTPLANUNG OFFSHORE WINDPARK 2015, BIOCONSULT SH et al. 2021, BIOCONSULT SH et al. 2023). Recent modelling has identified a main area of distribution for the autumn population of the guillemot in the German EEZ (Figure 33; Peschko et al. 2024). This overlaps with Sites N-12.4, N-12.5, N-13.4, N-16.1, and N-16.2. However, guillemots are not bound to specific habitats outside the breeding season (CAMPHUYSEN 2002, DAVOREN et al. 2002, VLIESTRA 2005, CRESPIN et al., 2006, FREDERIKSEN et al. 2006). In favour of this:

- the potential resting and foraging habitat extending over the entire North Sea
- the high mobility also during the management of young birds

- the repeatedly observed high spatial and temporal variability of occurrence.

Apparently, guillemots actively pursue schools of fish in this area. A special function of the areas described here as a foraging or breeding area can therefore not be determined on the basis of previous findings.

Areas N-17, N-19, and N-20 (Zone 5)

Zone 5 with Areas N-17 and N-19 has a rather low importance for the most common seabird species but sometimes a seasonally high importance for the typical seabird species of the German North Sea. In spring, for example, the fulmar is widespread there with the highest local densities in the border area with Zone 4; in summer it occurs irregularly in low densities. In summer, the razorbill is observed almost everywhere in low densities; in autumn, there are signs of an almost nationwide distribution with sometimes medium densities. No statements can be made about spring and the winter with the largest population (cf Table 9). Common guillemots occur in medium densities throughout the area in summer and regularly in higher densities in autumn. Gannets also occur in low densities throughout the area in summer. In contrast, the kittiwake is found there irregularly in summer at maximum medium densities; however, in spring, it is widespread with locally high to very high densities. Lesser black-backed gulls are only sporadically seen in higher densities in spring and summer and rarely in Zone 5 in autumn. Greater black-backed gulls are seen occasionally in summer, and divers are even rarer at the same time of year. Little gulls were not sighted at all between spring and autumn.

2.9.3. Status assessment

The high level of research effort in recent years and the current state of knowledge allow a good assessment of the importance and status of the Areas N-4 and N-5 considered here as habitats for seabirds and resting birds. For the areas and sites defined in the SDP 24, the current state of knowledge is considerably lower and an assessment of the importance and status is possible only on a rough basis.

2.9.3.1. Importance of areas and sites for seabirds and resting birds

Area N-4

Area N-4 is located in the immediate vicinity of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area (Ordinance on the Designation of the “Sylter Außenriff – Östliche Deutsche Bucht nature conservation area” of 22 September 2017 (Federal Law Gazette I p. 3423)) or its sub-area II, which is designated as a Special Protection Area (SPA). In addition, the area lies in the southernmost part of the main concentration area for divers in the German Bight in spring (BMU 2009). The surroundings of Area N-4 are therefore of high importance for divers, even if the densities are mostly lower than those recorded in the protected area and in the areas north-west of Area N-4.

For the resting and migratory bird species to be conserved in the protected area, the surroundings of Area N-4 are also of major importance. Other bird species listed in Annex I of the Birds Directive such as terns and little gulls are rather moderate in Area N-4. The abundance and distribution of seabirds show a high interannual species-specific variability within the areas. The area is of medium to species-specific high importance as a foraging ground. The existing pressures from shipping, fishery, and offshore wind farms in this area are of medium to seasonally high intensity for seabirds. However, in the sites of Area N-4, the existing pressure from fishery is to be categorised as low because of a prohibition of fishing in the wind farms. For breeding birds from the breeding colonies on Heligoland and on the islands off the North Frisian coast, Area N-4 is only of low importance as a foraging ground because of the distance.

Area N-5

All findings to date indicate that Area N-5 is of high importance for seabirds.

The surroundings of Area N-5 are of very high importance for the red-throated and black-throated divers listed in Annex I of the Birds Directive. All sub-areas are located in the main concentration area of divers (BMU 2009). Less than 20 km to the east of Area N-5 is sub-site II of the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area (Ordinance of 27 September 2017, Federal Law Gazette Part I No. 63, 3423). Depending on the season and species, a high occurrence of other protected seabird species has also been recorded here. To the south of Area N-5, less than 15 km away, current plans envisage a new sub-area III within the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area for the protection of the star and black-throated diver (BMUV 2022). Other bird species listed in Annex I of the Birds Directive such as terns and little gulls also occur in Area N-5.

Site N-5 and its surroundings are located in the transition area of the distribution range of many coastal bird species (e.g. diving sea ducks) within the Special Protection Area as well as an increasing occurrence of seabird species west of the area. The abundance and distribution of the bird species show a high interannual species-specific variability within the area. The area surrounding the area is of medium, but occasionally also high, importance as a foraging ground for many species of seabirds. Area N-5 is of major importance to divers as a foraging ground before the migrate home to the breeding grounds in spring.

For breeding birds, Area N-5 is only of minor importance because of the distance from the coast and the islands with breeding colonies as a foraging ground. Existing pressures from shipping, fishery, and offshore wind farms in and around Area N-5 are of medium to high intensity for seabirds.

Expansions of Areas N-9, N-12, N-13 (Zone 3) as well as Areas N-14 and N-16 (Zone 4)

All findings to date indicate that the areas on the south-eastern and north-western edges of shipping route SN10 are of medium importance for seabirds. Overall, the areas have a medium occurrence of seabirds. The areas are most frequently used by seabird species that are widely distributed throughout the North Sea; these include ship chasers that benefit from bycatch.

Species that are sensitive to disturbance (e.g. divers) are present only in the areas for a short time (e.g. in search of food) as well as during the main migration periods. The areas are located outside the main distribution area of divers in spring. For other seabird species of special conservation concern listed in Annex I of the Birds Directive, the areas are also not among the valuable resting habitats or favoured inhabitation areas in the German Bight. The abundance and distribution of seabirds show high interannual species-specific variability within the areas. The areas are of medium importance as a foraging ground for seabird species. Because of the distance from the coast, the areas are not important for breeding birds. The existing pressures from shipping and fishery in the areas are of medium to sometimes high intensity for seabirds. Because of the development of individual areas (N-6 and N-8) to date, the legacy impact of offshore wind farms can generally be regarded as low. However, it will increase continuously in the coming years because of the further expansion in Areas N-6 to N-12.

This estimation also applies to the area for other energy generation SEN-1 directly north of Area N-8.

Zone 5 (Areas N-17, N-19, N-20)

This zone is of at least medium importance for the deep-sea bird species of the German North Sea (e.g. guillemot, fulmar, and kittiwake). Their occurrence can sometimes be high depending on the season.

2.9.3.2. Protection status

Of the seabird species regularly observed in the German EEZ of the North Sea, albeit sometimes in low densities, the red-throated diver, black-throated diver, and little gull as well as the three tern species (sandwich, common, and Arctic tern) are listed in Appendix I of the EU Birds Directive (79/409/EWG) as already mentioned.

Table 10: Assignment of the regular seabird and resting bird species of the German EEZ of the North Sea to the current national and international endangerment categories. Definition according to IUCN: Definition according to IUCN: LC = least concern; NT = near threatened; VU = vulnerable; EN = endangered; CR = critically endangered (BIRDLIFE INTERNATIONAL 2021). Definition according to SPEC: SPEC 1 = European species in need of global protective measures (i.e. classified as “Critically Endangered”, “Endangered”, “Vulnerable”, “Near Threatened”, or “Data Deficient” on a global scale) SPEC 2 = Species WITH, SPEC 3 = Species WITHOUT a main area of distribution in Europe with negative population trends and unfavourable protection status that require Europe-wide protective measures (i.e. are classified on a European scale as Regionally Extinct, CR, EN, VU, NT or as having a declining or depleted population or as rare; BIRDLIFE INTERNATIONAL 2017). Categories of the Red List of breeding birds: 0 = extinct or lost, 1 = critically endangered, 2 = endangered, 3 = vulnerable, V = near threatened (declining but not yet acutely endangered), R = species with geographical restriction (natural rarity, often species at the edge of their distribution area; RYSLAVY et al. 2020).

Deutscher Name (wissenschaftlicher Name)	Anhang I der V-RL[1]	SPEC-Kategorie	Europäische Rote Liste der Vögel	Rote Liste der Brutvögel Deutschlands
Sterntaucher (*Gavia stellata*)	X	3_w	LC	
Prachttaucher (*Gavia artica*)	X	3_w	LC	
Eissturmvogel (*Fulmaris glacialis*)		3_b	VU	R
Basstölpel (*Morus bassanus*)			LC	R
Tordalk (*Alca torda*)		1_b	LC	R
Trottellumme (*Uria aalge*)		3_b	LC	R
Dreizehenmöwe (*Rissa tridactyla*)		3_b	VU	2
Zwergmöwe (*Hydrocoloeus minutus*)	X	3_{b+w}	LC	R
Sturmmöwe (*Larus canus*)			LC	
Mantelmöwe (*Larus marinus*)			LC	
Silbermöwe (*Larus argentatus*)		2_b	LC	V
Heringsmöwe (*Larus fuscus*)			LC	
Brandseeschwalbe (*Thalasseus sandvicensis*)	X		LC	1
Flussseeschwalbe (*Sterna hirundo*)	X		LC	2
Küstenseeschwalbe (*Sterna paradisaea*)	X		LC	1
Trauerente (*Melitta nigra*)			VU	
Skua (*Stercorarius skua*)			LC	
Spatelraubmöwe (*Stercorarius pomarinus*)			LC	

[1] 2009/174/EG des Europäischen Parlaments und des Rates
$_b$ breeding
$_w$ wintering

Red-throated and black-throated divers as well as little gulls, kittiwakes, guillemots, and Norther fulmars are also assigned to SPEC category 3 (not restricted to Europe but with negative population trends and unfavourable protection status), the herring gull to SPEC category 2 (species for which the global populations are concentrated in Europe and have an unfavourable conservation status in Europe), and the razorbill to SPEC category 1 (European species globally vulnerable) (BirdLife International 2017).

Fulmar, kittiwake, and black scoters are considered “vulnerable” according to the current pan-European endangerment status (BirdLife International 2021). In the Red List of Breeding Birds of Germany, the sandwich and Arctic tern are listed in ‘Category 1 = Critically Endangered’. Common tern and kittiwake are listed as Category 2 = “endangered”. The herring gull is near threatened (= V); the species fulmar, gannet, razorbill, guillemot, and little gull are species with geographical restriction (= R) (RYSLAVY et al. 2020). The red list of migratory bird species in Germany lists the red-throated diver as endangered, the common tern as vulnerable, and the Arctic tern as near threatened (HÜPPOP et al. 2013).

2.9.3.3. Existing pressures

The planning areas south-east of Shipping route SN10 (N-9.5, N-9.4, N-12.4, N-12.5, N-13.4) are located in the immediate vicinity of other planned wind farm projects, most of which will be built and commissioned by 2032. Together with the converter stations, these projects represent an existing pressure for seabirds and resting birds in the form of an increased risk of collision and an adverse effect on the areas in their function as resting and foraging areas. The planning areas to the north-west of the shipping route SN10 (N-14 to N-20) are located on and in north-western region of the German EEZ. Shipping route SN10 runs between them and the nearest wind farm projects. Maritime traffic, especially in the area of the main shipping routes but also because of service traffic for the wind farm represents an existing pressure for all planned areas. Overall, a relatively low volume and above all non-canalised maritime traffic is to be expected. However, this may be temporarily increased depending on the overlapping construction periods of the wind farm projects to be developed. In addition, fishery in the North Sea affects the availability of food resources and the occurrence of seabird species that are known as ship-followers, but sensitive to disturbances and adversely affects the seabed through bottom trawling. In addition, changes in the ecosystem may be associated with threats to seabird and resting bird populations. The following factors can cause changes in the marine ecosystem and thus also in seabirds and resting birds:

Climate change: Changes in water temperature are accompanied among other things by changes in water circulation, plankton distribution and the composition of fish fauna and benthos. Plankton, benthos and fish fauna serve as a food source for seabirds and resting birds. However, because of the uncertainty regarding the effects of climate change on the individual ecosystem components, it is hardly possible to predict the impacts of climate change on seabirds and resting birds.

Fishery: It can be assumed that fishery has a significant influence on the composition of the seabird community in the EEZ. On one hand, fishery can reduce the food supply or even limit it if seabirds and fishery have the same indicator species. The selective catch of fish species or fish sizes can then lead to changes in the food supply for seabirds and resting birds.

Shipping: Seabirds and resting birds have different species-specific responses to maritime traffic. The greatest scaring effect is observed in species that are sensitive to disturbance such as divers and black scoters (MENDEL et al. 2019, FLIESSBACH et al. 2019, BURGER et al. 2019). There is also a risk of oil spills.

Technical structures (offshore wind turbines, platforms): Technical structures can have similar effects on disturbance-sensitive species as maritime traffic. In addition, there is an increase in the volume of maritime traffic because of supply trips. There is also a risk of collision with such structures.

In addition, threats to seabirds and resting birds can come from eutrophication, pollutant accumulation in marine food webs, and rubbish floating in the water (e.g. parts of fishing nets and plastic debris). Epidemics of viral or bacterial origin also pose a threat to populations of seabirds and resting birds. The effects of the outbreak of avian influenza on the island of Heligoland in June 2022 (see DIERSCHKE & DIERSCHKE 2023, LANE et al. 2023) on the seabird and resting bird populations in the German North Sea will become apparent only in the coming years.

The existing pressures of the planned sites and their surroundings are to be assessed as “medium” because of the influences described.

2.10. Migratory birds

Bird migration is usually defined as periodic migrations between the breeding area and a separate non-breeding area, which in the case of birds at higher latitudes normally contains the wintering grounds. Bird migration is widespread throughout the world and is also known as annual migration because there is an annual return journey between breeding grounds and winter habitats. In addition to a wintering habitat, they often travel to one or more intermediate destinations be it species-specific for moulting, to explore favourable foraging areas, or for other reasons. Depending on the distance travelled and physiological criteria, migratory birds are divided into short-, medium-, and long-distance migrants (Alerstam 1990, Berthold 2000, Newton 2020, Newton 2022). However, this categorisation is rather subjective and can change depending on which region is considered (Bairlein 2022). With regard to Europe, short-distance migrants include mainly species that breed in northern and central Europe and winter in Great Britain, western and southern Europe, and north of the Sahara. On the other hand, medium- and long-distance migrants generally travel between breeding areas in the Arctic, Siberia, and northern Europe and wintering areas in central Europe, central, and southern Africa. However, migration strategies are not mandatory but rather can vary depending on location and population (e.g. Van Doren et al. 2017). There can thus be resident as well as short-, medium-, and long-distance migrants within a species (Bairlein 2022). Whether short-, medium- or long-distance migrants, several million individuals fly over the German Bight twice a year because of its central location in the migration route system (East Atlantic bird migration route) (Figure 44, Hüppop et al. 2019, Prokosch 2023).

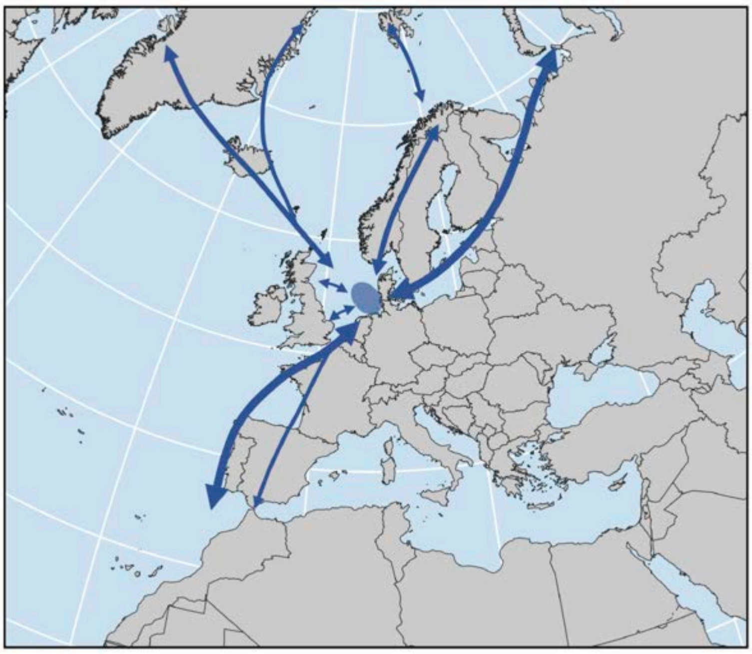

Figure 44: The European part of the East Atlantic bird migration route and the central position of the North Sea within the migration route system.

2.10.1. Data availability

Observations of bird migration over the south-eastern North Sea were made on Heligoland as early as the 19th century. Since 1909, systematic ringing of migratory birds has also been carried out by the Heligoland Ornithological Station (Bairlein & Hüppop 1997, Hüppop & Hüppop 2011). In particular, long-term observation series on phenology and species-specific changes in migratory behaviour are available for songbirds caught in the trapping garden of the institute (Hüppop & Hüppop 2002, 2004, 2011). In addition, visual observations at coastal sites (e.g. Sylt and Wangerooge, Hüppop et al. 2005, 2010) as well as visual and bird call surveys at various offshore sites provide data on bird migration in the German Bight (Dierschke 2001, Hüppop et al. 2005, 2012). In addition, historical data on approach and collision events of birds at formerly manned lighthouses, lightships and platforms (Blasius 1891, Hansen 1954, Müller 1981) can provide valuable information on bird migration across the North Sea and the effects of obstacles on migratory birds.

Accompanying ecological research, environmental impact studies (EIS), and monitoring during the construction and operation of offshore wind farm projects provide the latest data on bird migration over the German Bight and complement fundamental work. The radar measurements of bird migration carried out from 2003 to 2019 on the FINO1 research platform as well as the bird migration research carried out from 2012 to 2018 on the FINO3 platform are particularly noteworthy. Extensive results were published in the framework of the BeoFINO (Orejas et al. 2005), FINOBIRD (Hüppop et al. 2009) and OFFSHOREBIRDS+ (Avitec Research GbR 2019) reports. A summarised overview of bird migration for the inner German EEZ of the North Sea is also available from the ProBIRD study. Within the study, a cross-project evaluation of the monitoring data from 10 offshore wind farm projects located up to 110 km from the coast was carried out (Welcker 2019, Welcker & Vilela 2019). The latest data not yet considered in the ProBird study come from the preliminary site investigations of Area N-9 carried out by the BSH. This area is approx. 120 km from the mainland.

In addition to radar surveys, the marine environment investigations required in accordance with the BSH standard (StUK4, BSH 2013) also include visual observations during the day and call surveys at night. Visual observations provide information on the species, number, and migratory direction of the birds; however, the migration height above an altitude of 200 m is difficult to determine. Nocturnal migration call surveys provide information on calling species, although the number of individuals remains undetermined. Although radar surveys can provide reliable indications of migratory activity and make it possible to estimate the minimum number of migrating birds up to an altitude of 1,000 m (max. 1,500 m), they do not allow species-specific identification. In general, it should be noted that the methods required in the StUK4 can capture only parts of a complex migration event. However, the bird migration for the area of the inner EEZ can be adequately described by combining the data.

The BSH has no data on migratory bird activity for the outer German EEZ (approx. 120 km from the mainland) and is not aware of any studies that have systematically recorded bird migration. Older studies on bird migration over the North Sea between Great Britain and Scandinavia as well as observations on oil platforms can provide evidence that bird migration takes place over the outer EEZ (Lack 1959, Bourne 1982, Lensink et. al. 1999, Ronconi et al. 2015). However, statements on migratory activity and the assessment of the importance of the areas and sites are possible only to a limited extent or not at all and are associated with very high uncertainties, if at all.

Because of the aforementioned methodological limitations and the general difficulties in the survey of a dynamic phenomenon such as bird migration, there are still gaps in knowledge regarding the following points:

- There is currently a lack of sufficient knowledge of the effects of offshore construction in many areas. Findings from the territorial sea and on land are transferable only to a limited extent because of the different conditions.
- The species-specific risk of collision and quantification of bird strike for migratory birds with/at offshore wind turbines is largely unknown.
- Only a few studies are available on the possible barrier effects of offshore wind turbines and on species-specific behaviour towards them.

2.10.2. Spatial distribution and temporal variability of migratory birds

The North Sea lies on the migration route of numerous bird species (Hüppop et al. 2012, Hüppop & Hüppop 2011, Hüppop et al. 2019, Prokosch 2023). According to previous estimates, tens to hundreds of million birds migrate across the German Bight every year (Exo et al. 2003, Hüppop et al. 2005, 2006). Lensink et al. (1999) assume similarly high numbers. Based on 95 selected bird species, the authors estimate the annual migration volume across the North Sea to be at least 40–150 million individuals. The largest proportion is made up of songbirds, most of which cross the North Sea at night (Hüppop et al. 2005, Hüppop et al. 2006). Most birds have their breeding grounds in Norway, Sweden, and Denmark. For waterbirds and waders, on the other hand, breeding ranges extend far north-east into the Palearctic and north and north-west towards Svalbard, Iceland, and Greenland. Their wintering areas are in western and southern Europe, Africa, and Great Britain (Figure 44).

According to previous findings, migratory bird activity can be roughly divided into two strategies: broad-front migration and migration along migration routes (narrow-front migration). It is known that most migratory bird species fly over at least large parts of their migration areas in a broad front (parellel). According to Knust et al. (2003), this applies also to the North Sea. Species migrating at night in particular, which cannot be guided by geographical structures because of the darkness, move across the sea in broad-front migration. Broad-front migration is typical also for the diurnal migration of songbirds.

Spacial distribution

It is generally assumed that the intensity of migration decreases seawards from the coast (Knust 2003). A recent cross-project evaluation of bird migration data from two simultaneously investigated offshore wind farm projects showed that the migration intensities measured for nocturnal songbird migration over the North Sea were on average higher at the wind farm project close to the coast than at the wind farm project far from the coast (Welcker 2019). For songbird species primarily migrating during the day, a lower migration intensity can be observed on Heligoland than on Sylt or Wangerooge (Orejas et al. 2006, Hüppop et al. 2010). Also the comparative investigations of the visible diurnal migration of waders and waterbirds between Heligoland and the (former) Research Platform North Sea (FPN), 75 km north-west of Heligoland of DIERSCHKE (2001) indicate a gradient between the island of Heligoland, which is closer to the coast, and the FPN in the open North Sea. This assumption is confirmed in the BeoFINO final report (HÜPPOP et al. 2005) because the results presented show a clear concentration of waterbirds near the coast.

However, reliable information on the scale of the decrease is possible only to a limited extent because of the methodological requirements. Uncertainties of the visual observations result (e.g. from lack of knowledge about the proportion of migration at higher altitudes). Furthermore, species such as red-throated diver or pink-footed goose also stand out among water birds, which are observed at Heligoland with the same or higher numbers of individuals than from Sylt or Wangerooge (HÜPPOP et al. 2005, 2006). A certain proportion of the higher migration intensities from Wangerooge and Sylt is probably caused by local resting and foraging birds. It should also be borne in mind that for nocturnally migrating songbirds, there is little knowledge to date on decreasing migration intensity with coastal distance. A comparison of nocturnal migration intensities measured at the three sites FINO1, Heligoland, and the Alte Weser lighthouse shows a high degree of agreement (HÜPPOP et al. 2009).

Finally, the numbers of individuals documented on single migration nights with > 100,000 and 150,000 songbirds (primarily thrushes) at the Nordsee research platform and the *Buchan A-Platform* in the central North Sea should also be emphasised (MÜLLER 1981, in LENSINK et al. 1999). They provide evidence of mass migration far from the coast and argue against pronounced gradients in migration intensity for these species, at least temporarily. The frequency of such a mass migration in the offshore area and the total proportion of the migration of a biogeographical population attributable to it have not yet been clarified (LENSINK et al. 1999; HÜPPOP et al. 2006).

Figure 45 shows a schematic overview of the broad front over the south-eastern North Sea. It should be emphasised that the distances between the lines of individual migration flows merely indicate the direction of a gradient. Therefore, conclusions about the magnitude of spatial trends may not be drawn from the figure under any circumstances. The thickness of the lines also only qualitatively illustrates intensity differences between the migration streams.

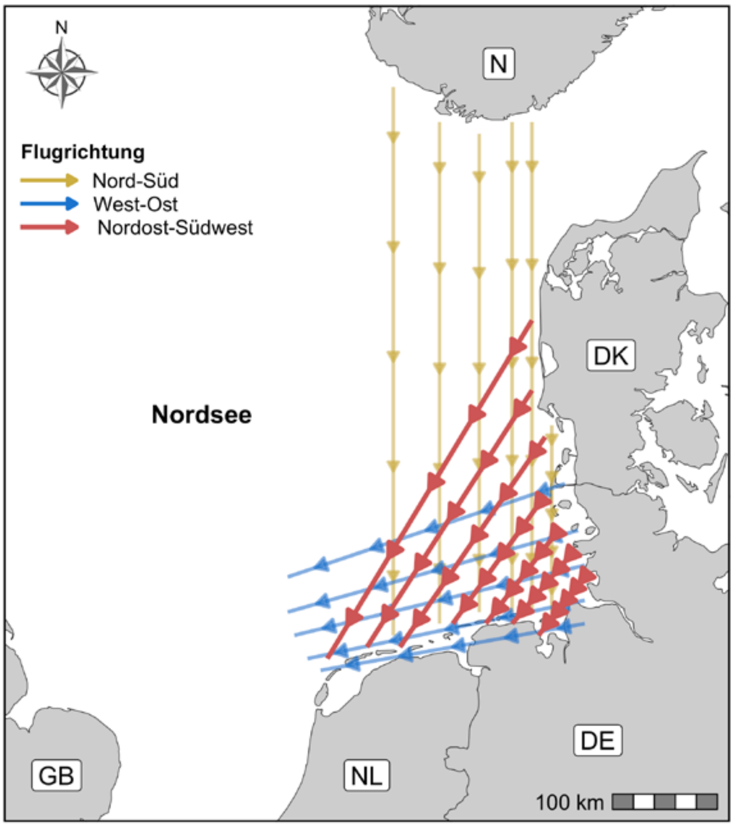

Figure 45: Diagram of main migration routes over the south-eastern North Sea. Depicted for autumn.

Variability

Bird migration takes place over the German Bight all year round with strong seasonal fluctuations. Periods with stronger migratory activity are in spring and autumn with lower intensities in summer and winter. (HÜPPOP et al. 2005, 2006, 2009, 2010, 2019). Seasonal migration intensity is closely linked to species- or population-specific life cycles such as breeding seasons (BERTHOLD 2000, BAIRLEIN 2022, HELM & LIEDVOGEL 2024).

Furthermore, migratory activity is subject to a pronounced diurnal rhythm (HELM & LIEDVOGEL 2024). Migration intensity is normally higher at night than during the day (AVITEC RESEARCH GBR 2019,HÜPPOP et al. 2019). The results of the automatic radar and migratory call surveys on FINO1 and FINO3 show a sharp increase in migratory activity in the evening and at night. This then decreases again during the second half of the night (HÜPPOP et al. 2009, AVITEC RESEARCH GBR 2019, WELCKER 2019). During the migration plan observations, the highest migration intensity was observed in the first hours after sunrise and then levelled off towards midday (HÜPPOP et al. 2010, HILL & HILL 2010, AVITEC RESEARCH GBR 2015). The characteristics of this rhythm can vary because of the distances of the sites to the coast, regions of origin, and flight speeds of the migratory birds (AVITEC RESEARCH GBR 2019).

In addition to these largely endogenously controlled annual and daily rhythms in migratory activity, the actual course of migration is determined mainly by weather conditions. Weather factors also influence at what altitude and at what speed the animals migrate. In general, birds wait for favourable weather conditions (e.g. tailwind, no precipitation, good visibility) for their migration in order to optimise it in terms of energy (BRADARIĆ et al 2020, MANOLA et al. 2020, RÜPPEL et al. 2023). As a result, bird migration typically occurs in waves with low bird migration during periods of bad weather being followed by particularly high migration intensity during fair weather (HÜPPOP et al. 2009). Bird migration is often concentrated on individual days or nights in autumn or spring. According to the results of an R&D project, half of all birds migrate in only 5–10% of all days (KNUST et al. 2003, siehe auch HÜPPOP et al. 2005, WELCKER 2019). Overall, migration intensity can vary greatly annually, seasonally, and daily because of changing weather conditions (HÜPPOP et al. 2019).

2.10.2.1. Species composition

The German Bight is on the migration route of numerous bird species. As part of the accompanying ecological research, 97 species were recorded on FINO1 (2004–2007, Figure 46, Hüppop et al. 2009) and 74 species on FINO3 (2010–2018, Avitec Research GbR 2019) with the help of automatic call survey. During migratory observations on Sylt, Heligoland, and Wangerooge, 192 species were recorded between 2004 and 2007 (Hüppop et al. 2009). Looking at the period between 2014 and 2020, an average of 255 (246–261) species per year were recorded on Heligoland; of these, on average only 44 species (43–49) also bred on the island (Dierschke et al. 2016–2021). If all rarities are included, more than 377 bird species have been recorded on Heligoland since 1990 (Dierschke et al. 2020).

During the course of the year and during the main migration periods in spring and autumn, flight and migration activity during the day is dominated mostly by species groups that use the area both as a resting and migration area (Figure 46). Among these, species from the groups of gulls, geese and ducks, terns, and seabirds are among the most frequently observed individuals (Table 11, Hüppop et al. 2009, Avitec Research Gbr 2019, 2020, IBL Umweltplanung GmbH et al. 2021, Planungsgemeinschaft Umweltplanung 2021). Of the migratory bird species that exclusively cross the maritime area, most are songbirds. Whilst songbirds are quite concentrated and relatively focussed on crossing the project area during the main migration months, gulls and seabirds are present almost all year round. The occurrence of gulls is often associated with fishing vessels or other vessels.

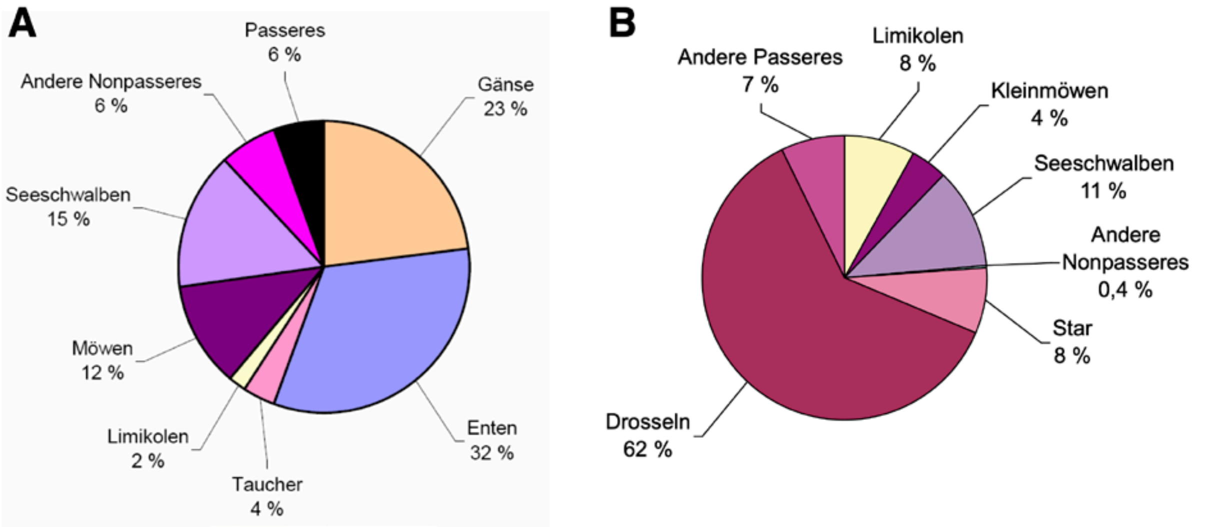

Figure 46: Proportions of the species groups in A) all observations (n = 142,423 individuals) over the sea in the first three hours after sunrise on Heligoland from 2003 to 2006 and B) all calls (n = 95,318 individuals) in the vicinity of the FINO1 research platform from 2004 to 2007 (from HÜPPOP et al. 2009).

According to the results of the migratory call survey, songbirds dominate the nocturnal migration. Depending on the migration period (spring/autumn), their relative proportions of the respective total calls are between 70 and 98% (HÜPPOP et al. 2009, AVITEC RESEARCH GBR 2019, 2020, IBL UMWELTPLANUNG et al. 2021, PLANUNGSGEMEINSCHAFT UMWELTPLANUNG 2021). Most recorded calls within the group of songbirds were made by thrushes (red-winged thrush, song thrush, blackbird, and fieldfare) and robins (WELCKER & VILELA 2018, Figure 46, Table 11). Species groups still frequently recorded at night include waders, gulls, and terns (Table 11).

In general, there are great similarities in the species composition and abundance ratios at the locations investigated in the south-eastern North Sea. This observation applies in particular to the nocturnal migration of songbirds. This supports the theory of nocturnal broad-front migration of these species across the German Bight (AVITEC RESEARCH GBR 2019).

Table 11: List of bird species that were regularly and/or frequently detected during visual observations during the day and migratory calls at night (HÜPPOP et al. 2009, AVITEC RESEARCH GBR 2019, 2020, IBL UMWELTPLANUNG et al. 2021, PLANUNGSGEMEINSCHAFT UMWELTPLANUNG 2021).

Bird species			
Divers, procellariids, gannets, cormorants		Herring gull	*Larus argentatus*
Red-throated diver	*Gavia stellata*	Lesser black-backed gull	*Larus fuscus*
Fulmar	*Fulmarus glacialis*	Greater black-backed gull	*Larus marinus*

Northern gannet	*Morus bassanus*	Little gull	*Hydrocoloeus minutus*
Cormorant	*Phalacrocorax carbo*	Kittiwake	*Rissa tridactyla*
Anatids		**Terns**	
Pink-footed goose	*Anser brachyrhynchus*	Sandwich tern	*Thalasseus sandvicensis*
Grey goose	*Anser anser*	Common tern	*Sterna hirundo*
Barnacle goose	*Branta leucopsis*	Arctic tern	*Sterna paradisaea*
Brent goose	*Branta bernicla*	**Auk**	
Wigeon	*Mareca penelope*	Guillemot	*Uria aalge*
Teal	*Anas crecca*	Razorbill	*Alca torda*
Eider	*Somateria mollissima*	**Songbirds**	
Black scoter	*Melanitta nigra*	Wood pigeon	*Columba palumbus*
Waders		Eurasian skylark	*Alauda arvensis*
Oystercatcher	*Haematopus ostralegus*	Meadow pipit	*Anthus pratensis*
Grey plover	*Pluvialis squatarola*	Robin	*Erithacus rubecula*
European golden plover	*Pluvialis apricaria*	Blackbird	*Turdus merula*
Lapwing	*Vanellus vanellus*	Fieldflare	*Turdus pilaris*
Dunlin	*Calidris alpina*	Song thrush	*Turdus philomelos*
Snipe	*Gallinago gallinago*	Red-winged thrush	*Turdus iliacus*
Eurasian curlew	*Numenius arquata*	Goldcrest	*Regulus regulus*
Seagulls		Starling	*Sturnus vulgaris*
Black-headed gull	*Chroicocephalus ridibundus*	Chaffinch	*Fringilla coelebs*
Common gull	*Larus canus*		

2.10.2.2. Migration intensities, migration altitudes, migratory direction

Migration intensities

Long-term studies in the offshore area confirm that many birds cross the German Bight throughout the year, both during the day and at night (HÜPPOP et al. 2005, 2006, 2012, AVITEC RESEARCH GBR 2019, WELCKER & VILELA 2019). Surveys at various locations in the south-eastern North Sea show that bird migration is particularly pronounced in spring from mid-March to May and in autumn from mid-September to mid-November. Migratory activity is comparatively low in the winter (December–February) and summer months (June–August) (HÜPPOP et al. 2005, 2009, AVITEC RESEARCH GBR 2019, WELCKER 2019). However, such a pattern should not be generalised because migration intensity is subject to high inter-annual and weather-related variability (HAEST et al. 2018, 2019, AVITEC RESEARCH GBR 2019, WELCKER 2019, WELCKER & VILELA 2019).

During the main migration periods, bird migration is often concentrated on a few days and nights with favourable migration conditions and then takes the form of a mass migration with many individuals of different species flying over the North Sea at the same time. According to information from various environmental impact studies, such mass migration events occur around 5 to 10 times a year (WELCKER 2019, WELCKER & VILELA 2019). The cross-project evaluation carried out by the authors (12 offshore wind farm projects in the North Sea and Baltic Sea) of the bird migration data recorded by radar from 2008 to 2016 showed that 80% of the bird echoes were measured on only 22% of the investigation nights (WELCKER 2019). In the BeoFINO study, more than 50% of the radar-detectable migration at the FINO1 platform was recorded in just eight nights in spring 2004; in autumn 2004, more than 50% of the migration was recorded on six of 61 measurement nights (HÜPPOP et al. 2005).

Vertical radar recordings at various EIS sites show that bird migration is generally subject to strong fluctuations. This is the case for both diurnal and nocturnal migration. In order to provide as good an overview as possible of migration intensity in the German EEZ in the North Sea, current results from the construction and operational monitoring for offshore wind farm projects (from individual wind farm areas) are used below:

Long-term investigations (2013–2019) in the maritime area around the FINO1 platform ("Nördlich Borkum" cluster, Areas N-1 through N-3) show that bird echoes can be detected almost continuously in spring and autumn (Figure 47, Avitec Research GbR 2020). This resulted in bird migration events of varying strength up to mass migration on a long-term site-specific scale. A comparison of diurnal and nocturnal migration shows that the average nocturnal migration rates were higher than the diurnal migration rates (Figure 47). For example, recent investigations from 2018 show that in spring, migration intensity was on average more than three times higher at night and in autumn 2018 more than 1.7 times higher than during the day (Avitec Research GbR 2019). In detail, the mean migration rates (MTR) in spring were 106 echoes/(h·km) during the day and 322 echoes/(h·km) at night. In autumn, an average migration rate of 100 echoes/(h·km) was recorded during the day and 158 echoes/(h·km) at night. The highest average migration rate recorded for individual nights was 2,103 echoes/(h·km) in spring and 1,594 echoes/(h·km) in autumn. MTRs averaging over 1,000 echoes/(h·km) were recorded on seven nights in spring and three nights in autumn (Avitec Research GbR 2019).

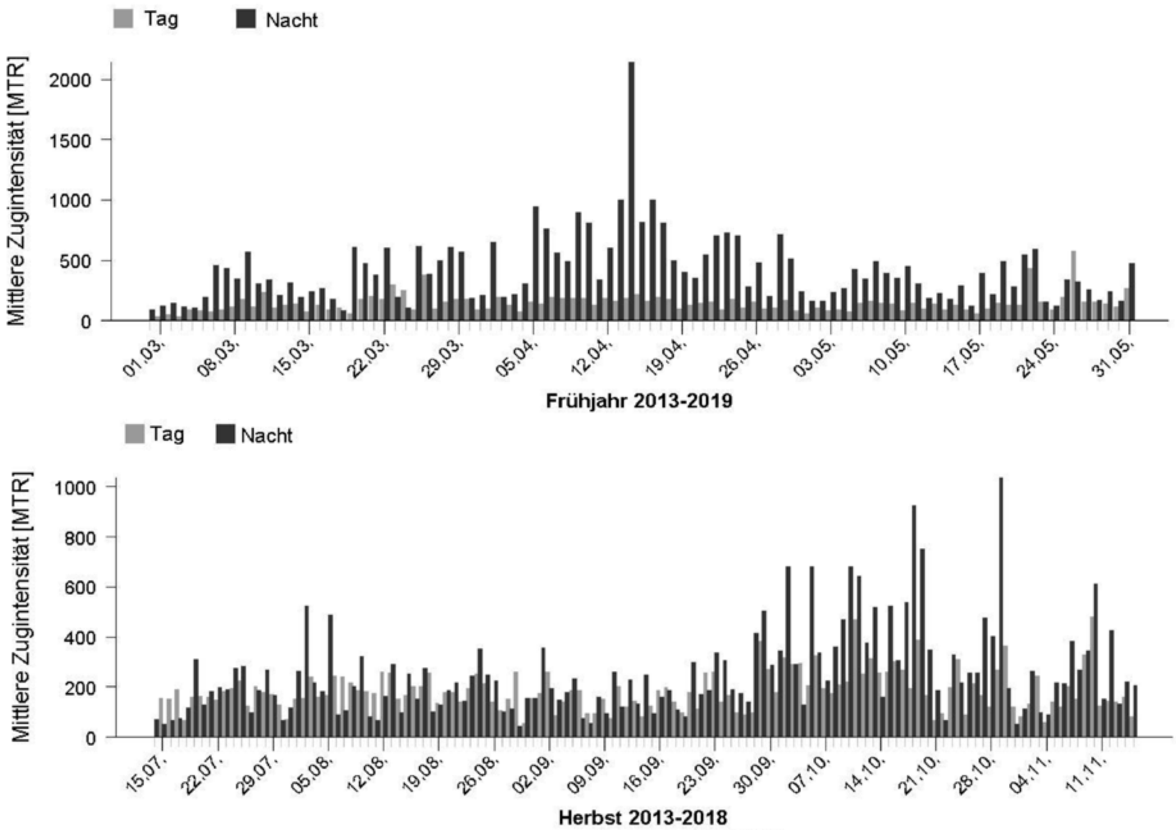

Figure 47: Cumulative migration rates (echoes/(h·km)) for spring migration (top) and autumn migration (bottom) between 2013 and 2019 at the FINO1 site during (from AVITEC RESEARCH GBR 2020).

In the "Nördlich Helgoland" cluster investigations (IBL UMWELTPLANUNG GMBH et al. 2019) in the area of Area **N-4**, the monthly means of the diurnal migration rates ranged from 29 echoes/(h·km) in November 2018 to 196 echoes/(h·km) in October 2018. On individual days, the highest average migration rates were 418 echoes/(h·km) in spring. A maximum value of 1,464 echoes/(h·km) was reached in autumn. Over the entire period, the mean migration rate was 81 echos/(h·km). Overall, migration rates of more than 1,000 echoes/(h·km) occurred on two days during the 2018 survey year – both in autumn (IBL UMWELTPLANUNG GMBH et al. 2019).

In 2018, the monthly nocturnal migration rates fluctuated between 31 echoes/(h·km) in July and 513 echoes/(h·km) in April. Over the entire period, the mean migration rate was 211 echos/(h·km). In spring 2018, the highest nocturnal migration rate was reached at the beginning of April with 3,953 echoes/(h·km). In autumn, the maximum nocturnal migration rate of 2,455 echoes/(h·km) was recorded in mid-October. Average migration rates of more than 1,000 echoes/(h·km) occurred on five nights in spring and seven nights in autumn (IBL UMWELTPLANUNG GMBH et al. 2019).

Measurements taken as part of the cluster monitoring "Westlich Sylt" (BIOCONSULT SH GMBH 2019), which also cover Area **N-5**, show that according to the results of the vertical radar from 2018, nocturnal migration is generally more pronounced than diurnal migration. On average, 25 echoes/(h·km) were recorded during the day in spring and 11 echoes/(h·km) in autumn. For the spring, the average migration rates were 27 echoes/(h·km) at night and 24 echoes/(h·km) during the day. High migration intensities were recorded during spring migration, particularly at the end of March to mid-April. The maximum value of 128 echoes/(h·km) was clearly above the maximum value of the autumn migration. During the 2018 autumn migration, intensive bird migration was recorded primarily in October. October also saw the year's highest migration rate of 661 echoes/(h·km). As expected, the months of July and August had lower migration intensities. Overall, migration rate of > 250 signals/(h·km) were achieved on only three nights.

As part of the investigations of Cluster 6 **(N-6**), bird migration showed strong fluctuations in the three survey years 2018 to 2020 (both during the day and at night), whereby the months of July, August, and September showed low values in all years (PLANUNGSGEMEINSCHAFT UMWELTPLANUNG 2021). In the spring, the average monthly daily migration rates fluctuated between 15 echoes/(h·km) in May 2019 and 89 echoes/(h·km) in March 2018. In autumn, the values fluctuated between 13 echoes/(h·km) in September 2020 and 149 echoes/(h·km) in October 2019. Averaged over all three years and months (139 recording days in total), the migration rate in the light phase was 56 echoes/(h·km). The highest maximum hourly value was reached in October 2020 with 1,432 signals/(h·km). Man train rates of over 1000 echoes/(h·km) were not achieved during the day.

Mean nocturnal migration rates per month ranged from 6 echoes/(h·km) in July 2019 to 528 echoes/(h·km) in April 2018. For the entire period (total of 144 recording nights), the mean nocturnal migration rate was 135 echoes/(h·km). The highest maximum nocturnal hourly value was recorded in October 2019 with 4,861 echoes/(h·km). A mean migration rate of over 1,000 echoes/(h·km) was measured on six nights. Three of these days were in March and April 2018, one day in October 2019, and one day each in March and October 2020.

The BSH has data from the 2018–2020 preliminary site investigations for the Area **N-7** (IBL UMWELTPLANUNG GMBH et al. 2021). Within the survey years, the mean monthly migration rates in the spring varied between 20 echoes/(h·km) in May 2020 and 163 echoes/(h·km) in May 2019. In the autumn months, monthly diurnal migration rates between 42 echoes/(h·km) in November 2018 and 367 echoes/(h·km) in August 2019 were measured. The average diurnal migration rates in both survey years were of a comparable order of magnitude of 151 signals/(h·km) in 2018/20019 and 123 echoes/(h·km) in 2019/2020. In both years, there was no significant difference in the daily migration rates between spring and autumn. On two days (22 August 2018 and 24 August 2019), average migration rates of approx. 1,000 echoes/(h·km) were recorded.

Nocturnal bird migration showed strong fluctuations over the course of the two-year survey period. In the spring, average nocturnal migration rates of between 24 echoes/(h·km) in May 2020 and 345 echoes/(h·km) in April 2020 were recorded. In autumn, the average nocturnal migration rates fluctuated between 43 echoes/(h·km) in November 2019 and 542 echoes/(h·km) in August 2019. Across seasons, average migration rates of 203 echoes/(h·km) were measured in the 2018/2019 survey period and 234 echoes/(h·km) in the 2019/2020 survey period. Average migration rates of approx. 1,000 echoes/(h·km) were achieved on two migration nights in August 2019. The maximum nocturnal hourly value was 3,452 echoes/(h·km).

The migration rates determined by vertical radar as part of the "Östlich Austerngrund"**(N-8**) cluster investigations from the 2018/2019 survey year are also characterised by a high degree of variability (IBL Umweltplanung GmbH et al. 2019). The monthly mean values of the diurnal migration rates in spring were between 18 echoes/(h·km) in March 2019 and 57 echoes/(h·km) in April 2018 and reached a mean value of 40 echoes/(h·km) over the entire spring period. In autumn 2018, the average daily migration rates fluctuated between 11 signals/(h·km) in September and 148 echoes/(h·km) in August. Over the entire period, the mean diurnal migration rate was 34 echoes/(h·km). Over the entire autumn period, the mean diurnal migration rate was 29 echoes/(h·km). For the day, the highest average migration rate of 156 echoes/(h·km) was measured in August. In individual hours in May 2018, maximum migration rates of approx. 1,000 echoes/(h·km) were achieved.

Compared to the light phase, the mean nocturnal migration rates were considerably higher in both spring and autumn. In Spring, mean nocturnal migration rates per month ranged from 58 echoes/(h·km) in March 2019 to 417 echoes/(h·km) in May 2018. In autumn 2018, September was the month with the lowest (8 echoes/(h·km)) and October with the highest (101 echoes/(h·km)) mean nocturnal migration rate. At night, migration rates were higher on average in spring (248 echoes/(h·km)) than in autumn (46 echoes/(h·km)). For the entire period, the mean nighly migration rate was 136 echoes/(h·km). The strongest and only migration night with over 1,149 echoes/(h·km) was recorded in May 2018. Over both migration periods, migration rates of over 100 echoes/(h·km) were measured on three out of 51 days and 12 out of 47 nights.

Table 12 and Table 13 show a summary of the data described above for 2018 and 2019. Although the comparability of the data is limited because of methodological differences between the sites (radar location, radar type, number of survey days), the mean migration intensities for all Areas (N-1 through N-8) are of a similar order of magnitude. Differences can be recognised in the maximum values. However, it must be taken into consideration that there is great interannual variability and that the methods required in the standard study concept (StUK 4) can detect only parts of a complex migratory event (BSH 2013).

Table 12: Mean diurnal migration rates (MTR) of birds comparing spring and autumn migration (2018/2019). N hours indicates the survey effort in hours.

Site	**year**	**Spring**				**Autumn**			
		mean MTR	min. MTR	max. MTR	N Std.	mean MTR	min. MTR	max. MTR	N Std.
FINO1	2018	106	0	817	1153	100	0	871	1361
N-4	2018	83	0	418	851	80	0	1464	1129
N-5	2018	25	–	122	–	11	–	91	–

N-6	2018	68	14	134	247	42	3	126	328
N-7	2018/2019	112	3	481	287	177	5	912	361
N-8	2018/2019	40	0	118	294	29	5	156	326

Table 13: Mean nocturnal migration rates (MTR) of birds comparing spring and autumn migration (2018/2019). N hours indicates the survey effort in hours.

Site	**year**	**Spring**				**Autumn**			
		mean MTR	min. MTR	max. MTR	N Std.	mean MTR	min. MTR	max. MTR	N Std.
FINO1	2018	322	0	2103	712	158	0	1594	1120
N-4	2018	225	0	3953	665	202	1	2455	1195
N-5	2018	27	–	128	–	24	–	661	–
N-6	2018	332	15	1344	162	70	1	639	249
N-7	2018/2019	252	8	567	171	167	11	890	264
N-8	2018/2019	248	13	1149	150	46	0	427	228

Migration altitudes

Radar recordings at various EIS sites show that the migration altitudes of birds are subject to both seasonal and diurnal fluctuations and can depend on the intensity of migration. Overall, most migratory activity was concentrated in the lower half of the recorded altitude range (0–500 m), whereby the lower 300 m dominated in most cases (Figure 48).

Most of the signals at **FINO1** were registered at all times of the year up to a height of 100 m (Figure 48 A). In the cumulative analysis (2013–2019), the flight altitude distribution differs only slightly between the light and dark phases. As a rule, relatively high-flying migratory bird species (e.g. limicoles and songbirds) occur primarily at night whilst other, mostly lower-flying species (e.g. seabirds or gulls) end their flight activity at night and rest on the water or on land. Especially on nights with high bird migration intensity, bird migration often took place at higher altitudes above 500 m (Avitec Research GbR 2020).

The values determined by IBL Umweltplanung GmbH et al. (2019) in the "Nördlich Helgoland" (**N-4**) cluster for 2018 for the altitude classes up to 200 m fluctuated between 13% in October and 53% in November. Overall, however, a preference for the lower height classes can also be seen here for the years 2017–2019 Figure 48 B).

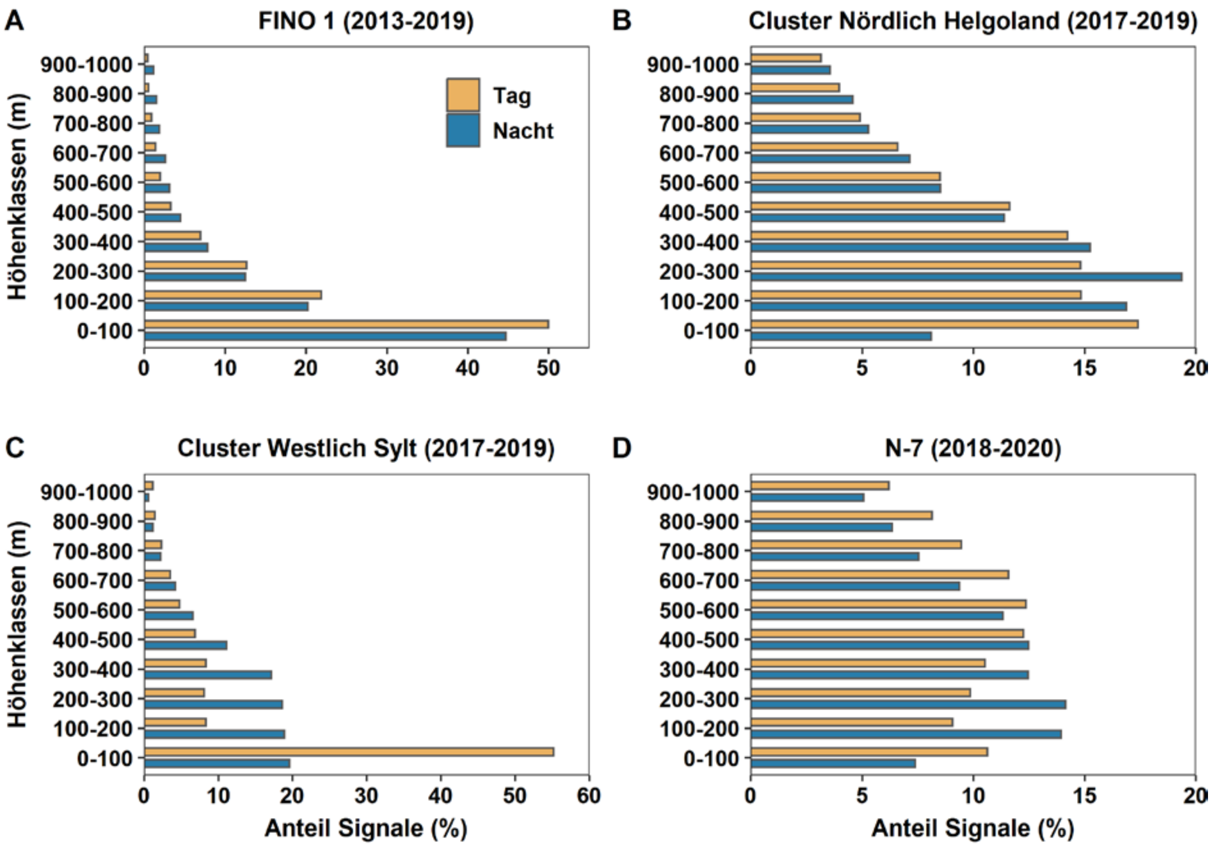

Figure 48: Percentage height distribution of bird migration (radar signals) during the day (yellow) and at night (blue) for four different locations (A, B, C, D) in the south-eastern North Sea. For methodological reasons, the proportion of signals in the lowest altitude layer 0–100 m is underestimated because very low-flying birds are only incompletely detected by the radars. Reference is made to the different scaling of the X-axes.

A comparison of the percentage distribution of bird signals from 2017 to 2019 in Area **N-5** ("West of Sylt" cluster) shows that heights between 0–100 m were used during the day in particular. In contrast, the altitude distribution during the night was relatively even within the first 500 m (Figure 48 C). Across all seasons, almost 80% of all signals below 500 m were recorded in 2018 (BioConsult SH GmbH 2019). The lowest 200 metres accounted for around 60% of migration during the day and 40% at night.

Within the surveys between 2018 and 2020 in Area **N-7**, a high variation in height distribution can be recognised (Figure 48 D, IBL Umweltplanung GmbH et al. 2021). Some months (July, August, and November 2018, March 2019) were characterised by a preference for the lower altitude layers up to 100 m whilst in other months (September and October 2018, April and May 2019), the focus of bird migration was on the upper altitude layers. During the night, most of the echo components were registered at altitudes below 500 m. However, altitudes between 400–800 m were favoured during the day.

Overall, it can be seen that in all seasons a large proportion of migration takes place over the sea at a height at which the birds are in the area of influence of wind turbines. It should be taken into consideration that the migration rates in the 0 to 100 m altitude layer are underestimated because very low-flying birds are only incompletely detected by the radars. However, the distribution of migration altitudes can differ greatly between individual nights and is strongly influenced by the current weather situation (Hüppop et al. 2006, Welcker & Vilela 2019). Migration above 1,500 m accounts for only a small proportion of migratory activity (Jellmann 1979, 1989).

Direction of migration

The seasonal north-east-south-west or south-west-north-east migration dominates over a wide area according to the current state of knowledge (cf red lines in Figure 45), although there may be some differences in the direction of migration and the degree of coastal orientation. Avitec Research GbR (2020) also identified a clear main migratory direction north-east in spring and a clear direction south-south-west in autumn (Figure 49) in their radar investigations on the FINO1 research platform between 2014 end 2019.

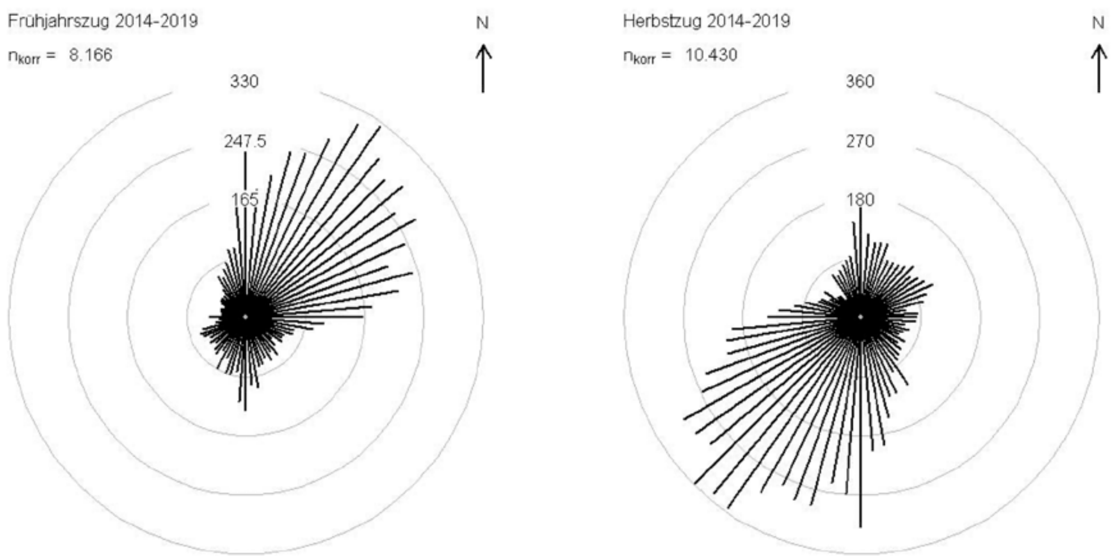

Figure 49: Directional distribution of bird tracks in spring (left) and autumn (right) of 2014–2019 at the FINO1 site (from Avitec Research GbR 2020).

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Radar recordings at other EIS sites also confirm this main migratory direction. However, there are indications of certain variations in the direction of migration per location. In northern areas away from the coast **(N-4** and **N-5**), a greater proportion of migrants were found to migrate southwards in autumn and northwards in spring (IBL Umweltplanung GmbH et al. 2019, BioConsult SH GmbH 2019). However, the investigations carried out within this framework according to StUK 4 were carried out on only a few days during the main migration periods (BSH 2013).

Further statements on spatial differences in the proportion of migratory directions for Areas N-14 to N-19 are currently not possible based on the data from EIS observations. However, investigations on bird migration suggest that, in addition to a predominant north-east–south-west migratory direction, there is also migration in a west–east and north-west–south-west direction, especially for the groups of limicoles and geese (cf Figure 44).

2.10.3. Status assessment

The status assessment of the protected asset migratory birds in the German EEZ of the North Sea is assessed on the basis of the following assessment criteria:

- Large-scale relevance of bird migration
- Assessment of the occurrence
- Rarity and endangerment
- Existing pressures

2.10.3.1. Spatial importance

Bird migration can be expected over the North Sea all year round with most birds migrating in just a few days and nights during the main migration periods in spring and autumn (HÜPOPP et al. 2005, HÜPOPP et al. 2010, HÜPOPP et al. 2012). Most birds have their breeding grounds in Norway, Sweden, and Denmark as well as Northwest Russia. As a rule, bird migration over the German Bight takes place in a broad front with a tendency towards coastal orientation. This is particularly the case for birds that migrate primarily during the day (DIERSCHKE 2001, HÜPPOP et al. 2009). Evaluations of large-scale migration intensities using vertical radar indicate that the migration rates of nocturnal migratory birds also decrease with increasing distance from the coast (WELCKER 2003, KNUST 2019).

No specific migration corridors can be identified for any migratory bird species in the EEZ of the North Sea. For Areas N-1 to N-20, this does not result in any differences in their large-scale importance for bird migration. The area of the German EEZ of the North Sea is therefore of "medium" importance for the protected asset migratory birds in all areas.

2.10.3.2. Assessment of the occurrence

The intensity of migration, with estimated numbers of 40 to 150 million individuals, is immense, and it can be assumed that a considerable proportion of the populations of songbirds breeding in northern Europe migrate across the North Sea.

In general, it has been recognised that the offshore area of the North Sea is of high importance, especially for nocturnally migrating songbirds from Scandinavian populations that cross the North Sea in large numbers. One characteristic of nocturnal bird migration is strong seasonal fluctuations in migration intensity with most migration occurring on just a few nights. In addition to the research projects BeoFINO (OREJAS et al. 2005), FINOBIRD (HÜPPOP et al. 2009), and OFFSHOREBIRDS+ (AVITEC RESEARCH GBR 2019) as well as the ProBIRD study (WELCKER 2019, WELCKER & VILELA 2019), this connection is also regularly demonstrated in the course of environmental impact studies on offshore wind farms and as part of construction and operational monitoring.

Migration and its intensity in the EEZ of the North Sea is considered to be of medium importance overall.

2.10.3.3. Rarity and endangerment

The species composition of the visible migration during the light phase in the area of the German Bight in 2003–2006 is estimated at up to 192 species (HÜPPOP et al. 2010). Other species that migrate at night should also be included. An average of 255 species per year were recorded on Heligoland between 2014 and 2020 (DIERSCHKE et al. 2016–2021).

In the EIS investigations on offshore wind farm projects, between 70 and 100 species are usually recorded for day and night (Hüppop et al. 2009, Avitec Research GbR 2019, IBL UMWELTPLANUNG GMBH et al. 2019, 2021).

Many bird species are listed in one or more of the following conventions and appendices on the protection status of birds in Central Europe:

- Appendix I of Birds Directive
- Bern Convention of 1979 on the Conservation of European Wildlife and Natural Habitats
- Bonn Convention of 1979 on the Conservation of Migratory Species of Wild Animals
- AEWA (African-Eurasian Waterbird Agreement)
- SPEC (Species of European Conservation Concern)
  SPEC categorises bird species according to the proportion of European populations and the degree of endangerment according to BirdLife International.

Of the species identified in the EIS, 23 are listed in Appendix I of the Birds Directive: Red-throated and black-throated divers, barnacle goose, short-eared owl, marsh harrier, hen harrier, osprey and merlin, sandwich tern, common tern, Arctic tern, little tern, black tern, black gull, avocet, dotterel, European golden plover, ruff, wood sandpiper, bar-tailed godwit, woodlark, bluethroat, and red-breasted flycatcher.

The species composition of over 200 that migrate across the North Sea each year can be described as average compared with the 377 bird species that have been recorded on Heligoland since 1990 (DIERSCHKE et al. 2020). However, a high proportion have international protection status and are endangered throughout Germany.

For these reasons, the EEZ of the North Sea is of "medium to high" importance in terms of the number of species and endangerment status for bird migration.

2.10.3.4. Existing pressures

Anthropogenic factors contribute in many ways to the threat to and mortality of migratory birds and can influence population size and current migration patterns in a complex interaction.

Major anthropogenic factors that increase mortality of migratory birds are legal and illegal hunting, destruction of habitat, collisions with anthropogenic structures and, for waterbirds and seabirds, pollution by oil or chemicals (CAMPHUYSEN et al. 1999, BAIRLEIN 2022). The various factors have a cumulative effect, making it almost impossible to determine the significance of individual factors. Especially in Mediterranean countries, a statistically insufficient amount of hunting still takes place (HÜPPOP & HÜPPOP 2002, BAIRLEIN 2022). BirdLife International estimates that between 11 and 36 million migratory birds are killed by illegal hunting in the Mediterranean region every year (in BAIRLEIN 2022).

Another main cause of population decreases in migratory bird populations is the loss of natural habitat and the associated lack of food. The main culprit here is the use of land for intensive agriculture (BAIRLEIN 2022).

In recent decades, the proportion of birds killed indirectly by humans has also risen sharply; collisions with buildings and vehicles are the main cause (HÜPPOP & HÜPPOP 2002, LOSS et al. 2015). Surveys of collision victims at four lighthouses in the German Bight show that songbirds dominate the casualties. Starlings and thrushes (song thrush, red-winged thrush, fieldfare and blackbirds) are particularly prominent among the birds found dead. Similar findings are available for research platform FINO1 (HÜPPOP et al. 2016), and NORDSEE (MÜLLER 1981) or former lighthouses on the Danish west coast (HANSEN 1954). During 45 of 160 visits to the research platform FINO1 with bird monitoring between October 2003 and December 2007, 767 dead birds (34 species) were found. Thrushes and starlings were the most common and accounted for 85% of the total. The species concerned are characterised by nocturnal migration and relatively large populations. It is striking that almost 50% of the collision victims recorded at FINO1 were found on only three survey days (HÜPPOP et al. 2016). It can be assumed that a brief period of favourable weather conditions in the run-up to the three survey days led to the departure of many birds (HÜPPOP et al. 2016, HAEST et al. 2019). In addition, crosswinds and poor visibility conditions during migration at sea could have led to a reduction in flight altitude and increased attraction by the illuminated platform (HÜPPOP et al. 2016).

Global warming and climate change also have measurable effects on bird migration (e.g. through changes in phenology or altered arrival and departure times), although these are species-specific and vary from region to region (cf BAIRLEIN & HÜPPOP 2004, BAIRLEIN 2022). 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 influence the conditions in breeding, resting, and wintering areas or the availability of these sub-habitats (BAIRLEIN 2022).

Overall, the existing pressures are rated as "medium to high".

2.10.4. Importance of areas and sites for the protected asset

In analogy to the status assessment of bird migration in the EEZ, the importance of the areas under consideration for bird migration is assessed using the following assessment criteria:

- Assessment of the occurrence
- Rarity and endangerment

These two criteria are applied separately for Areas N-4 and N-5, for Areas N-9, N-12, and N-13, and for areas N-14 through N-20. For the criteria large-scale relevance and existing pressures, please refer to the explanations in Chapters 2.10.3.1 and 2.10.3.4

Assessment of the occurrence

Areas N-4 and N-5

Long-term data series from the “Nördlich Helgoland” and “Cluster Westlich Sylt” cluster monitoring (IBL UMWELTPLANUNG GMBH et al. 2020, AVITEC RESEARCH GBR 2019) are available for Areas N-4 and N-5 planned for subsequent use.

In the 2015–2019 survey years, migratory activity was recorded in Area N-4 across all months (except for June: no surveys). In spring, migration intensities were highest in April and in autumn, in October and November. The average nocturnal migration rates (2015–2019) were 265 echoes/(h·km) in spring and 219 echoes/(h·km) in autumn. The highest mean nocturnal migration rate was achieved in October 2015 with 6,845 echoes/(h·km). The average daily migration rates over all years were 98 echoes/(h·km) in spring and 75 echoes/(h·km) in autumn. The maximum values on individual days were 1,486 echoes/(h·km) in spring and 1,464 echoes/(h·km) in autumn. Overall, there is a medium to high intensity of migration in Area N-4.

Continuous migratory activity was observed in Area N-5 across all survey years (2012-2018). In survey years 2015–2018, the average nocturnal migration rates in spring fluctuated between 7.4 echoes/(h–km) (2017) and 28.6 echoes/(h·km) (2015). In autumn, the average nocturnal migration rates were between 6.1 echoes/(h·km) (2017) and 23.3 echoes/(h·km) (2018) (BIOCONSULT SH GMBH 2019). In comparison with other EIS sites, the migration rates are therefore in the lower measured range (Chapter 2.10.2.2). Nevertheless, there may be occasional strong bird migration in Area N-5, especially in March/April and October.

The importance of the sites in Area N-4 is therefore rated as medium to high and in Area N-5 as medium.

Areas N-9, N-12, and N-13

Current results from the preliminary site investigation for Area N-9 from the July 2019 to 2021 (BioConsult SH GmbH et al. 2021). Current data for the Areas N-12 and N-13 are missing. However because these border area N-5 to the west (see above) and Area N-9 to the northeast, the following statements are transferable.

During migration periods, bird migration regularly occurs in the vicinity of Area N-9. Occasionally, there are stronger migratory events during the day and at night with the intensity typical of the site. In comparison, the mean nocturnal migration rates recorded in Area N-9 (140 echoes/(h·km) in autumn 2019 and 73 echoes/(h·km) in autumn 2020) are highly similar to the sites surveyed at the same time in Area N-6 (128 echoes/(h·km) in autumn 2019, 80 echoes/(h·km) in autumn 2020), which is located around 15 km to the south (IBL UMWELTPLANUNG et al. 2021).

In contrast, the average nocturnal migration rates determined for Area N-9 are below the migration rates measured in 2018 around the FINO1 research platform located south of N-9. Nocturnal migration rates of 323.5 echoes/(h·km) in spring and 158 echoes/(h·km) in autumn 2018 were recorded here (AVITEC RESEARCH GBR 2019). Although the migration rates determined on the FINO1 platform were not recorded in the same year, it can be assumed that migration intensity decreases with increasing distance from the coast (WELCKER 2019). The determined migration rates in the area of N-9 thus fit into the overall bird migration pattern over the German Bight (Table 12 and Table 13).

In connection with the measured migration intensities in the neighbouring Areas N-5, N-6, N-7 and N-8 (Chapter 2.10.2.2), the migratory activity and its intensity for Sites N-9.4, N-9.5, N-12.4, N-12.5, and N-13.4 is considered to be of medium importance.

Areas N-14 through N-20

The BSH currently has no current data from environmental investigations or results from other scientific studies for areas N-14 to N-20 in the north-western region of the German EEZ. An assessment of the areas is therefore possible only on the basis of the results of environmental investigations on existing offshore wind farms in the south-eastern German Bight. Further information on bird migration north-west of shipping route SN10 can be provided by older studies from Great Britain and observations on oil platforms (BOURNE 1982, LENSINK et. al. 1999, RONCONI et al. 2015).

From visual observations (Sylt, Wangerooge, Heligoland) as well as migration intensities recorded using vertical radar devices, it is clear that migration rates decrease with distance up to 100 km from the coast (KNUST 2003, HÜPPOP et al. 2009, WELCKER 2019). These results suggest that the migration intensities in Areas N-14 to N-19, which are more than 150 km from the coast, continue to decrease. Nevertheless, there are reasons to believe that strong bird migration, including mass migration, can occur also in the outer EEZ on individual days/nights. For example, tens of thousands of migrating songbirds have been recorded on British oil platforms (summarised in BRUINZEEL & VAN BELLE 2010). Radar surveys from the 1950s on the English coast north of Norfolk also showed that masses of songbirds set off eastwards in spring, presumably to migrate across the North Sea to their breeding grounds in Scandinavia (LACK 1959).

Based on the findings presented above in the area of the inner EEZ and the observations made in Great Britain and on oil platforms, the expected migratory activity and the expected migratory intensities for the Sites in Areas N-14, N-15, N-16, N-17, N-19, and N-20 are classified as medium.

Rarity and endangerment

Areas N-4, N-5, N-9, N-12, and N-13

In terms of species numbers and endangerment status, Areas N-4, N-5, N-9, N-12, and N-13 do not differ significantly. In the current investigations of the aforementioned neighbouring areas N-6, N-7, N-8, and N-9 from 2018 to 2021, between 84 and 110 species were found in the maritime areas. Of the species detected, 13–16 are listed in Appendix I of the Birds Directive. The species numbers recorded are rated as medium and the endangerment status as high.

Areas N-14 through N-20

For the sites in Areas N-14, N-15, N-16, N-17, N-19, and N-20, a similar species composition and a number of vulnerable species can be assumed as for the south-eastern zones. It seems likely that, in addition to the species groups mentioned so far (Chapter 2.10.2.1), further pelagic seabird species from the group of shearwaters (*Puffinus*) and storm petrels (*Oceanitidae*) will occur. There will probably also be an increase in waterbirds (e.g. white-fronted geese) and waders (e.g. Knutts, *Calidris canutus*), which migrate in a northwest-southeast direction between Greenland and the Wadden Sea. The number of individuals of the species in Areas N-14 through N-20 will probably be lower in most cases than in the areas south-east of Shipping route SN10 because of the distance to the coast.

In view of the expected range of species and the number of vulnerable species, the sites within Areas N-14, N-15, N-16, N-17, N-19, and N-20 are assigned medium importance in terms of rarity and endangerment.

Conclusion

Overall, based on the status assessment criteria and their assessment, Areas N-4, N-5, N-9, N-12 and N-13, N-14, N-15, N-16, N-17, N-19, and N-20 are of medium importance for bird migration.

It should be consideration that the BSH had no data from Areas N-14 to N-20 (neither from environmental monitoring nor from published studies) at the time of writing the environmental report. The assessments of Areas N-14 to N-20 were therefore made entirely based on findings from environmental impact studies in the south-eastern North Sea, the literature available, and considerations of the geographical location of the areas. As a result, the assessments made are subject to uncertainty and could change in based on new experiences and results from research projects.

2.11. Bats and bat migration

Bats are characterised by a high mobility. Whilst bats can travel up to 60 km per day in search of food, nesting grounds or summer resting places, and wintering areas are several hundred kilometres apart (HUTTERER et al. 2005, ALCALDE et al. 2021). Migration movements of bats in search of extensive food sources and suitable resting places are often observed on land (MESCHEDE et al. 2016). Bats can also be regularly observed in the coastal area and the offshore North Sea islands during their migration periods (RYDELL et al. 2014, SEEBENS-HOYER et al. 2021, BACH et al. 2022a, BACH et al. 2022b). Bats are also regularly found on Heligoland; because of the presence of buildings and vegetation the animals use the island for resting and foraging (SEEBENS-HOYER et al. 2021).

There are comparatively few systematic studies of migratory movements over the German Bight beyond the 12 nautical mile zone (HÜPPOP et al. 2019). However, the few available studies indicate an irregular occurrence of bats during migration periods over the open North Sea (Boshamer & Bekker 2008, HÜPPOP & HILL 2016, LAGERVELD et al. 2017).

2.11.1. Data availability

The data basis on bat migration over the North Sea is insufficient for a detailed description of the occurrence and intensity of bat migration in the offshore area in general and for the offshore environment of Areas N-9, N-12, N-13, and N-14 through N-20 in particular. In the following, reference is made to general literature on bats and findings from systematic surveys on Heligoland as well as acoustic surveys from the FINO1 research platform and other sources of knowledge in order to reflect the current state of knowledge. In view of the need for further knowledge on bat migration over the North Sea, the following can be stated:

- There is a lack of knowledge about the quality and quantity of migratory bat populations in the North Sea area.
- There is currently a lack of sufficient knowledge of the effects of offshore construction. Findings from the territorial sea and on land are only transferable to a limited extent because of the different conditions.
- The species-specific risk of bats colliding with offshore wind turbines is largely unknown.

2.11.2. Spatial distribution and temporal variability

Migratory movements of bats usually take place periodically or seasonally. The migratory behaviour of bats is highly variable. On the one hand, differences can occur depending on species and sex. On the other hand, migration or migratory movements can already vary greatly within populations of a species (FLEMING & EBY 2003, KRAUEL & MCCRACKEN 2013). Investigations show that the main migration of bats in the area of the German North Sea takes place in spring between mid-April and mid-June and in late summer/autumn between mid-August and the end of September (summarised in SEEBENS-HOYER et al.2021). A clear diurnal pattern for bat migration over the North Sea cannot yet be derived, and it is assumed that bats occur throughout the night. In general, bat activity can be observed especially at low wind speeds of 3–4 Bft (5–7 m/s) (SEEBENS-HOYER et al. 2021). However, according to the authors, there is no clear indication as to whether bats specifically use stable and calm weather conditions for their migrations.

In their search for nesting, feeding, and resting sites as well as during migration to their hibernation or breeding grounds, bats often migrate along corridors such as watercourses, mountain ranges, lakes, and coastlines (BAERWALD & BARCLEY 2009, FURMANKIEWICZ & KURSCHARSKA 2009, KRAUEL & MCCRACKEN 2013, MESCHEDE et al. 2016). However, long-distance migrations have been little researched to date, and migration routes have hardly been described for bats (POPA-LISSEANU & VOIGT 2009). This particularly applies to migratory movements across the open sea. In contrast to bird migration, which has been confirmed by extensive studies, the migration of bats remains largely unexplored because of their nocturnal behaviour and the lack of suitable methods or large-scale special monitoring programmes.

The final report on the R+D project “Effects of offshore wind farms on bat migration over the sea” (SEEBENS-HOYER et al. 2021) does not provide any relevant new findings on bat occurrence in the North Sea but does provide a good compilation of all currently available literature. The current state of knowledge, including assumed hypotheses about migratory species, migratory directions, and migration behaviour of bats in the North Sea and the plan area, can thus be used to make a rough classification of the spatial and temporal distribution of bat migration.

In the open North Sea, only a few systematic investigations of bat migration have been carried out over several years. However, SEEBENS-HOYER et al. (2021) show that bat contacts have been regularly detected in the North Sea area. Most bat records come from the East and North Frisian Islands or from the immediate coastal area. A recent study by BACH et al. (2022b) shows for the North Sea that the bats tagged for the study travelled mainly over land or with a strong coastal orientation. These observations suggest that the large bats follow the coastline from Denmark via Schleswig-Holstein and Lower Saxony towards the Netherlands in autumn.

Based on the geography of the land masses and considerations of flight duration and length of nights, SEEBENS-HOYER et al. (2021) assume that up to a certain distance, crossing the open North Sea can be advantageous for bats because the time saved leaves time for activities such as foraging or mating. This is also supported by the regular evidence of bats on Heligoland (SKIBA 2007). With the central location of Heligoland in the German Bight, the island offers migratory bats hunting and resting opportunities as well as the chance to make a longer intermediate stop during periods of bad weather (SEEBENS-HOYER et al.2021). Further seaward, beyond the borders of Heligoland, the flight over the open North Sea seems less attractive for bats because of the length of the route and the lack of resting opportunities (even in the event of sudden bad weather).

The study by SEEBENS-HOYER et al. (2021) shows that the detection of bats decreases with distance from the coast. From a distance of approx. 45 km or 80 km from the coast (research platforms FINO1 and FINO3), only a few isolated individuals were detected (cf LAGERVELD et al. 2017). At North Sea Buoy II, which is located around 120 km north-west of Heligoland, only four bat contacts were recorded during the migration period in late summer 2017 and only three in late summer 2018 (SEEBENS-HOYER et al.2021). In addition, most bats were observed on nights with offshore winds during investigations at FINO1 (HÜPPOP & HILL 2016). On the basis of this, the authors suggest that the fauna did not specifically fly to the offshore areas but got drifted to the EEZ.

For the survey of bat migration over the open sea, in addition to general occurrence and migration routes, the question also arises as to the heights at which bats migrate in order to be able to assess a possible risk of collision with offshore wind farms. Depending on location and method, the individuals surveyed by HÜPPOP & HILL (2016) were surveyed between 15 and 26 m at mean sea level; this includes the area between the lower rotor blade tip and the water surface of most wind farms. BRABANT et al. (2019) investigated bat occurrence at Thornton Bank offshore wind farm in the Netherlands using bat detectors at 16 m and 93 m above ground. Only 10% of the 151 bat recordings – and thus significantly fewer than at 16 m – were taken at a greater height. SEEBENS-HOYER et al. (2021) summarise that bats have been observed on anthropogenic structures such as ships, platforms, and OWT and that larger, structurally rich locations such as platforms or lighthouses in particular could be highly attractive to offshore migratory bats because they could be used as resting sites or as foraging habitats because of increased insect density.

25 bat species are native to Germany; all of these are protected species under European law. For four species, the mountain noctule bat (*Nyctalus noctula*), Nathusius' pipistrelle (*Pipistrellus nathusii*), the parti-coloured bat (*Verspertilia murinus*), and the lesser noctule (*Nyctalus leisleri*), regular migrations over a distance of 1,500–2,000 km have been recorded (HUTTERER et al. 2005, KRAUEL & MCCRACKEN 2013). Long-distance migratory movements are also suspected for the species soprano pipistrelle (*Pipistrellus pygmaeus*) and common pipistrelle (*Pipistrellus pipistrellus*) (KRAUEL & MCCRACKEN 2013).

Most (approx. 90%) of the bat calls detected in the North Sea area were made by Nathusius' pipistrelle followed by the lesser noctule (2.25%), the northern bat *(Eptesicus nilssonii*, 1.62%), and the common pipistrelle (1.46%) (SEEBENS-HOYER et al.2021). All other species were recorded with a proportion of less than 1% or much less (SEEBENS-HOYER et al.2021). SKIBA (2007) estimates the number of animals of all species that migrate across the German North Sea in autumn to be at least around 5,300 individuals. Further calculations show that around 1,100 specimens migrate from Denmark (south-west Jutland) south-westwards across the North Sea (SKIBA 2011).

Based on current knowledge of bat migrations in the North Sea region, the species range and abundance, and the geographical location of the assessment area and taking into consideration existing gaps in knowledge, the criterion of “large-scale importance” is assessed as “medium” subject to reservations.

Existing pressures

As with birds, anthropogenic changes contribute to the threat to and mortality of bats. First and foremost is the steadily increasing loss of natural habitats and foraging areas as well as the destruction of resting and winter habitats. The main reasons for this are the clearing of forests and the removal of old trees that serve as shelter for bats (FRICK et al. 2020). Migratory species are particularly susceptible to the loss of resting habitats because they are dependent not only on summer and winter habitats but also on resting opportunities along their migration route (SEEBENS-HOYER et al. 2021).

Intensive farming also contributes significantly to the endangerment of bats. The use of pesticides not only reduces the occurrence of insects, which are food source for many bat species, but can also lead to poisoning of the animals when the insects are consumed (O’SHEA et al. 2016, FRICK et al. 2020).

Other threats to bats come from hunting (less so in Europe) and disturbance by humans in resting and winter habitats. Disturbance is particularly problematic when entire colonies roosting in natural caves are impacted by recreational activities or industrial mining (FRICK et al. 2020).

Nowadays, also climate change has measurable effects on bats. For example, drought or flooding can affect food availability. So far, it is also unclear to what extent bats can adapt to the changed conditions (e.g. temperature) by changing their migratory behaviour (O’SHEA et al. 2016, FRICK et al. 2020). Since the 2000s, the number of bats killed by wind turbines has been increasing and is now one of the main causes of bat mortality (ARNETT & BAERWALD 2013, ARNETT et al. 2016, O’SHEA et al. 2016).

Regardless of the causal mechanisms, bat fatalities should be viewed critically because bats have a low reproductive rate and their population growth is relatively slow (ARNETT et al. 2016).

The existing pressures are therefore assessed as “medium to high” overall.

2.11.3. Importance of areas and sites for the protected asset

Analogous to the assessment of the status of migratory birds, the assessment of bat migration is based on the following assessment criteria:

- Assessment of the occurrence

- Rarity and endangerment

These two criteria are applied separately for Areas N-4 and N-5 as well as for areas N-9, N-12, N-13, and N-14 through N-20. For the criteria large-scale relevance and existing pressures, please refer to the explanations in Chapter 2.11.2.

Assessment of the occurrence

Areas N-4 and N-5

Within the possible migration routes mentioned above, there could be local concentrations of bats on the coast and the North and East Frisian islands. At greater distances from the coast, it can be assumed that the animals disperse and migrate over the open North Sea in a broad-font migration because there are no landmarks or guidelines that the bats can use for orientation (MESCHEDE et al. 2016). Overall, the results available indicate that bat migration in the North Sea area has a clear coastal orientation. The typical bat species expected for the North Sea area were detected only in small numbers at FINO1, FINO3, and North Sea Buoy II (SEEBENS-HOYER et al.2021). In this regard, it must be taken into consideration that the microphones of the bat detectors can often detect the ultrasonic sounds of bats only at a close range of approx. 20 m. The number of bat registrations may therefore be underestimated. This is also suggested by regular and comparatively much higher detection rates of bats on Heligoland (SEEBENS-HOYER et al.2021). Because the island offers hunting and resting opportunities for the animals, they may remain here longer and are more likely to be registered. The occurrence is limited mainly to the migration periods in spring and late summer.

Based on the primarily identified species composition and the frequency of detection of bats (also on the island of Heligoland, which is close to Areas N-4 and N-5), the criterion “Assessment of the occurrence” for the sites of Areas N-4 and N-5 is classified as “medium”.

Areas N-9, N-12, N-13 and N-14 through N-20

As part of the research project by SEBENS-HOYER (2021), acoustic data on the occurrence of bat migration was collected in the North Sea along a station network that was concentrated along the coast and included three offshore locations in the EEZ (FINO1, FINO3, North Sea Buoy II). The areas of Sones 3, 4 and 5 located in the outer EEZ were not covered with suitable stations. Bat activity was detected at all stations. However, activity was lowest at the offshore locations. Based on these observations, it can be assumed that the number of bats continues to decrease with increasing distance from the coast. Nevertheless, bat occurrences cannot be completely ruled out for Areas N-9, N-12, N-13, and N-14 through N-20. The criterion “Assessment of the occurrence” is therefore assessed as “low” for the sites of Areas N-9, N-12, and N-13 as well as Areas N-14 through N-19.

Rarity and endangerment

The bat surveys carried out by SEEBENS-HOYER et al. (2021) identified the typical bat species expected for the North Sea region: Nathusius’ pipistrelle, the soprano pipistrelle, the common pipistrelle, the mountain and lesser noctule, the parti-coloured bat, the serotine bat *(Eptesicus* *serotinus*), and the northern bat. All species are listed in Annex IV of the Habitats Directive as species requiring strict protection. In the current Red List of Mammals in Germany (MEINING et al. 2020), Nathusius' pipistrelle, the soprano pipistrelle, and the common pipistrelle are categorised as least concern. The mountain noctule bat is categorised as near threatened, and the northern bat and the broad-winged bat are categorised as vulnerable. The data availability is considered insufficient to assess the endangerment status of the lesser noctule and the parti-coloured bat. Apart from the regular occurrence of Nathusius' pipistrelle, the other species observed occur only in small numbers or sporadically over the North Sea.

Taking into consideration existing gaps in knowledge, in particular about the sizes of local bat populations or the biogeographical bat populations to be considered, the criterion "rarity and endangerment" is classified as "medium" for Areas N-4 and N-5 and as "low" for Areas N-9, N-12, N-13, and N-14 through N-20.

Conclusion

Overall, because of the regular migration of bat species typical for the project area and the degree of existing pressures, the assessment of the status of the protected asset bats is "medium" for Areas N-4 and N-5 and "low" for Areas N-9, N-12, N-13, N-14, N-15, N-16, N-17, N-19, and N-20.

It must be pointed out that the assessment was carried out on the assumption that there are still gaps in knowledge and on the basis of only a few systematically collected data. For Areas N-9, N-12, N-13, and N-14 through N-20 in particular, there are insufficient data for a reliable assessment. The assessment is therefore subject to certain uncertainties. If new findings emerge from research projects or wind farm projects, these must be taken into consideration in the further approval procedure.

2.12. Biological diversity

Biological diversity comprises the diversity of habitats and biotic biocoenoses, the diversity of species, and the genetic diversity within species (Article 2 Convention on Biological Diversity, 1992). Biodiversity is in the public eye. Species diversity is the result of an evolutionary process that has been going on for over 3.5 billion years, a dynamic process of extinction and species formation. Of the approximately 1.7 million species described by science to date, some 250,000 occur in the sea, and although there are significantly more species on land than in the sea, the sea is more comprehensive and phylogenetically more highly developed than the land in terms of its tribal biodiversity. Of the 33 known animal phyla, 32 are found in the sea; 15 of these are exclusively marine. (VON WESTERNHAGEN & DETHLEFSEN 2003).

Marine diversity cannot be directly observed and is therefore difficult to assess. For their assessment, tools such as nets, weirs, grabs, traps or optical registration methods must be used. However, the use of such devices can only ever provide a section of the actual species composition – precisely that which is specific to the device question. Because the North Sea, as a relatively shallow marginal sea, is more easily accessible than, for example, the deep sea, intensive marine and fishery research has been carried out for about 150 years. This has led to an increase in knowledge about its flora and fauna. This makes it possible to refer to inventory lists and species catalogues in order to document possible changes (VON WESTERNHAGEN

& Dethlefsen 2003). According to the results of the Continuous Plankton Recorder (CPR), about 450 different plankton taxa (phyto- and zooplankton) have been identified in the North Sea. Around 1,600 species of macrozoobenthos are known from the German North Sea region (Zettler et al. 2018). According to Yang (1982), the fish fauna of the North Sea is composed of 224 species of fish and lamprey. For the German North Sea, 189 species are reported (Fricke et al. 1995). In the EEZ of the North Sea, 19 seabird and resting bird species occur regularly in larger populations. Three of these species are listed in Appendix I of the Birds Directive.

With regard to the current state of biodiversity in the North Sea, it should be noted that there is countless evidence of changes in biodiversity and species assemblages at all systematic and trophic levels in the North Sea. The changes in biodiversity are due mainly to human activities (e.g. fishery and marine pollution) and climate change.

Red lists of vulnerable animal and plant species have an important monitoring and warning function in this context because they show the status of the populations of species and biotopes in a region. Based on the Red Lists, 32.2% of all currently assessed macrozoobenthos species in the North Sea and Baltic Sea (Rachor et al. 2013) and 27.1% of the fish and lampreys established in the North Sea (Thiel et al. 2013, Freyhof 2023) are assigned to a Red List category. Marine mammals form a group of species in which all common representatives (grey seal, harbour seal, harbour porpoise) are currently vulnerable or classified as indeterminate. The bottlenose dolphin has already disappeared from the German North Sea. Minke whales have been regularly sighted in the EEZ since 2013 but are considered critically endangered. White-beaked dolphins are repeatedly sighted in the North-western region of the German EEZ and are considered rare (Meinig et al. 2020). Of the 19 regularly occurring seabird and resting bird species, three species are listed in Appendix I of the Birds Directive. In general, in accordance with the Birds Directive, all wild native bird species are to be conserved and thus protected.

2.13. Air

The environmental report on the 2020 site development plan for the German North Sea (BSH 2020d) and the environmental report on the suitability assessment for Site N-3.7 (BSH 2020b) as well as the evaluation of the air hygiene monitoring of the federal states of Schleswig-Holstein (LLUR 2022) and Lower Saxony (GAA-HI 2021) were used for the description of the protected asset air in the project area.

Measurements of air pollutants are available/not available for Zones 2 and 3 of the EEZ. It can be assumed that the air pollutant concentrations of benzene, carbon monoxide, nitrogen dioxide, and sulphur dioxide are far below the guideline and threshold values of current assessment standards because of the great distance from conurbations and the low air pollution in Schleswig-Holstein and Lower Saxony (GAA-HI 2021; LLUR 2022). Emissions from vessels contribute to air pollution through the formation of particulate matter (PM) and ground-level ozone as well as through the emission of nitrogen dioxide (NO_2) and, in particular, the input of nitrogen into the environment at sea through atmospheric deposition contributes to the eutrophication of the oceans. To reduce emissions of nitrogen oxides, the IMO decided in 2017 to declare the North Sea a “Nitrogen Emission Control Area” (NECA) from 2021. However, the associated stricter threshold value for NOx will apply only to new ships from 2021. In addition, since 1 January 2015, shipping in the North Sea has been subject to stricter provisions as an emission control area. In accordance with Annex VI, Regulation 14 of the MARPOL convention, ships may only use heavy fuel oil with a maximum sulphur content of 0.10%. These regulations are intended to further reduce pollutant emissions.

Because of the location of the project area away from the emitters, the overall existing pressure of the protected asset air is assessed as low.

2.14. Climate

Climate refers to the summary of weather phenomena that represent the average state of the atmosphere in a place or area (Deutscher Wetterdienst 2023). This includes the overall statistical properties (mean values, frequencies, extreme values) over a longer period of time. In general, a period of 30 years, the normal period is used as a basis (Deutscher Wetterdienst 2023).

The entire German North Sea – and thus also the project area – is located in the temperate climate zone (BSH 2020b). The climate is influenced by warm Atlantic water from the North Atlantic Current, which also warms the air above the water (BSH 2020b). Because of the large-scale pressure distribution, with an Icelandic low and Azores High, the North Sea lies in the westerly wind zone. Icing occurs rarely and only along coastal areas (BSH 2020b). Uniformly strong winds from the west-southwest characterise the cold half of the year from October to March. In April and May, no preferred wind direction can be specified. In the course of spring, the influence of the Azores High prevails with characteristic west-north-west winds from June (LOEWE 2009).

Detailed information on the climate in the German Bight can be found in the "North Sea Manual, South-Eastern Part" (BSH 2023). The meteorological elements listed are average and extreme values for air pressure, wind (direction and speed), air temperature, relative humidity, visibility, cloudiness and precipitation.

In terms of the long-term behaviour of the wind, no significant trend in wind speed has been observed since the start of regular recordings in 1881 (Krieger et al. 2020). Instead, there are multidecadal fluctuations (i.e. longer phases with lower or higher wind speeds).

The climate has always been variable in the past and there have been smaller and larger climate fluctuations depending on changes in the intensity of solar radiation, the Earth's parameters, the land/sea distribution on Earth and the composition of the atmosphere. Since the beginning of industrialisation, humans have been changing the climate, particularly through the emission of radiation-active gases or greenhouse gases. For Germany and the coastal areas, the temperature has risen by around 1.5 K since 1881 (Deutscher Wetterdienst 2022).

Because of the heat capacity of water, temperature fluctuations are less pronounced seaward than on land. It is expected that the large-scale consequences of climate change will also have an influence on the North Sea (BSH 2020b). The increase in sea surface temperature and sea level is to be expected.

The North Sea is important for the maritime climate of the neighbouring land areas. Summers are only moderately warm, but winters remain mild because of the North Sea acts as a heat reservoir in winter. The importance as a climate function is assessed as **medium**.

2.15. Seascape

With regard to the description and assessment of the status of the protected asset seascape, reference is made to the statements in Chapter 2.15 of the North Sea Environmental Report on ROP 2021.

It is added in more detail that the seascape in the EEZ is also affected by existing platforms and offshore wind turbines. The shortest distance between the offshore islands of the Schleswig-Holstein coast and the nearest area is about 76 km (between the SW corner of N-5_neu and the centre of Sylt). The distance from the East Frisian Islands to the nearest area is around 118 km. This means that all the sites considered in this plan are well outside the visual range of land and the islands.

2.16. Cultural heritage and other material assets

In general, the protected asset in relation to the EEZ describes the cultural heritage located under water. The underwater cultural heritage includes, in particular, archaeological monuments and sites. According to the current monument protection laws of the north German coastal federal states, these are often objects, groups, or majorities of objects and parts of objects, expressly also traces of seabed discolouration or changes as well as evidence of plant and animal life insofar as these provide information about human life in the past. The protection of underwater cultural heritage in the EEZ is not yet regulated by law. However, it has been derived from the UN Convention on the Law of the Sea and implemented as part of maritime spatial planning and the site development plan.

Survey and availability of data

Known underwater cultural heritage in the territorial sea and to some extent in the EEZ is recorded in the registers of archaeological sites and monuments of the cultural authorities of the federal states. However, it is important to realise that this applies only to a small part of the underwater cultural heritage. The registers of archaeological sites and monuments therefore reflect the current state of knowledge but not the actual inventory of underwater cultural heritage. There is no systematic processing of information on the underwater cultural heritage. The quality of the data also varies, for example from identified historical wrecks to location-precise indications from records, and may need to be improved for a concrete planning statement.

Active recording of underwater obstacles – and thus also shipwrecks – in the territorial sea and in the EEZ is carried out only by the Federal Maritime and Hydrographic Agency (BSH). However, this survey is not focussed on underwater cultural heritage but rather concentrates primarily on objects rising from the seabed that could pose a risk to maritime shipping or fishery. It is therefore used mainly to locate and assess obstacles to navigation such as large stones, containers, ammunition remnants, and other items. Because underwater obstacles are subject to constant change, known obstacles are regularly investigated hydroacoustically and sometimes also by divers. The wreck information important for shipping is published in nautical charts. In addition, the BSH maintains a database on underwater obstacles (DUWHAS). The findings of the BSH are also incorporated into the registers of archaeological sites and monuments of the coastal states However, underwater cultural heritage that is covered by sediment or is barely visible on the seabed is not recorded in the wreck search of the BSH.

There is also no separate exploration of underwater cultural heritage as part of the preliminary site investigation for the determination of suitability. There is no investigation of seabed changes or elevations that could indicate a potential cultural find. An impression of the actual density of underwater obstacles in the EEZ is usually provided only by the exploratory surveys carried out by the developers as part of the respective planned offshore projects.

Population description

Only the information from the database on underwater obstacles of the BSH is used for the status description of the protected asset. Compared with the environmental report of the ROP (2021), there are currently no publications or extensive information on underwater cultural heritage, especially on archaeological monuments such as settlement remains in the EEZ.

Based on the entries in the database, there are isolated underwater obstacles such as wreckage, containers, and other objects mainly in the peripheral areas of the designated areas and sites. Several objects were mapped in the northern part of Site N 12.5; however, these were not identified in more detail. Along the planned submarine cable routes to Sites N-16.1 through N-16.3 in the area of Shipping route SN 10, there are also indications of some underwater obstacles (Figure 50).

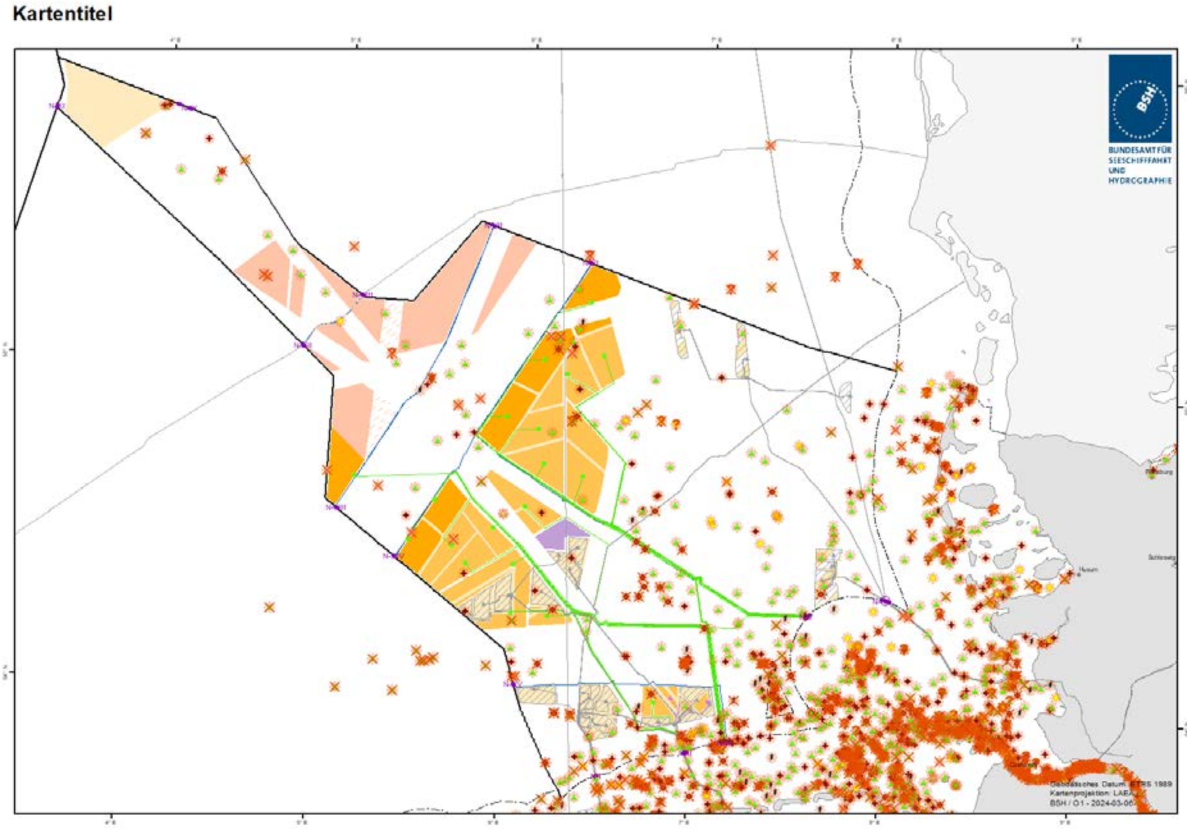

Figure 50: Overview of the underwater obstacles mapped to date in the EEZ of the North Sea.

These isolated underwater obstacles in the area of the sites and along the submarine cable routes must be taken into consideration in the specific approval procedures. After analysing the database, there are no findings on material assets or cultural heritage in the area of the planned platform locations. If culturally important artefacts or material assets are discovered in the course of the prescribed preliminary investigation of the subsoil during the approval procedure, suitable measures must be taken to preserve them.

Potential of underwater cultural heritage in the EEZ

A special feature of underwater cultural heritage is the often excellent preservation conditions in the low-oxygen milleu. This means that organic objects that would have long since been left to decay on land can be preserved in the sediment at the bottom of bodies of water. The documentation and analysis of underwater cultural heritage often provides unique insights into human history.

Not only the coastal areas but also areas in the EEZ of the North Sea were landfast regions in the early Holocene (Preboreal); these were colonised by humans between about 10,000 and 6,000 years ago (Schmölke et al. 2006, Behre 2003). In water depths of up to 20 m, preserved palaeoseascape remains in the form of peat and tree remains have been detected. Archaeological cultural heritage in the form of settlement sites has been explored in water depths of up to 10 m (Hartz et al. 2014). Accordingly, preserved prehistoric settlement traces in palaeoseascapes can be expected in the German EEZ of the North Sea with water depths between 15 m and 50 m. seascape reconstructions can be used to identify special potential areas for archaeological sites. An example of an area with high potential for the conservation of Stone Age settlement sites is the Ems Glacial Valley. The sub-surface of the North Sea basin was reconstructed using drill cores and reflection seismics, and the primeval valley of the Ems, which flowed into the Elbe Glacial Valley, was traced (Hepp et al. 2017, Hepp et al. 2019). In the Mesolithic Age, river valleys were important settlement areas for the hunting and fishing orientated population. Because of the rapid rise in sea level in the late Holocene and the accumulation of marine sediments over the mainland areas, finds of cultural and settlement importance in the EEZ of the North Sea cannot be ruled out. Another example is Doggerbank with a total area of approx. 18,700 km^2. It is the largest sandbank in the North Sea with an average water depth of just 30 m. Based on individual finds, there is evidence of colonisation from the Doggerland in the area of the Doggerbank from the early Mesolithic Age onwards (Ballin 2017, Bailey et al. 2020). A special potential for the conservation of archaeological sites is given by a natural event that took place when Doggerbank was still terrestrial and settled: Settlements could be preserved as a closed find context under a massive sediment layer that was deposited here by a tidal wave triggered by the Storegga landslide in Norway around 6225–6170 BC (Bondevik et al. 2012, Flemming 2004).

In addition to the Stone Age settlement finds, the underwater cultural heritage includes, underwater cultural heritage includes wrecks of watercraft, aircraft, and vehicles as well as wreckage and associated equipment, cargoes, and inventories. Most known wreck sites are boats and vessels from different eras. The spectrum ranges from Stone Age dugout canoes to wooden trading vessels from the Middle Ages to warships from the two world wars. The sources on the development of new shipping routes through the flourishing maritime trade in the Middle Ages as well as the sea routes used by coal and timber transports across the North and Baltic Sea from Great Britain and the Baltic States in the course of the 18th and 19th centuries show that shipping-related new discoveries in the EEZ of the North and Baltic Sea must be expected time and again. In general, wooden ships or remains thereof 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, like “time capsules”, allow unique insights into the past.

With the emergence of industrial aircraft construction from composite materials and iron and steel shipbuilding from the mid-19th century, the knowledge gained from written and pictorial sources predominates. Because of their often better conservation, aircraft and shipwrecks 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 because of the progressive corrosion of steel wrecks. Because of their historical importance and, in some cases, the lack of written sources on certain military and war-related aspects, shipwrecks 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). This also includes aircraft wrecks. Most of the known finds of aircraft wrecks in the North Sea and Baltic Sea are related to World War II. Aircraft crashes can rarely be precisely located, thus making it difficult to identify the wreckage. Whilst ditchings can lead to relatively well-preserved aircraft wrecks, crash sites are often characterised by extensive debris fields at the bottom of the water. In addition to providing insights into technical aspects of construction and use, the aircraft wrecks of World War 2 also bear witness to the events of the war.

Items of equipment or parts of cargo can also provide evidence of past maritime activities or war events. Among the most common objects are anchors that, for various reasons, were not recovered after an anchoring manoeuvre and remained on the seabed.

Status assessment

The cultural-historical value of the wrecks, wreck parts, and other objects discovered to date in the EEZ of the North Sea is mostly unclear because hardly any separate investigations and archaeological evaluations have been carried out by the monument protection authorities or have not been initiated. An assessment for the protected asset as such cannot be made.

Central factors for the definition of an archaeological monument (ground monument or underwater monument) are its cultural-historical importance (monument capability) and the public interest in its research and preservation (monument worthiness).

The assessment of the significance of the protected asset or its monument value is carried out according to the following criteria (see the monument protection laws of the federal states; Ickerodt 2014):

- Historical testimonial value
- Scientific or technical value, research value
- Social importance (place of remembrance such as a sea grave)
- Rarity value
- Integrity (degree of conservation, condition, threat)

The testimonial value varies depending on the conservation and type of site. For example, the historical testimonial value of underwater sites is generally very high because of the excellent 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 underwater sites can the way of life, the settlement structure, or the social organisation of the people of that time be further researched. The same applies to finds of organic materials from well-preserved shipwrecks, which may belong, for example, to personal equipment, cargo, or armament. Well-preserved wrecks with preservation of inventory and construction elements have a high testimonial value.

2.17. Humans, including human health

An area-specific description and assessment is required for the protected asset humans, including human health. Site N-3.7 is used as an example for the assessment of all sites of the EEZ in the North Sea. This site is much closer to the coast than the future sites in Zones 3, 4, and 5. This does not result in any change in the assessment of the protected asset population & human health compared with Site N-3.7.

For Site N-3.7, there are no special features with regard to the protected asset compared with a cross-area consideration.

The investigation of the relationship between human health and atmospheric environmental conditions is the subject of human biometeorology. Relevant interactions include, in particular:

- Radiation

- Temperature and

- Air quality:

In the area of radiation, the main focus is on UV radiation with an erythemal effect. This is relevant in the summer months around midday and can lead to sunburn.

In the thermal range, short-wave solar radiation, long-wave radiation from the atmosphere, air temperature, wind speed and humidity are the variables that determine population & human health thermal comfort. From this perspective, the area of the German Bight is categorised as a stimulating climate, which has positive effects on human health.

In the area of air quality, pollutants from various sources that have a negative effect on the human organism are relevant. On the other hand, maritime aerosols have a positive effect on human health. In general, the German Bight area can be described as low-polluting and at the same time rich in maritime aerosol.

2.18. Interactions between the protected assets

The various components of the marine ecosystem – from benthic and pelagic microbes to marine mammals and seabirds – influence each other through complex processes. The protected biological assets plankton, benthos, fish, marine mammals, and birds, which are described individually in Chapter 2, are interdependent within the marine food webs and influence each other in many different ways.

Both top-down and bottom-up processes play a decisive role in the regulation of population sizes and the dynamics of these protected assets. These processes are often integrated and determine how energy and nutrients flow through the food web and how the different levels of the food chain influence each other. In bottom-up processes, primary producers such as phytoplankton support the entire food chain. Changes in their productivity (e.g. because of light and nutrient availability, can greatly influence population dynamics along the food web. An increase in nutrients can lead to an increased growth of algae and phytoplankton. This, in turn, can increase the populations of herbivores and consequently those of predators or reduce them because of a lack of oxygen. In top-down processes, the structure and dynamics of an ecosystem are influenced downwards from the uppermost trophic levels (the top predators). In this approach, predators control the populations of herbivores or primary consumers; this, in turn, influences the producer level (such as phytoplankton and seagrasses). Predator-prey relationships or trophic relationships between size or age groups of a species or competition between species thus regulate the balance of the marine ecosystem. For example, the decline of cod populations in the Baltic Sea had a positive effect on the development of sprat populations

(Österblom et al. 2006). A decline in predators can lead to an increase in the herbivore population. This, in turn, can lead to overuse of primary producers and possibly a collapse of local vegetation or algae populations. This demonstrates how changes at both the top and the base of the food web can have profound effects on the entire ecosystem structure (Heithaus et al 2008).

The temporal and spatial sequence of development phases of different ecosystem components is of critical importance. For example, the growth of fish larvae is directly dependent on the available biomass of the plankton and the breeding success of seabirds depends, among other things, on the availability of suitable fish (species, length, biomass, energetic value). Disturbances in this trophic sequence can damage the early developmental stages of organisms in particular.

In addition to the complex interactions in the food web, species interact with each other through various behaviours. A distinction is made here between negative interactions (e.g. parasitism or amensalism) and a range of neutral/positive interactions such as commensalism (one species benefits), habitat formation, or improvement, and interactions from which both species benefit (mutualism).

Natural factors

Abiotic factors greatly influence the distribution and occurrence of species. For example, dynamic hydrographic structures, frontal formation, water stratification and currents play a decisive role in food availability (increase in primary production). The extensive “regime shift” of the North Sea ecosystem in the 1980s was probably triggered by large-scale changes in hydro-meteorological influences such as an increase in sea surface temperature and possibly a change in wind strength and direction in the late 1970s and resulted in far-reaching changes in species composition and biodiversity from plankton to fish (Beaugrand 2004).

Exceptional events such as storms and ice winters also influence trophic relationships within marine food webs. Also biotic factors such as toxic algal blooms, parasite infestations, and epidemics affect the entire food chain.

The warming of the water masses caused by climate change is progressing particularly strongly in the North Sea. Some of the consequences (e.g. the changed composition of the fish community because of the immigration of southern species or the migration of species for which the temperature optimum is exceeded) are already foreseeable.

Existing anthropogenic pressure

Anthropogenic activities also have a direct or indirect decisive influence on the interactions within the species of the marine ecosystem. Even before the first wind turbines were built, the North Sea was one of the most heavily used marine economic areas in the world (Emeis et al. 2015).

Commercial fishery in the North Sea has led to overfishing of large predatory fish in particular and to an increased occurrence of fish at a lower trophic level (Pauli et al. 1998, Sguotti et al. 2022). Overfishing of fish populations limits the food availability of top predators such as seabirds and marine mammals, which have to find new food resources. At the same time, jellyfish can become extremely widespread.

Furthermore, shipping and mariculture are an additional factor that can lead to changes in marine food webs via the introduction of non-native species. Discharges of nutrients and pollutants via rivers and the atmosphere also affect marine organisms and can lead to changes in trophic conditions.

Natural or anthropogenic impacts therefore affect marine food webs and can shift – and possibly jeopardise – the state of the marine ecosystem.

3. Expected development in the event of non-implementation of the plan

The expansion of offshore wind energy plays a key role in fulfilling Germany's international climate protection obligations (United Nations Framework Convention on Climate Change of 1992 (UNFCCC) and the Paris Agreement of 2015) and the climate protection and energy policy goals of the German government. This is also reflected in the statutory expansion targets for offshore wind energy (Section 1, para. 2, sentence 1 WindSeeG).

The purpose of the SDP is to spatially define the areas and sites for wind turbines as well as the expected generation capacity on them and the necessary routes and locations for the entire required grid infrastructure or grid topology in the EEZ (Section 4, para. 2, Section 5 WindSeeG). Furthermore, the SDP also develops the temporal component of the development by determining the temporal sequence of the calls for tender for the sites for offshore wind turbines and the calendar years of the commissioning of grid connection cables. The SDP also designates which site is to be centrally pre-surveyed and which is not in accordance with Section 5, para. 1, sentence 1, No. 3 WindSeeG). In addition, areas for other forms of energy generation can also be spatially designated for the practical testing and implementation of innovative concepts.

In accordance with the explanatory memorandum to WindSeeG, there are no alternatives (BT-Drs. 20/1634, p. 60). The law is necessary in order to achieve the ambitious German expansion targets for offshore wind energy as a major contribution to the climate targets and thus also the national contribution to the implementation of the Paris Agreement. In order to ensure early coordination and provide political support, in February 2022, the Federal Minister for Economic Affairs and Climate Action, Dr Robert Habeck, initiated an offshore dialogue with the federal ministers responsible for energy, the environment, transport, and maritime spatial planning and the affected (coastal) states, the BSH, the FNA, the BfN, and the transmission system operator as well as the offshore industry. The necessary steps and responsibilities were discussed in detail here. A new agreement on the development of offshore wind energy was concluded. This revealed a broad consensus for the further development of offshore wind energy and the implementation of the expansion targets (cf BMWK, Mehr Windenergie auf See – 30 Gigawatt Offshore-Windenergie bis 2030 realisieren – Vereinbarung zwischen dem Bund, den Länder Hansestadt Bremen, Hansestadt Hamburg, Mecklenburg-Vorpommern, Niedersachsen, Nordrhein-Westfalen und Schleswig-Holstein sowie den Übertragungsnetzbetreibern 50Hertz, Amprion und TenneT vom 3. November 2022).

Against this background and in view of the drastic consequences of climate change – also for the state of the marine environment – which would have to be expected if the climate protection targets were not achieved, the assumption of a zero alternative in which development is assumed without the additional development of offshore wind energy is unrealistic.

In order to achieve the expansion targets set out in Section 1, para. 2, sentence 1 WindSeeG, the construction of offshore wind turbines is necessary. As described above, no viable alternatives with which the climate protection targets could otherwise be achieved are currently apparent. Accordingly, the legislature considered the adverse effects on the marine environment caused by the legally designated expansion targets for offshore wind energy against the achievement of the climate protection targets within the framework of the expansion targets according to Section 1, para. 2, sentence 1 WindSeeG in favour of the orderly development of wind energy up to those expansion targets. As a result of this decision, the SDP serves the spatially and temporally ordered and efficient development of offshore wind energy with a series of additional provisions designed to minimise the adverse effect on the marine environment of the North Sea. In procedural terms, the orderly, centrally determined expansion is flanked by coordination requirements with the authorities listed in Section 6, para. 7 WindSeeG, which also include the BfN, for example.

In order to be able to feed the electricity generated in the offshore wind farms in the EEZ into the onshore extra-high voltage grid, it is absolutely necessary to lay current-carrying subsea cables to the grid connection points on land. In this respect, too, there is no apparent alternative to the expansion targets for offshore wind energy (including its grid connection) because of the need to protect the climate. In this framework, too, comprehensive planning by the SDP promotes the sparing use of land, and further provisions in the WindSeeG ensure that the environmental impacts of the subsea cables and pipelines designated in the SDP are as low as possible in each case.

With regard to the assessment for the individual protected assets, reference is made to the statements in Chapter 2 of the environmental report. In this respect, no additional or other significant effects are to be expected from the present revision of the SDP. Furthermore, the SEA reveals that no required updates or elaborations are apparent with regard to the likely development in the case of the non-implementation of the plan.

4. Description and assessment of likely environmental impacts of implementing the plan

In the following, the description and assessment of the environmental impacts concentrate on the protected assets for which significant effects cannot be excluded from the outset by the implementation of the SDP. This includes the protected assets seabed/space, benthos, biotope types, fish, marine mammals, seabirds and resting birds, migratory birds, bats and bat migration, climate, seascape, and cultural heritage and other material assets

According to Section 40, para. 1, sentence 2 UVPG, the likely significant impacts on the environment of the implementation of the plan must be assessed. According to Section 40, para. 3 UVPG, the environmental impacts of the plan are provisionally assessed with a view to effective environmental precaution. According to Section 3, sentence 2 UVPG, the environmental assessment serves to ensure effective environmental precaution according to the applicable laws. According to Section 5, para. 3, No. 5 WindSeeG, the SDP shall exclude any threat to the marine environment with regard to the designations contained in the plan. The marine environment includes the protected assets and their habitat, including possible interactions, described in this environmental report. In the corresponding assessment of adverse effects on the marine environment, the special designations of Section 5, para. 3, No. 5 WindSeeG (with regard to protected areas) and Section 72, Para. 2 WindSeeG (with regard to legally protected biotopes) must also be observed.

Protected assets for which a significant adverse effect was ruled out in the environmental report on SDP 2020 or SDP 2023 (cf Chapter 2) and for which an assessment did not provide any indications of additional or other significant environmental impacts and for which an update or elaboration of the SEA already carried out for this protected asset is not required are not taken into consideration (Section 5, para. 2, sentence 4 WindSeeG). This concerns the protected assets plankton, water, and air as well as the protected asset humans, including human health. Possible effects on the protected asset biological diversity are dealt with in the individual protected biological assets. Overall, the protected assets listed in Section 2, para. 1 UVPG are examined before the species protection and site protection assessments are presented. Statements on the general protection of nature and seascape according to Section 13 BNatSchG are also covered in the assessment of the individual protected assets.

According to Section 5, para. 2a WindSeeG, the SDP may make designations for areas for other forms of energy generation. In accordance with Section 3, No. 8 WindSeeG, an area for other forms of energy generation is an area outside areas where offshore wind turbines and installations for other forms of energy generation can be constructed in a spatial context. Installations in such areas may not be connected to the public power grid. The SDP defines the area for other forms of energy generation SEN-1 in the EEZ of the North Sea. In the context of the SEA, a “classic” offshore wind farm is assumed based on the findings to date with regard to electricity generation for the areas for other forms of energy generation. Impacts on the environment beyond this are highly dependent on the respective use variant and will therefore be comprehensively examined at the approval level. In this respect, the SEA for the area for other forms of energy generation is carried out in the same way as the assessment of sites for offshore wind energy.

As explained in Chapter 1.2, references to the term “sites” include both sites according to Section 5, para. 1, sentence 1, No. 2 WindSeeG and acceleration sites in accordance with Section 5, para. 1, sentence 1, No. 2 WindSeeG.

4.1. Seabed/space

4.1.1. Areas, sites, and platforms

Wind turbines and platforms are currently installed almost exclusively as deep foundations. However, the use of other foundation structures such as gravity foundations or suction bucket foundations can also be considered. For the deep foundation, the foundation of a wind turbine or platform is anchored in the seabed using one or more steel piles. The foundation pillars are generally driven into the seabed. Suction bucket foundations achieve their stability by creating a vacuum in the cylindrical foundation structure, which does not need to be driven. To protect against scouring, either scour protection in the form of mudmats or rockfill is placed around the foundation elements or the foundation pillars of deep foundations are placed correspondingly deeper into the seabed.

Construction-related impacts

For the foundations of the wind turbines and platforms, the installation measures lead to a spatially limited direct disturbance of the surface sediments. The intensity of the effects in the form of mechanical stress on the seabed through displacement, compaction, and vibrations is estimated to be low because of its small-scale and short-term nature. If the foundations of installations or platforms are realised as gravity foundations, preparatory construction measures are also necessary in order to ensure the stability of the installations or platforms. If levelling of the seabed is required, increased formation of turbidity plumes may occur depending on the proportion of fine grains. The sediment excavation and the transport of the material to another location directly disturbs the near-surface sediments of two rather small sites.

The resuspension that occurs during the construction work changes the sediment structure and morphology, temporarily changes the sedimentation regime, and leads to the formation of turbidity plumes. The extent of these effects essentially depends on the fines content in the seabed because clays and silts remain in suspension for some time after resuspension – in contrast to sand, which quickly sinks again – and are carried along by currents and sediment elsewhere. The suspended sediment in most of Areas N-4, N-5, N-9, N-12, N-14, N-17, N-19, N-20 is likely to settle quickly directly at the construction site or in its immediate vicinity because of the high sand content. The adverse effects thus remain limited to a small area. In addition to the dominant fine sand, many of the areas and sites identified in the SDP contain areas with fine grain contents of 20–50% or small-scale areas with over 50% clay and silt. Here, the effects associated with resuspension can reach a larger extent (small to medium scale). This is to be expected in particular in Site N-16.1 and the northern sub-site of N-16.6. In the coarse sediments of Area N-5 and large areas of Site N-13.4 (and N-13.3), the re-suspension of sediment in the course of construction measures would probably be lower. The resuspension of sediment in the areas and sites defined by the draft SDP will therefore occur on a small to medium scale during the short-term construction period. The intensity of this impact is therefore low in the sand-dominated areas and increases with increasing clay and silt content. However, in these fine-grained areas with comparatively stronger resuspension and larger turbidity plumes, neither a strong sediment discharge in the impact area of the construction measures nor a strong deposition of fine-grained material elsewhere is expected because of the short duration of the encroachments. A considerable change in the basic sediment structures and functions is therefore not to be feared – even in areas characterised by clay and silt. The intensity of the resuspension factor can also be categorised as low here.

Potential structural and functional changes to the seabed because of the construction-related impacts described above are categorised as low within all areas and sites identified in the draft SDP.

Installation/operation-related impacts

The seabed is permanently sealed locally by the introduction of the foundation elements of deep-founded wind turbines or platforms and the installation of scour protection. The sites that are affected essentially consist of the diameter of the foundation pillars plus any scour protection that may be required. The in-farm cabling of the sites and areas considered in this sectoral plan is connected directly to the planned converter platforms without an intermediate converter platform. An area of 11,500 m² is calculated for the use of marine space (sealing) of the planned converter platforms, including scour protection. A use of marine space of 1,964 m² is assumed for transformer and accommodation platforms. By far, the most common foundation variant for wind turbines is the monopile. The model parameters of the investigation framework include monopile diameters of 11.3 m (SDP scenario 1) or 14–18 m (SDP scenario 2) in Zones 3 to 5. Including scour protection, these assumptions are based on a use of marine space of 2,043 m² for Scenario 1 and 5,153 m² for Scenario 2 (maximum value of Scenario 2) per wind turbine. Within the sites built over with wind turbines, including scour protection, there is a complete loss of the in-situ sediments. On the affected sites, the protected asset seabed loses its original function as a (soft bottom) habitat and storage/buffer for nutrients and pollutants. The use of marine space caused by the introduction of hard substrate is therefore assessed as a small-scale, long-term impact of high intensity. For most sediments in the areas defined in the draft SDP, this loss of area is small compared with the large areas of sandy sediments in the German North Sea. The structural and functional change is therefore categorised as medium despite the high intensity of the factor “sealing of the sea floor”. However, the assessment is different, for large areas of Area N-5 and the extensive coarse sediments of Site N-13.4. Their diverse coarse sediments, which are rare in the German EEZ, are considered to be of high importance for the protected asset seabed (see Chapter 2.2.). Their loss because of localised, permanent sealing therefore weighs more heavily in comparison. The structural and functional change for the comparatively more valuable coarse sediments, which are also less represented in terms of area, is thus to be categorised as higher. It is assessed as medium to high for the affected sub-sites of Area N-5 and SDP Site N-13.4 (and N-13.3). Because of the high importance of the heterogeneous, coarse clastic sediments, significant adverse effects on the protected asset seabed are to be feared here because of the installation- and operation-related impacts taking into consideration the current model parameters of the investigation framework. Impact-avoiding, mitigating, and equalising measures such as bypassing these rare sediment types can counteract this.

The interaction of foundations and hydrodynamics can lead to a permanent resuspension and redistribution of sediments in the immediate vicinity of the installations as a result o f a change in the flow regime (including findings from FINO1 and FINO3 and from accompanying geological investigations in the "alpha ventus" offshore testing ground, Lambers-Huesmann & Zeiler 2011). On the hand, this can lead to a change in the sediment composition by spreading fine grain contents. On the other hand, scouring can occur in the immediate vicinity of the installations, whereby the scours can then act as sediment traps. The changes in sediment composition also influence the reservoir and buffering function as well as the habitat function of the seabed. They are generally small-scale but long-term. The intensity is assessed as low in sandy and coarse sediments as well as in silty sediments (clay and silt > 80%) because the structures and functions of these sediment types are only slightly altered by the discharge of fine-grained material and are preserved. However, in sandy sediments with a high proportion of fines (< 50%), the long-term discharge of clay and silt leads to a more pronounced change in the sediment structure in the vicinity of the installations; this can also adversely affect seabed functions. The intensity of these changes cannot be estimated precisely in the context of this SEA but is generally categorised as medium for this sediment type. Sands with a high fine grain content can be found in Site N-16.1 and the northern area of N-16.6 as well as in many small-scale areas of the other areas and sites. Here, the expected structural and functional changes because of scouring and sediment shift are categorised as medium.

The extensive prohibition of use and navigation will have a long-term and medium-term impact on the sediments within the safety zones of the OWFs and platforms. By eliminating the continuous mechanical impact on the near-surface sediments, a positive effect of medium intensity can be expected in previously heavily fished areas. This assessment is based on the assumption that the sediments are changed in their surface texture but not in their composition in the course of bottom-disturbing fishery. This means that basic sediment structures are preserved but the important function of the sediments as a habitat is temporarily – and repeatedly – disrupted. These medium-intensity negative changes caused by fishery are cancelled out by the use and navigation bans in OWFs. This results in positive "medium" structural and functional changes for the protected asset seabed. In the medium to long term, the surface structure, lost biogenic structures, and thus also the habitat function of the seabed will return to an undisturbed, near-natural state. These positive effects can be assumed for a large part of the sandy areas and sites defined in the draft SDP. However, within Areas N-4, N-5, the north-western part of Area N-19 and the coarse sediments of Site N-13.4 (centre and east), the intensity of this positive effect is assessed as lower. This is because the coarse sediments within Area N-5 and Site N-13.4 as well as the distant Area N-19 are currently affected comparatively little or not at all by bottom-disturbing fishery.

4.1.2. Subsea cables

Construction-related impacts

As with the installation of wind turbines, heavy resuspension of sediments is to be expected during the laying of cable systems. In addition to the formation of turbidity plumes, this leads to changes in the sediment structure, morphology, and sedimentation regime. The extent of the resuspension depends mainly on the cable laying procedure and the consistency of the seabed. As a rule, the sand fraction sinks again in the immediate vicinity whilst clays and silts remain in suspension for some time and sediment elsewhere. The transport and deposition of these turbidity plumes depend primarily on wind, current velocities, and water depth. With regard to the cable systems recorded in the present SDP, most of the sediment stirred up will settle directly in the area of the cable trenches or in their immediate vicinity because of the mostly strongly dominating fine sands. The changes in the proportion of fines in these areas and the sedimentation areas are estimated to be temporary because of the equalising effect of natural sediment dynamics. The expected adverse effects on the sediments caused by resuspension can therefore be categorised as short-term, small-scale, and low-intensity along most of the planned cable systems. Stronger changes are to be expected in the small-scale areas with fine grain fractions > 50% because a large proportion of the sediments can be stirred up and drifted further. The sedimentation zones can be expected to reach a small to medium scale. The – very fine-grained – sediment composition within the cable trench changes temporarily because of an increased accumulation of organic material and very fine sediments as well as an increase in the percentage of sandy fractions, which are not strongly drifted. A harmonisation of the morphology after completion of the construction work is also expected to result in a harmonisation of the sediment composition in the short to medium term. The intensity of these effects is assessed as low because the sediment structures and morphology within the cable trench will change but the structures and functions of the fine-grained sediments will be preserved. No major changes are to be expected in the sedimentation zones because of the dilution effect.

Because of sediment drift, temporary depressions in the ground remain after the cable is laid. This trench formation can cover several decimetres. It is more pronounced in fine-grained sediments than in sandy sediments. In the short to medium term, the morphology is harmonised by the accumulation of material and the slipping of the sides. The latter is more pronounced in sands than in very fine-grained sediments. Regional flow conditions play an important role in backfilling. The results of investigations of different methods in the North Sea reveal that the seabed levels off relatively quickly in some cases because of the natural sediment dynamics along the affected routes. Trench formation is categorised as a small-scale, short- to medium-term, and low-intensity construction-related impact.

In the course of the effects described above, there is also a direct disturbance of the sediments because of strong sediment shift within the cable trench. The storage and buffer function as well as the habitat function are adversely affected for a short time. This intensive encroachment is quite limited in space and ends with the construction work. Within the working widths of the laying equipment used, the seabed is subjected to mechanical stress from displacement, compaction, and vibrations. These disturbances are considered to be small-scale, short-term, and low-intensity.

Because of the generally low intensity of the aforementioned construction-related impacts, the structural and functional changes they cause to the protected asset seabed are assessed as low. However, in the small-scale areas with high clay and silt content along the cable routes, the adverse effects on the sediments will be somewhat greater.

Installation/operation-related impacts

In the area of cable crossings, the seabed will be permanently sealed by the erection of crossing constructions on an area of approx. 900 m² each. This results in a complete loss of the sediments. On the affected sites, the protected asset seabed loses its original function as a (soft bottom) habitat and storage/buffer for nutrients and pollutants. The use of marine space caused by the introduction of hard substrate is therefore assessed as a small-scale, long-term impact of high intensity. For most sediments in the area of the cable systems defined in the draft SDP, this loss of area is small compared with the large areas of fine sandy sediments in the German North Sea. The structural and functional changes in the fine sandy sediment structures are therefore categorised as medium despite the high intensity of the factor "sealing of the sea floor". In accordance with current plans, coarser sediments are not expected to be affected by cable crossings. Because the small-scale, fine-grain dominated areas (> 50% clay and silt) in the German EEZ are planned to be crossed several times by cable systems, this rare sediment type may be adversely affected by crossing constructions. Sealing would have to be assessed more critically here; however, the resulting structural and functional change is also categorised as medium because the limited extent of the potential encroachment.

During operation, the surrounding sediment heats up radially around the cable systems in both DC and AC subsea cables. The heat emission results from the thermal losses of the cable system during energy transmission.

These energy losses depend on several factors. The following output parameters have a significant influence:

• Transmission technology: Basically, greater heat emission as a result of thermal losses can be assumed with three-phase subsea cables than with DC subsea cables with the same transmission capacity (OSPAR Commission 2010).

• Ambient temperature in the area of the cable systems: Depending on the water depth and the time of year, fluctuation of the natural sediment temperature can be assumed, which influences heat dissipation.

• Thermal resistance of the sediment: In the EEZ, predominantly water-saturated sands occur. For the specific thermal resistance of these, a size range of 0.4 to 0.7 $K \cdot W^{-1}$ is valid, taking into consideration various sources (Smolczyk 2001, Bartnikas & Srivastava 1999, VDI 1991, Barnes 1977). According to this, more efficient heat removal can be assumed for water-saturated coarse sands than for finer-grained sands.

For the temperature development in the sediment layer near the surface, the burial depth of the cable systems is also decisive. According to the current state of knowledge, if a sufficient burial depth is achieved (2 K criterion, see planning principle 7.1.7) and state-of-the-art cable configurations are used, no significant structural and functional changes to the protected asset seabed are to be expected as a result of cable-induced sediment warming. The intensive water movement near the bottom of the North Sea also leads to the rapid removal of local heat.

4.2. Water

4.2.1. Areas, sites, and platforms

The construction and operation of wind turbines and platforms can lead to construction-, installation-, and operation-related impacts on the protected asset water.

Construction-related impacts: The introduction of the foundation elements leads to a resuspension of sediments in the immediate vicinity. Depending on the fine grain content in the sediment, turbidity plumes may form in the lower water column and thus lead to reduced sight depths. In this context, the content of organic material in the sediment can lead to higher oxygen depletion and release of nutrients and pollutants in the short term. These effects may vary because of the diverse sediment structures in the areas and sites defined in the SDP but will generally be characterised by low intensity. Structural and functional impairments are not expected.

Installation-related impacts: The support structures of offshore wind turbines represent obstacles in the water body that lead to a change in the flow conditions on both a small and medium scale. Numerical modelling of flow conditions in offshore wind farms has already been carried out within the GIGAWIND project (ZIELKE et al. 2001, MITTENDORF & ZIELKE 2002). From the modelling results it can be deduced that the flow velocity will increase in the immediate construction areas. The influence of a single structure on the flow extends laterally to only a small area. This can lead to a change in the dynamics of the stratification conditions in the water body in the immediate vicinity of the supporting structures. As a result of the mixing within the water column, stratified water bodies may experience an increased oxygen input in greater water depths. Furthermore, the swell changes as a result of the supporting structures because they cause additional friction in the wave field. This leads to a slight decrease in wave height on the side facing away from the swell and to a slight increase in wave height on the side facing the current (HOFFMANNS & VERHEIJ 1997, CHAKRABARI 1987). According to the results of the Gigawind project, the influence of a single structure on the swell, similar to that of the current, is limited to distances of about one to two structure diameters laterally and a few diameters behind. Wave dissipation is expected to result in minor attenuation, although the impact of large offshore wind farms on the wake of the wind field and thus on the wave field is the subject of current research. The changes in the flow regime and swell as a result of offshore wind turbines or offshore wind farms are long-term and medium-scale. The intensity of the effects is low. Based on this intensity assessment, the structural and functional changes are minor.

Operation-related impacts: Information on operation-related impacts caused by material emissions (e.g. corrosion protection, cooling systems, or sewage water) is described in detail in Chapter 5.4, where precautionary and safety measures against operating material leaks are also discussed.

4.2.2. Subsea cables

In the course of laying and operating subsea cables, there are generally only minor construction-related impacts on the protected asset water: The introduction of cables in the seabed leads to a resuspension of sediments in the immediate vicinity. Depending on the fine grain content in the sediment, turbidity plumes may form in the lower water column and thus lead to reduced sight depths. In this context, the content of organic material in the sediment can lead to higher oxygen depletion and release of nutrients and pollutants in the short term. These effects are classified as small-scale, short-term, and of low intensity because of the prevailing sediment characteristics in the German EEZ of the North Sea. Structural and functional impairments are not expected.

4.3. Plankton

The protected asset phytoplankton and zooplankton is already partially affected by the impacts of various uses such as fishery and shipping. In addition, the effects of climate change on phytoplankton and zooplankton are now clearly noticeable (BEAUGRAND et al. 2003, WILTSHIRE & MANLY 2004). Phyto- and zooplankton species will be increasingly affected in by possible effects of climate change, in particular by changes in temperature, salinity, and currents. The construction of wind turbines and converter platforms and the laying of subsea cables can have small-scale and short-term effects on phytoplankton and zooplankton because of the formation of sediment turbidity plumes.

Possible relevant installation- and operation-related impacts on plankton can be caused by turbulence, turbidity, and shadow flicker. At present, no reliable findings are available on the effects of OWFs on the small and medium-scale current system and the resulting potential large-scale ecosystem effects. Studies that identify potential changes are based on modelling results that take into consideration a possible development of offshore wind energy and describe possible changes to the environment. There is currently no evidence that these effects can be significantly distinguished from the natural variability of flow conditions (FLOETER et al. 2022; CHRISTIANSEN et al. 2022). In particular, there are currently no reliable findings on the potential impacts on the ecosystem. According to DAEWEL et al. (2022), the distribution of annual primary production may change on the basis of models with local changes in the range of ± 10%. On a large scale, however, these positive and negative effects cancel each other out. According to VAN DUREN (2021), the effects can act either antagonistically or synergistically on ecological processes in the water column. The southern North Sea is characterised by strong tidal and residual currents, and changes in the biotic and abiotic environment are therefore predominantly subject to advective processes. This makes it difficult to distinguish between natural and artificially induced changes (DAEWEL et al. 2022). To date, it has not been possible to derive in detail from the studies whether and to what extent there are relevant effects on ecosystem components. However, according to the current state of knowledge, significant effects from wind turbines, platforms, and subsea cables on phytoplankton and zooplankton can be ruled out with sufficient certainty. Because of the high natural dynamics of the hydrographic conditions in the EEZ, there are no signs of significant negative effects on a large scale.

4.4. Biotope types

A special consideration of the possible loss of function and area and thus the significant adverse effect on the legally protected biotope types according to Section 30 BNatSchG is given in Chapter 5.1.

4.4.1. Areas and sites

As a result of construction, the biotope function is temporarily adversely affected by sediment turbulence and redistribution. Possible site-related effects on the protected asset biotope types may result from direct use of marine space as well as from habitat changes because of scouring and as a consequence of the introduction of hard substrates. According to the current state of knowledge, the cumulative area loss will be well below 1% of the respective area (cf Chapter 4.17.1). The potential habitat changes as a result of scouring and the introduction of hard substrates are also limited to the vicinity of the installations.

The likely effects of the construction phase of the in-farm cabling are analogous to those of the wind turbines. Sediment turbulence and redistributions lead to a temporary adverse effects of the biotope function in the immediate vicinity of the construction area. According to the current state of knowledge, there will be no long-term or permanent change in the biotope structure. Persistent turbine-related effects may result from the erection of crossing constructions. Such cable crossings are usually secured through the introduction of non-native hard substrates. This represents a loss of area for the natural biotopes in the area. The introduced hard substrate also provides a new habitat for benthic organisms with an affinity for hard substrates and can lead to a change in the species composition and thus to a change in the biotope function.

4.4.2. Platforms

As a result of construction, the biotope function is temporarily adversely affected by sediment turbulence and redistribution. Possible site-related effects on the protected asset biotope types may result from direct use of marine space as well as from habitat changes because of scouring and as a consequence of the introduction of hard substrates. According to the current state of knowledge, the cumulative area loss, even taking into consideration the wind turbines, will be well below 1% of the respective area (cf Chapter 4.17.1). The potential habitat changes as a result of scouring and the introduction of hard substrates are also limited to the vicinity of the platforms.

4.4.3. Subsea cables

Construction-related sediment turbulence and redistribution lead to a temporary adverse effect on the biotope function in the immediate vicinity of the construction area. According to the current state of knowledge, there will be no long-term or permanent change in the biotope structure. In contrast, persistent turbine-related effects may result from the erection of crossing constructions. Such cable crossings are usually secured through the introduction of non-native hard substrates. These represent a loss of area for the natural biotopes in the area. The non-native hard substrate introduced provides new habitats for benthic organisms with an affinity to hard substrates. This can lead to a change in species composition and thus to a change in the biotope function.

4.5. Benthos

The construction of platforms, wind turbines, and subsea cables as well as the installations themselves can have effects on macrozoobenthos.

4.5.1. Areas and sites

The construction and operation of wind turbines can have various effects on the macrozoobenthos. These effects can occur in a comparable manner in all areas and sites designated by the SDP. The impact on individual benthic species and communities depends, among other things, on their specific sensitivity to construction-related disturbances and, if necessary, will be assessed on a case-by-case basis in the subordinate planning and approval levels based on additionally collected inventory data.

Construction-related: The deep foundation of the wind turbines causes disturbance of the seabed, sediment turbulence, and the formation of turbidity plumes. This can lead to the adverse effect on or damage of benthic organisms or communities in the immediate vicinity of the installations for the duration of construction activities.

During the construction of the installations, the resuspension of sediment in particular leads to direct adverse effects on the benthic biocoenosis through turbidity plumes and sedimentation in the vicinity of the construction site.

Turbidity plumes are to be expected during the foundation work for the installations. However, the concentration of the suspended material normally decreases quickly upon removal. The distribution of sediment particles depends to a large extent on the content of fine particles and the hydrographic situation (especially swell, current) (HERMANN & KRAUSE 2000).

Because of the predominant sedimentary composition in the areas and sites, the sediment released will settle quickly. The sand fraction is deposited again after small-scale drifting and can lead to adverse effects on the macrozoobenthos as a result of covering over. Many soft-bottom species are relatively insensitive to covering over and can survive several centimetres of additional sediment accumulation (BIJKERK 1988). According to ESSINK (1996), overburden with sandy sediments is better tolerated than overlaying with silty sediments. Polychaetes such as *Nereis* spp. and *Nephtys* spp. can overcome a layer of silt up to 60 cm thick and a layer of fine sand up to 85 cm thick. Investigations on *Tellina* spp. showed a lethal layer thickness of 38 cm when covering over with silt and a layer thickness of 45 cm when covering over with fine sand (ESSINK 1996). It can also be assumed that there will be only very little sedimentation and that the macrozoobenthos will be able to compensate for this rather slight covering over through active locomotion or behavioural changes. According to the current state of knowledge, the construction-related impacts resulting from turbidity plumes and sedimentation are to be classified as short-term and small-scale.

Installation-related changes in the benthic community may occur as a result to the sealing of the sea floor, the introduction of hard substrates, and the alteration of the flow conditions around the installations.

In the area of the installations and the associated scour protection, there will be sealing of the sea floor/use of marine space and thus a complete loss of habitats of the soft bottom biocoenoses.

In addition to habitat losses or habitat changes, new off-site hard substrate habitats are created. In addition, there may be changes in the flow conditions around the installations. This can have an influence on the soft-bottom fauna in the immediate vicinity. According to KNUST et al. (2003), the introduction of artificial hard substrate into sandy seabeds leads to the settlement of additional species. These species will most likely be recruited from natural hard substrate habitats (e.g. superficial boulder clay and stones). Colonisation of the new hard substrates will take place passively by larval drift or, in individual cases, by active immigration. Accompanying studies of OWFs in operation show that typical native species predominantly establish themselves (IFAÖ 2022a). Only the uppermost metres of the wind turbines directly below the water surface show an increased proportion of neozoa. Settlements of neozoa on the artificial hard substrates, which were not previously considered established in German waters, have not yet been documented (IFAÖ 2022a). This means that the risk of negative impacts on the benthic sand bed community by non-native species is low.

In the immediate vicinity of the structures, there may be an influence on the benthic biocoenoses with a change from formerly less mobile and sessile species to mobile species. Investigations on the FINO1 research platform have shown that there was an influence on the benthic biocoenoses in the immediate vicinity of the structures up to a distance of 17 m. A change from formerly sedentary and sessile species to mobile species was observed; this was caused by sediment erosion and an increase in predators (JOSCHKO 2007). Investigations of various foundation structures of wind turbines have shown that the hard substrate of the installations leads to an accumulation and proliferation of mobile mega-fauna species such as the edible crab *(Cancer pagurus*). This was particularly pronounced in installations with scour protection (KRONE et al. 2017).

According to the current state of knowledge, operation-related impacts of the wind turbines on the macrozoobenthos are not to be expected.

Based on the above statements and representations, the result of the SEA is that, according to the current state of knowledge, no significant effects on the protected asset benthos are to be expected as a result of the designation of the areas and sites in the draft SDP. The construction-related impacts on the protected asset benthos are assessed predominantly as short-term and small-scale. Small areas outside protected areas are permanently used.

With regard to the construction-, installation- and operation-related impacts of the in-farm cabling, the impact assessments described in Chapter 4.5.3 apply analogously.

4.5.2. Platforms

Construction-related: The deep foundation of the platforms causes disturbance of the seabed, sediment turbulence, and the formation of turbidity plumes. This can lead to the adverse effect on or damage of benthic organisms or communities in the immediate vicinity of the platforms to be constructed for the duration of construction activities.

The effects described in Chapter 4.5.1 resulting from disturbance of the seabed, formation of turbidity plumes, and sedimentation apply analogously to the construction of platforms. Overall, the construction-related impacts can be categorised as short-term and small-scale.

Installation-related changes in the benthic community may occur as a result of the local sealing of the sea floor, the introduction of hard substrate, and the alteration of the flow conditions around the platforms. In addition to local habitat losses or habitat changes, new off-site hard substrate habitats are created. This can have an influence on the soft-bottom fauna in the immediate vicinity. The system-related effects described in Chapter 4.5.1 also apply analogously to the platforms. Although the effects are long-term, they are limited to the immediate vicinity of the platforms.

According to the current state of knowledge, operation-related effects of the wind turbines and the accommodation platform on the macrozoobenthos are not to be expected.

Based on the above statements and representations, the result of the SEA is that, according to the current state of knowledge, no significant effects on the protected asset benthos are to be expected as a result of the designation of the locations for the platforms in the SDP.

Overall the construction-related impacts on the protected asset benthos are assessed as short-term and small-scale. Very small areas outside protected areas are permanently used.

4.5.3. Subsea cables

Construction-related: Possible effects on benthic organisms depend on the cable laying procedure used. Because of the careful laying of the subsea cables by means of a jetting method, only small-scale, short-term, and thus minor disturbances of the benthos in the area of the cable route are to be expected. Local sediment turbulence and turbidity plumes are to be expected during the laying of the subsea cables. This may result in a small-scale and short-term habitat loss for benthic species or adverse effects on or damage to benthic organisms or communities during construction activities in the vicinity of the cables. The main risk of sedimentation of the released sediments is the burying of sessile benthic organisms such as mussels and tube-building polychaetes (OSPAR 2023).

In the event of a stock decline as a result of a natural or anthropogenic disturbance (e.g. jetting of cables), enough potential organisms remain in the overall system for recolonisation (KNUST et al. 2003). According to BOSSELMANN (1989), distribution occurs not only via the larval stages but also through the dispersion of post-larval and adult forms. Furthermore, accompanying investigations of the benthos as well as the fish and decapod fauna (crustaceans) in the Europipe pipeline laid in 1994 showed that just two years after completion of the construction work there was a clear recovery of the communities with a development of the community structure towards the state prior to the construction work. The linear character of the subsea cables also favours recolonisation from the undisturbed edge areas.

Turbidity plumes are caused by the disturbance of the sediment during the jetting of the cable system. The distribution of sediment particles depends to a large extent on the content of fine particles and the hydrographic situation (especially swell, current) (HERRMANN & KRAUSE 2000). Because of the predominant sediment composition in the EEZ of the North Sea, most of the sediment released will settle directly at the construction site or in its immediate vicinity.

Thus, according to the current state of knowledge, the disruption during the construction phase will remain small-scale and generally short-term. A short-term occurrence of elevated concentrations of suspended substances does not appear to be harmful to adult mussels. The growth of filter-feeding mussels can even be promoted. However, eggs and larval stages are generally more sensitive than adult individuals and could be damaged by the turbidity plumes in the short term and on a small scale. Although the concentration of suspended particles can reach levels that are harmful to certain organisms, the impacts on the macrozoobenthos are considered to be low because such concentrations occur only spatially and temporally and are quickly degraded again by dilution and distribution effects (HERRMANN & KRAUSE 2000).

Benthic organisms can also be adversely affected in the short term and on a small scale by the release of nutrients and pollutants associated with the resuspension of sediment particles. The oxygen content can decrease when organic substances are brought into solution (HERRMANN & KRAUSE 2000). The effects are generally considered to be low because the jetting of the cable systems is limited in time and space and the pollution of the sediments in the EEZ is comparatively low. In addition, waves and currents quickly dilute any increases in the concentration of nutrients and pollutants.

Potential effects resulting from any repair work that may become necessary are comparable to the possible construction-related impacts. Because the damaged cable section can be localised quite precisely as described, the effects should be limited directly to the cable section affected.

Installation-related: For the cable trenches themselves, a temporary installation-related adverse effect on the macrozoobenthos is expected because cable trenches usually backfill naturally in the medium term because of the sediment dynamics. In the area of possible cable crossings, the disturbances are permanent but also small-scale. Necessary cable crossings are secured by the introduction of non-native hard substrates. This hard substrate provides a new habitat for benthic organisms. This makes it possible for species and biocoenoses to colonise areas in which they were previously absent so that their distribution areas can expand (SCHOMERUS et al. 2006). The off-site hard substrate habitats may have an influence on the soft-bottom fauna in the immediate vicinity.

For operational reasons, depending on the sensitivity of the respective species and the intensity of the cable heating, higher activity, stress-related behavioural changes, deterrence or increased mortality may occur. According to the current state of knowledge, no major effects on the benthos from the cable-induced sediment warming are to be expected if sufficient burial depth is maintained and state-of-the-art cable configurations are used. As part of the environmental reports for downstream cable systems of offshore wind farms, various calculations on the sediment warming resulting from the operation of submarine cables were presented; these demonstrate compliance with the 2K criterion. The intensive water movement near the bottom of the North Sea also leads to the rapid removal of local heat.

Taking into consideration the above results and forecasts, compliance with the “2 K criterion” can be assumed for a respective minimum laying depth. Specific proof of compliance with the 2K criterion must be provided in the corresponding approval procedures.

Electric and electromagnetic fields are also not expected to have any significant effects on macrozoobenthos. When using state-of-the-art DC cables, an electric field occurs only within the respective cable (i.e. only between the conductor and the earthed shielding). There is therefore no external electric field. Even with three-phase cables, electric fields outside the cable system can be avoided by suitable insulation or by appropriate cable configuration so that electric fields do not occur in a significantly measurable way.

The magnetic fields generated by the individual cables during operation largely cancel each other out in both the DC subsea cables (which consist of supply and return conductors with opposite current flow directions) and the AC subsea cables and are well below the strength of the Earth's natural magnetic field. Modelling for DC subsea cables resulted in values of 11 to max. 15 µT at the seabed surface (PGU 2012a, PGU 2012b). In comparison, the Earth's natural magnetic field is 30 to 60 µT depending on location. Because of the lower load current and the three-wire technology, a weaker magnetic field can be assumed for three-phase cable systems than for DC cable systems. Values of less than 10 µT are to be expected for three-phase cable systems (cf PGU 2013). The strongest fields occur directly above the cable system. The strength of the fields decreases quickly with increasing distance.

Electromagnetic fields can lead to behavioural changes in organisms that can orient themselves to the Earth's magnetic field or perceive electromagnetic fields (e.g. large decapod crustaceans, ALBERT et al. 2020). The intensity of the change in behaviour depends primarily on the strength of the field as well as the distance of the individual from the emission source. According to the current state of knowledge, no significant effects on the benthic communities are expected from the laying and operation of the subsea cables, assuming a sufficient burial depth and taking into consideration that the effects will occur on a small scale (i.e. only a few metres on either side of the cable). According to the current state of knowledge, the ecological effects are small-scale and predominantly short-term.

4.6. Fish

The fish fauna in the areas and sites defined in the draft SDP has a typical species composition. The demersal fish community in the areas and sites is also dominated by the flatfish species typical of the German Bight.

4.6.1. Areas and sites

The construction-, installation- and operation-related impacts of OWFs on fish fauna are spatially and partly also temporally limited and are concentrated mainly on the site of the planned project. The effects of the various wind farm phases are described in detail below.

Construction-related

- Noise emissions from driving the foundations
- Sedimentation and turbidity plumes

Noise emissions

In the area of the projects, temporary noise emissions are to be expected because of the use of vessels, cranes, and construction platforms as well as the installation of the foundations and, if necessary, the introduction of scour protection. It is known from the literature that pile driving impacts under water produce high sound pressures in the low-frequency range. All fish species and their life stages studied to date can perceive sound as particle movement in the inner ear or as sound pressure using the swim bladder, whereby there are species-specific differences in the ability to perceive sound (KNUST et al. 2003, KUNC et al. 2016, HALVORSEN et al. 2017, WEILGART 2018, POPPER &; HAWKINS 2019).

Depending on the intensity, frequency, and duration of sound events, sound could have a direct negative impact on the development, growth, reproductive success, and behaviour of fish (HAWKINS & POPPER 2014). Furthermore, acoustic environmental signals, which are sometimes crucial for the survival of the fish, can be superimposed (KUNC et al. 2016, WEILGART 2018, DE JONG et al. 2020). For some fish species it has already been shown that they react to sounds by fleeing or turning away from the sound source (e.g. BLAXTER 1981; KNUDSEN et al. 1992). However, most of the evidence to date on the effects of sound on fish comes from laboratory studies (WEILGART 2018). There have been few studies of the range of perception and possible species-specific behavioural reactions in the marine habitat to date.

Fish can suffer physical damage that can lead to permanent or temporary hearing impairment (hearing threshold shift) (HASTINGS & POPPER 1996). In the Belgian EEZ, DE BACKER et al. (2017) showed that the sound pressure generated during pile driving was sufficient to cause internal haemorrhaging and barotrauma of the swim bladder in Atlantic cod. This effect was found at a distance of 1,400 m or closer from a pile driving sound source without any noise protection (DE BACKER et al. 2017). Investigations such as this indicate that significant disturbances or even the killing of individual fish in the vicinity of the ramming points are possible. EVANS (1998) gives 180 to 220 dB as the threshold values for physical damage to fish, and 160 to 180 dB (re 1 µPa) as the threshold value for avoidance behaviour.

Hydroacoustic measurements showed that construction measures (pile driving and other construction activities) in the “alpha ventus” testing ground resulted in a greatly reduced population of pelagic fish relative to the surrounding area (KRÄGEFSKY 2014). More recent results also show that Atlantic cod move away from the sound source during pile driving and move towards the scour bed (VAN DER KNAAP et al. 2022). It is therefore likely that fish will be deterred by short, intense noise events during the construction phase, especially during the installation of the foundations. Investigations on noise impacts on fish by NEO et al. (2016) showed that the animals largely returned to their usual behaviour 30 min after the auditory stimuli. It is therefore likely that the fish will return to their original behaviour after the noise-intensive construction measures have been completed. Some aspects of the marine mammal deterrence measures are likely to be applicable to fish. The risk to fish posed by the sound input from pile driving is likely to be reduced by the noise mitigation measures that have been ordered.

The effects of pile driving noise on fish fauna is expected to be localised and temporary. Significant adverse effects on fish fauna are not to be expected if the noise protection measures are observed.

<u>Sedimentation and turbidity plumes</u>

The construction activities of the WT foundations result in sediment turbulence and turbidity plumes, which – albeit temporary and species-specific – can cause adverse physiological effects as well as deterrent effects. The extent depends mainly on the sediment composition in the site, the construction methods used, and the number of WT foundations.

Predators that hunt in open water (e.g. mackerel and horse mackerel) avoid areas with high sediment loads and thus avoid the danger of gill adhesion (EHRICH & STRANSKY 1999). Increased foraging activity was observed in bottom-dwelling fish such as plaice and sole following storm-induced sediment turbulence (EHRICH et al. 1998). However, a covering over of the benthic food base as a result of the sedimentation of the released substrate could have a negative impact on fish that use wind farm areas as nursery or foraging habitats. Demersal species such as scaldfish and yellow sole spend their entire life cycle in one area without undertaking pronounced migrations and are therefore highly likely to spawn in the wind farm areas (HEESSEN et al. 2015). The spawn of these species could therefore be particularly affected in the event of increased sedimentation rates. Gobies lay their eggs on the seabed and partially guard them (MUUS & NIELSEN 2013). Adults of such fish species could be harmed, particularly during spawning periods because increased sedimentation rates can restrict gill function and thus oxygen supply (ENGELL-SØRENSEN & SKYT 2002). However, in principle, adult fish are unlikely to be directly affected by sedimentation and turbidity plumes because of their pronounced sensory abilities (lateral line) and their high mobility (WESTERBERG et al. 1996).

Eggs and larvae for which the reception, processing, and realisation of sensory stimuli are not yet or only slightly developed are generally more sensitive than adults of the same species. However, demersal fish eggs in particular form a dermis after fertilisation; this makes them resistant to mechanical stimuli such as resuspended sediments (HELFMAN et al. 2009). There is a risk of the fish spawn deposited on the seabed being covered by the sedimentation of the substrate released. This can result in an undersupply of oxygen to the eggs and, depending on the degree of effect and duration, can lead to damage or even death of the spawn (cf DAVENPORT & LÖNNING 1980). In addition, suspended sediment can adhere to pelagic fish eggs and thus lead to the eggs sinking more quickly into areas with unfavourable oxygen concentrations (WESTERBERG et al. 1996; CORELL et al. 2023). For most fish species occurring in the EEZ, no damage to the spawning population is expected because they their spawning grounds in shallow waters outside the EEZ. Fish spawn are more sensitive to suspended sediment than fish eggs (ENGELL-SØRENSEN & SKYT 2002). In experiments, WESTERBERG et al. (1996) showed higher mortalities for fish larvae than for fish eggs and surmised that the gills of the larvae were blocked by the sediment.

Although the concentration of suspended particles can reach levels that are harmful to certain organisms, the impacts on fish are considered to be relatively low because 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 resulting from the resuspension of sediment particles (ICES 1992, ICES WGEXT 1998).

Increased sedimentation and turbidity plumes occur locally and for a limited time during construction. They are not expected to result in any permanent loss of spawning, foraging, and nursery habitats. Adverse physiological effects and deterrent effects are also expected to be localised and temporary. Significant adverse effects on the fish fauna are therefore not to be expected.

Installation-related

- Use of marine space
- Introduction of hard substrate
- Expected restriction of fishery

Use of marine space

The construction of the foundations of the OWT and technical platforms as well as the scour protection means that habitats are built over and are no longer available for fish. Localised overbuilding leads to a permanent loss of habitat for demersal fish species and their food source, the macrozoobenthos. However, this habitat loss is limited to the immediate, small-scale location of the individual OWT and platforms. Significant adverse effects on the fish fauna are therefore not to be expected.

Introduction of hard substrate

The construction of wind farms changes the structure of the often uniformly sandy seabed of the North Sea by introducing new hard substrate (foundations and scour protection).
In accordance with the reef effect, fish are attracted to the turbine foundations and the scour protection layer around the OWFs and aggregate near the artificial structures (LANGHAMER & WILHELMSSON 2009; ANDERSSON & ÖHMAN 2010; KRONE et al. 2017; DEGRAER et al. 2020). The epifauna growing on the hard substrate can increase food availability or food efficiency for the fish and provides a complex habitat that can serve as protection from currents and predators (GLAROU et al. 2020). This habitat can also lead to increased ecological production by providing habitats for the recruitment or settling of individuals (RANDALL 1963; BOHNSACK 1989).

The attraction effect of artificial reefs on fish described is well documented (GLAROU et al. 2020; FLÁVIO et al. 2023). GLAROU et al. (2020) reviewed 89 scientific studies on artificial reefs; of these, 94% demonstrated positive or no effects of artificial reefs on the abundance and biodiversity of fish fauna. In 49% of the studies, locally increased fish abundance was recorded after the construction of artificial reefs.
Using hydroacoustic methods, COUPERUS et al. (2010) demonstrated an up to 37-fold increase in the concentration of pelagic fish in the vicinity (0–20 m) of the foundations of wind turbines compared with the areas between the individual wind turbines. It is known that some species such as bib and Atlantic cod in particular aggregate in higher densities in the vicinity of the foundations than in the surrounding soft substrate because they feed primarily on the fouling (REUBENS et al. 2011, 2013, 2014a, b; GIMPEL et al. 2023). Foundations with scour protection are favoured over other foundation types (GIMPEL et al. 2023; WERNER et al. 2024). However, this reef effect appears to be limited to a few hundred metres (WERNER et al. 2024).

Effects of turbine foundations and scour protection on typical flatfish species are less well understood. It is generally assumed that they are not attracted to the artificial structures because they prefer the sandy habitat (VAN HAL et al. 2017). However, there are indications that the artificial hard substrate within OWFs can provide an important habitat for demersal fish such as plaice if there is sufficient soft sediment between the turbines (BUYSE et al. 2023). The fish can benefit from the increased availability of prey and use the habitat as a refuge. So far, no negative effects have been observed on other species such as sand eels, which live on the original sandy bottom between the turbines (VAN DEURS et al. 2012; STENBERG et al. 2015).

Higher fish abundance and higher biodiversity in the wind farm areas could lead to a change in the dominance ratios within the fish community as a result of the increase in predatory fish and thus increase the predation pressure on prey fish species. At the same time, increased fish abundance because of the attraction effect of certain species could lead to overfishing outside the wind farm boundaries (BOHNSACK 1989; SMITH, LOWRY & SUTHERS 2015). So far, only a few studies have provided evidence of increased productivity in OWFs (REUBENS et al. 2014a; BUYSE et al. 2023). However, there are initial indications that Atlantic cod are reproducing in the wind farms of the "Nördlich Helgoland" cluster (GIMPEL et al. 2023).

In summary, it can be concluded that fish populations have not yet experienced any significant changes as a result of the introduction of hard substrates in OFPs (VAN HAL et al. 2017; DE BACKER et al. 2020). Whist individual adults benefit from the increased prey availability on the hard substrate in OWFs, there is no evidence that this can also lead to changes at the population level (BERGSTRÖM et al. 2013). Secondary effects such as the reef effect and the refugium effect as well as the associated increased productivity have so far been identified only locally and at species level (REUBENS et al. 2014a, 2014b; DE BACKER et al. 2020; DE BACKER et al. 2022; BUYSE et al. 2023; GIMPEL et al. 2023). Significant adverse effects on the fish fauna are not to be expected.

Expected restriction of fishery

The prohibition or significant restriction of fishery in the wind farm areas, which is to be expected on the basis of the legal framework and current practice, could have a positive effect on the fish fauna because fishing disturbances would no longer occur or would occur to a lesser extent. Disturbance of the seabed as well as catch and bycatch of many species would be eliminated or would not occur to the same extent, thereby creating potential refuges. In the long term, the fish community could recover overall because of the lack of or reduced fishing pressure. Recolonisation by rare or site-loyal species could be the result (cf VAN HAL et al. 2017). The age structure of the fish fauna within the project area could return to a more natural distribution (BUYSE et al. 2023). The refugium effect (recruitment or emigration from surrounding areas because of fishing exclusion) could, together with the reef effect, lead to higher fish abundance and biomass (DEGRAER et al. 2020). However, the reef effect appears to be limited to a few hundred metres (WERNER et al. 2024), and there is a lack of empirical evidence for the existence of "spillover effects" (export of biomass to the surrounding area) by OWFs (DE BACKER et al. 2022). There is also a need for research to transfer any effects identified locally and at the species level to the population level of fish. Overall, according to the current state of knowledge, no significant effects on the protected asset fish fauna as a result of the construction and operation of offshore wind farms in the designated areas and sites are to be expected.

4.6.2. Platforms

According to the current state of knowledge, the planned converter sites do not represent a favoured habitat for any of the fish species protected under the Habitats Directive. As a result, the fish population in the planning area is of no particular ecological relevance.

The construction-, installation- and operation-related impacts of the converter platforms on the fish fauna are limited in terms of space and time.

Construction-related

- Noise emissions
- Sedimentation and turbidity plumes

Construction activities generate noise emissions from the use of ships, cranes, and construction platforms as well as from the installation of the platform foundations. Information on the effects of noise emissions on fish fauna can also be found in Chapter 4.4.1. It is expected that the fish will return to the area once the installation work has been completed. Furthermore, sediment turbulence and turbidity plumes are created during the construction of the platforms. Information on the effects of turbidity plumes and sedimentation on fish can be found in Chapter 4.4.1. No significant adverse effects on the fish community are to be expected.

Installation-related

- Use of marine space
- Introduction of hard substrate

The construction of the foundations for the platforms and the scour protection will overbuild local habitats. The construction of platforms changes the structure of the seabed by introducing new hard substrate (foundations, scour protection). Explanations can be found in Chapter 4.4.1.

In summary, it can be concluded that, according to the current state of knowledge, the planned platform sites are not expected to have a significant adverse effect on the protected asset fish.

4.6.3. Subsea cables

According to the current state of knowledge, the areas of the planned submarine cable routes do not represent a favoured habitat for any of the fish species protected under the Habitats Directive. As a result, the fish population in the planning area is of no particular ecological relevance.

The construction-, installation- and operation-related impacts of the subsea cables on the fish fauna are limited in terms of space and time.

Construction-related

- Noise emissions
- Sedimentation and turbidity plumes

During the construction phase of subsea cables, noise and vibrations are caused by the use of ships and cranes as well as by the installation of the cable systems. Information on the effects of noise emissions on fish fauna can be found in Chapter 4.6.1. As described in detail above, the fish are expected to return to the area once the installation work has been completed.

Furthermore, construction-related turbidity plumes can occur near the bottom, and localised sediment relocation can take place. The ecological effects on fish are described in detail in Chapter 4.6.1.1. No significant adverse effects on the fish community are to be expected.

Installation-related

- Use of marine space
- Habitat change as a result of cable crossings

In the long term, a loss of habitat is to be expected as a result of the construction of the rockfill in the area of the planned cable crossings, and a local change in the fish community is to be expected. Explanations on the effects of the use of marine space and newly introduced hard substrate can be found in Chapter 4.4.1.

Operation-related

- Heating of the sediment
- Electric/electromagnetic fields

Heating of the sediment

Regarding sediment warming in the immediate vicinity of the cables, Planning principle 6.4.8 of the Site Development Plan 2024 states that any potential adverse effects on the marine environment resulting from cable-induced sediment warming should be reduced as far as possible when laying subsea cables.

The “2 K criterion”, which defines a maximum tolerable temperature increase of the sediment by 2 degrees (Kelvin) at a sediment depth of 20 cm, must be observed as a precaution for nature conservation. According to Section 17d, para. 1b EnWG, greater warming is permissible if it does not last more than 10 days per year or affects less than 1 km of the length of the offshore connecting cable. Taking into consideration the planning principle, no significant adverse effects on the fish community are to be expected.

Electric / electromagnetic fields

When operating subsea cables, the generation of magnetic fields cannot be ruled out. Direct electric fields do not occur in a significantly measurable way in either the direct current or the AC subsea cables. Magnetic fields of the individual cable systems largely cancel each other out in the bipolar (supply and return conductors) or three-wire cable configurations. Modelling for DC subsea cables resulted in values of 11 to max. 15 µT at the seabed surface (PGU 2012a, PGU 2012b). In comparison, the Earth’s natural magnetic field is 30 to 60 µT depending on location. Because of the lower load current and the three-wire technology, a weaker magnetic field can be assumed for three-phase cable systems than for DC cable systems. Values of less than 10 µT can be expected for three-phase cables. The strongest magnetic fields occur directly above the cable system. The strength of the fields decreases relatively quickly with increasing distance from the cable system. Orientation to the Earth’s magnetic field has been documented for a number of fish species, especially migratory species such as salmon and river eel. These species can perceive electric fields, which in some cases can lead to behavioural changes (Marhold & Kullink 2000). However, a possible adverse effect on the orientation behaviour of adult specimens of species that use electric or magnetic fields for orientation is at most short-term because fish rely on different environmental parameters that interact to provide orientation. Behavioural changes were detected in the immediate vicinity of the cable; however these mesocosm investigations did not allow any conclusions to be drawn about positive or negative effects of EMFs on elasmobranchs (Gill et al. 2009). Van Hal et al. (2022) also found no negative effects of cables on the abundance of flatfish and elasmobranchs studied. The current state of knowledge suggests that electric fields influence the behaviour of cartilaginous fish; however, there is still no clear evidence of negative effects of EMFs from OWF cables (e.g. Öhman et al. 2007, Svendsen et al. 2022). Because research on this topic is still in its infancy (cf Gill & Desender 2020, Taormina et al. 2018, Hermans et al. 2023), this aspect will also be considered.

The effects of electrical or electromagnetic fields are expected to be localised and permanent. If the installation depth is sufficient, EMFs will occur only at a low level, and the effects will be very small-scale. A significant adversely affect on the fish fauna is therefore not to be expected.

4.7. Marine mammals

4.7.1. Areas and sites

The overall effects of WT on marine mammals through the designation of the areas and sites for wind energy is expected to be insignificant. This also applies to a cumulative view. The function and importance of the areas and sites in the German EEZ of the North Sea for harbour porpoises were assessed in Chapter 2.8.4 according to the current state of knowledge.

Construction-related impacts

Threats can be caused to harbour porpoises, grey seals and harbour seals because of noise emissions during the construction of offshore wind turbines 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 noise, which occurs when driving piles with hydraulic hammers, has been well investigated. The current state of knowledge about impulse noise makes a major contribution to the development of technical noise mitigation systems. In contrast, the current state of knowledge on the input of continuous noise as a result of the installation of foundation pillars using alternative methods is quite limited. All installations are monitored.

In 2011, the Federal Environment Agency (UBA) has already recommended compliance with noise emission values during the construction of foundations for offshore wind turbines. The sound exposure level (SEL) outside of a circle with a radius of 750 m around the pile driving or insertion point must not exceed 160 dB (re 1 µPa²s). The maximum peak sound pressure level must not exceed 190 dB (re 1 µPa) if possible. The UBA recommendation does not include any further substantiation of the SEL noise protection value (https://www.umweltbundesamt.de/publikationen/empfehlung-von-laermschutzwerten-bei-errichtung-von, as of: May 2011, last accessed March 2024).

The noise emission value recommended by the UBA has already been developed through preliminary work by various projects (UNIVERSITY OF HANOVER, ITAP, FTZ 2003). For precautionary reasons, “safety margins” were taken into consideration (e.g. for the previously documented inter-individual variation in hearing sensitivity) and above all because of the problem of repeated exposure to loud sound impulses such as the ones that will occur when foundations are being rammed (ELMER et al., 2007). Pile driving operations, which can last several hours, are much more potentially damaging than a single pile driving operation. It currently remains unclear what kind of deduction should be applied to the aforementioned threshold value should be applied to a series of individual events. A reduction of 3 dB to 5 dB for each tenfold increase in the number of pile driving pulses is being discussed among experts. Because of the uncertainties in the assessment of the exposure time shown here, the threshold value used in approval practice is stricter than the threshold value proposed by SOUTHALL et al. (2007) for cetacean species that have good hearing in the high-frequency range.

The scientific findings that have led to the recommendation or designation of noise emission values are mainly based on observations of other cetacean species (SOUTHALL et al. 2007, SOUTHALL et al. 2019, SOUTHALL et al. 2021) or on experiments on harbour porpoises in captivity using air guns or air pulsers (LUCKE et al. 2009).

Results concerning the acoustic resilience of harbour porpoises have been obtained as part of the MINOSplus project. After sonication with a maximum peak sound pressure level (Lpk-pk) of 200 dB re 1 µPa and a sound exposure level of 164 dB re 1 µPa²/s, a temporary threshold shift (TTS) was detected for the first time in a captive animal at 4 kHz. It was also shown that the auditory threshold shift lasted for more than 24 h. Behavioural changes were already registered in the animal at a sound pressure level of 174 dB re 1 µPa (Lucke et al. 2009). However, in addition to the absolute volume, the duration of the signal also determines the effects on the exposure limit. The exposure limit decreases as the duration of the signal increases (i.e. damage to the hearing of the animals can occur in the event of prolonged exposure – even at lower volumes) (Kastelein et al. 2021).

As part of the preparation of a measuring instruction for the survey and assessment of underwater noise from offshore wind farms, the BSH has substantiated the stipulations from the UBA recommendation (UBA 2011) and the findings of the research projects with regard to noise protection values and standardised them. In the instruction for measuring underwater sound of the BSH, the SEL05 value is defined as the assessment level (i.e. 95% of the measured individual sound exposure level must be below the statistically determined SEL05 value) (BSH 2011).

In the overall assessment of the technical information available, the BSH therefore assumes that the sound exposure level (SEL05) outside a circle with a radius of 750 m around the pile driving or installation site may not exceed the value of 160 dB (re 1 µPa²s) in order to be able to exclude adverse effects on harbour porpoises with the necessary certainty.

Without the use of noise mitigating measures, significant adverse effects on marine mammals during the pile driving of the foundations cannot be ruled out (see Chapter 5.7.1.2 for noise mitigating measures).

A basic requirement of the current assessment practice is also applied in the strategic environmental assessment of the draft 2024 site development plan with regard to the impact factor noise: Prohibited offences under species protection law are not fulfilled if the threshold values of the noise protection concept of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (2013) are complied with. The test parameters for wind turbines set out in Chapter 1.5.5 stipulate maximum pile diameters of 14–18 m in Scenario 2 of Zones 3 through 5. In general, the larger the pile diameter, the greater the sound input. The pile diameters from Scenarios 1 and 2 for Zones 3 to 5 have not yet been used in practice. It is not possible to make a reliable forecast of the diameter up to which the noise limits can be complied with. The BSH currently assumes that with increasing pile diameters as described in the upper limit of Scenario 1 and the pile diameters in Scenario 2 (see Table 2 in chapter 1.5.5), further technical developments with regard to noise mitigation systems and alternative foundation methods are necessary. Empirical data and experience with noise protection measures are included at all times. However, this can only be finalised once the planning parameters have been established. Part of the planning documents is a noise forecast with specific pile diameters (usually the maximum planned diameter). As soon as the planning parameters have been specified, the operator must submit a noise protection concept designed for this purpose; this should plausibly demonstrate the application of noise mitigation measures to comply with the threshold value. This is to ensure that the threshold value set in the noise protection concept of the BMU are complied with. Only under the condition that these threshold values are adhered to can prohibited offences under species protection law be ruled out.

Other marine mammals

In principle, the considerations listed in detail for harbour porpoises regarding noise pollution from construction and operational activities of offshore wind turbines apply to all marine mammals otherwise occurring in the sites of Zones 4 and 5. However, dependent on the species, hearing thresholds, sensitivity and behavioural responses vary significantly among marine mammals. The differences in the perception and analysis of sound events among marine mammals are based on two components: On the one hand, the sensory systems are morphoanatomically and functionally species-specific. As a result, marine mammal species hear and react to sound differently. On the other hand, both perception and reaction behaviour depend on the respective habitat (KETTEN 2004). The context-related perception and response of marine mammals has also been used in recent studies to develop threshold values (SOUTHALL et al. 2021).

Harbour seals are generally considered tolerant of sound activities, especially in the case of an abundant food supply. However, telemetric investigations have shown flight reactions during seismic activity (RICHARDSON 2004). In the case of white-beaked dolphins, which have occasionally been found in the German EEZ and in the investigation area of the sites considered here, the BSH assumes that the statements on harbour porpoise are transferable. This is because the hearing ability of white-beaked dolphins is similar to that of harbour porpoises (Nachtigall et al., 2008).

According to the current state of knowledge, operational noises from the wind turbines do not have significant effects on highly mobile fauna such as marine mammals. In addition, the investigations carried out as part of the operational monitoring for offshore wind farms have so far given no indications of avoidance by wind farm-related maritime traffic. So far, avoidance has been observed only during the installation of the foundations; this could be related to the large number and varying operating conditions of vehicles on the site.

Any operation-related impacts are limited to the immediate vicinity of the installation and depend on noise propagation in the specific area and, not least, on the presence of other sound sources and background noise such as maritime 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 off shore wind turbines (LUCKE et al. 2007). Current results from the monitoring of underwater noise in offshore wind farms and their surroundings also show that the noise emissions from the operation of the installations are not clearly distinguishable from the background noise after a distance of just a few hundred metres. At a distance of only 1 km from the wind farm, higher sound levels are always measured than in the centre of the wind farm. The standardised measurements of the continuous sound input as a result of the operation of the wind farms have shown that the underwater noise emitted by the installations cannot be clearly distinguished from other sound sources (e.g. wave sounds or ship noises) even at short distances. The wind farm-related maritime traffic was also hardly differentiated from the general ambient noise, which is introduced by various sound sources such as other maritime 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 that various natural sound sources such as wind and waves (permanent background noise) can be detected in the water over a broad band and contribute to the broadband permanent background noise.

In the measuring instruction for recording and analyses of underwater sound (Federal Maritime and Hydrographic Agency, 2011), a level difference of at least 10 dB is required between pulsating and background noise for a technically unambiguous calculation of impulse noise during pile driving. On the other hand, for the calculation or assessment of continuous sound measurements there is no minimum requirement in this respect because of a lack of experience and data. Within the airborne sound range, a level difference of at least 6 dB is required between plant and background noise in order to achieve an unambiguous assessment of installation noise and operating noise. If this level difference is not achieved, a technically unambiguous assessment of the installation noise is not possible, or the installation noise is not clearly distinguishable from the background noise level.

The results from the measurements of underwater noise that are available show that a 6 dB criterion such as this based on airborne sound can be fulfilled only in the close proximity to one of the installations at most. However, this criterion is no longer fulfilled even a short distance from the edge of the wind farm. As a result, from an acoustic point of view, the sound emitted by the operation of the installations outside the project areas does not clearly differ from the existing ambient noise.

As part of a research project commissioned by the BSH (R&D project “OWF Noise”), the data from the underwater noise measurements at all wind farms in operation were evaluated and subsequently assessed (Bellmann et al., 2023). The results from the research project to date have confirmed the following:

- The construction of the foundation (e.g. monopile, jacket) apparently has no influence on the sound radiated. Monopile wind turbines are no louder or quieter than other foundation types.
- Gearless wind turbines may be somewhat quieter than installations with gearboxes but at least not louder.
    - Nominal capacity of the WT: An increase of the sound level with the nominal capacity was not detected. On the contrary, in the range from 2 MW to 8 MW, there is a tendency for the level to drop by 2 to 3 dB.

The biological relevance of continuous sound on marine species, particularly the harbour porpoise, has not yet been conclusively clarified. However, it can be assumed that the installation-related operational noise from offshore wind farms does not cause significant disturbance to harbour porpoises because most of the sound emitted is outside the hearing range of harbour porpoises. Continuous noise is the result of emissions from various anthropogenic uses as well as from natural sources. Reactions of fauna in the immediate vicinity of a source such as a moving vessel 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 that were not observed in the immediate vicinity of noise sources can no longer be assigned to a specific source.

The vast majority of behavioural changes are the result of a wide range of effects. Noise can be a possible cause of behavioural changes. However, behavioural changes are primarily driven by the survival strategies of the fauna to capture food, escape predators, and communicate with conspecifics. For this reason, behavioural changes always occur in a situational way and in a different form.

References to possible changes in behaviour resulting from ship noise are found in the literature (WISNIEWSKA et al. 2018, BENHEMMA-LE GALL et al. 2021), the results of which, however, are based on a very small sample size and thus on a single animal reaction (WISNIEWSKA et al. 2018) or cannot be transferred to the construction sites including noise protection measures in the German EEZ (BENHEMMA-LE GALL et al. 2021). Thus, conclusions about the significance of behavioural changes resulting from these two studies are not concrete. The significant of a potential disturbance caused by service traffic is therefore not based on the individual, which may well show avoidance reactions to an approaching vessel, but rather on the adverse effect on the entire population. In this sense, according to the current state of knowledge, no significant disturbance resulting from service traffic can be assumed.

In the “Cumulative effects” chapter of the environmental report on SDP 2023, an analysis of service traffic (without including UW noise data) was carried out, an analysis of service traffic in the EEZ was carried out or described as an example for the months of July 2019 and December 2019, which are representative of the summer and winter months and the associated service traffic. Non-offshore wind farm-related traffic accounts for 70% of total maritime traffic in summer and 80% in winter. Overall, the spatial distribution varies greatly because the proportion of service traffic is consequently much higher near wind farms than on major shipping routes.

A noise-related analysis of maritime traffic (including service traffic) as included for the first time in the Environmental Report of SDP 2023 is discussed below. UW noise measurements from the periphery of operating wind farms were used for this purpose (see Chapter 4.18). From the data, there is no clearly recognisable pattern; however, the stations differ depending on the season, and there are marked differences between the years. Stations located in the immediate vicinity of OWFs (e.g. ALB_HS, N6, N3_nord) are in part less affected by sound inputs compared with stations that are not located near OWFs or near shipping routes (e.g. N9, Westl. N2 2018, SN5, German Bight Western Approach – GBWA); however, some of the sound inputs are also similar (ALB_HS, N6 vs Westl. N2 2021). Further effects with concrete AIS data in the measurement periods are necessary here in order to be able to make clearer statements. In general, the stations in offshore wind farms are in any case no louder than stations in shipping routes. It can thus not be assumed that service traffic or operational noise alone has a significant influence on the distribution of harbour porpoises. Various influences such as season and food availability are probably decisive here. The results are presented in Chapter 4.17.3 in Figure 51.

The monitoring results from the operation of the offshore wind farms in the German EEZ of the North Sea and further study data and the current state of knowledge also give no indication of avoidance or behavioural changes that would suggest significant disturbance from the operation of the offshore wind farm.

In areas with a high occurrence of harbour porpoises, there are offshore wind farm sites that are frequented both before construction and during operation of the offshore wind farm. This result applies both to wind farms located within the main distribution area of the harbour porpoise in the German Bight – such as “Butendiek” – as well as to wind farms in areas outside the main distribution area such as the monitoring of the offshore wind farms “Deutsche Bucht”, “VejaMate”, and “BARD Offshore 1” (PGU, 2021). For example, the findings from 2014–2021 as part of the monitoring of the operating phase of the three offshore wind farms “BARD Offshore 1”, “Veja Mate” and “Deutsche Bucht” support the assumption that the operation of the offshore wind farms, including service traffic (by supply and maintenance vehicles), has no effects on either the abundance and distribution or the habitat use of the harbour porpoise. For example, the acoustic survey shows higher detection rates of harbour porpoise in the wind farm sites than outside the wind farms (PGU 2021).

Results of a study on habitat use of offshore wind farms by harbour porpoises in operation from the Dutch offshore wind farm “Egmont aan Zee” confirm this observation. With the help of the acoustic survey, the use of the area of the wind farm and/or of two reference areas by harbour porpoises was considered before the construction of the installations (benchmark assessment) and in two consecutive years of the operating 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 operating phase compared to the activity or use during the benchmark assessment (SCHEIDAT et al. 2011). The increase in harbour porpoise activity within the wind farm during operation significantly exceeded the increase in activity in both reference areas. The increase in use of the wind farm area was significantly independent of seasonality and interannual variability. The authors of the study see a direct correlation between the presence of the installations and the increased use by harbour porpoises. They suspect the causes to be factors such as an enrichment of the food supply resulting from a “reef effect” or calming of the area because of the absence of fishery and intensive shipping or possibly a positive combination of these factors.

The results from the investigations during the operating phase of the “alpha ventus” project also indicate a return to distribution patterns and abundances of harbour porpoises that are comparable – and in some cases higher – than those from the 2008 benchmark assessment.

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). The acoustic survey in the immediate vicinity of platforms have 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 be attractive to marine mammals.

With regard to harbour seals and grey seals, there is also no evidence from monitoring of the operating phase of existing offshore wind farms in the EEZ that indicates avoidance of the sites or aversive changes in behaviour.

According to the current state of knowledge, no avoidance reactions of marine mammals by wind farms or significant adverse effects at the population level can be derived from the current development. Large-scale and continuous monitoring to survey potential changes at the population level as a result of the ongoing expansion must ensure that there are no negative effects on the marine environment during the expansion. This is in line with the view expressed in the current WinMon report by the Belgian authorities (DEGRAER et al., 2023).

4.7.2. Platforms

The explanations under Chapter 4.7.1 can also be applied to platforms.

4.7.3. Subsea cables

During the installation phase, which is limited in time and space, short-term deterrent effects of individual animals may occur as a result of construction-related maritime traffic. However, these effects do not go beyond the disturbances generally associated with slow ship movements. Possible changes in sediment structure and associated temporary and spatially limited benthic changes do not have significant effects on marine mammals because they search for their prey in widely extended areas.

Operation-related sediment warming has no direct effects on highly mobile fauna such as marine mammals. The influence of electromagnetic fields from subsea cables on the migration behaviour of marine mammals is largely unknown (GILL et al. 2005). However, because the strength of the magnetic fields that occur is considerably lower than the strength of the Earth's natural magnetic field, no significant effects on marine mammals are to be expected.

4.8. Seabirds and resting birds

The individual parts of the North Sea are of varying importance for seabirds and resting birds. The areas and sites defined in the SDP are of no particular importance for breeding birds because of the distance to the coast and to the islands with the breeding colonies as a foraging ground. Protected bird species listed in Annex I of the Birds Directive (Directive 2009/147/EC) occur in varying densities in the areas and sites defined by the SDP and their surroundings. For seabirds, including species listed in Annex I of the Birds Directive, all findings to date indicate a medium, sometimes species-specific, seasonally high importance of sites N-14 to N-20 as well as within the expansions of Areas N-9, N-11, N-12 and N-13 now defined in comparison to the SDP 2023.

4.8.1. Areas and sites

Construction-related

During the construction of offshore wind turbines, effects on seabirds and resting birds are to be assumed (e.g. DIERSCHKE & GARTHE 2006); however, the nature and extent of these effects are limited in time and space.

Species sensitive to disturbance may react to the construction site or construction traffic with avoidance behaviour. The installation process can create turbidity plumes in the water; these can make foraging more difficult in terms of time and space. Attraction effects caused by the illumination of the construction site and the construction site vehicles cannot be ruled out.

Because of the temporal and spatial limitation of the construction work and the high mobility of seabirds and resting birds, significant effects can be ruled out.

Operation-related and installation-related

Constructed 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). The extent of such incidents to date is not easy to quantify because it is assumed that a large proportion of the colliding birds do not collide with a fixed structure (HÜPPOP et al. 2006). The collision risk of a species is determined by factors such as manoeuvrability, flight altitude, and proportion of time spent flying (GARTHE & HÜPPOP 2004). The collision risk for seabirds and resting birds must therefore be assessed differently depending on the species.

During the operating phase of the wind farms, species-sensitive species can be expected to avoid the wind farm sites to a species-specific extent. As a result of the restriction of fishery on the sites, which is to be expected based on the legal framework and previous practice, it is possible that fish populations will recover during the operating phase. In addition to the introduction of hard substrate, the species composition of the fish occurring could therefore increase and provide an attractive food supply for foraging seabirds.

The relevant height parameters of the installations are an important key figure for assessing the possible risk of collision for seabirds and resting birds with offshore wind turbines. In line with current technical developments with regard to the dimensions of future wind turbines, two scenarios for Zones 3 to 5 are examined. These take into consideration possible relevant turbine parameters (cf Chapter 1.5.5 as well as the draft scope of the Strategic Environmental Assessment for the German Exclusive Economic Zone of the North Sea and Baltic Sea published on 1 September 2023). In accordance with Scenario 1, wind turbines with a hub height of 150 m and a rotor diameter of 240 m would be used; these would thus reach a total height of 270 m. According to Scenario 2, these would be wind turbines with a hub height of 210 m, a rotor diameter of 350 m, and a total height of 385 m. This means that the lower rotor-free area from the water surface to the lower rotor blade tip would be 30 m in Scenario 1 and 35 m in Scenario 2.

As part of StUKplus, the "TESTBIRD" project used rangefinders to determine the flight altitude distribution of seven species of seabirds and resting birds. The larus gull species herring gull, lesser black-backed gull, and greater black-backed gulls flew at altitudes of 30–150 m in most of the flights recorded. Species such as black-legged kittiwake, common gull, little gull, and gannet, on the other hand, were observed mainly at lower altitudes up to 30 m (MENDEL et al. 2015). A recent study at the Thanet Offshore Wind Farm in England investigated the flight height distribution of Northern gannet, black-legged kittiwake, and the large larus gull species like Herring gull, greater black-backed gull, and lesser black-backed gull, also using the rangefinder (SKOV et al. 2018). The flight altitude measurements of larus gulls and gannets were comparable to the altitudes determined by MENDEL et al. (2015). The black-legged kittiwakes, on the other hand, were observed mostly at an altitude of about 33 m.

In general, great 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), which investigated not only the flight altitude but also the immediate, small-scale, and large-scale evasive behaviour of the species considered. Furthermore, the investigations using radar and thermal imaging cameras revealed low nocturnal activity. The risk of collision at night as a result of attraction effects caused by the illumination of the wind turbines can therefore also be assessed as low.

The risk of collision is estimated to be quite low for disturbance-sensitive species such as red-throated diver and black-throated diver because they do not fly directly into or near the wind farms because of their avoidance behaviour (BIOCONSULT SH et al. 2020, GARTHE et al. 2018).

The terns, which are listed in Appendix I of the Birds Directive, are also not endangered by collisions with the installations because they prefer low flight altitudes and are extremely agile flyers (GARTHE & HÜPPOP 2004).

Overall, an increased risk of collision for seabird and resting bird species is not to be assumed with the realisation of the wind turbines specified in Scenarios 1 and 2 for Zones 3 to 5 on the sites in these zones.

During the operating phase of the wind farms, species-sensitive species can be expected to avoid the wind farm sites to a species-specific extent. Red-throated divers and black-throated divers show pronounced avoidance behaviour towards offshore wind farms. A recent study conducted by the FTZ on behalf of the BSH and the BfN, which took into consideration data from wind farm monitoring in the EEZ as well as research data and data from Natura 2000 monitoring, determined a statistically significant decrease in diver abundance up to 10 km from the periphery of a wind farm and reduced abundance up to 24 km across all built-up areas in the EEZ (Garthe et al. 2018, 2023). This was also the conclusion of a study commissioned by the BWO, which used a modified data source and different statistical analysis methods than the FTZ study (BIOCONSULT SH et al. 2020). Both studies do not show total avoidance, but partial avoidance with increasing diver densities up to 10 km from a wind farm. As a result, the spatial distribution of divers within the main concentration area of divers has changed and is less extensive after the construction of OWFs within and on the edge of the main concentration area with a concentration point at the greatest possible distance from the OWFs. Both studies confirm the continuing high importance of the main concentration area harbour for divers (BIOCONSULT SH et al. 2020, GARTHE et al. 2018). Even after extending the data time series of the study conducted on behalf of the BWO by a further three years until 2021, the study by BioConsult SH et al. (2022) comes to the following conclusion: “Between the years, the diver population in spring fluctuated without a trend, and the population size was stable between 2001 and 2021”. The study by Garthe et al. 2023 also calculated a reduced individual density within a 10 km radius of the OWF of 29–68% for the various OWF clusters and 52% for all clusters taken together.

In order to quantify the habitat loss, early decisions concerning the project approval procedure were based on a shooing distance of 2 km (defined as complete avoidance of the wind farm site including a 2 km buffer zone) for divers. The assumption of a habitat loss of 2 km was based on data from the monitoring of the Danish wind farm “Horns Rev” (PETERSEN et al. 2006). The study by GARTHE et al. (2018) shows more than a doubling of the shooing distance to an average of 5.5 km. This shooing distance, which is also known as calculated total habitat loss, is based on the purely statistical assumption that no divers occur within 5.5 km of an offshore wind farm. The study commissioned by the BWO showed a calculated total habitat loss (‘theoretical habitat loss’) of 5 km for wind farm projects in the entire area of investigation under consideration and therefore provided a comparable result. In the individual consideration of a northern and a southern sub-area, a calculated total habitat loss of 2 km in the southern sub-area indicated that there were regional differences. For wind farm projects in the northern sub-area, which includes the main concentration area harbour, the overriding value of 5 km was confirmed (BIOCONSULT SH et al. 2020).

Investigations conducted as part of the operational monitoring of the OWFs located in the main concentration area for divers revealed clear avoidance reactions on the part of the divers. In the “Nördlich Helgoland” cluster, a avoidance distance of up to approx. 10 km from the wind farms was determined in the years of investigation 2015–2021 (IBL et al 2021). Divers were observed only sporadically in the vicinity or in the wind farms. Within the OWFs, the maximum was seven individuals out of 546 divers in the observation area in the year of investigation 2020. The last calculated average distance based on data from spring 2021, the season with the highest occurrence, was 8.6 km (interval 7.4–11.7 km). The continuation of the operational monitoring for the protected asset divers in 2022 and 2023 also shows the aforementioned main area of distribution of divers (cf BIOCONSULT SH et al. 2020, 2022) in spring at the greatest possible distance from the nearest OWFs (Bioconsult SH 2022a,b, 2023). The effect ranges most recently determined in the operational monitoring of the Butendiek OWF were between 4 and 8 km in years of investigation 2021 to 2023. An average disturbance effect of the wind farm of up to around 6 km can thus be assumed. In the first four years of investigation, the effect range was up to 10 km. The main factor explaining the distribution of divers appears to be the wind farm, which is supported by the overall very low numbers of divers within the wind farm boundaries and the gradual increase with increasing distance from the OWF. The baseline surveys prior to the start of construction showed that the sighting rates of divers within the planned wind farm site were just as high as outside the site (considered up to 16 km away). Statements on the conservation status of the diver population cannot be derived from this.

No clear findings on the avoidance behaviour of divers towards operating wind farms are available from the Area N-8, which is being investigated as part of the “Östlich Austerngrund” cluster investigations. The experts attribute this to the low numbers of diver sightings in this area of the EEZ, which is not part of the feeding and preferred habitat of divers because of the area and surrounding characteristics (IBL UMWELTPLANUNG et al. 2018b). Also for the investigations accompanying the construction of the OWF projects in the “Östlich Austerngrund” cluster, it has so far not been possible to statistically prove avoidance effects. However, the experts do not completely exclude avoidance effects of the cluster on divers but assume that these are not detectable because of the naturally low diver occurrence and the small scale of the areas of investigation (IBL UMWELTPLANUNG et al. 2019b, IBL UMWELTPLANUNG et al. 2020b). It can be assumed that further investigations will provide a clearer picture of the avoidance behaviour of divers in this area of the EEZ.

According to the analysis of flight and ship survey data from five years of operation of the OWF “Butendiek”, terns can be assumed to avoid the OWF site. There is also a weak partial avoidance of the surrounding area up to 2 km (BIOCONSULT SH 2022). With the investigation results from the operating phase of the wind farm cluster “North of Borkum”, the calculated avoidance distance is between 0.6 km for ship surveys and 1.4 km for flight surveys (IFAÖ et al. 2020). In the operational monitoring of the OWF “Global Tech I” in the cluster “Östliche Austerngrund”, no statistically significant avoidance effect was recorded. This is due mainly to the low numbers of individuals recorded, which do not allow a reliable statistical detection of significant avoidance effects (IBL UMWELTPLANUNG et al. 2018a).

For the guillemot, which is widespread in the German North Sea, previous findings indicate that reactions to offshore wind farms depend on a number of factors. DIERSCHKE et al. (2016) compiled findings on the behaviour of seabirds from 20 European wind farms. From the studies that were taken into consideration, it was found that guillemots appear to react differently depending on the location of an offshore wind farm. In the wind farms considered, complete avoidance of the OWF area, partial avoidance behaviour up to adjacent areas or no avoidance behaviour at all was observed (DIERSCHKE et al. 2016). The authors attribute these differences to food availability at the respective location. MENDEL et al. (2018) add a seasonal aspect to the avoidance behaviour of guillemots. Using digital aerial transect surveys in the area north of Heligoland, the authors found differences in the avoidance behaviour before and during the breeding season. In spring, for example, a significant reduction in density up to 9 km from the wind farm projects north of Heligoland was observed, whilst no effect radius was found during the breeding season. MENDEL et al. (2018) link these differences to the reduced range and attachment to the breeding colony on Heligoland during the breeding season. In spring, however, guillemots are independent of a specific range and generally show a more westerly distribution (MENDEL et al. 2018). The results of MENDEL et al. (2018) were scientifically published by PESCHKO et al. (2020, 2020a). An ongoing update of the study by GARTHE et al. (2018) commissioned by the Federal Agency for Nature Conservation with an extension of the species composition considered provides indications of significant avoidance effects for guillemot, razorbill, gannet, and fulmar and a variable response of black-legged kittiwake and lesser black-backed gull for species-specific seasons. The initial results of these evaluations were presented at the Marine Environmental Symposium on 19 May 2022 (GARTHE et al. 2022). In addition to data source from the environmental monitoring of offshore wind farms in the German EEZ of the North Sea, the data sources also include scientific research data and data from seabird monitoring commissioned by the Federal Agency for Nature Conservation. Until the study is completed, additional factors that may influence the distribution of seabirds and resting birds will be included in the analysis. The results of GARTHE et al. 2022 for the common guillemot were scientifically analysed and published in PESCHKO et al. 2024. The study found that guillemot density is significantly adversely affected in autumn within an average radius of 19.5 km (18–21 km) from the wind farm boundary. The density in this area is reduced by an average of 79%, within a 10 km radius by an average of 76%, within a 5 km radius by an average of 80%, and within a 1 km radius by an average of 91%. In winter, the effect was less far-reaching and strong: the density was reduced by an average of 51% in a radius of up to 16.5 km (15–18 km). Based on these mean radii and the modelled distribution of guillemots in the German EEZ, the study by PESCHKO et al. 2024 concludes, among other things, that an estimated 69% of the autumnal common guillemot occurrence in the German EEZ would be affected by potential habitat loss if offshore wind energy in the EEZ of the North Sea were to be developed in line with ROP 2021.

For razorbill, gannet, and fulmar, the evaluations of GARTHE et al. (2022) also show significant avoidance distances but only up to 3 km, for fulmar up to 6 km from the wind farm. In general, the effect size (i.e. what percentage of individuals were affected by habitat loss) revealed a dependence on the season. This seasonality as well as a seasonality of response (avoidance, attraction, indifferent behaviour) was also evident in the kittiwake and the lesser black-backed gull. For the latter species, avoidance effects were found up to 15 km away in summer, whilst an attraction effect was found up to 3 km away in autumn. Kittiwakes were also found to be attracted in winter – also up to 3 km away. In contrast, the species showed an avoidance reaction in the same radius of action in spring. A study with radio-tagged gannets showed that breeding individuals cross OWF in search of food or on their way to foraging areas but avoid doing so outside the breeding season (PESCHKO et al. 2021).

More recent investigations from the operating phases of German offshore wind farms confirm the small-scale avoidance behaviour previously observed in these offshore wind farms in terms of partial avoidance by the gannet, the guillemot, and the razorbill as well as for the little gull (IFAÖ et al. 2020, PGU 2021, BIOCONSULT SH 2022).

Thus, in the fifth year of the operating phase of the “Butendiek” OWF, for the species guillemot and razorbill, which were analysed together as auks, an avoidance distance of about 4 km was calculated based on the flight and ship survey results. The avoidance range determined after ship survey was between 2.8 and 5.4 km, whilst that determined after aerial survey was between 3.4 and 6.4 km (BIOCONSULT SH 2022). The distance calculated for the gannet ranges from 2.2 km for ship observations to 3.4 km for flight surveys; for the little gull, it ranges from 4.3 km (flight surveys) to 3.2 km (ship surveys; BIOCONSULT SH 2022). Comparable values resulted from the investigations on the “Östliche Austerngrund” cluster from the operational monitoring for the “Global Tech I” OWF (IBL UMWELTPLANUNG et al. 2018a): For gannets, significant avoidance effects were found between 2 km (ship surveys) and 3.4 km (aerial transect surveys). For little gulls, significantly lower densities were observed up to 3 km from the OWF compared with outside this range; however a robust avoidance distance was not estimated (IBL UMWELTPLANUNG et al. 2018b). Also, for the species guillemot and razorbill, which were analysed together, it was not possible to determine avoidance distance by means of statistics. However, significantly lower densities were observed up to 6 km and increasing densities at greater distances from the OWF (IBL UMWELTPLANUNG et al. 2018b). Investigations from the operating phase of the wind farm cluster “North of Borkum” indicate a lower use of the wind farm areas in the operating phase for the little gull; furthermore, an avoidance reaction is not clearly recognisable (IfAÖ et al. 2020). For the gannet, the joint observation of the flight and ship surveys made it possible to statically determine a range of up to 2 km. For the species guillemot and razorbill analysed together as auks, the different analysis methods in the cluster “Nördlich Borkum” indicate an avoidance range of up to at least 4 km; it was not possible to calculate avoidance distances. During the construction and operating phase, razorbills, guillemots, and gannets were observed in lower densities within the OWFs of “Cluster 6”; there was also as an increase in densities with increasing distance to the wind farm from 1 km distance (PGU 2021a). Little gulls were not detected within the OWFs but rather directly in the immediate vicinity of the projects.

In the individual consideration of the more recent findings from OWF monitoring in the German EEZ, the avoidance effects – at least for the guillemot and gannet – are lower than from the combined analysis of monitoring and scientific research data by GARTHE et al. (2022).

In Belgium, large numbers of gannets, razorbills, and guillemots were observed inside wind farms for the first time during the first two-day ship-based monitoring of all Belgian offshore wind farms in February 2021 (VANERMEN et al. 2021). All wind farms were in the operating phase; the most recent project went into operation at the end of 2020. The authors state that further investigations are needed in order to find out whether these observations are an episodic snapshot or the first indications of a habituation effect. A previously published study reported significant avoidance of the Belgian wind farms “Thorntonbank” and “Bligh Bank” as well as correspondingly significantly reduced numbers of gannets, guillemot, and razorbill in the immediate vicinity of the wind farm (VANERMEN et al. 2016). Both wind farms had an attraction effect on greater black-backed gulls. For three species, this was observed at only one of the two wind farms: Lesser black-backed gull, herring gull (each “Bligh Bank”) and sandwich tern (“Thornton Bank”). Black-legged kittiwakes avoided one wind farm whilst they tended to be attracted to the other. The data came from five years of operational monitoring of the “Bligh Bank” OWF and three years of operational monitoring of the “C- Power” OWF. An extension of the data series by three years confirmed the results from the OWF “Thorntonbank” (VANERMEN et al. 2019). Most recently, fewer gannets, little gulls, herring gulls, lesser black-backed gulls, herring gulls, Sandwich terns, and guillemots were recorded in the sites with wind turbines in the Belgian EEZ than in the reference site, which was more than 1 km away from the nearest turbines. There is a lack of detailed information on investigation area sizes and transect lengths as well as statistical analyses of abundance. The opposite was observed for cormorants, common gulls, great black-backed gulls, kittiwakes, and razorbills. The results are based on six vessel-based surveys between February 2021 and April 2023; the data are mean values of the surveys in the area of offshore wind farms ("concession zone (the area built with turbines)") and on sites outside ("control area outside the wind farms (> 1 km away from the nearest turbine)"; VANERMEN et al. 2023).

Monitoring at the "Robin Rigg" offshore wind farm in Scotland found no change in the abundance of the guillemot at the wind farm over the investigation period (VALLEJO et al. 2017). The investigation period covered a little more than 10 years of which the last 24 months fell on the operating phase and followed a construction phase of 18 months beforehand.

For all the above findings on avoidance effects of the species under consideration, it should be noted that these are partial avoidances and not complete avoidances up to the corresponding distances. A "calculated total loss" has so far been determined only for the diver species group (GARTHE et al. 2018).

Current findings and information from monitoring and research on the avoidance behaviour of some seabird species, in particular the common guillemot have all been incorporated into the present considerations. Overall, knowledge on the avoidance behaviour of the guillemot is heterogeneous. At the present time, there are no sufficiently concrete indications that the designations of the SDP will have a significant adverse effect on guillemots in particular and on the protected asset seabirds and resting birds in general.

In view of the avoidance distances of several kilometres identified to date for many seabird and resting bird species (this chapter), the resulting potential cumulative habitat impairment of 26% and more because of the designations of sites for offshore wind energy (Chapter 4.17.4), the drastic reductions in various populations and the negative population trends (Chapter 2.9) of some species, which, in accordance with the literature, are presumably due to various factors, and the as yet unpredictable changes caused by offshore wind energy in the North Sea ecosystem, which can or will affect seabirds and resting birds via various pathways (cf Watson et al. 2024), this assessment must be viewed taking into consideration the current state of knowledge. The assessment will be adapted to the current state of knowledge. New findings are taken into consideration both at the site investigation and approval levels as part of the tiering required according to Section 5, para. 3, sentences 5–7 WindSeeG and Section 39, para. 3, sentences 1–3 UVPG as well as in the context of updating and/or amendment procedures of the SDP according to Section 8, para. 2 in conjunction with Section 5 WindSeeG.

4.8.2. Platforms

Construction-related

Direct disturbance of seabirds as a result of deterrent effects during the construction phase of platforms is to be expected locally and for a limited time at most. Because of the high mobility of birds and the measures to be taken in the respective project approval procedure to prevent and mitigate intensive disturbance, significant effects can be ruled out with a high degree of certainty. The construction of platforms is spatially limited so that any effects such as avoidance behaviour or attraction effects by the construction vessels can occur only locally.

However, against the background of the existing pressure from maritime traffic, the effects of the construction-related traffic volume will not lead to a considerable increase in the disturbance and scaring effect. In summary, the potential disturbance or adverse effects on seabirds associated with construction operations is to be assessed as low.

Operation-related and installation-related

According to the current state of knowledge, significant effects of platforms on seabirds and resting birds during the operating phase are not to be expected. The platforms are built either in the wind farm or in the safety zone of a wind farm. This means that any effects of the platforms do not exceed the potential effects of the directly neighbouring wind farms.

Should the benthic species composition change in the area of the platforms and wind farms, this change could attract more fish and then also predators such as seabirds. However, the effects of sediment and benthic changes in the immediate vicinity of the platforms have remained insignificant for seabirds because they forage for their prey organisms predominantly in the water column in widespread areas. During the operation of the platforms, temporary deterrent effects could occur because of maritime and helicopter traffic as part of maintenance and repair work.

Offshore platforms have often been found to be used as resting places by many bird species. An attraction effect of the platforms can therefore not be ruled out for many gull species.

In addition, the SDP makes designations regarding the consideration of best environmental practice and the respective state of the art. In this context, regulations for the prevention and mitigation of negative effects on seabirds caused by the construction and operation of platforms, particularly in the form of measures to minimise pollutant and light immissions, must be established at the approval level. This corresponds to the current approval practice.

Significant effects on seabirds and resting birds resulting from the construction and operation of platforms can therefore be ruled out with the necessary certainty.

4.8.3. Subsea cables

During the installation phase, which is limited in time and space, short-term deterrent effects may occur as a result of construction-related maritime traffic. However, these effects do not go beyond the disturbances generally associated with slow ship movements. There may also be local effects on food availability from construction-related sediment and turbidity plumes or changes in sediment and benthos in the area of the crossing constructions.

4.9. Bird migration /migratory birds

During the realisation of the SDP and thus the construction of offshore wind farms, transformer stations, and converter platforms as well as the laying of the associated cables, the following general adverse effects on migratory birds may occur:

4.9.1. Areas and sites

Construction-related impacts

In the first instance, adverse effects during the construction phase may be caused by light emissions and visual disturbance. These can cause species-specific, differently pronounced deterrent and barrier effects on migrating birds. However, the lighting of construction equipment can also attract migrating birds and increase the risk of collision (REBKE et al. 2019, DIERSCHKE et al. 2021, BURT et al. 2023). Because the limited duration of the construction work, no significant effects on the protected asset migratory birds are expected.

Installation and operation-related impacts

Possible effects of offshore wind farms in the operating phase may be that they constitute a barrier to migrating birds or a risk of collision (KRIJGSVELD et al. 2009, BRABANT et al. 2015, HÜPPOP et al. 2016, WELCKER &; NEHLS 2016). The fly-around or otherwise changing flight behaviour may result in higher energy consumption, which may affect the fitness of the birds and subsequently their survival rate or breeding success (MASDEN et al. 2009, BRUST et al. 2019, KELSEY et al. 2021). For further information on potential barrier effects, please refer to Chapter 4.17.5. Collision events can occur on the vertical structures (e.g. rotors and support structures of the wind turbines). Poor weather conditions – especially at night and in strong winds – increase the risk of collision (HÜPPOP et al. 2016, MOLIS et al. 2019). In addition, there are possible glare or attraction effects caused by the safety lighting of the installations; this can lead to birds becoming disoriented (REBKE et al. 2019, DIERSCHKE et al. 2021, JÄGERBRAND & SPOELSTRA 2023). Furthermore, birds caught in wake currents and air turbulence at the rotors could be influenced in their manoeuvrability (DÜRR 2011). For the aforementioned effects, it can be assumed that the sensitivities and risks are different for each species.

As a general rule, bird migration is not threatened if there is an abstract risk of harm to individual birds migrating through an offshore wind farm. A threat to bird migration only exists if there is sufficient knowledge to justify the prediction that the number of potentially affected birds is such that, taking into consideration their respective population sizes, it can be assumed with sufficient probability that individual or several different populations will be significantly adversely affected. The biogeographical population of the respective migratory bird species is the reference point for the quantitative analysis.

There is agreement that, according to the existing legal situation, losses of individuals during bird migration must be accepted. In particular, it must be taken into consideration that bird migration in itself poses many dangers and subjects populations to harsh selection. It can be assumed that between 60 and 80% of young songbirds do not complete their first year of life (ELLE et al. 2014). For larger species, the natural mortality rate is lower. Individual species also have different reproductive rates; the loss of individuals can thus have different consequence for each species.

A generally applicable acceptance threshold for assessing the hazard potential of offshore wind farms has not yet been defined. The threshold value of 1% of the biogeographical population, which is often used by experts in avifaunistic studies of migratory waterbird species, is used as a reference value for the assessment (WAHL et al. 2007, GÜPNER et al. 2020). In the absence of other reliable criteria, this internationally recognised acceptance threshold for waterbirds, waders, and seabirds could also be used for other species groups in order to quantify the encroachment of wind farm projects. A prerequisite for the application of such a criterion is that the population sizes of the biogeographical populations (GÜPNER et al. 2020) as well as the specific number of individuals of each species affected by bird collision are known. However, the identification of collision victims in the offshore area remains a technical challenge because potential collision victims fall into the sea, and the recording systems are not currently able to assign collisions to individual species. Inevitably, the only remaining option for assessing the collision risk of migratory birds is to consider data on migration intensity and migration altitudes from existing wind farms with the relevant parameters of the new planning areas.

The relevant height parameters of the installations are an important key figure for assessing the possible collision risk for migratory birds with offshore wind turbines. For Zones 3, 4 and 5, the SDP makes assumptions of 15 to 30 MW installations with a hub height of 150 to 210 m and, based on rotor diameters of 240 m to 350 m, a total height of 270 m to 385 m. This means that the lower rotor-free area from the water surface to the lower rotor blade tip would be between 30 and 35 m (cf Table 2). The larger dimensions of potential 30 MW installations also increase the area covered by the rotor. However, this influence is reduced by the possible decrease in the number of installations.

Previous investigations of bird migration using vertical radar at the FINO1 site (2013–2019) show a concentration of migrating birds at low altitudes. According to this, most bird migration recorded by vertical radar takes place at altitudes of up to 300 m (cf Figure 48, AVITEC RESEARCH GBR 2020). This is in the hazard area of wind turbines. In autumn 2018, 30.8% of all flight movements were at altitudes of up to 100 m and 62.8% at altitudes of up to 300 m. Around 11.4% of the signals were registered at altitudes above 700 m. However, there were differences in the altitude distribution depending on the time of day. Especially in spring, bird migration was concentrated at lower altitudes during the day. During the visual observations in the spring of 2013–2019, observations of migrating birds from altitudes of up to 20 m above sea level also dominated. In spring 2018, 79.4% of all migrating birds were recorded in this altitude range during visual observations (AVITEC RESEARCH GBR 2019). However, these height profiles can vary and deviate from the respective scheme on individual migration days or nights as well as seasonally (cf Figure 48). For example, radar surveys in Area N-7 for the 2018/2019 survey year showed that the proportion of echoes below 300 fluctuated between 25% in August (2019) and 54% in November (2018) (IBL UMWELTPLANUNG GMBH et al. 2021).

Considering the low flight altitudes of diurnal migrants, most of which fly below 20 m and thus also below the lower rotor tip in accordance with the underlying bandwidths, no significant effects on diurnal migrants is to be expected from the plans in the SDP.

Taking migration behaviour into consideration, there is a particular collision risk for the nocturnal migration of small birds caused by migration in the dark, high migration volumes, and the strong attractiveness of artificial light sources (BALLASUS et al. 2009, HÜPPOP et al. 2016, JÄGERBAND & SPOELSTRA 2023).

In general, migrating birds fly higher in good weather than in bad weather (e.g. rain or poor visibility; KNUST 2003,HÜPPOP et al. 2005, WELCKER & VILELA 2019). It is also known that most birds wait for good weather for their migration decision and choose departure conditions (e.g. favourable tailwinds) so that they can fly long distances in the best possible weather (BAIRLEIN

2022). In a recent study, BRUST et al. (2019) found that individuals that stayed longer at intermediate stations along the coast tended to cross the North Sea along an offshore route rather than following the coastline. The result suggests that individuals that rested longer waited for weather conditions favourable for migration across the open sea.

Under the clear weather conditions preferred by birds for their migration, the probability of collision with wind turbines is therefore very low. In contrast, surprising fog and rain that lead to poor visibility and low flight altitudes are a potential threat situation (PANUCCIO et al. 2019). Research results obtained on the FINO1 research platform showed that most birds fly below 200 m on rainy nights. This is in the hazard area of wind turbines (cf Table 2). Furthermore, in autumn, the birds flew higher with good visibility (> 10 km) than with medium visibility (3 to 10 km) (HÜPPOP et al. 2005).

The coincidence of bad weather conditions with mass migration events is particularly problematic in such cases. According to information from various environmental impact studies, mass migration events, in which birds of a wide variety of species fly over the North Sea at the same time, occur about five to 10 times a year (WELCKER 2019, WELCKER & VILELA 2019). An analysis of all existing bird migration surveys 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 poor weather conditions at less than 1% of the migration times (WELCKER & VILELA 2019).

Based on the above statements, it can currently be concluded that the planned expansion of offshore wind farm projects on the sites in Areas N-4, N-5, N-9, and N-12 through N-19 is unlikely to have significant effects on nocturnal migratory birds. Nevertheless, despite many years of monitoring during the construction and operation of offshore wind farm projects, uncertainties remain in the assessment of the risk, particularly for the most frequently recorded group of songbirds, which primarily migrate at night. For further details, please refer to Chapter 5.2.1.2.

4.9.2. Platforms

In the clear weather conditions favoured by the birds for their migration, the probability of a collision with a converter platform is quite low because the platforms are clearly visible. Poor weather conditions increase the risk. Because the converter platforms are individual structures that are also regularly planned in the immediate vicinity of offshore wind farms, no significant adverse effects on bird migration is to be expected. It can also be assumed that negative effects during the operating phase of the converter platforms can be minimised by using lighting that is as compatible as possible and that leads to the greatest possible reduction of attraction effects. This includes, for example, the choice of suitable light intensities and spectra or lighting intervals.

Based on the above statements, it can be concluded for the SEA that the planned converter platforms are not expected to have any significant effects on migratory birds.

4.9.3. Subsea cables

Installation- and operation-related impacts of the planned subsea cables on migratory birds can be excluded with the necessary certainty. A possible risk of collision from construction vehicles can be classified as very low because of the short-term nature of the construction phase.

4.10. Bats and bat migration

During the realisation of the SDP and thus the construction of offshore wind farms, transformer stations, and converter platforms as well as the laying of the associated cables, the following general adverse effects on bats may occur:

4.10.1. Areas and sites

Construction-related impacts

Construction activities during the erection of OWT are associated with an increased volume of shipping. The lighting of the vessels and the construction site could attract bats migrating across the sea (VOIGT et al. 2018). There would then be a risk of collision with the vessels and the construction site. Because the limited duration of the construction work, no significant effects on bats are expected.

Installation and operation-related impacts

As on land, there is a potential danger for bats from flying close to wind turbines when hunting insects that are attracted by the safety lighting (HÜPPOP & HILL 2016, PETERSON 2016). This increases the collision risk or risk of being injured by rotating rotor blades. Furthermore, the manoeuvrability of bats caught in wake currents and air turbulence at the rotors could be affected. Another indirect cause of death caused by the rotating rotor blades, which is expected to result in a large number of deaths in bats, is barotrauma (DÜRR & BACH 2004, KUNZ et al. 2007, BAERWALD et al. 2008). Barotrauma is lung damage caused by pressure differences between the front and back of the rotor blades (DÜRR & BACH 2004).

Previous investigations have shown that bats, especially long-distance migratory species, fly in the area of the coastline and the North Sea islands (RYDELL et al. 2014, SEEBENS-HOYER et al. 2021, BACH et al. 2022a). However, both the number of investigations and the number of bat records over the open North Sea are low, and the current results suggest that the number of individuals decreases with increasing distance from the coast. However, because there is a lack of concrete information on migration altitudes and exact migration concentrations of the species involved (HÜPPOP et al. 2019, SEEBENS-HOYER et al. 2021), collisions or other injuries to individuals caused by turbines cannot be completely ruled out.

Nevertheless, based on the current results, it can be assumed that wind farm projects in the planning areas will not have any negative effects on the development of bat populations.

4.10.2. Platforms

The safety lighting of platforms can have an attracting effect on migrating bats (VOIGT et al. 2018). This means that it is not possible to completely rule out the risk of individual birds colliding with platforms. However, because the platforms are immobile individual structures that should be easily recognised by the echolocation of bats, a significant adverse effect on migratory bat populations can be ruled out according to the current state of knowledge.

4.10.3. Subsea cables

Potential impacts of subsea cables and pipelines on bats are limited mainly to the construction phase. Illuminated construction vehicles can cause attraction effects, which can lead to collisions. The installation work is usually only localised and takes place for a limited period of time. Significant effects on bats from the laying and operation of subsea cables can be ruled out with the required degree of certainty.

4.11. Air

The protected asset air is not affected by any project-related impact factor because no measurable effects on air quality are to be expected either during construction or operation.

With increasing intensity of use, maritime traffic in the North Sea also increases; this can have a negative influence on the air quality. However, this development is largely independent of the construction of wind farms in Zones 3, 4, and 5 because the construction and operation of the installations and the in-farm cabling would have no measurable effects on air quality in this area. Therefore, the development of the protected asset air will develop in the same way regardless of whether the construction project is carried out.

The areas and sites defined in the SDP are located at a great distance from conurbations and are characterised by good mixing conditions because of their open location. As a result, no preventive and mitigation measures are planned for the protected asset because the effects of the plan do not require any.

4.12. Climate

The protected asset climate is not affected by any project-related impact factor because no measurable climate-relevant emissions occur either during construction or operation. As a result, the project is not expected to have any significant adverse effects on the protected asset climate in the project area.

Depending on the development of future greenhouse gas emissions, climate change will continue on the sites of the EEZ. A further temperature rise is expected. Also other meteorological parameters are changing. An increase in precipitation is expected in winter, and a slight decrease is exptected in summer (Deutscher Wetterdienst, 2022). There should be no long-term trend in wind speed in the future either (Ganske et al. 2016).

A change in the wind field is to be expected when the planned wind farms are commissioned. Kinetic energy is taken from the wind field by wind turbines in operation, which leads to a reduction in the wind speed in the wind farm. This reduced wind speed continues in the wake of the wind farm. At the same time, there is also a pre-congestion effect, which leads to a decrease in the wind speed in front of the wind farm. Furthermore, turbulence increases in the wind farm and in the wake (Maas 2023).

On the other hand, the wind farms on the sites have a positive effect on the (global) climate if they replace conventional types of energy generation.

At the level of the testing of the suitability of the area, the concrete, emission-relevant parameters of a wind farm are not yet known.

No effects on the climate are expected from the construction and operation of wind turbines, a platform, and in-farm cabling because no measurable climate-relevant emissions occur during either construction or operation.

On the contrary, the CO_2 savings associated with the expansion of offshore wind energy can be expected to have positive effects on the climate in the long term. This means that the development of the protected asset climate is independent of the non-implementation or implementation of a construction project on the sites in Zones 3, 4, and 5.

As a result, no preventive and mitigation measures are planned for the protected asset because the effects of the plan do not require any.

4.13. Seascape

According to the assessment of Section 15, para. 1, No. 3 BKompV, despite the distance of offshore wind farms from the coast and islands, an adverse effect of the protected asset seascape can generally be assumed. However, Section 15, para. 1, No. 3 BKompV provides for the lowest value level 2 for wind turbines at the level of compensation. This is justified by the fact that this seascape area is largely hidden from the eye of the “average” observer, particularly because of the great distance to the coast and islands (BT Drs. 19/17344, p. 172). According to the assessment of Section 15, para. 1, No. 3 BKompV, apart from subsea cables and pipelines, installations according to Section 65 WindSeeG-E generally have an adverse effect on the scenery in the EEZ. However, Section 15, para. 1, No. 3 BKompV provides for the lowest value level 2 for wind turbines in the EEZ at the level of compensation. This is justified by the fact that the seascape area of the EEZ is largely hidden from the eye of the “average” observer, particularly because of the great distance to the coast and islands (BT Drs. 19/17344, p. 172). At the approval level adverse effects on the scenery are thus compensated for through appropriate compensation measures.

4.14. Cultural heritage and other material assets

Both known and unknown underwater cultural heritage may be damaged or destroyed by the construction activities in the future project areas as well as by the laying of the submarine cables. The foundation and installation work for offshore wind turbines and the construction of scour protection and the laying of cables can irrevocably destroy previously unknown archaeological monuments or other cultural artefacts and their layers of cultural and historical significance. Dredging or jetting work could lead to erosion (e.g. on a shipwreck). The subsea cables can also damage an area with prehistoric finds.

The SEA for the SDP does not include a systematic survey or assessment of existing underwater cultural heritage. There is also no systematic survey in the downstream approval procedures; however, occasion-related investigations can be carried out or ordered. Effects on the protected asset cultural heritage and other material assets can therefore not be ruled out in principle.

4.15. Humans, including human health

Residential use is limited to the offshore islands of Lower Saxony, Schleswig-Holstein, Heligoland, and the mainland. In a broader sense, the marine space in the area of the project represents the working environment for the people employed on the vessels. Pleasure craft are found mainly close to the coast and are rarely if ever encountered in the planning area. Because of its distance from the coast, the area of the EEZ in which the areas and site are located is of secondary importance for active recreational use. The areas along the coast frequented by tourists are largely low-disturbance, near-natural recreational areas. However, they are located at a great distance from the planning area.

No special importance for human health and well-being can be derived. Overall, the planning area has a low relevance for the protected asset population & human health.

As a result, no preventive and mitigation measures are planned for the protected asset because the effects of the plan do not require any.

4.16. Interactions between the protected assets

In principle, all changes resulting from the effects of a project on a protected asset can lead to subsequent effects and interactions. For example, effects on the abiotic environmental conditions (recorded via the protected assets seabed and water) usually also have effects on the respective biotic protected assets 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. Furthermore, direct or indirect changes in individual protected biological assets can be passed on to other protected biological assets via the trophic cascade of the food web.

The following aspects can trigger secondary effects in the trophic cascade and thus cause relevant interactions between the various components of the living marine environment (WANG et al. 2023, GALPARSORO et al,.2022, DEGRAER et al. 2020):

– Changes in the species composition or dominance structure of lower trophic levels because of changes in abiotic environmental conditions (phyto- and zooplankton, benthos),

- Changes in the available biomass at lower trophic levels, including a decrease in food quality (especially phytoplankton but also benthos),
- Loss or decline of key species (groups) in the food web (plankton, benthos, fish)
- Changes in seasonal succession (phytoplankton, zooplankton),
- Loss or decline of top predators (seabirds, marine mammals),
- Change in the composition of top predators through attraction and avoidance (fish, benthos, possibly seabirds, and marine mammals).
- Establishment of non-native species (phyto- and zooplankton, benthos, fish).

The list of aspects listed above does not claim to be exhaustive and includes olnly potentially relevant aspects for the expected effects. When estimating the consequences and interactions between the protected assets, it must always be taken into consideration that the individual impact factors already have a cumulative, synergistic, or antagonistic effect on the respective protected asset (cf Chapter 4.5 through 4.9). A separate consideration of the individual impact factors when assessing the interactions is therefore not expedient. Therefore, the interactions that may occur during the construction and operating phase are primarily considered below.

However, it should be emphasised that actual impacts that significantly exceed the direct effects on the protected assets because of secondary effects have hardly been investigated to date and have not yet been quantified. The following comments are therefore limited to a description of potential secondary effects.

Construction phase

Because of acoustic disturbances (noise emissions), top predators both in the air (seabirds and resting birds) as well as in the water (harbour porpoises, fish) will avoid the OWF site and the surrounding area during the construction phase. At the same time, visual stimuli (light emissions) can attract seabirds. Because of the short-term nature of the disturbance, no significant secondary effects on the food web are to be expected provided that appropriate preventive and mitigation measures specific to the protected species are applied and there is no significant disturbance at the population level.

During the construction phase of wind farms and platforms or the laying of subsea cables, also sediment relocations and turbidity plumes occur. This results in a localised disturbance of the macrozoobenthos and a short-term repellence of fish. Sediment shift leads to increased mortality of the benthos in the area of cable trenches and the working area of the device, thereby resulting in a reduced local food supply for benthophagous fish. However, damaged or dead individuals are also washed to the sediment surface. The food supply can thus be increased in the short term. However, a significant effect on the food web can be ruled out because of the short-term and small-scale nature of the effects. Because the turbidity plumes are also very small-scale and short-lived and remain in the lower water layers, no effects on the pelagic communities that could trigger notable secondary effects in the trophic cascade are to be expected.

Operating phase

Possible interactions between the protected biological assets during the operating phase of the OWF include possible changes in the presence and composition of top predators (top-down control) through deterrence and attraction effects as well as changes in the composition of biocoenoses at lower trophic levels (bottom-up control).

Seabird and resting bird species show different inter- and intraspecific reactions to the presence and operation of offshore wind farms Whilst individual species show clear avoidance reactions (e.g. divers, guillemots), large gulls, for example, often fly directly into wind farms. For gannets, for example, both behaviours have been demonstrated in different individuals (cf Chapter 4.8). For harbour porpoises, on the other hand, it is still unclear whether there may also be individually different behavioural patterns. At present, the results of various studies contradict each other here (cf Chapter 4.7). Local effects of the possibly altered density and species composition of predators on the primary prey organisms (generally pelagic fish) are possible but cannot be quantified based on the current data situation.

On the other hand, other direct and indirect effects of wind farms can also lead to a local increase in fish fauna. These, in turn, can lead to an increased density of prey organisms and thus to attraction effects for predators. Such a refugial effect can be favoured by the exclusion of active fishery within the safety zones of wind farms and by the altered or increased food supply for benthophagous fish and top predators (GIMPEL et al. 2023). The change in the food supply results from the use of marine space and the associated loss of endo- and epibenthic soft-bottom fauna as well as the colonisation of the artificial hard bottoms by a generally individual and biomass-rich epifauna. The increased food supply attracts not only benthic and benthophagous fish but also large mobile invertebrates such as the European lobster and the edible crab. Both species can exert additional feeding pressure on mussels, among others, especially in the vicinity of the artificial hard bottoms and thus locally change the functional composition of the benthic cenosis.

Effects from the additional, partly selective feeding pressure by the predominantly filter-feeding organisms on the vertical hard-bottom structures as well as secondary effects from increased turbulence and turbidity can lead to a change in the community structure of the phytoplanktonic and zooplanktonic community in the vicinity of the piles. However, their dimensions and possible consequences for the food web cannot be fully assessed at present (cf Chapter 4.3). Ultimately, for all the interactions and ecosystem effects described here, the data basis required to conclusively describe or assess the impacts is still lacking.

4.17. Cumulative effects

4.17.1. Seabed/space, benthos, biotopes

Construction-related environmental impacts on seabed, benthos, and biotopes (e.g. formation of turbidity plumes, sediment shift and disturbance) resulting from the implementation of the plans and projects in the areas and sites as well as the platform sites and subsea cables are predominantly temporary and take place in a spatially limited area. Because of the gradual realisation of the construction projects, significant cumulative construction-related environmental impacts can also be ruled out according to the current state of knowledge.

Possible significant cumulative effects on the seabed, which could have a direct effect on the protected assets benthos and biotope types, therefore result primarily from the permanent direct use of marine space of the foundations and scour protection systems of the installations and, in part, from the laid cable systems (crossing constructions).

According to the precautionary principle, the maximum values resulting from the range of the model wind farm scenarios were used to calculate the use of marine space. The calculation of the loss of function resulting from the in-farm cabling was carried out in accordance with the reported capacity, assuming a 1 m wide cable trench. In the area of the cable trench, however, the adverse effect 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 shell layers, permanent adverse effect would have to be assumed.

Based on this conservative estimate, a maximum of 2205 ha of area will be claimed for the areas and sites for wind energy use or temporarily adversely affected in the case of in-farm cabling.

For the subsea cables, this results in a mostly temporary loss of function over an area of maximum 874 ha. Outside the sensitive biotopes, a permanent loss of area and function as a result of the cable systems results exclusively from the crossing constructions that become necessary. Based on an area of approx. 900 m² per crossing structure, the direct use of marine space for approx. 390 crossing constructions amounts to approx. 36 ha. In total, therefore, up to 3115 ha of seabed will be claimed or, in the case of the submarine cable, temporarily adversely affected; this corresponds to a share of approx. 0.11% of the total EEZ area.

In addition to the direct use of the seabed and thus of the habitat of the organisms that have settled there, the installation foundations, scour protection, and crossing constructions lead to an additional supply of hard substrate. As a result, hard substrate-loving species untypical of the site (aufwuchs and mobile predators) can colonise and directly or indirectly influence the natural soft substrate community. In addition, artificial substrates can lead to an altered distribution of invasive species, among others. These indirect effects can lead to cumulative effects resulting from the construction of several offshore structures or rockfill in crossing areas of subsea cables and pipelines. However, reliable findings on effects beyond the sites of the wind farms or on the altered connectivity of invasive species are not yet available.

Because the (mainly temporary) use of marine space is below 0.1% of the EEZ area even in the cumulative consideration of the grid infrastructure and the wind farm sites, according to current knowledge, no significant adverse effects that lead to a threat to the marine environment with regard to the seabed and the benthos are to be expected – even in the cumulation of indirect effects.

4.17.2. Fish

A considerable part of the environmental impacts of the areas and sites, platforms, and subsea cables on the protected asset fish will occur during the construction phase and in a spatially limited area, in particular through underwater noise, sedimentation, and turbidity plumes. Because of the gradual realisation of the construction projects, there will be sufficient opportunity for escape, and there is unlikely to be a cumulative effect such as a barrier effect. Significant cumulative construction-related environmental impacts can therefore be ruled out with the necessary certainty.

Electromagnetic fields can have an operational effect. This creates magnetic fields along the cables that can influence the behaviour of certain species. The total length of the submarine cables is expected to be approx. 6500 km, and EMFs are likely to be generated along this length in the vicinity of the submarine cables. From a cumulative perspective, the affected site is small in relation to the entire German EEZ of the North Sea; a superposition of magnetic fields of different cable routes is not to be expected because of the small-scale effect. A cumulative effect caused by the magnetic fields generated along the cables is not to be assumed because a barrier effect is also unlikely here, and any avoidance behaviour of individual species is to be expected only in the immediate vicinity of the cables.

Possible effects of the accumulation of local effects (described analogously in Chapter 4.6.1) could therefore result primarily from the permanent direct use of marine space, the artificially introduced hard substrate, and navigation bans. According to estimates, the foundations of the OWT, platforms, scour protection, and cable crossings will take up a maximum of approx. 1,280 ha of land. This corresponds to approx. 0.04% of the entire EEZ area. This means that the use of marine space remains low even when considered cumulatively, and significant adverse effects on the fish communities are therefore not to be expected. Furthermore, the supply of artificially introduced hard substrate and the sites free for use will increase; according to the current state of knowledge, this can lead to mostly positive effects.

The refugium effect (recruitment or emigration from surrounding areas as a result of fishing exclusion) together with the reef effect (recruitment or emigration from surrounding areas as a result of the introduction of hard substrate and sessile fouling communities living on it) could cumulatively lead to higher fish abundance and biomass (DEGRAER et al. 2020). The conditions of the fish could improve as a result of a larger and more diverse food base, increased food efficiency (LINDEBOOM et al. 2011), and protection from currents and predators (GLAROU et al. 2020). Fish populations could recover by eliminating the disturbance of the seabed and the loss of catch and bycatch. This could result in a more natural distribution of the age structure of the fish fauna (BUYSE et al. 2023) as well as recolonisation by rare or site-loyal species (VAN HAL et al. 2017). Ecological production could be increased by providing habitats for the recruitment or settlement of individuals (RANDALL 1963; BOHNSACK 1989). To date, few studies have provided evidence of fish production in OWFs (REUBENS et al. 2014a; BUYSE et al. 2023; GIMPEL et al. 2023). Results indicate that aggregation effects are locally limited (WERNER et al. 2024) and there is still a lack of empirical evidence for the existence of “spillover effects” (export of biomass to the surrounding area) by OWFs (DE BACKER et al. 2022). There could be increased fishing pressure on certain species if there is increased fishery in the peripheral areas of the wind farms.

The general species composition and diversity of the fish fauna could change directly because species with different habitat preferences than the established species (e.g. reef dwellers) find more favourable living conditions and occur more frequently (LEONHARD et al. 2011). This change could intensify as the number of wind farms on an area increases. Furthermore, the wind farms of the southern North Sea could have an additive effect and beyond their immediate location in that the mass and measurable production of plankton could be dispersed by currents and thus influence the qualitative and quantitative composition of the zooplankton (FLOETER et al. 2017). This, in turn, could affect planktivorous fish, including pelagic schooling fish such as herring and sprat, which are the target of one of the largest fisheries in the North Sea.

Based on the current state of knowledge, no cumulative negative impact on the protected asset fish can be assumed. Reliable conclusions on the potential of OWFs to have cumulative positive effects on fish fauna have yet to be drawn. In order to be able to reliably predict the effects of the progressive expansion of offshore wind energy on fish fauna, further knowledge is required on the accumulation and aggregation of the various fish species in the OWF. Further research results on species that show better condition and increased productivity in the OWF would also provide important information for making further estimations of the cumulative effects and incorporating these into the assessment.

4.17.3. Marine mammals

Construction-related impacts

Cumulative effects on marine mammals, especially harbour porpoises, may occur mainly because of noise exposure during the installation of deep foundations. For example, marine mammals can be significantly adversely affected by the fact that – if pile driving is carried out simultaneously at different locations within the EEZ – there is not enough equivalent habitat available to avoid and retreat to.

So far, the implementation of offshore wind farms and platforms has been relatively slow and gradual. From 2009 to 2018, pile driving work was carried out at 20 wind farms and eight converter platforms in the German EEZ of the North Sea. Since 2011, all pile driving work has been carried out using technical noise mitigation measures. Since 2014, the noise protection values have been reliably complied with and even undercut thanks to the successful use of noise mitigation systems. Most of the construction sites were located at distances of 40 to 50 km from each other and were temporally decoupled. There was thus no overlapping of sound-intensive pile driving work that could have led to cumulative effects. Only in the case of the two directly adjacent projects Meerwind Süd/Ost and Nordsee Ost in Area N-4 was it necessary to coordinate the timing of the pile driving work, including the deterrence measures. The coordination was carried out successfully. The extensive monitoring methods have confirmed that cumulative effects were excluded.

The evaluation of the noise results with regard to noise propagation and the possibly resulting accumulation has shown that the propagation of impulsive noise is strongly limited when effective noise-minimising measures are applied (Brandt et al. 2018, Dähne et al., 2017).

Cumulative effects of the SDP on the population of harbour porpoise are considered in accordance with the provisions of the noise protection concept of the BMU of 2013.

The noise protection concept of the BMU (2013) follows a habitat-based approach with regard to the assessment and avoidance of cumulative effects and includes area-related threshold values. In concrete terms, the provisions from the noise protection concept of the BMU (2013) provide for the following:

- It shall be ensured with the necessary certainty that, at any time, no more than 10% of the area of the German EEZ of the North Sea is affected by disturbance-triggering sound inputs from sound-intensive pile driving activities for the foundations of the piles (species protection law prohibition of disturbance, Section 44, para. 1, No. 2 BNatSchG).
- At the same time, it is necessary to exclude any adverse effect on the conservation objectives of the nature conservation areas by ensuring that no more than 10% of the area of one of the nature conservation areas is affected by noise-intensive pile driving for the foundation of the piles from disturbance-triggering sound inputs. During the sensitive period of the harbour porpoise from 1 May to 31 August, it shall also be ensured with the necessary certainty that no more than 1% of sub-area I of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area as well as the “Doggerbank” FFH area with its special function as a breeding area is affected by sound-intensive pile driving work for the foundations of the piles from disturbance-triggering sound inputs (habitat protection in accordance with Section 34 BNatSchG).
In addition, the following assumptions were made in the noise protection concept based on the findings on the propagation of pile driving noise and on the effects of pile driving noise on the harbour porpoise:

(1) The **propagation is**calculated **using a formula derived from ELMER et al., (2007)**, which depicts a stronger propagation attenuation at greater distances than that of THIELE & SCHELLSTEDE (1980). Investigations have shown that the frequently used formula according to THIELE & SCHELLSTEDE (1980) leads to an overestimation of the propagation of impact sound at large distances (Chapter 6, page 1, formula (1)).
(2) A **significant disturbance of the harbour porpoise occurs at 140 dB broadband sound exposure level** (Chapter 6, page 21).
(3) Taking into consideration (a) and (b), the result for practical implementation is a disturbance radius of **8 km with compliance with the noise limits of 160 dB SEL at 750 m** (Chapter 6, page 21, Table 1).

The aforementioned provisions from the noise protection concept of the BMU (2013) are part of the arrangements in the subordinate approval procedures for offshore projects and the definition of the catalogue of mitigation measures for the acceleration sites designated in the draft SDP

On one hand, the requirements of the noise protection concept take into consideration the requirements of the designations of the BNatSchG and the Habitats Directive with regard to the protection of strictly protected species such as the harbour porpoise (cf BMU 2013, p. 5). At the same time, the requirements from the noise protection concept also fulfil requirements from Resolution 2017/848/EU of the commission[2], which, among other things, designates criteria and methodological standards for the description of good environmental status of marine waters and sets out specifications and standardised procedures for monitoring and assessment. The provisions thus ensure the implementation of Directive 2008/56/EC[3] (Marine Strategy Framework Directive, hereinafter: MSFD) with regard to the designation of threshold values for the protection of the marine environment from impulsive sound inputs.

Within the framework of the implementation of the MSFD, the sustainable use of the seas is required in order to achieve and maintain a good environmental status (Article 1, para. 1 MSFD). Recommendations for practical implementation were developed by an expert group (TG-Noise) on behalf of the Commission (Dekeling et al. 2014). Good environmental status (GES) is thus a common European objective. In a list of qualitative descriptors for the designation of good environmental status (Annex I), the MSFD also includes descriptor 11, which comprises provisions and objectives for the management of energy inputs/underwater noise in the marine environment. Resolution 2017/848/EU of the EU Commission sets out criteria for good environmental status as described above and addresses standards relevant to the assessment of the descriptors. The criteria regarding impulsive underwater noise include both a spatial and temporal component. The EU states are called upon to define and use threshold values in order to ensure that the input of impulse noise does not have negative effects on populations of marine species (EU Commission, SWD (2020) 62 final).

From a species protection perspective, the area of the EEZ represents the habitat of the local population of the harbour porpoise. In accordance with the noise protection concept, it must be ensured that less than 10% of the area of the EEZ is affected by disturbance-triggering pile driving noise at any time.

With a total area of the German EEZ in the North Sea of 28,539 km^2, the maximum area to be polluted is therefore 2,854 km^2. The application of the 10% criterion from the noise protection concept theoretically means that parallel pile driving work would be possible at up to 14 construction sites in the German EEZ of the North Sea whilst complying with the noise limits.

In order to prevent and mitigate cumulative effects on the harbour porpoise population in the German EEZ, the arrangements of the downstream approval procedure shall designate a restriction of the sound exposure of habitats to maximum permitted proportions of the EEZ and nature conservation areas. According to this, 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 the animals at all times for their avoidance. The ordinance primarily serves to protect the harbour porpoise as a species as well as marine habitats by avoiding and minimising disturbances caused by impulsive sound input.

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[2] Resolution (EU) 2017/848 of the commission of 17 May 2017 designating criteria and methodological standards for the designated of good environmental status of marine waters and specifications and standardised methods for monitoring and assessment as well as the repealing of resolution 2010/477/EU, OJ L 125, 18 May 2017 p. 43.

[3] Directive 2008/56/EC of the European Parliament and the Council dated 17 June 2008 for the establishment of a Framework for Community Action in the Marine Environment (Maritime Strategy Framework Directive (MSFD)), OJ L 164 dated 25 June 2008, p. 19.

The seasonally restricted reservation area for the harbour porpoise in the summer months (May–August) established in the ROP 2021 comprises the Natura 2000 site “Sylter Außenriff” or Area I of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area and its indirect surroundings. Pile driving activities that have the potential to cause disturbances as a result of sound inputs in the main concentration area of the harbour porpoise during the sensitive season are coordinated in such a way that the proportion of the affected site remains below 1% at all times.

As a result of the spatial planning designation of the harbour porpoise reservation area, the standards for the protection of impulsive sound inputs applicable to projects at the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area will also have to be taken into consideration for projects located in and near the reservation area within the framework of downstream approval procedures.

In addition, in accordance with the noise protection concept of the BMU (2013), all pile driving activities are coordinated with the objective of always keeping sufficient alternative sites in the protected areas, in equivalent habitats, and in the entire German EEZ free of pile driving noise that could cause disturbance to the harbour porpoise.

The SDP provides for an expanded development of offshore wind energy. The current SDP shows that the simultaneous construction of several offshore wind farms is to be expected, especially in the years 2031 to 2037. Within the framework of the SEA, it is therefore necessary to screen possible cumulative effects caused by the construction of the wind farms with regard to compliance with species protection and site protection provisions of the noise protection concept (BMU, 2013).

The noise protection concept of the BMU is a preventive measure to ensure the protection of the harbour porpoise from cumulative effects caused by pile driving noise during the construction of offshore wind farms. The noise protection concept contains specific provisions that take into consideration species protection and habitat protection with regard to cumulative effects.

As part of the SEA for the draft SDP, four scenarios were developed, and the potential exposure to disturbance-triggering pile driving noise was determined in accordance with the habitat-based approach anchored in the noise protection concept. The determination of polluted habitat parts serves the practical implementation of species and habitat protection requirements of the noise protection concept within the framework of the downstream suitability and approval procedures for offshore wind energy projects. The overall objective of this assessment is to identify measures to avoid and mitigate cumulative effects from the planned development of offshore wind energy, in particular the acceleration of the development in Zone 4 and Zone 5.

<u>Determination of the possible cumulative effects of relevance to species protection law</u>

For the calculation of the noise impact resulting from the simultaneous construction of several offshore wind farms (as absolute area in km^2 and % share of the area of the EEZ), assumptions are made regarding the spatial and temporal sequence of construction. Although the scenarios are based on the current state of planning, they are structured in such a way that the results can be transferred even if the spatial or temporal planning changes. The calculations of noise-impacted sites in the individual scenarios represent a “worst case”. The values calculated as a matter of priority assume the maximum area exposed to sound that would be achieved by the simultaneous construction of several wind farms. In addition, however, more realistic values are also given; these result from an overlap of noise-impacted sites as a result of the simultaneous construction of offshore wind farms (area calculations in brackets).

The three scenarios are based on the following assumptions:

- 500 MW capacity corresponds to an offshore wind farm.
- Areas with higher planned capacity are divided into 500 MW offshore wind farm projects for the calculation; accordingly, a wind farm of corresponding size is integrated into the area consideration with several construction sites as a precaution.
- For every 500 MW of power, one construction site will be active with foundation work using pulse hammers.
- For neighbouring sites, the pile driving points are assumed to be as far apart as possible for the purpose of calculation.
- The foundations will be laid 12 to 18 months before the wind turbines go into operation.
- The foundation work using impulse pile driving for a 500 MW site takes an average of four months.
- Unrestricted availability of vessels and construction technology is assumed.
- It is assumed that, limited by the alternative foundation technologies still under development, most foundations will be installed using impulse pile driving.
- Compliance with the noise limits of 160 dB SEL_{05} re 1 µPa^2s and 190 dB re 1µPa peak level at 750 m from the pile driving site is assumed.
- The definition, measurement units, calculation formulas, and verifiability of the noise limits shall be applied strictly according to the measuring instruction of the BSH (2011).

The summary table "Designations and informational outlook for sites and grid connection systems" from the SDP (cf Table 1 of the SDP) contains information on the provision of the grid connection and commissioning of wind turbines in the areas and sites of Zone 4. In order to achieve the objectives of the WindSeeG, it can be assumed that the number of construction sites from 2031 to 2037 will be between four and 12 simultaneously active construction sites. The test is carried out only for the sites that have already been prioritised because only for these areas can concrete assumptions about potential simultaneous noise pollution be made.

Scenario 1 (IBN 2032, 2033, no area with particularly high occurrence or calf sightings)

The draft SDP as well as the associated environmental report provides for preventive and mitigation measures in order to exclude cumulative effects as a result of the input of impulse noise during the foundation works for the foundations of the installations. These measures include the timing coordination of pile driving works. Pile driving work at construction sites located in the same area or directly adjacent sites shall be coordinated in such a way that it can be ruled out with the necessary certainty that the prohibitions according to Section 44, para. 1, No. 2 BNatSchG will be realised.

As an example, the disturbance radii of 8 km (pile driving noise > 140 dB SEL) for eight construction sites (yellow dots) in Zone 4 for 2032 and 2033 (commissioning, development of Sites N-9.4 and N-6.8 or N-9.5 and N-12.4) were represented a geographic information system (GIS), and the area affected by disturbance-triggering noise was calculated. In accordance with Scenario 1, the polluted area would be up to 1,600 km^2 (max. 1435 km^2 with overlap) and is shown in Figure 51 (top left, top right). Under Scenario 1, 5.6% (max. 5.0% with overlap) of the habitat would thus be exposed to disturbance-triggering pile driving noise; this is below the 10% provision of the noise protection concept.

If there are more than five construction sites with pile driving work within a year, the arrangements for temporal and spatial coordination will, in any case, be supplemented in the downstream planning approval or planning permission procedure (Chapter 7) The spatial and temporal coordination of pile driving works by the project developer is a purposeful addition to the previous arrangements in order to avoid cumulative effects even if there are more than five construction sites within one year and to exclude the realisation of the prohibitions according to Section 44, para. 1, No. 2 BNatSchG with the necessary certainty. Within the framework of enforcement, the BSH will reserve the right to take over the coordination of the pile driving work as required. Such coordination has already taken place in previous years and is an integral part of the enforcement practice of the BSH.

A significant disturbance in accordance with Section 44, para. 1, No. 2 BNatSchG can be excluded provided that additional measures are arranged as part of the downstream approval procedures.

Scenario 2 (IBN 2034, 2035, 2037, one area with high occurrence or calf sightings)

Like in Scenario 1, the draft SDP as well as the associated environmental report provides for preventive and mitigation measures in order to exclude cumulative effects as a result of the input of impulse noise during the foundation works for the foundations of the installations. The measures include not only temporal but also spatial coordination of pile driving. Pile driving work at construction sites located in the same area or directly adjacent sites shall be coordinated in such a way that the realisation of the prohibitions according to Section 44, para. 1, No. 1 and No. 2 BNatSchG is excluded with the necessary certainty.

In Scenario 2, as in Scenario 1, eight construction sites are active at the same time. In this scenario, the installed capacity (4 GW in total) is divided between two sites, one of which is located near the main concentration area of the harbour porpoise (N-12.5) or is frequently frequented by harbour porpoises or calves (N-16.1, N-16.4) because of its location in the transition area between Sylter Außenriff and Doggerbank.

The disturbance radii of 8 km (pile driving noise > 140 dB SEL) for eight construction sites of the four for commissioning in 2034, 2035, or 2037 (development sites N-14.1 and N-12.5 or N-14.2 and N-16.1 as well as N-14.3 and N-16.4) were depicted using GIS, and the area affected by the noise causing the disturbance are calculated.

The polluted area would be up to 1,600 km^2 (max. 1,461 km² with overlap) and is shown in Figure 51 (centre left, centre right, bottom left). In the second scenario, 5.6% (ma.x. 5.1% with overlap) of the habitat would be subject to disturbance-inducing pile driving noise.

In the draft SDP and the associated environmental report, in order to avoid the cumulative effects of pile driving that may lead to the significant disturbance of harbour porpoise, measures for spatial coordination are included in addition to the measures for the temporal coordination of parallel pile driving activities.

In addition, for the sites taken into consideration in Scenario 2, such a measure of spatial and temporal coordination of pile driving would be necessary because of the proximity to the main concentration area of the harbour porpoise and to Area I of the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation areas in order to exclude any adverse effect on the conservation objectives of the nature conservation area. A habitat protection assessment is provided in the final section of this chapter ("Determination of the possible cumulative effects of relevance under site protection law"). In addition, as part of the downstream planning approval or planning permission procedure for areas that are of high seasonal importance for harbour porpoises (between May and August), it should be stipulated that only one pile driving operation at a time should take place within this area during the sensitive period.

A significant disturbance in accordance with Section 44. Para. 1, No. 2 BNatSchG can be excluded provided that additional measures for spatial and temporal coordination are arranged as part of the downstream approval procedures.

Scenario 3 (IBN 2036, site with high occurrence or calf sightings, vicinity of other sites with high seasonal importance for harbour porpoises)

The draft SDP as well as the associated environmental report includes principles and objectives as well as preventive and mitigation measures as in Scenario 1 and 2. However, the number of construction sites with **parallel pile driving works within the construction year 2035 (commissioning 2036) increases to the theoretically maximum possible number of 12**.

As an example, the disturbance radii of 8 km (pile driving noise > 140 dB SEL) for 12 construction sites of Zone 4 for 2036 (development of Sites N-16.2, N-16.3, and N-16.5) were represented with GIS, and the area affected by disturbance-triggering noise was calculated.

The polluted area would be up to 2,412 km^2 (1559 km^2 with overlap) and is shown in Figure 51 (bottom left). In the third scenario, 8.5% (5.5% with overlap) of the habitat will be subject to disturbance-inducing pile driving noise.

If there are more than five construction sites with pile driving work within a year, the arrangements will always be supplemented in the downstream planning approval or planning permission procedure, regardless of whether the site is an acceleration site or not (see catalogue of preventive and mitigation measures). As was already the case for Scenario 2, the ordinance would therefore also be supplemented in the downstream approval procedures in Scenario 3. In this case, coordination of the pile driving work by the project developers with the involvement of the BSH would be imperative and purposeful in order to avoid cumulative effects and to exclude a realisation of the prohibitions according to Section 44, para. 1, No. 2 BNatSchG. In addition, as part of the downstream planning permission procedure for sites that are of high seasonal importance for harbour porpoises (between May and August), it should be stipulated that no simultaneous pile driving should take place within this site during the sensitive period (N-16.5). Because of the immediate vicinity of the site to other such sites (N-16.1, N-16.4), in this case, it must be stipulated in the subsequent plan approval or planning permission procedure as well as in the catalogue of preventative and mitigation measures that a maximum of three pile driving sites can be active at the same time during the simultaneous realisation of these areas in the sensitive period from May to August and, of these, a maximum of one in a site of high seasonal importance (here: N-16.5). Outside the sensitive period, a maximum of five to eight pile driving points should be active at the same time as in Scenario 1. The reduction of the number of parallel active pile driving sites to five to eight is necessary in order to be able to avoid possible overlaps of pile driving works resulting from technical or weather-related delays as far as possible.

A significant disturbance in accordance with Section 44. Para. 1, No. 2 BNatSchG can be excluded provided that the aforementioned additional measures for spatial and temporal coordination are arranged as part of the downstream approval procedures.

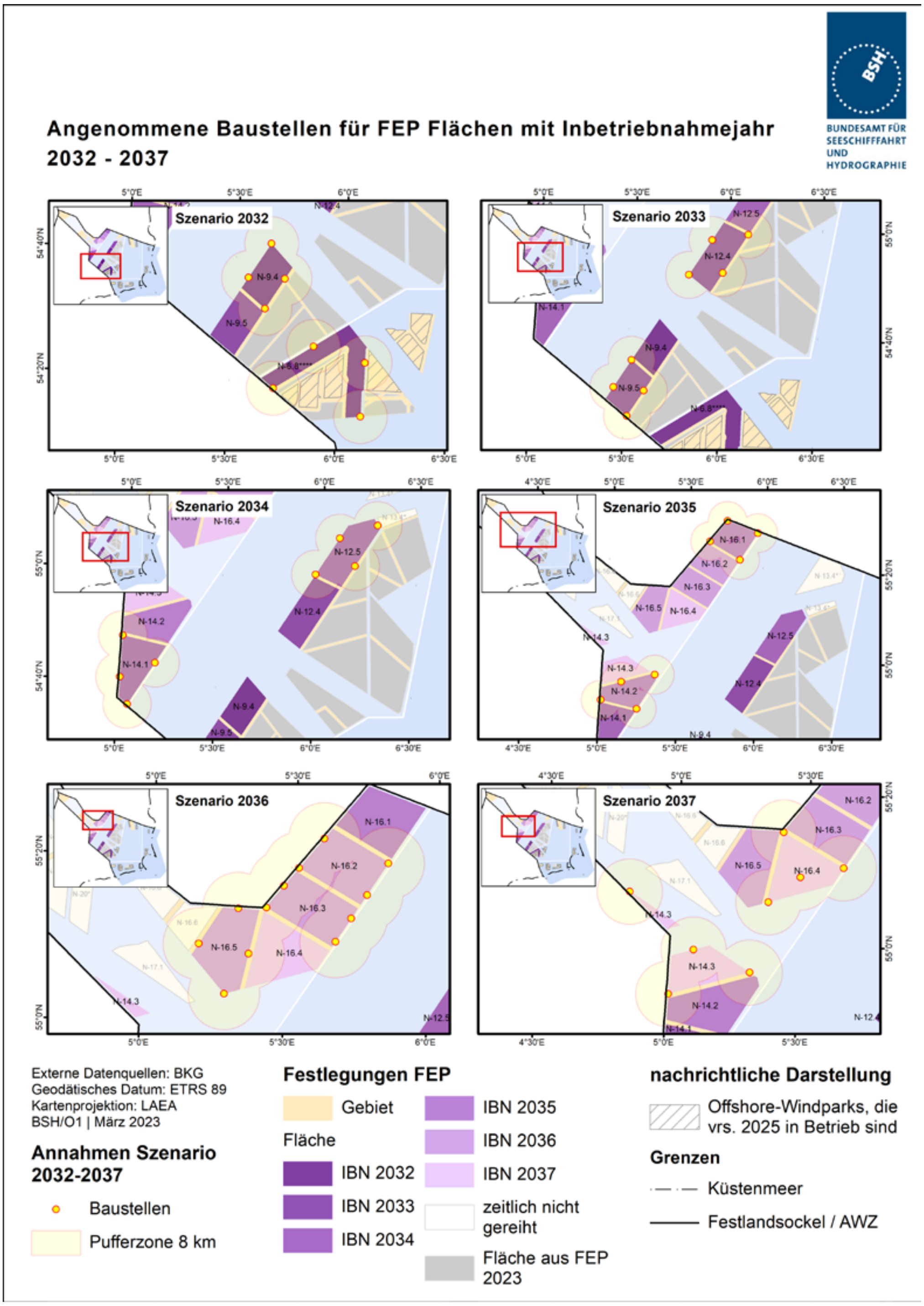

Figure 51: Assumed construction sites (yellow) for the three realisation scenarios

Result of the assessment of three scenarios for realisation by 2037

Cumulative effects from realisation in accordance with Scenario 1 are not expected. A prerequisite for this is the maintenance of the measure for the coordination of construction sites active in parallel in the subordinate approval procedures.

Cumulative effects through realisation in accordance with Scenarios 2 and 3 can also be ruled out. However, in addition to time coordination, this requires additional spatial coordination of pile driving work by the project sponsors in consultation with the BSH or potentially the designation of time quotas for the implementation of pile driving work as part of the arrangements in subordinate approval procedures. By limiting the number of parallel pile driving operations to five to eight and distributing the pile driving operations accordingly throughout the year, it is possible to exclude with the required degree of certainty the realisation of species protection prohibitions according to Section 44, para. 1, No. 2 BNatSchG.

The assessment of and obligation of the project developer to coordinate the pile driving work in a superordinate manner or the restriction of parallel pile driving work also takes into consideration further sources of impulsive sound inputs. The planned overarching coordination ensures that at any time no more than 6% of the area of the German EEZ in the North Sea is affected by disturbance-triggering noise from pile driving. This overarching coordination ensures compliance with the 6% target for all offshore projects in accordance with the scenarios presented. This target is stricter than the 10% criterion from the noise protection concept of the BMU (2013). However, in accordance with the precautionary principle, it takes into consideration the possible cumulative effects of further impulsive sound inputs resulting from further activities in the context of the realisation of the expansion targets. It is clear from the scenarios presented that meeting a 6% target is feasible without any problems.

As a result, a number of preventive and mitigation measures are derived from the assessment of construction-related cumulative impacts; these are presented in more detail in Chapter 7. In addition, monitoring measures will be required (Chapter 10); these will be specified at the approval level.

<u>Determination of the possible cumulative effects of relevance to habitat protection law</u>

Part of the sites in Zone 3 and Zone 5 in which foundation work will be carried out from 2032 onwards border directly on Area I of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area or on the “Doggerbank” FFH area. The analysis relates exclusively to sites for subsequent use or sites that have not yet been phased. The sub-sites located within a buffer zone of 8 km from the outer boundary of this area are shown in Figure 52. A sub-area of 44 km² is affected for areas N-5 and a sub-area of 125 km² for N-4, which lie adjacent to the Sylt Outer Reef. In the North-western region of the German EEZ (Zone 5), 122 km² of area N-17 and 196 km² of area N-19 are affected because these border directly on the Doggerbank FFH area.

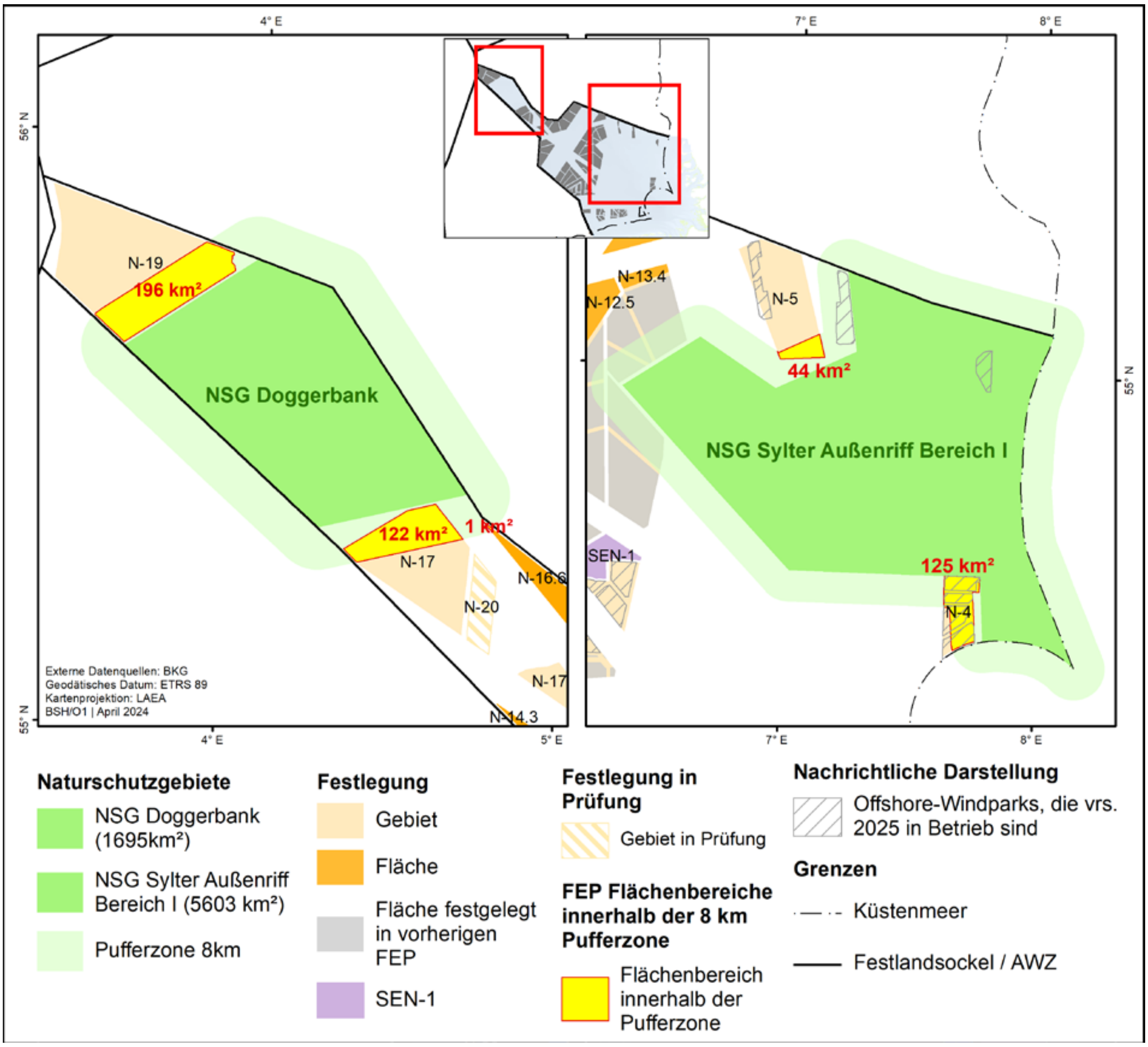

Figure 52: Representation of the areas or sites bordering Area I of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area or the Doggerbank FFH area and subject to the 1% criterion for pile driving during the sensitive period 1 May – 31 August.

For all sub-areas mentioned here, it is necessary that during pile driving work in the period from 1 May to 31 August, less than 1% of the area of Area I of the Sylter Außenriff or the Doggerbank FFH area is affected by disturbance-inducing sound input. In the course of implementation, it must be ensured that, in accordance with the provision of the noise protection concept, the effect radius of 8 km must be estimated from the centre of the respective actual sites in order to determine the proportion of the affected sites of Area 1 of Sylter Außenriff or Doggerbank.

Cumulative effects that lead to an adverse effect on the conservation objectives of the nature conservation area are excluded by arrangements for spatial and temporal coordination of pile driving works in the downstream approval procedures as well as in the catalogue of preventive and mitigation measures.

The 1% criterion in the period from 1 May to 31 August also applies to all sites located in and around the main concentration area of the harbour porpoise in the German EEZ of the North

Sea. The main concentration area extends west and north west beyond Area I of the nature conservation area. For this reason, overlaps with the main concentration area including a buffer zone of 8 km with sites of Zone 3 are shown in Figure 53.

The impact of sub-sites for subsequent use is 100% of the sites because Areas N-4 and N-5 are located entirely in the main concentration area of the harbour porpoise. Site N-13.4 is also partly located in the main concentration area. Of these, 155 km^2 are within the main concentration area, and 39 km^2 are within an 8 km buffer around the main concentration area. This means that 100% of Site N-13.4 is affected by the 1% rule during the sensitive period. Site N-12.5 is located adjacent to the main concentration area. Here 47 km^2 lie within the 8 km buffer.

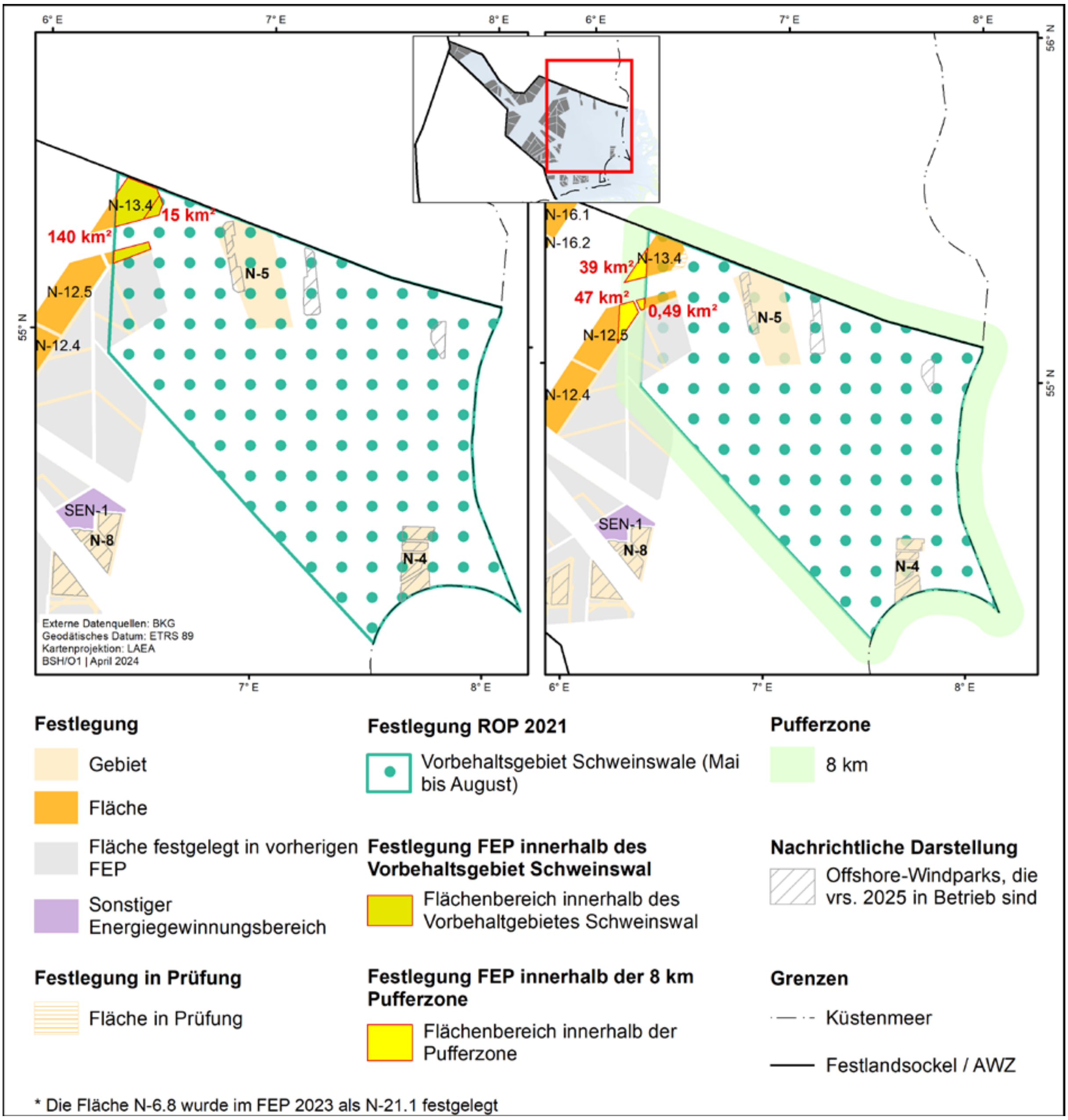

Figure 53: Presentation of the sub-sites located in or adjacent to the main concentration area of the harbour porpoise and which have to comply with the 1% criterion for pile driving during the sensitive period 1 May – 31 August.

Cumulative effects that would lead to significant disturbance of the stock in the main concentration area of the harbour porpoise are excluded by arrangements for spatial and temporal coordination of pile driving in the downstream approval procedures.

Operation-related impacts

According to the current state of knowledge, cumulative effects from the operation of offshore wind turbines are not expected.

For the area of the targeted development by 2031 in Zone 3 and the immediately neighbouring areas in Zone 4, the results from the long-term monitoring from 2014 to 2021 of the offshore wind farms “BARD Offshore 1”, “Veja Mate” and “Deutsche Bucht”, which are located in the immediate vicinity, are decisive. Both the airborne investigations and the acoustic survey have confirmed that wind farm-related changes in the distribution and abundance of the harbour porpoise have not occurred. The acoustic survey even confirmed a more intensive use of the sites within the wind farms compared with the surrounding area (PGU, 2021).

The investigation of underwater noise in and around offshore wind farms has so far shown that the sound emitted by the installations can be perceived only in the immediate vicinity (up to 100 m from the installation). As part of a research project commissioned by the BSH (R&D project “OWF Noise”), the data from the underwater noise measurements at all wind farms in operation were evaluated and subsequently assessed. The results from the research project to date have confirmed the following:

- The construction of the foundation (e.g. monopile, jacket) apparently has no influence on the sound radiated. Monopile wind turbines are no louder or quieter than other foundation types.
- Gearless wind turbines may be somewhat quieter than installations with gearboxes but at least not louder.
- Nominal capacity of the WT: An increase of the sound level with the nominal capacity was not detected. On the contrary, in the range from 2 MW to 8 MW, there is a tendency for the level to drop by 2 to 3 dB.

In view of the planned development, monitoring measures will continue to be necessary and will be specified at the approval level. An overview of the planned monitoring measures is provided in Chapter 8.

Consideration of service traffic

In SDP 2023, an analysis of service traffic in the EEZ was carried out as an example for the months of July 2019 and December 2019, which are representative of the summer and winter months and the associated service traffic. Non-OWF-related traffic accounts for 70% of total maritime traffic in summer and 80% in winter. Overall, the spatial distribution varies greatly because the proportion of service traffic is consequently much higher near wind farms than on the major shipping routes. In Figure 54, the continuous sound level is shown as an example for some stations in the German EEZ of the North Sea at different times of the year and in different years. The stations are located near the respective gate (fictitious line on which the vessel crossings are recorded according to type and number) from the consideration of service traffic in SDP 2023 or, depending on the location, are labelled according to their proximity to shipping routes or spatial proximity to areas and sites of the SDP. There is no clearly recognisable pattern; however, the stations differ depending on the season, and there are marked differences between the years. Stations located in the immediate vicinity of OWFs (e.g. ALB_HS, N6, N3_nord) are in part less affected by sound inputs compared with stations that are not located near OWFs or near shipping routes (e.g. N9, Westl. N2 2018, SN5, GBWA); however, some of the sound inputs are also similar (ALB_HS, N6 vs Westl. N2 2021). Further effects with concrete AIS data in the measurement periods are necessary here in order to be able to make clearer statements. In general, the stations in OWFs are in any case not louder than stations in shipping routes. It can thus not be assumed that service traffic or operational noise alone has a significant influence on the distribution of harbour porpoises. Various influences such as season and food availability are probably decisive here.

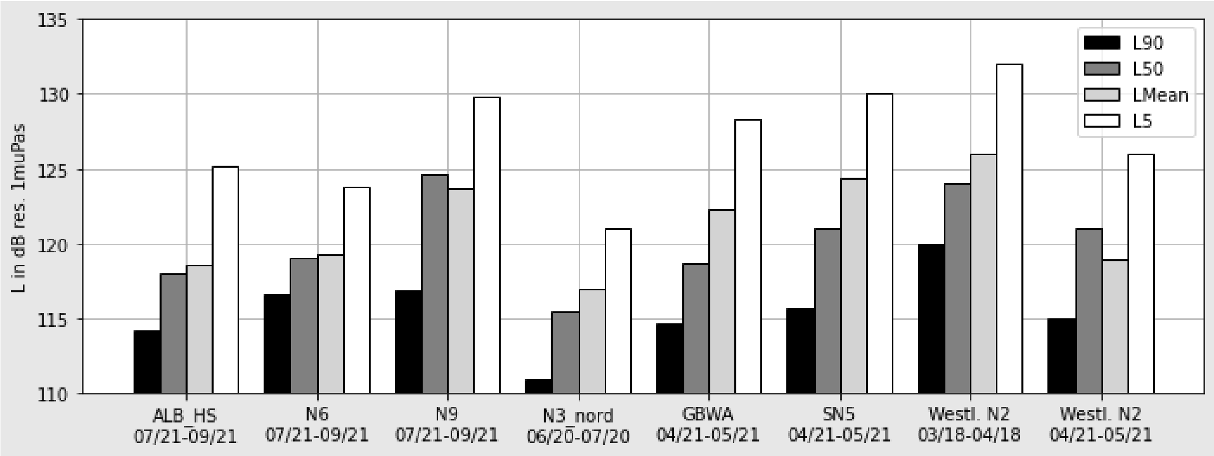

Figure 54: Continuous sound levels at selected stations in the German EEZ of the North Sea

4.17.4. Seabirds and resting birds

In order to estimate the potential cumulative impact on habitats resulting from the implementation of the 70 GW expansion target by 2045, in the following a calculation is made on the basis of the area outline of the draft SDP up to Zone 5 in the overall view with existing wind farm projects and those currently being realised.

The different avoidance reactions identified so far in operational monitoring are represented by avoidance radii of different sizes (2, 4, and 6 km) around the defined areas for the purpose of scientific approximation (Figure 55). Because the impact areas of the individual areas overlap in total and in particular between the areas, the mean radii were placed around the areas and not around the sites. A calculated total loss has so far been calculated only for divers, which are considered quite sensitive to disturbance, and is 5.5 km for these species (Garthe et al. 2018). The selected avoidance radii also cover a large part of the avoidance distances determined for other seabird and resting bird species in the operational monitoring; however, these are partial avoidances and not complete avoidances (cf Chapter 4.8.1).

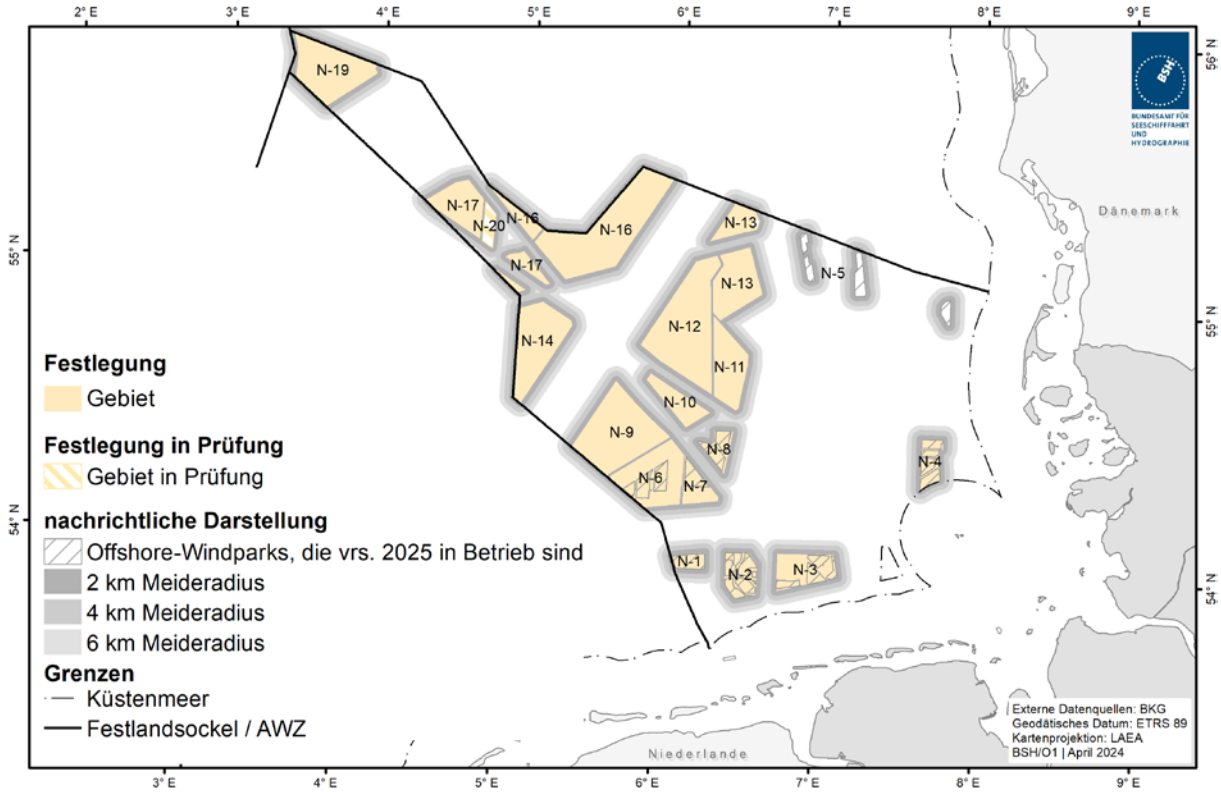

Figure 55: 70 GW expansion target with the designations of SDP 2019, 2020, 2023, and 2024 or the current territorial allocations of N-5.

In a next step, the sum of the area definitions with the assumed mean radii is methodically set in relation to the total area of the EEZ of the German North Sea and to the Special Protection Area “Östliche Deutsche Bucht” (Sub-area II of the”Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area) as well as to the main concentration area of divers (BMU 2009) (Table 14).

The results in Table 14 show that around 26% of the EEZ will be developed with OWF with the designations, including the present draft SDP. With an avoidance radius around these areas, depending on the actual avoidance distance, between around 35% (2 km avoidance radius) and 51% (6 km avoidance radius) of the German EEZ of the North Sea could be adversely affected by the deterrent effects of offshore wind energy. The overall analysis of the mean radii presented above also takes into consideration the Butendiek OWF even if this is not defined by the SDP.

With the current 70 GW expansion scenario by 2045, between 5% (2 km radius) and 19% (6 km avoidance radius) of the Special Protection Area (SPA) “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area, Sub-area II) are affected by offshore wind energy in and around the SPA (Table 14). No further sites are designated in this area, whereby Area N-5 is to be spatially expanded, redrawn, and designated at a sufficient distance from the SPA. The impact on the SPA will then come only from Area N-4.

Table 14: Area sizes of the designated areas and the different radii around them (2 km, 4 km, 6 km) as well as their proportion in relation to the German EEZ of the North Sea, the main concentration area of divers (BMU 2009) and the Special Protection Area "Östliche Deutsche Bucht".

	Anteile der Gebiete für Windenergie auf See		
	an der deutschen AWZ der Nordsee (28.521 km²)	am Hauptkonzentrations-gebiet der Seetaucher (7.036 km²)	am Vogelschutzgebiet „Östliche Deutsche Bucht" (3.138 km²)
Gebiete für Windenergie (km²)	7.309,4	280,2	31,4
Anteil am Gesamtgebiet in %	**25,6**	**4,0**	**1,0**
2 km Meideradius (km²)	2.765,0	357,8	130,6
Gebiete für Windenergie + 2 km Meideradius (km²)	10.074,4	638,0	162,0
Anteil am Gesamtgebiet in %	**35,3**	**9,1**	**5,2**
4 km Meideradius (km²)	5.280,6	765,6	332,6
Gebiete für Windenergie + 4 km Meideradius (km²)	12.590,0	1.045,8	364,1
Anteil am Gesamtgebiet in %	**44,1**	**14,9**	**11,6**
6 km Meideradius (km²)	7.182,8	1.228,3	575,3
Gebiete für Windenergie + 6 km Meideradius (km²)	14.492,2	1.508,5	606,7
Anteil am Gesamtgebiet in %	**50,8**	**21,4**	**19,3**

When interpreting the results, it should be taken into consideration that although seabirds and resting birds use the entire EEZ as a habitat, they are not evenly distributed, as described in Chapter 2.9. The main focus for divers is in the area west of Sylt. For a well-founded assessment of the potential effects, more detailed knowledge of the occurrence (e.g. from habitat modelling) is necessary. In combination with the avoidance radius actually determined by monitoring, this would make it possible to calculate the number of theoretically affected individuals. Effects at the population level, which are the benchmark for assessing significance, were estimated only approximately in this way. However, the number of individuals affected by the habitat impairment is currently unknown, and the size of the local population must first be clearly defined as a reference point for the assessment. The individuals occurring in the German EEZ are part of a larger, biogeographical population. Relocations to other areas of the North Sea are thus also possible, whereby other littoral states of the North Sea also planning a development of offshore wind energy.

However, the above analysis makes it clear that the planned expansion and the associated increase in areas for offshore wind energy could result in major habitat changes for seabird and resting bird species with a large-scale distribution in the entire German EEZ of the North Sea. The maritime areas outside the sites for wind energy are also used by other activities such as shipping, military exercises, and fishery (see BSH 2021); these activities can have effects on the habitat quality of these maritime areas for seabirds and resting birds.

There are currently gaps in our knowledge regarding the assessment of the effects of cumulative habitat change. The extent of the consequences of the scaring effects or potential habitat impairment at the population level is still largely unknown. In long-lived species, these can occur with a considerable time delay. Population trend analyses can provide an indication; however, these cannot be clearly traced back to individual stressors. Definable threshold values above which further pressures on an individual stressor are no longer tolerable for individual species are not yet available for all seabird and resting bird species. The expansion of offshore wind energy should be accompanied by continuous monitoring and in-depth analyses such as the aforementioned population trend analyses.

Based on the current state of knowledge of the avoidance behaviour of various species of seabirds and resting birds and the current threat to their populations because of avian influenza, environmental pollution and climate and ecosystem changes (cf Chapter 5.2.2.2), it does not appear impossible at the present time that, even taking into consideration the ongoing actual development situation, significant effects on seabirds and resting birds within the meaning of Section 3 UVPG may result from the construction and operation of the planned offshore wind farms under cumulative consideration of the authorised offshore wind farm projects at the population level. The prognostic uncertainties must be investigated further.

4.17.5. Migratory birds

The potential threat to bird migration results not only from the effects of the individual projects but also cumulatively in conjunction with other planned, authorised, or already constructed wind farm projects in the EEZ of the North Sea.

South-east of the Shipping route SN10, Areas N-6 to N-8 are already developed with offshore wind farms. In addition to the seven wind farms “Deutsche Bucht”, “Veja Mate”, “BARD Offshore 1” (Area N-6), “He Dreiht” (Area N-7), “Albatros”, “Hohe See”, and “Global Tech 1” (Area N-8), which are under construction or in operation, Sites N-6.6 and N-6.7 and N-6.8 and N-7.2 have been determined to be suitable for the construction and operation of an offshore wind farm by the 2nd and 3rd Offshore Wind Energy Ordinance. Further neighbouring areas are Areas N-9 and N-10 (north-west) as well as Areas N-11, N-12, and N-13 (north-east). All five areas are earmarked for future wind energy use in the draft SDP.

With a development as envisaged in the site development plan and an assumed main migratory direction of north-east to south-west (cf Figure 45), migrating birds would encounter a larger total area of wind energy use. In addition to the aforementioned areas in the German EEZ, the total area would include the NL 5-Oost area with the Doordewind Site I and Site II areas in the Dutch EEZ and would have a roughly estimated length of over 150 km and, in some places, a width of over 65 km. Further areas in the Dutch and Danish EEZ are likely to be added. The potential danger for migratory birds increases with every additional wind farm located in the direction of migration. Another total area, albeit on a smaller scale, would be created in north-western region of the German EEZ with the development of Areas N-14 through N-17 and N-20.

On land and at sea, birds collide with various obstacles under different environmental conditions (ERICKSON et al. 2005, DREWITT & LANGSTON 2008, LOSS et al. 2015). Many species migrate over the sea, sometimes in considerable numbers (see Chapter 2.10.2.2). Collisions with OWT can thus be completely ruled out – even under favourable visibility conditions. Furthermore, it is reasonable to assume that the collision risk increases greatly in abrupt bad weather. However, because of the lack of knowledge about the relationship between migration intensity and collision rates at OWTs, there is still uncertainty regarding this aspect (see also Chapter 4.9.1).

Although collisions with OWT cannot be completely ruled out for diurnal migratory birds and seabirds, darkness and/or uncertain weather conditions generally harbour a higher risk of collision for all species. In addition to the light and weather conditions as well as the flight altitude, the collision risk plays a role in whether a species avoids a wind farm (i.e. flies over, around, or through it).

Some species avoid wind farms by flying horizontally or vertically around them. In addition to observations on land, this behaviour has also been demonstrated offshore (e.g. KAHLERT et al. 2004, HORCH & KELLER 2005, AVITEC RESEARCH GBR 2020). Evasive reactions in different directions occurred; however a reverse migration was not observed (KAHLERT et al. 2004). For example, avoidance behaviour was observed in ducks, gannets, auks, and kittiwakes (AVITEC RESEARCH GBR 2020). Even if the large-scale fly-around represents a response of some bird species to individual wind farms (e.g. MASDEN et al. 2009, AVITEC RESEARCH GBR 2020, IFAÖ GMBH et al. 2020), cumulative effects could lead to an extension of the migration route for migrating birds. In addition to species-specific behaviour, the alignment of wind farms to the main migratory directions must therefore also be taken into consideration in the event of a potential adverse effect on bird migration in the sense of a barrier effect.

When considering the main migratory directions north-east to south-west for autumn migration and south-west to north-east for spring migration, Areas N-6 to N-13 described above lie in the direction of migration from which larger barrier effects could emanate in cumulation with the sites in Area NL 5-Oost. Taking into consideration the main migratory directions (north-east–south-west), the occurrence of barrier effects could result in avoidance manoeuvres of over 50 km. If stronger easterly or westerly components are taken into consideration, large-scale avoidance manoeuvres (> 100 km) result if the original migration route is resumed after the avoidance manoeuvre. An additional migration distance of 50–100 km seems small in view of the non-stop flight performance of several thousands of kilometres some species (BERTHOLD 2000, BAIRLEIN 2022). Nevertheless, there is always an increased demand for energy because of the fly-around of wind farms. In the absence of compensation (e.g. by resting on the migration route), increased energy consumption could have an impact on reproductive success and, in the worst case, on survival (BRUINZEEL & VAN BELLE 2010, KELSEY et al. 2021, RÜPPEL et al. 2023).

large, contiguous wind farm areas such as those planned in the German EEZ and in the EEZ of neighbouring countries make horizontal avoidance increasingly difficult. Although long-range avoidance is generally part of the species-specific behavioural repertoire of some species, fly-over or fly-through is more likely. Particularly for the group of songbirds most frequently recorded over the North Sea (which primarily migrate at night), there is still uncertainty as to whether they fly around large areas (macro-avoidance) (SCHULZ et al. 2014, WELCKER & VILELA 2019) or whether they fly through offshore wind farms (OWFs) at a certain distance from the individual wind turbines and their components (meso- and micro-avoidance) (SCHULZ et al. 2014, AVITEC RESEARCH GBR 2019). Results of the long-term monitoring of the “Nördlich Borkum” cluster suggest that a fly-through appears more likely (AVITEC RESEARCH GBR 2020).

Flying through the OWFs could result in an increased number of collisions. However, based on current knowledge, a proportionality between migration rates and collision rates as is often assumed in collision models (MASDEN & COOK 2016) cannot generally be assumed. In other words, high migration rates do not necessarily go hand in hand with high collision numbers (absolute number of colliding birds) or collision rates (relative proportion of colliding birds in the total number of migrating birds). Rather, collision rates appear to depend on species-specific behaviour and weather conditions. Also the wind farm design could play a role (MASDEN & COOK 2016, LEEMANS & COLLIER 2022).

If visibility conditions are good, it can be assumed that the birds will recognise the WTs and avoid them so that the number of fatalities is low even with high migration intensity (ASCHWANDEN et al.2018). On the other hand, the potential risk of collision can increase considerably under unfavourable weather conditions for bird migration, especially if the birds are lured into the danger zone by turbine lighting. The migration rates can therefore not be used to estimate collision-related mortality. Lower migration rates also do not automatically mean a lower collision risk. Whether a potentially increased flight through the wind farms would be associated with an increased collision rate therefore remains uncertain because of the current insufficient data availability.

Taking into account the existing findings on the migratory behaviour of the various bird species and the current findings on the collision risk of birds with OWT, it cannot be assumed that the construction and operation of the planned offshore wind farms is likely to pose a significant threat to bird migration with cumulative assessment of the already approved offshore wind farm projects However, with regard to a cumulative overall view, there are prognostic uncertainties that should be investigated further (BRABANT et al. 2015, AVITEC RESEARCH GBR 2020). At present, a fly-around or fly-through the projects is not expected to have any significant negative effects on the further development of the populations.

In this regard, it should be taken into consideration that there is a certain degree of uncertainty, both at the level of the individual wind farm sites and in a cumulative analysis, particularly for the most frequently recorded group of songbirds, which migrate primarily at night. The uncertainty is due mainly to the fact that there is currently no systematically recorded scientific knowledge regarding species-specific migration behaviour in poor weather conditions (headwinds and crosswinds, rain, fog), evasive behaviour, and its subsequent effects as well as real losses caused by collisions in offshore wind farms. In order to address the remaining forecast uncertainty at the level of the sites as well as in a cumulative view, Planning principle 7.1.6 on bird collision monitoring in the SDP provides for monitoring to measure bird collisions.

5. Assessment of the likely effects of the implementation of the plan on marine environment in accordance with the applicable laws

5.1. Biotope protection (Section 30 BNatSchG)

In accordance with Section 30, para. 2, sentence 1 BNatSchG, all actions that may cause destruction or other significant adverse effect on the biotopes listed in Section 30, para. 2, sentence 1 BNatSchG are generally prohibited. In accordance with Section 72, para. 2 WindSeeG, Section 30, para. 2 BNatSchG shall be applied to projects under the WindSeeG with the proviso that a significant adverse effect on biotopes within the meaning of Section 30, para. 2, sentence 1 BNatSchG shall be avoided as far as possible. Even if the aforementioned provisions expressly refer only to the approval level, they are nevertheless also examined at the upstream planning level so as not to lead to a lack of enforceability in the context of the approval of projects. At the planning level, it does not make sense to make a designation in this respect if the intended use would not be legally permissible from the outset.

The direct and permanent use of a protected biotope according to Section 30, para. 2 BNatSchG is generally a significant adverse effect, which should be avoided as far as possible in accordance with Section 72, para. 2 WindSeeG. A central component of the assessment approach according to LAMBRECHT & TRAUTNER (2007) is orientation values for quantitative-absolute area losses of an affected biotope occurrence, which may not be exceeded depending on its total size. For large biotope areas, an orientation value of 5 ha has been established as the maximum value for the absolute area loss and an orientation value of 1% for the relative area loss (BFN 2012). When calculating the area loss, temporary disturbances (e.g. because of working areas and sedimentation) must also be taken into consideration proportionately as area equivalents in addition to direct use of marine space.

Because comprehensive biotope mapping has not yet been carried out for most sites and areas an no specific assumptions can be made (e.g. regarding the location of installation), a final assessment cannot be carried out as part of the SEA for the draft SDP. At this point, reference is therefore made to the subordinate planning and approval levels.

The following is therefore only a rough assessment based on the data available as well as assumptions as to whether potentially significant effects in terms of biotope protection can be ruled out.

Area N-4

The current BfN biotope map does not indicate the presence of legally protected biotopes in Area N-4. In contrast, there are indications from the procedures of the existing wind farms of the occurrence of coarser sediments in connection with a *Spisula goniadella community* (see Chapters 2.2.2, 2.5.5, and 2.6.4), especially in the northern part of the area. A small-scale occurrence of the legally protected biotope type species-rich gravel, coarse sand and shell layers can therefore not be completely ruled out. In this case, any adverse effects in accordance with Section 72, para. 2 WindSeeG should be avoided as far as possible. For a detailed assessment in the context of subsequent use, reference is made to the downstream planning and approval levels or assessments in SEAs for subsequent SDP.

Area N-5

In the western part of Area N-5, which is intended for subsequent use and expansion, there is a sandbank measuring approx. 200 km²; of this, approx. 105 km² lie within the area (approx. 25% of the area). To the east and west of this, numerous smaller reef areas have been mapped by the BfN and as part of the licensing procedure for the “Sandbank” OWF, which, according to the current state of knowledge, cover a total area of approx. 6.4 km². The mapping of the legally protected biotope species-rich gravel, coarse sand and shell layers has not yet been completed for the maritime area. However, the BfN biotope map for this area shows 35 km² of coarse sediments and around 20 km² of coarser sands with a *Goniadella-Spisula* community. In these areas, local occurrences of the legally protected biotope cannot be ruled out.

Because of the large extent of the FFH habitat type sandbank and the local occurrence of other legally protected biotopes, it cannot be ruled out that the guidance values will be exceeded if the plan is implemented taking into consideration the model wind farm parameters. In this case, any adverse effects in accordance with Section 72, para. 2 WindSeeG should be avoided as far as possible. For a detailed assessment, please refer to the downstream planning and approval levels.

Site N-13.4

An extensive reef band runs through both sub-sites of Site N-13.4 from north to south. According to the current state of knowledge, this covers approx. 20.4 km² and thus approx. 11% of Site N-13.4. The mapping and verification of potential additional reef areas has not yet been completed (as of 29 February 2024). Because of the orientation and extent of the reef structures, it can be assumed in the worst-case scenario that these cannot be completely avoided when laying the in-farm cabling and selecting the wind turbine locations. In addition, initial analyses of underwater video recordings show unusually high densities of larger blocks, at least locally for the EEZ of the North Sea. Furthermore, there are findings on residual and coarse sediment areas in the area of Site N-13.4; these could also be designated as a reef or partially assigned to the legally protected biotope of species-rich gravel, coarse sand and shell layers. However, the biotope mapping, including the biological characterisation of the reef areas in Site N-13.4, has not yet been completed.

For a detailed examination, please refer to the next SDP environmental report.

Area N-19

Area N-19 lies entirely in the area of a sublittoral sandbank. Taking into consideration the assumed parameters of the model wind farms, the use of marine space of a single WT is between 2,043 m² (Scenario 1) and 5,153 m² (Scenario 2). This means that the orientation value of 5 ha of area loss would already be exceeded from 10 installations (Scenario 2) or 25 installations (Scenario 1). Smaller areas with coarser sediments are embedded in the sandbank. From a sedimentological point of view, some of these meet the criteria for the legally protected biotope species-rich gravel, coarse sand and shell layers. However, biological verification is still pending.

For a detailed assessment, please refer to the downstream planning and approval levels.

Other other sites and areas

There are no findings on the occurrence of legally protected biotopes in any other sites and areas. However, very small-scale or localised occurrences (especially reefs of the marine boulder type) cannot be ruled out. In practice, these sites are bypassed during the planning of the installation sites and the laying of the in-farm cabling so that significant adverse effects are generally avoided. Until a comprehensive biotope map is available, a detailed assessment can be carried out only at the downstream planning and approval levels.

Routes of subsea cables and interconnectors

Because of the lack of a completed biotope mapping, no conclusive statement can be made regarding the impact of the laying of the cable systems on the small-scale protected biotopes “reefs” and “species-rich gravel, coarse sand and shell layers” on the use of specially protected biotopes according to Section 30, para. 2 BNatSchG.

The small-scale occurrence of coarse sediments, which form the basis for the legally protected biotope type species-rich gravel, coarse sand and shell layers, cannot be completely ruled out in the corridors of all grid connection systems that enter the EEZ in the area of the Gates N-II and N-III. For the route corridor, which enters the EEZ in the area of the Gate N-V, there are concrete indications of the occurrence of coarse sediments.

A reef area was identified directly adjacent to the route of the NeuConnect interconnector south-east of Area N-3. Reef occurrences within the cable routes for the grid connection systems coming from Gate N-III are not known but cannot be completely ruled out.

Furthermore, there are concrete findings on the occurrence of the “reefs” biotope along the route of the connection systems coming from Gate N-V.

On the first 10 km of the route from Gate N-V to the west, several smaller reef areas have been identified in ongoing investigations in individual procedures (in particular BorWin6). Because of their spatial orientation, these are unlikely to be completely bypassed. Effects on individual reef areas or their biocoenoses could be minimised through the bypassing or redistribution of individual stones.

Reefs (especially in the form of marine boulders) along the route of the interconnectors I-NOR-10 and I-NOR-11 cannot be completely ruled out. As part of the investigations into the Viking-Link interconnector, individual larger blocks were identified along the route.

The two interconnectors planned in the direction of Denmark south-east of Shipping route SN10 (I-NOR-6 and I-NOR-7) cross at least a sub-site the reef band running there (cf Site N-13.4). If it is not possible to bypass this reef area, a significant adverse effect on the reef cannot be ruled out if projects are realised on both routes.

In practice, both protected biotopes are bypassed in the course of route planning; significant adverse effects are thus generally avoided. Detailed consideration must be given to the specific characteristics of the respective projects at the subordinate planning and approval levels.

The NOR 6-4 grid connection system runs along a stretch of approx. 9 km within the sandbank at Borkum Riffgrund (outside the protected area of the same name). Because of the length of the encroachment (dimensions of the cable trench 9,000 × 1 m, functional area loss of the working areas to be calculated equivalently), a significant adverse effect resulting the construction and operation cannot be ruled out *a priori*.

Corridors for hydrogen pipes for the grid connection of Site SEN-1

The corridor variant for the hydrogen pipeline SEN-1 in the direction of the Gate N-I crosses the sandbank within the “Borkum Riffgrund” nature conservation area over a distance of approx. 21 km as well as a further 7 km through the same sandbank outside the aforementioned protected area. Furthermore, it crosses coarse substrates (potential occurrences of the legally protected biotope of species-rich gravel, coarse sand and shell layers) along around 7 km of the route within the nature conservation area and crosses at least one designated reef area. Because of the unknown dimensions and laying technique of the pipeline, it is not possible to assess the significance. This would have to be examined in more detail when designating this corridor.

A smaller reef area is also crossed on the alternative corridor in the direction of Gate N-III. Because of the unknown dimensions and laying technique of the pipeline, it is not possible to assess the significance. This would have to be examined in more detail when designating this corridor.

5.2. Species protection (Section 44, para. 1 BNatSchG)

Section 39 BNatSchG regulates general protection for all wild species. According to Sections 44 et seq. BNatSchG, special provisions apply to animals of specially or strictly protected species. These standards are also applicable in the German EEZ according to Section 56, para. 1 BNatSchG.

It is examined whether the implementation of the plan (i.e. the construction and operation of wind turbines on the sites) is in line with Section 44, para. 1 BNatSchG. A site is not suitable if the construction and operation of wind turbines violates one of the prohibited offences set out in Section 44, para. 1 BNatSchG and the requirements for granting an exception according to Sections 44 and 45 BNatSchG are not met. For acceleration sites, Section 70a, para. 2, sentence 3 WindSeeG-E stipulates that when implementing the measures, including measures according to rules, from the site development plan according to Section 5, para. 2c, sentence 1 WIndSeeG-E or measures ordered by the BSH according to Section 70a, para. 4 WindSeeG-E, it can be assumed that compliance with the requirements of Section 44, para. 1 BNatSchG is guaranteed.

In the species protection assessment, an assessment based on the benchmark of practical reasonableness is necessary but also sufficient. The authority does not have to be certain that adverse effects will not occur (BVerwG, judgement of 9 7. 2009 – 4 C 12/07, NVwZ 2010, 123, 132).

5.2.1. Prohibition of killing and injury (Section 44, para. 1, No. 1 BNatSchG)

In accordance with Section 44, para. 1, No. 1 BNatSchG, it is prohibited to injure or kill wild animals of specially protected species.

In accordance with Section 7, para. 2, No. 13 BNatSchG, specially protected species are animal and plant species listed in Appendix A or B of the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (Ordinance (EC) No. 338/97 of 9 December 1996 on the protection of species of wild fauna and flora by the monitoring trade (OJ L 61, 3.3.1997, p. 1, L 100, 17 April 1997, p. 72, L 298, 1 November 1997, p. 70, L 113, 27 April 2006, p. 26) as last amended by Ordinance (EC) No. 709/2010 (OJ L 212, 12 August 2010, p. 1)), animal and plant species listed in Appendix IV of the Habitats Directive (Directive 92/43/EEC), European bird species, and (in conjunction with Section 54, para. 1 BNatschG) the species listed in the Regulation on the Protection of Wild Fauna and Flora (Federal Species Protection Regulation – BArtSchV). European bird species are naturally occurring bird species in Europe within the meaning of Article 1 of Directive 2009/147/EC, Section 7, para. 2, No. 12 BNatSchG.

The prohibition of access of Section 44, para. 1, No. 1 BNatSchG is individual-related and thus not amenable to a population-related relativisation (Gellermann in Landmann/Rohmer UmweltR, 96th EL Sept. 2021, BNatSchG Section 44 marginal no. 9 with further references). In accordance with Section 44, para. 5, sentence 2, No. 1 BNatSchG, adverse effects on nature and seascape that are unavoidable according to Section 15, para. 1 BNatSchG do not constitute a violation of the prohibition of killing and injury according to para. 1, No. 1 for the animal species listed in Appendix IV of the Habitats Directive and European bird species, inter alia, if the adverse effects caused by the encroachment or the project does not significantly increase the risk of killing or injury for specimens of the species concerned and this adverse effect cannot be avoided by applying the required, professionally recognised protective measures. The provision of Section 44, para. 5, No. 1 BNatSchG restricts the offence of Section 44, para. 1, No. 1 BNatSchG according to case law (BVerwG, judgement of 13 May 2009, 9 A 73/07, marginal no. 86; BVerwG, judgement of 8 January 2014, 9 A 4/13, marginal no. 99) relating to operation-, construction- and installation-related risks to the effect that the unavoidable loss of individual specimens because of a project does not automatically and always constitute a violation of the prohibition of killing. This regulation was intended to confirm the significance approach according to the case law of the Federal Administrative Court on Section 44, para. 1, No. 1 BNatSchG (Bundestag printed paper 18/11939, p. 17).

The criterion of significance, which is to be filled in using an evaluative consideration, takes account of the fact that there is already a general risk of killing and injuring fauna irrespective of the project, which does not only result from the general natural process, but can also be socially appropriate and is therefore to be accepted if it is caused by humans but only affects individual individuals. Because animal life does not exist in an untouched seascape, but in a seascape designed by people. These are circumstances that play a role in the assessment of significance, in particular species-specific behaviour, frequent use of the intersected space, the effectiveness of intended protective measures, and, where applicable, other criteria related to the biology of the species (cf Judgements of 9 July 2008 – 9 A 14.07 – BverwGE 131, 274 marginal no. 91, of 6 April 2017 – 4 A 16.16 – NuR 2018, 255 marginal no. 73 et seq. and of 27 November 2018 – 9 A 8.17 - BVerwGE 163, 380 marginal no. 98 et seq.).

5.2.1.1. Marine mammals

Harbour porpoise

In accordance with Section 44, para. 1, No. 1 BNatSchG, a killing or injury of the harbour porpoise as a specially protected species according to Section 7, para. 2, No. 13, lit. b, sublit. aa in conjunction with Appendix IV of the Habitats Directive is prohibited.

The harbour porpoise uses the frequency range between 80 kHz and 150 kHz for communication and echolocation and thus belongs to the group of very high-frequency whales (SOUTHALL et.al. 2021). Excessive sound inputs can lead to a permanent or temporary auditory threshold shift in harbour porpoises, which can limit the echolocation of the fauna.

In addition to noise, bycatch poses a major threat to the harbour porpoise – as do diseases, attacks by other marine mammals, the enrichment of food organisms with pollutants, and microplastics (EVANS 2020).

(1) Construction-related

With regard to the construction of the wind turbines on the site and the possible ramming of the foundations, it is particularly necessary to assess whether the noise pollution caused by this results in a significant injury or killing of an individual of the strictly protected species, the harbour porpoise. In 2013, the BMU (Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection) published a noise protection concept for the area of the German EEZ of the North Sea in order to better assess a possible violation of the prohibition of injury to the harbour porpoise. The noise protection concept of the BMU offers an interpretation aid for the undefined legal term “infringement” within the meaning of Section 44, para. 1, No. 1 BNatSchG. According to the noise protection concept of the BMU (BMU 2013), there is no violation of Section 44, para. 1, No. 1 BNatSchG if the established noise protection values, which consist of a dual criterion of a sound exposure level (SEL) of 160 dB re 1μPa² s (unweighted) and a peak sound pressure level (SPLpeak-peak) of 190 dB re 1μPa at a distance of 750 m are complied with. For the areas where higher sound pressures occur, suitable measures must be taken to ensure that no animals are present at the time of the sound events (e.g. deterrence).

In its comments, the BfN regularly assumes that, according to the current state of knowledge, injuries in the form of temporary hearing loss occur in harbour porpoises if animals are exposed to a sound exposure level (SEL) of 164 dB re 1μPa²/Hz or a peak level of 200 dB re 1 μPa.

If the foundations are rammed without the use of preventive and mitigation measures, it is assumed that the aforementioned threshold values are exceeded. In previous projects in the German EEZ, sound exposure levels of up to 182 dB were measured at a distance of 750 m during measurements without noise protection systems (JURETZEK et al. 2021, ROSE et al. 2019). In the case of pile driving without preventive and mitigation measures, a significant increase in the risk of killing and injury of the harbour porpoise within the meaning of Section 44, para. 1, No. 1 in conjunction with para. 5, sentence 2, No. 1 BNatschG must therefore be assumed.

The use of preventive and mitigation measures is therefore necessary in order to exclude the realisation of the prohibition of killing and injury according to Section 44, para. 1, No. 1 BNatSchG with the necessary certainty.

According to estimation of the BfN and the noise protection concept of the BMU, it is ensured with sufficient certainty that, if the specified threshold values of 160 dB for the sound exposure level (SEL_{05}) and 190 dB for the peak level at a distance of 750 m from the point of emission are complied with, with regard to the harbour porpoise, the killing and injury offence according to Section 44, para. 1, No. 1 BNatSchG cannot be realised.

The Federal Agency for Nature Conservation 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.

The site development plan and the associated environmental report contain specifications on noise protection measures and other preventive and mitigation measures (conflict preventing or mitigating measures; cf LAU in FRENZ/MÜGGENBORG, BNatSchG, Section 44, marginal no. 3).

Planning principle 6.1.9, lit. a of the draft of the 2024 site development plan stipulates that the noise protection concept of the BMU must be observed when foundations are driven. This means that the aforementioned threshold values of 160 dB for the sound exposure level and 190 dB for the peak level required by BMU (2013) and Federal Agency for Nature Conservation must be met. This provision is also necessary from the point of view of the BSH in order to prevent a threshold value auditory threshold shift (see Section 4.7.2 for the technical reasoning of the threshold value). Because according to Section 6, para. 9, sentence 2 WindSeeG the site development plan is binding for the approval procedure, no additional specification in the WindSeeV is required. Compliance with these preventive and mitigation measures (Chapter 7) is also ensured for all sites.

In the case of blasts, the threshold values mentioned are usually substantially exceeded. Planning principle 6.1.9 lit. c of the 2024 draft site development plan stipulates that blasting is generally not permitted. If blasting is unavoidable for the removal of ammunition that cannot be transported, a noise protection concept must be submitted to the BSH in good time beforehand. In this respect, too, no additional provisions are required in the WindSeeV for the reasons mentioned above.

According to Planning principle 1.6.9 of the site development plan and the associated environmental report, the working method that is as quiet as possible given the circumstances must also be used in accordance with the state of the art, and the duration of the pile driving process, including deterrence, must be kept to a minimum in accordance with letter b of the Planning principle. This should minimise the encroachment. According to letter d of the planning principle, for prevention or reduction of significant cumulative effects, an overall temporal and spatial coordination of the pile driving work should be ordered within the framework of the subordinate approval procedure, taking into consideration the project-specific framework conditions. In this way, cumulative effects (i.e. the disturbance radius) are kept as small as possible and actual disturbance is avoided (see Chapter 4.7 for details of the technical reasoning). Because according to Section 6, para. 9, sentence 2 WindSeeG the site development plan is binding for the approval procedure, no additional specifications in the WindSeeV are required.

Planning principle 6.1.9 lit. a of the draft of the 2024 site development plan, according to which the requirements of the noise protection concept of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMU, 2013) must be observed when pile driving foundations (Planning principle 6.1.9 lit. a), in conjunction with 7.2 of the concept, stipulates that suitable measures must be taken to ensure that no animals are present in areas where sound pressures are higher than the aforementioned sound limit values at the time of the sound events (deterrence).

According to case law, “a measure ordered to prevent the risk of killing (Section 44 I, No. 1 BNatSchG) such as the deterrence of a species […] may also fulfil the offence of the prohibition of disturbance according to Section 44 I, No. 2 BNatschG if it takes place during the protected periods and is significant” (BVerwG, judgement of 27 November 2018 – 9 A 8/17 4th guiding principle).

The development of new configurable deterrence systems such as the Fauna Guard System or the APD System (see Chapter 4.7.1) 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 injury offence within the meaning of Section 44, para. 1, No. 1 BNatSchG can be ruled out with certainty without the simultaneous realisation of the disturbance offence within the meaning of Section 44, para. 1, No. 2 BNatSchG. Within the framework of the approval procedure, this – but also another type of deterrence can be ordered – if this proves to be more suitable based on the then given state of knowledge and the state of the art. In addition, the project approval procedure regularly arranges a monitoring and sound measurements of the necessary preventive and mitigation measures (efficiency control) via appropriate arrangements.

The binding preventive and mitigation measures specified in the site development plan for an approval procedure according to Section 6, para. 9, sentence 2 WindSeeG and regularly specified by the BSH as part of a project approval procedure as well as the preventive and mitigation measures specified by the BSH in the environmental report prevent the fulfilment of the prohibited offences under species protection law in Section 44, para. 1, No. 1 BNatSchG with the necessary certainty.

(2) Installation- and operation-related

According to the current state of knowledge, because of the currently measured values of the operational noise in combination with the hearing ability of the harbour porpoise, neither the operation of the installations nor the laying and operation of the in-farm cabling will have any significant negative effects on marine mammals that fulfill the killing and injury offence according to Section 44, para. 1, No. 1 BNatSchG (for technical details, see Chapter 4.7.1). In order to ensure that future developments (e.g. more powerful installations, larger diameters) do not have any negative effects, the draft of the 2024 site development plan stipulates that, according to the state of the art, the installation design that is as low in operational noise as possible under the given circumstances should be selected (Planning principle 6.1.9). According to Section 6, para. 9, sentence 2 WindSeeG, the site development plan is binding for the approval procedures for offshore wind farms. The approval agency is therefore obliged to implement the provisions of the site development plan within the framework of the approval procedure.

Other marine mammals (grey seal, harbour seal)

In accordance with Section 44, para. 1, No. 1 BNatSchG, the killing or injury of native marine mammals as specially protected species is prohibited according to Section 7, para. 2, No. 13 lit. c, Section 54, para. 1 BNatSchG in conjunction with Section 1, sentence 1, Annex 1 BArtSchV. This includes in particular the harbour seal and the grey seal.

(1) Construction-related

For pile driving work without the application of preventive and mitigation measures (deterrence, technical noise mitigation), a significant increase in the risk of killing and injury of grey seals and harbour seals within the meaning of Section 44, para. 1, No. 1 in conjunction with para. 5, sentence 2, No. 1 BNatschG must therefore be assumed.

The use of preventive and mitigation measures is therefore necessary in order to exclude the realisation of the prohibition of killing and injury according to Section 44, para. 1, No. 1 BNatSchG with the necessary certainty.

Based on the necessary preventive and mitigation measures outlined for the harbour porpoise in the draft of the 2024 site development plan and the associated environmental report, it can be assumed that the prohibition according to Section 44, para. 1, No. 1 BNatSchG will not be fulfilled for harbour seals and grey seals either, because harbour porpoises are more sensitive to noise pollution.

Furthermore, the sites to be considered in the draft SDP are of no particular importance for harbour seals and grey seals. The nearest commonly frequented resting places in the German EEZ are located on Heligoland and the East Frisian Islands. With regard to harbour seals and grey seals, there is also no evidence from monitoring of the operating phase of existing offshore wind farms in the EEZ that indicates avoidance of the sites or changes in behaviour.

Overall, it can be assumed that the prohibition of Section 44, para. 1, No. 1 BNatSchG is not fulfilled with regard to harbour seals and grey seals because of the distances to resting places as well as because of the aforementioned requirements of the 2024 draft site development plan, which are binding for the approval procedure according to Section 6, para. 9, sentence 2 WindSeeG as well as the requirements of the associated environmental report, regularly specified in the approval.

(3) Installation and operation related

Overall, it can be assumed that the prohibition of Section 44, para. 1, No. 1 BNatSchG is not fulfilled with regard to harbour seals and grey seals by the operation of the wind turbines because of the aforementioned distances to resting places as well as because of the aforementioned requirements of the 2024 draft site development plan, which are binding for the approval procedure according to Section 6, para. 9, sentence 2 WindSeeG as well as the requirements of the associated environmental report, regularly specified in the approval.

5.2.1.2. Avifauna

In the case of industrial installations, especially wind turbines, the loss of individuals of avifauna is always to be expected. This is why the prohibition of the killing and injury of birds is not realised in accordance with Section 44, para. 5, sentence 2, No. 1 BNatSchG if the risk in this regard is not significantly increased (In general terms, see above in Chapter 5.2.1).

A significant increase in the risk of killing requires evidence that this risk is significantly increased by the operation of the installation; for this, it is neither sufficient that individual specimens are harmed (e.g. by collisions nor that specimens of affected species have been encountered at all in the encroachment area (cf BVerwG, judgement of 9 July 2009 – 4 C 12.07 – Buchholz 442.40 Section 8 LuftVG No. 35 marginal no. 42). In this context, it must be taken into consideration that bird migration in itself poses many dangers and subjects populations to harsh selection. The mortality rate of young birds can be between 60 and 80% in songbirds (ELLE et al. 2014); the natural mortality rate is lower in larger species. The individual species also have different reproduction rates, and hence the loss of individuals can be of different consequence for each species.

With regard to collision-related losses of individual specimens, the Federal Administrative Court has stated that the elements of the killing and injury offence are not fulfilled if a project/plan does not cause a significantly increased risk, at least because of to preventive measures (i.e. remains below the risk threshold in a risk area that is always associated with such a project in the natural environment; cf BVerwG, judgement of 9 July 2008 - 9 A 14.07, NVwZ 2009, 302, Ls.). Zero risk is not required, which is why the requirement that the planned protective measures must, on their own, avoid collisions with almost 100% certainty is too extensive (BVerwG, judgement of 28 April 2016 - 9 A 9/15, NVwZ 2016, 1710, marginal no. 141).

In accordance with Section 44, para. 1, No. 1 BNatSchG in conjunction with Section 7, para. 2, No. 13, lit. b, sublit. bb BNatSchG, the killing or injury of European bird species is prohibited. This includes all naturally occurring species in Europe.

European bird species, including red-throated diver, black-throated diver, little gull, sandwich gull, Sandwich tern, common tern, and Arctic tern, (which are protected under Annex I of the Birds Directive) as well as other regularly occurring species such as the lesser black-backed gull, black-legged kittiwake, fulmar, gannet, guillemot, and razorbill occur in varying densities in the vicinity of the sites.

For seabirds, all findings to date indicate a medium but also species-specific seasonal increase in the importance of the sites and their surroundings. The sites lies outside the concentration centres of various bird species listed in Appendix I of the Birds Directive (e.g. divers, little gulls, and terns).

In addition to the seabird species mentioned above, waterbirds such as ducks and geese are regularly observed in large numbers in the environmental impact studies for offshore wind farm projects (Chapter 2.10.2.1). These include the barnacle goose, which is listed in Appendix I of the Birds Directive. Because of the frequent occurrence of geese and the possible migration of ducks and geese in a north-west–south-east direction between Greenland and the Wadden Sea, Areas N-4, N-5, and N-9 through N-19 as well as their surroundings are of medium importance for ducks and geese.

European waders are also regularly observed, albeit in small numbers (see Chapter 2.10.2.1). Five species (avocet, dotterel, European golden plover, bar-tailed godwit, and wood sandpiper) listed in Annex I of the European Birds Directive were also identified. Because of the low numbers and the fact that waders generally migrate along the German Wadden Sea coast in a coastal direction, Areas N-4 and N-5 are of medium importance for waders, and Areas N-9 to N-19 are of low importance.

Furthermore, considerable numbers of songbirds breeding in northern Europe migrate across the North Sea on a broad front. In contrast to the territorial sea, vision and guiding principles and concentration areas for bird migration are however not known in the EEZ. There is evidence that migration intensity decreases with distance from the coast (see Chapter 2.10.2). The sites of Areas N-4, N-5, N-9 through N-13, and N-14 through N19 are located approx. 50 km, 70 km, 120 km, and over 150 km from the mainland and, including their surroundings, are of medium importance for songbird species.

In the following, those species or species groups are examined in detail for the areas and sites for which a threat cannot be ruled out from the outset (e.g. because of the observed frequency and frequency of use of the space, their species-specific behaviour, or their protection category; for these criteria, see the introduction to Chapter 5.2.1).

Areas and sites for offshore wind turbines

Divers

The main concentration area for divers in the German North Sea is west of Sylt (BMU 2009). The closest sites of the draft SDP are N-13.4, both sub-sites of which are directly adjacent to the main concentration area, and N-12.5, which is around 13.4 km away. The BSH maps (Figure 28) show only a few divers in the sites covered by the draft SDP, whereby the availability of data for seabirds and resting birds in the outermost part of the German EEZ of the North Sea is limited.

As species that are highly sensitive to disturbance, both diver species (red-throated and black-throated divers, *Gavia stellata* and *Gavia arctica*) have high values in the “Wind Turbine Sensitivity Index” (WSI) according to GARTHE & HÜPPOP (2004) (Table 16

Table 16). This index combines nine factors that assess general behaviour, flight behaviour, and protection status into an overall assessment of sensitivity to wind turbines. The black-throated diver then has the highest wind turbine sensitivity index (WSI) of all considered species, closely followed by the red-throated diver. Their poor manoeuvrability and their pronounced flight activity between different rest and feeding areas could in principle mean an increased collision risk. However, as described in detail in Chapter 4.8.1 (DIERSCHKE et al. 2016, GARTHE et al. 2018, BIOCONSULT SH et al. 2020), both species exhibit strong avoidance behaviour towards vertical structures, particularly offshore wind turbines (OWT); this reduces the risk of collision with OWT. Furthermore, divers mainly fly close to the water surface and at the most at heights of about 10 m (GARTHE & HÜPPOP 2004). Because divers generally prefer the lower flight altitude ranges, they would therefore mainly move below the rotor area, which starts at a height of 30 m in Scenario 1 and 35 m in Scenario 2, even if they became increasingly accustomed to the wind turbines (see Chapter 4.8.1). A significantly increased collision risk is therefore not to be expected. In case of adverse weather conditions during migration, divers can also land on water and wait for better migration conditions.

As a result, because of the comparatively low occurrence in the area of the sites of the draft SDP and the demonstrably pronounced avoidance behaviour towards offshore wind turbines, it can be assumed that the risk of killing and injury for specimens of the divers species group is not significantly increased within the meaning of Section 44, para. 1, No. 1, para. 5, sentence 2, No. 1 BNatschG. According to the current state of knowledge, it can be assumed with the necessary certainty that the prohibition of injury or killing in accordance with Section 44, para. 1, No. 1 BNatSchG in relation to divers will not be realised by the designations of the draft SDP.

Gannets and fulmars

As typical seabird species that spend most of their lives at sea and use marine habitats (MENDEL et al. 2008), gannets (*Morus bassanus*) and fulmars (*Fulmarus glaciali*s) are considered together in one section.

The northern gannet is an important breeding bird on Heligoland and has shown a continuously increasing breeding population since the first breeding pairs settled there in 1991 (DIERSCHKE et al. 2011, DIERSCHKE et al. 2023). Most recently, the number of breeding pairs decreased by almost half from 1,485 in 2022 to 887 in 2023 (personal communication Jochen Dierschke/Heligoland Bird Observatory). This coincides with the outbreak of avian influenza in the gannet breeding colony on Heligoland (June 2022) (LANE et al. 2023). Over a period of twelve years (2003/04-2015/16), surveys over the entire German North Sea showed a positive trend in the population with a winter resting population of 3300 individuals (GERLACH et al. 2019). Gannets are partial migrants, so individuals can occur in the German North Sea at any given point in time (MENDEL et al. 2008). They are diurnal and are considered to be particularly good fliers that can also glide with the wind. Various studies on Heligoland have shown that gannets prefer to fly at altitudes of 0–50 m above the water surface (HÜPPOP et al. 2004, DIERSCHKE & DANIELS 2003, MENDEL et al. 2008). Because of their relatively good manoeuvrability, they are not considered to be particularly susceptible to collision risks and fall in the lower middle range of the WSI (GARTHE & HÜPPOP 2004).

The fulmar, like the gannet in Germany, breeds exclusively in Heligoland but with very small and decreasing number of breeding pairs. With 25 pairs in 2021, 23 in 2022, and 25 in 2023, the number has recently been stable at a low level (personal communication Jochen Dierschke/Heligoland Bird Observatory, DIERSCHKE et al. 2023). According to expert estimates, the winter resting population in the German North Sea declined sharply between 1980/81 and 2015/16 and stands at around 3,700 individuals (GERLACH et al. 2019). According to GARTHE & HÜPPOP (2004), the fulmar is classified to be less susceptible to collisions with technical structures such as WEA. It only has medium manoeuvrability and shows comparatively high nocturnal flight activity. However, because the animals fly at only very low altitudes (less than 10 m) above the water (GARTHE & HÜPPOP 2004), they rarely reach the rotor area, which begins at an altitude of 30 m in Scenarios 1 and 2 and 35 m in Scenario 2 (see Chapter 4.8.1). In case of adverse weather conditions during migration, gannets and fulmars can also land on water and wait for better migration conditions.

According to the current state of knowledge, there is no recognisable significantly increased risk of collision of gannets or fulmars in the areas and sites defined in the draft SDP. It can therefore not be assumed that the prohibition of injury and killing of Section 44, para. 1, No. 1 BNatSchG is realised.

Geese and ducks

Pink-footed goose, grey geese, barnacle geese, and brent geese are among the most common goose species in the German Bight (Table 11). Of the group of sea ducks, black scoters and eiders are regularly observed in considerable numbers in the south-eastern North Sea. Two species of dabbling duck, the wigeon and the teal, are also regularly present. Visual observations in recent years have shown that geese flew mainly at altitudes of 20–200 m and thus in the hazard area of possible wind turbines. All species mentioned are primarily diurnal migrants. It is therefore to be expected that they will be able to recognise obstacles in good time and avoid them. In geese, avoidance reactions towards wind farms have been observed on land and at sea (HÖTKER et al. 2004, PLONCZKIER & SIMMS 2012). Furthermore, geese generally choose good weather conditions with tailwinds and good visibility for their offshore overflights and then migrate over the open North Sea on a few days (HÜPPOP et al. 2007). The number of documented collision victims from coastal (HANSEN 1954) and terrestrial areas (DÜRR 2023) is also low for geese. Ducks were primarily observed flying at low flight altitudes just above the water surface at heights of up to 50 m and thus often below the hazard area of possible wind turbines. Because of the observed frequency and based on the flight altitude distribution in the project area, there could be an increased collision risk for geese. Because of the proven avoidance behaviour towards OWFs and the generally low flight altitudes, the risk of collision for geese and ducks in the North Sea can be considered low. The realisation of the prohibition of killing and injuring in accordance with Section 44, para. 1, No. 1 BNatSchG can therefore be ruled out with the necessary certainty for geese and ducks.

Gulls (little gulls, black-legged kittiwakes and larus gulls)

Gulls were one of the most frequently observed species groups during bird migration surveys at the EIS sites. Large numbers of lesser black-backed gulls and herring gulls, which breed in the North Sea, were recorded. In comparison, great black-backed gulls were observed less frequently. Of the small gull species, the common and black-headed gull were frequently represented with the latter being more common in the coastal areas. The little gull *(Hydrocoloeus minutus*), which is listed in Annex I of the European Birds Directive, is regularly observed in the offshore area. Within the framework of scientific research projects, flight altitude measurements using rangefinders for Larus gull specifies such as Herring gulls, lesser black-backed gulls and greater black-backed gulls showed flights at altitudes of 30–150 m in most cases. Small gull species such as black-legged kittiwakes, Common gulls and little gulls, on the other hand, were observed mainly at altitudes of up to 30 m (MENDEL et al. 2015, SKOV et al. 2018). According to GARTHE & HÜPPOP (2004), little gulls have a WSI value in the lower third. They have high manoeuvrability and usually fly during the day (GARTHE & HÜPPOP 2004).

The kittiwake and lesser black-backed gull are also in the lower range of the WSI (GARTHE & HÜPPOP 2004, Table 16). Current results on avoidance behaviour show that both species react variably to OWF with both attraction and displacement (GARTHE et al. 2022). A slightly increased installation or operation-related mortality is thus possible. However, because kittiwakes and lesser black-backed gull are agile fliers with high manoeuvrability and fly almost exclusively during the day and predominantly in the area below the rotors (GARTHE & HÜPPOP 2004), the risk of collision with offshore wind turbines can be classified as low (see also MENDEL et al. 2008). On the other hand, herring gulls are somewhat less manoeuvrable, thereby making the species one of the more frequent victims of strikes on land (DÜRR 2023). Little gulls are known to exhibit avoidance behaviour up to a few kilometres from the OWF (cf chapter 4.8.1); this somewhat reduces the risk of collision. Considering this behaviour, large and small gulls are exposed to a certain risk of collision.

However, in general, all gull species 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), which investigated not only the flight altitude but also the immediate, small-scale, and large-scale evasive behaviour of the species considered. Usually, the collision risk at night is assumed to be higher than that during the day because of the poorer visibility of the rotors and the possible attraction caused by the lighting of the installations. However, the investigations using radar and thermal imaging cameras revealed low nocturnal activity (SKOV et al. 2018). The overall collision risk during the night can thus be considered to be low. In case of adverse weather conditions during migration, gulls can also land on water and wait for better migration conditions. In adverse weather conditions, gulls can also land on the water and wait for better migration conditions.

The realisation of the prohibition of killing and injury in accordance with Section 44, para. 1, No. 1 BNatSchG can therefore be excluded with the necessary certainty for the gulls mentioned.

Terns

In the areas of the North Sea far from the coast, terns are typically found in low to average densities, especially during the migration periods in spring and autumn (Chapters 2.9 and 2.10). Terns are active during the day and nocturnal flight activities are usually low. Terns tend to fly low above the water surface, often in an altitude range below 25 m (KRÜGER & GARTHE 2001, BIOCONSULT SH GMBH et al. 2022) and thus predominantly below the rotor range of 30 or 35 m in the two model parameters defined for Zones 3, 4, and 5. They exhibit a high level of flight activity, especially during breeding season. They are good fliers with a high degree of manoeuvrability and thus the ability to evade (MENDEL et al. 2008). In case of adverse weather conditions during migration, terns can also land on water and wait for better migration conditions.

Because of their flight and migration behaviour, in particular their high manoeuvrability, low nocturnal migration activity, low flight altitude, and the indications of evasive behaviour in relation to offshore wind farms, it can be assumed that the collision risk in accordance with Section 44, para. 1, No. 1, para. 5, sentence 2, No. 1 BNatSchG is not significantly increased for the tern species group and therefore the prohibition of killing and injury in accordance with Section 44, para. 1, No. 1, para. 5, sentence 2, No. 1 BNatSchG will not be realised.

Auks

Auks have limited manoeuvrability but are not particularly active during the day or at night. As a rule, they fly flat above the sea surface (MENDEL et al. 2008) and only exceptionally reach the rotor area of wind turbines. In addition, a recent study demonstrated strong avoidance effects in guillemots and considerably less pronounced avoidance effects in razorbills (GARTHE et al. 2022, PESCHKO et al. 2024). In the case of adverse weather conditions during migration movements, they can also land on water and wait for better conditions. The collision risk for alcids can therefore be categorised as very low.

Because of their general flight and avoidance behaviour towards offshore wind turbines, it can be assumed with the necessary certainty that the collision risk for the auks species group is not significantly increased and that the prohibition of killing and injuring in accordance with Section 44, para. 1, No. 1, para. 5, sentence 2, No. 1 BNatSchG will therefore not be realised.

Waders

At the EIS sites, few wading bird species were recorded in only small numbers of individuals both at night and during the day during the bird migration investigations carried out in previous years. Overall among the waders, oystercatcher, grey plover, European golden plover, lapwing, dunlin, snipe, and European curlew were the most common waders (Table 11). Wading bird migration usually takes place at night and at higher altitudes of up to several thousand metres (SENNER et al. 2018). For migration across the Baltic Sea, Eurasian curlews were also primarily found to migrate at migration altitudes below 50 m (SCHWEMMER et al. 2022). In the vicinity of windaprks, the authors observed horizontal avoidance in most birds (70%) (SCHWEMMERet al. 2023).

Based on current knowledge, it can be assumed with the necessary certainty that the collision risk for the species group of waders is not significantly increased and that the prohibition of killing and injuring in accordance with Section 44, para. 1, No. 1, para. 5, sentence 2, No. 1 BNatSchG will therefore not be realised.

Songbirds

Songbirds dominate the nocturnal bird migration (Chapter 2.10.2.1). Because of migration in the dark, high migration volumes, and the strong attractiveness of artificial light sources, there is a particular collision risk for nocturnal migration of small birds (BALLASUS et al. 2009, HÜPPOP et al. 2016). In view of the model parameters for Zones 3 to 5 assumed in the scope for this draft SDP, the night-time radar observations carried out at various offshore locations would show that between 38.3% and 55.5% (Scenario 1, Table 15) and 45.4% and 67.7% (Scenario 2, Table 15) of the birds would fly in the height range of the rotors.

Table 15: Proportions of radar signals in the rotor area for the model parameters of wind turbines in Zones 3 to 5 designated in the SDP.

Model parameters for Zones 3 through 5	FINO1 (2013–2019)	Area N-4 (2017–2019)	Area N-5 (2017–2019)	Area N-7 (2018–2020)
Scenario 1	Proportion of signals (%)			
0–30 m	18.9	0.5	3.7	0.5
30–270 m	55.5	38.3	48.8	30.7

270–1000 m	25.6	61.2	47.9	68.8
Scenario 2	Proportion of signals (%)			
0–35 m	21.4	0.6	4.4	0.7
35–385 m	62.9	57.0	67.7	45.4
385–1000 m	15.6	42.4	27.9	53.9

As already described above (see chapter 4.9.1), it can be assumed that the probability of collision with wind turbines is rather low in the clear weather conditions favoured by birds during migration. In contrast, surprising fog and rain that lead to poor visibility and low flight altitudes are a potential threat situation. In these poor weather conditions, which can influence the orientation of migrating birds, the lighting of wind turbines often has an attracting effect on birds migrating at night. As a result, the attracted individuals could fly into the installations or at least be adversely affected by the blinding effects. In a study, REBKE et al. (2019) investigated the influence of different coloured and different luminous light sources on nocturnal songbird migration at different cloud cover levels. As a result, birds were more attracted to continuous than to flashing lighting. In addition, the authors recommended using red light in cloudy weather conditions in order to reduce attraction effects in poor visibility conditions Planning principle 7.1.3 stipulates that light emissions are to be avoided or, if unavoidable, minimised in order to reduce attraction effects and thus collisions of nocturnal migratory species with offshore wind turbines.

In addition to the light and weather conditions as well as the flight altitude, an important factor for collision risk is whether a species avoids a wind farm (i.e. flies over, around, or through it). In the cumulative assessment of large, contiguous wind farms such as those planned in the German and neighbouring EEZs, fly-over or fly-through is more likely (see Chapter 4.17.5. For the group of songbirds, it is uncertain whether large-scale avoidance (macro-avoidance) occurs (SCHULZ et al. 2014, WELCKER & VILELA 2019) or whether they fly over or through offshore wind farms at a certain distance from the individual wind turbines and their components (meso- and micro-avoidance) (SCHULZ et al. 2014, AVITEC RESEARCH GBR et al. 2019). However, many years of research on the FINO1 platform indicate that a fly-through is likely (AVITEC RESEARCH GBR et al. 2020). However, based on current knowledge, a proportionality between migration rates and collision rates cannot generally be assumed even in the case of birds flying through wind farms (see Chapter 4.17.5). Even according to current higher court rulings, high migration rates alone are not sufficient to establish a significantly increased risk of killing and injury (cf OVG Koblenz, judgement of 31 October 2019, NVwZ-RR 2020, 726 (on the collision risk of cranes on land with wind turbines located in the migration corridor)).

Based on current knowledge, it cannot be assumed that the collision risk for the group of songbirds is significantly increased and that the prohibition of injury and killing of Section 44, para. 1, No. 1, para. 5, sentence 2, No. 1 BNatSchG will be realised. However, for the group of songbirds, because of the lack of empirical findings on the relationship between migration intensity and collision rates at OWT, uncertainty remains as to whether an increased number of birds flying through the wind farms would be associated with an increased collision rate.

These uncertainties are addressed by the draft SDP, which specifies the obligation to carry out monitoring with regard to the recording of migratory birds contained in Section 77, para. 3, No. 1 WindSeeG. In Planning principle 7.1.6, the draft SDP stipulates that a collision survey of birds with wind turbines must be carried out and is binding for the approval procedures for offshore wind farms. This planning principle therefore also applies to the sites in Areas N-4, N-5, and N-9 through N-20. Collision detection will be further specified in the approval procedure for individual wind farm projects. If, contrary to the current impact assessment, the risk of collision is significantly increased, the BSH could issue arrangements in according to Section 79 WindSeeG; these may also include shutdowns.

Platforms

Collisions with converter platforms can result in the death or injury of birds. It can be assumed that mainly nocturnal migratory songbird species and only a few species of seabirds and resting birds will be affected. In its comments based on current case law, the BfN regularly points out that the killing or harming of individual specimens fulfil the prohibition in Section 44, para. 1, No. 1 BNatSchG only if there is a significant increase in the risk of collision-related losses of individual specimens. In view of the fact that a converter platform is a single structure in close spatial association with an offshore wind farm, no significantly increased collision risk can be assumed with regard to the platform. Appropriate measures to minimise the risk of birds colliding with the installation must also be ordered in the specific approval procedure. According to the current state of knowledge, a significant adverse effect on avifauna can be ruled out even when cumulatively considering the effects of the converter platforms designated for the EEZ in combination with wind farms.

Subsea cables

According to the current state of knowledge, the operation of subsea cables will not have any significant negative effects on seabirds and migratory birds that fulfil the criteria for the killing and injury offence according to Section 44, para. 1, No. 1 BNatSchG. During the laying of the subsea cables, the high and strongly illuminated cable-laying vessels can attract migratory birds. Because of the short duration of the laying phase, the risk of a violation of species protection prohibitions can be ruled out according to the current state of knowledge. Suitable measures must also be taken on the construction ships to minimise the effects of attraction, taking into consideration occupational safety aspects.

5.2.1.3. Bats and bat migration

All 25 bat species occurring in Germany are subject to Section 7, para. 2, No. 13, lit. b, sublit. aa BNatSchG in conjunction with Annex IV of the Habitats Directive. Killing or injuring them is prohibited in accordance with Section 44, para. 1, No. 1 BNatSchG. In terms of species protection, the same considerations apply in principle as those already mentioned in the assessment of avifauna. Specifically, this means that neither the mere presence of the affected species in the plan area nor the abstract danger posed by the operation of the installations can be assumed to pose an increased risk of killing.

Collision with offshore structures does not constitute deliberate killing. Here, explicit reference can be made to the guidelines on the strict protection system for animal species of community interest under the Habitats Directive. In accordance with Article 12, para. 4 of the Habitats

Directive, continuous monitoring must be carried out to ensure that unintentional killing does not have significant negative effects on the species concerned. There are no indications for the examination of further facts according to Article 12, para. 1 of the Habitats Directive.

Areas and sites for offshore wind turbines

In general, very little is known about the migration behaviour of bats because of their nocturnal lifestyle (HÜPPOP et al. 2019). This applies in particular to the EEZ of the North Sea and thus also to the sites within the planning areas. The few systematic investigations that have been carried out in the open North Sea show that long-distance migratory species in particular (e.g. Nathusius' pipistrelle and the lesser noctule) migrate over the North Sea. The animals mainly follow the coastline and along the Wadden Sea islands (RYDELL et al. 2014, SEEBENS-HOYER et al. 2021, BACH et al. 2022a). The occurrence of bats decreases with increasing distance from the coast (LAGERVELD et al. 2017, SEEBENS-HOYER et al. 2021). A large proportion (approx. 90%) of the bat calls detected in the North Sea area are made by Nathusius' pipistrelle, and isotope analyses suggest that most of the animals originate from Eastern European populations with a high number of individuals (KRUSZYNSKI et al. 2021, SEEBENS-HOYER et al. 2021).

Reconnaissance behaviour demonstrated on offshore structures does not completely rule out collisions between bats and OWT (HÜPPOP & HILL 2016); however, surveys on OWT showed that the main activity of bats (approx. 90%) took place below the rotor area (BRABANT et al. 2019). There is no concrete evidence of collisions with offshore wind turbines; this is probably also because it is difficult or impossible to determine actual collision victims at sea (SEEBENS-HOYER et al. 2021). In view of the limited information on bat migration over the German EEZ (SEEBENS-HOYER et al. 2021), the number of individuals potentially affected by OWT cannot be conclusively estimated.

Based on the results of the aforementioned studies (see also chapter 2.11), it can be assumed with regard to the distance of the planning areas to the coast (N-4 approx. 50 km, N-5 approx. 70 km, N-9 to N-13 approx. 120 km, N-14 to N-20 > 150 km) that there is no higher concentration of bats even during migration periods. It can therefore not be assumed that the construction and operation of wind farm projects in the planning areas will significantly increase the collision risk for bats and thus lead to the realisation of the killing and injury offence according to Section 44, para. 1, No. 1, para. 5, sentence 2, No. 1 BNatSchG.

However, because of the few existing studies on migratory bat species and their migration movements and migration intensity in the German EEZ, an uncertainty remains in the assessment. Experiences and results from future research projects or from offshore wind farms such as those obtained during bird collision monitoring (Planning principle 7.1.6), must be taken into consideration in the further approval procedure.

Platforms

The typical bat species to be expected for the North Sea region were detected only in small numbers in the planning area (see Chapter 2.11). Based on the current data basis, individual collisions of bats with platforms cannot be ruled out. However, a significant increase in the project-related risk of death and injury that goes beyond the "general life risk" is not to be expected according to the current state of knowledge. The realisation of the prohibition of killing and injury in accordance with Section 44, para. 1, No. 1 BNatSchG can therefore be excluded with the necessary certainty for bats.

Subsea cables

Potential impacts of subsea cables and pipelines on bats are limited mainly to the construction phase. Illuminated construction vessels can cause attraction effects, which can lead to collisions. According to the current state of knowledge, the laying and operation of subsea cables will not have any significant negative effects on bats that fulfil the criteria for the killing and injury offence according to Section 44, para. 1, No. 1 BNatSchG.

5.2.2. Prohibition of disturbance (Section 44, para. 1, No. 2 BNatSchG)

According to Section 44, para. 1, No. 2, 1st half-sentence BNatSchG, wild animals of strictly protected species and European bird species may not be significantly disturbed during the reproduction, breeding, moulting, hibernation, and migration periods.

In accordance with Section 7, para. 2, No. 14 BNatSchG, species listed in Appendix A of the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (Ordinance (EC) No. 338/97), animal and plant species listed in Appendix IV of the Habitats Directive (Directive 92/43/EEC) and (in conjunction with Section 54, para. 2 BNatSchG) the strictly protected species in accordance with BArtSchV. European bird species are naturally occurring bird species in Europe within the meaning of Article 1 of Directive 2009/147/EC, Section 7, para. 2, No. 12 BNatSchG.

A disturbance within the meaning of the standard is any effect on the psychological well-being of the animals that triggers a behavioural reaction (e.g. fear, flight, or flight reactions of the animals) (Gellermann in Landmann/Rohmer, UmweltR, BNatSchG, Section 44 marginal no. 10 with further references).

According to Section 44, para. 1, No 2, 2nd half sentence BNatSchG, a significant disturbance exists if the disturbance worsens the conservation status of the local population of a species.

According to the reasoning of the amendment to the Federal Nature Conservation Act 2007, a local population includes […] those (partial habitats and activity areas of the individuals of a species that are in a spatial-functional relation that is sufficient for the life (or habitat) 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 mitigated. However, this must be investigated and assessed on a species-specific basis for each individual case (explanatory memorandum for the BNatSchG amendment 2007, BT-Drs. 16/5100, p. 11). According to the Guidance Document on the Strict System of Protection for Species of Community Interest under the Habitats Directive (marginal no. 39), disturbance as per Article 12 of the Habitats Directive is said to occur if the act in question reduces the chances of survival, the reproductive success or the ability to reproduce of a protected species, or if this act leads to a reduction in its distribution area. On the other hand, occasional disturbances with no foreseeable negative effects on the species concerned should not be regarded as a disturbance as per Article 12 of the Habitats Directive.

It is thus essential whether the effects of the disturbance, in view of the circumstances of the individual case and the conservation situation of the species in question, appear likely to have a detrimental impacts on the conservation status of the local population (Gellermann in Landmann/Rohmer UmweltR, BNatSchG, Section 44 marginal no. 13 with reference to OVG Berlin NuR 2009, 898 (899), among others). This is the case, for example, if individuals of rare or endangered species are disturbed, if disturbed individuals of small local populations are involved, or if all fauna of the population in question are affected by the disturbance (Gellermann in Landmann/Rohmer Environmental Law, 96 EL Sept. 2021, BNatSchG Section 44 marginal no. 13). In contrast, the widespread distribution of a species with possibly large local populations (BVerwG NuR 2008, 633 marginal no. 258) or the existence of low-disturbance alternative habitats usable by the animals may argue against a significant disturbance if these alternative habitats are not already occupied by individuals of the species (see BVerwG NuR 2014, 638 marginal no.61, Gellermann in Landmann/Rohmer UmweltR BNatSchG, Section 44 marginal no. 13).

5.2.2.1. Marine mammals

Harbour porpoise

In accordance with Section 44, para. 1, No. 2 BNatschG, it is prohibited to significantly disturb the harbour porpoise as a strictly protected species according to Section 7, para. 2, No. 14, lit. b in conjunction with Annex IV of the Habitats Directive during the reproduction, breeding, moulting, hibernation, and migration periods. A significant disturbance exists if the disturbance worsens the conservation status of the local population of a species.

(1) Construction-related

(a) the existence of a breeding, rearing, moulting, hibernation or migration period

In the EEZ of the North Sea, the “Sylter Außenriff – Östliche Deutsche Bucht” and “Doggerbank” nature conservation areas are the areas that function as a breeding area for harbour porpoises in the summer months (May to August) (see Chapter 2.8.2). High calf percentages are recorded there between 1 May and the end of August. The “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area is also located in the main concentration area of the harbour porpoise (cf noise protection concept of the BMU, Appendix 1).

b) Significant disturbance

With regard to the construction of the wind turbines and the possible pile driving of the foundations, it is particularly necessary to examine whether the noise exposure caused by this results in a significant disturbance according to Section 44, para. 1, No. 2 BNatSchG. When a significant disturbance within the meaning of Section 44, para. 1, No. 2 BNatSchG exists, it can in turn be derived from the noise protection concept of the BMU or exists if the conservation status of the local population of a species deteriorates as a result of the disturbance. In accordance with the noise protection concept, the prohibition of interference must be considered differently depending on the season. It is assumed that within the particularly sensitive breeding period (May to August), a significant disturbance can only be excluded if the main concentration area harbour (cf noise protection concept of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection, Appendix 1) is kept free from such noise-intensive construction measures, where cumulatively more than 1% of the area is located within the disturbance radius. The areas of the disturbance radii of all projects in which the construction phase for the foundations of the project has already started and is not yet complete are cumulated. Outside the sensitive period, there is no significant disturbance if sufficient areas not affected by pile-driving noise are available for the harbour porpoise. It is assumed that these are always sufficiently available if no more than 10% of the area of the EEZ of the German North Sea is located within the disturbance radii of the OWF under construction and the threshold value from the prohibition of killing and injuring impulsive noise (broadband sound exposure level (SEL) of 160 dB re 1 μPa² s or peak sound pressure level (SPLpeak-peak) of 190 dB re 1 μPa at a distance of 750 m from the place of noise generation is complied with.

In accordance with the studies cited in the noise protection concept of the BMU, a significant effect on harbour porpoises with unmitigated pile driving noise (Alpha Ventus) up to 16.4 km can be demonstrated based on the waiting times; no significant effects were found at a distance of 21 km (BMU 2013). In Chapter 4.17.3 (Cumulative effects), three scenarios are considered with regard to marine mammals and noise pollution:

In each scenario, the sites that are in operation in the same year and are therefore also developed for construction are considered. As a result, Scenario 1 considers eight potential construction sites, Scenario 2 also assumes eight potential parallel construction sites, and Scenario 3 assumes 12 potential parallel construction sites. Scenario 3 is therefore a worst-case scenario. With unmitigated pile driving noise, an area of 10,140 km² would be affected. This corresponds to 35.5% of the German EEZ and thus the habitat of the local population. This would constitute a significant disturbance because more than 10% (threshold value in accordance with the noise protection concept of the BMU) of the habitat would be affected.

The regular arrangement of preventive and mitigation measures reduces the impacted area in Scenario 3 (potentially 12 parallel construction sites) to a maximum of 2,413 km² (1,559 km² if the disturbance radii overlap); this corresponds to 8.5% (5.5% if the disturbance radii overlap) of the habitat and is therefore below the 10% target. However, the cumulative consideration of simultaneous construction sites in Chapter 4.18 also takes into consideration the proximity to sites that are of high seasonal importance for the harbour porpoise. In the course of this, further measures are listed in Chapter 4.18; these provide for temporal and spatial coordination.

Furthermore, the main concentration area of the harbour porpoise needs to be considered for species protection reasons. Between the months of May and August, this area may not be exposed to more than 1% of its surface area to noise pollution according to the noise protection concept of the BMU; outside this period, it may not be exposed to more than 10% of its surface area. Based on a disturbance radius of 8 km, part of Site N12.5 is located in an area from which disturbance-inducing noise can affect the main concentration area of the harbour porpoise. Similarly, Site N-13.4 (not yet ranked in terms of time) is largely located within the main concentration area of the harbour porpoise and Areas N-4 and N-5, which are intended for subsequent use, are located within the main concentration area of the harbour porpoise. For Sites N-12.5 and N-13.4 as well as Areas N-4 and N-5, measures (such as temporal and spatial coordination) will therefore be necessary in order to comply with the species protection requirements of the BMU noise protection concept:

- Proportion of area of the main concentration area of the harbour porpoise affected by disturbance-inducing noise < 1% between May and August

By applying the noise protection and noise mitigation measures mentioned in the 2024 site development plan, the spatial and temporal coordination of noise-intensive work and the regularly specified arrangements in the approvals, significant disturbances within the meaning of Section 44, para. 1, No. 2 BNatSchG can be ruled out with the necessary certainty.

(2) Installation- and operation-related

(a) the existence of a breeding, rearing, moulting, hibernation or migration period

In the EEZ of the North Sea, the nature conservation area "Sylter Außenriff – Östliche Deutsche Bucht" is the area that functions as a breeding area for harbour porpoises in the summer months (May to August) (see Chapter 2.8.2). High calf percentages are recorded there between 1 May and the end of August. The main concentration area of the harbour porpoise in the German EEZ is also of particular importance because of the breeding season between May and August. The "Doggerbank" nature conservation area is also considered a breeding area for the harbour porpoise.

b) Significant disturbance

Current results from the monitoring of underwater noise in offshore wind farms and their surroundings show that the noise emissions from the operation of the installations are not clearly distinguishable from the background noise after a distance of just a few hundred metres. At a distance of only 1 km from the wind farm, higher sound levels are always measured than in the centre of the wind farm. The standardised measurements of the continuous sound input as a result of the operation of the wind farms have clearly shown that the underwater noise emitted by the installations cannot be clearly distinguished from other sound sources such as wave sounds or ship noises – even at short distances.

Based on the low sound inputs from wind turbines during operation described in Chapter 4.7.2 as well as the specification of a state-of-the-art installation design that minimises operational noise in accordance with the corresponding Planning principle 6.1.9 of the 2024 site development plan, no negative long-term effects from noise emissions from the turbines for harbour porpoises are to be expected based on the current state of knowledge if the installations are designed regularly.

The fact that offshore wind farms do not have a significant effect on marine mammals based on current knowledge is also evident from current environmental studies in Belgium (DEGRAER, et al., 2023).

However, in the course of increasing offshore expansion, it must be ensured that potential changes are recorded. Suitable monitoring is therefore mandatory for the operating phase of future individual projects according to Section 77, para. 3, No. 1 WindSeeG in order to be able to record and assess any location- and project-specific effects.

Taking into consideration Planning principle 6.1.9 of the 2024 Site Development Plan, which is binding in the approval procedure, it can be assumed with the necessary certainty that the operation of offshore wind turbines will not significantly disturb harbour porpoises in accordance with Section 44, para. 1, No. 2 BNatSchG according to the current state of knowledge.

5.2.2.2. Avifauna

In accordance with Section 44, para. 1, No. 2 BNatschG, it is prohibited to significantly disturb European bird species during the reproduction, breeding, moulting, hibernation, and migration periods. A significant disturbance exists if the disturbance worsens the conservation status of the local population of a species. The species protection assessment in accordance with Section 44, para. 1, No. 2 BNatSchG relates to the population-relevant disturbances of local populations, the occurrence of which may vary in the areas covered by the plan.

As already explained in Chapter 5.2.1 European bird species, including several species protected under Annex I of the Birds Directive, occur in varying densities in the plan area. Please refer to Chapter 2.9 and Chapter 2.10 with regard to the general design of occurring bird species. In the following, the species or species groups potentially affected because of the observed frequency of use of the area or species-specific behaviour are discussed analogously to Chapter 5.2.1.2.

Because offshore wind turbines exist and are operated as permanent structures all year round and the construction phase usually lasts at least one year, it can be assumed from the outset that there is a reproduction, breeding, moulting, wintering, or migration period for avifauna period during the construction and operation of a wind farm on the sites of areas N-4, N-5, and N-9 through N-19 designated in the SDP because the entire German EEZ of the North Sea is used by European bird species as a reproduction, breeding, moulting, wintering, and migration area.

Areas and sites for offshore wind turbines

Divers

The red-throated divers (*Gavia stellata*) and black-throated divers (*Gavia arctica*) belonging to the divers group are migratory seabirds that are widely spread in the northern hemisphere, with breeding areas in boreal and arctic areas of Europe, Asia and North America. The global population of the red-throated diver is estimated to be 200,000-600,000, of which approximately 42,100-93,000 pairs fall in the European breeding population (BIRDLIFE INTERNATIONAL 2017). It is assumed that there are between 53,800-87,800 breeding pairs of the black-throated diver in Europe. The global population is approx. 275,000-1,500,000 (BIRDLIFE INTERNATIONAL 2017). Red-throated divers and black-throated divers are included among the species listed in Appendix I to the Birds Directive and are listed in SPEC Category 3 (“Widespread species that are not concentrated in Europe but that show a negative evolution and an unfavourable protection status”) according to BIRDLIFE INTERNATIONAL (2017).

GARTHE & HÜPPOP (2004) certify that divers are very sensitive to structures. Their strong avoidance behaviour towards offshore wind farms has been confirmed and further characterised in several studies as described in detail in Chapter 4.8.1 and Chapter 4.17.4. The scientifically accepted “calculated total loss” (i.e. a radius around an OWF in which there are theoretically no divers as a result of the total avoidance effect calculated) is 5.5 km (BIOCONSULT SH et al. 2020, GARTHE et al. 2018). For a project on Site N-9.1, the findings so far indicate that this is highly likely to cause avoidance effects for divers. The biology of divers is described in detail in Chapter 5.2.2.1 of the Environmental Report for the 2020 SDP of the North Sea (BSH 2020).

Divers use the German EEZ as a hibernation and passage migration area (MENDEL et al. 2008). The highest densities are reached in spring. Based on a very good assessment of the data availability and on technical analyses that are widely accepted by scientists, a main concentration area harbour of the divers was established to the west of Sylt and included in a BMU position paper (2009). The area covers all areas with very high density and a majority of the areas with high density in the German Bight and represents the spatial and functional unit of the local population of divers in the German EEZ of the North Sea (BMU 2009). Based on the data available in 2009 at the time of designation of main concentration area harbour, the main concentration area harbour was home to around 66% of the German North Sea divers population or around 83% of the EEZ population in spring, and is therefore, among other things, of particular importance in terms of population biology (BMU 2009) and an important functional component of the marine environment with regard to seabirds and resting birds. Against the background of the current population assessments, the importance of the main concentration area harbour for divers in the German North Sea and within the EEZ has increased further (SCHWEMMER et al. 2019). The designation of the main concentration area harbour of divers in the German EEZ of the North Sea as part of the position paper of the BMU (2009) is an important measure to ensure species protection of those species of red-throated and black-throated divers that are sensitive to disturbances. The BMU assumed that the main concentration area should be used as a benchmark for the cumulative assessment of habitat loss for divers in future licensing procedures for offshore wind farms.

The assessment revealed that divers are highly sensitive in terms of population biology, that the main concentration area is highly important for the conservation of the local population, and that the adverse effects resulting from avoidance behaviour are intense and permanent. The current planning status envisages that the subsequent use of N-5 will be accompanied by an extended area layout with only one area instead of the previous three so that after the dismantling of the Butendiek and Dan Tysk OWF, the new area will be around 396 km² in the area of the Sandbank OWF (cf Figure 2 in the draft SDP 2024). The Area N-5 for subsequent use area is thus 254 km² larger than the current area of N-5 with around 143 km². The area proportion of the main concentration of divers (7,036 km²) thus increases from around 2" (N-5 with 143 km²) to around 6% ("subsequent use N-5" with 396 km²).

In order to prevent a deterioration of the conservation status of the local population because of the cumulative effects of the wind farms, it is necessary to keep the area of the main concentration area currently available to divers outside the impact zones of already realised wind farms free of new wind farm projects.

The BSH concludes that significant disturbance within the meaning of Section 44, para. 1, No. 2 BNatSchG as a result of implementation of the plan can be ruled out with the necessary certainty if it is ensured that no additional habitat loss will occur in the main concentration area. For the designation of Sites N-13.4, N-13.4* and "subsequent use N-4 and N-5", this assessment can be made only taking into consideration the overall plan assessment of the SDP (cf Chapter 8).

Based on the findings on the avoidance behaviour of divers towards offshore wind energy presented in Chapter 2.9, according to the current state of knowledge, it must be assumed that the wind farm project to be realised on N-13.4, N-13.4* and "Subsequent use N-4 and N-5" will have scaring effects on the diver priority area to the extent determined (cf chapter 2.9). More recent findings will be taken into consideration in future revisions of the SDP, and the assessments will be adjusted accordingly.

Gannets and fulmars

The breeding population of the gannet (Morus bassanus) in Europe is estimated at around 323,000 breeding pairs (BIRDLIFE INTERNATIONAL 2017). In the German Bight, Heligoland is the only breeding place of the gannet. Other European breeding grounds are located, for example, along the Norwegian coast and on the famous Scottish island of Bass Rock. As a highly mobile species, the gannet uses wide-ranging food habitats within a radius of up to 120 km from the breeding colony (MENDEL et al. 2008). Although the gannet showcases a large-scale, partially isolated occurrence, it is listed in the category “R” (species with geographical concentration) of the Red List because of the high concentration of breeding areas (NABU 2021). However according to European endangerment categories, its population is classified as “least concern” (LC) (BIRDLIFE INTERNATIONAL 2021).

The fulmar (*Fulmarus glacialis*) is a typical offshore bird and is present all year round in the German EEZ. The main distribution area lies offshore beyond the 30 m depth line (MENDEL et al. 2008). The European breeding population is estimated at 3,380,000-3,500,000 breeding pairs. The species is listed as “vulnerable” (VU) in the pan-European Red List (BIRDLIFE INTERNATIONAL 2021).

Both species breed on Heligoland, whereby the breeding population of the northern gannet has recorded a collapse in the number of breeding pairs in the last two years whilst the number of breeding pairs of the fulmar has been decreasing for 20 years (DIERSCHKE & DIERSCHKE 2023).

Little is known so far about the reactions of the fulmar to offshore wind farms that are under construction or in operation because generally low sighting rates and insufficient data availability do not allow reliable conclusions to be drawn. However, a WSI in the lowest range indicates a very low sensitivity to OWF (GARTHE & HÜPPOP 2004). There are also few, statistically insignificant investigations available for the gannet that suggest a potential avoidance behaviour towards wind turbines (Chapter. 4.8). Avoidance distances of between 2 and 3.4 km were found in German OWF (IBL UMWELTPLANUNG et al. 2018a). Clear statements often cannot be made because of the increased mobility of the species and, similar to the fulmar, the associated low sighting rates and small samples. From the investigation in the cluster of “North of Borkum”, findings of avoidance effects up to 2 km are available. As with other species, partial avoidance can be seen here as well (IFAÖ et al. 2017, IFAÖ et al. 2018, IFAÖ et al. 2019, IFAÖ et al. 2020). However, the current analysis of GARTHE et al. (2022) shows a strong displacement for gannets and fulmars as well, albeit at short distances. Depending on the season, a density up to 81% lower at a distance of 1 km and a density up to 43% lower at a distance of 5 km was calculated for the gannet. In fulmars, the density is reduced by 91% at 1 km or up to 84% at 5 km. Accordingly, a disturbance in the close vicinity of a wind farm on the SDP24 sites is likely.

Both species are widely distributed in the EEZ. The fulmar favours areas further away from the coast.

At the present time, no significant disturbance in accordance with Section 44, para. 1, No. 2 BNatSchG can be assumed for gannets and fulmars because of their wide distribution, their high flexibility in habitat use, and the low number of individuals affected by the potential disturbance. However, the situation may change in the coming years with the expansion of offshore wind energy in areas of the German EEZ of the North Sea favoured by the species mentioned and the associated habitat disturbance, the avoidance behaviour observed for the species to date, and the parallel further development of the populations (in particular breeding populations and successes as a result of the outbreak of avian influenza and the impact of plastic waste, especially on gannets (cf Guse et al. 2020, Dierschke 2021 in Dierschke et al. 2023). It is therefore important to record the occurrence of both species in the coming years and adjust the assessment if necessary.

Gulls (little gulls, black-legged kittiwakes and larus gulls) and terns

Gulls are generally widespread in the North Sea and can be found near the coast or offshore in a species-specific manner. The density of the individual species can therefore differ greatly from one another.

According to the current pan-European endangerment status, kittiwakes are classified as vulnerable, herring gulls and little gulls as near threatened (BIRDLIFE INTERNATIONAL 2021). The little gull is a species listed in Annex I of the European Birds Directive – as are the Sandwich tern, common tern, and Arctic tern, which regularly occur in the German EEZ.

Overall, gulls and terns do not show a clear behaviour pattern towards offshore WEA. For example, the current analysis of GARTHE et al. (2022) for black-legged kittiwakes and lesser black-backed gulls provided different reactions depending on the season. For the latter species, avoidance effects were found up to 15 km away in summer, whilst an attraction effect was found up to 3 km away in autumn. Kittiwakes were also found to be attracted in winter – also up to 3 km away. In contrast, the species showed an avoidance reaction in the same radius of action in spring. For little gulls, avoidance distances between 4.3 km (flight surveys) and 3.2 km (vessel surveys; OWF Butendiek; BIOCONSULT SH 2022) and significantly lower densities for a distance of up to 3 km from the OWF (Global Tech I OWF; IBL UMWELTPLANUNG et al. 2018a) were found were found during investigations on individual wind farm projects. For terns, partial avoidances were seen at short distances (BIOCONSULT SH 2022; IFAÖ et al. 2020). These results suggest that there could be small-scale disturbance effects from wind farms on gulls and terns. These vary from one season to another in case of species.

Because of the large-scale distribution of the species in the EEZ and the overall low sensitivity of gulls and terns to disturbance (GARTHE & HÜPPOP 2004, FLIESSBACH et al. 2019), it can be assumed with the necessary certainty that there will be no significant disturbance and thus no realisation of the disturbance offence in accordance with Section 44, para. 1, No. 2 BNatschG for these species groups.

Guillemot (Uria aalge) and razorbill (Alca torda)

The guillemot (*Uria aalge*) is of the most common seabird species in the northern hemisphere and has a breeding population of around 2.46–3.17 million individuals in Europe. The most important breeding areas are located on the rocky coasts of Iceland and the British Isles, the latter with about 1.4 million individuals (BIRDLIFE INTERNATIONAL 2017). Studies on ringed guillemots have shown that individuals from these large colonies migrate to the southern and eastern North Sea in the post-breeding season for the purpose of foraging (TASKER et al. 1987). The north-western European population, which includes the breeding birds of Heligoland, is estimated at around 471,000 individuals (NAGY & LANGENDOEN 2018). For the populations in the German North Sea, the BfN determined a “strong decline” in the period 2004 to 2016 (−12.35% average change per year) (Table 9). The winter population of the common guillemot (with a most recently recorded average size of 31,000 individuals) shows a decline of around 75% from 2003/2004 to 2015/2016 (Gerlach et al. 2019).

The only breeding colony of the guillemot in the German North Sea is located on Heligoland. Most recently, 4,007 (2022) and 4,435 (2023) breeding pairs were counted there (personal communication Jochen Dierschke/Heligoland Bird Observatory). The Heligoland breeding colony was hit by an outbreak of avian influenza in spring 2023; this “…[caused] hundreds of dead young birds on Heligoland and many washed up adult birds on the beaches of the East Frisian Islands, some of which had been fitted rings from Heligoland. The effects on the breeding population cannot yet be estimated. …“ (DIERSCHKE & DIERSCHKE 2023). In the summer, the fauna is usually in the vicinity of the breeding colony, but is seen only in small densities within a radius of 30 km. In autumn and winter, guillemots increasingly spread to the offshore area with water depths between 40-50 (MENDEL et al. 2008).

Outbreaks of avian influenza in breeding colonies of guillemots have also been recorded in other littoral states of the North Sea (Tremlett et al. 2024). There are also reports that guillemots found dead show signs of malnutrition (NL: Wageningen University and Research 2019; NO: SEAPOP 2022; D: NDR 2024). Weather phenomena can also lead to the death of numerous, already weakened guillemots through exhaustion as observed in France in March this year (Reuters 2024).

The razorbill *(Alca torda)* is another common auk species in the North Sea alongside the guillemot. Their population in Europe is estimated at approx. 1 million individuals. The largest proportion, around 60%, breed on rocky coasts in Iceland, followed by other important breeding areas on the British Isles and in Norway (BIRDLIFE INTERNATIONAL 2017). In contrast, the breeding colony on Heligoland, the only one in Germany, reached a new high in 2023 with 114 breeding pairs after the count of 74 breeding pairs in the previous year (personal communication Jochen Dierschke/Heligoland Bird Observatory, DIERSCHKE & DIERSCHKE 2023). At the time of breeding, razorbills limit their foraging to the nearby vicinity of the breeding place. The winter resting population in the German North Sea is estimated to be 20,000 individuals (GERLACH et al. 2019). Here, the fauna is increasingly located within the 20 m depth range (MENDEL et al. 2008). The BfN determined a “moderate decrease” in populations in 2004–2016 (7.04% average change per year) (Table 9). Because of the geographically limited distribution of the breeding areas, razorbills are included in category ‘R’ (species with geographical restriction) in the Red List of breeding birds (NABU 2021). However, the breeding colony in Heligoland is very small and is therefore not decisive for the occurrence of the razorbill in the German North Sea.

For guillemots and razorbills, the German EEZ is part of the large-scale habitat in the North Sea. Typical medium to high densities were recorded with indications of increased importance during the post-breeding season (Chapter 2.9). The SEA for the SDP on the occurrence of guillemot and razorbill in the area of the site designation does not result in any considerable deviations from the assumption of the SEA of SDP 2020 or 2023.

As described in Chapter 4.8.1, individual accompanying investigations at German OWF have so far identified different avoidance reactions in the guillemot. These ranged up to 6.4 km and were thus, alongside those of the diver, the highest response recorded among the seabird and resting bird species analysed.

Based on a large-scale modelling of avoidance effects in the German EEZ of the North Sea, avoidances up to 21 km away from the wind farm were modelled (Garthe et al. 2022). Further scientific analysis of the data shows that up to 69% of the common guillemot population in the German EEZ of the North Sea would be affected by habitat loss in autumn because of these mean radii (PESCHKO et al. 2024).

The potential cumulative impact on habitats from offshore wind energy areas in the German EEZ accounts for around 23% of the total area; with a 6 km buffer around the offshore wind energy areas this amounts to around 51% (cf Chapter 4.17.4).

Based on the knowledge summarised in this and the previous chapters (Chapter 2.9, 4.8, 4.17.4), the BSH concludes that, at the present time, significant disturbance of the guillemot and razorbill within the meaning of Section 44, para. 1, No. 2 BNatSchG as a result of the implementation of the plan can be ruled out with the necessary certainty.

However, with the expansion of offshore wind energy in areas of the German EEZ of the North Sea favoured by these species and the parallel further development of guillemot and razorbill populations, the situation may change in the coming years. It is therefore important to record the occurrence and behaviour of both species in the coming years and adjust the assessment if necessary.

Songbirds

The migration of songbirds accounts for most bird migration over the North Sea in spring and autumn (see Chapter 2.10). In case of migration, a distinction must be made between diurnal migrants and nocturnal migrants. Whilst diurnal migrants mainly orient themselves to landmarks such as coastlines and islands, most songbirds move across the German Bight in broad front migration during the night. The nocturnal broad-front migration usually runs in a north-easterly or south-westerly direction although there are indications that the intensity of migration decreases with distance from the coast (KNUST 2003, WELCKER 2019).

On their way to the breeding and wintering areas, the birds also encounter offshore wind farms (such as those planned in Areas N-9 to N-20), which can have a deterrent and barrier effect on migrating birds. Some species react by flying horizontally around the disturbance area. The fly-around means an extension of the migration path, which can lead to greater energy consumption. Adverse effects are not to be expected when flying around a single wind farm over a total distance of several thousand kilometres (BERTHOLD 2000, BAIRLEIN 2022) (MASDEN 2009, HÜPPOP et al. 2019). However, effects on condition and, in extreme cases, on reproductive success (KELSEY et al. 2021, RÜPPEL et al. 2023, SCHINDLER et al. 2024) could arise if the migration route is extended because of several neighbouring wind farms (or wind farm areas, see Chapter 4.18) through a large-scale fly-around (FOX et al. 2006, MASDEN et al 2009, HÜPPOP et al. 2019).

With a direct fly-over, the migration route over the south-eastern German Bight would be approx. 150 km (BRUST & HÜPPOP 2022). However, the migration naturally does not take place on a straight line. Changes and course corrections are made by migrating birds several times along the migration route (KELSEY et al. 2021). The length of the migration route is therefore generally subject to a certain amount of variation, which is influenced by natural factors such as wind drift (HORTON et al. 2016). Usually, most migratory birds can compensate for the additional weather-related effort by means of a prolonged resting period. In this context, KELSEY et al. (2021) also showed that 91% of the blackbirds they studied that made an intermediate stop on Heligoland during migration had enough energy reserves to continue their migration to at least the nearest mainland. According to the calculations of the authors, in good weather conditions, 36% of the individuals even had enough energy reserves to fly a further 400 km without an intermediate stop. With regard to a possible barrier effect of wind farms and an extended migration distance of more than 150 km in cumulative consideration, it can be assumed that the additional energy losses incurred can be cushioned (at least in the case of short-distance migrants such as blackbirds) or compensated for by additional resting periods of one to two days. Even if the results are not directly transferable to other species (e.g. long-distance migrants), an increased mortality rate that exceeds the natural rate is not to be expected in connection with a possible barrier effect.

Although disturbance could therefore occur, it can be assumed with the necessary certainty that there will be no significant disturbance in accordance with Section 44, para. 1, No. 2 BNatSchG in the sense of a deterioration in the conservation status of migratory songbird populations.

Platforms

All converter platforms are planned in the immediate vicinity of offshore wind farms and therefore in their immediate area of operation. It can therefore be assumed that the deterrent effects of the neighbouring wind farms on disturbance-sensitive seabirds and resting birds and any associated habitat loss because of the converter platforms will increase only marginally. The same applies to possible deterrent and barrier effects on migratory birds.

Based on the current state of knowledge, it can therefore not be assumed that any disturbance of seabirds and resting birds or migratory birds relevant to species protection law within the meaning of Section 44, para. 1, No. 2 BNatSchG will occur.

Subsea cables

Scaring effects on seabirds and resting birds as well as migratory birds are limited to the small-scale and temporally limited laying of submarine cables. These disruptions do not go beyond the disruptions generally associated with slow maritime traffic Therefore, the planned subsea cables are not expected to disturb seabirds and resting birds or migratory birds in accordance with Section 44, para. 1, No. 2 BNatSchG.

5.2.2.3. Bats

In accordance with Section 44, para. 1, No. 2 and Section 7, para. 2, No. 14, lit. b BNatSchG in conjunction Annex IV of the Habitat Directive, it is prohibited to significantly disturb the 25 strictly protected bat species found in Germany during the reproduction, breeding, moulting, hibernation, and migration periods. A significant disturbance exists if the disturbance worsens the conservation status of the local population of a species.

Bats react differently to light emissions. Investigations on land have shown that light emissions can have both an attracting and repelling effect on (hunting) bats (VOIGT et al. 2018). More energy could be required because of the possible fly-around of wind farms. Similar investigations on the effects of light emissions on bats over the sea are not known.

In the area of Areas N-4 and N-5, small numbers of bats were detected during the assumed migration periods. There are no data for Areas N-9, N-12, and N-13 as well as N-14 through N-20 A comparison between different survey locations in the south-eastern North Sea suggests that the migration focus of bats is along the coastline and the Wadden Sea islands (SEEBENS-HOYER et al. 2021, BACH et al. 2022a, 2022b). A low occurrence of bats is therefore to be expected in the area of the aforementioned project areas.

Because summer and/or winter habitats of the bat species present are located far from the EEZ of the North Sea on land, disturbance during the reproduction, breeding, moulting, hibernation, and migration periods as well as the destruction of breeding and resting sites can be safely ruled out. Disturbances caused by project-related light emissions during migration across the open sea will affect only individual animals at most. A deterioration in the conservation status of the local bat populations as a result of the project can therefore be ruled out.

According to the current state of knowledge, it can therefore not be assumed with the necessary certainty that the construction and operation of wind farms and platforms on the sites of Areas N-4, N-5, N-9, N-12, N-13, and N-14 through N-20 as well as the laying of subsea cables will result in significant disturbance in accordance with Section 44, para. 1, No. 2 BNatschG.

5.3. Habitat protection (Section 34, para. 1, in conjunction with Section 36 BNatSchG)

In accordance with Section 36, Sentence 1, No. 2 in conjunction with Section 34, para. 1, No. 1 BNatSchG, plans must be assessed for their compatibility with the conservation objectives of a Natura 2000 site before they are adopted or implemented if they are likely (either individually or in interaction with other projects or plans) to significantly adversely affect the area. This also applies to designations outside the area that are capable of significantly affecting the protective purpose of the sites, either individually or in interaction with other projects or plans. The Natura 2000 network comprises the sites of Community importance (fauna-flora-habitat areas) under the Habitats Directive and the Special Protection Areas (SPA) according to the Birds Directive.

5.3.1. Test standard

According to Section 5, para. 3, No. 5 of the Offshore Wind Energy Act, designations are not permissible if the site is not compatible with the protective purpose of a protected area ordinance issued according to Section 57 of the Federal Nature Conservation Act. In this context, Section 5, para. 3, No. 5, 2nd half sentence WindSeeG clarifies when such compatibility is to be assumed. Accordingly, designations are permissible if, according to Section 34, para. 2 BNatSchG, they cannot lead to significant adverse effects on the components of the site relevant to the protective purpose of the respective protected area ordinance or if they meet the requirements according to Section 34, para. 3 to 5 BNatSchG. Against this background, it must be examined whether the designations according to Section 36, sentence 1, No. 2 in conjunction with Section 34, para. 2 BNatSchG may significantly adversely affect a Natura 2000 site in its components relevant to the conservation objectives or the protective purpose.

If significant adverse effects cannot be ruled out with certainty on the basis of a preliminary assessment, an impact assessment according to Section 34 et seq. BNatSchG must be carried out for further clarification. The impact assessment is carried out based on the conservation objectives established for the area. The term conservation objectives is defined in Section 7, para. 1, No. 9 BNatSchG as objectives set for a Natura 2000 site with a view to maintaining or restoring a favourable conservation status of a natural habitat type of community interest, a species listed in Appendix II of the Habitats Directive or in Article 4, para. 2, or Annex I of the Birds Directive (Directive 2009/147/EC).

In special protection areas, the protective purpose that constitutes the reference point for the impact assessment is the conservation of the birds listed in Appendix I to the Directive on Bird Conservation and of migratory birds according to Article 4, para. 2 of the Directive on Bird Conservation, the conservation of which the protected area has been designated. In view of the protective purpose of a special protection area, only the favourable conservation status of the protected bird species that must be preserved or restored constitutes an appropriate criterion for assessing the significant adverse effect. Possible individual losses that do not lead to the species no longer forming a viable element of the habitat to which it belongs, taking into consideration the data on population dynamics, are irrelevant (VGH Kassel NVwZ 2009, 343). If a Protected Area Ordinance is intended to conserve certain bird species listed in Appendix I to the Birds Directive and to restore habitats and stable viable populations of those bird species, and if the underlying area declaration contains information that the area is also important for other bird species, the latter may be exceptionally relevant for the impact assessment only if those bird species are characteristic species of that habitat type (BVerwG NVwZ 2007, 1054 (1073); BVerwGE 130, 299 (329)). The limitation of the impact assessment to the species of birds which are characteristic of the area and which determine its conservation objectives is in line with the legal provision as per which the project must be checked for compatibility with the conservation objectives of the area before its approval (OVG Koblenz DVBl. 2008, 321 (321 f.)).

The scope of application of the impact assessment is therefore narrower than that of the rest of the SEA because it is limited to reviewing the compatibility with the conservation objectives defined for the protected area (i.e. it has a territorial reference).

As part of this SEA, the compatibility of development and the operation of wind turbines on the designated sites (Zones 4 and 5 as well as subsequent use of Areas N-4 and N-5) with the protective purposes of the individual nature conservation area is examined separately according to protected assets and protected areas.

The impact assessment carried out here for the defined sites takes place at the higher level of the site development plan and does not replace the assessment at the level of the specific project in knowledge of the specific project parameters; this is carried out within the framework of approval procedures. In this respect, further preventive and mitigation measures are to be expected if these are deemed necessary by the impact assessment within the framework of planning approval procedures in order to exclude any adverse effect on the conservation objectives of the Natura 2000 sites or protective purposes of the protected areas by the use within or outside a nature conservation area. The compatibility within the framework of the suitability assessment is therefore to be investigated based on the previously executed assessments for the nature conservation areas and/or areas under the Habitats Directive.

Before being designated as protected maritime areas in accordance with Sections 20, para. 2 and 57 BNatSchG under European law dated 12 December 2007, the nature conservation areas in the EEZ had been included as areas under the Habitats Directive in the first updated list of areas of Community importance in the Atlantic biogeographical region in accordance with Article 4, para. 2 Habitats Directive (Official Journal of the EU, 15 January 2008, L 12/1) so that an FFH impact assessment had already been performed as part of the Federal Offshore Grid Plan for the German EEZ of the North Sea (BSH 2017). Most recently, an impact assessment according to Section 34, para. 1 BNatSchG was carried out as part of the SEA for the 2023 site development plan (BSH 2023a, p. 76–90).

In principle, the impact assessment examines the habitats listed in Appendix I to the Habitats Directive, including their characteristic species, species listed in Appendix II to the Habitats Directive or bird species listed in Appendix I and Article 4, para. 2 Birds Directive, including their habitats and sites as well as biotic and abiotic site factors, spatial-functional relationships, structures, site-specific functions or features important to the above habitats and species.

Insofar as a Natura 2000 site is a protected part of nature and seascape within the meaning of Section 20, para. 2 BNatSchG, the standards for compatibility are derived from the protective purpose and the provisions issued for this purpose if the respective conservation objectives have already been taken into consideration. For protected parts of nature and seascape within the meaning of Section 20, para. 2 BNatSchG, Section 34, para. 1 through 6 BNatSchG apply only insofar as the protection regulations, including the provisions on exceptions and exemptions, do not contain stricter regulations for the permissibility of projects, Section 34, para. 7 BNatSchG.

It must be examined whether the designations can lead to significant adverse effects on a Natura 2000 site as regards its **components relevant** to the conservation objectives.

Adverse effects are effects on the protected area which have a negative effect on the protected habitat or protected species, taking into consideration the conservation objectives and the protective purpose. The benchmark for assessing the significance of area impairments is therefore the conservation objectives defined for the respective area (Lüttgau/Kockler, in: BeckOK Umweltrecht, Giesberts/ Reinhardt, 53. Edition, Last revised: 1 July 2019, Section 34 BNatSchG, marginal no. 5–6). In principle, any adverse effect on the conservation objectives is significant and must be assessed as an adverse effect on the area as such (BVerwG, judgement of 17 January 2007 – - 9 A 20/05, NVwZ 2007, 1054, marginal no. 41). Materiality can be determined only on a case-by-case basis, whereby the criteria to be taken into consideration include the extent, intensity, and duration of the adverse effects. In order to assess whether the extent of an adverse effect is to be classified as significant, the definition of favourable conservation status according to the Habitats Directive or, if available, specific conservation objectives from a protected area ordinance or a management plan can provide guidance. In the context of Article 6, para. 3 of the Habitats Directive, only adverse effects that do not adversely affect any conservation objective are irrelevant.

The “**favourable conservation status**” of a habitat of Appendix I or a species of Appendix II of the Habitats Directive is defined in accordance with Section 7, para. 1, No. 10 BNatSchG in Article 1, para. e and i of the Habitats Directive. The important factor here is the extent, on the basis of the available data and using model parameters, to which the significance of the effects of the designations of the plan can be assessed at level of strategic environmental assessment itself. Whether the provisions of the plan can lead to adverse effects on habitat types must be assessed prognostically, taking into consideration project-specific effects.

The concept of stability of the conservation status includes restorability in the sense of the capacity to return to the original equilibrium after a disturbance. If the conservation status remains stable (taking into consideration its potential for restoration), it can be assumed that even if the conservation status is currently unfavourable, there are prospects of improving it.

5.3.2. Data source

The environmental report presented here is based on the data presented in the sub-chapters of Chapter 2 relevant to the respective protected assets. According to the methodology used, these are suitable at the SEA level for surveying and assessing possible effects on the conservation objectives or on the components of Natura 2000 sites relevant to the protective purpose or for setting a framework for lower planning levels.

Further data sources provide the respective management plans published in the Federal Gazette on 13 May 2020 and the standard data sheets relevant to the protected areas.

5.3.3. Construction, installation and operation-related effects on projects

The designations have effects that may impact the conservation objectives of the Natura 2000 sites under review. Effect factors must be differentiated depending on the designation.

The effects and the preventive and mitigation measures to be implemented for the protective purposes to be assessed are described in the sub-chapters of the Chapter 4 (which is relevant to the respective protected assets) as well as in Chapter 5.3.5.

5.3.4. Preliminary assessment

As part of a preliminary assessment, it must be examined whether there is a possibility that the designations of the plan will significantly adversely affect a Natura 2000 site or whether this cannot be clearly ruled out based on objective circumstances (cf BVerwG, judgement of 17 January 2007 – 9 A 20.05 – Westumfahrung Halle – marginal no. 58 with reference to ECJ, judgements of 20 October 2005 – C-6/04 – ECR 2005, I-9017, marginal no. 54 and of 10 January 2006 - C-98/03 - ECR 2006, I-53 marginal no. 40). Accordingly, the preliminary assessment must clarify whether there are project-related effects that may affect one or more Natura 2000 sites and whether there is a possibility that these effects will have a significant adverse effect on an area in terms of its components relevant to the conservation objectives or the protective purpose. In contrast to the actual impact assessment in the narrower sense, the assessment standard for the preliminary assessment is therefore initially only the serious concern of significant adverse effects on Natura 2000 sites (BVerwG, resolution of 26 November 2007 – 4 BN 46/07 marginal no. 7). A corresponding significance assessment is carried out below for the “Borkum Riffgrund” nature conservation area with regard to the habitat types and protected species. For the “Sylter Außenriff – Östliche Deutsche Bucht” and “Doggerbank” nature conservation areas, significant adverse effects cannot obviously be ruled out. A main assessment is therefore carried out for these two nature conservation areas in Chapter 5.3.5.

Section 3 of the NSGBRgV formulates the protective purpose for the entire “Borkum Riffgrund” nature conservation area. In accordance with Section 3, para. 1 NSGBRgV, the protective purpose is to realise the conservation objectives of the Natura 2000 site. In accordance with Section 3, para. 2, No. 3 in conjunction with para. 2 NSGBRgV, the conservation and, where necessary, the restoration to a favourable conservation status of the species listed in Annex II of Directive 92/43/EEC are harbour porpoise *(Phocoena phocoena*, EU code 1351), grey seal *(Halichoerus grypus*, EU code 1364), and harbour seal *(Phoca vitulina*, EU code 1365) as well as twaite shad *(Alosa fallax*, EU code 1103). In the “Borkum Riffgrund” nature conservation area, sandbanks with only slight permanent flooding by seawater (EU code 1110) and reefs (EU code 1170) occur as habitat types characterising the area according to Annex I of Directive 92/43/EEC in accordance with Section 3, para. 3 NSGBRgV.

Habitat types according to Appendix 1, Habitats Directive

All areas and sites defined in the SDP are located at a distance from the “Borkum Riffgrund” nature conservation area that is far above the known impact radii on benthic habitats. Significant effects from the construction and operation of OWF in the designated sites on the habitat types “sublittoral sandbank” and “reef” in the aforementioned protected area can therefore be ruled out *a priori* with the necessary certainty.

The SDP does not specify any grid connection cables that cross the protected area outside the corridors that have already been conclusively examined in the environmental assessments for previous side development plans. Therefore, significant effects resulting from the laying of grid connection cables through the “Borkum Riffgrund” nature conservation area can be ruled out with the necessary certainty.

Protected marine mammal species

For the designated sites, there is no serious concern that the construction and operation of the installations will have a significant adverse effect on protected mammal species in the "Borkum Riffgrund" nature conservation area as a result of the effects relevant to marine mammals. This assessment also takes into consideration the interaction with the existing wind turbines from the nearby offshore wind farms or areas already defined in the SDP 2023 with regard to their relevance for the protective purposes and conservation objectives of the nature conservation areas.

An impact assessment in the narrower sense is not required because of the large distance between the new areas designated for offshore wind energy use or the sites in subsequent use and the "Borkum Riffgrund" nature conservation area. The distance to the "Borkum Riffgrund" nature conservation area is 57 km in the shortest case (N-9.5). The distance is even greater for all other sites or areas. In accordance with the studies cited in the noise protection concept of the BMU, a significant effect on harbour porpoises with unmitigated pile driving noise (Alpha Ventus) up to 16.4 km can be demonstrated based on the waiting times; no significant effects were found at a distance of 21 km (BMU 2013). The impact area is therefore far below the distance to the "Borkum Riffgrund" nature conservation area.

Other species

Alosa fallax (twaite shad). Because of the large distance of the areas of the current planning project to the "Borkum Riffgrund" nature conservation area (shortest distance to N-9.5 is 57 km), no significant effects on the twaite shad are to be expected.

5.3.5. Main examination

5.3.5.1. Protected area "Sylter Außenriff – Östliche Deutsche Bucht"

Overview of the protected area and the components relevant to its conservation

(1) Area description and location of the project

The "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area has an area of 5,603 km² and is located in the southern North Sea. It includes the outer grounds off Sylt and Amrum and the moraine ridge of the north-eastern flanks of the Elbe Glacial Valley. The nature conservation area is divided into two zones I and II, zone I comprising the 'Sylt outer reef' area and zone II comprising the 'Eastern German Bight' area. Area I contains sub-areas Ia and Ib. Area I is 5311.30 km² and area II 3133.39 km².

The effects of the plan are examined based on the protective purposes of the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area. In accordance with Section 1 NSGSylV, the nature conservation area combines the "Sylter Außenriff" FFH area and the European Special Protection Area "Östliche Deutsche Bucht" and is divided into two areas in accordance with Section 2, para. 4: Area I designates the area "Sylter Außenriff", whilst Area II designates the area "Östliche Deutsche Bucht".

(2) Protective purpose of the area (in accordance with NSG-VO in conjunction with the management plan)

According to Section 3, para. 1 NSGSylV, the protective purpose is to achieve the conservation objectives of the Natura 2000 areas. In accordance with Section 3, para. 2, No. 3 NSGSylV, the conservation and restoration of the specific ecological values and functions of the area are to be protected, in particular the populations of harbour porpoises, grey seals, harbour seals, and seabird species as well as their habitats and natural population dynamics.

In Section 3 NSGSylV, the protective purpose for the entire nature conservation area "Östliche Deutsche Bucht" is formulated.

In accordance with Section 3 NSGSylV, the protective purpose is:

(1) the achievement of the conservation objectives of Natura 2000 sites by means of the permanent preservation of the maritime area, the diversity of the habitats, biocoenoses, and species relevant to these areas as well as the uniqueness of the shallow water areas of the southern North Sea off the North Frisian Islands and the slope areas of the Elbe Glacial Valley to the West,

(2) the conservation or, where necessary, the restoration of the specific ecological values and functions of the areas, in particular

1. its characteristic morphodynamics and the hydrodynamics shaped by the tidal currents and the inflow of Elbe water,

2. a natural or near-natural expression of species-rich gravel, coarse sand and shell layers as well as the development of silt beds and burrowing mega-fauna communities,

3. the populations of harbour porpoises, grey seals, harbour seals, and seabird species as well as their habitats and natural population dynamics,

4. the diverse, species-rich, and closely interconnected benthic biocoenoses in the central-western area of the protected area (sub-area Ia), which is characterised by a special ecological interlocking of reefs, coarse and medium sands, and benthic communities that are either not influenced at all or are influenced only to a limited extent by human usages in the area of the Amrumbank (sub-area Ib)

5. the function for the interconnectedness of the benthic biocoenoses in the German Bight.

With the publication in the Federal Gazette on 13 May 2020, the management plan for the nature conservation area "Sylter Außenriff – Östliche Deutsche Bucht" in the German EEZ of the North Sea was officially announced (BAnz AT 13 May 2020 B11, Management Plan for the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area (MPSyl)). The implementation of the programme of measures contained in the management plan will be further specified.

Existing pressures or threats/pressures and anthropogenic activities are mentioned in the standard data sheet under No. 4.3 (SDB July 2020, Official Journal of the EU, L 198/41) and in the management plan. In accordance with the information from the standard data sheet, anthropogenic activities take place within the area. These include sand and gravel extractions, shipping, military exercises, oil and gas exploration, power lines, fishery (pots, baskets, fishing rods), water sports, and other usages. Pollution entering the area from outside includes marine water pollution and air pollution.

(3) Conservation objectives for protected species

The conservation objectives of the nature conservation area Sylt Outer Reef is divided into two sub-areas I and II and have therefore been separately considered below.
In accordance with Section 5, para. 1, No. 1 and 2 NSGSylV, the conservation or, if necessary, the restoration of a favourable conservation status of bird species listed in Annex I of the Birds Directive (red-throated diver, black-throated diver, Sandwich tern, common tern, Arctic tern) as well as of regularly occurring migratory bird species (fulmar, gannet, common scoter, skua, pomarine skua, common gull, lesser black-backed gull, kittiwake, guillemot, and razorbill) are among the protective purposes of the nature conservation area in Area II.
For Area II under Section 5, para. 2, No. 1 to No. 4 SGNSylV, the ordinance then specifies what is required in particular to protect the habitats and to safeguard the survival and reproduction of the bird species listed in Section 5, para. 1 SGNSylV as well as the functions of Area II in accordance with para. 1. Accordingly, it is necessary in particular to maintain or, where necessary, restore:

- No.1: the qualitative and quantitative populations of bird species with the aim of achieving a favourable conservation status, taking into consideration the natural population dynamics and the population trends; special attention must be paid to bird species with negative trends in their biogeographical population,
- No.2: the main organisms serving as food for bird species, in particular their natural population densities, age-group distributions and distribution patterns,
- No.3: the increased biological productivity at vertical fronts, which is characteristic of the area, and the geo- and hydro morphological characteristics with their species-specific ecological functions and effects as well as
- No.4: the natural quality of habitats with their respective species-specific ecological functions, their fragmentation and spatial interrelationships, and unimpeded access to adjacent and neighbouring maritime areas.

AREAS FOR SUBSEQUENT USE

Area N-4 for subsequent use is located in the immediate vicinity of the European Special Protection Area “Östliche Deutsche Bucht” (Sub-area II of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area) and the currently planned expansion of the area (future sub-area III of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area). The impact radius of the projects in the sub-areas depends on the species-specific reaction of the aforementioned bird species to OWF. Of the other areas designated, the Area N-5 for subsequent use is closest to Sub-areas II and III. A remote effect of a project in this area on the protective purpose and conservation objectives of Sub-area II of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area can be ruled out with the necessary certainty because of the great distance. Because of the large distance to the sub-areas, this test result also applies to all other areas and sites designated in the draft SDP 2024.

Examination of sub-area I

Under Section 4, para. 3, No. 1 to 5 NSGSylV, the ordinance sets out objectives to safeguard the conservation and restoration of the marine mammal species harbour porpoise, harbour seal, and grey seal mentioned in Section 3, para. 2 NSGSylV as well as the conservation and restoration of their habitats in Area I.

Conservation and, where necessary, restoration:

- No. 1: of the natural population densities of these species with the aim of achieving a favourable conservation status, their natural spatial and temporal distribution, health status and reproductive fitness, taking into consideration natural population dynamics, natural genetic diversity within the population in the area, and genetic exchange opportunities with populations outside the area,
- No. 2: of the area as a largely undisturbed habitat, which is unaffected by the local pollution, of the species of marine mammals listed in para. 1, No. 2 and, in particular, as a particularly important breeding, rearing, feeding and migration habitat for harbour porpoises in the area of the southern North Sea,
- No. 3: of unfragmented habitats and the possibility of migration of the species of marine mammals referred to in para. 1, No. 2 into Danish waters, into the immediately adjacent protected areas for harbour porpoises of the Federal State of Schleswig-Holstein and into the protected areas of the Wadden Sea and off Heligoland
- No. 4: of the essential food sources of the species of marine mammals referred to in para. 1, No. 2, in particular the natural population densities, age group distributions and distribution patterns of the organisms serving as food sources for these species of marine mammals
- No. 5: a high vitality of individuals and species-typical age structure of fish and cyclostomes populations as well as the spatial and temporal distribution patterns and population densities of their natural food sources

The current data sources on the occurrence of harbour porpoises in the German EEZ of the North Sea as well as in the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area was presented in Chapter 2.7.1 and can be described as very good. An excellent data source is also available for the assessment of possible effects of offshore wind farms based on the results from effect monitoring for compliance with arrangements from permits and planning approval decisions. The species protection assessment also takes into consideration Planning principle 7.1.2 of the SDP and the recommendations of the BfN, according to which the threshold value of the BMU noise protection concept (BMU 2013) must be observed (cf Planning principle 7.1.4 of the SDP) in order to prevent and mitigate significant adverse environmental impacts and monitoring measures. The aforementioned data sources are suitable for surveying and assessing possible effects on the conservation objectives or on the components of Natura 2000 sites relevant to the protective purpose. In addition, the management plan for the nature conservation area and the current standard data sheet (BAnz AT 13 May 2020 B11, Management plan for the “Borkum Riffgrund” nature conservation area (MPBRg; Official Journal of the European Communities, No L 198/41, DE2109301, SDB of 07/2020) is applicable.

a) Protected marine mammal species

Area I of the nature conservation area “Sylter Außenriff – Östliche Deutsche Bucht” is congruent with the Natura 2000 site “Sylter Außenriff” (DE 1209-301). Area I has a size of 5314 km².

Three marine mammal species occur in the Natura 2000 site “Sylter Außenriff” in varying degrees of abundance: Harbour porpoise, harbour seal, and grey seal (Amtsblatt der Europäischen Gemeinschaften, No. L 198/41, DE2109301, SDB dated 07/2020):

Phocoena phocoena (harbour porpoise): The data quality is rated as good and is based on surveys. The population in the area ranges between 1001 and 10000 individuals; compared with the local population, the relative size or density of the population at the site ranges from 15 to 100%. Good conservation is a given. The population is not isolated within the distribution area. The overall assessment results in an excellent value.

Phoca vitulina (harbour seal). The data quality is rated as poor. The population in the area ranges between 101 and 250 individuals; compared with the local population, the relative size or density of the population at the site is estimated to be between 0 and 2%. Good conservation is a given. The population is not isolated within the distribution area. The overall assessment results in an excellent value.

Halichoerus grypus (grey seal). The data quality is rated as poor. The estimated population in the area is between 11 and 50 individuals, and as compared to the local population, the relative size or density of the population at the site is estimated to be between 0 and 2%. Good conservation is a given. The population is not isolated within the distribution area. The overall assessment results in a good value.

The Natura 2000 site “Sylter Außenriff” is the most important area for harbour porpoises in the German North Sea. The area has a special function as a breeding area for harbour porpoises. Regular sightings of mother-calf pairs in the summer months underline the special importance.

For harbour seals and grey seals, this area is of high importance as a foraging habitat.

Representative and characteristic benthic biocoenoses for the habitat types “sandbank” and “reef” occur in the area. In terms of benthic biocoenoses, it is a regeneration area that provides a basic place for foraging for seabirds and fish, among others.

Area I is characterised by great habitat diversity and occurrences of various vulnerable biotope types. The area is also of international importance as a resting, feeding, and wintering habitat for seabirds (Official Journal of the European Communities, No. L 198/41, DE2109301, SDB dated July 2020). In addition to the species listed in Appendix II of the Habitats Directive, other characteristic species are also listed in the standard data sheet.

Among marine mammal species, the harbour porpoise has a significant occurrence in the nature conservation area and is considered an indicator or key species as regards the assessment of effects of the plan from the perspective of nature conservation.

b) Other species

Alosa fallax (twaite shad). The habitat fish species twaite shad is listed as a pelagic migratory species in the Sylt Outer Reef nature conservation area. However, the main area of distribution of the species is in the estuaries of the rivers. A significant occurrence in the nature conservation area is thus not to be expected. In particular, sensitive spawning and nursery areas are located in Limnic waters.

Lampetra fluviatilis (river lamprey). River lampreys spend several years as larvae in the freshwater of rivers; after this, they migrate to the sea. They return to the rivers to spawn. River lampreys are thus widespread in the coastal waters of the North Sea and Baltic Sea; however, their main areas of distribution are in inland streams and rivers. In the North Sea, the river lamprey lives parasitically off the body tissues of other fish. There is no quantitatively appropriate method of determination and therefore no conclusion can be drawn as to the occurrence in the North Sea. However, the sensitive spawning and nursery areas are located in limnic waters.

(4) Conservation objectives for protected habitat types

In order to protect the habitat types listed in para. 3, No. 1, including their characteristic species, Section 4, para. 2 NSGSylV defines objectives for the conservation or, where necessary, the restoration

1. of the ecological quality of the habitat structures and their areal extent

2. of the natural quality of these habitats with largely natural distribution, population density, and dynamics of the populations of the characteristic species and the natural expression of their biocoenoses

3. the unfragmented nature of the habitat and its function as a regeneration area, especially for benthic fauna

4. of the function of the area as a starting point and distribution corridor for the recolonisation of surrounding areas by benthic species and biocoenoses.

(5) Functional relationships of the protected area with other Natura 2000 sites

As outlined in the management plan, there are close functional interactions between the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area and the marine protected areas of the coastal federal states and littoral states. There are also interactions with the other marine protected areas in the German EEZ of the North Sea. Because of its size and location, Area I has an important connecting and stepping stone function for the distribution of benthic species in the German Bight. It represents a link between the biocoenoses of the central North Sea and those of the Schleswig-Holstein territorial sea. The reefs in particular act as stepping stones to the reef occurrences of Heligoland and ensure the presence of characteristic species with a large radius of action. For the harbour porpoise, the protected area represents an important migration habitat, which is connected with Doggerbank, Borkum Riffgrund and the harbour porpoise protected area, among others. Also because of its importance for numerous seabird species, the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area contributes to the coherence of the Natura 2000 network (BAnz AT 13 May 2020 B11, MPSyl).

Assessment of project-related adverse effects

The assessment on the basis of the relevant scientific findings has shown that the designations of the plan cannot lead to significant adverse effects on the “Sylter Außenriff – Östliche Deutsche Bucht” area in its components relevant to the conservation objectives or the protective purpose, Section 34, para. 2 BNatSchG. According to Section 34, para. 1, sentence 1 BNatSchG, not only the effects of the designations of the plan but also their interaction with other plans and projects were taken into consideration in the assessment.

(1) Adverse effects on protected species

Whether the designations of the plan can lead to adverse effects on protected species must be assessed prognostically, taking into consideration project-specific effects.

a) Harbour porpoise

The harbour porpoise is one of the strictly protected species for which a special sensitivity to impulse sound has been demonstrated. The assessment of the potential adverse effects of sound input on the harbour porpoise is based on the noise protection concept of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (2013) for the North Sea. The noise protection concept of the BMU (2013) for the North Sea provides the framework for assessing the effects of offshore wind farms and associated infrastructure in terms of habitat protection to meet the requirements from the national implementation of the Habitats Directive (92/43/EEC) or BNatSchG.

Based on the noise protection concept of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (2013) for the North Sea, a significant adverse effect on the area is to be assumed if at least 10% of the area is within the disturbance radius (if the threshold value of the sound exposure level (SEL) of 160 dB re 1 μPa² s or peak sound pressure level (SPL) of 190 dB re 1 μPa) is observed at a distance of 750 m). Within the framework of the implementation of the Maritime Strategy Framework Directive (MSFD, 2008/56/EC), the harbour porpoise is also used nationally as well as regionally within the framework of the OSPAR and HELCOM conventions as an indicator species for the assessment of anthropogenic effects such as those caused by offshore wind farms. From the perspective of nature conservation, the use of indicator species is a common procedure to analyse and evaluate anthropogenic effects with the necessary depth and to take measures to protect marine habitats and species as required. According to current knowledge, measures to protect harbour porpoises are effective and suitable to also ensure the protection of the harbour seal and grey seal. In particular, it can be assumed that measures to prevent death or injury as well as disturbance of harbour porpoises are also beneficial for the protection of other animal species (e.g. fish).

<u>(aa) Relevant effect factors</u>

The effects described in Chapter 4.7 can be traced back to the noise emissions during the construction.

<u>(bb) Assessment of the adverse effects on conservation objectives</u>

The revision of the maritime spatial plan 2021 (BSH, 2021) also provides for the designation of a reservation area for the harbour porpoise in the German EEZ of the North Sea. The reservation area represents the main concentration area of the harbour porpoise during the sensitive period from 1 May to 31 August, which was identified during the development of the noise protection concept of the BMU (2013). The seasonal reservation area of the harbour porpoise covers Area I of the nature conservation area “Sylter Außenriff – Östliche Deutsche Bucht” and its surroundings. From a physical point of view, the reservation area thus generously encompasses the area of the frontal system west of the North Frisian Islands. The front system spreads into the reservation area quite dynamically because of weather and currents and ensures increased productivity and rich food supply for top predators such as the harbour porpoise and many seabird species. By designating the seasonal reservation area, the maritime spatial plan takes a preventive measure to safeguard the food-rich alternative habitat of the harbour porpoise outside Area I of the nature conservation area.

According to the current state of knowledge, effects of sound-intensive pile driving are to be expected in the immediate vicinity of the nature conservation area if no sound prevention and noise mitigation measures are taken. The exclusion of significant effects, in particular as a result of disturbance of the populations in the nature conservation area and the population of the respective species, requires the implementation of strict noise protection measures. The maritime spatial plan and the Site Development Plan contain a number of principles and objectives in this regard. In the context of the species protection assessment, noise protection measures were also described according to the state-of-the-art science and technology. According to the current state of knowledge, the application of these excludes any significant disturbance of the population in the nature conservation areas.

In 2008, the BSH introduced arrangements that contain binding limit values for the impulsive sound input from pile driving work in its approval notices. The introduction of the binding threshold values is based on findings about the triggering of temporary auditory threshold shifts in harbour porpoises (LUCKE et al., 2008, 2009). The compliance with the threshold values (160 dB individual sound exposure level (SEL_{05}) re 1µPa2s and 190 dB re 1µPa at a distance of 750 m) is monitored by the Federal Maritime and Hydrographic Agency using standardised measurement and analysis methods. Additional noise protection measures with regard to the coordination of parallel pile driving and to reduce the impact on nature conservation areas are also derived from the noise protection concept of the BMU (2013) as well as the catalogue of measures in the present environmental report and are created as part of the suitability assessment and ordered and strictly monitored in the individual approval procedures by the BSH and adapted to the site- and project-specific characteristics. Since 2011, all pile driving work in German waters of the North Sea and Baltic Sea has been executed by utilising noise mitigation systems. Monitoring of the noise protection-related measures has clearly shown that they have been quite effective since 2014 so that significant disturbance of the populations and an associated adverse effect on the local population in the German EEZ of the North Sea can therefore be excluded.

(2) Adverse effects on protected habitat types listed in Appendix 1, Habitats Directive

The possibility of a significant adverse effect on the habitat types can be ruled out for the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area.

The shortest distance between Areas N-5 and an area of reef habitat type within the nature reserve is around 4 km. The distances between Area N-4 and the reef (7 km) and sandbank (6 km) habitat types are somewhat greater. This distances are outside the drift distances discussed in the literature. Thus, no release of turbidity, nutrients, and pollutants that could adversely affect the nature conservation areas and FFH area in its components relevant to the conservation objectives or the conservation objectives or the protective purpose is to be expected. Because the other anticipated construction-, installation- and operation-related impacts relevant to the habitat types are also small-scale, significant adverse effects from the construction and operation of the wind farms on the “reef” and “sublittoral sandbank” habitat types in the nature conservation area can be ruled out.

The SDP does not specify any grid connection cables that cross the protected area outside the corridors already examined under site protection law in the environmental assessments for previous site development plans. Therefore, significant effects on the habitat types resulting from the laying of grid connection cables through the Sylter Außenriff – Östliche Deutsche Bucht nature conservation area can be ruled out with the necessary certainty.

(3) Assessment of the adverse effect of other plans and projects on conservation objectives (cumulative assessment)

Cumulative effects from parallel pile driving activities in other sites within the German EEZ in the North Sea will be avoided through appropriate coordination. In accordance with the requirements of the noise protection concept of the BMU (2013), higher-level coordination ensures that

(a) always less than 10% of the area of the German EEZ in the North Sea; and

(b) less than 10% of the area of the nearest Natura 2000 site “Sylter Außenriff”

c) less than 1% of the main concentration area harbour of the harbour porpoise is continuously affected by pile driving noise between May and August.

This measure will ensure that the animals will always have sufficient suitable habitats free from noise exposure from pile driving.

Result of the impact assessment

Subsequent use of Areas N-4 and N-5, expansion of Area N-12 (sub-areas N-12.4 and N-12.5), expansion of area N-13 (sub-area N-13.4*)

The examination of the possible effects of the plan with regard to the development of the extension of Areas N-12 and N-13 as well as the subsequent use of Areas N-4 and N-5 has shown that shown that there will be no significant adverse effects associated with the construction of the installations and the laying and operation of subsea cables. An adverse effect on the protective purposes of the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area through the construction and operation of offshore wind turbines in the areas in compliance with the planning principles of the 2024 site development plan and taking into consideration appropriate measures in the course of implementation can be ruled out with the necessary certainty.

The 2024 Site Development Plan sets out comprehensive requirements, particularly in Planning Principles 7.1.2 and 7.1.4 in conjunction with the BMU noise protection concept (BMU 2013). According to Section 6, para. 9, sentence 2 WindSeeG, the site development plan is binding for the approval procedure.

Nevertheless, the compatibility of the project with the protective purposes and conservation objectives will be re-examined and, if necessary, measures adapted as part of the subordinate approval procedure taking into consideration the planning principles of the 2024 site development plan and on the basis of the concrete information provided by the future project sponsors regarding the structural design of the project and possible temporal overlap with noise-intensive work in other projects.

Expansions of Area N-9, Areas N-14 through N-20

Because of the great distance of more than 50 km between these areas and the Sylter Außenriff, it can be ruled out with the necessary certainty that the protection objectives will be adversely affected.

5.3.5.2. Doggerbank protected area

Overview of the protected area and the components relevant to its conservation

(1) Area description and location of the project

The "Doggerbank" nature conservation area covers an area of 1,692 km² and is located in the central North Sea around 250 km from the mainland. It includes the German portion of the largest sandbank in the North Sea, which stretches from the UK continental shelf to the Danish Exclusive Economic Zone.

The examination of the effects of the plan will be based on the protective purposes of the "Doggerbank" nature conservation area.

(2) Protective purpose of the area (in accordance with NSG-VO in conjunction with the management plan)

According to Section 3, para. 1 NSGDgbV, the protective purpose is to achieve the conservation objectives of the Natura 2000 sites. In accordance with Section 3, para. 2 and para. 3 NSGSylV, conservation and restoration of the specific ecological values and functions of the area are to be protected – in particular, the populations of harbour porpoises and harbour seals as well as their habitats and natural population dynamics – as are the maintenance or restoration of a favourable conservation status.

Section 3 of the NSGDgbV formulates the protective purpose for the entire "Doggerbank" nature conservation area.

In accordance with Section 3 NSGDgbV, the protective purpose is:

(1) the realisation of the conservation objectives of the Natura 2000 site by permanently preserving the maritime area and the diversity of its biocoenoses and species relevant to this area as well as the function of Doggerbank as a separating geological structure between the northern and southern North Sea.

(2) the conservation or, where necessary, the restoration of the specific ecological values and functions of the areas, in particular

1. its supra-regionally significant, largely natural hydromorphological conditions

2. of the populations of harbour porpoise and harbour seal as well as their habitats and natural population dynamics.

(3) the preservation or, where necessary, the restoration of a favourable conservation status

1. of the habitat type characterising the area according to Appendix I of Directive 92/43/EEC Sandbanks with only slight permanent overtopping by seawater (EU code 1110),

2. of the species listed in Appendix II to Directive 92/43/EEC harbour porpoise (Phocoena phocoena, EU code 1351) and harbour seal (Phoca vitulina, EU code 1365).

The official announcement of the management plan for the “Doggerbank” nature conservation area in the German EEZ of the North Sea took place with the publication in the Federal Gazette on 13 May 2020 (BAnz AT 13 May 2020 B10, Management plan for the “Doggerbank” nature conservation area (MPDgb)). The implementation of the programme of measures contained in the management plan will be further specified.

Existing pressures or threats/pressures and anthropogenic activities are mentioned in the standard data sheet under No. 4.3 (SDB July 2020, Official Journal of the EU, L 198/41) and in the management plan. In accordance with the information from the standard data sheet, anthropogenic activities take place within the area. These include shipping, military exercises, oil and gas exploration, energy pipelines, fishery (gillnets, bottom trawls, purse seines), and marine pollution

(3) Conservation objectives for protected species

The following is an assessment of the identified species harbour porpoise and harbour seal and the conservation objectives that apply to them.

Under Section 3, para. 5 NSGDgbV, the ordinance sets out objectives to safeguard the conservation and restoration of the marine mammal species harbour porpoise and harbour seal mentioned in Section 3, para. 3 NSGDgbV as well as the conservation and restoration of their habitats.

For conservation and, where necessary, restoration:

1. of the natural population densities of these species with the aim of achieving a favourable conservation status, their natural spatial and temporal distribution, health status, and reproductive fitness, taking into consideration natural population dynamics and genetic exchange opportunities with populations outside the area

2. of the area as a habitat for harbour porpoises and harbour seals that is largely undisturbed and unaffected by local pollution and, in particular, as an important feeding, migration, breeding, and nursery habitat for harbour porpoises in the area of the central North Sea,

3. of unfragmented habitats and the possibility of migration of harbour porpoises and harbour seals within the German North Sea and into Dutch, British, and Danish waters

4. of 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.

The current data sources on the occurrence of harbour porpoises in the German EEZ of the North Sea as well as in the “Doggerbank” nature conservation area was presented in Chapter 2.7.1 and can be described as sufficient. An good data source is available for the assessment of possible effects of offshore wind farms based on the results from effect monitoring for compliance with arrangements from permits and planning approval decisions. The species protection assessment also takes into consideration Planning principle 6.1.9 of the 2024 site development plan presented in the environmental report in Chapter 5.2 and the recommendations of the BfN, according to which the threshold value of the BMU noise protection concept (BMU 2013) must be observed in order to prevent and mitigate significant adverse environmental impacts and monitoring measures (cf Planning principle 6.1.11 of the 2023 site development plan). The aforementioned data sources are suitable for surveying and assessing possible effects on the conservation objectives or on the components of Natura 2000 sites relevant to the protective purpose. In addition, the management plan for the nature conservation area and the current standard data sheet (BAnz AT 13 May 2020 B10, Management plan for the “Doggerbank” nature conservation area (MPBRg; Official Journal of the European Communities, No L 198/41, DE1003301, SDB of 07/2020) is applicable.

a) Protected marine mammal species

Three marine mammal species occur in the Natura 2000 site “Doggerbank” in varying degrees of abundance: Harbour porpoise and harbour seal (Amtsblatt der Europäischen Gemeinschaften, Nr. L 198/41, DE1003301, SDB vom 07/2020):

Phocoena phocoena (harbour porpoise): The data quality is rated as good and is based on surveys. The population in the area ranges between 1001 and 10000 individuals; compared with the local population, the relative size or density of the population at the site ranges from 15 to 100%. Good conservation is a given. The population is not isolated within the distribution area. The overall assessment results in an excellent value.

Phoca vitulina (harbour seal). The data quality is classified as poor; there are no data on population size, and in accordance with the standard data sheet, the harbour seal is considered “widespread”. The relative size or density of the population in the area compared to the local population is between 0 and 2%. Good conservation is a given. The population is not isolated within the distribution area. The overall assessment results in a significant value.

The Natura 2000 site “Doggerbank” is an area of high importance for the harbour porpoise as a migration, foraging, and reproduction habitat. Because of the productive slopes, it is a key habitat in terms of reproduction, rearing young, and foraging. Regular sightings of mother-calf pairs in the summer months underline the special importance.

Among marine mammal species, the harbour porpoise has a significant occurrence in the nature conservation area and is considered an indicator or key species as regards the assessment of effects of the plan from the perspective of nature conservation.

(4) Conservation objectives for protected habitat types

In order to protect the habitat type referred to in Section 3, para. 3, No. 1 NSGDgbV, including its characteristic species, it is particularly necessary to conserve or, where necessary, restore

1. the ecological quality of the habitat structures and their areal extent

2. the natural quality of the habitat with largely natural distribution, population density, and dynamics of the populations of the characteristic species and the natural expression of their biocoenoses

3. the unfragmented nature of the habitat and its function as a regeneration area, especially for benthic fauna

4. the high autochthonous biological productivity

5. its function as a starting point and distribution corridor for benthic species in the entire North Sea as well as its function as a particularly species-rich biogeographical border area between the northern and southern North Sea.

(5) Functional relationships of the protected area with other Natura 2000 sites

The Natura 2000 site "Doggerbank" is part of a unique sandbank in the North Sea and the largest sandbank in the German maritime area. Because of its location and the confluence of different water masses, various biotopes and biocoenoses that differ considerably from those of the German Bight occur here. The special function of the Doggerbank as a biogeographical divide between the northern and southern North Sea is emphasised in the management plan. As outlined in the management plan, there are close functional interactions between the "Doggerbank" nature conservation area and the other marine protected areas in the German EEZ of the North Sea – the "Sylter Außenriff – Östliche Deutsche Bucht" and "Borkum Riffgrund" nature conservation areas and with marine protected areas of littoral states. Because of its location in the EEZs of the Netherlands, Denmark, and Germany as well as on the continental shelf of Great Britain and, in particular, its interaction with the protected areas of these neighbouring countries, the Doggerbank nature conservation area contributes to the coherence of the Natura 2000 network.

The area is of major importance for the harbour porpoise because it is an important migration, foraging, and reproduction habitat. (BAnz AT 13 May 2020 B10, MPDgb).

Assessment of project-related adverse effects

The assessment on the basis of the relevant scientific findings has shown that the designations of the plan cannot lead to significant adverse effects on the "Doggerbank" area in its components relevant to the conservation objectives or the protective purpose, Section 34, para. 2 BNatSchG. According to Section 34, para. 1, sentence 1 BNatSchG, not only the effects of the designations of the plan but also their interaction with other plans and projects were taken into consideration in the assessment.

(1) Adverse effects on protected species

Whether the designations of the plan can lead to adverse effects on protected species must be assessed prognostically, taking into consideration project-specific effects.

a) Harbour porpoise

The harbour porpoise is one of the strictly protected species for which a special sensitivity to impulse sound has been demonstrated. The assessment of the potential adverse effects of sound input on the harbour porpoise is based on the noise protection concept of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (2013) for the North Sea. The noise protection concept of the BMU (2013) for the North Sea provides the framework for assessing the effects of offshore wind farms and associated infrastructure in terms of habitat protection to meet the requirements from the national implementation of the Habitats Directive (92/43/EEC) or BNatSchG.

Based on the noise protection concept of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (2013) for the North Sea, a significant adverse effect on the area is to be assumed if at least 10% of the area is within the disturbance radius (if the threshold value of the sound exposure level (SEL) of 160 dB re 1 μPa² s or peak sound pressure level (SPL) of 190 dB re 1 μPa) is observed at a distance of 750 m). Within the framework of the implementation of the Maritime Strategy Framework Directive (MSFD, 2008/56/EC), the harbour porpoise is also used nationally as well as regionally within the framework of the OSPAR and HELCOM conventions as an indicator species for the assessment of anthropogenic effects such as those caused by offshore wind farms. From the perspective of nature conservation, the use of indicator species is a common procedure to analyse and evaluate anthropogenic effects with the necessary depth and to take measures to protect marine habitats and species as required. According to current knowledge, measures to protect harbour porpoises are effective and suitable to also ensure the protection of the harbour seal and grey seal. In particular, it can be assumed that measures to prevent death or injury as well as disturbance of harbour porpoises are also beneficial for the protection of other animal species (e.g. fish).

<u>(aa) Relevant effect factors</u>

The effects described in Chapter 4.7 can be traced back to the noise emissions during the construction.

<u>(bb) Assessment of the adverse effects on conservation objectives</u>

According to the current state of knowledge, effects of sound-intensive pile driving are to be expected in the immediate vicinity of the nature conservation area if no sound prevention and noise mitigation measures are taken. The exclusion of significant effects, in particular as a result of disturbance of the populations in the nature conservation area and the population of the respective species, requires the implementation of strict noise protection measures. The maritime spatial plan and the Site Development Plan contain a number of principles and objectives in this regard. In the context of the species protection assessment, noise protection measures were also described according to the state-of-the-art science and technology. According to the current state of knowledge, the application of these excludes any significant disturbance of the population in the nature conservation areas.

In 2008, the BSH introduced arrangements that contain binding limit values for the impulsive sound input from pile driving work in its approval notices. The introduction of the binding threshold values is based on findings about the triggering of temporary auditory threshold shifts in harbour porpoises (LUCKE et al., 2008, 2009). The compliance with the threshold values (160 dB individual sound exposure level (SEL_{05}) re 1µPa2s and 190 dB re 1µPa at a distance of 750 m) is monitored by the Federal Maritime and Hydrographic Agency using standardised measurement and analysis methods. Additional noise protection measures with regard to the coordination of parallel pile driving and to reduce the impact on nature conservation areas are also derived from the noise protection concept of the BMU (2013) as well as the catalogue of measures in the present environmental report and are created as part of the suitability assessment and ordered and strictly monitored in the individual approval procedures by the BSH and adapted to the site- and project-specific characteristics. Since 2011, all pile driving work in German waters of the North Sea and Baltic Sea has been executed by utilising noise mitigation systems. Monitoring of the noise protection-related measures has clearly shown that they have been quite effective since 2014 so that significant disturbance of the populations and an associated adverse effect on the local population in the German EEZ of the North Sea can therefore be excluded.

(2) Adverse effects on protected habitat types listed in Appendix 1, Habitats Directive

The possibility of significant adverse effect on the fauna-flora-habitat habitat types can be ruled out for the “Doggerbank” nature conservation area.

Areas N-17 and N-19 each border directly on the “Doggerbank” nature conservation area so that in the worst-case scenario, the distance between a wind turbine site and the “sandbank” habitat type within the protected area is only a few hundred metres. Because sandy sediments settle again after a short time in the immediate vicinity of the encroachment, a drifting into the protected area and thus an influence on the habitats there is not to be expected. In addition, the exposed sediments of the Doggerbank are subject to regular rearrangements because of natural events (e.g. storms) and are therefore not considered sensitive to redistribution. Because the other anticipated construction-, installation-, and operation-related impacts relevant to the habitat types are also small-scale, significant adverse effects on the “sublittoral sandbank” habitat type in the nature conservation area can be ruled out.

The SDP does not specify any grid connection cables that cross the protected area. Therefore, significant effects on the sandbank resulting from the laying of grid connection cables through the “Doggerbank” nature conservation area can be ruled out with the necessary certainty.

(3) Assessment of the adverse effect of other plans and projects on conservation objectives (cumulative assessment)

Cumulative effects from parallel pile driving activities in other sites within the German EEZ in the North Sea will be avoided through appropriate coordination. In accordance with the requirements of the noise protection concept of the BMU (2013), higher-level coordination ensures that

(a) always less than 10% of the area of the German EEZ in the North Sea; and

(b) always less than 10% of the area of the nearest Natura 2000 site “Doggerbank”

c) between May and August, less than 1% of the main concentration area of the harbour porpoise as well as the protected areas that have the reproduction of the harbour porpoise as their protective purpose (i.e. the Sylter Außenriff FFH areas and Doggerbank FFH area) are exposed to pile driving noise.

This measure will ensure that the animals will always have sufficient suitable habitats free from noise exposure from pile driving.

Result of the impact assessment

Subsequent use of Areas N-4 and N-5, expansion of Area N-12 (sub-areas N-12.4 and N-12.5), expansion of area N-13 (sub-area N-13.4*), expansion of Area N-9, Areas N-14 through N-16 (except N-16.5)

Because of the great distance of more than 39 km between these areas and the Doggerbank FFH area, it can be ruled out with the necessary certainty that the protection objectives will be adversely affected.

Area N-16 (Sub-site N-16.5), Area N-17 through N-20

The examination of the possible effects of the plan with regard to the development of Areas N-16 (here: sub-site N-16.5) as well as Areas N-17 through N-20 has shown that there will be no significant adverse effects associated with the construction of the installations and the laying and operation of subsea cables. An adverse effect on the protective purposes of the “Doggerbank” nature conservation area through the construction and operation of offshore wind turbines in the areas in compliance with the planning principles of the SDP and taking into consideration appropriate measures in the course of implementation can be ruled out with the necessary certainty.

The Site Development Plan sets out comprehensive requirements, particularly in Planning Principles 7.1.2 and 7.1.4 in conjunction with the BMU noise protection concept (BMU 2013). According to Section 6, para. 9, sentence 2 WindSeeG, the site development plan is binding for the approval procedure.

Nevertheless, the compatibility of the project with the protective purposes and conservation objectives will be re-examined and, if necessary, measures adapted as part of the subordinate approval procedure taking into consideration the planning principles of the site development plan and on the basis of the concrete information provided by the future project sponsors regarding the structural design of the project and possible temporal overlap with noise-intensive work in other projects.

5.4. Other threats to the marine environment in terms of concerns about pollution of the marine environment

In order to ensure operation for offshore installations (wind turbines and platforms), techniques that may be associated with material discharges into the marine environment are used. Corrosion protection in the underwater area of the structures in particular results in permanent emissions into the marine environment. At the same time, corrosion protection is essential for the structural integrity of the installations. Galvanic anodes (sacrificial anodes) can be used on the foundation structures as a common corrosion protection variant in the underwater area. The gradual dissolution of these anodes releases the components into the marine environment. The anode mass required for a service life varies depending on the foundation structure, building type, anode composition, and local environmental conditions. According to current experience, emissions from offshore wind turbines are around 150–750 kg per wind turbine per year (BSH & Hereon 2022). Galvanic anodes used for offshore wind energy typically consist of aluminium-zinc-indium alloys (approx. 95% aluminium, 2.5–5.75% zinc, 0.015–0.04% indium;

DNV GL 2010). In principle, the galvanic anodes may also contain small quantities of particularly environmentally critical metals (e.g. cadmium, lead, copper) because of the production process (Reese et al. 2020). These are also released into the marine environment during operation. When assessing this impact, it must be taken into consideration that inputs from corrosion protection can spread through distribution and dilution processes in the individual environmental compartments of the North Sea and do not necessarily have to accumulate locally and lead to harmful concentrations.

As an alternative to galvanic anodes, external current anodes have now established themselves on the market and are increasingly being used, especially for the corrosion protection of structurally simple foundation structures such as monopiles These external current anodes and associated only with minimal emissions (e.g. as a result of minimal material removal).

With regard to the effects of corrosion protection-related emissions in the area of offshore wind farms, the BSH conducted the “OffCHEm” research project in collaboration with the Helmholtz Centre Hereon and is currently conducting the “Anemoi” research project in collaboration with other European partners (https://www.bsh.de/DE/THEMEN/Forschung_und_Entwicklung/Aktuelle-Projekte/OffChEm/OffChEm_node.html, https://www.bsh.de/DE/THEMEN/Forschung_und_Entwicklung/Aktuelle-Projekte/Anemoi/anemoi_node.html). The data obtained so far in the German Bight as part of the OffCHEm research project show that the concentrations of the selected elements, which also occur in galvanic anodes, in both water and sediment are largely within the range of variability known for the investigation area. However, in certain weather conditions, local increases in concentration of indium, gallium, zinc, and aluminium were observed in the water. Local increases in concentration were also evident in the sediment, especially for lead; however, their causes cannot be clearly identified and may be due to the existing pressure of the sediments. At present, there are no discernible direct effects from the use of galvanic anodes. However, the continued operation and development of offshore wind energy will also lead to a further increase in material emissions from corrosion protection (BSH & Hereon 2022).

According to the precautionary principle, material discharges are to be avoided according to the state of the art for the protection of the marine environment (cf Planning principle 7.1.3 of the SDP). In particular, the use of external power systems is to be preferred. Furthermore, the use of galvanic anodes is permitted only in combination with coatings; this significantly reduces emissions from galvanic anodes into the water body. Subsequently, only galvanic anodes for which the production-related content of environmentally critical heavy metals is minimised may be used; the use of zinc anodes is prohibited.

When taking into consideration these provisions, the effects from corrosion protection are assessed as long-term, small-scale, and of low intensity according to the current state of knowledge. The Structural and functional changes in the marine environment are minor.

For the operation of the wind turbines and platforms, high volumes of operating materials hazardous to water (including hydraulic oils, lubricating greases, transformer oils and diesel for emergency power generators, and extinguishing agents) are inevitably required in some cases. Because of their water-polluting properties, these fuels have a fundamental hazard potential for the marine environment. The risks arising from operational substance leaks/accidents can thus be prevented by taking structural and operational precautionary and safety measures (e.g.

enclosures, double-walled tanks, catch basins, and management concepts). The same applies to fuel changes and refuelling measures to be carried out. If environmentally compatible and, as far as possible, biodegradable substances are used, the overall effects on the marine environment resulting from accidental discharges is assessed as low, taking into consideration the probability of occurrence.

In addition to the material emissions mentioned, further emissions into the water can occur at specific points during the regular operation of platforms. Rainwater and drainage water can be contaminated with oil or chemicals (e.g. because of leakages) as a result of the operating materials contained in the installations of the platform. Light liquid separators (oil separators) are therefore used to reduce the oil content of this sewage water. According to technical availability and the current state of implementation, the oil content can be procedurally reduced to 5 ppm.

On manned platforms, sewage water from sanitary facilities, laundry, and canteen operations is treated by a certified sewage water treatment plant or collected in wastewater collection tanks and disposed of on land. This sewage water is collected on unmanned platforms and disposed of on land. The sewage water treatment plant must be state of the art and reduce nitrogen and phosphorus compounds.

For the purpose of systems cooling, closed cooling systems without continual material discharges have been established on the platforms. Only in justified exceptional cases, when the required cooling capacity cannot be achieved by glosed systems (such as converter platforms), can "open" state-of-the-art seawater cooling systems be used in addition. To ensure the permanent operational readiness of these system-relevant cooling systems, biocides (usually sodium hypochlorite) are partially added in order to protect pipelines and pumps from marine fouling. The sea cooling water is then discharged back into the sea; the residual biocide content and its degradation products are then subject to local distribution and dilution processes.

According to current experience, the use of sodium hypochlorite can be 10–30 t per converter per year. However, there is currently a lack of data and investigations that can determine the risk potential of biocide use on the marine environment. According to the precautionary principle, the inputs of sodium hypochlorite should therefore be avoided or reduced using state-of-the-art technology. A reduction in discharges could be achieved through needs-based metering. (e.g. reduction of the active ingredient concentration, shock treatment and seasonal treatment on the basis of vegetation intensity monitoring). Technical alternatives (e.g. use of backwash filters, increasing the cooling water flow, use of ultrasound, mechanical cleaning) can also be considered.

Foundation structures of offshore structures can lead to increased turbulence and mixing within the water column (e.g. Christiansen et al. 2023). The extent to which this also leads to the resuspension of sediments and possibly the release of previously bound nutrients and pollutants into the seawater cannot be assessed at present. There is thus a need for further research.

In summary, the effects of the aforementioned material emissions into the marine environment are also assessed as long-term, small-scale, and of low intensity according to the current state of knowledge assuming implementation of the state of the art and compliance with the minimisation requirement (cf Planning principle 7.1.3 of the SDP). Structural and functional changes are minor.

5.5. Transboundary effects

Fish

With regard to the protected asset fish, the SEA comes to the conclusion that, according to the current state of knowledge, no significant transboundary impacts on the protected asset are to be expected as a result of the implementation of the SDP because, on one hand, the areas for which the SDP makes designations do not have a prominent function for the fish fauna. On the other hand, the recognisable and predictable effects are of a small-scale and temporary nature.

Harbour porpoise

Because of the large distance (at least 27 km), no negative transboundary impacts are to be expected for the Friese Front (NL), Sydlige Nordsø (DK), and Doggerbank (GB) nature conservation areas, which are located in the littoral states

The Doggerbank nature conservation area (NL) is located adjacent to Areas N-17 and N-19. Because these areas also border on the “Doggerbank” FFH area in the German EEZ, the conditions listed in the species and area conservation assessment as well as in the “Cumulative effects” chapter apply here in order to avoid any adverse effect on the area. This includes the noise protection concept of the BMU (BMU 2013), which, in addition to the threshold value in species protection, also excludes cumulative adverse effect by requiring spatial and temporal coordination of pile driving work in these areas. This coordination also benefits the Doggerbank nature conservation area (NL) nature conservation area because only a small part of this nature reserve is adversely affected by disturbance-inducing noise at any one time. The smallest distance to the protected area is 0.69 km. Because of the specifications in the noise protection concept, a threshold value of 160 dB SEL05 must be observed at a distance of 750 m during construction work. Harbour porpoises must be deterred from the hazard area so that no animals (including those on the Dutch side) are present in the danger zone. The propagation attenuation of the noise protection measures provided for in the site development plan (e.g. the use of noise mitigation systems (e.g. bubble curtain systems) that are far from the pile and, if necessary, also those that are near the pile (e.g. HSD network) according to the state of the art, also has a radial effect. In addition, a possible directional dependency of the noise propagation at the beginning of the installation is checked and, if necessary, repaired (e.g. by repairing the bladder hose). This is done by means of sound measurements in different spatial directions and if necessary, an improvement of the double large bubble veil, which is generally used as a noise protection measure. It is to be expected that there will be a limited avoidance radius; this will also extend into the Dutch EEZ. Experience from previous construction projects shows that the animals return to the area of the wind farms after the end of the construction period and the start of the operating phase (Brandt et al. (2018), Rose et al. (2019)).

International coordination is recommended if construction projects are taking place at the same time in the German, Dutch, or British EEZ adjacent to the Doggerbank nature conservation area (NL) that could cumulatively affect this protected area.

Seabirds and resting birds

During the operating phase of wind farms, species sensitive to disturbance can be expected to avoid wind farm sites to a species-specific extent. In the case of offshore wind farms close to the border, this can have an impact beyond the border of the German EEZ. Possible significant transboundary effects may result from this for the highly mobile protected asset seabirds and resting birds if all planned wind farm projects in the North Sea are considered cumulatively. Based on the findings presented in Chapter 4.8 on the avoidance behaviour of various species of seabirds and resting birds towards offshore wind energy, according to the current state of knowledge, it must be assumed that wind farm projects in Area N-5 will have scaring effects on the Danish Special Protection Area "Sydlige Nordsø" to the extent identified because the two areas are directly adjacent to each other. In the Special Protection Area "Sydlige Nordsø", the following species are the declared protective purpose: Razorbill, little auk, red-throated and black-throated divers, little gull, bloack scoter, gannet, eider, skua, and guillemot. In the case of the Dutch "Friese Front" SPA, scaring effects can be ruled out because of the distance of around 27 km to the nearest German site for offshore wind energy (N-9.5). All other European special protection areas are located at an even greater distance from areas and sites for wind energy in the German EEZ. Scaring effects into these areas can therefore be ruled out. In general, it can be assumed that scaring effects beyond the boundaries of the German EEZ can be observed in the border area with neighbouring EEZs.

In order to be able to holistically assess the cumulative effects on seabirds and resting birds, it is necessary to take a cumulative cross-border assessment that includes all offshore wind farms in the North Sea to be considered. An international exchange and a joint evaluation are therefore recommended.

There are currently large gaps in our knowledge regarding the assessment of the effects of cumulative habitat change. The extent of the consequences of the scaring effects or potential habitat impairment at the population level is still largely unknown. In long-lived species, these can become recognisable with a considerable time delay. Population trend analyses for the entire North Sea can provide an indication; however, these cannot be clearly traced back to individual stressors. Definable threshold values above which further pressures on an individual stressor are no longer tolerable for individual species are not yet available for all seabird and resting bird species.

Migratory birds

For migratory birds, the wind turbines and platforms constructed on the sites of the site development plan may represent a barrier or a collision risk. Considering the main migratory directions north-east in spring and south-west in autumn, cumulative consideration of all planned wind farm projects in the German North Sea could result in major barrier effects for migratory birds. A possible fly-around caused by the wind farms would mean an increased demand for energy. In the absence of compensation (e.g. by resting on the migration route), increased energy consumption could have an impact on reproductive success and, in the worst case, on survival (BRUINZEEL & VAN BELLE 2010, KELSEY et al. 2021, RÜPPEL et al. 2023). However, the length of the migration route is generally subject to some variation (e.g. because of wind drift, HORTON et al. 2016). Most migratory birds can usually compensate for this additional effort by resting for longer periods. At this stage, a fly-around of the wind farm projects is not expected to have any significant negative effect on the further development of the populations.

Even if long-distance avoidance is generally part of the species-specific behavioural repertoire of some species, results from investigations in offshore wind farms suggest that flying through, especially by songbirds migrating at night, appears more likely (AVITEC RESEARCH GbR 2020). Flying through could increase the risk of collision. However, because the platforms are individual structures in the immediate vicinity of offshore wind farms, platforms alone are not expected to significantly adversely affect bird migration. When considering the collision risk posed by wind turbines, it can be assumed that the probability of a collision is rather low in the clear weather conditions favoured by birds during migration. In contrast, surprising fog and rain that lead to poor visibility and low flight altitudes are a potential threat situation (HÜPPOP et al. 2016, MOLIS et al. 2019, PANUCCIO et al. 2019). However, there is currently a lack of scientific knowledge regarding the species-specific migration behaviour in poor weather conditions, the evasive behaviour or attraction behaviour, and its subsequent effects as well as the real losses as a result of collisions in offshore wind farms. The site development plan therefore provides for monitoring programmes to measure collisions between birds and wind turbines (Planning principle 7.1.6). Collision detection will be further specified in the approval procedure for individual wind farm projects.

In order to be able to holistically assess the cumulative effects on bird migration, it is necessary to take a cross-border view that includes all offshore wind farms in the North Sea to be considered. An international approach and a joint evaluation are therefore recommended.

6. Derivation of the technical basis for the exercise of discretion in the designation of acceleration sites within the meaning of Section 5 WindSeeG-E

6.1. Introduction and general conditions

In accordance with Section 5, para. 2b Draft WindSeeG, the SDP also designates some of the sites as acceleration sites. The designated Areas N-17, N-19 and N-20 as well as Areas N-4 and N-5 intended for subsequent use are not taken into consideration because these areas have not yet been zoned in the current SDP.

In accordance with Section 5, para. 2b, sentence 3 Draft WindSeeG, a site should be designated as an acceleration site if no significant environmental impacts within the meaning of Section 5, para. 2b, sentence 4 Draft WindSeeG are to be expected as a result of the construction and operation of offshore wind turbines. Because of the criteria set out in Section 5, para. 2b, sentence 7, No. 1–6 Draft WindSeeG, Sites N-12.5 and N-13.4 are excluded from additional designation as acceleration sites: Site N-13.4 is partially located within the reservation area for harbour porpoises designated in ROP 2021 and is therefore to be classified as an area within the meaning of Section 5, para. 2b, sentence 7, No. 1 WindSeeG-E in conjunction with Section 5, para. 2b, sentence 8 Draft WindSeeG. Site N-12.5 is partially located within a radius of less than 8 km around the aforementioned harbour porpoise reservation area and is therefore excluded as an acceleration site in accordance with Section 5, para. 2b, sentence 7, No. 5 Draft WindSeeG.
According to Directive (EU) 2018/2001[4], Member States shall use all appropriate and proportionate instruments and data sets when designating acceleration sites. In this environmental report, the BSH has compiled all known and available data so that the descriptions in Chapters 2 through 5 form a sufficient basis for the designation of acceleration sites. Directive (EU) 2018/2001 also stipulates that the member states use sensitivity maps for the designation of acceleration sites. The sensitive areas in the German EEZ of the North Sea are already specified by law in Section 5, para. 2b, sentences 7 and 8 WindSeeG-E. At the same time, aspects of sensitivity mapping are applied in the following chapter in order to additionally examine whether there are indications of other special ecological features in the sites that must be taken into consideration in the limited exercise of discretion provided for by law.

[4] Renewable Energy Directive 2018/2001 as amended by Directive 2023/2413 of 18 October 2023 on the update of Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Council Directive (EU) 2015/652, available at CL2018L2001EN0020010.0001.3bi_cp 1..1 (europa.eu).

6.2. Exercise of discretion with regard to the designation of acceleration sites

6.2.1. Methodology

Section 5, para. 2b, sentence 3 WindSeeG-E places the designation of acceleration sites at the discretion of the BSH. A site should be designated as an acceleration site if no significant environmental impacts within the meaning of Section 5, para. 2b, sentence 4 WindSeeG-E are to be expected as a result of the construction and operation of offshore wind turbines. According to Section 5, para. 2b, sentence 5 WindSeeG-E, the construction and operation of offshore wind turbines is not expected to have any significant environmental impacts unless an acceleration sites falls under Section 5, para. 2b, sentence 7, Nos. 1-6 WindSeeG-E. A structured analysis of special ecological features of benthic biotopes and specially protected species according to Section 7, para. 2, No. 13 BNatSchG of which the following species were examined forms the basis for the exercise of discretion with regard to the designation of acceleration sites: Harbour porpoise *(Phocoena phocoena*), gannet *(Morus bassanus)*, kittiwake *(Rissa tridactyla)*, fulmar *(Fulmarus glacialis)*, lesser black-backed gull *(Larus fuscus*), great black-backed gull *(Larus marinus)*, black-throated diver *(Gavia arctica)*, herring gull (Larus *argentatus)*, trf-throated diver *(Gavia stellata)*, razorbill *(Alca torda),* guillemot *(Uria aalge)*, little gull *(Larus minutus).*
For this purpose, data on the spatial and temporal distribution of the relevant protected assets were used. These originate from several research projects financed and coordinated by the Federal Agency for Nature Conservation (BfN (2023)) and/or by the BSH and from the environmental impact studies or preliminary site investigations/baseline surveys as well as from the monitoring of offshore wind farm projects during construction and operation in accordance with StUK4 (BSH 2023). Data from Gilles et al. (2020) were also used.

For spatial visualisation, distribution maps with a grid cell resolution of 5 × 5 km were created for each species (Step 1 in Figure 56). These were intersected with the specific features (2) to create species- or biotope-specific maps (3). The species/protected asset-specific characteristics were selected with regard to their relevance for assessing the suitability of the SDP sites as acceleration sites. These were categorised into two categories: “lower suitability” and “higher suitability”.

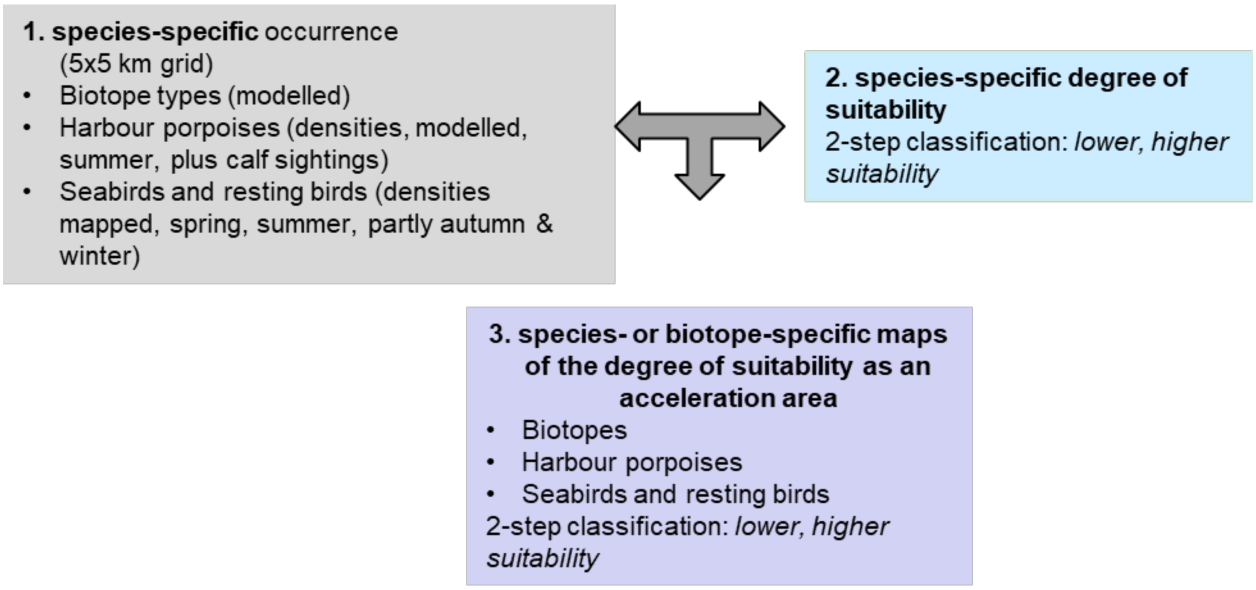

Figure 56: Schematic representation of the procedure for the supplementary analysis to examine the degree of suitability of the sites for designation as acceleration sites.

Biotopes

The suitability of the sites for the protected asset biotopes is assessed by considering the abiotic characteristics (sediments) and the prevailing benthic biocoenosis. The categorisation is based on the study by BIOCONSULT (2019) and other relevant literature data (cf Chapter 2.5.3 and 2.6.3) for the characteristics (1) rarity and endangerment (= risk of loss), (2) resilience, and (3) regeneration potential.

Based on these characteristics, areas characterised by geogenic reefs, species-rich gravel, coarse sand and shell layers, or "sublittoral sands with *Goniadella-Spisula community*" are to be classified as less suitable for acceleration sites.

Marine mammals

The assessment of the protected asset marine mammals focusses on the harbour porpoise *(Phocoena phocoena*). For the other marine mammal species such as grey seal and harbour seal a low to medium importance of all areas considered in the SDP was determined (cf Chapter 2.8.4), whereby the degree of suitability of the sites is largely determined by specific characteristics in the occurrence of the harbour porpoise.

The estimation is based on modelled harbour porpoise densities (ind./km²; Gilles et al. 2020); the value range of these above the second tercile (> 0.95 ind./km² in the data set used) describes a lower suitability of the respective grid cell. This is similar to the approach taken by HAMMOND et al. (1995, 2002, 2017) and GILLES et al. (2023), who rate harbour porpoise occurrences as high (corresponding to low suitability) based on SCANS investigations for densities > 1 ind./km².

For the assessment of suitability, the characteristic of whether the animals were calving was also included. This was done against the background that harbour porpoises reproduce from an age of around four years at the earliest, give birth to only one offspring per birth cycle, and thus do not give birth to many offspring within the decreasing life expectancy (approx. 5.7 years in the North Sea) (KESSELRING et al. 2017).

Seabirds and resting birds

The assessment of the protected asset seabirds and resting birds (hereinafter referred to as seabirds) is carried out with a focus on the typical and most common seabird species in the North Sea (see above). Depending on their ecology and behaviour, these 11 species show different species-specific reactions to wind turbines; these can essentially be divided into attraction and avoidance (cf Chapter 4.8).

The methodology described in GARTHE & HÜPPOP (2004) was used to determine the suitability of the sites for the protected asset seabirds. Nine factors (corresponding here to ecological characteristics) are classified; these describe the flight behaviour, general behaviour, and status of a species. In this scoring system by GARTHE & HÜPPOP, each factor is assessed on a 5-point scale from 1 (low threat to seabirds) to 5 (high threat to seabirds) and summarised in a "sensitivity index" (SSI).

In line with more recent findings, two of the nine factors were updated compared with GARTHE & HÜPPOP (2004). Furthermore, the factor (e) "Disturbance by ship and helicopter traffic" was replaced by "Avoidance behaviour". The classification is based on the technical categorisation of the state of knowledge from literature and the expert opinion of the operational monitoring according to StUK4 (Table 16).

Table 16: Sensitivity indices (SSI) for 11 seabird species based on the calculations in GARTHE & HÜPPOP (2004) and the factors used there from 1 (low endangerment for seabirds) to 5 (high endangerment for seabirds), which were included in this calculation. The factors marked with * were adjusted from the values in GARTHE & HÜPPOP based on a literature analysis. a: Flight manoeuvrability; b: Flight altitude; c: % Flying; d: Nocturnal flight activity; e*: Avoidance behaviour; f: Flexibility of habitat use; g*: Biogeographical population size; h: Survival rate of adult animals; i*: European threat and conservation status

	Flight behaviour				general behaviour		Conservation and protection status			
Type	**a**	**b**	**c**	**D**	**e*[1]**	**f**	**g*[2]**	**h**	**i*[3]**	**SSI**
Black-throated diver	5	2	3	1	5	4	4	3	3	**41.3**
Red-throated diver	5	2	2	1	5	4	4	3	3	**37.5**
Guillemot	4	1	1	2	5	3	1	4	3	**21.3**
Razorbill	4	1	1	1	3	3	2	5	5	**21**
Northern gannet	3	3	3	2	3	1	2	5	1.5	**15.6**
Fulmar	3	1	2	4	3	1	1	5	3	**15**
Kittiwake	1	2	3	3	3	2	1	3	3	**13.1**

	Flight behaviour				**general behaviour**		**Conservation and protection status**			
Greater black-backed gull	2	3	2	3	1	2	4	5	1.5	**13.1**
Little gull	1	1	3	2	1	3	4	2	3	**10.5**
Herring gull	2	4	2	3	1	1	2	5	4	**10.1**
Lesser black-backed gull	1	4	2	3	1	1	3	5	1.5	**7.9**

[1] Compared with Garthe & Hüppop, in factor e "Disturbance by ship and helicopter traffic" was replaced with "Avoidance behaviour"; classification based on technical classification of knowledge from literature and expert opinion of the operational monitoring according to StUK4

[2] updated with values from Wetlands International (2021) Waterbird Populations Portal. Retrieved from www.wetlands.org

[3] updated with information from BirdLife International (2017) European birds of conservation concern: populations, trends and national responsibilities. Cambridge, UK: BirdLife International.

According to the methodology of Garthe & Hüppop (2004), the species-specific seasonal densities were first added with 1, logarithmised, multiplied by the respective species-specific SSI, and summed per grid cell and season. This resulted in a "Wind Power Sensitivity Index (WSI)" map for each species for each of the four seasons in the sense of Garthe & Hüppop (2004); in this study, this is interpreted as suitability for the protected asset seabirds.

The highest WSI value was selected from these four values for each grid cell. Following the approach of Garthe & Hüppop (2004), all WSI values above the median were categorised as areas with a lower suitability.

This approach did not allow a WSI value to be determined directly for each grid cell for the protected asset seabirds and resting birds. To create an area-wide map, the empty cells were therefore filled with the highest value of the surrounding grid cells within a 10 km radius following the precautionary principle.

6.2.2. Results

Biotopes

Almost none of the suitable areas for wind energy to be considered here are less suitable for designation as an acceleration site for the protected asset biotopes. Only Site N-13.4 has a lower suitability (Figure 57). However, because of the criteria set out in Section 5, para. 2b, sentence 7, No. 1–6 WindSeeG-E, Sites N-12.5 and N-13.4 are excluded a priori from additional designation as acceleration sites (cf Chapter 6.1).

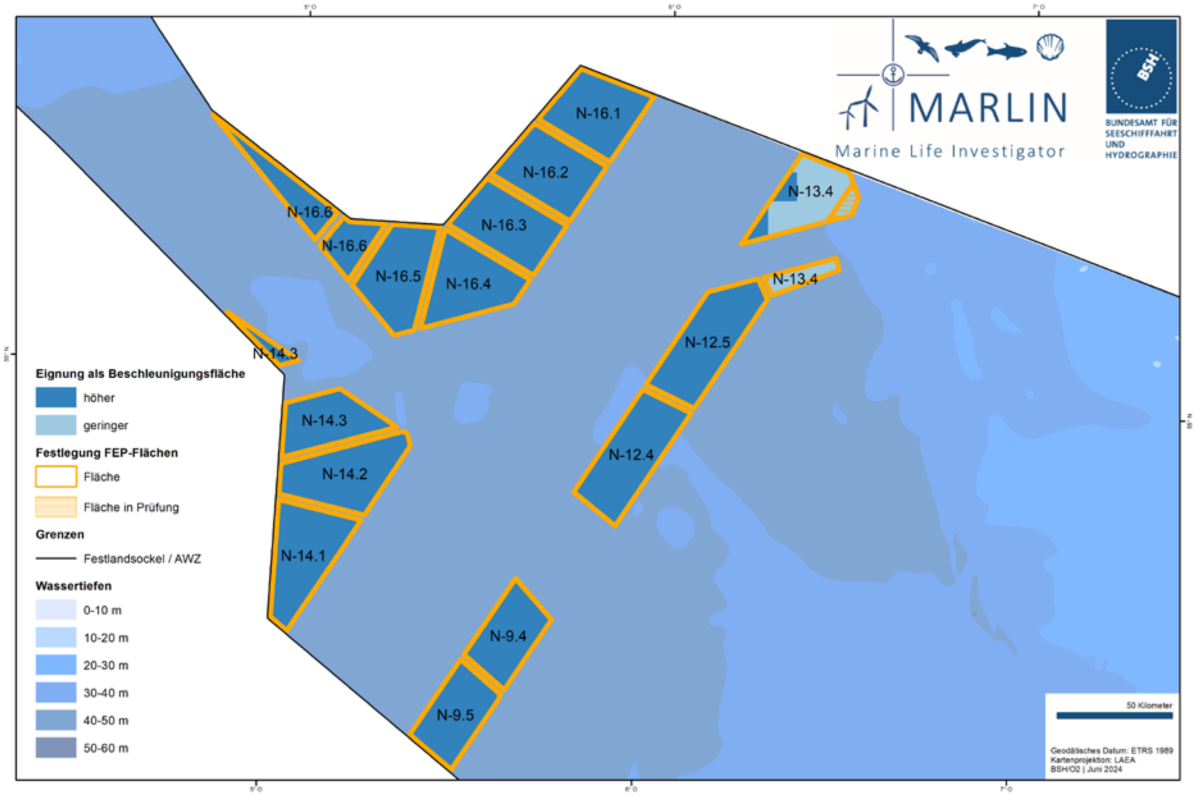

Figure 57: Suitability of the SDP sites as an acceleration site for the protected asset biotopes (BSH 2024). Shown in light blue = lower, dark blue = higher suitability; outlines in orange = SDP sites.

Marine mammals

For the protected asset marine mammals, areas with a higher suitability for designation as an acceleration site can be identified in Area N-14 as well as in individual sites of Areas N-9 and N-12 (Figure 58). A lower suitability for the additional designation as an acceleration site can be determined for parts of Area N-16 with a focus on Site N-16.1. Such areas can also be found in other sites (e.g. N-9.5).

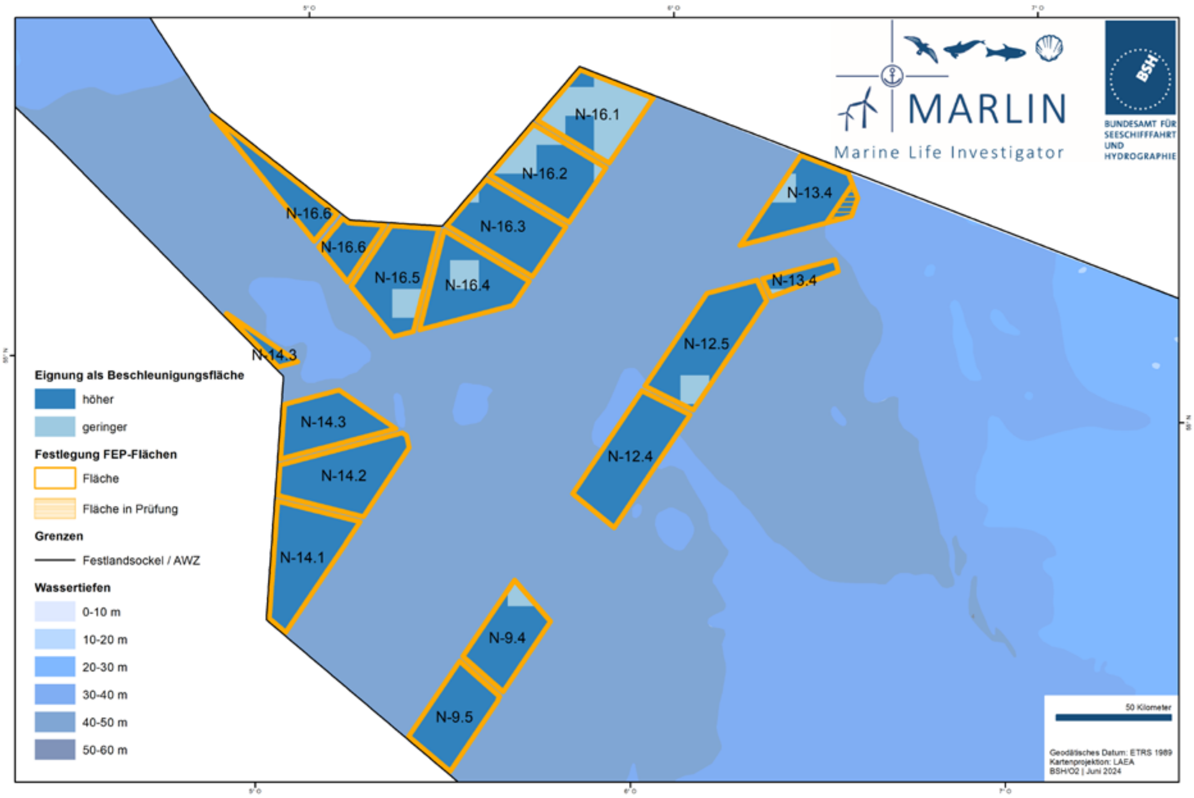

Figure 58: Suitability of the SDP sites as an acceleration site for the protected asset marine mammals (BSH 2024). Depicted in light blue = lower, dark blue = higher suitability; outlines in orange = SDP sites.

Seabirds and resting birds

Areas with a higher suitability as acceleration sites for the protected asset seabirds and resting birds can be found in Area N-14 as well as in the north-western parts of area N-16 (e.g. Site N-16.6).

Areas with a lower suitability as acceleration sites for the protected asset seabirds and resting birds are found within the SDP sites, particularly in the southern and north-eastern parts of area N-16 (with a focus on Sites N-16.1 and N-16.4) as well as in Site N-9.5. Such areas can also be found in individual other sites (e.g. N-12.4) (Figure 59).

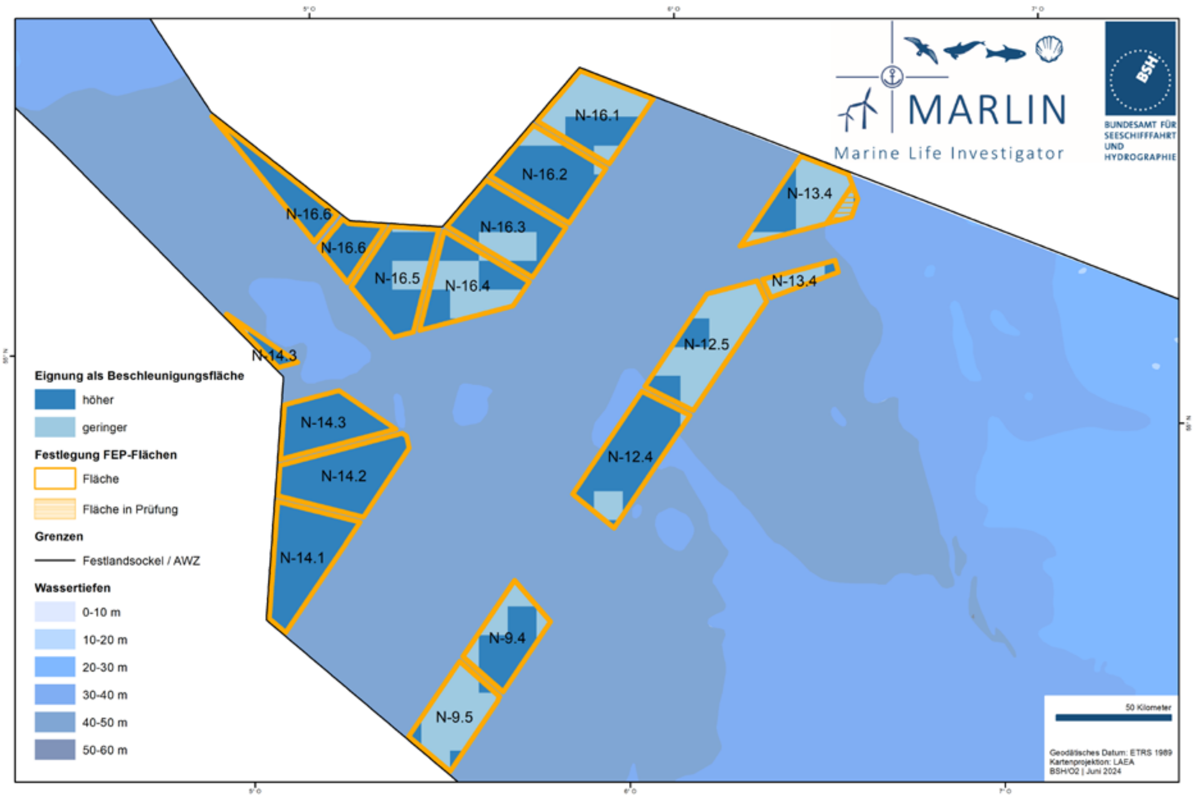

Figure 59: Suitability of the SDP sites as an acceleration site for the protected asset seabirds and resting birds (BSH 2024). Shown in light blue = lower, dark blue = higher suitability; outlines in orange = SDP sites.

6.2.3. Examination of the existence of relevant characteristics for the exercise of discretion

The results presented in Chapter 6.6.2 for the protected assets under consideration form the basis for examining the existence of possible special ecological characteristics that could constitute an atypical case that would preclude the designation as an acceleration site. The examination of whether a site could be excluded from the designation as an acceleration site is carried out on a case-by-case basis using verbal arguments. Sites that are not suitable as acceleration sites should be pre-analysed centrally.

For Sites N-14.1, N-14.2, N-14.3, and N-16.6, the analyses presented above did not identify any ecological characteristics for any of the protected assets under consideration that would prevent designation as an acceleration site. There are also no clear indications from the specialist literature of special occurrences of species, species groups, or biotope structures in these sites that could sufficiently justify an atypical case. In any case, Sites N-14.1, N-14.2, N-14.3, and N-16.6 can therefore be designated as acceleration areas provided that the preventive and mitigation measures described in Chapter 7 and listed in Appendix 5.2 to the current SDP relating to the specially protected species within the meaning of Section 7 BNatSchG (B, D through L, and R) are arranged and implemented in the respective procedure.

Neither effects on the conservation objectives within the meaning of Section 7, para. 1, No. 9 BNatSchG nor on the specially protected species according to Section 7, para. 2, No. 13 BNatSchG are expected for the sites examined. This fulfils the requirements for the designation of acceleration sites.

The analyses revealed a marginal occurrence of potentially special features for the protected assets marine mammals and/or seabirds and resting birds in Sites N-9.4, N-12.4, N-16.2, and N-16.3. However, none of the sites represents a main area of distribution for the species tested. There are therefore no particular occurrences of specially protected species in these sites nor are there any significant large-scale occurrences of particularly sensitive biotopes. Taking into consideration the arrangement and implementation of the preventive and mitigation measures described in Chapter 7 and listed in Annex 5.2 to the current SDP with regard to the particularly protected species (B, D through L, and R) within the meaning of Section 7 BNatSchG, there are therefore no sufficient reasons to refrain from designating Sites N-9.4, N-12.4, N-16.2 and N-16.3 as acceleration sites.

This is different for Sites N-9.5, N-16.1, N-16.4, and N-16.5 These areas do not fall under Section 5c, para. 2b, sentence 7 Nos. 1-7, and should therefore be designated as acceleration sites. However, the aforementioned results as a whole give cause for closer scrutiny in the context of the exercise of discretion. The BSH is convinced that in these sites there are atypical cases that initially justify a deviation from the target provision of the legislator.

In Site N-9.5, the protected asset seabirds and resting birds in particular have higher densities of specially protected species according to Section 7, para. 2, No. 13 BNatSchG. It is therefore necessary to collect further data and carry out site-specific environmental impact assessment for this site. It is therefore proposed to refrain from designating Site N-9.5 as an acceleration site as a precautionary measure. The area should be pre-investigated centrally.

In Site N-16.1, areas were identified both for the protected asset marine mammals and for the protected asset seabirds and resting birds that make the site less suitable overall for designation as an acceleration site. According to the data available, this is due to the increased density of harbour porpoises for the protected asset marine mammals. The actual functional importance of this area for the protected asset marine mammals cannot be finally assessed on the basis of the data available. Parts of Site N-16.1 were also found to be less suitable for the protected asset seabirds and resting birds. Data availability for this area is limited so that, taking into consideration recent scientific studies, a significant occurrence of protected seabird species in the site cannot currently be ruled out with the necessary certainty. The collection of further data as well as the implementation of an area-specific environmental impact assessment is therefore recommended for this site. It is therefore not advisable to designate Site N-16.1 as an acceleration site. The area should be pre-investigated centrally.

The assessment for Sites N-16.4 and N-16.5 leads to the same result. These two sites exhibit only selective special features for the protected assets marine mammals as well as seabirds and resting birds. However, with regard to the protected asset marine mammals, these are due to the sighting of mother-calf pairs of harbour porpoises. Mother-calf pairs are considered to be particularly sensitive to the effects of OWF construction and operation because harbour porpoises suckle their calves for up to a year, thus making the separation of mother-calf pairs particularly critical. To protect them, special preventive and mitigation measures may need to be defined for sites under preliminary investigation; these may include additional measures for the spatial and temporal coordination of construction work (cf Chapter 7). Data availability for these sites is limited for the protected asset seabirds and resting birds. Therefore, and based on recent scientific studies, an important occurrence of protected seabird species in the sites cannot currently be ruled out with the necessary certainty. The inclusion of site-specific data and the implementation of project-specific environmental impact assessments is therefore recommended. Sites N-16.4 and N-16.5 are therefore not suitable for designation as acceleration sites. The sites should be pre-investigated centrally.

Informational illustration

The following map serves to illustrate which designations are made in the SDP on the basis of the results presented. This purely informative representation shows which of the areas under consideration in the SDP are defined as acceleration sites [cf the definition in the SDP Chapter 2 Acceleration sites] or as sites to be pre-investigated [cf the designation in the SDP Chapter 5.1 Central preliminary site investigation].

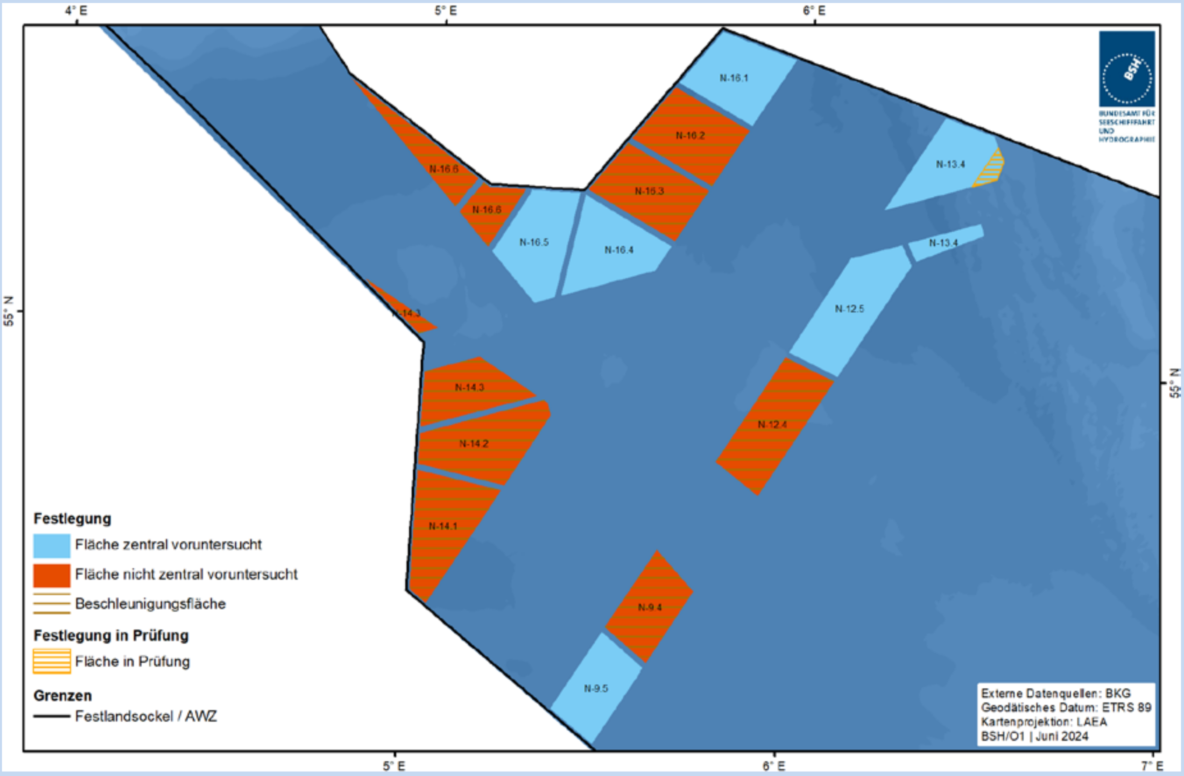

Figure 60: Acceleration sites and sites to be pre-examined shown for information.

6.3. Review of the species and area protection law assessments

For the acceleration sites to be defined as part of the current SDP, both a site protection assessment in accordance with Section 36, sentence 1, No. 2 in conjunction with Section 34, para. 1, No. 1 BNatSchG and a species protection assessment in accordance with Section 44, para. 1 BNatSchG must be carried out in accordance with the requirements of the WindSeeG because the corresponding tests at the project level are no longer required. The basic results of the technical assessments are presented in detail in Chapters 5.2 and 5.3. Taking into consideration the mitigation measures A to S described in Chapter 7 and listed in Appendix 5.2 to the current SDP, the statements made there also remain valid in the case of an site-specific assessment for Sites N-9.4, N-12.4, N-14.1, N-14.2, N-14.3, N-16.2, N-16.5, and N-16.6 considered as acceleration sites.

In particular, significant adverse effects according to Section 34, para. 2 BNatSchG on the protective purposes of the three nature conservation area in the German EEZ can be ruled out for all sites considered as potential acceleration sites because all sites have a minimum distance of more than 8 km to the protected areas according to the regulations in Section 5, para. 2b, sentence 7, No. 5 Draft WindSeeG. Consideration of preventive and mitigation measures A through S described in Chapter 7 and listed in Appendix 5.2. to the current SDP, no significant effects are to be expected (cf explanations in Chapter 5.3).

The realisation of prohibited offences under species protection law can be ruled out with the necessary certainty for all relevant species groups according to the explanations in Chapter 5.2.1, taking into consideration the mitigation measures for acceleration sites (B, D to L and R) listed in Annex 5.2. to the current SDP in all potentially eligible acceleration sites. Taking into consideration the supplementary analyses (Chapter 6.2), significant disturbance of the harbour porpoise within the meaning of Section 44, para. 1, No. 2 BNatSchG can also be ruled out with the necessary certainty by applying the noise protection and noise mitigation measures mentioned in the SDP, the spatial and temporal coordination of noise-intensive work and the regularly specified arrangements in the approval notices (cf Chapter 5.2.2). In this respect, the assessment can be fully maintained.

7. Measures envisaged to prevent, reduce and offset any significant adverse effects of the site development plan on the environment

7.1. Introduction

In accordance with Section 40, para. 2, sentence 1, No. 6 UVPG, the environmental report includes a description of the planned measures to prevent, mitigate and, as far as possible, compensate for significant adverse environmental impacts resulting from implementation of the plan. Environmental protection concerns are comprehensively taken into consideration in the planning of the SDP. The designations of the SDP will prevent negative effects on the development of the environmental status of the EEZ of the North Sea as far as possible. This takes into consideration the fact that the need to expand offshore wind energy and the corresponding grid connection cables exists in any case and that the corresponding infrastructure (wind farms, platforms, and subsea cables) must be created in any case in order to achieve the expansion targets set by law (cf Chapter 3). However, in the event of non-implementation of the plan, the uses would develop without the space-saving and resource-conserving steering and coordination effect of the SDP.

Moreover, the designations of the SDP are subject to a continuous optimisation process because the knowledge obtained from the SEA, the consultation process, and other procedures is taken into consideration in the development of the plan.

The measures listed below serve to prevent and mitigate potential significant negative effects in the specific implementation of the SDP. If necessary, these plans are to be substantiated and made binding in the subsequent planning and approval procedures.

7.2. Areas and sites for offshore wind turbines and platforms

In the specific planning and construction of wind turbines, the following measures to mitigate and prevent potentially significant negative environmental impacts must be taken into consideration for all sites and areas defined in the SDP, including the defined acceleration sites and platforms (converter, collection, transformer, and accommodation platforms). The measures defined in the SDP also apply to acceleration sites and are already mandatory at the SDP level.

- When installing foundations, suitable measures shall be taken to ensure that the noise emission (sound pressure SEL_{05}) at a distance of 750 m does not exceed 160 decibels (dB re 1 µPa²s) and the peak sound pressure level does not exceed 190 decibels (dB re 1 µPa) (Planning principle 7.1.4).
- Selection of the construction method producing the lowest noise level according to the state of the art and the existing conditions
- The use of alternative foundation methods (if they are not yet state of the art) must be provided for at least a certain number of piles (i.e. test piles)

- Compliance with driving times, including deterrence measures, of no more than 180 minutes for the installation of monopiles and no more than 140 minutes per pile for jacket structures (Planning principle 7.1.4)
- Monitoring measures during the construction phase, in particular by recording the underwater noise level during the installation of foundations. Monitoring of noise level and compliance with limits must be carried out by an accredited institution. The suitability of the measuring system must be verified by accreditation according to DIN EN ISO/IEC 17025 with regard to ISO18406:2017 and DIN SPEC 45653:2017 (Planning principle 7.1.4)
- Use of the best available state-of-the-art method (e.g. large bubble curtain, hydro silencer, or cladding tube) to mitigate the input of underwater noise to comply with applicable noise protection values during the installation of foundation piles. The noise protection measures must be specified in detail in the project approval procedure for specific locations and installations (Planning principle 7.1.4).
- Adaptation of the pile driving process to the site and project-specific conditions by controlling the pile driving energy and impact frequency (Planning principle 7.1.4)
- The use of appropriate methods to avoid killing and injury of animals in the vicinity of the pile driving site (Planning principle 7.1.4):
    - Use of suitable deterrents such as the FaunaGuard system or APD (Acoustic Porpoise Deterrent)
        - The functionality of the configurable deterrence system is ensured by monitoring measures.
    - “Soft-start procedure”: By increasing the pile driving energy with a time delay, animals in the vicinity of the pile driving site should be enabled to move away from the construction site.
- Monitoring of the presence of harbour porpoises in the construction site area
- General avoidance of blasting. If, during planning or construction of installations, any until now undiscovered unexploded ordnance is found on or in the seabed, corresponding protective measures must be taken. If blasting is unavoidable for the removal of ammunition that cannot be transported, a noise protection concept must be submitted to the BSH in good time beforehand in order to avoid the killing and injury of animals
- Spatial and temporal coordination of pile driving work for various projects to avoid cumulative effects (compliance with the noise protection concept (BMU 2013) (Planning principle 7.1.4):
    - Assurance that no more than 10% of the EEZ or 10% of nature conservation areas are exposed to disturbance-inducing noise (140 dB) at any time
    - Assurance that during the sensitive period (May–August) less than 1% of Area I of the Sylter Außenriff nature conservation area, less than 1% of the main concentration area and less than 1% of the Doggerbank FFH area are affected by noise that causes disturbance.
    - Spatial and temporal quotas are arranged by the approval agency in the individual project approval procedure.

- Planning and realisation of the system design by the project sponsor that is as low-noise as possible according to the state of the art (Planning principle 7.1.4).
- Submission of a concept for verifying the efficiency of the deterrence and noise mitigating measures,
- Preparation of a noise forecast taking into consideration the site and installation-specific characteristics (basic design) before the start of construction in order to be able to assess the effectiveness of the planned measures
- Reduction of maritime traffic for erection and operation of wind turbines, and the associated acoustic and visual adverse effects, to a minimum by optimal construction and time planning (Planning principle 7.1.2)
- Submission and application of a transport logistics concept for projects for which the vessel-related service traffic crosses the main concentration area of divers, Sub-area 2, or the future Sub-area III of the “Sylter Außenriff and Östliche Deutsche Bucht” nature conservation areas (Planning principle 7.1.7)
- Assurance that no avoidable emissions occur during the construction or operation of the installation according to the state of the art and implementation of emission reduction measures. In particular: operating materials that are as environmentally compatible as possible, precautionary and safety measures to prevent material leaks, non-polluting and low-emission corrosion protection, closed cooling systems, and waste disposal on land. (Planning principle 7.1.3)
- Preparation of emission studies and concepts for waste and operating materials (Planning principle 7.1.3)
- Lighting that is as compatible as possible with nature during operation of the installations in order to reduce attraction as far as possible, taking into consideration the requirements of safe shipping and air traffic and occupational safety (e.g. switching obstruction light on and off as required, selection of suitable lighting intensities and spectra or lighting intervals) (Planning principle 7.1.3)
- possible arrangement of measures based on the results of bird collision monitoring for wind energy sites (Planning principle 7.1.6) (e.g. arrangement of shut-downs and, as a basis for this, designation of site-specific shut-down conditions)
- Avoidance of turbine locations in sensitive legally protected biotopes as far as possible provided this is proportionate and technically feasible.
- Restriction on the introduction of hard substrate to the minimum required for technical realisation (Planning principle 7.1.5)
- Use of only natural hard substrates (natural stones or inert and natural materials) for scour protection (Planning principle 7.1.5)
- Consideration of cultural and material assets, taking into consideration the choice of location and route (Planning principle 7.7)

For non-accelerated sites, the aforementioned measures can be further specified or supplemented as part of the downstream review levels. These can include the following measures:

- Simultaneous operation of only one active pile driving site on sites of high seasonal importance for harbour porpoises between May and August

- Use of low-noise foundation methods provided they are state of the art in sites of high seasonal importance for harbour porpoises
- In the case of simultaneous construction on sites of high seasonal importance and directly adjacent areas, the number of construction sites during the porpoise-sensitive period must be limited to one construction site within the sensitive area and a maximum of two more on the neighbouring areas (three pile driving sites in total) (site of high seasonal importance and each neighbouring site).
- Outside the period of harbour porpoise sensitivity, a maximum of five to eight pile driving sites are to be active simultaneously throughout the EEZ

The right to order further measures for non-accelerated sites is expressly reserved within the framework of the downstream review levels.

7.3. Subsea cables including interarray cabling

The following measures to mitigate and prevent potentially significant negative environmental impacts must be considered when planning and laying subsea cables and interarray cabling.

- Selection of the shortest possible route and laying as far as possible outside nature conservation areas and known occurrences of protected biotope structures (Planning principle 7.1.1)
- Optimisation of route selection within the framework of fine routing in order to prevent and not effect known occurrences of particularly sensitive biotopes as far as possible according to Section 30 BNatSchG (Planning principle 7.1.1)
- bundled laying (Planning principle 7.1.3)
- For installation of the cable systems, use of a cable laying procedure that protects the seabed as much as possible depending on sediment conditions and water depths and taking into consideration the required minimum coverage (Planning principle 7.1.7)
- Monitoring of the covering over during the operating phase of the cables (Planning principle 7.1.7)
- The reduction of the potential adverse effects on the marine environment resulting from sediment warming as far as possible by complying with the 2 K criterion, taking into consideration current legal requirements (Planning principle 7.1.7)
- Use of cable types that generate the lowest possible electric and magnetic fields (Planning principle 7.1.3)
- Use of materials that are as environmentally compatible as possible and reduction of crossing constructions to the technically necessary minimum (Planning principle 7.1.5)
- General avoidance of blasting. If, during planning or construction of installations, any until now undiscovered unexploded ordnance is found on or in the seabed, corresponding protective measures must be taken. If blasting is unavoidable for the removal of ammunition that cannot be transported, a noise protection concept must be submitted to the BSH in good time beforehand in order to avoid the killing and injury of animals.

8. Evaluation of the overall plan

In summary, with regard to the planned areas and sites, platform sites, and submarine cable routes as well as the designation of the area for other forms of energy generation SEN-1, the effects on the marine environment will be minimised as far as possible by means of orderly, coordinated overall planning of the SDP. By adhering strictly to preventive and mitigation measures, in particular for noise mitigation during the construction phase, significant effects can be prevented by implementing the planned sites, areas, and platforms.

No areas or sites were designated in nature conservation areas. The requirements of Section 5, para. 3n No. 5 WindSeeG are thus fulfilled. According to Section 5, para. 3, No. 5 WindSeeG, a designation is inadmissible if the area, the site, or area for other energy generation is not compatible with the protective purpose of a protected area ordinance issued according to Section 57 BNatSchG.

By applying appropriate preventive and mitigation measures (Chapter 7), the effects of construction and operational activities can be further minimised and designed to be as environmentally friendly as possible.

Based on the description and assessment, it must be concluded for the SEA, also with regard to any interactions, that, according to the current state of knowledge, no significant effects on the marine environment within the area of investigation are to be expected as a result of the planned designations. The potential impacts are frequently small-scale and short-term because they are limited to the construction phase.

9. Examination of reasonable alternatives

In accordance with Art. 5, para. 1, sentence 1 SEA Directive in conjunction with the criteria in Appendix I SEA Directive and Section 40, para. 2, No. 8 UVPG, the environmental report contains a brief description of the reasons for the choice of the reasonable alternatives examined. For an assessment of reasonable alternatives (Section 40, para. 1, sentence 2 UVPG), different types of alternatives can be considered for an examination of reasonable alternatives – in particular strategic, spatial or technical alternatives. Reasonable means that not all conceivable alternatives but rather realistic, realisable alternatives that can be identified and implemented with reasonable effort must be examined This means that only those alternatives that will lead to the achievement of the planning objective can be considered. The legal requirement is to achieve a capacity of 70 GW in the German EEZ by 2045.

The obligation to investigate thus extends to all alternatives that "are not obviously […] remote" (Wulfhorst 2011). The examination of reasonable alternatives does not explicitly require particularly environmentally-friendly alternatives to be developed and examined. Instead, the "reasonable" alternatives in the above sense should be presented in a comparative manner with regard to their environmental impacts so that consideration of environmental concerns becomes transparent when deciding on the alternative to be pursued (Balla et al., 2009).

At the same time, the effort required to identify and assess the alternatives under consideration must be reasonable. The following applies: The greater the expected environmental impacts and thus the need for conflict management in planning, the more likely it is that extensive or detailed investigations will be required.

In addition to the zero alternative, this environmental report will examine spatial and technical alternatives in particular. Alternatives already analysed in the previous SDP procedures that do not require updating or deepening will not be repeated.

In principle, it should be noted that preliminary assessment of possible and conceivable alternatives is already inherent in all designations of the SDP in the form of standardised technical and planning principles. As can be seen from the reasoning of the individual planning principles, the respective principle is already based on a consideration of possible affected public concerns and legal positions so that a "preliminary assessment" of possible alternatives has already taken place. There are already many different uses and legally protected concerns in the EEZ. An overall assessment of the uses and functions in the EEZ has already been carried out as part of the preparation and revision of the maritime spatial plan. The objectives and principles of ROP 2021 are to be largely adopted in the SDP and will be reviewed and weighed up with regard to the specific subjects of regulation of the concerns and rights presented in this procedure.

The zero alternative (i.e. not implementing the SDP) is not a reasonable alternative because the development of offshore wind energy is indispensable for achieving the national climate protection goals according to the current state of technology and scientific knowledge in order to avert drastic negative effects of climate change – also for the state of the marine environment. The importance of achieving the expansion targets is now explicitly stated in Section 1, para. 3 WindSeeG. Accordingly, the construction of offshore wind turbines and offshore connection cables is in the overriding public interest and serves public safety (cf also Chapter 3).

The purpose and aim of introducing a sectoral plan with not only spatial but also temporal designations and standardised technology and planning principles is the precautionary control of the development of offshore wind energy necessary for climate protection. This is intended to ensure at the planning level that the legally designated expansion targets for wind energy can be achieved through a spatially ordered and land-saving development (Section 4, para. 2, No. 2 WindSeeG) and that environmental concerns are also examined at the planning level.

A strategic alternative (e.g. with regard to the targets of the federal government on which the planning is based) is not currently being considered for the SDP because the expansion targets of the federal government represent the planning horizon for the SDP. The expansion targets result from the legal provision in Section 1, para. 2, sentence 1 WindSeeG. These are classified as imperative for climate protection; they are in the overriding public interest and serve public safety. Furthermore, they are also an essential basis for the demand planning of the onshore grid expansion. Because a coordinated approach to onshore and offshore grid and capacity expansion to mitigate vacancies or curtailments appears to make sense, choosing an alternative expansion strategy in this context is out of the question.

Spatial alternatives are rare in view of the underlying territorial context of ROP 2021 and against the backdrop of the considerably increased expansion targets. In accordance with Section 1, para. 2 WindSeeG, the aim of the WindSeeG is to increase the installed capacity of offshore wind turbines connected to the grid to at least 30 GW by 2030, to at least 40 GW by 2035, and to at least 70 GW by 2045.

In detail:

a) Temporal designations for Sites N-13.3 and N-13.4

Sites N-13.3 from SDP 2023 and N-13.4 from the current draft SDP are defined only spatially. There are no designations for grid connection systems for the sites concerned as well as no designation of years or quarters for tendering and commissioning. The reason for dispensing with the temporal designations is that other sites, particularly in Areas N-14 and N-16, appear more suitable from a nature conservation perspective than Sites N-13.3 and N-13.4. Sites N-13.3 and N-13.4 border on the main concentration area of divers, overlap in large parts with the main distribution area of the harbour porpoise, and have protected biotope structures. For this reason, the deferral of the sites appears to be preferable to the alternative of a time frame that follows the principle of intersection-optimised expansion based on the distance from the coast.

b) Positioning of the converter sites

The preliminary draft SDP included a consultation question on the positioning of the NOR-14-1, NOR-9-4, and NOR-9-5 converter sites. In addition, the question of the general positioning of converter platforms in the centre of the site, which had already been consulted on as part of the update process for SDP 2023, was taken up again with regard to new findings. Based on the results of the consultation, the locations of the converter platforms will generally be determined centrally in the site. Only in exceptional cases such as NOR-9-4 and NOR-9-5 (comparatively high power density and designation of a connection between the converter platforms) or if the site to be connected consists of several sub-sites, are the converter platforms designated at the edge of the site.

The main reason for the central positioning in the area is the routing of the park's internal cables to the converter platform. Particularly in the case of large sites, the length of the required cables necessitates power factor correction, which may require an additional platform. Also, with increasing length of the in-farm cables, the losses would increase and cables with larger diameters might be necessary.

A nature conservation assessment of the two alternatives of positioning on the edge or in the centre of the area, as requested in the consultation on the preliminary draft, is difficult because of the lack of knowledge about the specific OWF layout within the individual sites. However, according to initial estimates, the central positioning of the converter platforms can be expected to reduce the overall cable lengths and thus minimise the overall encroachment into the marine environment.

c) Number of sites in Area N-16

For Area N-16, IWES carried out extensive modelling in various expansion scenarios as part of the scientific report commissioned by the BSH to accompany the SDP update process (Vollmer & Döhrenkämper 2024). As alternatives, the designation of six sites as opposed to five sites in Area N-16 was examined (cf Chapter III.1 SDP). The designation of six sites in Area N-16 also appears to be preferable from a nature conservation perspective because the planning is more economical in terms of space overall.

10. Measures envisaged for monitoring environmental impacts

According to Section 40, para. 2, sentence 1, No. 9 UVPG, the environmental report also contains a description of the planned monitoring measures according to Section 45 UVPG. Monitoring is necessary, in particular to identify unforeseen significant effects at an early stage and to be able to take appropriate remedial measures. The monitoring measures must be defined on the basis of the information in the environmental report. Monitoring is the responsibility of the BSH because this is the authority responsible for the SEA (see Section 45, para. 2 UVPG). In this context, as intended by Article 10, para. 2 SEA Directive and Section 45, para. 5 UVPG, existing monitoring mechanisms can be used to avoid duplication of monitoring work. In accordance with Section 45, para. 4 UVPG, the results of the monitoring activities are to be taken into consideration in the revision of the site development plan.

With regard to the planned monitoring measures, it should be noted that the actual monitoring of the potential impacts on the marine environment can begin only when the SDP is implemented (i.e. when the designations made within the framework of the plan are implemented. The project-related monitoring of the effects of the uses regulated in the plan is therefore particularly important.

At this point, reference is made to the obligation laid down according to Section 77, para. 4, No. 1 WindSeeG for the persons responsible according to Section 78 WindSeeG (in particular, the addressees of the planning approval resolution or the planning permission, operators of the OWF) to carry out monitoring of the construction- and operation-related impacts of the installations on the marine environment during the construction phase and during the 10 years of operation of the installations and to transmit the data obtained to the BSH and the BfN without delay. Furthermore, please refer to the planned revision and corresponding adaptation of StUK4.

The main function of plan monitoring is to bring together and evaluate the results of different phases of monitoring at the level of individual projects or clusters of projects developed in a spatial and temporal context. The assessment will also cover the unforeseen significant effects of the implementation of the plan, the marine environment and the review of the forecasts in the environmental report. In this context, the BSH will request the monitoring results required to carry out the monitoring measures available from the competent authorities in accordance with Section 45, para. 3 UVPG.

Results from existing national and international monitoring programmes must also be taken into account, also with a view to preventing duplication of work. This includes data from the national monitoring of the North Sea, data from monitoring measures as part of the implementation of the MSFD, and data and findings from federal and state research projects as well as data and information from assessments within the framework of international bodies and conventions such as OSPAR, ASCOBANS, AEWA, and BirdLife International.

The monitoring of the conservation status of certain species and habitats required according to Article 11 of the Habitats Directive must also be included, as must the investigations to be carried out in the course of the management plans for the “Sylter Außenriff – Östliche Deutsche Bucht”, “Borkum Riffgrund”, and “Doggerbank” nature conservation areas.

Reference is also made to monitoring instruments as presented in the environmental reports on ROP 2021 and SDP 2020 (MARLIN, MarinEARS).

For reasons of practicability and the appropriate implementation of requirements from the Strategic Environmental Assessment, the BSH will pursue an ecosystem-oriented approach as far as possible when carrying out the monitoring of the potential effects of the plan; this focuses on the interdisciplinary consolidation of marine environmental information. To be able to assess the causes of planned changes in parts or individual elements of an ecosystem, the anthropogenic variables from spatial observation (e.g. technical information on maritime traffic from AIS data resources) must also be considered and included in the assessment.

New since SDP 2023 and adapted in the current SDP is the requirement to provide bird collision monitoring as a matter of principle (cf Planning Principle 7.1.6). The installation of state-of-the-art collision detection systems at several representative installations is envisaged.

11. Non-technical summary

11.1. Subject and occasion

In the context of the amendment and revision of the SDP initiated on 1 September 2023, areas and sites as well as acceleration sites are designated for the implementation of the statutory expansion targets for offshore wind energy that go beyond SDP 2023 and were therefore not included in the SEA carried out in previous preparation, update, and revision procedures of the SDP.

The revision of the SDP essentially builds on the designations of the maritime spatial planning for offshore wind energy and subsea cables and pipelines and further develops these in terms of technical planning based on SDP 2023.

Against this background, the SEA for the revision of the SDP will also be based on the results of the SEA carried out in the maritime spatial planning revision procedure. According to Section 5, para. 3, sentences 5–7 WindSeeG, it must be determined at which stage certain environmental assessments are to be focussed in order to avoid multiple assessments in multi-stage planning and approval procedures. The environmental assessment shall be limited to additional or other significant impacts on the environment as well as to necessary updates and elaborations.

The same applies with regard to previous, more recent results from environmental assessments to the SDP as part of centralised preliminary site investigations or the previous SDP.

The situation is somewhat different for acceleration sites because there is generally no multi-stage planning and approval procedure. Accordingly, the environmental assessment for the SDP addresses all relevant environmental impacts.

The SEA for the revision of the SDP is also based on the environmental reports for the preparation and revision of the SDP from 2019, 2020, and 2023 and, where they provide relevant and more up-to-date or in-depth results, on the SEAs for central site investigations of sites. Insofar as new knowledge on existing designations is available and relevant, this will also be taken into consideration.

In the following, the scope of the examination with regard to the designation of areas, sites, platforms, and subsea cables is therefore limited to additional or other significant environmental impacts as well as necessary updates and in-depth analyses.

The appendix to the SDP contains the draft of the infrastructure area plan. In this infrastructure area plan, the BSH designates routes, route corridors, and converter sites for offshore connection cables in the EEZ as infrastructure areas. For these designations, the likely effects on the environment were determined, described, and assessed in this Strategic Environmental Assessment.

The main document of the SEA is the present Environmental Report. It identifies, describes, and assesses the likely significant effects that the implementation of the SDP will have on the environment and possible alternative planning options, taking into consideration the essential purposes of the plan. The update and revision of the SDP and the implementation of the SEA will be carried out taking into consideration the environmental conservation objectives.

11.2. Methodology of the Strategic Environmental Assessment

The methodology is based primarily on the designations of the plan to be examined. Within the framework of this SEA, it is determined, described, and evaluated for each of the designations whether the designations have likely significant impacts on the protected assets concerned. According to Section 1, para. 4 UVPG in conjunction with Section 40, para. 3 UVPG, in the environmental report, the competent authority provisionally assesses the environmental impacts of the designations with regard to effective environmental precaution according to the applicable laws. According to the special legal benchmark of Section 5, para. 3, sentence 1 and 2 WindSeeG, the designations may not pose a threat to the marine environment, among other things. In addition, the provisions of Section 5, para. 3, sentence 1, No. 5 WindSeeG (protected areas) and Section 72, para. 2 WindSeeG (marine biotopes) must be observed in particular.

The methodology of the SEA is explained in detail in the scope. Reference is made at this point to the designated scope of 5 June 2024.

Data sources

With regard to the data and knowledge bases for the SEA, reference is made to Chapter 5 of the scope for dated 5 June 2024.

11.3. Result of the assessment of the individual protected assets

Site

The increased expansion targets, which envisage achieving at least 30 GW by 2030, at least 45 GW by 2035, and at least 70 GW by 2045, lead to the expansion of the designated sites and areas in this SDP. Because of the limited availability of space in the German EEZ of the North Sea, it is imperative that expansion is minimised. The model wind farm parameters listed in the scope are used to calculate the use of marine space resulting from sealing. Sites are sealed by the foundation structures of wind turbines and platforms, by crossing constructions, and by scour protection measures. In addition, the encroachment into the seabed caused by the laying of in-farm cabling, grid connections, and interconnectors is taken into consideration when determining use of marine space. The results are based on the existing and planning data for Areas N-1 to N-8 and for all other areas on model parameters of the investigation framework and show a total land consumption of 2,857 ha (Scenario 1) to 3,037 ha (Scenario 2). This corresponds to 0.1–0.106% of the area of the EEZ of the North Sea. The results, taking into consideration the existing and planning data, show only a slightly higher use of marine space of 2906 ha for Scenario 1 to 3115 ha for Scenario 2. This corresponds to 0.102–0.109% of the area of the EEZ of the North Sea. In relation to the respective SDP areas, this results in use of marine space of between 0.2% and 0.4%. This applies to both the model calculations and the inventory data Because the use of marine space in relation to both the individual SDP areas and the EEZ remains well below 1%, no significant adverse effect on the protected asset space can be assumed.

Seabed

The sediment-specific descriptions of the areas, sites, and submarine cable route corridors defined in the SDP are based on various sediment mappings, which have been interpolated from grab samples taken at specific points as well as on the basis of area-wide hydroacoustic surveys.

The sediment type fine sand dominates in almost all areas and sites (N-4, N-9.4/9.5, N-12.4/12.5, N-14, N-16, N-17, N-19, N-20) and along the submarine cable corridors. it also contains strongly varying fine grain fractions of < 5 to > 50%. Large admixtures of silt and clay can be found in Sites N-16.1 and N-16.5, among others. Areas N-4 and N-19, which also contain coarse sediment areas, have very low fine grain contents. These occur on a small scale within Area N-19; in Area N-4, they are more extensive and represented by stone deposits. Large-scale coarse sediment and stone/block deposits are particularly characteristic of Areas N-5 and Site N-13.4. This is due to superficial moraine clay ridges and leads to the high importance of these areas for the protected asset seabed.

During the foundation of wind turbines and the laying of submarine cables, the surface sediments are directly disturbed by displacement, compaction, and vibrations. These effects are usually short-term and small-scale, and, in the case of trench formation during cable laying, also medium-term. The escaping resuspension that occurs and which can change the sediment structure and morphology as well as the sedimentation regime can also have a medium-scale effect in sediments with a high fine-grain content. In general, potential structural and functional changes because of construction-related impacts in the predominantly sandy areas of the areas and sites identified in the draft SDP are assessed as low.

As a result of installation and operation, the seabed is permanently sealed locally by the introduction of the foundation elements of deep-founded wind turbines/platforms and the installation of scour protection as well as by cable crossing structures. This is seen as a small-scale, long-term impact of high intensity. For most sediments in the areas defined in the draft SDP, this loss of area is small compared with the large areas of sandy sediments in the German North Sea. The loss of heterogeneous coarse sediments – rare in the German EEZ – within Area N-5 and Site N-13.4 would have a greater weighting in comparison. The structural and functional change for the comparatively more valuable coarse sediments, which are also less represented in terms of area, is to be categorised as higher. Impact-avoiding and impact-mitigating measures such as bypassing these rare sediment types can counteract severe adverse effects on the protected asset seabed in these areas.
The interaction between the foundation and hydrodynamics can lead to a permanent resuspension and redistribution of sediments in the immediate vicinity of the installations because of a change in the flow regime. The associated changes in sediment composition are usually minor but can be more pronounced in sandy sediments with a high proportion of fine grains (e.g. Site N-16.1). The expected structural and functional changes because of scouring and sediment shift are therefore categorised as low and in some cases medium in the context of this SEA.

Extensive bans on use and navigation will have a long-term and medium-term impact on the sediments within the safety zones of the OWFs and platforms. In the medium to long term, the surface structure, lost biogenic structures, and thus also the habitat function of the seabed will return to an undisturbed, near-natural state. These positive structural and functional changes will occur to varying degrees within the areas and sites defined in the draft SDP depending on the previous fishing intensity.

Pollutants

With regard to the status description and status assessment of the protected asset seabed, a general decrease in the concentration of pollutants from the coast to the open sea can be observed because river inputs are considered to be one of the main sources. The sediment is particularly contaminated with the metals lead and mercury as well as organotin compounds.

The effects of material emissions from offshore installations in the seabed are also assessed as long-term, small-scale and of low intensity, assuming implementation of the state of the art and compliance with the minimisation requirement (cf Chapter 7) according to the current state of knowledge. According to the current state of knowledge, there are no significant effects on the protected asset seabed in terms of nutrients and pollutants. In addition, the effects of material emissions from offshore installations on the marine environment are the subject of current research.

Water

Effects on the water body may occur during the construction phase of the wind turbines and the subsea cables as a result of the resuspension of sediment, pollutant discharges, and the formation of turbidity plumes. An increase in turbidity in the course of scouring around the foundations cannot be ruled out for operational reasons. However, these effects on the protected asset water are not significant because they occur only on a small scale or only in the short term.

Nutrients and pollutants

With regard to the status description and status assessment of the protected asset water, a general decrease in the concentration of nutrients and pollutants in seawater from the coast to the open sea can be observed because river inputs are regarded as one of the main sources of these inputs. Almost the entire North Sea can be categorised as eutrophic because of an excess of nutrients. Organotin compounds, polycyclic aromatic hydrocarbons, and perfluorooctane sulfonic acid are particularly harmful to seawater near the coast.

The effects of material emissions from offshore installations in the water are also assessed as long-term, small-scale and of low intensity, assuming implementation of the state of the art and compliance with the minimisation requirement (cf Chapter 7) according to the current state of knowledge. According to the current state of knowledge, there are no significant effects on the protected asset water in terms of nutrients and pollutants. In addition, the effects of material emissions from offshore installations on the marine environment are the subject of current research.

Plankton

Phyto- and zooplankton species will be increasingly affected in by possible effects of climate change, in particular by changes in temperature, salinity, and currents. The construction of wind turbines and converter platforms and the laying of subsea cables can have small-scale and short-term effects on phytoplankton and zooplankton because of the formation of sediment turbidity plumes. Possible relevant installation- and operation-related impacts on plankton can be caused by turbulence, turbidity, and shadow flicker. Because of the high natural dynamics of the hydrographic conditions in the EEZ, significant effects from wind turbines, platforms, and subsea cables on phytoplankton and zooplankton can be ruled out with sufficient certainty based on the current state of knowledge. Even in normal operation, effects on the plankton can be ruled out with the necessary certainty.

Biotope types

Based on the biotope map created by the BfN as part of various mapping projects (working status February 2024), it was possible for the first time to create a reliable examination and assessment of the individual areas and sites for the protected asset biotope types. The summary of the results is found in Table 17.

Possible effects of converter platforms and submarine cables on biotopes may result from a direct claim on these biotopes, their covering over by sedimentation of material released as a result of construction, or from potential habitat changes.

Because of the predominant sediment composition, adverse effects caused by covering over are likely to be small-scale and temporary because the released sediment will settle quickly. Permanent habitat changes are limited to the immediate area of foundations and crossing constructions for cable crossings. Required cable crossings are secured with rockfill; this permanently represents a non-native hard substrate. This provides new habitats for benthic organisms that love hard substrates and can lead to a change in the species composition. These small-scale habitat changes are not expected to have any significant effects on the protected asset biotope types. In addition, the risk of a negative influence on the benthic soft-bottom community by species untypical of the area is low because the species are recruited mainly from the natural hard substrate habitats.

Permanent habitat changes are limited to the immediate vicinity of foundations and rockfill, which are required in the case of cable laying on the seabed and cable crossings. rockfill permanently represents non-native hard substrate. These small-scale areas are not expected to have any significant effects on the protected asset biotope types. In addition, the risk of a negative influence on the benthic soft-bottom community by species untypical of the area is low because it is highly likely that the species will be recruited from natural hard substrate habitats.

Benthos

For the description of benthic invertebrates and the importance of the individual sites and areas, the joint dataset of the BSH and BfN, the modelled distribution of benthic biocoenoses updated as part of the biotope mapping, and modelled distribution maps of individual endangered species provided a significantly improved data situation compared with previous environmental reports. The summary of the results is found in Table 17.

Deep foundations of wind turbines and platforms cause disturbances of the seabed, sediment turbulence and the formation of turbidity plumes. The resuspension of sediment and the subsequent sedimentation can lead to an adverse effect or damage of the benthos in the immediate vicinity of the foundations for the duration of construction activities. However, because of the prevailing sediment composition, these adverse effects will have only a small-scale effect and are limited in time. As a rule, the concentration of the suspended material decreases quickly upon removal. Depending on the respective turbines, changes in species composition may occur as a result of the local sealing of the sea floor and the introduction of hard substrate in the immediate vicinity of the structures.

The laying of the subsea cables is also expected to cause only small-scale and short-term disturbances of the benthos by sediment turbulence and turbidity plumes in the area of the cable route. Possible effects on the benthos depend on the cable laying procedure used. With the laying using the jetting method, only minor disturbances of the benthos in the area of the cable route are to be expected. Local sediment relocations and turbidity plumes are to be expected during the laying of the subsea cables. Because of the predominant sediment composition in the EEZ of the North Sea, most of the sediment released will settle directly at the construction site or in its immediate vicinity.

Benthic habitats are directly overbuilt in the area of necessary rockfill for cable crossings. The resulting habitat loss is permanent but small-scale. The result is a non-native hard substrate that can cause changes in the species composition on a small scale.

Because of operational conditions, a warming of the uppermost sediment layer of the seabed can occur directly above the cable system. If the cable is laid at sufficient burial depth and taking into consideration that the effects will occur on a small scale, no significant effects on benthic biocoenoses are expected According to the current state of knowledge. With the planning principle for sediment warming, the SDP stipulates that the 2 K criterion must be met. According to the assessment of the BfN, this precautionary value ensures with sufficient probability, based on current knowledge, that significant negative effects of cable warming on the marine environment are avoided.

As things stand at present, the planned converter platforms and submarine cable routes are not expected to have any significant effects on the protected asset benthos if the 2 K criterion is met. The ecological effects are small-scale and mostly short-term.

Table 17: Result of the assessment of the importance of the areas and sites for the protected assets biotope types and benthos (explanations below the table)

Site/area	Occurrence Section 30 BNatSchG Biotopes	Meaning Biotope types	Meaning Benthos
N-4	KGS possible locally	low to medium	low to medium

N-5	1110, 1170, KGS	medium to high	medium to high
N-9.4	–	low to medium	medium (to high)
N-9.5	–	low to medium	medium (to high)
N-12.4	–	low to medium	Medium
N-12.5	–	medium to high	medium to high
N-13.4	1170, KGS	High	medium to high
N-14.1	–	low to medium	low to medium
N-14.2	–	low to medium	low to medium
N-14.3	–	low to medium	low to medium
N-16.1	–	medium to high	medium to high
N-16.2	–	low to medium	Medium (locally possibly medium to high)
N-16.3	–	low to medium	Medium
N-16.4	–	low to medium	Medium
N-16.5	–	low to medium	low to medium
N-16.6	–	low to medium	low to medium
N-17	–	low to medium (medium – northern sub-site)	low to medium (medium to high – northern sub-site)
N-19	1110, potential KGS	High	medium to high
N-20	–	low to medium	low to medium

Abbreviations of biotopes legally protected according to Section 30 BNatSchG: 1110 = sublittoral sandbanks, 1170 = reefs, KGS = species-rich gravel, coarse sand and shell layers

Fish

The fish fauna in area of the EEZ of the North Sea has a typical species composition. In all areas, the demersal fish community is dominated by flatfish.

According to current state of knowledge, the priority areas for wind energy do not represent a preferred habitat for any of the protected fish species. As a result, the sites in the planning area are not of any particular ecological importance for the fish populations in the German EEZ of the North Sea. During the construction phase of the foundations, the converter platforms and the laying of the subsea cables, the fish fauna may be temporarily subjected to adverse effects in small areas by sediment turbulence and the formation of turbidity plumes. The turbidity in the water is expected to decrease again quickly because of the prevailing sediment conditions and current conditions. Furthermore, during the construction phase, noise and vibrations may temporarily scare away fish. Noise emissions during the construction phase must be reduced by appropriate measures. The effects of EMFs on fish have been investigated only to a limited extent so far, but no clear negative effects can be seen at this stage. Additional local effects on the fish fauna can be assumed from the additional hard substrates introduced as a result of a change of the habitat. The fish community will lose a part of its habitat as a result of the installation of the wind farm. On the other hand, the fish can benefit from the structures introduced because they provide protection and food. The fish community can also benefit from possible restrictions on fishery as a result of navigation regulations.

The effects on the fish fauna from the construction of the wind farms, converter platforms, and subsea cables are limited in space and partly in time. According to the current state of knowledge, independent of the wind farm scenario, the planned construction of wind farms and the associated converter platforms and subsea cables systems is not expected to have a significant adverse effect on the protected asset fish.

Marine mammals

According to the current state of knowledge, it can be assumed that the German EEZ is used by harbour porpoises for traversing and inhabitation and as a foraging- and area-specific breeding area. Based on the knowledge available, it can be concluded that the EEZ is of medium to high importance for harbour porpoises in certain areas. Use varies in the areas/sub-areas/sites of the EEZ. This also applies to harbour seals and grey seals. According to the current state of knowledge, Areas N-4 and the northern sub-area N-13 are of medium importance for harbour porpoises (and of high importance in summer) and are part of the main concentration area identified for harbour porpoises in the German North Sea. This assessment applies also to the extended Area N-12. The extended sites are directly adjacent to the sites already described and have comparable water depths, seabed characteristics, and hydrographic properties. It can therefore be assumed that these are also of medium to high seasonal importance for the harbour porpoise in summer. For harbour seals and grey seals, Area N-4 is of medium importance.

The sites of Area N-5 are located in a large area which is used both as a feeding and breeding area for harbour porpoises – even though the main concentration area is located within Area I of the "Sylter Außenriff – Östliche Deutsche Bucht" nature conservation area. In general, it can be assumed that Area N-5 is particularly important for harbour porpoises. For harbour seals and grey seals, Area N-5 is of medium importance.

Area N-14 is regularly used by harbour porpoises for crossing, inhabitation, and foraging. Overall, the use is low compared with other areas of the EEZ. The area can be assigned medium importance for harbour porpoises. For seals, Area N-14 is of little importance.

The sites of Areas N-16 and N-17 are located in the transition zone between the German Bight and the Doggerbank. They are used intensively in parts but, in any case, regularly for crossing, inhabitation, and foraging. The areas are of medium importance for harbour porpoises; in some parts, they are of high importance in the spring and summer months; for seals, they are of low importance.

The sites of Area N-19 are regularly used by harbour porpoises for crossing and inhabitation, and the directly adjacent “Doggerbank” FFH area is used as a foraging ground and breeding area. It can be assumed that the edge of the area is also used as a breeding area. According to the current state of knowledge, the environment in which the sites of Area N-19 are located is of medium importance for harbour porpoises and of high importance in spring and summer; for seals, it is of low importance.

Threats to marine mammals can be caused by noise emissions during pile driving of the foundations of offshore wind turbines and converter platforms. Without the use of noise protection measures, significant adverse effects on marine mammals during pile driving could not be excluded. In the specific approval procedure, therefore, the driving of piles of offshore wind turbines and converter platforms will only be permitted if effective noise mitigation measures are used. For this purpose, the SDP will designate the principle of noise mitigation in the text.

This states that the installation of the foundations must be carried out using effective noise mitigation measures to comply with applicable noise protection values. In the specific approval procedure, extensive noise mitigation measures and monitoring measures are ordered to comply with applicable noise protection values (sound exposure level (SEL) of 160 dB re 1μPa²s and maximum peak level of 190 dB re 1μPa at a distance of 750 m around the pile driving or placement 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 reduction of underwater noise show that the effects by sound input on marine mammals can be considerably reduced by the application of appropriate measures. The noise protection concept of the BMU has also been in force since 2013. In accordance with the noise protection concept, pile driving activities must be coordinated in such a way that sufficiently large areas, especially within the protected areas and the main distribution area of the harbour porpoise in the summer months, are kept free of effects caused by impact noise (see following section “Cumulative effects”). According to the current state of knowledge, significant effects on marine mammals caused by the operation of offshore wind turbines and converter platforms can be excluded.

After implementation of the mitigation measures to be ordered (for centrally pre-investigated sites) as part of the determination of suitability or (for all sites) in the approval procedure to comply with applicable noise protection values in accordance with the planning principle, the construction and operation of the planned offshore wind turbines and converter platforms is currently not expected to have any significant negative effects on marine mammals. No significant effects on marine mammals are expected from the laying and operation of subsea cables.

Seabirds and resting birds

The individual areas for offshore wind energy in the EEZ of the North Sea are of varying importance for seabirds and resting birds (hereinafter referred to as seabirds). For breeding birds, the areas have no particular importance because of the distance from the coast and the islands with breeding colonies as a foraging ground. Protected bird species listed in Appendix I of the

Europpean Birds Directive are found in the vicinity of the areas in varying densities. Area N-4 (Zone 1) is only of medium importance for most species of seabirds and resting birds; however, divers (red-throated and black-throated divers) occur in high densities in the north-west of the area in spring. Because of its location within the main concentration area of divers, Area N-4 is of high importance. Area N-5 (Zone 1 + 2) has a high occurrence of seabird species, in particular protected species of Appendix I of the Birds Directive (e.g. disturbance-sensitive divers). It is located in the main concentration area for divers in the German North Sea and is therefore highly important for this species group (BMU 2009). Overall, Area N-5 is of medium to temporarily high importance for seabirds. For all other areas (N-6 to N-20), a medium to temporarily high importance for seabirds was determined based on the species occurring there and their spatial distribution as well as occurrence depending on the time of year (seasonality). The data basis available can be assessed as excellent for Areas N-1 through N-6 and as sufficient for Areas N-7 through N-20.

Laying, installation, and operation-related impacts of the planned subsea cables on seabirds and resting birds can be excluded with the necessary certainty. A possible risk of collision from construction vehicles can be classified as very low because of the short-term nature of the construction phase. Direct disruptions during the construction phase of offshore wind farms and platforms because of deterrent effects are to be expected at most locally and temporarily. Because of the high mobility of birds, significant effects can be ruled out with a high degree of certainty. Offshore wind turbines will have a permanent disturbance and scaring effect on species sensitive to disturbance such as divers (red-throated and black-throated divers) and guillemots. Current knowledge shows a more pronounced avoidance behaviour of divers and guillemots towards existing offshore wind farms than was originally assumed. Some species are attracted to offshore wind farms. There are no findings to date on habituation effects in avoidance and attraction.

Current findings and information from monitoring and research on the avoidance behaviour of some seabird species, in particular the common guillemot (Garthe et al. 2022, Peschko et al. 2024), have all been incorporated into the present considerations. Overall, knowledge on the avoidance behaviour of the guillemot is heterogeneous. At the present time, there are no sufficiently concrete findings that the designations of the SDP will have a significant adverse effect on guillemots in particular and on the protected asset seabirds and resting birds in general.

In view of the avoidance distances of several kilometres identified to date for many seabird and resting bird species, the resulting potential cumulative habitat impairment of 26% and more because of the designations of sites for offshore wind energy (Chapter 4.17.4), the drastic reductions in various populations and the negative population trends of some species (cf Chapters 2.9.1 and 5.2.2.2), which, in accordance with the literature, are presumably due to various factors, and the as yet unpredictable changes caused by offshore wind energy in the North Sea ecosystem, which can or will affect seabirds and resting birds via various pathways (cf WATSON et al. 2024), this assessment must be viewed taking into consideration the current state of knowledge. The assessment will be adapted to the current state of knowledge. New findings are taken into consideration both at the site investigation and approval levels as part of the tiering required according to Section 5, para. 3, sentences 5–7 WindSeeG and Section 39, para. 3, sentences 1–3 UVPG as well as in the context of updating and/or amendment procedures of the SDP according to Section 8, para. 2 in conjunction with Section 5 WindSeeG.

Migratory birds

The EEZ of the North Sea lies on the migration route of numerous bird species and is of major importance for bird migration overall. It is hereby assumed that considerable proportions of the songbirds breeding in northern Europe will migrate across the North Sea. No specific migration corridors can be identified for any migratory bird species in the area of the EEZ of the North Sea because bird migration is either guideline-oriented and takes place close to the coast or in an unspecified broad-front migration across the North Sea. There is evidence that migration intensity decreases with distance from the coast. However, this has not been conclusively clarified for the group of songbirds that migrate at night because strong bird migration can also be recorded in isolated cases far from the coast. However, the BSH does not have any data on migratory bird activity in the outer EEZ (Areas N-14 through N-20). Older studies on bird migration at oil platforms can provide clues but allow only limited conclusions to be drawn about the migratory activity of these areas and sites.

In general, migrating birds can be observed over the German Bight all year round with the strongest migration activity taking place in spring and autumn. The migratory activity is subject to a pronounced daily rhythm. In addition, weather factors influence at what altitude and at what speed the animals migrate. As a rule, birds wait for favourable weather conditions. This means that most birds often migrate across the North Sea in just a few days or nights. Radar surveys show that most bird migration takes place at altitudes of up to 300 m, which is within the height range of wind turbines.

Possible effects could be that the wind turbines in the area will represent a barrier and/or a collision risk. In the clear weather conditions preferred by birds for their migration, the probability of collision with wind turbines or a platform is low. Poor weather conditions such as fog or rain increase the risk. In these poor weather conditions, which can influence the orientation of migrating birds, the lighting of wind turbines often has an attracting effect on birds migrating at night. This could cause the attracted individuals to fly into the installations.

In order to counteract the attraction effects and the associated risk of collision, the site development plan stipulates in the planning principle of minimising emissions that light emissions are to be avoided or reduced where they are unavoidable. Based on the current state of knowledge, it is therefore unlikely that there will be a significant adverse effect on bird migration.

It should be taken into consideration that there is a certain degree of uncertainty, both at the level of the individual areas and in a cumulative analysis, particularly for the most frequently recorded group of songbirds, which migrate primarily at night. The uncertainty is due mainly to the fact that there is currently no systematically recorded scientific knowledge regarding species-specific migration behaviour in poor weather conditions, evasive behaviour, and its subsequent effects as well as real losses caused by collisions in offshore wind farms.

In order to address the remaining forecast uncertainty, the planning principle of bird collision monitoring in the site development plan provides for monitoring to measure bird collisions. Then for the monitoring of bird collisions with wind turbines, state-of-the-art collision detection systems shall be installed at several representative installations in offshore wind farms within all sites designated in the Site Development Plan. Collision detection will be further specified in the approval procedure for individual wind farm projects. If, contrary to the current impact assessment, the risk of collision is found to be significantly increased, the planning approval authority can order measures to prevent or mitigate this risk.

Bats and bat migration

Basically, relatively little is known about the migration patterns of bats because of their nocturnal lifestyle and the lack of suitable methods or large-scale special monitoring programmes. Previous studies have shown that bats, especially long-distance migratory species, can be found along the coastline and on the North Sea islands. On the other hand, records of bats over the open North Sea are low, and the current results suggest that the number of individuals decreases with increasing distance from the coast. Investigations also show that the main migration activity of bats in the North Sea area is in spring (mid-April to mid-June) and late summer (mid-August to late September). Migration is largely (approx. 90%) dominated by just one species, Nathusius' pipistrelle

A potential danger for bats arises from flying close to wind turbines when hunting insects that are attracted by the safety lighting. Also exploratory behaviour has been demonstrated on offshore structures. This increases the collision risk or risk of being injured by rotating rotor blades. However, there are no concrete indications of collisions or other causes of death caused by offshore wind turbines; this is probably also because it is difficult to identify actual fatalities at sea. In view of the limited information on bat migration over the German EEZ, collisions or other injuries to individuals caused by turbines cannot be completely ruled out.

Based on current knowledge, it can be assumed that there will be no higher concentration of bats during the migration periods because of the distance of the planning areas from the coast. It is therefore unlikely that the construction and operation of wind farm projects in the planning areas will have a significant adverse effect on bat migration over the EEZ of the North Sea.

Biological diversity

Biological diversity comprises the diversity of habitats and biocoenoses, the diversity of species, and the genetic diversity within species (Article 2 Convention on Biological Diversity, 1992). Biodiversity is in the public eye.

With regard to the current state of biodiversity in the North Sea, it should be noted that there is countless evidence of changes in biodiversity and species assemblages at all systematic and trophic levels in the North Sea. These are mainly because of human activities (e.g. fishery and marine pollution) or climate change. Red lists of vulnerable animal and plant species have an important monitoring and warning function in this context because they show the status of the populations of species and biotopes in a region. In the environmental report, possible effects on biodiversity are dealt with under the individual protected assets. In summary, according to the current state of knowledge, the planned development of offshore wind energy and the corresponding grid connections is not expected to have any significant effects on biological diversity.

Air

Because of the great distance from conurbations and the low levels of air pollution in Schleswig-Holstein and Lower Saxony, it can be assumed that the air pollutant concentrations of benzene, carbon monoxide, nitrogen dioxide, and sulphur dioxide (GAA-HI 2021; LLUR 2022) are far below the guideline and threshold values of current assessment standards.

Since 1 January 2015, shipping in the North Sea has been subject to stricter provisions as an emission control area. In accordance with Annex VI, Regulation 14 of the MARPOL convention, vessels may use heavy fuel oil only with a maximum sulphur content of 0.10%. To reduce emissions of nitrogen oxides, the IMO decided in 2017 to declare the North Sea a “Nitrogen Emission Control Area” (NECA) from 2021.

Because of the location of the project area away from the emitters, the overall existing pressure of the protected asset air is assessed as low. The protected asset air is not affected by any project-related impact factor because no measurable effects on air quality are to be expected either during construction or operation. Because of the open location of the areas defined in the SDP, this area is characterised by good mixing conditions. As a result, no preventive and mitigation measures are planned for the protected asset because the effects of the plan do not require any.

Climate

The entire German North Sea – and thus also the project area – is located in the temperate climate zone (BSH 2020b). Because of the large-scale pressure distribution, with an Icelandic low and Azores High, the North Sea lies in the westerly wind zone. Uniformly strong winds from the west-southwest characterise the cold half of the year from October to March. In April and May, no preferred wind direction can be specified. In the course of spring, the influence of the Azores High prevails with characteristic west-north-west winds from June (LOEWE 2009).

The North Sea is important for the maritime climate of the neighbouring land areas. Summers are only moderately warm, but winters remain mild because of the North Sea acts as a heat reservoir in winter. The importance as a climate function is assessed as medium.

The protected asset climate is not affected by any project-related impact factor because no measurable climate-relevant emissions occur either during construction or operation. As a result, the project is not expected to have any significant adverse effects on the protected asset climate in the project area.

No effects on the climate are expected from the construction and operation of wind turbines, a platform, and in-farm cabling because no measurable climate-relevant emissions occur during either construction or operation.

On the contrary, the CO_2 savings associated with the expansion of offshore wind energy can be expected to have positive effects on the climate in the long term. This means that the development of the protected asset climate is independent of the non-implementation or implementation of a construction project on the sites in Zones 3, 4, and 5.

As a result, no preventive and mitigation measures are planned for the protected asset because the effects of the plan do not require any.

Seascape

The SEA has shown that, compared with the statements in the North Sea Environmental Report for the ROP 2021, no necessary updates or elaborations of the protected asset seascape are evident when taking into consideration the compensation services according to the BKompV. This applies accordingly to the assessment of environmental impacts on the protected asset. Here, too, reference is made to the North Sea Environmental Report on ROP 2021. Overall, no significant effects on the protected asset seascape can be assumed.

Cultural heritage and other material assets

Only the database on underwater obstacles of the BSH was available as a current database for describing the status of the protected asset. No new findings of cultural-historical importance were available for the SEA. Based on the evidence of human settlement in the North Sea region in the late Holocene, archaeological monuments or other cultural artefacts cannot be ruled out. Sediment shifts during construction activities for the construction of wind turbines or the laying of submarine cables could result in chance finds. Underwater obstacles such as wrecks, containers, ammunition, or other objects cannot be ruled out. Compared with the statements in the North Sea Environmental Report for the 2021 ROP, no necessary updates are apparent. No significant effects on the protected asset are assumed. At the level of the approval procedure, an archaeological expert report must be submitted after UXO investigations have been carried out at the planned wind farm.

Protected asset humans, including human health

No special importance for human health and well-being can be derived for Zones 3–5. Overall, the planning area has a low relevance for the protected asset population & human health.

As a result, no preventive and mitigation measures are planned for the protected asset because the effects of the plan do not require any.

11.4. Interactions/cumulative effects

The operation of wind turbines and platforms can result in material emissions that can have effects on the protected asset water and sediment as well as the associated other environmental compartments. In principle, the expansion of offshore wind energy represents a further point source for (harmful) substances. The cumulative effect of other existing pollutants (or stressors) can intensify the effects. Particular mention should be made of the technically necessary corrosion protection, which can release metals over the course of the operating life. Current research shows that there are currently no recognisable direct environmental impacts from the use of galvanic anodes (sacrificial anodes). On the other hand, this is a long-term release of metals over the service life. Based on current knowledge, it can therefore not be ruled out that accumulations may occur in water, sediment, and/or other environmental compartments. Other material inputs during the regular operation of platforms (e.g. sewage water and cooling water) as well as general accidental spills of operating materials can also occur and have equivalent effects on the marine environment.

Even if no final assessment is currently possible as part of the cumulative analysis and there is still a need for further research, the use of mitigation measures and emission-reducing technologies is necessary against the background of the increasing expansion of offshore wind energy.

Seabed/space, benthos, and biotope types

Construction-related environmental impacts on seabed, benthos, and biotopes (e.g. formation of turbidity plumes, sediment shift and disturbance) resulting from the implementation of the plans and projects in the areas and sites as well as the platform sites and subsea cables are predominantly temporary and take place in a spatially limited area. Because of the gradual realisation of the construction projects, significant cumulative construction-related environmental impacts can also be ruled out according to the current state of knowledge.

Possible significant cumulative effects on the seabed, which could have a direct effect on the protected assets benthos and biotope types, therefore result primarily from the permanent direct use of marine space of the foundations and scour protection systems of the installations and, in part, from the laid cable systems (crossing constructions).

Based on a conservative estimate, a maximum of 2205 ha of area will be claimed for the areas and sites for wind energy use or temporarily adversely affected in the case of in-farm cabling.

For the subsea cables, this results in a mostly temporary loss of function over an area of maximum 874 ha. Outside the sensitive biotopes, a permanent loss of area and function as a result of the cable systems results exclusively from the crossing constructions that become necessary. Based on an area of approx. 900 m² per crossing structure, the direct use of marine space for approx. 390 crossing constructions amounts to approx. 36 ha. In total, therefore, up to 3115 ha of seabed will be claimed or, in the case of the submarine cable, temporarily adversely affected; this corresponds to a share of approx. 0.11% of the total EEZ area.

In addition to the direct use of the seabed and thus of the habitat of the organisms that have settled there, the installation foundations, scour protection, and crossing constructions lead to an additional supply of hard substrate. As a result, hard substrate-loving species untypical of the site (aufwuchs and mobile predators) can colonise and directly or indirectly influence the natural soft substrate community. In addition, artificial substrates can lead to an altered distribution of invasive species, among others. These indirect effects can lead to cumulative effects resulting from the construction of several offshore structures or rockfill in crossing areas of subsea cables and pipelines. However, reliable findings on effects beyond the sites of the wind farms or on the altered connectivity of invasive species are not yet available.

Because the (mainly temporary) use of marine space is below 0.1% of the EEZ area even in the cumulative consideration of the grid infrastructure and the wind farm sites, according to current knowledge, no significant adverse effects that lead to a threat to the marine environment with regard to the seabed and the benthos are to be expected – even in the cumulation of indirect effects.

Fish

A considerable part of the environmental impacts of the areas and sites, platforms, and subsea cables on the protected asset fish will occur during the construction phase and in a spatially limited area, in particular through underwater noise, sedimentation, and turbidity plumes. Because of the gradual realisation of the construction projects, there will be sufficient opportunity for escape, and there is unlikely to be a cumulative effect such as a barrier effect. Significant cumulative construction-related environmental impacts can therefore be ruled out with the necessary certainty.

Electromagnetic fields can have an operational effect. This creates magnetic fields along the cables that can influence the behaviour of certain species. A cumulative effect caused by the magnetic fields generated along the cables is not to be assumed because a barrier effect is also unlikely here, and any avoidance behaviour of individual species is to be expected only in the immediate vicinity of the cables. Possible effects of the accumulation of local effects could therefore result primarily from the permanent direct use of marine space, the artificially introduced hard substrate, and navigation bans. Even when considered cumulatively, the use of marine space is low, and significant adverse effects on the fish community are therefore not to be expected. Furthermore, the supply of artificially introduced hard substrate and the sites free for use will increase; according to the current state of knowledge, this can lead to mostly positive effects.

Based on the current state of knowledge, no cumulative negative impact on the protected asset fish can be assumed. Overall, there is a need for research into cumulative positive effects on the fish fauna.

Marine mammals

Cumulative effects on marine mammals, in particular harbour porpoises, may occur mainly as a result of noise exposure during pile driving of the foundations. For example, these protected assets could be significantly adversely affected by the fact that, if pile driving takes place simultaneously at different locations within the EEZ, there may not be sufficient space to evade and retreat.

The current SDP provides for an expanded development of offshore wind energy. The current SDP shows that the simultaneous construction of several offshore wind farms is to be expected, especially in the years 2031 to 2037. Within the framework of the strategic environmental assessment, it is therefore necessary to screen possible cumulative effects caused by the construction of the wind farms with regard to compliance with species protection and site protection requirements of the noise protection concept (BMU, 2013).

On the basis of the noise protection concept and some basic assumptions (Chapter 4.18), various development scenarios with cumulative effects on noise pollution are therefore presented in this environmental report on the current SDP. In accordance with the noise protection concept, an area share of 10% of the German EEZ is used as a threshold value for the maximum area exposed to sound. In contrast, in the different scenarios, the sounded area is calculated by an increasing number of simultaneous construction sites. For each construction site, a disturbance radius of 8 km is assumed. Theoretically, 12 simultaneous construction sites with pile driving are possible when considering Scenario 3 of the cumulative effects (Chapter 4.18); this results in a total area of up to 2,413 km² (1,559 km² if the disturbance radii overlap). This corresponds to an area proportion of 8.5% (5.5% with overlapping of the disturbance radii of individual construction sites) of the habitat that is affected by disturbance-triggering pile driving noise. However, in order to establish a buffer for further impulse noise sources (other than those caused by pile driving) as well as temporal overlaps of different construction projects as a result of construction delays or bad weather phases, a designation of a maximum of five to eight parallel construction sites is sought (For details, see Chapter 4.18). This means that the maximum area affected by sound inputs based on the noise protection concept will be considerably undercut, and a cumulative negative effect is not to be expected provided that the corresponding measures are complied with.

Seabirds and resting birds

In order to estimate the possible impact on habitats resulting from the implementation of the 70 GW expansion target by 2045, a calculation is made on the basis of the area outline of the draft SDP up to Zone 5 in the overall view with existing wind farm projects and those currently being realised. The different avoidance reactions of seabirds and resting birds observed so far in the operational monitoring of offshore wind farms are represented by avoidance radii of different sizes (2, 4, and 6 km) around the defined areas for the purpose of scientific approximation. Their area is calculated, totalled, and presented as a percentage of the respective total area of the German EEZ of the North Sea, the “Östliche Deutsche Bucht” Special Protection Area (SPA), and the main concentration area for divers (BMU 2009).

The site designated for offshore wind energy for the current 70G W expansion scenario by 2045 is currently around 26% of the German EEZ of the North Sea. Depending on the actual avoidance distance, between around 35% (2 km avoidance radius) and 51% (6 km avoidance radius) of the German EEZ of the North Sea could be adversely affected by the deterrent effects of offshore wind energy. In the “Östliche Deutsche Bucht” SPA, between 5% (2 km radius) and 19% (6 km avoidance radius) of the site is potentially affected by offshore wind energy in and around the SPA. The proportion will be reduced by the currently planned subsequent use scenarios.

With regard to the assessment and evaluation of the effects of cumulative habitat change, there are currently knowledge gaps in various nature conservation aspects. The expansion of offshore wind energy should be accompanied by continuous monitoring and in-depth analyses.

Based on the current state of knowledge of the avoidance behaviour of various species of seabirds and resting birds and the current threat to their populations because of avian flu, environmental pollution and climate and ecosystem changes, it does not appear impossible at the present time that, even taking into consideration the ongoing actual development situation, significant effects on seabirds and resting birds within the meaning of Section 3 UVPG may result from the construction and operation of the planned offshore wind farms under cumulative consideration of the authorised offshore wind farm projects at the population level. The prognostic uncertainties must be investigated further.

Migratory birds

Many bird species migrate across the North Sea on their way to the breeding and wintering areas with considerable populations, whereby they will also encounter wind farms. The potential threat to bird migration results not only from the effects of the individual projects but also cumulatively in conjunction with other planned, authorised, or already constructed wind farm projects in the EEZ of the North Sea.

With a development as envisaged in the site development plan and an assumed main migratory direction of north-east to south-west, migrating birds would encounter a larger total area of wind energy use. In addition, the areas in the German EEZ would be adjacent to wind farm areas in the Dutch and Danish EEZs.

Possible effects could be that the wind turbines in the area will represent a barrier and/or a collision risk. The potential danger for migratory birds increases with every additional wind farm located in the direction of migration. During the day and in the clear weather conditions preferred by the birds for their migration, the probability of collision with wind turbines or a platform appears to be rather low. Migration in the dark and/or in poor weather conditions generally harbours a higher risk of collision across all species.

Some species avoid wind farms by flying horizontally or vertically around them. Large, contiguous wind farm areas such as those planned in the German and neighbouring EEZ make horizontal avoidance increasingly difficult. Although long-range avoidance is generally part of the species-specific behavioural repertoire of some species, fly-over or fly-through is more likely. Especially for the group of songbirds most frequently recorded over the North Sea, which primarily migrate at night, long-term investigations on the FINO 1 platform suggest that songbirds fly through the wind farms.

Flying through the OWFs could result in an increased number of collisions. However, based on current knowledge, a causality between migration rates and collision rates in the offshore area cannot be assumed to be generally valid. The migration rates can therefore not be used to estimate collision-related mortality. Low migration rates also do not automatically mean a lower collision risk. Whether a potentially increased flying through of the wind farms would be associated with an increased collision rate remains uncertain because of the current insufficient data situation regarding the correlation between migration intensity, weather conditions, and collision rates.

Taking into account the existing findings on the migratory behaviour of the various bird species and the current findings on the collision risk of birds with OWT, it cannot be assumed that the construction and operation of the planned offshore wind farms is likely to pose a significant threat to bird migration with cumulative assessment of the already approved offshore wind farm projects

The large-scale fly-around that some bird species show in response to individual wind farms could cumulatively lead to an extension of the migration route for migrating birds. When considering the main migratory directions north-east to south-west for autumn migration and south-west to north-east for spring migration, Areas N-6 to N-13 in particular form a larger overall area in the direction of migration. Larger barrier effects could therefore occur cumulatively with the sites in the Netherlands and Denmark.

The occurrence of barrier effects could result in avoidance manoeuvres of 50–100 km. An additional migration distance of 50–100 km seems small in view of the non-stop flight performance of several thousands of kilometres some species. Nevertheless, there is always an increased demand for energy because of the fly-around of wind farms. In the absence of compensation (e.g. by resting on the migration route), increased energy consumption could have an impact on reproductive success and, in the worst case, on survival. However, the migration naturally does not take place on a straight line. Changes and course corrections are made by migrating birds several times along the migration route. In addition, the length of the migration route is subject to a certain variation, which is influenced by natural factors such as wind drift. A fly-around of the projects therefore does not currently indicate any significant negative effect on the further development of migratory bird populations.

It should be taken into consideration that there is a certain degree of uncertainty, both at the level of the individual wind farm sites and in a cumulative analysis, particularly for the most frequently recorded group of songbirds, which migrate primarily at night. The uncertainty is due mainly to the fact that there is currently no systematically recorded scientific knowledge regarding species-specific migration behaviour in poor weather conditions (headwinds and crosswinds, rain, fog), evasive behaviour, and its subsequent effects as well as real losses caused by collisions in offshore wind farms. In order to address the remaining forecast uncertainty at the level of the sites as well as in a cumulative view, the planning principle of bird collision monitoring in the site development plan provides for monitoring to measure bird collisions.

11.5. Transboundary effects

The SEA concludes that, as things stand at present, the designations of the SDP do not have significant effects on the areas of neighbouring countries bordering the German EEZ of the North Sea.

Significant transboundary effects can generally be ruled out for the following protected assets: seabed, water, plankton, benthos, biotope types, seascape, cultural heritage and other material assets and the protected asset human beings and human health. There are no potential significant transboundary effects for the highly mobile protected assets, marine mammals, seabirds and resting birds, and migratory birds even if all planned wind farm projects in the German North Sea are considered cumulatively because preventive and mitigation measures and monitoring are ordered as part of downstream approval procedures. With regard to the protected asset fish, the SEA comes to the conclusion that, according to the current state of knowledge, no significant transboundary impacts on the protected asset are to be expected as a result of the implementation of the SDP because, on one hand, the areas for which the SDP makes designations do not have a prominent function for the fish fauna. On the other hand, the recognisable and predictable effects are of a small-scale and temporary nature. According to the current state of knowledge and taking into consideration preventive and mitigation measures, significant transboundary effects can also be excluded for the protected asset marine mammals. For example, the installation of the foundations of wind turbines and converter platforms is only permitted in the specific approval procedure if effective noise mitigation measures are implemented.

During the operating phase of wind farms, species of seabirds and resting birds sensitive to disturbance can be expected to avoid wind farm sites to a species-specific extent. In the case of offshore wind farms close to the border, this can have an impact beyond the border of the German EEZ. Possible significant transboundary effects may result from this for the highly mobile protected asset seabirds and resting birds if all planned wind farm projects in the North Sea are considered comprehensively. Based on the findings on the avoidance behaviour of various species of seabirds and resting birds towards offshore wind energy, according to the current state of knowledge, it must be assumed that wind farm projects in Area N-5 will have scaring effects on the Danish Special Protection Area “Sydlige Nordsø” to the extent identified because the two areas are directly adjacent to each other. In the case of the Dutch “Friese Front” SPA, scaring effects can be ruled out because of the distance of around 27 km to the nearest German site for offshore wind energy (N-9.5). All other European special protection areas are located at an even greater distance from areas and sites for wind energy in the German EEZ. Scaring effects into these areas can therefore be ruled out. In general, it can be assumed that scaring effects beyond the boundaries of the German EEZ can be observed in the border area with neighbouring EEZs.

There are gaps in scientific knowledge regarding the cumulative effects of all wind energy projects in the entire North Sea as well as their effects at the population level of the species. An international exchange and a joint evaluation are therefore recommended.

For migratory birds, constructed wind turbines in particular can represent a barrier or a collision risk. With a development as envisaged in the site development plan and an assumed main migratory direction of north-east to south-west, migrating birds would encounter a larger total area of wind energy use. In addition to the aforementioned areas in the German EEZ, further areas in the Dutch and Danish EEZ are likely to be added. From these, larger barrier effects could emanate in cumulation with the offshore wind farms in the German EEZ. If possible barrier effects occur, and the birds fly around the wind farms, this could result in an additional migration route of over 100 km. However, most migratory birds can usually compensate for this additional effort by resting for longer periods. At this stage, a fly-around of the wind farm projects is not expected to have any significant negative effect on the further development of the migratory bird populations.

Even if long-distance evasion is fundamentally part of the species-specific behavioural repertoire of some species, fly-through is becoming more likely, especially for the group of songbirds that is most frequently recorded over the North Sea and primarily migrates at night. Flying through the OWFs could result in an increased number of collisions. The risk of being caught by the rotor blades appears to exist mainly in unfavourable weather conditions (fog, rain, headwind), when the installation lighting has a certain attracting effect on the disoriented migratory birds. Whether an increased flight through the wind farms would be associated with an increased collision rate therefore remains uncertain because of the current insufficient data availability.

Taking into account the existing findings on the migratory behaviour of the various bird species and the current findings on the collision risk of birds with OWT, it cannot be assumed that the construction and operation of the planned offshore wind farms is likely to pose a significant threat to the migratory bird population with cumulative assessment of the already approved offshore wind farm projects

In order to address the remaining forecast uncertainty at the level of the individual sites as well as in a cumulative view, the planning principle of bird collision monitoring in the site development plan provides for monitoring to measure bird collisions. In order to be able to holistically assess the cumulative effects on bird migration, it is necessary to take a cross-border view that includes all offshore wind farms in the North Sea to be considered. An international approach and a joint evaluation are therefore recommended.

The SEA concludes that, as things stand at present, the designations of the SDP do not have any significant effects on the marine environment of the areas of neighbouring countries bordering the German EEZ of the North Sea.

11.6. Assessment of biotope protection law

In accordance with Section 30, para. 2, sentence 1 BNatSchG, all actions that may cause destruction or other significant adverse effect on the biotopes listed in Section 30, para. 2, sentence 1 BNatSchG are generally prohibited. In accordance with Section 72, para. 2 WindSeeG, Section 30, para. 2, sentence 1 BNatSchG shall be applied to projects under the WindSeeG with the proviso that a significant adverse effect on biotopes within the meaning of Section 30, para. 2, sentence 1 BNatSchG shall be avoided as far as possible. The direct and permanent use of a biotope protected according to Section 30, para. 2 BNatSchG is generally considered to have a significant adverse effect if it has significant negative effects on the biotope in question. A central component of the assessment approach according to LAMBRECHT & TRAUTNER (2007) is orientation values for quantitative-absolute area losses of an affected biotope occurrence, which may not be exceeded depending on its total size (BFN 2012).

For the sites to be defined in SDP24, there are only concrete indications of the occurrence of legally protected biotopes (reefs, potential occurrence of species-rich gravel, coarse sand and shell layers) in Site N-13.4. This area is neither chronologically ranked nor designated as an acceleration site in the current SDP.

In the other areas to be assessed without specific sites being designated, (potentially) legally protected biotopes exist in Areas N-4 (potential occurrence of species-rich gravel, coarse sand and shell layers), N-5 (sandbank, reefs, and species-rich gravel, coarse sand and shell layers), and N-19 (sandbank, potential occurrence of species-rich gravel, coarse sand and shell layers) according to the current state of knowledge (Table 17). In the current planning phase, significant effects on legally protected biotopes do not seem impossible for these areas. Reference is made to the aforementioned obligations under the WindSeeG.

Concrete findings on the occurrence of the legally protected biotope “reefs” are available in the area of the routes of the subsea cables and interconnectors for the course of the connection systems coming from Gate N-V. On the first 10 km of from Gate N-V to the west, several smaller reef areas have been identified in ongoing investigations. Because of their spatial orientation, these are unlikely to be completely bypassed.

The two interconnectors planned in the direction of Denmark south-east of Shipping route SN10 (I-NOR-6 and I-NOR-7) cross at least a sub-site the reef band running there (cf Site N-13.4).

The small-scale occurrence of coarse sediments or marine boulder cannot be completely ruled out in the shallow areas of the corridors of all grid connection systems and interconnectors. In practice, these areas are bypassed in the course of route planning; significant adverse effects are thus generally avoided.

11.7. Species protection assessment

In Chapter 5.2 of the environmental report, the species protection assessment in accordance with Section 44, para. 1 BNatSchG concludes that, according to the current state of knowledge, compliance with the planning principles of the 2024 site development plan and the preventive and mitigation measures regularly specified by the BSH as part of the project approval procedure will prevent the fulfilment of the prohibited offences under species protection law with the necessary certainty.

With regard to marine mammals, Chapter 4.18 examined possible cumulative effects on the harbour porpoise with relevance to species protection in the context of the present SEA and against the background of the expected development by 2037 in the area of Zones 3 to 5. Based on three scenarios, it was determined that the implementation of the prohibitions according to Section 44, para. 1, No. 2 BNatSchG can be excluded by means of measures or additional arrangements in the subordinate approval procedures. The additional measures to avoid cumulative effects by accelerating the development until 2037 are presented in Chapter 6 or for the cumulative assessment in Chapter 4.18. In the subordinate approval procedures, the species protection assessment is examined more closely based on concrete construction and operation plans, and the measures to avoid the realisation of prohibited offences under species protection law according to Section 44, para. 1, Mo. 2 BNatSchG are specified.

11.8. Assessment under site protection law

The examination of the potential impacts of the plan with regard to the development of the areas/sub-areas/sites has shown that there will be no significant adverse effects associated with the construction of the installations and the laying and operation of subsea cables.

In the German EEZ of the North Sea, the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area is located directly adjacent to Area N-5 for subsequent use, the “Borkum Riffgrund” nature conservation area at a distance of 57.15 km from Site N-9.5, and “Doggerbank” nature conservation area in the immediate vicinity of Areas N-17 and N-19. The “Nationalpark Niedersächisches Wattenmeer” in the territorial sea is more than 50 km away.

A significant adverse effect on the “Borkum Riffgrund” nature conservation area can be ruled out because of the long distance of more than 50 km from the nearest Site N-9.5. Therefore, only a preliminary assessment (screening) was carried out here.

The following should be noted for the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area

For the nature conservation area “Sylt Outer Reef - eastern German bay”, the possibility of a significant adverse effect on the habitat types of fauna-flora-habitat must be excluded.

The shortest distance between Areas N-5 and an area of reef habitat type within the nature reserve is around 4 km. The distances between Area N-4 and the reef (7 km) and sandbank (6 km) habitat types are somewhat greater. This distances are outside the drift distances discussed in the literature. Thus, no release of turbidity, nutrients, and pollutants that could affect the nature conservation area in its components is to be expected. Because the other anticipated construction-, installation- and operation-related impacts relevant to the habitat types are also small-scale, significant adverse effects from the construction and operation of the wind farms on the “reef” and “sublittoral sandbank” habitat types in the nature conservation area can be ruled out.

The SDP does not specify any grid connection cables that cross the protected area outside the corridors already examined under site protection law in the environmental assessments for previous site development plans. Therefore, significant effects on the habitat types resulting from the laying of grid connection cables through the Sylter Außenriff – Östliche Deutsche Bucht nature conservation area can be ruled out with the necessary certainty.

A significant adverse effect on the “Sylter Außenriff – Östliche Deutsche Bucht” nature conservation area with regard to the harbour porpoises, grey seals, and harbour seals protected there can also be excluded with the necessary certainty taking into consideration the planning principles of the 2024 Site Development Plan for noise protection and **taking into consideration suitable measures as part of the implementation**. In particular, any effects from construction-related noise emissions can be efficiently prevented by specifying noise mitigation measures and subsequently coordinating them with the construction measures of other projects.

The impact assessment for the “Doggerbank” nature conservation area has the following results:

Areas N-17 and N-19 each border directly on the “Doggerbank” nature conservation area so that in the worst-case scenario, the distance between a wind turbine site and the “sandbank” habitat type within the protected area is only a few hundred metres. Because of the small-scale nature of the anticipated construction-, installation-, and operation-related impacts and the insensitivity of the biocoenosis of the habitat type sandbank to covering over, significant adverse effects on the habitat type “sublittoral sandbank” in the nature conservation area can be ruled out.

A significant adverse effect on the “Doggerbank” nature conservation area with regard to the harbour porpoises and harbour seals protected there can also be excluded with the necessary certainty taking into consideration the planning principles of the 2024 Site Development Plan for noise protection and **taking into consideration suitable measures as part of the implementation**. In particular, any effects from construction-related noise emissions can be efficiently prevented by specifying noise mitigation measures and subsequently coordinating them with the construction measures of other projects.

In this respect, the 2024 Site Development Plan sets out comprehensive requirements in Planning Principles 6.1.9 and 6.1.11 in conjunction with the BMU Noise Protection Concept (BMU 2013). These are binding for the approval procedure according to Section 6, para. 9, sentence 2 WindSeeG.

Derivation of the technical basis for the exercise of discretion in the designation of acceleration sites within the meaning of Section 5 WindSeeG-E

In accordance with Section 5, para. 2b, sentence 3 WindSeeG-E, a site should be designated as an acceleration site if no significant environmental impacts within the meaning of Section 5, para. 2b, sentence 4 WindSeeG-E are to be expected as a result of the construction and operation of offshore wind turbines. Because of the criteria set out in Section 5, para. 2b, sentence 7, No. 1–6 WindSeeG-E, Sites N-12.5 and N-13.4 are excluded from additional designation as acceleration sites: Site N-13.4 is partially located within the reservation area for harbour porpoises designated in ROP 2021 and is therefore to be classified as an area within the meaning of Section 5, para. 2b, sentence 7, No. 1 WindSeeG-E in conjunction with Section 5, para. 2b, sentence 8 WindSeeG-E. Site N-12.5 is partially located within a radius of less than 8 km around the aforementioned harbour porpoise reservation area and is therefore excluded as an acceleration site in accordance with Section 5, para. 2b, sentence 7, No. 5 WindSeeG-E.

According to Directive (EU) 2018/2001[5], Member States shall use all appropriate and proportionate instruments and data sets when designating acceleration sites. In this environmental report, the BSH has compiled all known and available data so that the descriptions form a sufficient basis for the designation of acceleration sites. Directive (EU) 2018/2001 also stipulates that the member states use sensitivity maps for the designation of acceleration sites. The sensitive areas in the German EEZ of the North Sea are already specified by law in Section 5, para. 2b, sentences 7 and 8 WindSeeG-E. At the same time, aspects of sensitivity mapping are applied in the environmental report in order to additionally examine whether there are indications of further special ecological features in the sites that are to be taken into consideration in the limited exercise of discretion provided for by the legislator (atypical case) and that prevent designation as an acceleration site. Sites that are not suitable as acceleration sites should be pre-analysed centrally.

In any case, Sites N-14.1, N-14.2, N-14.3, and N-16.6 can be designated as acceleration sites provided that the listed preventive and mitigation measures relating to the specially protected species within the meaning of Section 7 BNatSchG are arranged and implemented in the respective procedure.

[5] Renewable Energy Directive 2018/2001 as amended by Directive 2023/2413 of 18 October 2023 on the update of Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Council Directive (EU) 2015/652, available at CL2018L2001EN0020010.0001.3bi_cp 1..1 (europa.eu).

For Sites N-9.4, N-12.4, N-16.2, and N-16.3, a marginal occurrence of possibly special features for the protected assets marine mammals and/or seabirds and resting birds was identified. However, none of the sites represents a main area of distribution for the species tested. There are therefore no particular occurrences of specially protected species in these sites nor are there any significant large-scale occurrences of particularly sensitive biotopes. Taking into consideration the arrangement and implementation of the listed preventive and mitigation measures with regard to the particularly protected species within the meaning of Section 7 BNatSchG, there are therefore no sufficient reasons to refrain from designating Sites N-9.4, N-12.4, N-16.2 and N-16.3 as acceleration sites.

This is different for Sites N-9.5, N-16.1, N-16.4, and N-16.5 These areas do not fall under Section 5c, para. 2b, sentence 7 Nos. 1-7, and should therefore be designated as acceleration sites. However, the results of the environmental report as a whole give cause for closer scrutiny in the context of the exercise of discretion. The BSH is convinced that in these sites there are atypical cases that initially justify a deviation from the target provision of the legislator. These sites should be pre-investigated centrally.

For the acceleration sites to be defined as part of the current SDP, both a site protection assessment in accordance with Section 36, sentence 1, No. 2 in conjunction with Section 34, para. 1, No. 1 BNatSchG and a species protection assessment in accordance with Section 44, para. 1 BNatSchG must be carried out in accordance with the requirements of the WindSeeG because the corresponding tests at the project level are no longer required. In particular, significant adverse effects according to Section 34, para. 2 BNatSchG on the protective purposes of the three nature conservation area in the German EEZ can be ruled out for all sites considered as acceleration sites because all sites have a minimum distance of more than 8 km to the protected areas according to the regulations in Section 5, para. 2b, sentence 7, No. 5 WindSeeG-E. Taking into consideration the listed preventive and mitigation measures listed, significant effects can be ruled out. The realisation of prohibited offences under species protection law can be ruled out with the necessary certainty for all relevant species groups taking into consideration the mitigation measures listed in all acceleration sites.

11.9. Measures envisaged to prevent, reduce, and offset significant negative effects on the marine environment

With regard to the measures envisaged to prevent, reduce, and offset any significant negative effects of the SDP on the marine environment, please refer to the statements in Chapter 6 as well as Chapter 4.18 of the North Sea Environmental Report on the SDP.

The present SEA explicitly considered possible cumulative effects of sound input during the installation of foundations by means of impulse pile driving in the context of the planned development of offshore wind energy projects in the years 2032 to 2037 in Zones 3 to 5.

The assessment of cumulative effects from the currently planned development in 2032–2037 has shown that in accordance with Scenarios 1 and 3 with eight or even 12 offshore wind farms built in parallel in each case, additional preventive and mitigation measures will be necessary. The temporal and spatial coordination of pile driving is being considered as an effective measure; this must be determined as part of the approval procedure. In this respect, the approval agency will set quotas per construction year (i.e. determine time periods that each individual construction project must comply with in order to construct the foundations with impulse pile driving). The designation of pile driving quotas has the objective of limiting the number of construction projects carrying out simultaneous pile driving to a maximum of five to eight. By limiting this number of parallel pile driving operations and distributing the pile driving operations accordingly throughout the year, it is possible to exclude the realisation of species protection prohibitions according to Section 44, para. 1, No. 2 BNatSchG.

11.10. Examination of reasonable alternatives

In accordance with Art. 5, para. 1, sentence 1 SEA Directive in conjunction with the criteria in Appendix 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. For an assessment of reasonable alternatives (Section 40, para. 1, sentence 2 UVPG), different types of alternatives can be considered for an examination of reasonable alternatives – in particular strategic, spatial or technical alternatives. Reasonable means that not all conceivable alternatives but rather realistic, realisable alternatives that can be identified and implemented with reasonable effort must be examined This means that only those alternatives that will lead to the achievement of the planning objective can be considered. The legal requirement is to achieve a capacity of 70 GW in the German EEZ by 2045.

The zero alternative (i.e. not implementing the SDP) is not a reasonable alternative because the orderly yet accelerated development of offshore wind energy as designated in Section 1, para. 1 WindSeeG (with regard to the expansion targets) and in Sections 2, 2a WindSeeG is imperative for achieving the national climate protection targets. Without this development, drastic consequences – also for the marine environment – are threatened by climate change (cf Chapter 3). The purpose and objective of introducing a sectoral plan with not only spatial but also temporal designations and standardised technology and planning principles is the precautionary and orderly control of the development of offshore wind energy.

This is intended to ensure at the planning level that the statutory expansion targets for offshore wind energy set out in Section 1, para. 2 WindSeeG are achieved and that development takes place in a spatially orderly and land-saving manner (in accordance with Section 4, para. 2, No. 2, para. 3 of the WindSeeG) and that environmental concerns are also examined at the planning level.

A strategic alternative (e.g. with regard to the targets of the federal government on which the planning is based) is not currently being considered for the SDP because the expansion targets of the federal government represent the planning horizon for the SDP. The expansion targets result from the legal provision in Section 1, para. 2, sentence 1 WindSeeG.

Spatial alternatives are rare in view of the underlying territorial context of ROP 2021 and against the backdrop of the considerably increased expansion targets. In accordance with Section 1, para. 2 WindSeeG, the aim of the WindSeeG is to increase the installed capacity of offshore wind turbines connected to the grid to at least 30 GW by 2030, to at least 40 GW by 2035, and to at least 70 GW by 2045. The examination of spatial alternatives includes the examination of temporal designations for Sites N-13.3 and N-13.4. Both sites will be postponed on the basis of nature conservation considerations. In addition, an examination of reasonable alternatives for the positioning of the converter sites and with regard to the number of sites to be defined in Area N-16 is being carried out.

11.11. Measures envisaged for monitoring environmental impacts of implementing the site development plan

According to Section 40, para. 2, sentence 1, No. 9 UVPG, the environmental report also contains a description of the planned monitoring measures according to Section 45 UVPG. Monitoring is the responsibility of the BSH because this is the authority responsible for the SEA (see Section 45, para. 2 UVPG). In this context, as intended by Article 10, para. 2 SEA Directive and Section 45, para. 5 UVPG, existing monitoring mechanisms can be used to avoid duplication of monitoring work. In accordance with Section 45, para. 4 UVPG, the results of the monitoring activities are to be taken into consideration in the revision of the site development plan.

With regard to the planned monitoring measures, it should be noted that the actual monitoring of the potential impacts on the marine environment can begin only when the SDP is implemented (i.e. when the designations made within the framework of the plan are implemented. The project-related monitoring of the effects of the uses regulated in the plan is therefore particularly important.

At this point, reference is made to the obligation laid down according to Section 77, para. 4, No. 1 WindSeeG for the persons responsible according to Section 78 WindSeeG (in particular, the addressees of the planning approval resolution or the planning permission, operators of the OWF) to carry out monitoring of the construction- and operation-related impacts of the installations on the marine environment during the construction phase and during the 10 years of operation of the installations and to transmit the data obtained to the BSH and the BfN without delay. Furthermore, please refer to the planned revision and corresponding adaptation of StUK4.

The main function of plan monitoring is to bring together and evaluate the results of different phases of monitoring at the level of individual projects or clusters of projects developed in a spatial and temporal context. The assessment will also cover the unforeseen significant effects of the implementation of the plan, the marine environment and the review of the forecasts in the environmental report. In this context, the BSH will request the monitoring results required to carry out the monitoring measures available from the competent authorities in accordance with Section 45, para. 3 UVPG.

Results from existing national and international monitoring programmes must also be taken into account, also with a view to preventing duplication of work. The monitoring of the conservation status of certain species and habitats required according to Article 11 of the Habitats Directive must also be included, as must the investigations to be carried out in the course of the management plans for the nature conservation areas of the EEZ. Reference is also made to monitoring instruments as presented in the environmental reports on ROP 2021 and SDP 2020 (MARLIN, MarinEARS).

For reasons of practicability and the appropriate implementation of requirements from the Strategic Environmental Assessment, the BSH will pursue an ecosystem-oriented approach as far as possible when carrying out the monitoring of the potential effects of the plan; this focuses on the interdisciplinary consolidation of marine environmental information. To be able to assess the causes of planned changes in parts or individual elements of an ecosystem, the anthropogenic variables from spatial observation must also be considered and included in the assessment.

New since SDP 2023 and adapted in the current SDP is the requirement to provide bird collision monitoring as a matter of principle (cf Planning Principle 7.1.6).

11.12. Evaluation of the overall plan

In summary, with regard to the planned areas and sites, platform sites, and submarine cable routes as well as the designation of the area for other forms of energy generation SEN-1, the effects on the marine environment will be minimised as far as possible by means of orderly, coordinated overall planning of the SDP. By adhering strictly to preventive and mitigation measures, in particular for noise mitigation during the construction phase, significant effects can be prevented by implementing the planned sites, areas, and platforms.

No areas or sites were designated in nature conservation areas. The requirements of Section 5, para. 3n No. 5 WindSeeG are thus fulfilled. According to Section 5, para. 3, No. 5 WindSeeG, a designation is inadmissible if the area, the site, or area for other energy generation is not compatible with the protective purpose of a protected area ordinance issued according to Section 57 BNatSchG.

By applying appropriate preventive and mitigation measures (Chapter 7), the effects of construction and operational activities can be further minimised and designed to be as environmentally friendly as possible.

Based on the description and assessment, it must be concluded for the SEA, also with regard to any interactions, that, according to the current state of knowledge, no significant effects on the marine environment within the area of investigation are to be expected as a result of the planned designations. The potential impacts are frequently small-scale and short-term because they are limited to the construction phase.

12. Designations of the infrastructure area plan

The appendix to the SDP contains the draft of the infrastructure area plan. In this infrastructure area plan, the BSH designates routes, route corridors, and converter sites for offshore grid connections in the EEZ as infrastructure areas in accordance with Section 12j, para. 1 Draft EnWG.

According to Section 12j, para. 6, sentence 3, Draft EnWG, a Strategic Environmental Assessment is to be carried out for corresponding offshore connection cables in the EEZ only if this has not yet been carried out in the SDP procedure and the Strategic Environmental Assessment of the SDP does not take into consideration the environmental impacts in the infrastructure area.

For grid connections and converter platforms that have been designated as infrastructure areas, routes and route corridors for offshore connections as well as locations for converter platforms within the meaning of Section 5, para. 1 Nos. 6 and 7 Draft WindSeeG are also designated as part of the SDP. For these SDP designations, the likely effects on the environment were determined, described, and assessed in this Strategic Environmental Assessment. Please also refer to Chapters 2, 4, and 5.

According to Section 12j, para. 6, sentence 3 EnWG, a separate Strategic Environmental Assessment for the infrastructure area plan is therefore not required because the Strategic Environmental Assessment carried out for this SDP also takes into consideration the environmental impacts of the infrastructure areas in the EEZ.

According to Section 12j, para. 1, sentence 7 Draft EnwG, the infrastructure area plan must avoid certain areas unless there are no proportionate alternatives taking into consideration the objectives associated with the area. This includes the following areas relevant to the EEZ:

1. Natura 2000 sites

2. Areas with important occurrences of one or more species that regularly use the area and are likely to be adversely affected by the expansion of the grid infrastructure; these can be identified by the planning approval authority or the relevant authority under federal state law on the basis of existing data on known species occurrences or on particularly suitable habitats

3. Maritime areas protected by an ordinance according to Section 57 of the Federal Nature Conservation Act.

The routes designated as infrastructure areas do not cross either Natura 2000 sites or the spatially congruent maritime areas protected according to Section 57 of the Federal Nature Conservation Act.

The following assessment results for areas according to Section 12, para. 1, sentence 7, No. 5:

Protected assets benthos and biotopes

The construction of converter platforms leads to a permanent loss of area for the protected assets benthos and biotopes as well as to temporary adverse effects during the construction phase (cf Chapters 4.4 and 4.5). The effects affect only the direct area of the platform and the immediately neighbouring areas. They are therefore to be assessed as small-scale. There are no indications of the presence of legally protected biotopes at any of the planned converter sites. There is evidence of endangered benthic species at some platform sites. However, a significant adverse effect on particularly important occurrences of these species because of the planned construction of the installations can be ruled out with the necessary certainty. In addition, all converter sites are located within the planned wind farm sites and thus probably within safety zones in which, according to the current state of knowledge, the exclusion of active bottom-disturbing fishing equipment is generally to be expected because of the regulations to be imposed. The exclusion of one of the most important current sources of pollution could lead to a recovery of the local biocoenosis in the immediate vicinity of the converter site in the medium to long term. This could also help to stabilise the populations of endangered species.

For the cables within the infrastructure areas, there is a mostly temporary loss of function over a maximum area of 558 ha. This corresponds to significantly > 0.1% of the German EEZ in the North Sea (cf Chapter 4.17.1). Because of the gradual expansion of the subsea cables, the actual cumulative loss of function will be limited to an even smaller area. A permanent loss of area and function as a result of the cable systems results from the crossing constructions that become necessary. Based on an area of approx. 900 m² per crossing structure, the direct use of marine space for approx. 390 crossing constructions amounts to approx. 36 ha. There is evidence of endangered benthic species along individual route sections (e.g. in Sites N-12.3/12.4 and N-16.1/16.2; cf Chapter 2.6.5). According to the current state of knowledge and taking into consideration the relevant preventive and mitigation measures (Chapter 7), the planned construction of the grid connections is not expected to have any significant adverse effects on particularly important occurrences of these species and thus on the protected asset benthos because of the small-scale nature of the mostly temporary adverse effects of the individual encroachment and the gradual expansion.

It is true that geogenic reefs do not belong to the areas to be avoided according to Section 12j, para. 1, sentence 6 Draft EnWG simply because they are biotopes. However, because of their great importance for the marine environment, they will be briefly discussed here.

As a general rule, if legally protected biotopes occur along the routes, a significant adverse effect should be avoided as far as possible by bypassing the relevant areas on a small scale (cf Chapter 5.1). According to the current state of knowledge, there are indications that it will not always be possible to completely bypass reefs, particularly for the infrastructure areas coming from Gate N-V. On the first 10 km of the route from Gate N-V to the west, several smaller reef areas have been identified in ongoing investigations in individual procedures (in particular BorWin6). Because of their spatial orientation, these are unlikely to be completely bypassed. Effects on individual reef areas or their biocoenoses could be minimised through the bypassing or redistribution of individual stones.

There is no proportionate alternative available for the designation of infrastructure areas for the grid connection systems running in the direction of Gate N-V.

Protected asset marine mammals

The construction of converter platforms is generally associated with sound inputs that can have effects on marine mammals if no preventive and mitigation measures are taken. In addition, cumulative effects from the parallel construction of converter platforms and the construction of neighbouring offshore wind farms must be taken into account and prevented through the appropriate preventive and mitigation measures.

The converter platforms for grid connection systems NOR 9-4, NOR 12-3, NOR 14-1, NOR 14-2, NOR 14-3, NOR 16-2, and NOR 16-3 are located in sites designated as acceleration sites.

The converter platforms for Grid connection systems NOR 9-5, NOR 12-4, NOR 16-1, NOR 16-4, and NOR 16-5 are located in sites not designated as acceleration sites.

The construction of all converters must comply with the requirements of the noise protection concept of the BMU (BMU, Konzept für den Schutz der Schweinswale vor Schallbelastungen bei der Errichtung von Offshore-Windparks in der deutschen Nordsee, 2013, available at https://www.bsh.de/DE/THEMEN/Offshore/Meeresfachplanung/Flaechenentwicklungsplan/_Anlagen/Downloads/FEP_2022_2/Schallschutzkonzept_BMU.html) as well as measures envisaged to prevent, reduce, and offset any significant adverse effects of the site development plan on the environment (Chapter 5). In addition, spatial and temporal coordination (see catalogue of avoidance and mitigation measures in the SDP, Appendix to Chapter 7) by the project developers is required, particularly for the construction of the converter platforms in the sites not designated as acceleration sites because of the potential simultaneous construction with the surrounding offshore wind farms in order to prevent cumulative effects (Chapter 4.17.3). The potential temporal and spatial coordination is specified at the approval level. If the catalogue of preventive and mitigation measures – in particular the noise protection concept of the BMU (BMU, 2013) – as well as the spatial and temporal coordination of the construction work with the surrounding areas are adhered to, a significant adverse effect can be ruled out with the necessary certainty.

Accordingly, it cannot be assumed that areas with important occurrences of one or more species that regularly use the area will be adversely affected by the designated infrastructure areas for the protected asset marine mammals.

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