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COMPARISON OF NORTH SEA EIA'S AND SEA'S[1] OF MARITIME SPATIAL PLANS AND WIND ENERGY DEVELOPMENT

An analysis of similarities and differences between North Sea Countries in benefit of the SEANSE-project.

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[1] Environmental Impact Assessment and Strategic Environmental Assessment

1 Introduction

Implementing the Renewable Energy Directive in 2009, the European Union (EU) achieves to fulfil at least 20% of its total energy needs with renewables by the year 2020 (and up to 27% by 2030). The harnessing of offshore wind power is, among others, an important source for the production of renewable energy and therefore an important part to achieve the EU's target. Due to the increasing number of windfarm installations in the North Sea and the evaluation of their environmental impact, the project "Strategic Environmental Assessment North Sea Energy" (SEANSE) was established to develop a coherent approach to environmental assessments among North Sea countries. One of the assignments within SEANSE is to take a closer look at the similarities and differences between North Sea countries regarding current SEA (Strategic Environmental Assessment) and EIA (Environmental Impact Assessment) contents with respect to cumulative effect assessment for offshore wind farms in the North Sea. This study provides an overview of these differences and similarities within current assessments of cumulative ecological effects linked to offshore wind energy plans or projects in the North Sea.

According to the European "EIA Directive (85/337/EEC) on the assessment of the effects of certain public and private projects on the environment" an EIA is not mandatory in case of projects that are listed in Annex II of this directive, which includes among other things installations for the harnessing of wind power for energy production (wind farms). According to the EIA Directive the national authorities of the member states have to decide whether an EIA is needed in this case. It is up to the member states if and how to carry out the assessment procedure and what kind of approach to use when it comes to the evaluation of assessment criteria, the cumulation of impacts and valuation of threshold levels[2]. Contracting parties have decided that an EIA is necessary for the majority of offshore wind farm developments in the OSPAR-area (OSPAR, 2008a). The SEA Directive (2001/42/EC) differs from the EIA Directive, meaning that an Environmental Impact Assessments of specific developments and activities is required (now codified by Directive 2011/92/EU, which is itself amended by Directive 2014/52/EU). Under the terms of Article 3(2a) of the SEA Directive, all plans/programmes prepared for energy must be subject to environmental assessment.

Scope

Present study focuses on Germany, The Netherlands, Belgium, England and Scotland. France and Denmark are not included in this study due to the absence of SEA for those countries with regard to marine spatial plans and wind park developments in the North Sea.

[2] An EIA is to be carried out under certain conditions... Art. 4 Nr. 2 EIA Directive: "...for projects listed in Annex II, Member States shall determine whether the project shall be made subject to an assessment in accordance with Articles 5 to 10. Member States shall make that determination through:
a) a case-by-case examination; or b) thresholds or criteria set by the Member State.

2 Methodology

The main goal of this study is to detect similarities and differences in the systematic approach (methodologies) within SEA and EIA reports concerning the assessment of cumulative ecological effects regarding offshore wind farms in the North Sea. The following paragraphs provide the approach on how the information is structured within present study. This approach is based on general methods on structuring ecological information for impact assessments.

2.1 European assessment of environmental effects

In 1999 the European Environmental Agency adopted the causal framework DPSIR for describing the interactions between society and the environment, such as human impacts on the environment. This framework is based on five different components, which have to be successively defined to estimate the impact of human activity on the environment:

- Driving forces
  economic or social human activities that can affect the environment.
- Pressures
  pressures on the environment that result from those activities.
- State
  estimating possible changes of the environmental state due to those pressures.
- Impact
  estimating/defining the impact of those pressures on (parts of) the environment.
- Response
  human response on the impact by measures to prevent or mitigate the effects.

DPSIR introduces a general method to assess human impacts on the environment. To assess cumulative ecological effects of human impacts this method can be followed to a great extent, but has to be adapted/ broadened at some points, as explained in the following paragraphs below.

2.2 Assessment of cumulative ecological effects (offshore wind farms)

As mentioned above this chapter focuses on the adaption of the DPSIR framework to assess cumulative ecological effects. The assessment first of all starts with a planned project or a (strategic) plan that has to be investigated. This project/plan comes along with certain activities (on different temporal and spatial scales) that cause certain pressures on the environment. For those pressures it has to be estimated whether they (alone or in cumulation with other already planned activities in the relevant temporal and spatial scales) are likely to produce significant effects on relevant species or habitats. After that the significance of those effects on species and habitats has to be compared to the present situation without the planned project/plan – the reference state. At that point the range of considered (cumulative) effects from the plan/project on different temporal and spatial scales is determining for a comprehensive validation of the significant ecological effects of the planned project/plan on species and habitats.

The following paragraphs show this study's approach to structure ecological information which provides a framework for the detection of similarities and differences within EIA's and SEA's. Additionally different temporal and spatial scales are discussed that play an essential part in context with the assessment of cumulative ecological effects.

Six Assessment steps (based on DPSIR)

The six steps listed below are based on the DPSIR framework and represent a basic approach for the assessment of cumulative ecological effects of offshore windfarms. Relations between human activities and the environment can be estimated in a quantitative/qualitative way using models and/or expert judgement. The six steps are developed by the Dutch government on behalf of a guideline to estimate cumulative ecological effects called 'Framework for Assessing Ecological and Cumulative Effects' (in Dutch: Kader Ecologie en Cumulatie t.b.v. uitrol windenergie op zee" (KEC).)

1.) Describing the relevant pressures of the planned activity (offshore wind farm)

Step 1 is related to step 2: Pressures are only relevant if there are (sensitive) species and habitats present responding to them. Describing the pressures starts with a detailed description of the planned activity concerning duration and spatial extent of all phases of the activity including specific pressures on the environment. E.g. under water noise: the duration of noise could be linked to the building phase or to the complete operational phase of the wind turbines or both. The spatial extent for noise can be defined as the area within which it has significant effects on the behavior of individuals of a species

2.) Evaluating habitats and species that can be affected

Ecological approach: First all species (and habitats) that are present within the area of influence of the occurring pressures have to be identified. Then those species (and habitats) that are sensitive to the specific pressures are identified.
Legal approach: Not all of the present species in the investigated area are legally protected by national law. The legal protection of single species can additionally differ per country. Only those species that fall within the EU Birds- and Habitats-Directive are legally protected the same way in different EU countries.
In general it can be assumed that species that are not legally protected are indirectly taken into account due to the protection of the most sensitive species. Still, extra attention should to be paid here if a species forms an important part of the food chain.

3.) Describing all other (planned) activities with pressures/effects on those species and habitats

Ecological approach: This step 3 starts with the evaluation of all relevant existing and planned activities surrounding the investigated area (also transboundary) that can influence abundant species and habitats. Those pressures are not necessarily the same as the ones caused by the planned activity. These activities can be relevant if they have potential impact on the species or habitats that are affected by the plan. Existing activities can be relevant if they are relatively new and their impacts are not yet balanced in the population development of species potentially affected by the plan.

4.) Estimating possible ecological impacts of the pressures of those activities on the evaluated (sensitive) species and habitats by using models or expert judgement.

This step can start with the review of all the evaluated possible pressures in relation to their possible cumulative effects on species and habitats. A selection based on expert judgement can be done regarding which pressures may, cumulatively, cause significant negative effects on species/habitats. After the pre-selection, all those aspects that, according to expert judgement, may (cumulatively) have a significant negative effect on species and habitats, can then be part of a more detailed investigation. Therefore models can be used if possible, to quantify the impact of a pressure per activity per species/habitat. If quantitative estimation is not possible, the impact is estimated qualitatively by expert judgement. The set of estimated impacts per pressure per species/habitat is the basis to assess whether the different effects of the different pressures amplify or weaken each other.

5.) Evaluating cumulative effects

Step 5 contains the validation of the impacts estimated in step 4 on (sensitive) species and habitats based on associated limit values. Step 5 concludes whether the cumulative effect of these pressures is acceptable.

6.) In case of potential significant effects on the environment resulting from the planned activity it can be necessary to undertake mitigation .

In case it is constituted in step 5 that there are significant cumulative effects on species/habitats due to the planned activity, response is necessary which means that mitigation measures have to be undertaken. It has to be investigated if the planned activity still causes significant negative effects considering possible mitigation measures.

The six assessment-steps as a framework to detect similarities and differences

Based on the five components of the DPSIR framework, the six assessment-steps serve as a representative basic framework in present study to detect similarities and differences in the assessment of cumulative ecological effects in SEA's and EIA's among the investigated North Sea countries.

The main goal of this study, the comparison of the assessment of cumulative ecological effects within SEA's and EIA's, would technically be step 4 and 5. However, these steps demand input from all of the previous steps 1 until 3 in order to identify similarities and differences within the national SEA/EIA methodologies. That is why all of the steps have to be taken into account and respectively compared among the North Sea countries.

Cumulative ecological effects offshore wind farms

Within this section attention is paid to different spatial and temporal scales of cumulative ecological effects which can occur in relation to offshore wind farms. For a comprehensive validation of the significant ecological effects of the planned activity on species and habitats those different scales have to be taken into account.

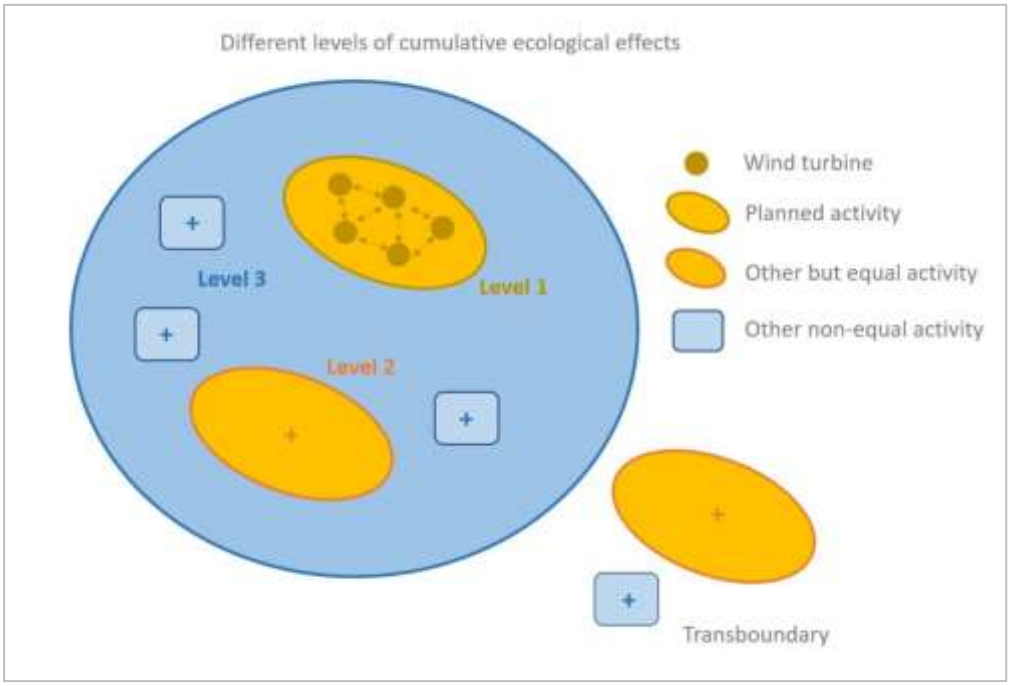
Pressures in different time scales

Pressures on the environment from offshore wind farms may occur across a range of timescales. They may also occur during three different phases in windfarm life cycles: construction (several years), operation (several decades) and decommissioning(several years),. Since the activities and associated pressures differ across each of these phases, all phases respectively have to be taken into account when it comes to the assessment of cumulative ecological effects of offshore wind projects.

Activities on different levels

Figure 1 below shows the different levels at which activities may act cumulatively. These levels may be assessed in both SEA as in EIA..

Figure 1 Different levels of cumulative ecological effects



Level 1 (see figure 1) within an EIA concerns the cumulative ecological effects of the single wind turbine of a windfarm that can cause several pressures for different species and habitats. The effects of the single turbines have to be summed up to estimate the effects of the whole wind farm on the species and habitats in the investigated area. Level 1 describes the cumulative ecological effects of all the single wind turbines within one wind farm. In an SEA level 1 can be a(n) (part of an) area designated for the development of offshore wind energy.

The second level shown in figure 1 implies also adding the ecological effects of other offshore wind farms to the total calculation of ecological effects on the same species and habitats. This can also implicate wind farms beyond national borders..

Besides the pressures that wind turbines cause on the environment also other activities can entail pressures (e.g. shipping, fishing, the extraction of sand or the production of oil and gas, land based sources of pollution). These pressures can be similar as those by wind farms or

different but having an similar effect on the selected species.. Therefore the third level of related activities at which cumulative effects can be estimated would include all ecological effects of all present (and relevant) activities with ecological effects on the (same) species and habitats within the investigated areas. This could also implicate activities across national borders.

The effects on species on different levels

On all the afore mentioned temporal and spatial levels, effects of pressures on species can be assessed. In defining the effect on species, the relevant reference population or levels has to be taken into consideration. These population levels can be categorized as the individual, the local population, the national population or the international population, see figure 2 below. The impact of ecological effects on a species and their significance has to be framed within the appropriate reference population.

Figure 2. Different levels of a species population

At first, possible effects of a stressor on an individual are investigated. This investigation can focus on different spatial areas used as study area of this species. For example the study area can be the local abundance of the species when looked upon the effects of the construction of a single wind turbine; how many porpoises are influenced by the pile driving of a wind turbine foundation on a specific location? The local abundance and distribution of the investigated species within the study area are assessed to verify the relevance of the species. If deemed relevant, first the influence on individuals of the baseline is assessed. In a further step it has to be assessed in how far effects on this baseline influence the (national) population. This (national) population comprises a far greater area than the direct influenced area due to the pile-driving. This means that the study area depends on the activity range of a species. For example the range of big marine mammals is assumed to be much wider than the range of the local benthic fauna, the actual effect on a population of marine mammals reaches further (spatially) than effects on benthic fauna. After it is stated that there might be significant effects

on an individual of a species, the impact of these effects is usually estimated and also validated in relation to the population of this species. The estimation/ validation of the significance of stressors for a species' population can also focus on different spatial levels, such as the local population, the national population or the international (usually more transboundary) population.

2.3 Key Questions

To compare the systematic approaches (methodologies) within SEA and EIA reports regarding cumulative ecological effect assessment, key questions were defined beforehand by members of the SEANSE Project. These questions are primarily based on the six assessment steps as mentioned in the paragraph above, since those steps represent a basic framework for the assessment of cumulative ecological effects in general. The key questions are therefore categorized by those assessment steps, as shown in table 1 below.

Tabel 1 Key Questions

Assessment-steps cumulative ecological effects	**Key Question for comparison SEA and EIA**
1.) Describing the relevant pressures of the planned offshore wind farm activity	• Which stressors (pressures) are taken into account? • What is the relevant time scale of those stressors?
2.) Evaluating habitats and species that can be affected	• Which receptors (species/habitats) are taken into account? • What is the relevant time scale per stressor per receptor?
3.) Describing all other activities with pressures/ effects on those species and habitats	• What is the relevant spatial scale of activities taken into account other than the planned activity: • Are there other offshore wind farms taken into account? (Level 2) • Are there other activities than offshore wind are taken into account? (Level 3) If yes, which ones? • Are transboundary activities and pressures taken into account within level 2 or level 3? • What cumulative stressors are taken into account per species per activity?
4.) Estimating possible ecological impacts of the pressures of those activities on the evaluated (sensitive) species and habitats by using models or expert judgement.	• Which methods/models are used for the estimation of ecological effects? • Is expert judgement included?
5.) Evaluating cumulative effects	• How is the significance of impacts determined? • What is the spatial scale of the receptors of the cumulative stressors? (see fig.2)
6.) In case of possible negative effects on the environment resulting from the planned activity, or as precautionary action it can be necessary	• Are cumulated ecological effects calculated with or without mitigation and/or preventing measures?

Assessment-steps cumulative ecological effects	Key Question for comparison SEA and EIA
to undertake mitigating or preventing measures.	

2.4 Literature Research

This study is a qualitative investigation of similarities and differences in the systematic approach (methodologies) within SEA and EIA reports concerning the assessment of cumulative ecological effects. Therefore literature research has been carried out, based on a variety of SEA and EIA reports between the years 2011 and 2018 for each country that is part of this investigation. For information about the specific documents that have been used per country see the table below. To be able to answer (all of) those key questions experts were consulted besides the literature research, to ascertain more detailed facts about the individual methodologies/frameworks to assess cumulative ecological effects within SEA and EIA.

Table 2 Overview literature SEA and EIA

North Sea Country	Plan / SEA documents	EIA documents
The Netherlands	National water plan (2014)	Kavel V en VI Windenergiegebied Hollandse Kust Noord (2018)
Belgium	Marine spatial plan (2014) Plan-m.e.r. ontwerp marien ruimtelijk plan (29 mei 2018)	Windpark Mermaid (2014)
Germany	Umweltberichte Bundesfachpläne Offshore (Environmental reports on spatial offshore grid plans for the German EEZ of the North Sea (2012; 2013/2014; 2016/2017) Umweltberichte Raumordnungspläne für die deutsche AWZ 2009 (Environmental reports on Maritime Spatial Plans for the German EEZ 2009); Umweltbericht Flächenentwicklungsplan 2019 (Environmental report on site development plan 2019 (final version 06/2019)	OWP West (2014)
England	Draft plan/program offshore energy in the UK (2014) OESEA3 Environmental Report (March 2016) – SEA OESEA3 Post Consultation Report (July 2016)*	East Anglia Three (2015)
Scotland	National marine plan – Sustainability Appraisal Report (2013) Strategic Environmental Assessment of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters; Volume 1 Environmental Report (May 2010)	Forth Wind Offshore (2015) Beatrice Offshore Wind Farm Environmental Statement, Non Technical Summary (2012)

North Sea Country	Plan / SEA documents	EIA documents

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3 Similarities and differences regarding cumulative ecological effects within Strategic Environmental Impact Assessments (SEA)

This chapter provides the analysis on similarities and differences in SEA methodologies per country. These will be assessed per assessment step as presented in the previous chapter.

The following paragraphs give an overview of similarities and differences regarding cumulative ecological effects within the investigated SEA's of the North Sea countries Belgium, Germany, The Netherlands, England and Scotland. Two types of strategic plans can be identified beforehand; on the one hand a sectoral plan in which only wind energy areas are designated and on the other hand a comprehensive Maritime spatial plan which includes the policy update on all offshore functions and usage. when possible the following paragraphs will leave this difference out of the analysis.

3.1 Pressures of the planned offshore wind energy areas

In assessing the potential impact of a strategic plan concerning the location of offshore wind energy areas, several pressures or stressors are taken into account. Albeit not at an exact detail. In most SEA's the timescale of effects is left out or only mentioned but not thoroughly assessed. Therefore this factor has been left out in the analysis of the SEA's.

Table 3 Stressors taken into account in SEA (focus on offshore wind)

Stressors SEA offshore wind	The Netherlands	Belgium	Germany	England	Scotland
Introduction of non-native species			x	x	x
Physical presence of structure	x	x	x	x	x
Displacement/ Habitat loss			x		
Collision risk	x	x	x	x	x
Barrier effect	x	x	x	x	x
Noise disturbance	x	x	x	x	x
Sedimentation (alteration)		x	x	x	x
Chemical and other inputs	x	x		x	x
(avoided) Atmospheric emissions		x		x	x
Electromagnetic fields / heat		x	x	x	x
Waste disposal onshore				x	
Climatic factors		x			x
Accidental events	x	x		x	x

3.2 Habitats and species that can be affected

This paragraph focuses on the species that are investigated as a possible receptor on the evaluated stressors. The following table shows the stressors listed separately per species.

Table 4 Species / habitats and stressors taken into account in SEA (focus on offshore wind)

Species / habitats and stressors SEA	The Netherlands	Belgium	Germany	England	Scotland
Birds	x	x	x	x	x
Collision risk	x	x	x	x	x
Barrier effect		x	x	x	x
Behavioral disturbance			x	x	x
Displacement/ Habitat loss			x		
Bats	x		x	x	
Collision risk	x		x	x	
Barrier effect					
Fish			x	x	
Behavioral disturbance			x	x	
Noise disturbance			x	x	
Barrier effect			x	x	x
Sedimentation	*[3]	*	x	*	*
Electromagnetic fields/heat	*	*	x	*	*
Marine mammals	x	x	x	x	x
Noise disturbance	x	x	x	x	x
Behavioral disturbance					x
Barrier effect					x
Benthos/biotopes	x	x	x	x	
Physical presence of structure	x	x	x	x	x
Chemicals and other inputs	x			x	
Introduction of non-native species			x	x	x
Sedimentation	*	*	x	*	*
Electromagnetic fields/heat	*	*	x	*	*
Protected area's	x	x	x	x	
Habitat directive (*AA)	x*	x	x	x	x
Bird directive (*AA)	x*	x	x	x	x
other			x		x

*AA = Appropriate Assessment. If checked with the asterisk, the impact assessment relies on the outcome of the AA.

[3] Not all stressors listed in Table 3 are assessed for this table. Germany added Sedimentation and Electromagnetic fields/heat for this table. For other countries these pressures are not considered in the assessment made for this table.

3.3 (Other) activities which causes pressures on relevant habitats / species

This paragraph focuses on how far the different spatial levels of cumulated ecological effects are taken into account within SEA's of the different North Sea countries (see the table below).

Table 5 Activities taken in to account in Strategic Environmental Assessment

Spatial Scale of Stressors Cumulative effects SEA	The Netherlands	Belgium	Germany	England	Scotland
Level 1 – The planned activity itself	x	x	x	x	x
(National) Marine Spatial Plan	x	x	x		x
Strategic energy plan			x	x	x
Level 2 – Other but equal activity (Other offshore wind farm)		x	x	x	x
transboundary		x	x	x	
Level 3 – Other national non-equal activities	x		x	x	x
Shipping			x		x
Seismic research	x	x	x	x	x
Aggregate dredging (sedimentation disturbance)	x	x			x
Oil and gas exploration and development	x	x	x	x	x
Tidal & Wave energy				x	x
Fisheries		x	x		x
Gas Storage				x	x
Carbon Dioxide Capture and storage	x			x	x
Aquaculture			x		x
Cables and pipelines (construction)	x	x	x		
Level 3 – Other transboundary non-equal activities (mentioned)		x		x	
Noise disturbance (other sources)		x		x	
Marine discharges				x	
Accidental events				x	

3.4 Estimated ecological impact

All SEA's use existing impact assessments on the same spatial scale and similar activities. The actual estimation of the impact of the planned activity is carried out based on expert judgement for all researched countries.

3.5 Evaluation of cumulative impacts

This paragraph focuses on the question how the significance of impacts is determined and provides information about the approach for the determination of the significance of impacts. Due to the different approach per SEA per country, no coherent table can be drawn up.

The Netherlands

Cumulative effects are assessed in two ways. The first being an aggregation of all effects caused by national activities and policy objectives of the National Water Plan 2. The effects are aggregated to 7 themes, being: water safety (flood risk), fresh water supply, environment and water quality, nature, landscape, user functions and sustainability. Effects of both the policy objectives and activities encouraged with the NWP2 are put against the effects of the policy objectives as presented in the Delta Program 2015. This assessment is solely based on expert judgement. Scoring is done by a rating scale (-, o and +).

The cumulative assessment of NWP2 and DP2015 shows that flood risk management, fresh water supply, environment and water quality, nature and sustainability benefit from the combined effects that result from the total number of measures. Landscape benefits partially from the measures, but in particular the provisions on the North Sea have a negative effect on the landscape experience. The effects on user functions vary.

Belgium

The approach of the Belgian SEA is to present an overall comprehensive assessment of the planned activities. Given the SEA-subject; a marine spatial plan, all presented effects are cumulative effects, given that all stressors caused by Belgian offshore activities are taken into account. These stressors and activities are presented in table 4. The potential of cross boundary effects of Belgian activities on neighboring countries is also mentioned.

The SEA concludes with the statement that the realization of new wind energy areas energy and zones for commercial and industrial activities cause an additional pressure on the Natura 2000 sites, and in particular the Habitat Directive area 'Flemish Banks'. The further development of these projects must be subjected to in-depth research into the possible effects and that they will only be feasible with strict compliance to specific preconditions.

Germany

In Germany the evaluation of cumulative effects is dependent on the focus of the respective plan. For the current site development plan (in German Flächenentwicklungsplan/FEP) only cumulative effects of wind farms and respective platforms including in-project cabling are assessed. Other activities are mentioned and assessed in the SEA of the marine spatial plan.

With regards to seabirds, divers are the main concern in Germany, since they are both very prone to disturbance and highly protected species. There is a special area defined within the EEZ of the German North Sea where red-throated divers and black-throated divers occur in high numbers in spring. Cumulative effects are not likely to have a significant effect on the local diver population as long as there are no further offshore wind farms being permitted and thus built within this area. For migrating birds not much is known about actual collision risk and barrier effects. Potential cumulative effects are discussed in detail for each stressor but no final conclusionsare drawn. Knowledge gaps are discussed in detail..
According to the protection plan for harbour porpoises in the German EEZ of the North Sea (BMU 2013) construction work has to be coordinated in a way that a minimal impact on individuals or on population level of harbour porpoise is expected. At all times, no more than 10% of a nature conservation site is allowed to be disturbed by underwater sound. This is based on the general approach established by the federal agency, which states that when an area of more than 1% is lost, the impact is considered significant. However, since piling is a temporary

activity a disturbance area of 10% is considered acceptable. For the Natura2000 area Sylt Outer Reef, there is one exception to the rule. In the period from April to August no more than 1% of this area can be disturbed. This is because Sylt Outer Reef is an important breeding area for the harbour porpoise. The construction of several wind farms at the same time has to be coordinated accordingly and the use of technical noise mitigation is compulsory.
For benthos, based on conservative assumptions, the area which is permanently sealed to due wind farms, platforms and cabling is calculated in relation to the size of the entire German EEZ of the respective sea. For fishes, cumulative effects are descriptively assessed.

England

The SEA of the UK offshore energy strategic plan dedicates a separate chapter to potential cumulative effects. In this chapter, cumulative effects are considered in a broader context, to be potential effects of activities resulting from implementation of the plan which act additively or in combination with those of other human activities (past, present and future); in an offshore SEA context notably fishing, shipping (including crude oil transport) and military activities, including exercises (principally in relation to noise) – i.e. what could be described as the other major "industrial" uses of the sea

The scale and consequences of environmental effects in adjacent state territories due to activities resulting from adoption of the draft plan / programme will be less than those in UK waters and are considered unlikely to be significant.

Scotland

The scope of the Appraisal report of the National Marine Plan is broad, since it focusses on a Marine Spatial Plan. The researched SEA document itself is not an comprehensive SEA, but presented as a Sustainability Appraisal Report. Therefore the scope is broad and covers economic, social/community and environmental interests. This is a strategic-level appraisal of national-level planning policies and sectoral objectives and policies, which broadly assesses their expected effects. A series of key questions ('sustainability appraisal objectives') is used to structure the assessment. The appraisal identifies positive and negative effects, including 'cumulative' effects. All based on a qualitative analysis.
The SEA of the Draft Plan for Offshore Wind Energy in Scottish Territorial Waters describes in a separate chapter cumulative effects (effects of other national offshore wind developments) and in combination effects (effects of other national plans, activities or strategies).

3.6 Mitigating measures

This paragraph elaborates on the mitigation measures prescribed per researched country. Due to the different approach per SEA per country, no coherent table can be drawn up.

Netherlands

Possible mitigating effects which can be taken into account are mentioned such as reducing the level of underwater sound with technical provisions or avoiding constriction during important periods of time for certain bird species.

Belgium

Every assessed aspect is concluded with possible mitigation measures, although none is strictly prescribed. Possible mitigating effects which can be taken into account are mentioned such as reducing the level of underwater sound with technical provisions. Also suggested is to minimize

the amount of scour protection (hard substrate) in order to limit the effects of non-native (benthic) species.

Germany

Measures to avoid and mitigate cumulative effects are always taken into account as part of the siting process, e.g. by excluding Natura2000 sites and other sensitive areas the effects on marine mammals and sea birds are mitigated. Legally binding measures for underwater noise reduction during construction are taken into account as well.

England

Every aspect is assessed with and without possible mitigation measures. None is strictly prescribed. Possible mitigating effects which can be taken into account are mentioned such as reducing the level of underwater sound with technical provisions, avoiding periods of time in order not to disturb breeding birds or other vulnerable species.

Scotland

The Appraisal report of the National Marine Plan says that *(…) there are existing pressures on biodiversity (including flora and fauna) from many of the activities and uses of the marine environment. Climate change is also exerting pressure on biodiversity. The objectives and policies of the draft NMP recognize and address the potential for effects on biodiversity, while recognizing that the NMP will work in conjunction with the overall legislative and policy framework for the marine*
Environment.(…). No particular mitigation measures are assessed. The SEA mainly refers to the more generic policy framework, within which mitigation measures can be prescribed.
The SEA of the Draft Plan for Offshore Wind Energy in Scottish Territorial Waters proposes mitigating measures to manage significant adverse effects that are identified in this SEA. Implementation of these actions is required to ensure that adverse effects of the plan are minimised where possible (to be detailed at the subsequent project level).

3.7 Knowledge gaps

This paragraph focusses on the identified knowledge gaps in the SEA and how the assessments treats these knowledge gaps.

The Netherlands

The Netherlands acknowledges the lack of knowledge on the North Sea ecosystem but states that this knowledge is in development. In this respect different studies are undertaken within an overarching research programme on ecological effects of offshore wind farm developments; Wozep (Wind op zee ecolgisch programma). This Wind on Sea Ecological Programme establishes research on cumulative effects of wind turbines on birds, bats, marine mammals and fish.

Belgium

Every assessed aspect is concluded with mentioning the current lack of knowledge on that very aspect. Although this does not have any impact on the rating of the effects of the planned activity and the researched alternatives.

Germany

Every assessed aspect is concluded with mentioning the current lack of knowledge on that very aspect.

England

The SEA of the UK Offshore Strategic Energy plan does not have a separate chapter or paragraph concerning knowledge gaps. The methodology of this SEA is, before assessing the effects, setting the baseline. During this, relevant knowledge gaps are mentioned. With one of them being that there is a knowledge gap in the existing noise levels / pollution over the entire North Sea. There is a lack of a comprehensive register of noise generating sources /activities.

Scotland

The SEA Appraisal report does not mention relevant knowledge gaps.
The SEA of the Draft Plan for Offshore Wind Energy in Scottish Territorial Waters gives recommendation for future works and describes a framework for future monitoring of the (potential) significant adverse effects. Knowledge gaps are identified in these recommendations and the framework for monitoring on a national, regional and local level.

4 Similarities and Differences regarding cumulative ecological effects within Environmental Impact Assessment (EIA)

This chapter provides the analysis on similarities and differences in EIA methodologies per country. These will be assessed per assessment step as presented in chapter 2.

The following paragraphs give an overview of similarities and differences regarding cumulative ecological effects within the investigated EIAs of the four North Sea countries Belgium, The Netherlands, Germany, England and Scotland. The results are provided in the form of tables which show a "x" for every criteria that is present in the investigated EIA report of the different countries.

4.1 Pressures of the planned offshore wind farm activity

The investigated countries of the North Sea take different pressures of offshore wind farms into account to estimate possible ecological effects on species and habitats. The table below provides an overview of all those pressures per country and per different temporal scale.

Table 6 Temporal Scale of Stressors EIA

Temporal Scale of Stressors EIA	The Netherlands	Belgium	Germany	England	Scotland
Construction phase	x	x	x	x	x
Habitat disturbance / Habitat loss	x	x	x	x	x
New habitat (hard structures)		x	x		
Barrier effect	x		x		x
Food availability	x	x	x	x	x
Noise disturbance	x	x	x	x	x
Vibration	x	x	x	x	x
Sedimentation		x	x	x	x
Sediment agitation		x	x	x	x
Sediment / Seabed disturbance	x	x	x	x	x
Risk of contact with fuel or chemicals		x	x		x
Collision risk with vessels / machines	x	x	x	x	
Risk of entanglement with cables		x			
Risk of entanglement with waste products in the water			x		
Release of sediment bound contaminants			x	x	x
Exploitation phase	x	x	x	x	x
Time span	25 years	30 years	25 years	50 years	25 years
Collision risk	x	x	x	x	x
Collision risk with vessels / machines			x	x	

Temporal Scale of Stressors EIA	The Netherlands	Belgium	Germany	England	Scotland
Barrier effect	x	x	x	x	x
Habitat disturbance / Habitat loss	x	x	x	x	x
Food availability		x	x	x	x
Indirect effects wind farm	x	x	x	x	x
Vibration	x	x	x	x	
New habitat (hard structure)	x	x	x	x	x
Change in physiochemical water quality		x			
Changes to the hydrodynamic regime			x		x
Heat effects due to cabling		x	x		x
Sediment / Seabed disturbance			x	x	x
Release of sediment bound contaminants				x	x
Risk of contact with fuel or chemicals					x
Sedimentation				x	x
Sediment agitation				x	x
Noise disturbance	x	x	x	x	x
Electromagnetic fields due to cables	x	x	x	x	x
Decommissioning phase	x	x	x	x	x
Habitat disturbance / Habitat loss	x	x	x	x	x
Barrier effect	x		x		
Collision risk with vessels / machines	x	x	x	x	
Risk of entanglement with cables		x			
Food availability	x	x	x	x	
Noise disturbance	x	x	x	x	x
Vibration	x	x	x	x	x
Sediment / Seabed disturbance	x	x	x		
Sedimentation		x	x	x	x
Sediment agitation		x	x	x	x
Risk of contact with fuel or chemicals		x	x		x
Risk of entanglement with waste products in the water			x		
Release of sediment bound contaminants			x	x	x
Expecting less impact than while		x		x	x

Temporal Scale of Stressors EIA	The Netherlands	Belgium	Germany	England	Scotland
construction phase due to leaving the foundations					

Definitions:

Habitat disturbance / loss: effects on the availability of habitats as foraging or resting areas
Collision risk: the risk that animals collide with parts of the turbine or building machines and therefore die or are injured.
Barrier effect: the avoidance of the area around the wind turbine by animals due to its effects.
Indirect effects wind farm: effects of restricted fishery in the area of the wind farm (includes effects on the sediment due to restricted near bottom fishery).
New habitat: effects the wind farm has due to the introduction of hard substrate on which (exotic) species can settle
Noise disturbance: underwater or above water noise that come along with the wind farm on any temporal scale (e.g. rotation wind turbines, shipping, drilling, seismic research)
Vibration: vibrations due to activities that come along with the wind farm on any temporal scale
Sediment / seabed disturbance: effects due to disturbance of sediments (e.g. while building fundament). Those effects can result in instantly killing local fauna such as benthos and fish.
Sedimentation: sediments that are lifted from the ground and replaced somewhere else
Sediment agitation: effects of turbidity/smoothing caused by agitated sediments
Food availability: effects (due to habitat disturbance or other effects) on the food availability

4.2 Habitats and species that can be affected

This paragraph focuses on the species that are investigated as a possible receptor on the evaluated stressors. The table below shows the stressors listed separately per species and temporary scale.

Table 7 Species and stressors EIA

Species and Stressors EIA With temporal scale of stressors per species	The Netherlands	Belgium	Germany	England	Scotland
Birds	x	x	x	x	x
Construction phase:					
Habitat disturbance / Habitat loss	x	x	x	x	x
Sediment agitation		x			
Food availability		x		x	x
Barrier effect			x		x
Noise disturbance					
Risk of entanglement with waste products in the water					
Exploitation phase:					
Collision risk	x	x	x	x	x
Barrier effect	x	x	x	x	x

Species and Stressors EIA With temporal scale of stressors per species	The Netherlands	Belgium	Germany	England	Scotland
Habitat disturbance / Habitat loss	x	x	x	x	x
Food availability		x	x	x	x
Indirect effects wind farm			x		x
Noise disturbance					
Electric magnetic fields/thermal radiation from cables					x
Decommissioning phase:					
Habitat disturbance / Habitat loss	x	x	x	x	x
Food availability				x	
Sediment agitation					
Barrier effect			x		
Noise disturbance					
Risk of entanglement with waste products in the water					
Expecting less impact than while construction phase due to leaving the fundament				x	
Bats	x	x	x		
Construction phase:					
Habitat disturbance / Habitat loss	x				
Exploitation phase:					
Collision risk	x	x	x		
Barrier effect	x				
Habitat disturbance / Habitat loss	x				
Decommissioning phase:					
Habitat disturbance / Habitat loss	x				
Marine mammals	x	x	x	x	x
Construction phase:					
Habitat disturbance / Habitat loss	x	x	x		x
Barrier effect	x				
Noise disturbance	x	x	x	x	*x
Sediment agitation		x			
Vibration	x	x		x	
Collision risk with vessels / machines	x	x		x	x
Risk of entanglement with cables		x			
Risk of entanglement with waste products in the water					
Food availability	x	x		x	x
Risk of contact with fuel or		x			

Species and Stressors EIA With temporal scale of stressors per species	The Netherlands	Belgium	Germany	England	Scotland
chemicals					
Exploitation phase:					
Noise disturbance	x	x	x	x	*
Vibration	x	x		x	
Habitat disturbance / Habitat loss		x		x	x
Food availability		x		x	x
Electromagnetic fields due to cables		x			x
Indirect effects wind farm					x
Collision risk with vessels / machines				x	x
Barrier effect				x	
Decommissioning phase:					
Habitat disturbance / Habitat loss	x	x	x		x
Barrier effect	x				
Noise disturbance	x	x	x	x	*
Sediment agitation		x			
Vibration	x	x		x	
Collision risk with vessels / machines	x	x		x	
Risk of entanglement with cables		x			
Food availability	x	x		x	
Risk of contact with fuel or chemicals		x			
Risk of entanglement with waste products in the water					
Expecting less impact than while construction phase due to leaving the fundament		x		x	x
Benthos	x	x	x	x	x
Construction phase:					
Noise disturbance	x	x		x	x
Vibration	x	x		x	x
Habitat disturbance / Habitat loss	x	x	x	x	x
New habitat (hard structures)		x	x		
Sedimentation		x	x	x	x
Sediment agitation		x	x	x	x
Sediment / Seabed disturbance	x	x	x	x	x
Release of sediment bound contaminants			x	x	x

Species and Stressors EIA With temporal scale of stressors per species	The Netherlands	Belgium	Germany	England	Scotland
Risk of contact with fuel or chemicals					x
Exploitation phase:					
Noise disturbance	x	x			
Vibration	x	x			
Habitat disturbance / Habitat loss	x		x	x	x
New habitat (hard structure)	x	x	x	x	x
Indirect effects wind farm	x	x	x		
Change in physiochemical water quality		x			
Changes to the hydrodynamic regime			x		x
Electromagnetic fields due to cables		x	x		x
Heat effects due to cabling		x	x		x
Sediment / Seabed disturbance			x	x	x
Release of sediment bound contaminants				x	x
Risk of contact with fuel or chemicals					x
Sedimentation				x	x
Sediment agitation					x
Decommissioning phase:					
Noise disturbance	x	x		x	x
Vibration	x	x		x	x
Habitat disturbance / Habitat loss	x	x	x	x	x
Sediment / Seabed disturbance	x	x	x		
Sedimentation		x	x	x	x
Sediment agitation		x	x	x	x
Risk of contact with fuel or chemicals					x
Release of sediment bound contaminants			x	x	
Expecting less impact than while construction phase due to leaving the fundament		x			x
Fish	x	x	x	x	x
Construction phase:					
Noise disturbance	x	x	x	x	x
Vibration	x	x		x	x
Habitat loss / Habitat disturbance	x	x	x		x

Species and Stressors EIA With temporal scale of stressors per species	The Netherlands	Belgium	Germany	England	Scotland
Sediment / Seabed disturbance	x	x	x	x	x
Sedimentation		x	x	x	x
Sedimentation agitation		x	x	x	x
Risk of contact with fuel or chemicals					x
Release of sediment bound contaminants			x	x	x
Exploitation phase:					
Noise disturbance	x	x	x	x	x
Vibration	x	x	x	x	
Habitat loss / Habitat disturbance	x		x	x	x
Sediment / Seabed disturbance			x	x	
New habitat (hard structure)	x		x	x	x
Barrier effect			x		
Electromagnetic fields due to cables	x	x	x	x	x
Heat effects due to cabling		x	x		x
Indirect effects wind farm	x	x	x	x	
Changes in hydrodynamic regimes					x
Risk of contact with fuel or chemicals					x
Sedimentation				x	
Sediment agitation				x	
Decommissioning phase:					
Noise disturbance	x		x	x	x
Vibration	x			x	x
Sediment / Seabed disturbance	x		x		x
Habitat disturbance / Habitat loss	x	x	x	x	x
Sedimentation		x	x	x	x
Sediment agitation		x	x	x	x
Risk of contact with fuel or chemicals					x
Release of sediment bound contaminants			x	x	x
Expecting less impact than while construction phase due to leaving the fundament		x		x	x
Shellfish				x	x
Construction phase:					
Noise disturbance				x	x

Species and Stressors EIA With temporal scale of stressors per species	The Netherlands	Belgium	Germany	England	Scotland
Vibration				x	x
Habitat disturbance / Habitat loss				x	x
Sedimentation				x	x
Sediment agitation				x	x
Risk of contact with fuel or chemicals					x
Release of sediment bound contaminants				x	x
Exploitation phase:					
Noise disturbance				x	x
Habitat loss / Habitat disturbance				x	x
New habitat (hard structure)				x	x
Electromagnetic fields due to cables				x	x
Heat effects due to cabling					x
Sedimentation				x	
Sediment agitation				x	
Indirect effects wind farm				x	
Changes in hydrodynamic regimes					x
Risk of contact with fuel or chemicals					x
Decommissioning phase:					
Noise disturbance				x	x
Vibration				x	x
Habitat disturbance / Habitat loss				x	x
Sedimentation				x	x
Sedimentation agitation				x	x
Risk of contact with fuel or chemicals					x
Release of sediment bound contaminants				x	x
Expecting less impact than while construction phase due to leaving the fundament				x	x

* Scotland undertook consultation in respect of the marine mammal assessment by Marine Scotland Science and Scottish Natural Heritage. Due to the location of the development and the proposed foundation method (missing out the impact “piling”) the necessity of underwater noise assessment for marine mammals was, based on that consultation, excluded beforehand from the Forth Wind assessment,.

4.3 Other activities with pressures/ effects on those species and habitats

This paragraph focuses on how far the different spatial levels of cumulated ecological effects are taken into account within EIA's of the different North Sea countries (see the table below).

Table 8 Spatial scale of stressors cumulative effects EIA

Spatial Scale of Stressors Cumulative effects EIA	The Netherlands	Belgium	Germany	England	Scotland
Level 1 – The planned activity itself	x	x	x	x	x
Irrelevant in cumulative perspective					
Level 2 – Other but equal activity (Other offshore wind farm)	x	x	x	x	x
Licensed and planned	x	x	x		x
transboundary scope	x		x	x	
national scope		x	x		x
Level 3 – Other non-equal activities	x			x	x
Shipping (habitat loss)	x			x	x
Seismic research (noise disturbance)	x				
Marine protected areas and other closed or restricted areas					x
Aggregate dredging				x	
Oil and gas exploration and exploitation				x	x

The table below shows the stressors per species that are taken into account analyzing cumulative ecological effects on the different spatial and temporal levels. The stressors listed in the table below concern only those stressors that have been actually part of the estimation and validation within the analysis of cumulative ecological effects. With regard to cumulative effects during the decommissioning phase of a wind farm, the investigated North Sea countries usually refer to the same pressures as those that are expected during the construction phase. For this reason the stressors of the decommissioning phase are not listed separately in the table below.

Table 9 cumulative stressors taken into account per species EIA

Cumulative stressors taken into account per species EIA	The Netherlands	Belgium	Germany	England	Scotland
Level 2 – other offshore wind farms:	x	x	x	x	x
Birds	x	x	x	x	x
Construction phase:					
Habitat disturbance / loss			x		x
Exploitation phase:					
Collision risk	x	x	x	x	x
Habitat disturbance / Habitat loss	x	x	x	x	x
Barrier effect		x	x	x	x
Food availability				x	x

Cumulative stressors taken into account per species EIA	The Netherlands	Belgium	Germany	England	Scotland
Bats	x	x	x		
Exploitation phase:					
Collision risk	x	x	x		
Habitat disturbance / Habitat loss	x				
Marine Mammals	x	x	x	x	x
Construction phase:					
Habitat disturbance / Habitat loss	x		x		x
Noise disturbance	x	x	x	x	x
Vibration	x	x		x	
Food availability					x
Barrier effect				x	
Exploitation phase:					
Habitat disturbance / Habitat loss					x
Food availability		x			
Noise disturbance		x		x	
Vibration		x			
Barrier effect					
Electromagnetic fields due to cables					
Benthos		x	x		x
Construction phase:					
Habitat disturbance / loss		x	x		x
Sediment / Seabed disturbance		x	x		
Sediment agitation		x			x
Sedimentation					x
Release of sediment bound contaminants					x
Noise disturbance					x
Vibration					x
Exploitation phase:					
Indirect effect of wind farm		x			x
New habitat (hard structures)		x	x		x
Heat effects due to cabling			x		x
Electromagnetic fields due to cables					x
Fish		x	x	x	x
Construction phase:					
Habitat disturbance / loss		x	x	x	x
Noise disturbance		x		x	x
Vibration		x			x

Cumulative stressors taken into account per species EIA	The Netherlands	Belgium	Germany	England	Scotland
Sedimentation			x		x
Sediment agitation			x		x
Sediment / Seabed disturbance			x		
Exploitation phase:					
Indirect effects wind farm		x	x		
Noise disturbance			x		x
Vibration					x
Electromagnetic fields due to cables		x	x		
Habitat disturbance / Habitat loss			x		x
New habitat (hard structures)			x		x
Level 3 – other activities than offshore wind farms	x			x	x
Birds / Bats	x				
Shipping (habitat loss)	x				
Marine Mammals	x			x	x
Seismic research (noise disturbance)	x				
Shipping (habitat loss)				x	x
Marine protected and other closed or restricted areas					x
Aggregate dredging				x	
Oil and gas exploration and exploitation				x	x
Fish and Shellfish				x	x
Shipping (noise disturbance / vibration, chemical spills)				x	x
Aggregate dredging				x	
Oil and gas exploration and exploitation				x	x

The Netherlands investigate cumulative effects of planned / licensed offshore wind farms in the Southern North Sea, which counts as transboundary approach. All other activities that have not been included in the analysis of cumulative effects are considered as reference state.
Cumulative effects on fish and benthos from other wind parks are considered beforehand as not significant due to the distance. In future assessments it may be interesting to investigate the effect of the increasing introduction of hard substrate due to the rising number of offshore wind parks on the fauna diversity. Cumulative effects on marine mammals are only taken into account during the construction phase.

Belgium takes planned and licensed other offshore wind farms in the Belgian part of the North Sea into account when measuring cumulative ecological effects. The cumulative effects are investigated for each of the three different phases of a wind farm. The estimation of the impacts

of the cumulative effects is taking receptors into account concerning the whole Belgian part of the North Sea.

England has generally stated in the methodology of the EIA report that stressors of other activities that can lead to cumulative effects have to be taken into consideration. This includes other offshore wind farms, aggregate extraction and dredging, licensed disposal sites, navigation and shipping, existing and planned construction of sea cables and pipelines, potential port/ harbor development, oil and gas installations and onshore infrastructure projects. England bases the investigation for cumulative effects for each receptor group on generic advice beforehand. In present study only those stressors have been listed which have actually been evaluated and validated within the investigated EIA report.

Scotland takes planned and licensed offshore wind farms and other activities like oil and gas related activities within the Scottish territorial waters and also on the United Kingdom Continental Shelf, albeit only those in the vicinity of Scotland.

Germany takes other neighbored offshore wind farms (planned and licensed) into account for the estimation of cumulative ecological effects, regardless national boundaries. This also includes cumulative ecological effects due to the cabling of those wind farms.

4.4 Estimated ecological impacts of those pressures on species and habitats

This paragraph focuses on the methods/models that are used to estimate ecological impacts.

Table 10 Models used to estimate ecological impact

Models that are used	The Netherlands	Belgium	Germany	England	Scotland
BAND model (birds)	x	x		x	x
Bradbury – model (bats)	x				
iPCoD (marine mammals)	x	x		x	x
Source-pathway-receptor model				x	

The table above shows that the models used to assess the effects on birds and marine mammals are the same in most countries. The difference between relevant countries is that the Netherlands - in addition to the methods/models mentioned - also use the Bradbury model (bats). In assessing the impact on bats, the Netherlands rely on expert judgement instead of the BMU/Oikostat model. Germany does not use modeling approaches to assess the effects on different receptors.

England states within its EIA methodology that the impact assessment of each topic uses a source-pathway-receptor principle when considering the potential impacts due to offshore wind activities: The model identifies potential impacts resulting from the proposed activities on the environment and sensitive receptors within it. This process provides an easy to follow assessment route between impact sources and potentially sensitive receptors ensuring a transparent impact assessment. Sources are designated as the origin of a potential impact, pathways are designated as the means by which the effect of the activity could impact a

receptor and receptors are designated as the element of the receiving environment that is impacted.

In general this source-pathway-receptor model is also kind of used by other countries, despite not mentioned literally within their methodologies.

4.5 Evaluation of cumulative ecological effects

This paragraph focuses on the question how the significance of impacts is determined. The table below provides information about the approach for the determination of the significance of impacts per country. Besides that the table also refers to the spatial scale of receptors the impact is related to during the assessment.

Table 11 Significance of the impact

How is the significance of the impact determined regarding ecological effects?	Spatial Scale of species
The Netherlands	
The significance of the impact of effects on receptors is evaluated per effect per species according to the scheme below. The value of the single effects is assessed qualitatively and quantitatively if possible: Significant positive ++ / modest positive + / slightly positive + (nearly) no effect 0 Modest negative - / significant negative – The single values of possible effects according to the scheme above is assessed for the stressors of the planned activity per receptor (level 1). Based on the outcome conclusions are drawn about the significance of the effects. The significance of cumulative ecological effects is discussed qualitatively and quantitatively if possible per investigated stressor and receptor. Concerning cumulative ecological effects on birds and bats, the significance of effects is determined by the PBR-criterium (Potential Biological Removal). Concerning cumulative ecological effects on marine mammals the significance of impacts is determined by iPCoD calculation based on an estimated limit value for noise disturbance (Interim Population Consequences of Disturbance).	<u>Birds:</u> Number of bird victims of the population in the Southern North Sea was calculated and related to the PBR of the population in the Southern North Sea as well as the Dutch part of the North Sea. The populations taken into account are breeding birds and overwintering birds. <u>Marine mammals</u>: Effects on marine mammals are related to the population of the total North Sea as well as to the Dutch part of the North Sea.
Belgium	
The significance of the impact of effects on receptors is evaluated per effect per species according to the scheme below. The value of the single effects is	Effects are related to the Belgian part of the North Sea as well as the development-site of the planned activity.

How is the significance of the impact determined regarding ecological effects?	Spatial Scale of species
assessed qualitatively and quantitatively if possible: Significant positive ++ / modest positive + / slightly positive + (nearly) no effect 0 Modest negative - / significant negative -- The single values of possible effects according to the scheme above is assessed for the stressors of the planned activity per receptor (level 1) and translated into an average value. An average value is also given for relevant cumulative effects due to other wind farms (level 2) per receptor-group. Based on the outcomes conclusions are drawn about the significance of the (overall) impact on receptor-groups. Cumulative effects: In most cases the cumulative ecological effects result in the sum of the single effects per activity (1+1=2). Sometimes the cumulative effect differs from the sum, since the single effects can weaken or strengthen each other (1+1<2 or 1+1>2). In both cases the significance of the cumulative impact is discussed qualitatively and quantitatively if possible.	
Germany	
The significance of the (overall) impact of the offshore wind farm on a receptor-group is evaluated by using an “Impact significance matrix” which determines the impact on a receptor-group as: Impact (endangerment) / no impact The matrix takes the identification of the receptor’s value and sensitivity into account as well as the magnitude of the effects. To be able to draw conclusions about the significance of the (overall) impact of the activity on a specific receptor-group, the two components of the matrix have to be evaluated beforehand: an average value for the sensitivity of the different receptor-groups and an average value for the magnitude of every single effect on those receptor-groups. The average value is based on single values according to the scheme below: • The sensitivity of every receptor is evaluated as: high / modest / slightly	Birds: Since 2013, monitoring for birds is done in clusters, meaning that the survey area encompasses multiple wind farms in close vicinity to each other as well as an area around those wind farms which serves as reference area. The area in focus (in which the OWF in question is located) is assessed in terms of its function for resting birds, its uniqueness as a habitat, levels of other anthropogenic use and previous impacts etc. in relation to other parts of the EEZ . Based on this description/assessment of the area, a “forecasting” of potential significant impacts on resting birds is made. Migrating birds and resting birds are assessed separately. Monitoring of bird migration is performed using radar technology, acoustic monitoring and visual observations. Monitoring is done for a cluster of wind farms for autumn and spring migration separately. The site of an OWF and the surrounding area is described based on multiple parameters indicating the importance of

How is the significance of the impact determined regarding ecological effects?	Spatial Scale of species
• The magnitude of every possible effect on receptors is evaluated as: none / slightly / modest / high / very high The single values for the magnitudes of possible effects is assessed for the stressors of the planned activity (level 1). The significance of cumulative ecological effects is assessed qualitatively or quantitatively. Compulsory mitigation measures are always taken into account. For further details see description of cumulative effect assessment in SEAs (chapter 3.5).	a particular area/site for bird migration. The reference population for migratory bird species is the relevant biogeographic population. <u>Marine mammals:</u> Since 2013, visual/digital monitoring for marine mammals from planes and ships is done in clusters, meaning that the survey area encompasses multiple wind farms in close vicinity to each other as well as an area around those wind farms which serves as reference area. For harbour porpoises, also acoustic monitoring is performed. The site of a wind farm and the surrounding area are assessed in terms of its importance as habitat compared to other parts of the German North Sea region based on data. <u>Benthos and fish</u>: The abundance and distribution of fish- and benthos species are defined within the development-site of the planned activity and a reference area with comparable features. Effects are related to the population within these areas.
England	
The significance of the impact of single effects linked to the planned activity on a receptor is evaluated per effect by using an “Impact significance matrix” which determines the impact of the effect on a receptor as: Major / moderate / minor / negligible / no impact The matrix takes into account the identification of the receptor’s value and sensitivity as well as the magnitude of the single effects. To be able to draw conclusions about the significance of the impact of an effect on a receptor, those two components of the matrix have to be evaluated beforehand according to the scheme below: • The sensitivity of the receptor is evaluated as: high / medium / low / negligible • The magnitude of the potential effect on receptors is evaluated as: high / medium / low / negligible	<u>Birds:</u> The sensitivity of each species is determined on the size of its population whether it is of local, regional, national or international significance. Ornithological abundance and distribution is defined within a 4 km buffer zone around the development-site of the planned activity. Non-breeding as well as breeding species. Overwintering species, migrating species. <u>Marine mammals</u>: The individual study area is defined per marine mammals species (UK waters, North Sea). Transboundary impacts are taken into account especially for noise with 200 m radius around de development site. <u>Fish:</u> Following areas related to resource aspects for fish and shellfish in the East Anglia Zone are considered: Spawning grounds, nursery grounds, feeding grounds, shellfish production areas; overwintering areas for crustaceans and

How is the significance of the impact determined regarding ecological effects?	Spatial Scale of species
The single values according to the scheme above are assessed per stressor of the planned activity per receptor (level 1). The significance of cumulative ecological effects is discussed qualitatively and quantitatively if possible per investigated stressor where cumulative effects have been identified.	migration routes.
Scotland	
Forth Wind Offshore: The significance of the impact of effects linked to the planned activity on a receptor is evaluated for every potential effect by using an "Effect significance matrix" which determines the impact of the effect as: Major / moderate / minor / negligible / no impact The matrix takes into account the identification of the receptor's value and sensitivity as well as the magnitude of the single effects. To be able to draw conclusions about the significance of the impact of an effect on a receptor, those two components of the matrix have to be evaluated beforehand according to the scheme below: • The sensitivity of the receptor is evaluated as: high / medium / low / negligible • The magnitude of the potential effect on receptors is evaluated as: high / medium / low / negligible The single values according to the scheme above are assessed per stressor of the planned activity per receptor (level 1). The significance of cumulative ecological effects is discussed qualitatively and quantitatively if possible per investigated stressor. Beatrice: Significance from individual stressors is related to the magnitude of potential effects (evaluated as negligible, minor, moderate,..) For marine mammals also a distinction is made between short term and (medium and) long term effects	Forth Wind Offshore: Birds: The magnitude of an effect on a species is assessed in terms of the population for which the relevant area is designated. Effects on breeding bird populations are assessed in a regional context. Effects on non-breeding or passage bird populations are assessed in a national context. Marine mammals: Study area = East Coast of Scotland Benthos: Core study area was synonymous with the development site of the planned activity Fish: Effects on receptors are related to the following areas: key-spawning, nursery, feeding and over-wintering as well as pathways for potential migration. The researched geographical extent of the effects/receptors reaches from a site-specific to a national extent. Beatrice: Apart from effects on benthos, effects on other species are related to pressures on regional (Moray Firth) and national (North sea area) scale. For benthos only the Moray Firth region is considered .

4.6 Mitigating/preventing measures

This paragraph focuses on the question whether cumulated ecological effects are calculated with or without mitigation and/or preventing measures.

Table 12 Mitigating measures EIA

Country	Calculation with/without mitigating measures
Netherlands	• First assessment is on worst-case assumptions without mitigating measures. If significant effects cannot be excluded, mitigating measures are proposed and again assessed.
Belgium	• Depending on the study and probability of using mitigation techniques • No calculation with mitigating measures for birds (no mitigating measures are proposed) • Different scenarios have been calculated with regards to porpoises
Germany	• Compulsory mitigating measures are already included in the assessment beforehand (e.g. the choice of the location of the development site, noise mitigation, the choice of cables to reduce electromagnetic fields, choice of coating-ingredients,…) • Besides these embedded mitigating measures the first assessment is on worst-case assumptions without mitigating measures. • Additional mitigating measures are advised per aspect if relevant, but are not included in the assessment. It is mentioned that those measures can further reduce the significance of impacts that were assessed on worst-case assumptions.
England	• Embedded mitigation is incorporated into the project design where relevant. Impacts have then been assessed with this mitigation in place. This is listed per chapter. • Besides these embedded mitigating measures the first assessment is on worst-case assumptions without mitigating measures. • Where impacts are significant and additional mitigation is required, impacts are re-assessed and the post-mitigation or 'residual impact' identified. If the impact does not require mitigation (or none is possible) the residual impact will remain the same.
Scotland	• Embedded mitigation is incorporated into the project design where relevant. Impacts have then been assessed with this mitigation in place. This is listed per chapter. • Besides these embedded mitigating measures the first assessment is on worst-case assumptions without mitigating measures. Secondly a scenario with additional mitigating measures is assessed. • Both results are then presented at the cumulative scale, in which level 2 activities are assessed with a realistic worst case scenario.

The Netherlands firstly assess a realistic worst case scenario without the implementation of mitigating measures. Only if this assessment shows that there is a potential for significant effects, mitigating measures are presented, followed by new calculations including these measures. If the outcome of this assessment is that significant effects are excluded, these mitigating measures are strongly suggested to be part of the permit prescriptions.

Belgium proposes mitigating measures per effect per species, if necessary. Those mitigating measures are taken into account within the assessment of cumulated ecological effects (during the motivation for the significance of the cumulative effects).

England firstly assesses the (significance of the) impact based on a worst case scenario besides embedded mitigation measures. These are already incorporated in the project design and therefore also part of the assessment. If the impact is labeled as ‘major’ or ‘moderate’ mitigating measures are required. The impact will again be assessed with mitigating measures, which will be the ‘residual impact’.

Scotland assesses cumulative ecological effects in two steps. In the first step possible mitigating measures are not taken into account besides embedded mitigation measures. These are already incorporated in the project design and therefore also part of the assessment. In a second step possible mitigating measures are taken into account, which then results in the residual impact.

Germany includes compulsory mitigation measures into the assessment of cumulative ecological effects beforehand, since these measures are already included within the project design. Besides these compulsory mitigation measures the assessment is based on worst-case assumptions. After assessing the cumulative ecological effects other additional mitigation measures are proposed and their contribution for a possible reduction of the significance of impacts is discussed.

4.7 Knowledge gaps

This paragraph focusses on the identified knowledge gaps in the Environmental Impact Assessments and how the assessments treats these knowledge gaps.

Table 13 Knowledge gaps and methodology

Knowledge gaps and methodology	The Netherlands	Belgium	Germany	England	Scotland
Knowledge gaps mentioned per aspect	x	x	x	x	x
Knowledge gaps mentioned in cumulative respect	x	x	x		
Scoring of the effects (level 1) takes knowledge gaps into account	x		x		x
Scoring of the cumulative effects (level 2 and 3) takes knowledge gaps into account	x	x	x		

As the table above shows, each country has a different approach with regards to knowledge gaps.

Both Belgium and the Netherlands mention uncertainties on the possible effects (level 1) and cumulative effects between several offshore wind farms (level 2) and the combination with other marine activities (level 3). They refer to the knowledge gaps which are mentioned in the separate chapters in the EIA (single effects). Suggested is to prepare a monitoring scheme which needs to be carried out during the activity.

England does not systematically mention knowledge gaps per aspect. These are only mentioned when it is found relevant for setting the baseline situation (data sources). The assessment of cumulative effects does not include knowledge gaps.

Scotland: the Forth Wind Offshore report mentions data gaps before the level 1 effects are assessed. These gaps are only mentioned in the individual effect chapters (level 1), and are not focused on cumulative effects (levels 2 and 3). In the Beatrice NTS knowledge gaps are mentioned occasionally, not systematic.. Further details are given in the EIA report,

Germany systematically mentions knowledge gaps per aspect. Those mentioned uncertainties are taken into account when estimating the possible effects (level 1) as well as the cumulative effects between several offshore wind farms (level 2). In case of knowledge gaps the worst-case scenario is assumed and suggestions are given to prepare a monitoring scheme which needs to be carried out during the activity.

5 Conclusion

As expected, the researched relevant countries use both similar and different methodologies in their Impact Assessments. This short chapter presents the conclusions that can be drafted based upon the analysis as set out in the chapters above.

Strategic Environmental impact Assessments

The most common pressures are taken into account in every SEA by every country that is included in this study; collision risk, noise disturbance and the physical presence of the structure. Most countries also take barrier effects into account.

Germany and the Netherlands only assess the effects of those pressures relevant on a high strategic level. Belgium, Scotland and England do take up other pressures in their SEA's. England, Scotland and Germany do focus on the effects on fish. Germany investigate the effects on protected areas in the SEAs as "Verträglichkeitsstudie". Concerning transboundary effects, only Belgium, Germany and England do investigate the cumulative effects of wind farms outside their territory. Belgium and England investigate the cumulative effects of other transboundary activities

Environmental Impact Assessment

All countries cover all the same species in their assessment, only Scotland adds the effects on shellfish to their assessment and only Belgium and the Netherlands take the effects on bats into account.

Important differences are seen in the ways the EIA's deal with cumulative effects on species that are of main concern to their country. This is often linked to specific habitat areas and receptors that have a potential effect. The same accounts for differences in spatial scale. There is often focused on the national EEZ. Assessment of transboundary effects are often missing.

Planned, licensed and existing wind farms are included in most calculations, but the stressors of other activities not always. In short, all assessments do thoroughly cover the effects on levels 1 and 2. Level 3 effects are not taken into account in all countries. All countries but Germany, use the same models in predicting (quantitative) effects on birds and marine mammals. The Netherlands add a model to assess the effects on bats.

The countries deal differently with the significance of the potential effects. This results in a lack of comparative results, because when no significant effect is expected, the methodology often requires no further calculation. This results in the lack of a cumulative impact assessment on all relevant receptors for all countries, which includes detailed calculations on all level 1,2 and 3 stressors.

Concluding:

The analysis and comparison of the different approaches to assess cumulative effects in the different North Sea countries shows that there are many similarities with regards to the species considered and that the most common pressures are taken into account in every SEA. Concerning transboundary effects, only a few countries do investigate the cumulative effects of wind farms outside their territory. There are also some major differences in the approaches applied by countries, e.g. quantitative vs. qualitative approaches. SEANSE respects each other's approaches and advises to continue to work on knowledge exchange and the development of a broader, more coherent assessment methodology to enable discussions on how to evaluate, mitigate, and monitor cumulative effects of future wind farm developments in the North Sea.