Addressing Environmental Impacts within Decision-making Processes of Offshore Wind Farms

A Comparison between The Netherlands and Germany

Master Thesis

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Double Master Degree

Water and Coastal Management
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Abstract

The production of offshore wind energy is a young field gaining in importance in countries, like The Netherlands and Germany, concentrating on renewable energies for the energy supply in future. But due to a high pressure on the marine environment of the North Sea by many activities causing a partly intensive use and the few experiences in planning and constructing offshore wind farms resulting in a lack of knowledge about impacts on the marine environment as well as missing standards against the background of political pressure on constructing offshore wind farms an improvement is necessary. The challenge is to indicate and assess the main impacts and to ensure they are addressed within an information-based decision-making process as well as by measures avoiding and minimising negative impacts, to know changes caused and, hence, protect the marine environment. Another point is the development of mitigating measures and an exchange of knowledge between countries.

The thesis takes a look at two offshore wind farm projects, showing and comparing the praxis in The Netherlands and Germany. The impacts including cumulative impacts assessed, measures addressed within the projects as well as the legal base, including standards, steps taken and stakeholder involved within the decision-making process about the authorisation of the projects are evaluated. After comparing the praxis of the two projects, recommendations for improvements of the praxis (regarding measures, impacts addressed, standards, stakeholder involved) as well as to push the exchange of data and knowledge on national, but especially on international level, are given.

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Chapter I: Introduction, recognising problems and the approach

1. Introduction

“The marine environment is a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive” (Marine Strategy Framework Directive, Recital 3).

As stated in the European Directive for the protection of the oceans and seas, an important aim for all countries is the protection, preservation and, hence, a sustainable use which includes an avoidance of negative impacts caused by human activities. Human activities, in general, cause changes within the environment, but especially large-scale projects have effects which are often hard to predict. The ecosystems of the seas and oceans are not fully understood and large gaps of knowledge make preliminary studies about impacts often difficult (Köller et al., 2006). Beside basic research, different environmental policy instruments are important within the planning and licensing process of the project. The environmental impact assessment (EIA) is (besides others) an important tool to ensure that possible impacts are known, discussed and a base for decision-making (Peters et al., 2008). Furthermore, requirements and measures are made up which have to be met to avoid and minimise negative impacts and protect the environment (Storz et al., 2009).

A good example to show how negative impacts on the marine environment are addressed within a decision-making process about the authorisation of a large project are offshore wind farms. Wind energy is a renewable energy, a so called “environmentally friendly” technology, which is going to make a big contribution to the energy production in future (BMU, 2007). Nowadays, offshore wind energy does not play an important role for the electricity supply, but in Germany as well as in The Netherlands there are plans for expanding the electricity production by offshore wind energy (Federal government, 2010; Noordzeeloket, 2010). Future perspectives show a fast growing rate of wind farms in the German and Dutch North Sea. But even it is called environmentally friendly, it causes negative impacts on the marine environment.

In order to prove the project is ecologically compatible, both countries have developed a legal base, standards, take measures and gather knowledge about effects on the environment. But as offshore wind energy is a very young technology, nowadays, the main problems which have to be addressed are the lack of basic knowledge and experiences regarding the changes and impacts the wind farms cause on the marine environment. As discussed below, data need to be collected, tools developed and improved which ensure the impacts are getting addressed within the decision-making process. Especially in the light of high political pressure on realisation of wind farms need to be ensured that impacts are considered and projects rejected if they harm the environment significantly. Also measures have to be developed and stipulated to avoid, minimise or compensate impacts. This thesis shows how changes caused by the installation of offshore wind farms, causing negative and positive, direct and indirect impacts, are addressed within the licensing procedure in Germany and The Netherlands. As explained below, the focus lays on the impacts addressed, important for the decision-making about the environmental compatibility of the project as well as measures taken to minimise and avoid negative ones. But also an overview of the legal base and standards developed and used in both countries is given.

In the case of offshore wind farms, the presence, construction, operation and removal of the turbines cause positive, negative, direct and indirect impacts (OSPAR, 2008). One big problem is the demand of space of offshore wind farms as the North Sea is already used quite intensive (BSH, 2009a). Specific impacts and, especially, long-term effects of those projects on the marine environment, particularly on the ecosystem, are largely unknown, whereas uncertainties are also caused by a lack of basic knowledge about the marine ecosystems (Köller et al., 2006). Therefore, with the growing interest on the development of offshore wind farms research on impacts started to be made. Within the last years data have been collected in research projects, environmental impact assessments and monitoring programmes at already built and operating offshore wind farms, e.g., in the UK and Denmark. In the German and Dutch North Sea research focuses mainly on migrating birds, sea birds, marine mammals, fish and benthos. Two big issues are the noise emission into the water body while pile driving with large impacts on marine mammals and fishes on one hand and the collisions risk of migrating birds with the rotating blades of wind turbines on the other hand. Furthermore, hydrodynamics, sediment dynamics, effects on the seabed and sea water quality as well as interactions between these factors and human beings need to be considered (Köller et al., 2006). Especially data about these very significant effects have been collected, but there are still many open questions about details and other impacts which are partly not studied further or not even known yet. To ensure the impacts are met, monitor to collect experiences and ensure this knowledge builds the base for the decision-making about the authorisation of new offshore wind farm and other projects with similar effects.

"At the scale of development in 2008, national and international controls are in place to ensure that the environmental impacts associated with offshore wind-farm developments are appropriately evaluated and managed. The main instruments are the Strategic Environmental Assessments and Environmental Impact Assessments" (OSPAR, 2008, p.4).

For the decision-making about the project authorisation it is important to know the impacts different activities are causing. To close gaps of basic knowledge and knowledge about the effects of wind farms on the marine environment, beside research projects the environmental impacts assessments (EIA) is an important instrument to ensure the interests of the environment are protected and is therewith an important base for decision-making (OSPAR, 2008). Within the European Union, the Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (EIA Directive) requires for specific projects an assessment of environmental conditions and possible impacts on protected assets. Implemented into national law, in Germany and The Netherlands the building and operation of offshore wind farms can only be permitted when an environmental impact assessment is done. It clarifies if the project harms the marine environment. Protected assets defined by the EIA Directive are flora and fauna, human being, soil, water, air, climate, interaction of these assets, landscape and cultural heritage. The way of decision-making bases on a licensing system, including an EIA, taking into account international treatise, EU directives, marine spatial planning, national laws and other instruments introduced briefly later. A permit is only given if the project does not harm the marine environment and specific requirements are met. In The Netherlands and Germany the ways are quite similar, but with a few important differences (BSH, 2005; Noordzeeloket 2010; Rijkswaterstaat Dienst Nordzee, 2010). Addressing impacts of offshore wind farms on an earlier, strategic level within the Strategic

Environmental Assessments (SEA) is not taken into account further within this thesis, as the focus lays on the decision-making about the environmental compatibility of the project within the licensing process.

On international as well as on national scale there exist instruments which are used for the assessment, analysis and mitigation of potential negative impacts on the marine environment. But as the rate of offshore wind farm developments is growing in future, the pressure on the marine environment and their ecosystems will grow and new instruments or their improvement in practice are needed (Peters et al., 2008). Aims of the instruments should be a sustainable use and to weigh up alternatives to keep negative effects low and safeguard a protection of the marine environment, to ensure a healthy and productive sea.

Offshore wind farms are mostly planned outside the territorial waters in the Exclusive Economic Zone (EEZ), an area outside the full sovereignty of the state, inter alia under jurisdiction of international laws. An important convention is The United Nations Convention on the Law of the Sea which defines maritime zones for coastal states with different national jurisdictions, rights, duties and management responsibilities (UN, 1982). It needs to be taken into consideration when planning offshore wind farms. Within the territorial sea national laws are to be applied and planning proceeds like inland. This is different in the EEZ which affects the national jurisdiction as well as the planning practice. Project planning, licensing, decision-making, management and in the end also the consideration of environmental impacts are made under special jurisdiction by the Federal government (BSH, 2005; Rijkswaterstaat Dienst Noordzee, 2006).

The expansion of renewable energies, especially offshore wind energy, is a key element of the energy strategies in many countries, like The Netherlands and Germany. Due to the “National renewable energy action plan” (Federal government, 2010) it safeguards the energy supply in future by making countries independent of fossil fuels, diversifying the energy mix or just as new diverse energy sources. The reduction of carbon emissions to meet international obligations on climate change mitigation or the independence of nuclear energy are also seen as major advantages of renewable energies compared to conventional power plants. The national goal of the German Federal Government is a contribution of renewable energies to the energy supply of at least 18% until 2020 (Federal government, 2010). The aim of the Dutch government is an energy supply of 10% delivered by renewable energy until 2020 (Storz et al., 2009). As a goal of the German government, the contribution of offshore wind energy to the energy supply should rise continuously to at least 15% (reference year 1998) until 2030, which means an installed offshore output of between 20.000 and 25.000 MW (BMU, 2007). In The Netherlands 20% (6000MW) of the electricity demand should be covered by offshore wind energy till 2020 (Noordzeeloket, 2010). According to these ambitious plans, the political pressure on the realisation of offshore wind farm projects is quite high. Hence, also the increasing risk of overlooking impacts or ignoring their significance need to be seen.

Although there are many different impacts of offshore wind farms, it is not the objective of this thesis to take into account all issues and activities affected, like economical, social or political ones. Also not all environmental assets are discussed. The research will concentrate on physical impacts on the marine ecosystem as they have an important role in decision-making but are not yet fully understood (Schuchardt et al., 2009; BioConsult SH, 2009; Brandt et al., 2009; BSH, 2009; Köller et al., 2006; OSPAR, 2008; Storz et al., 2009 and others). Requirements, measures and standards for assessing and mitigating impacts were developed over years and are still a challenge (OSPAR 2008; Köller et al., 2006; Peters et al., 2008; Peters, 2011). As mentioned, according to the European EIA Directive impacts need to be taken into consideration when planning large scale projects. The German *Marine Facilities Ordinance* (SeeAnlV), for instance, requires that with the approval procedure for offshore wind turbines in the exclusive economic zone (EEZ) it needs to be ensured that the project is not detrimental to the marine environment. According to this ordinance, the project can not be authorised, if it harms the marine environment and its protected assets significantly. But which impacts are currently known and discussed, are crucial for decision-making and which are taken into consideration when coming up with requirements and measures avoiding or minimising negative impacts for the construction and operation of offshore wind farms? Especially in the face of a fast growing rate and scale of wind farms and therewith a growing pressure on the already densely used sea, impacts need to be known, requirements and standards are necessary to make the licensing process more efficient and ensure the impacts on the marine ecosystems are limited (OSPAR, 2008; Köller et al., 2006; Peters et al., 2008).

Studies were made, e.g., by Köller et al. (2006) considering impacts and affected protected assets to be addressed within the decision-making process about the impairment of the marine environment and the refusal or authorisation of the project. The focus lays on defining the contents of the EIA which is the most important instrument to address impacts of a specific project. The content of the EIA for offshore wind farms gets defined by every country bringing it in line with their legal, but also with the natural base (Köller et al., 2006; Peters et al., 2008). But as the use of wind farms offshore is a young field and offshore wind farms are a young technology there are still many gaps of knowledge about impacts and a necessity of improvements due to these gaps (Storz et al., 2009; OSPAR, 2008; Köller et al., 2006). It is important to know the changes offshore wind farms cause to base the decision about the project authorisation on broad information and, hence, ensure a sustainable use and protect the ecosystems of the seas and oceans we are depending on. Experiences need to be made and data collected in research projects, while planning and while monitoring the construction and operating offshore wind farms. Important for collecting this knowledge are, besides the monitoring programmes, assessments (EIA) made during the planning process of offshore wind farms using current literature and databases (OSPAR, 2008). The missing data are often basic ones about the abundance, migration or occurrence of species and hence important when trying to understand the marine ecosystem as well as the short-term and long-term effects of offshore wind farms on these ecosystem. The new experiences made and new data collected need to be implemented and considered within the decision-making. Hence, it is important to ask where the used instruments (like EIA, licensing system) could get improved. With the development of knowledge also the instruments need to develop, e.g., the content of the EIA has to go with the knowledge and new tools and methods for addressing cumulative effects need to be developed.

Especially as many offshore wind farms are planned in future, it needs to be asked for efficient instruments on one hand, but on the other hand all affected protected assets need to be considered. In the end it is necessary to find a balance between these different demands. Furthermore, requirements and new measures to avoid or minimise impacts need to be developed, discussed and used. Also a challenge is the addressment of cumulative effects, like further discussed in Peters et al. (2008). Single impacts on a protected asset which are seen as insignificant can add up and impair this asset strongly in the end. These cumulations of impacts are hard to consider and not yet addressed sufficiently in the current decision-making process and its documents (Peters et al., 2008). According to Storz et al. (2009), a method needs to be developed helping to consider cumulative effects. The biggest gaps of knowledge regard cumulative effects of different offshore wind farms as well as cumulative effects of offshore wind farms and other uses. Nevertheless, or maybe especially due to this gap, cumulative effects are important to consider as these effects can harm the environment strongly and could be a reason for the refusal of a project authorisation (Peters et al., 2008).

To push an improvement of instruments and gather knowledge it can be helpful to look at the praxis in other countries and compare it. A comparison of which impacts are addressed in both countries, The Netherlands and Germany, can be useful to address gaps of knowledge and uncertainties regarding impacts due to missing experiences within this young field. Also new inspirations for mitigating measures can be given. Furthermore, getting a short insight into the praxis of how the EIA and decisions are made in both countries can be useful to make the own procedure more efficient. “BARD Offshore NL 1” in The Netherlands and the German offshore wind farm “MEG Offshore I” are chosen as examples as they are comparable in some points. Both projects are relatively young, authorised recently, located close to each other in the North Sea within the EEZ of Germany and The Netherlands. In addition, the two countries are suitable as both are members of the European Union and are therewith bound to the same directives.

1.2 Research objective and questions

Objective

Germany and The Netherlands are two of many countries dependent on the North Sea. It is used intensively for many different activities causing changes which are having positive as well as negative impacts on the marine environment. Now the energy sector is finding its way into the North Sea with a quite new technology, offshore wind farms. To ensure the well-being of the seas, protect their ecosystems and avoid a loss of biodiversity we need to know possible impacts, need rules and instruments for the use and an integrated

management of the North Sea. This thesis should show which of the known impacts are considered in the decision-making process and which requirements and measures are used to avoid or minimise negative impacts on the environment and its protected assets.
By showing impacts and evaluate which impacts are addressed, it should contribute to knowledge and understanding of how the countries are dealing with impacts and where the gaps in addressing them are. By comparing impacts and the way to deal with them in Germany and The Netherlands, an understanding between the countries should be pushed as a base to learn from each other and a border cross cooperation as environmental impacts do not stop at political borders. The main goal to be pushed forward with the thesis is any possible improvements of instruments for both countries, The Netherlands and Germany, which are pointed out in the end.

Our basic knowledge about the marine ecosystem and effects of offshore wind farms on these ecosystems is limited. But to install such a large project like an offshore wind farm it needs - due to international law, EU law and national law – to be ensured that the marine environment and its protected assets are not harmed significantly. Every country is responsible for the environmental protection of its territory and “entrusted” areas (like EEZ) and tries to ensure the demands of the environment are taken into account as a part of the decision-making by putting into practice different instruments. An important instrument is the EIA and as part of it an area specific assessment taking into account targets of Natura 2000 areas and the protection of species. For the final decision, to weight up the effects and see if the project is ecologically compatible a licensing text is drawn. But to do justice to all factors of the marine environment is not easy with many gaps of knowledge causing uncertainty. Guidelines have been developed for the EIA, based on current research results giving advices about which impacts and protected assets have to be taken into account (Köller et al., 2006). Still a problem is the assessment of cumulative effects which are hard to assess, even harder with gaps of knowledge. According to Zeelenberg (2005), especially cumulative effects are a challenge, as they can cause significant impacts on protected assets but are often not taken into consideration in documents important for decision-making about the environmental compatibility of a project.

In this context, the main problem when aiming to protect the marine environment is that offshore wind energy is a young technology with limited experiences about their impacts, uncertainties, gaps in basic knowledge about ecosystems and the need of more measures, for instance, to minimise noise emissions during pile driving. Also the consideration of impacts within the decision-making process and the documents is a challenge as all possible impacts important for the decision-making need to be taken into account (Köller et al., 2006; Peters et al., 2008; OSPAR, 2008). But which are the most important, most significant impacts? The improvement of knowledge and minimisation of impacts on the marine environment of this future technology is a current challenges.

Therefore, it is interesting to see how different countries deal with it, the decision-making base, legal aspects, the stakeholder, but especially the impacts considered and having an influence on the decision about the ecologically compatibility of the project and about the measures to be taken to avoid or minimise negative impacts. This is what this thesis is going to do, the practice in the Netherlands and Germany are compared, gaps in addressing impacts, cumulative effects and measures taken are shown. It is also interesting to compare the practice of the two countries as both countries are member states of the EU and see how the different states are dealing with regulations in praxis. This thesis is also a review, looking at the current state of how impacts are getting addressed and which are crucial for decision-making. This is an important step for the improvement of the praxis, which is again important as offshore wind energy is a future technology and many more wind farms are going to be build in future, building a new base for the energy supply, affecting the marine environment lasting. The results of the thesis can contribute to the improvement of the current praxis of addressing impacts within the decision-making process. It can be helpful for improving the EIS or measures taken by taking inspirations from other country, looking “over the rim of the own teacup”. Offices making EIAs for offshore wind farms or the authority deciding about the project authorisation can use it therefore. As it is a comparative study it is also meant to push the understanding between countries, especially member states of the European Union growing together more and more (Fauldi, 2005) and enable a common European method for addressing impacts of offshore wind farms in future.

Questions

The main questions addressed here are: (1) which impacts caused by offshore wind farms currently discussed, are crucial for the decision-making about the environmental compatibility of the project and hence for its authorisation in Germany and The Netherlands? (2) Which impacts are taken into consideration in these countries when coming up with requirements and measures for the construction, operation and removal of offshore wind farms? Which measures are taken to mitigate these impacts?

To answer these questions, other basic questions have to be answered first. In chapter II a first part deals with the question: which instruments and legal bases are dealing with environmental impacts on the international level? This overview helps also to clarify on which instruments to look at when searching for impacts addressed in the decision-making process. Another important question to get a general overview of impacts discussed and, hence, to look for in the documents is: What are expected environmental impacts found in the literature and addressed in preliminary studies?

When studying how environmental impacts are addressed within decision-making processes of offshore wind farms, the main questions stated above have to be asked more precisely and further questions have to be asked. More concretely, the issues discussed and questions to be answered within this thesis, mainly addressed in chapter III and IV, are:

(1) (a) Which environmental impacts of offshore wind farms are getting addressed within the decision-making process in The Netherlands and Germany? This question gets addressed by analysing the EIS and the licensing text of two offshore wind farm projects, each in one country. Later on, a short look is also taken at impacts discussed within the area specific assessments. It needs to be asked: which impacts are seen as crucial for the decision in the end? To answer this question it needs to be asked: Which impacts are mainly focused on in the EIS? And especially, which impacts are finally discussed in the licensing text? To see the detail and range of impacts discussed: Which impacts are not taken into consideration compared to impacts found in literature and compared to the other country? How detailed are they described?

(1) (b) When talking about impacts of offshore wind farms, not only the impacts of single sources on the different protected assets need to be considered, but also the cumulation of different impacts caused by the same or different sources on one protected asset. This is known as cumulative effects which should have an important role for the decision-making, but are often not getting addressed adequately as they are hard to consider. So the questions are: are they addressed and if so, how detailed?

Regarding the measures taken to protect the marine environment and its protected assets the following issues are interesting: (2) Which measures and requirements need to be met to avoid and minimise or compensate impacts? Which impacts are addressed by which measures? Regarding the minimisation and avoidance of impacts, which impacts are mainly addressed by which measures? Are there requirements or measures taken addressing cumulative effects?

An important part when talking about how impacts on the environment are getting addressed is a brief look at the praxis in both countries, including the legal base, stakeholder involved, steps taken until the final decision as well as the documents EIS, licensing text and area specific assessment serving as the base for the analysis. One pile this thesis bases on is that all impacts taken into consideration within the decision-making are written down and discussed intensively in this documents (Storz et al., 2009). So, which are the standards for the EIA in both countries making a first selection about impacts addressed? Who is taking this decision by developing the guidelines? Who are the most important stakeholder and which are the main steps taken within the licensing process?

In the end the results of both countries are compared: Which are the main differences between the outcomes of both countries? Can they learn form each other?

1.3 Research method

This thesis basically contains an overview and introduction to the topic in chapter I, chapter II gives an insight into marine environmental impacts of offshore wind farms recently discussed in literature summarised in a table which builds the structure for the analysis of documents addressed within this thesis. Furthermore, a brief view is taken on the legal base, on EU and international level, which is used to define assets to be protected and taken into consideration for decision-making. In chapter III the German offshore wind farm project “MEG Offshore 1” and in chapter IV the Dutch offshore wind farm project “BARD Offshore NL I” are analysed An analysis of the EIS and licensing texts of each offshore wind farm projects is made. Also stakeholder involved within this decision-making and and steps to be taken are described briefly. In chapter V a comparison of the praxis in both countries is made.

The comparative analysis used here can show gaps, ideas for a better practice, countries can learn from each other and understand each other which is important for cooperative or cross-border work, EU work and directives. Also Faludi (2005) in “Comparative Planning Cultures” points out the necessity of comparative work. “As European integration progresses”, joined decisions, for instance on policies regarding environmental protection, need to be made in negotiation rounds joined by member states with sometimes very different planning systems.

In **chapter I** a first overview is given with an introduction, research objective and questions to answer and the research method which should give an overview and explain the steps taken to come to a conclusion in the end.

Chapter II contains information about environmental impacts and the legal background. It starts with an overview of relevant EU Directives and international treaties which build a base for considering environmental impacts in decision-making processes of large projects. The definition of protected assets by the so called EIA Directive is also a base for structuring the part about environmental impacts of this chapter. In that part effects on the marine environment expected for the North Sea caused by the construction, operation or removal of offshore wind farms which can be found in the literature, like books, journal articles, reports, case studies, environmental impact assessments or monitoring programmes, will be introduced. Effects on the protected assets (according to EIA Directive) marine mammals, birds, fish, benthos, the flora but also abiotic factors like hydrodynamics and sediment dynamics as well as human being are outlined and explained briefly. The conclusions are summarised in a table which delivers a good overview of affected assets with the respective sources of impacts and potential impacts for each asset. Further, this table serves as the main structure for the analysis made in chapter four.

In chapter III and IV two offshore wind farms, “MEG Offshore I” in Germany (chapter III) and “BARD Offshore NL 1” in The Netherlands (chapter IV), are used as an example to show which impacts are discussed and crucial for the decision-making of the environmental compatibility of the project. Also requirements and measures used in practice addressing these impacts are described. The countries Germany and The Netherlands are chosen to show the practice in countries with a future in offshore wind energy and a quite developed planning systems. The two offshore wind farms are appropriate as they are recently approved and therewith contain (more or less) the current knowledge about impacts and reflect the actual licensing and planning system, requirements and measures.

These chapters start with the background of a legal frame and approval procedure in Germany and The Netherlands nowadays. Also a brief overview of stakeholder involved in decision-making and steps taken within the approval procedure is given. Furthermore, the project area and relevant data will be introduced. The classification of impacted assets and sources of impacts developed in chapter II will serve as the main structure of the analysis. The research bases mainly on documents of the wind farms “MEG Offshore I” in Germany and “BARD Offshore NL 1” in The Netherlands. The EIS, including an area specific assessment and the licensing text will be analysed for each country to get an overview of which impacts are discussed and serve as a base for a decision about the environmental compatibility of the project and therewith about its authorisation in the end. A closer look will be taken for how detailed the impacts are discussed. A valuation system (described in the annexe) should give the reader a quick overview of the importance the different impacts are getting in the documents of both cases. Further, the requirements and measures mentioned in the EIS, the area specific assessment and the licensing text will be listed as well.

In chapter V the results of the analysis of the German case and the Dutch case are compared. A comparison of the practice in both countries is very useful to learn from each other. To analyse the similarities and differences can also be quite useful to improve knowledge about impacts and ways to deal with them.

A conclusion, an outlook and recommendations are given in **chapter VI**.

This thesis is a content analysis basing on a literature study. The literature study is necessary to get an overview of the main impacts offshore wind farms cause which are known and discussed recently in literature. Furthermore, an insight into problems of addressing these impacts, an overview of the legal base, different steps taken and stakeholder involved into decision-making can be given. All these information are necessary for the interpretation of the results in the end. The main sources providing these informations are books, journal articles, research reports, environmental impact assessments and further documents as well as different web pages. Important bodies providing the necessary documents for the content analysis, the EIS and the licensing text of each project, are the BSH in Germany and the Ministry for Transport, Public Works and Water Management, more specific the DNZ, in The Netherlands. Furthermore, BioConsult SH doing environmental impact assessments and further research projects on impacts of offshore wind farms on the marine ecosystems delivered useful information about environmental impacts.

Chapter II: Offshore wind farms, their environmental impacts and the legal background

There are many sources which cause different impacts at different periods of time and on different areas on the marine environment and its protected assets. The wind farms itself, the turbines including the rotor blades, mast, piles, foundation, scour protection, facility lightning, but also electric submarine cable and the boat and air traffic are having effects on flora and fauna, water, soil, landscape and human beings. The construction, operation and removal as well as the physical presence of the wind farm have serious positive and negative, direct and indirect impacts as well as cumulative effects on the marine environment above and below sea level. All of these mentioned impacts are considered here. Impact factors are, for instance, noise and light emissions or the introduction of artificial substrate into the sea. Their intensity depends very much on the technological and conceptual quality of different elements of the offshore wind farm. It is possible to soften these impact factors, for example, by the use of technological measures, like bubble curtains around the pile during pile driving, to minimise noise emissions. To ensure the best quality to avoid and minimise the damage and conserve and protect the marine environment policy instruments can be used forcing the actors with legal measures or giving incentives. Impacts need to be known and taken into account within the decision-making about large projects, like offshore wind farms.

This theoretical chapter describes, based on a literature research, sources of impacts, possible impact factors and the expected negative impacts on the marine environment, more precisely the biological, physical and chemical impacts as well as effects on human beings. The protected assets taken into account in this thesis are a choice of many based on the definition of protected assets in the Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (EIA Directive) and protected assets discussed in the literature. The EIA Directive is seen as an appropriate base, as with The Netherlands and Germany two EU member states are compared. This directive is the main baseline for assessing impacts in both countries and makes it comparable in the end. The choice is limited to protected assets and impacts relevant for the marine ecosystem, which explains why other in the EIA Directive mentioned assets are not taken into consideration in this thesis. Impacts on cultural heritage, the landscape and partly on human beings, like socio-economic effects, are not mentioned here. These impacts are social aspects and not directly relevant for the marine ecosystem. Furthermore, as this list of protected assets defined by the EIA Directive is a list of political choices already, further assets or other relevant issues found in literature currently, dealing with impacts are also included. Important issues in this context are the cumulative effects of offshore wind farms and the effect on nature conservation areas, especially Natura 2000 areas (Schuchardt et al., 2009).

The EIA Directive is one important policy instrument of many to manage and control impacts on the environment by large projects. Besides impacts on protected assets, these instruments are also briefly introduced in this chapter.
The results of this theoretical part are serving as the base for the empirical part, building an analysis structure used for the content analysis (annexe). They are listed in a table in the end of this chapter, consisting of an overview of important affected environmental assets, sources of impacts and impacting factors. The findings of this theoretical part are, furthermore, helpful for the interpretation of the outcomes of the content analysis of the documents EIS and licensing text in the end. This content analysis of the documents shows which of these impacts discussed in literature are addressed within the decision-making by looking for which impacts are found in the documents and how detailed which impacts on which protected assets are discussed. It also builds a base for looking at cumulative effects addressed within the documents and measures avoiding or minimising negative impacts on the environment. Which impacts are mainly addressed and by which measures?

2.1 International conventions and EU Directives

When planning an offshore wind farms national laws as well as international directives and conventions protecting the marine environment need to be taken into consideration. EU directives and international conventions and agreements are safeguarding environmental protection in Europe and worldwide. Especially the strong role of the EU is increasingly influencing and steering environmental protection issues of its member states (Christiansen, 2009). In the following text, the most important international conventions and EU directives are introduced with the view on their role in considering and avoiding impacts on the marine environment. An overview of the national legislation (including the implementation of these directives into national law) of Germany and The Netherlands will be given in chapter III and IV.

a) The United Nations Convention on the Law of the Sea

As the wind farms are build offshore in the North Sea the *United Nations Convention on the Law of the Sea* (UNCLOS) gets applied. It defines maritime zones for coastal states with different national jurisdictions, rights, duties and management responsibilities named internal waters, territorial sea, contiguous zone, exclusive economic zone and continental shelf. It includes the air space, water surface, water column, sea bed as well as its subsoil. It contains regulations about navigation and passage of foreign ships, use of resources, responsibilities for management tasks, protection of the marine environment, or settlement of disputes, to name just a few (UN, 1982).

As offshore wind farms are build within the exclusive economic zone (EEZ) the jurisdiction within this zone is important. The EEZ is an area which should not extend beyond 200 nautical miles from the baseline. Within this area the state does not have the full sovereignty. It has a specific legal regime and gives a state the sovereign rights of explore, exploit, conserve and manage all natural resources as well as for other activities of economic interest like energy production (including offshore wind energy), scientific research, and protection of the marine environment. Important for this zone is the freedom of navigation and overflight and laying of submarine cables and pipelines, but the states acting in this zone need to pay regard to national rights and duties of the coastal state. States can install offshore wind farms within their own EEZ and are at the same time responsible for a protection of the marine environment (UN, 1982).

But UNCLOS is just a base when its about addressing environmental impacts. It regulates which state is responsible for which area, but it does not ensure the safety and protection of the marine environment and a sustainable use of resources or meets the development aims, spacial targets and principles of every country. The principles and goals regarding environmental protection are implemented and specified in other laws and conventions (Art. 237 (2) UNCLOS, UN, 1982). In this view, marine spatial planning, the EIA Directive, the Habitats and Birds Directive or the OSPAR Convention are other more important instruments in the light of marine environmental protection.

b) Marine spatial planning

Marine spatial planning (MSP) is meant to solve problems on a smaller scale within a specific defined area. It sets special targets of spacial planning to contribute mainly to an environmental protection, safety of the sea, an economic development and especially a sustainable use of resources within one country. The main stimulating factors for marine spatial planning in the German and Dutch EEZ were the fast growing development of offshore wind farms and the designation of marine protected areas. In case of offshore wind farms, many applications were handed in overlapping with other uses in the same area, like conservation areas. The demand of managing all these different interests leaded to the development of a spatial plan for the EEZ in the end (Marine Spatial Planning Initiative, 2010).

Marine spatial planning within the Exclusive Economic Zone (EEZ) is a very young field. The Spatial Plan for the German EEZ in the North Sea, for instance, was drawn in the form of an Ordinance on Spatial Planning in the German Executive Economic Zone in the North Sea in September 2009 (Federal Ministry of Transport, Building and Urban Affairs, 2009). It manages the space of a densely used North Sea, taking into account the different activities and, e.g., demands of conservation of nature and natural resources. Impacts on the environment are not addressed directly here, but can be avoided by declaring nature protection areas prohibiting other activities within this area. In Germany, for instance, zones with priority areas for offshore wind energy outside of MPA and Natura 2000 are defined (BSH, 2009a), inter alia, based on an environmental report also addressing changes different activities cause (BSH, 2008). Due to Ehler & Douvere (2009), Marine Spatial Planning defines the activities and use of resources over time and space to avoid a depletion of the resources. It enables a more rational use of space, coordinates the interactions of groups of interest as well as the sectors in this area and it meets different demands and achieves goals of economic development and environmental protection. The result is a comprehensive spatial management plan which is a new approach for an information based decision-making supporting permit procedures concerning the activities in the region.

The European Union supports an implementation of maritime spatial planning within the member states. The main objectives are to facilitate the coordination of different activities through stakeholders and authorities, optimise the use of space and strengthen economic activities and the environment in the end. The process of decision-making should become more transparent and due to a common European approach, inter alia, cross border impacts are taken into consideration by decision-making on a national level (European Commission, 2010a).

c) Environmental Impact Assessment

The Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (EIA Directive) is nowadays the most important instrument addressing environmental impacts within a planning process of a project, supporting an information based decision-making. It requires an assessment of environmental effects for specific projects which could harm the environment. Offshore wind farms are listed in Annex II as “installations for the harnessing of wind power for energy production (wind-farms)” requiring an impact assessment. According to EIA Directive, Article 3,

“The environmental impact assessment will identify, describe and assess in an appropriate manner, in the light of each individual case and in accordance with the Articles 4 to 11, the direct and indirect effects of a project on the following factors:

- human beings, fauna and flora,
- soil, water, air, climate and the landscape,
- the inter-action between the factors mentioned in the first and second indents,
- material assets and the cultural heritage.”

Impacts on these assets need to be identified, described, assessed and integrated into the decision-making process. The EIA is one part and a non-autonomous element of the authorisation process of many countries worldwide (Köller et al., 2006). In The Netherlands and Germany the installation and operation of offshore wind farms also requires (in most cases) an environmental impact assessment (BSH, 2010; Rijkswaterstaat Dienst Nordzee, 2006). The EIA as a predictive tool for information based decision-making is embedded into national legislation and permit systems. Standards, defining a base for deciding about refusal or acceptability of impacts and certain requirements, are not specified in the EIA itself. These standards are found in other international and, especially, national laws and guidances (Köller et al., 2006).

The outcomes of the EIA are summarised within the Environmental Impact Statement (EIS). It contains a description of the project, including different alternatives, as well as of the current environmental status. The main point is the assessment of possible changes and impacts on the protected assets, defined by the directive, the project causes and the sources. Also recommendations for measures to avoid or minimise negative impacts are given within the EIS. The EIS has to be made public, everyone has the right to inspect it and raise an objection. So, within the EIA all important information leading to a decision need to be written down and be comprehensible to everyone (Article 6 (2), EIA Directive). In the end, this document serves as a base for the decision-making, by assessing and analysing possible impacts of the project on the environment (Peters et al., 2008) which is the main reason for focusing on the EIS to analyse how impacts are addressed in decision-making processes.

The table below shows protected assets defined by the EIA Directive and assets in the North Sea defined by Köller et al. (2006), completed according to the results of the literature study below in chapter II.

EIA Directive	**North Sea**
Fauna	Birds, marine mammals, fish, bats, zoobenthos, zooplankton
Flora	Phytoplankton, phytobenthos, macrophytes
Soil, water	Seabed, sea water, flow-changes (sediment structure, hydrodynamic)
Air, climate	Air, climate
Human being, landscape	Human health and life, recreation areas
Material assets, cultural heritage	Wrack
Interaction between mentioned factors	Interaction between mentioned factors

Table 2.1-1: Protected assets defined in EIA Directive and assets relevant for offshore wind farm projects in the North Sea

d) Strategic Environmental Assessment (SEA)

The strategic environmental assessment is an assessment made for public plans or programmes based on the Directive 2001/42/EC (SEA Directive). It aims to protect the environment by addressing impacts at an earlier stage, the strategic level, than an EIA. Plans and programmes which are likely to have a significant effect on the environment, e.g., plans setting a framework for future development, like (marine) land use plans, require a SEA. The SEA includes an environmental report identifying possible impacts on the environment and alternatives to the actual plan or programme. The public as well as neighbour states affected by the effects of the plan or programme are getting involved into the decision-making process (European Commission, 2011a). Therewith, it is an important instrument for environmental protection addressing impacts at an early stage of decision-making, e.g. for the consideration of impacts on the environment during the development of a spatial plan (Arts, 2004). But as the SEA is not relevant for the consideration of impacts within the final licensing procedure, it is not considered further in this thesis.

e) Habitat and Birds Directive

The Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (Habitat Directive) and the Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (Birds Directive) are key instruments for the nature conservation policy of the EU. Natura 2000 areas, the worldwide largest network of protected areas, and a system of protecting endangered species are based on these Directives. The overall aim is to conserve biodiversity by protecting valuable, endangered wild species and regenerate and conserve their natural habitats (European Commission, 2011).

The *Birds Directive* aims to protect endangered and migratory bird species, their eggs, nests and habitats. It covers the protection, management and control of these species and lays down rules for their exploitation (Article 1).

The *Habitat Directive* protects species and habitat types of European importance. Article 3 of this directive regulates the designation of Natura 2000 areas by each Member State on land as well as on sea. According to article 6 (3) projects having an effect on Natura 2000 sites require an assessment in view of the conservation objectives of the site concerned. Only projects which do not affect the integrity of the site negatively are acceptable and do not oppose a favourable conservation status as defined in article 1 (e) and (i).

In case of offshore wind farms, an assessment is necessary evaluating possible impacts on Natura 2000 areas and protected species which could be concerned.

Article 1 (Habitat Directive) with regard to the conservation of *Natura 2000 sites* states:
(e)The conservation status of a natural habitat will be taken as 'favourable' when:

- its natural range and areas it covers within that range are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable as defined in (i);

(i) The conservation status of a species will be taken as 'favourable' when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis;

The points below are regarding the protection of endangered wild species. For assistance and definition the "Guidance Document" has been developed and published by the EU Commission (2007).

According to article 12 (1) *Habitat Directive* "Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV (a) in their natural range, prohibiting:
(a) all forms of deliberate capture or killing of specimens of these species in the wild;
(b) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;
(c) deliberate destruction or taking of eggs from the wild;
(d) deterioration or destruction of breeding sites or resting places."

According to the *Birds Directive*, article 5, “Member States shall take the requisite measures to establish a general system of protection for all species of birds referred to in Article 1, prohibiting in particular:
(a) deliberate killing or capture by any method;
(b) deliberate destruction of, or damage to, their nests and eggs or removal of their nests;
(c) taking their eggs in the wild and keeping these eggs even if empty;
(d) deliberate disturbance of these birds particularly during the period of breeding and rearing, in so far as disturbance would be significant having regard to the objectives of this Directive;
(e) keeping birds of species the hunting and capture of which is prohibited.

These directives are quite specific, helping to judge when is a project to be rejected. They are designating areas, define development goals, prohibited activities within this area and listing animals strictly protected.

f) Marine Strategy Framework Directive

Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 aims to reach a good environmental status of the seas until 2020 and therewith protects the marine environment, its ecosystems, biodiversity and resources more effectively. Every member state has to assess the current environmental status and special characteristics of its sea. Furthermore, strategies need to be developed containing a definition of a “good environmental status” as well as environmental targets and monitoring programmes. Data and information are gathered and knowledge exchanged between the states (European Commission, 2010b). This can serve as an important database containing biological features, like the predominant habitat types of the seabed and water column, biological communities associated to this habitats, fish populations, marine mammals, macro-algea or sea birds (to name just a few), and parameter for assessing them and taking action (Federal Agency of Nature Conservation, 2010). This outcomes help understanding ecosystems and therewith indirectly help predicting possible effects of projects like offshore wind farms.

g) OSPAR Convention

The Convention for the Protection of the marine Environment of the North-East Atlantic (OSPAR Convention) is an important international convention where fifteen governments and the EU are working together to protect the marine environment, the ecosystems and biodiversity of the North-East Atlantic. It is an unification of the Oslo Convention against pollution by dumping and the Paris Convention against dumping form offshore industry and land-based sources. Another annexe adopted later prevents the sea against non-polluting human activities causing negative impacts on the sea. Parts of the convention are assessing the environmental quality and eliminate and prevent pollution (OSPAR Commission, 2011). OSPAR also takes action in the field of the development of offshore wind farms, for instance, by the development of measures. The "Guidance on Environmental Considerations for Offshore Wind-Farm Development" (OSPAR, 2008b) has been developed to assist contracting parties in assessing environmental impacts of offshore wind farms. For the increasing risk of ship collision marine pollution, contingency plans need to be established and implemented. Also research and monitoring programmes, the establishment of databases for gathering data and exchange of knowledge are part of the work (OSPAR, 2008).

h) Conclusion

Legislation by itself does not contribute directly to address impacts or measures, but they are instruments providing the context to address impacts or measures. The probably most important instrument is the EIA Directive, regulating the development of an environmental impact assessment (EIA) for large projects, like offshore wind farms. Also to take into consideration when addressing environmental impacts are the Habitats and Birds Directives. They build a base helping to define when projects have to be rejected by defining animals and their habitats strictly protected, designating protected areas and defining development and conservation targets.

Marine spatial planning (MSP) does not address environmental impacts, but helps protecting the environment by defining protected areas and forbidding other activities within this areas contradicting to development and conservation targets. Therewith, negative impacts on the marine environment can be avoided. As, according to the SEA

Directive, an SEA has to be made when drawing plans, an assessment of impacts on the strategic level is done, evaluating the environmental status and the influence of the plan. In the end, this plan supports an information based decision-making, coordinates different uses and interests, collects data and prevents indirectly negative impacts on the environment.

The UNCLOS has to be applied on national laws and, hence, influences the national legislation which is addressing nature conservation and environmental protection. The legislation is different than on land and within the territorial waters. Partly, it still needs to be developed and extended to the EEZ, as it is not yet fully regulated. For instance, in The Netherlands acts regarding nature conservation are getting applied, but are not yet extended to the EEZ and, hence, have not to be applied obligatorily (de Graaf, 2008). Also the responsible bodies taking decisions are changing, regional authorities or planning bodies have, in the opposite to planning within the territory, rarely any direct influence.
Within the member states of the OSPAR Convention waste dumping is prohibited, hence, by addressing this source causing pollution negative impacts on the environment can be avoided. But in the context of the OSPAR Convention, especially the work of the OSPAR Commission has to be taken into account. Regularly, the environmental status of the area is getting assessed, reports and guidelines for different issues are done, including the addressing of negative impacts on the marine environment of offshore wind farms.

2.2 Environmental impacts of offshore wind farms

Offshore wind farms cause significant changes to the marine environment and are therewith and due to their significant demand of space competing with many other interests within the area, like in this case environmental protection. These changes caused by the wind farms can lead to biological, physical and chemical impacts. Regarding the marine biota, especially sea birds and migrating birds, marine mammals, fish species and the benthos are affected. Altering abiotic factors include hydrodynamics, morphodynamics, sediment shift and turbidity, and chemical impacts. The landscape, human beings, or cultural heritage are also considered. The changing abiotic and biotic factors are in interaction, affecting each other, leading to further indirect impacts. Also cumulative aspects with other wind farms and activities harming the marine environment need to be considered. With a big amount of wind turbines effects add up and become more significant. An example is the permanent habitat loss for birds due to the physical presence of offshore wind farms (Hoffmann et al., 2009). Understanding these changes and their effects is the base and at the same time the challenge to ensure the impacts are addressed in decision-making processes and the project does not endanger the marine environment.

At date, knowledge has been gathered at existing wind farms (especially in the UK and Denmark), at research and oil platforms, but there are still big gaps of data and basic knowledge about ecological issues, e.g. species behaviour, important feeding and resting areas, habitat use, abundance, migrating routes or their ability to adapt to environmental changes. These changes are not only dependent on the introduction of wind turbines, but also on external natural effects which are often very complex and not 100% understood. Further, as offshore wind farms are a quite young field the long-term effects are not known and hard to predict. These uncertainties make forecasts about specific impacts hard and answers on specific issues and assets affected can not always be given. Many studies focus on collecting basic ecological data and looking for methodologies suitable to collect data and help to measure and predict impacts. Since 2003, the research platform FINO 1 in the German North Sea is collecting data for understanding offshore conditions and determine impacts on the marine flora and fauna (FINO, 2002). Another source for information is, for instance, COWRIE the “Collaborative Offshore Windfarm Research Into the Environment”, an institution in the UK publishing reports on these issues (COWRIE, 2008).

In the following text, a brief insight into environmental impacts discussed in literature will be given. The impacts listed and explained are not exhaustive, the focus is on giving an overview of important possible ecological impacts which could in particular be important for the decision-making process (Peters et. Al, 2008; Storz et al., 2009; BioConsult SH, 2008 and other*)*. Also the changes in physical characteristics affecting marine organisms, as well as effects on human beings are taken into account. It should be mentioned that the impacts described here do not necessarily need to occur, they are discussed in literature. The significance of impacts can differ depending on the location of the wind farm, some areas are important to harbour porpoises, some are within main route of birds migration, others are between resting and feeding grounds of birds or seals. This is important to know to predict impacts and to avoid or minimise them, e.g., with mitigation measures. The extend of the impacts is also often not clear. Especially long term effects due to the presence of offshore wind farms need to be studied, for instance, with Monitoring and Evaluation Programmes (Peters, 2011). In the end of this section 2.2, a table listing protected assets concerned, impacts affecting them and their specific sources summarises the outcomes and serves as the analysis structure used in chapter IV.

2.2.1 Seabed and water

Following, an overview of abiotic impacts, like a shift of hydrodynamic and sediment conditions, the re-suspension and increased turbidity of sediments, sealing of ground and rising temperature in the vicinity of cable, is given. These changes affect first of all the seabed and sea water, but have also effects on flora and fauna living in or on the seabed and water or using their resources of the sea as explained in this chapter later.

a) Sediments

During the construction phase of an offshore wind farm dredging activities cause a disturbance of the seabed. *Dredging* of the seabed and cable laying cause a complete shift of sediments. A release of nutrients and harmful substances like heavy metals by moving or re-suspension of sediments can harm the water quality, an oxygen deficiency or germs can be the result (Schuchardt et al., 2009). Also the *construction* of the foundation, pile driving, maintenance works, but especially dredging of the seabed to form a platform for foundations or trenches for electric cable will re-suspend sediments from the ground. Due to the construction of the wind farm Nystedt (72 turbines) a re-suspension of about 16.000 m³ sediment was expected (Storz et al., 2009). This causes an increased turbidity and smothering of the water (OSPAR, 2006). Dependent on different parameters the big grain size sediments sink down to the seabed close to the place they got eroded, finer sediments like silk get transported with currents and accumulate later at other places again. Fine sediments can build stripes of turbidity which also have an influence on flora and fauna (Schuchardt et al., 2009).

The *sealing of the sediment surface* by the introduction of foundations and if applied a scour protection leads to a compression of soil by mechanical pressure and decreases the value of the seabed as a habitat. As the North Sea is naturally dominated by soft sediment it has consequently effects on marine organisms, especially benthos (BioConsult SH, 2009).

Vibrations from the foundation into the sediment could also influence the sediment conditions. As it is not much known about possible changes, research is done on FINO and Alpha Ventus (BSH, 2009).

b) Hydrodynamics

Altering *hydrodynamic conditions* include an increase of the flow velocity around the piles, like measured at the research platform FINO I (Schröder et al., 2006). Also on a large-scale a change of hydrodynamics is expected. According to BioConsult SH (2009) the flow velocity decreases on about 1-3% in the vicinity of the wind farm and is therewith not very significant.

The swell in the area of the wind farm will get less, but as the turbulences on the sea surface increase a stronger stirring of the *temperature stratification* can be the result. (BioConsult SH, 2009).

Regarding the *physical presence, changes of hydrodynamics* are important to consider as they cause other changes in sediment flow or morphology. Around the turbines a local alteration of the hydrology can occur, like local current speeds around the piles and foundations. These hydrodynamics lead to a shift of sediment dynamics and compositions, cause erosion, creating scour pits in soft sediment and therewith change the morphology of the seabed. Due to observations at FINO 1 a significant different sediment composition to more heterogeneous grain size can be seen. Also scouring at the vicinity of the piles or foundation of the turbine can be a problem (Schröder et al., 2006). Due to conditions scour pits can be small or especially in soft sediment and in very dynamic waters quite large. At FINO 1 scour pits of 1 to 1,5 meter depth have been observed. They are concentrated around the piles and usually not connected. In exposed areas also scour tails can be observed. In general, changes due to modified flow regimes are expected to be small.

Impacts on the seabed are local direct ones around the base of the turbine and limited to 100 to 200 meter (OSPAR, 2006). According to BioConsult SH (2009) strong changes of the sediment structure due to shifts in hydrodynamics are found within a distance of 5 meter around the pile.

Around *electric cable* the temperature of the sediment and pore water during operation increases of several degrees within several decimetre around the cable, which has further effects on organisms and other abiotic factors (Schuchardt et al., 2009). According to Storz et al. (2009), the increasing temperature in the sediment as well as in the water can lead to a release of harmful substances. Furthermore, an increasing degradation process of organic substance due to an increased temperature can lead to an oxygen deficit.

The physical presence of the wind farm increases the *collision risk* for ships. With a safety related fishing ban also bottom trawling stops, protects the seabed and a natural sediment structure can develop. The risk of pollution of the sea ground as a result of increasing ship traffic, ship collisions or other accidents increases. Accidental release of harmful substances or other pollution like oil and anit-corrosion paint while construction, maintenance, or operation of the wind farm can harm inter alia water and soil (BioConsult SH, 2009).

An increasing risk of ship collisions is also taken into account when discussing risks for human beings and the marine environment. In this context offshore wind farm form an obstacle ships can collide with. Further, it is studied how they impact the radar, communication and position systems of ships. In some cases operating wind farms do impair a few systems (OSPAR, 2006). An accident would endanger human beings and the ecosystem when losing oil, or other harmful substances.

Besides an increasing **risk of pollution** due to ship collisions, other accidents can occur which, when recurring often, also have a negative effect on the marine environment. OSPAR (2006) reports about three accidents. An accidental release of grout into the sea used for construction of the turbines has been documented, the composition of grout also contained ecotoxological materials. Further, in two cases the protection pained of a pile failed.

As fouling organisms settle down at the piles, the biomass increases significantly. According to Zettler & Pollehne (2006), summarising the outcomes of the project BeoFINO1, a biomass of circa 500 tones can be expected in a wind farm with 100 turbines. The biomass falling off the pile, accumulating in the sediment can lead to an oxygen deficit. Sulphur bacteria observed at BeoFINO1 producing hydrogen sulphide can lead to a sulphite pollution of benthic organisms.

The *removal* of a wind farm has similar effects than the construction. An increasing sediment turbidity can be observed on one hand. If the piles in the ground are removed by water jet cutting a pollution of the sea ground by splinter of steel and parts of the piles left in the ground need to be noted on the other hand (BioConsult SH, 2009).

2.2.2 Air and climate

Effects on the air circulation are limited to the wind farm area and are very low. Also the emissions by construction and maintenance traffic are relatively low. Regarding emissions, wind farms are beneficial as they serve as an alternative to fossil energy sources. Negative effects on the air and climate are not expected as stated in BioConsult SH (2009). Also in other literature not significant negative impacts on air and climate were found.

2.2.3 Flora and fauna

a) Benthos (zoo- and phytobenthos)

Changes and impacts on benthos are expected, especially during the construction phase when dredging or pile driving cause a disturbance of the seabed and changes in sediment composition and structure. To close gaps of knowledge long-term studies need to be done. An example is the research platform FINO 1 where data for a better understanding of specific impacts are gathered. The impacts discussed regarding benthos are listed below, but it needs to be said that the effects depend on many factors like abiotic conditions, material used, structure, scour protection or anti-fouling protection used or not (Schröder et al., 2006).

While construction of the turbines, including pile driving, dredging the seabed and cable laying (later also due to maintenance works), the *turbidity of sediments* increases. In form of stripes of turbidity the material gets drifted away over several kilometre dependent on the grain size. The light transmission of the water body is reduced and, as a result of this, especially suspension feeding species are concerned by clogging of their filter organs and a reduced food intake. Benthic species are getting eliminated locally, reduced biomass and production could be a consequence. Nevertheless, serious long term damages are unlikely as the change is reduced to a small area and short time (Hagendorff et al., 1996). In Schuchardt et al. (2009) it is mentioned further, that a greater availability of germs in the water column by sediment relocation can cause diseases.

The construction and removal of the turbines and cable cause a *re-suspension and relocation of sediments.* Endobenthic organisms are laid open when sediments are brought in suspension. When re-suspended sediments are accumulating again epibenthic organisms can get covered by them. The survival of the organisms is due to their mobility (Schuchardt et al., 2009). For most of the benthic organisms a covering with several decimetre of sediment is no problem (BioConsult SH, 2008).

The installation or rather the physical presence of turbines within the seabed causes alterations of the hydrology and therewith *sediment flux, sediment composition and morphology* (see physical impacts). As specific sediment compositions and structures define as an important parameter the occurrence of benthic species, this change can lead to a different benthic community composition and elimination of benthic species or whole associations. Especially less mobile species and suspension feeding species are endangered (Schröder et al., 2006). A complete shift of sediments caused by construction and cable laying activities eliminates or damages organisms, they can get covered with sediments or laid open. A recolonisation of the area to initial abundance is expected within a few month till years depending on the species. Also due to cable laying activities and a development of trenches a local change of the morphology is possible. The disturbance is limited to a certain time and area and of less intensity (Schuchardt et al., 2009).

With the *introduction of artificial hard substrate* a new habitat is created which attracts new epibenthic species. It can lead to a shift of species composition or biocoenosis and an increase of biomass and abundance in the vicinity of the piles. Inter alia at BeoFINO1

(Zettler & Pollehne, 2006) more detailed research has been done about the settlement of organisms at piles. The following succession can take several years till a stable community has developed. The new occurring community and soft bottom fauna could potentially compete about food resources, an example are suspension feeding species. Further fish species are attracted by the under water structure, the predatory pressure could, due to this, increase (see fish). Another result of the introduction of hard substrate is the *sealing of parts of the seabed* which result in a permanent habitat loss (Schröder et al., 2006) and a mortality of organisms by mechanic pressure where foundations are introduced. Sealing of seabed on a large scale would lead to a change of the benthic communities, now specialised on soft sediment, and elimination of benthic species or assosiations.

When the wind farm gets removed again the *removal of hard substrate* leads to a habitat loss and a change of the community composition (Schuchardt et al., 2009).

An increasing temperature of the sediment and pore water in the vicinity of *electric cables* has a strong influence on the activities of poikilothermic organisms. The temperature tolerance is a key factor determining the geographic distribution. Temperature increase of only a few degrees can have effects both on the cellular level and the distribution. Locally higher temperatures can change the structure of the community, increase the mortality or decrease it in winter because it keeps the temperature high enough for survival (Schuchardt et al., 2009). According to Schröder et al. (2006) more knowledge has to be gathered about specific impacts.

Electromagnetic fields tested in laboratory experiments by Bochert & Zettler (2006) have no clear effect on the orientation, movement or physiology of the benthic organisms. Not clear is if they have effects on the sub-cellular level which can over a longer term damage the individuals. A study made by CROWIE shows evidence for responses of cancer to magnetic fields. Long-term studies are recommended as there are still many uncertainties and gaps of knowledge (Grill et al., 2005).

Vibrations into the seabed by operating turbines can lead to a permanent habitat loss of sensitive organisms on a small scale (Schuchardt et al., 2009).

Withdrawal of cooling water and introduction of heated water leads to a damage or mortality of eggs and larvae. Effects due to an increasing water temperature by introduction of heated water are weak as the scale is relatively to the water body small and the tides mix it quite fast with the colder sea water. It is a permanent but slight impairment on a small scale (Schuchardt et al., 2009).

Reduced fishing due to a *fishing ban* and an additional attraction of fish by the under water structures can lead to a higher predatory pressure. On the other hand a fishing ban protects the area from bottom trawling, which again has an effect on the benthic community and its composition (Schröder et al., 2006).

Another issue is the release of *nutrients and harmful substances*, like heavy metals, form sediments and their accumulate in organisms. Reasons for the release are diverse mainly because of the re-suspention and relocation of sediments while construction, but also due to an increasing sediment temperature in the vicinity of piles. Also an oxygen deficiency and germs can harm for instance benthic organisms (Schuchardt et al., 2009). Also splinter of steel, left behind after removing the wind farm are polluting the seabed and can harm benthic organisms (Storz et al., 2009).

b) Fish

In the literature following effects are mentioned which may arise over a short- or long-term. Especially regarding long term effects there are still many uncertainties (Köller et al., 2006).

Turbidity of sediments are occurring while the construction of the turbines and cable laying later also due to maintenance works. During these activities causing *stripes of turbidity* fishes can suffer damage, dislocation and a temporary habitat loss (Köller et al., 2006). They show species-specific reactions and impairment, especially pelagic fishes are concerned. These fishes leave the area as their gills can get damaged which reduces the efficiency of breathing, further pelagic fishes are dependent on their visual perception for pray. Damage of less mobile fish eggs or larvae is another result, when re-suspended sediments are accumulating again the increasing sedimentation can harm fish spawn (Schuchardt et al., 2009). Furthermore, as explained already, a temporary change of the *sediment structure and composition* due to construction works and a related re-suspension of sediments as well as a permanent change in the vicinity of the piles can be expected.

Only a few fish species are sensitive to this changes and avoid the area. A shift of sediments with the *introduction of the cable or dredging* can damage individual benthic fish species. This is unlikely as fishes are very mobile, although, they suffer a temporary habitat loss (Schuchardt et al., 2009).

The *release of nutrients and harmful substances* like heavy metals with the re-suspension of sediments can lead to an oxygen deficiency, also germs can impair fishes, fish spawn and larvae. Nevertheless, the release of such substances, the increase of diseases or symptoms of intoxication can be excluded with high probability (Schuchardt et al., 2009).

The *sealing of seabed* by foundations affect benthic fish species as they loose parts of their habitat. It can also have an indirect impact on fishes when and dominant species benthic organisms, and therewith their pray animals, are affected negatively (Schuchardt et al., 2009).

Noise emission and vibration into the water body during construction can lead to damage, dislocation and habitat loss. It can also disturb intra-specific communication or the recognition of prey and natural enemies due to masking effects (Schuchardt et al., 2009). Noise during construction especially while pile driving could, according to OSPAR (2006) and Nedwell et al. (2003), release stress and behavioural effects, can cause injury and mortality from gas embolism (barotraumas), affect the sense of hearing leading to deafness and impair the survival. Behavioural changes due to noise and vibration are observed like escaping from the building site and ships, but they return after construction noises stop (Schuchardt et al., 2009). Also *fish larvae and spawn* are damaged or eliminated. They are very vulnerable and less mobile, so they can not escape from the building site. Observations show that, for instance, the mortality of fish eggs increases with a noise emission of 20 dB over the background noises. While pile driving, in a distance of about 1 km from the building site a mortality rate of 100% is expected. Moreover, the growth in length and biomass of fish larvae exposed to noise is lower than of larvae growing under quiet conditions. This can also have long-term effects on fishs, their growth and fitness (Storz et al., 2009). Nehls (2009) takes as the threshold value for fish from which physical damage occurs 208dB (187dB SEL) (due to values given by the American National Marine Fisheries Service). Knust et al. (2003) are describing observations of dead fish with internal bleeding, open wounds, burst swim bladders, and heavily damaged viscera shortly after and in the vicinity of pile driving. There are gap of knowledge about long-term effects on fish. Effects of pile driving lead to a clear impairment of the fish fauna, but the exact effects are largely unknown and can not be predicted yet.

Water is a very good transport medium for sound waves, even though it has a damping effect with increasing distance to the source of noise. The propagation loss of underwater sound depends on many parameters like water depth, stratification and soil structure. The noise dB in different distances form the source depends on many factors besides the named, e.g. size and structure of the pile. A comparison of noise emission while pile driving form different projects was made and showed that in a distance of 1 m from the construction site a level of more than 200 dB is reached. In a distance of 750 m more than 180dB are still measured. Sound propagates very good under water and is perceived very well especially by marine mammals but also fish causing negative impacts (Nehls, 2009). Noise emission and vibration into the water body while operation effects an increased noise level compared to the natural sound level in the range of the wind turbines (Schuchardt et al., 2009).

Dislocation, damage and habitat loss are caused by an *emission of noise and vibration into the water body during the operation* of the wind farm (Köller et al., 2006). Sounds can be perceived, although the sensitivity to noise and vibration depends on the species. As these noise emissions are permanent, the disturbance of intra-specific communication, recognition of prey and natural enemies due to masking by noise are important to be considered (Schuchardt et al., 2009).

The *physical presence* of the wind farm itself is unlikely to create a barrier to fish movements and mitigation (OSPAR, 2006). The wind farm structure might rather have a beneficial effect on most fish species as a nursery area, protection from predators, refuge from intense fishing with an increased food supply. Studies for instance at oil platforms (Løkkeberg et al., 2002), at the offshore wind farm Horns Rev or research platform FINO1 (Zettler & Pollehne, 2006), show an attraction of fish by these underwater structures. Also new fish species have been observed. The *introduction of new artificial hard substrate* can, like other alterations of abiotic conditions, cause a change of species composition of marine organisms. The hard substrate serves as a new habitat for fouling organisms like algae or mussels. As a result, the availability of pray organisms will change and increase, as they are likely to change or become more diverse (Ehrich et al., 2006). The intensity of colonisation also depends on other environmental factors such as flow direction and velocity, light, sounds or shape. It is not clear yet if the abundance increases in the whole offshore wind farm area or only in the vicinity of piles. As these structures also build a new habitat for fishes, besides the abundance, the diversity can increase and new dominant species as well as a new community composition can occur (Schuchardt et al., 2009).

With the *removal* of the turbines and therewith the underwater structures after several years when the community adapted to new environmental conditions a habitat gets lost.

An increase of the *temperature* of sediments and pore water in the vicinity of electric cable could affect some benthic fish species (Schuchardt et al., 2009). Concerning submarine electric cable also a barrier effect by *electromagnetic field* of a sub-sea electric cable is discussed. A study published by CROWIE (2003) using computer based models comes to the conclusion that the fields produced by cable can affect the behaviour of electro-sensitive fish. Data on the specific effects are missing. Observations at the wind farm Nysted showed a disturbance of fish species by electromagnetic fields in the vicinity of submarine cable (Peters et al., 2008). According to Schuchardt et al. (2009), referring to different studies, behavioural and barrier effects on some fish species are possible, impacts on migration and orientation are possible but unlikely.

The *illumination* of the construction site can affect pelagic fish species which are attraction by the light or avoid it. The artificial illumination can be beneficial for fish praying by visual perception. The impacts are limited to a small area and a short time period. Effects due to a *shading or light reflection by rotor blades* is hard to predict with the present state of knowledge. An avoidance behaviour by some species is possible (Schuchardt et al., 2009).

Withdrawal of cooling water and introduction of heated water can damaged or eliminated fish eggs and larvae. As the natural mortality of larvae and eggs is high and the area relative to the total habitat small the impact is seen as less strong. Distribution and density of adult fish fauna are not expected to decrease significantly as a result of this. The higher water temperature could lead to a shift of the fish community. Limited to a small area and with the strong tide in the North Sea the warm water gets mixed with the cold water quite fast (Schuchardt et al., 2009).

The *fishing ban* would be beneficial for fishes and serve as a refuge from intense fishing. A recovery of stocks, a development of natural age structures, protection of biodiversity and genetic variability can be possible in this area. However, there is no guaranty for a recovery of fish stock or an increasing abundance and in other areas the pressure due to intensive fishery will increase (Schuchardt et al., 2009).

Risk of pollutions by accidents increases. Ship collisions and oil spills or release of harmful substances. And accidents like described above can lead to impairment and mortality of many fishes.

c) Marine mammals

One very urgent issue when talking about impacts is the noise emission into the water body. Water is a good transport medium for sound waves as briefly explained above. Close to the source of noise physical damage is likely, kilometre away from the source it still causes stress and disturbance. Especially during pile driving within the construction phase the noise level is very high, but also during operation, removal or due to maintenance vessels the emitted sounds can affect the animals. In the North Sea attention is paid especially to harbour porpoise, harbour seals and grey seals, but also other marine mammals like dolphins need to be considered. They are dependent on their hearing system for intra-specific communication, orientation and searching for food. The noises are very intensive during construction and permanent damage or even lethal effects can affect the animals. Due to the large number of turbines an extensive but permanent low-frequency noise is emitted into the water body while operation. Experiences at Horns Rev and other offshore wind farms show an abundance of mammals while operation of the wind farm comparable to before, Nehls (2009) does not expect significant negative impacts on marine mammals. Long-term studies are necessary. It is indisputable that acoustic emissions have negative effects on marine mammals. To gain a better understanding of possible impacts many studies have been done within the last years. It needs to be clarified to which extend it impairs and damages the animals and e.g. find out about sensitive sites. Surveys, monitoring programmes or projects like MINOS (described in Siebert et al., 2006) are collecting basic data about habitat use, density and distribution patterns as well as operational and construction related sound emissions. A good overview regarding acoustic emissions and references to further research gives, inter alia, Nehls (2009).

In the context of *noise related impacts* on marine mammals the following issues are discussed:

Mortality of individuals, permanent and temporary physiological damage are a result of high acoustic pressure from *pile driving* activities. tissue of the animals are getting destroyed leading to hearing damage, the impair of their survival and loss of individuals. The physical impairment values is over 200dB (TTS=Temporary Threshold Shift; PTS=Permanent Threshold Shift). Nehls (2009) giving an overview of studies about threshold value for small whales and seals. The value for small whales is 230dB (198dB SEL) PTS, 223dB (183dB SEL) TTS and for seals 218dB (186dB SEL) PTS, 212dB (171dB SEL)TTS (Southall et al.2007). Other studies show that limits may be at lower level already, this is e.g. expected for harbour porpoise.

Behavioural change and disturbance can also be caused by noise emission. According to Nehls (2009) a first reaction of mammals can be pointed at a value of about 120dB, a disturbance at a level of about 140dB . Short-term observations of porpoises at Horns Rev offshore wind farm by Tougaard et al. (2006) show a behavioural change over a long distance away from the source of noise while pile driving. In the whole study area of 21 km around the offshore wind farm reactions were measured, a disturbance and reduction of the abundance goes probably beyond this observation area. The animals escaped from the building site and adjacent areas. At Horns Rev 2, after pile driving it took 16-23 hours (3-6 km from source) till the abundance of porpoises returned back to normal (Brandt et al., 2009). The disturbance and absence of animals is limited to the pile driving phase but observed over a long distance. While the construction phase in the vicinity of the area (160dB SEL radius) marine mammals are absent. Effect on seals seams to be less than on porpoises (Nehls, 2009). Nevertheless, during construction (maintenance and removal) the increasing boat traffic, cable laying, turbidity of water or permanent noise leading to avoidance and a temporary habitat loss.

Changed behaviour and disturbance of the animals can be caused by *operational noises*. The resulting effects on marine mammals are depending on the distance to the source and on the species. According to BSH (2009) research by Henriksen et al. (2003) the operational noises of turbine are laying about 17 – 20 dB re 1µPa over the threshold of audibility of harbour porpoises and can be recognised by the animals in a distance of 50-100m from the source of noise. Marine mammals perceive the sound but react differently. Harbour porpoises are seen in operating wind farms, e.g. Horn Rev, seals are more sensitive to these noises and disturbance effects are possible due to their very good sense of hearing (Witte et al., 2009). The permanent noise emission can lead to a habitat loss for sensitive species or build a barrier to mitigating marine mammals. A fragmentation of resting, hunting and reproduction areas is as well possible (Köller et al. 2006). Depending on the sound frequency masking effects can also be registered (Lucke et al., 2007). Further research for single projects is recommended.

A disturbance of intra-specific communication due to *masking by noise* can result in a reduction of the reproduction rate (Köller et al. 2006). Regarding construction noises this factor is due to Nehls (2009) of less importance as it is only of short duration.

<u>Further impacts</u> on marine mammals:

The *physical presence* of a wind farm can be an obstacle, cause fragmentation and a barrier effect. Wind farms could fragment interrelated units like resting and hunting areas of seals (Köller et al. 2006).

Disturbance of the animals can be due to *stripes of turbidity* occurring while construction, but the impact is limited to a small scale and short time (BSH, 2008).

The *ship traffic* seem to have different effects on the animals. Depending on the species an attraction, disturbance or avoidance can be seen. Harbour porpoises avoid ships (Witte et al., 2009). Seals can be affected differently as the wind farm areas sometimes overlap with their feeding grounds and due to their good low-frequency hearing. Data on effects on seals are rare, also long-term data on marine mammals are outstanding (Siebert et al., 2006).

Shades from the rotor blades lead, according to OSPAR (2008), to a habitat loss due to avoidance.

Electromagnetic fields can have a barrier effect to mitigating marine mammals but there is no prove for this yet (Köller et al. 2006).

Electromagnetic fields. On all places around the world there are specific static geomagnetic fields, which have an effect on marine organisms. For instance, sea turtles use it for orientation while travelling around the oceans (Bochert & Zettler, 2006). Also the produced electricity of operating offshore wind farms causes electromagnetic fields, which can affect marine organisms. More about electromagnetic fields can be read, for instance, in Bochert & Zettler (2006). They are also summarising outcomes of experiments done on the effects of artificial magnetic fields on marine animals, e.g., the orientation, reproduction or mortality.

Indirect effects (positive or negative) can occur depending on the impacts on the fish abundance and allocation (Köller et al. 2006). Effects of harmful substances on pray organisms, for instance, can affect marine mammals via the food chain (Storz et al., 2009). The introduction of artificial hard substrate can be seen as positive as the abundance of epifauna and fish increases. Negative effects on the abundance of fish populations can occur due to the increasing mortality of fish larvae during pile driving (Peters et al., 2008).

An *increasing risk of pollution* due to accidents described above can harm marine mammals and lead to a death of individuals.

d) Birds

Every year, during autumn and spring more than 10 million migrating birds are crossing the North and Baltic Seas (Köller et al., 2006). When talking about impacts on birds, migrating as well as sea birds need to be considered. Inter alia the research platform FINO 1 in the North Sea helps collecting data about risks for birds. Depending on the species they are in some cases more, in others less sensitive to changes.

Migrating birds

Disturbance by *visual effects of construction and maintenance works*, the removal and increasing ship traffic during this times lead to avoidance of this area by some species sensitive to this impact factor. They fly around the wind farm which costs slightly more energy (Grajetzky et al., 2009).

According the effects of *noise emissions* there are still gaps of knowledge. Especially while pile driving an avoidance behaviour is expected. For negative impacts of operational noise emissions there is no prove (Grajetzky et al., 2009).

The physical presence of offshore wind farms in a normally barrier free North Sea area leads to an increasing *collision risk* with masts and especially rotating rotor blades and therewith to an increasing mortality. This is an important issue when discussing impacts on birds. The collision risk is high in nights and weather conditions with poor visibility because of mist or drizzle. Especially in nights with poor visibility when bad weather forces birds to fly on a lower hight big amounts of birds collide with turbines (observed at FINO 1) (Hüppop et al., 2006). According to observations at FINO1 in Hüppop et al. (2009) about 50% of the 770 birds (2003-2007) collided in two nights with poor visibility due to mist and drizzle. Due to observations at Nysted and Horns Rev most birds fly on heights above the turbines. However the flying altitude differs from species to species, some species fly above, some on the same hight of rotor blades and others below. Grajetzky et al. (2009) identify the location, hight of turbines and distance between them, the orientation of the wind farm to the direction of birds migration (Zugkorridore), further the size, hight (in relation to the flying altitude of different birds) and velocity of turning rotor blades as well as facility illumination and other external factors, like the weather, as decisive for the collision risk.

In the light of collision risk, also the *wake of turbines* is discussed. Birds can be caught by the wake stream and air turbulence of the turbines and pushed on the water. But as the influence of the wake ends above the water, birds can probably avoid contact with the water. It is still a disturbance causing energy loss, injury or mortality (Storz et al., 2009).

Attraction by *facility illumination or illumination of construction* and maintenance facilities costs extra energy since birds fly around the facility (observed at FINO) (Hüppop et al., 2006), stay at the wind farm for longer and increase the collision risk (Grajetzky et al., 2009). Due to Storz et al. (2009) green light avoids these impacts. This green light was tested positive on its feasibility on an oil platform, but without conclusions regarding avoidance of negative effects on birds. Grajetzky et all. (2009) describe illumination as a main problem for collision during the night and drizzle and mist. While unfavourable weather conditions birds fly lower and look for resting areas. Attraction by the light can lead to a lose of orientation and/ or flying around the light source, the birds suffer energy loss and little birds can die as a result of it.

The physical presence and *visibility* of an offshore wind farm can end up in a disturbance and barrier effect as sensitive species avoid the area. Most mitigating birds fly around the wind farm which costs them energy resources (Hüppop et al., 2006). The dimension of the barrier effect on the energy budget and fitness of birds is hard to predict. Due to observations at the wind farm Nysted the amount of migrating birds passing this area went down from 24-48% before construction to 9% after. Birds passing the area often change the flight direction and hight to pass through the corridors between the turbines. Depending on the sensitivity of the birds it can have long-term and large-scale impacts (Grajetzky et al., 2009).

An *increasing ship and air traffic* due to construction, maintenance and removal of the wind turbines and a concentration of other ship traffic in other areas outside of wind farms causes more flying off and a bigger demand on energy. Also a loss of feeding or resting areas are an negative impact of the ship traffic (Hüppop et al., 2006).

The *collision risks of ships and pollution* by oil spills also increases. Birds are affected negative in case of a ship collision and release of oil or other *harmful substances* into the sea, damage and a high mortality of birds can be the result.

<u>Sea birds</u>

Construction works of offshore wind farms have different effects on sea birds. Due to a disturbance by *visual effects of construction works*, the removal and an increasing ship traffic during this times species sensitive to this visual effects are avoiding the area during this time, a temporary habitat loss is the result (Hoffmann et al., 2009). Depending on the area important resting, feeding or wintering areas can be affected. Also dislocation and scaring-off effects impair the bird (Dierschke et al., 2006). The *construction light* leads to species specific reactions. Some birds show avoidance and suffer a temporary habitat loss, other birds are attracted by the illumination and use the facilities as resting areas (Hoffmann et al., 2009). *Noise emission* while construction can lead to an avoidance of the area and a temporary habitat loss. Flying around the area costs extra energy and reduces their fitness (Storz et al., 2009).

A *collision risk* with rotor blades or masts and an increasing mortality due to the *physical presence* of offshore wind farms is given especially in nights with poor visibility because of mist or drizzle (observed at FINO 1) (Dierschke et al., 2006). Statements about the quantity of colliding birds are hard to make. Important parameter for the collision risk are for instance the location and hight of the turbines. Sea birds fly mainly below the rotor blade hight of about 30 m minimum which decreases the collision risk, but keep small distance to the turbines which leads to an increasing risk (Hoffmann et al., 2009).

Also sea birds are endangered to get into the *wake of turbines*, like explained for mitigating birds. Disturbance, injury or mortality are the results.

The *physical presence and visibility* of an offshore wind farm can lead to a fragmentation and barrier effect between associated areas like feeding and resting areas (Dierschke et al., 2006). The wind farms is a barrier to birds susceptible to interference, they fly around the wind farm which leads to an increasing energy consumption (Hoffmann et al., 2009). According to OSPAR (2006) many bird species show an avoidance behaviour of wind farms, however, some others are attracted. The disturbance of important resting, feeding or wintering areas leads to a habitat loss and dislocation of some species (Dierschke et al., 2006), or sensitive species on a large scale and over a long term. This effect is not always limited to the wind farm area, also areas around are sometimes avoided. Although, it is possible that birds get used to the presence, these effect need to be seen as very significant (Hoffmann et al., 2009). Also shading effects and reflection of light by the rotating blades can lead to avoidance and make the win farm an obstacle. According to Storz et al. (2009), especially bigger birds, like ducks and sea gulls, avoid the area. Although it is possible that birds get used to the wind farm. At the Wind Farm Horns Rev, for instance, little gulls were observed which first avoided the area but showed a shift of behaviour, after a while they were attracted by the area (Petersen et al., 2006).

Increasing ship traffic during construction, maintenance, removal and in areas outside the offshore wind farm can disturb important resting, feeding or wintering areas, lead to a habitat loss, dislocation and scaring-off effects (Dierschke et al., 2006). The reactions on ship traffic are very species specific. Some birds avoid ships and suffer habitat loss and show flight responses to ships which cost extra energy reserves and reduces the fitness, other birds are attracted by ships (OSPAR, 2006). The responses of birds to ships are dependent on size, speed and noise emission. Due to Dierschke et al. (2006) birds are absent in areas with heavy vessel traffic. Another issue to be considered is the pollutant emissions by ships into air and water.

The impacts of *operational noises* in the air as well as into the water body, in case of diving birds, are relevant for species sensitive to noises. An avoid of the area and habitat loss can be observed. According to Hoffmann et al. (2009) a habitation of birds to these impacts are expected, further, effect is limited to the wind farm area.

The *introduction of artificial hard substrate* causes changes of species composition like explained in above in the benthos and fish passage. Consequently, it has an indirect beneficial effect to sea birds due to a higher abundance and availability of food (Dierschke et al., 2006). But due to Hoffmann et al. (2009) only a few bird species profit from this beneficial effect. Still, the area seems to attract bird. Regarding the *availability of food resources*, positive as well as negative indirect effects on birds can occur, depending on impacts of the wind farms on fish and other marine organisms. A problem is a possible pollution by the release of harmful substances and a reduction of food resources (see other assets).

Also an indirect effect causes the safety related *fishing ban*. Over a long term a higher fish abundance and new species are expected (see fish). This would offer new food resources beneficial to (some) sea birds (Hoffmann et al., 2009).

During activities while construction, maintenance and removal as well as while operation of the wind farm and increased boat traffic the *risk of accidents increases*. For instance, in cases of oil spills drifting on the sea surface many birds are dying or suffer physical impairment as a result.

e) Bats

Bats are, like birds, tracking over the North Sea and use offshore areas for hunting. There is not much known about tracking routes of bats over the North Sea yet. But according to Bach & Rahmel (2008) migrating bats were observed coming from the North Sea. The *collision risk* with masts and, especially, rotating rotor blades of the wind turbines is estimated as quite high. It is expected that bats use their visual system and magnetic fields for orientation, the intervals between their ultrasound calls are getting larger during large-distance flights. As bats are moving during the night and twilight it is hard to spot rotating rotor blades early enough.
Observations in the Baltic Sea, Öresund showed migrating bats resting at the turbines and hunting in the vicinity of the turbines as more insects are available here. But as they hunt close to rotor blades the risk of collision increases (OSPAR, 2008). Also in the North Sea hunting bats were observed offshore, hence, bats need to be expected in the offshore wind farm areas. The presence of an offshore wind farm can *attract* bats or lead to an *avoidance* and habitat loss by other species. Bats were also observed to not only hunt, but using the wind turbine as a resting area. This can again lead to a higher collision risk with rotating rotor blades. The wind farm can further be a *barrier* on their migration routes and forces the animals to fly around the wind farm which costs extra energy. Destruction of bats, an avoidance or attraction due to *ultrasound emissions* also need to be taken into consideration (Bach & Rahmel, 2008).

f) Zooplankton

Zooplankton could be affected negatively depending on effects on the abundance of phytoplankton as their main food resource (BioConsult SH, 2009). Furthermore, an increasing pollution burden due to an increased ship traffic and suspension of harmful substances with the sediments while construction works could harm the organisms. In case of an accident more harmful substances can affect the organisms negatively and lead to a higher mortality. Also shading effects by the turbines can lead to avoidance behaviour.

g) Phytoplankton

Phytoplankton can be affected by the turbidity of sediments and smothering of the water while construction. A decreasing light transmission of the water column leads to a reduced photosynthesis and habitat loss. This is very unlikely as turbidity effects are appearing in a water depth without enough sunlight for an existence of phytoplankton. The effect is further limited to time of construction (Schuchardt et al., 2009). Later, shading effects can reduce the photosynthesis. Harmful substances from ships, the turbines, introduced by accidents or re-suspended with sediments while construction as well as a change of the habitat due to the physical presence can affect species sensitive to these changes negatively (OSPAR, 2008).

h) Macrophytes

Sediment turbidity, stripes of turbidity and smothering of the water leads to a reduced photosynthesis and habitat loss. Also sealing of the seabed and a change of sediment flux and conditions as well as flow regimes can destroy habitats or lead to an alteration of the community composition. The introduction of artificial hard substrate causes a shift in plant community. Due to this on one hand species can suffer a habitat loss, but on the other hand the piles creates a new habitat, e.g. for algae (OSPAR, 2008). As offshore wind farms are usually builds in areas with high water depth, the effects on marcophytes are very low or do not affect them (see phytoplankton).

2.2.4 Human beings

The impacts on human beings are very diversified, here the focus is on the effects on human health and life. Health of people working at the wind farm can be affected directly, for instance by noise emissions. Pollution and emission of harmful substances by ship collision or working and maintenance works and traffic can have an effect on human health, pollution burden can effect humans via the food chain. But the emissions are very low and not expected to harm human beings. Changes can affect food resources like fish, due to a safety risk for fishing boats within the wind farm these areas are not open for fishing (BioConsult SH, 2009). On the other hand overfished fish stocks can regenerate which is beneficial for human being as well. An indirect effect of wind farms is their visibility and therewith intrusion of the landscape which can lead to a disturbance or loss of recreational areas. Furthermore, noise emission while construction and maintenance works can have negative effects on the human health (OSPAR, 2008).

2.2.5 Cumulative effects

When looking at effects of offshore wind farms on the environment and its protected assets, it is not sufficient to evaluate the single impacts and changes the project is expected to cause. Mostly these single impacts alone are not very significant and do not affect the protected assets and, hence, the decision about the environmental compatibility of the project. When planning a large project, like an offshore wind farm, it is important to take into account the effects other activities and wind farms cause which cumulate with impacts by the planned wind farm (Peters et al., 2008).

These so called cumulative effects can be defined as "impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project" (European Commission, 1999, p.7). The impacts are caused by different activities or activities of the same type, as well as by different parts, phases or activities of one project. The effects are overlapping in time and space affecting the same protected asset (Peters et al., 2008).

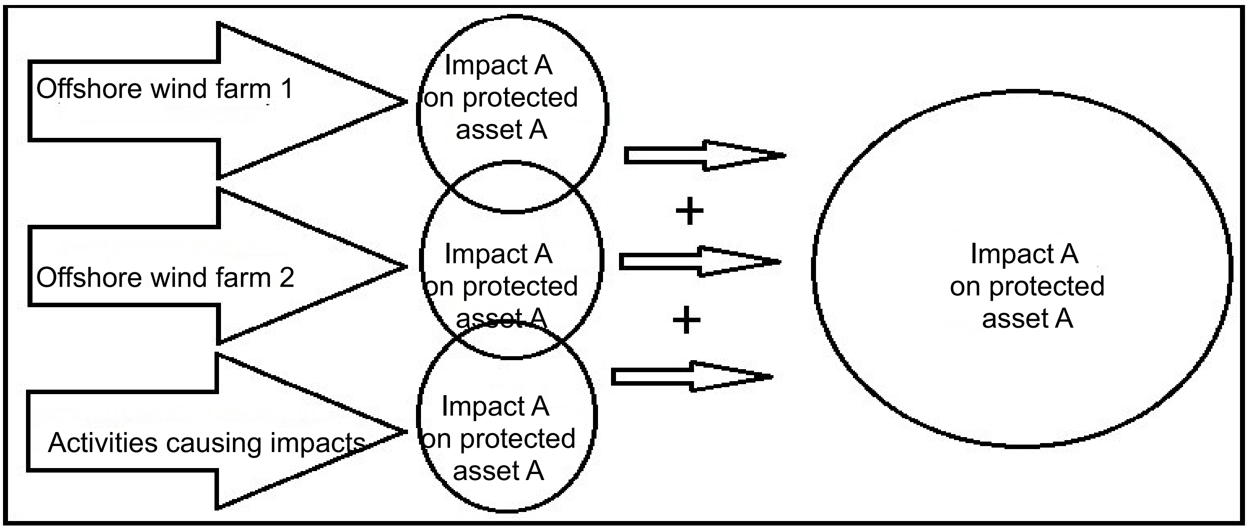

Figure 2.2.5-1: Cumulative effects

Cumulative effects are not easy to assess. According to Storz et al. (2009), the biggest gap of knowledge to close is about cumulative effects of different wind farms and of wind farms and other uses or activities. A main problem are the gaps of knowledge about basic knowledge of the marine ecosystem (biotic and abiotic factors), impacts of human activities and the interaction of these factors. There is also not much known about impacts of offshore wind farms on the marine environment, as offshore wind energy is a very young field and experiences about the long-term and short-term effects are missing. Furthermore, the assessment of cumulative effects is quite complicated as many thinks have to be taken into account. But it is important to consider cumulative effects affecting the environment, as many negligible impacts on a protected asset can add up to a significant negative impact impairing this asset and the marine ecosystem strongly (Peters et al., 2008). Due to this, Storz et al. (2009) ask for a method to assess cumulative effects. A possible model could be CUMULEO developed by TNO, based on a database.

Central issues to be defined for the assessment of cumulative effects, according to Peters et al. (2008), are:

- spatial scale
- temporal scale
- activities to be included: wind farm, other wind farms, other type of projects (pipeline, mineral extraction) and different uses (shipping, fishery etc.)
- impacts of the planned project on protected assets have to be included within the assessment of cumulative effects
- important interdependencies (of biotic and abiotic factors within the ecosystem or of human activities and ecosystem) affected by cumulative effects

The relevant scope can be over a long-term or short-term, on a local, regional or global level. The larger the scope gets, the more diverse are the sources of impacts adding up. The scope needs to get defined for every single protected asset, as every asset has different requirements. For instance, impacts on migrating animals need to be seen on a global level as they are caused by activities and have consequences far in excess, beyond the borders of the wind farm area and the North Sea. It is important to identify them, including their temporal and spatial occurrence and their overlapping (BioConsult SH, 2008).

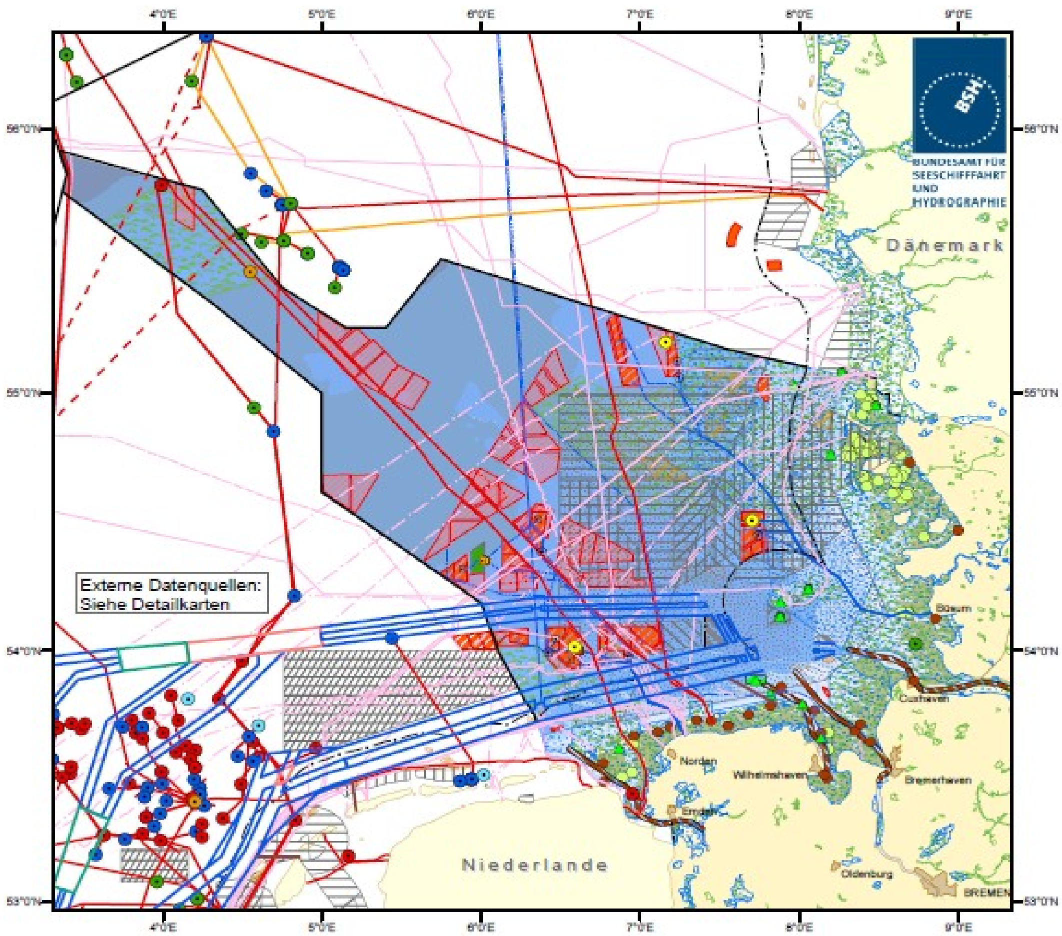

Figure 2.2.5-2: Activities within the North Sea (BSH, 2011)

The figure above shows the activities or planned activities within the North Sea area. As the North Sea area is used quite intensive by many groups of interest with different activities and as the rate of offshore wind farms expands further within the next years, it is likely that insignificant impacts are adding up causing a strong impairment of the marine environment and its protected assets. To take into account the impacts on the environment and its protected assets fully it is imperative that cumulative effects with other offshore wind farms as well as with other activities and uses are getting addressed within the decision-making process (Peters et al., 2008).

2.2.6 Results

The table below summarises the impacts and its sources found in the literature. It contains an overview of many different impacts which are not all very significant and therewith not all important for decision-making. It is a detailed, but still not exhaustive list. Impacts and its sources which do not find attention in the literature as they are not known yet or are not significant are left out. On the other hand it contains sources of impacts whose exact impacts and its significance are not known yet. The table builds the base for the evaluation matrix (see annexe) used for the context analysis of the documents EIS and licensing text of the two offshore wind farm projects.

The structure of the table and therewith of the evaluation matrix (annexe) bases on the protected assets defined by the EIA Directive, Article 3:
human beings, fauna and flora,
soil, water, air, climate and the landscape
interaction between the factors mentioned in the first and second indents
material assets and the cultural heritage.

As this thesis concentrates on physical impacts on the marine ecosystem, having an important role in decision-making but are not yet fully understood (Schuchardt et al., 2009; BioConsult SH, 2009; Brandt et al., 2009; BSH, 2009; Köller et al., 2006; OSPAR, 2008; Storz et al., 2009 and others) the protected assets landscape, material assets and the cultural heritage as well as socio-economical issues are not taken into consideration. Based on the first definition of protected assets by the EIA Directive, further literature research is done to specify the protected, potentially affected assets within the North Sea.

The definition by the European EIA Directive is suitable as this EU Directive gets applied in both countries. The Netherlands as well as Germany are EU member states and therewith bound to the directive which says that the assessment of effects on these assets by projects like offshore wind farms are obligatory in both countries. Hence, to use this structure as a base for the analysis table makes it applicable for the documents of both countries and comparable in the end.

Protected asset	Source of impact	Potential impact
Water	Construction (e.g. dredging, pile driving, cable laying)	Suspended sediments in water body, stripes of turbidity, turbidity and smothering of the water
	Re-suspension of sediments	Release of nutrients and harmful substances (→ oxygen deficit, germs)
	Physical presence	Change of hydrodynamics mainly small scale, local current speeds, minimal on large-scale Less swell, higher turbulence at water surface (->stronger steering of temperature stratification)
	Electric cable	Increasing water temperature → release of harmful substances
	Indirect effect due to increased biomass	Harming water quality (e.g. oxygen deficit, sulphite pollution)
	Increased ship traffic (construction e.g.)	Pollution
	Accidents (ship collision, release of harmful substances due to accidents or from turbines)	Water pollution
Seabed	Construction (e.g. dredging, pile driving, cable laying)	Sediment turbidity, erosion and relocation of sediment, compression of soil, strong disturbance of sediment, changing sediment structure and composition (heterogeneous), morphology
	Dredging (foundation, cable laying)	Shift of sediments and disturbance of the seabed
	Introduction of artificial hard substrate (and demand of space)	Sealing of sea ground; Value of seabed as a habitat decreases
	Physical presence (due to changing hydrodynamics)	Change of sediment dynamics (erosion and sedimentation), composition and structure, morphology, scour pits and tails (close to turbine)
	Vibration (during operation)	Sediment characteristics
	Operatin g submarine electric cable	Increasing temperature of sediment and porewater; Release of harmful substances (due to increased temperature)
	Physical presence as safety risk for fishing boats	Prevent seabed from bottom trawling
	Increasing ship traffic	Pollution
	Accidents, ship collision	Pollution
	Release of harmful substances due to accidents or from turbines	Pollution

	Removal (by water jet cutting)	Sediment turbidity; Polluntion by splinter of steel
Air and climate	Physical presence	Air circulation (limited to wind farm area)
	Increased ship traffic	Emissions
	Renewable energy	Reduces emissions
Benthos	Sediment turbidity, stripes of turbidity	Habitat loss, disturbance of habitat, elimination of benthic species locally (especially filtering), risk of diseases due to germs in water
	Re-suspension and relocation of sediments	Endobenthic organisms laid open, epibenthic organisms covered
	Dredging and sediment shift	Elimination and damage of organisms (mechanical pressure, laid oper or covered)
	Sealing of seabed	Change of benthic community, elimination of benthic species or associations
	Introduction of artificial hard substrate	New habitat, mortality, permanent habitat loss; New species, shift of community composition, increased biomass and abundance at the piles (->may compete about food resources)
	Physical presence and changing sediment flux, composition, structure and morphology (→ Release of harmful substances)	Habitat loss, new species; Released harmful substances from sediment accumulate in organisms
	Vibration (during operation)	Habitat loss for sensitive species
	Increasing sediment temperature (electric cable)	Alteration of endobenthic community, damage of individuals, non-residential species; Released harmful substances from sediment accumulate in organisms
	Electromagnetic fields	No clear evidence but could damage individuals, possible responses of cancer (lack of knowledge)
	Water quality (e.g. oxygen deficit and germs)	Damage and mortality of organisms
	Cooling water and heated water	Damage and mortality of eggs and larvae
	Physical presence as safety risk for fishing boats	Higher predatory pressure, protection against bottom trawling
	Accidents (ship collision, release of harmful substances)	damage mortality
	Removal of turbines	Pollution by splinter of steel; Habitat loss, mortality and damage of individuals, change of community composition

Fish	Sediment turbidity, stripes of turbidity	Damage, dislocation, temporary habitat loss (especially pelagic fish), damage to fish eggs and spawning grounds
	Dredging and sediment shift (introduction of cable)	Temporary habitat loss, damage of epibenthic fish species
	Sealing of seabed	Permanent habitat loss for epibenthic fish, indirect impact due to impacts on their pray
	Physical presence and changing sediment flux, composition, structure and morphology (→ Release of harmful substances)	Habitat loss of some sensitive species; Released harmful substances from sediment accumulate in organisms
	Introduction of artificial hard substrate	New habitat, attraction of fish and new species, change of community composition, nursery area, protection from predators, availability and diversity of prey organisms changes and increases
	Construction noise and vibration (especially pile driving)	Stress, behavioural effects, injury, mortality from gas embolism, impair sense of hearing, deafness, impair survival, dislocation and temporary habitat loss, masking effect, damage and elimination of fish spawn and larvae
	Construction noise and vibration (effects on fish larvae)	Mortality, damage, neg. effect on development
	Vibration and noise emission into the water body (during operation)	Habitat loss, dislocation, barrier effect, behavioural effects, stress, masking by noise (pray, enemies, intra-specific)
	Light reflection and shading effect (rotor blades)	Not known, but avoidance of some species is possible
	Illumination	Attracted by light, beneficial for fish praying by visual perception or avoidance
	Increasing temperature in sediment and pore (electric cable)	Could affect some benthic species
	Electromagnetic fields	Behavioural and barrier effect (electro-sensitive fish) , on migration and orientation possible but unlikely (gaps of knowledge)
	Water quality (e.g. oxygen deficit)	Damage and mortality
	Cooling water and heated water	Damage or eliminate fish eggs or larvae, possible but very unlikely is shift of community, distribution and density

	Physical presence as safety risk for fishing boats	Refuge from intense fishing, regeneration area (recovery of stock, natural age structure and more)
	Accidents (ship collision, release of harmful substances)	Mortality, damage
	Removal of turbines	Habitat loss, less food resources
Marine mammals	Construction noise (especially pile driving, also boat traffic, cable laying, removal)	Temporary habitat loss, behavioural change, avoidance, temporary or permanent physical damage like hearing damage impair survival, loss of individuals, disturbance of intra-specific communication due to masking by noise therewith reduction of reproduction rate
	Vibration and noise emission into the water body (during operation)	Barrier effect to mitigating marine mammals, fragmentation of resting, hunting and reproduction areas, changed behaviour, disturbance and permanent habitat loss possible, masking effect & disturbance of intra-specific communication
	Sediment turbidity, stripes of turbidity	Disturbance, disadvantages for praying and orientation
	Indirect due to impactzs on food resources	Effects ofharmful substances (released from sediments) on pray organisms
	Physical presence (also illumination)	Fragmentation of interrelated units, obstacle and barrier effect
	Shading effect (from rotor blade)	Avoidance behaviour (habitat loss)
	Electromagnetic fields	Barrier effect, disturbance of small- and large-scale orientation (gap of knowledge)
	Increasing boat traffic	Species-specific effects, change of behaviour, stress, avoidance
	Physical presence as safety risk for fishing boat	Increasing food resources within wind farm area
	Accidents (ship collision, release of harmful substances)	Damage and mortality of individuals
	Removal of turbines	Noise emission
Migrating birds	Noise emission	Avoidance while pile driving expected, for impacts of operational noise no prove (uncertainties)
	Visual effects of construction and maintenance	Temporary habitat loss of species sensitive to this impact, avoidance, flying around, reduction of fitness
	Physical presence and collision risk	Mortality, especially in nights with poor visibility
	Wake of turbines	Damage, mortality

	Physical presence and visibility	Barrier effect and fragmentation of migratory routes, avoidance or flying around costs energy and reduces fitness
	Facility illumination	Attraction, flying around the facility costs extra energy (mortality possible) and increased collision risk
	Increasing boat and air traffic	Habitat loss, loss of feeding and resting area, stress, more flying-off causing reduction of biological fitness; Emissions
	Accidents (ship collision and other harmful substances)	Mortality, damage, destruction of feeding and resting areas
Sea birds	Visual effects of construction works	Avoidance, temporary habitat loss (feeding, resting, wintering areas can be affected)
	Noise emission (during construction)	Avoidance or flying around costs energy and reduces fitness, habitat loss
	Illumination (construction light)	(Species specific reaction) avoidance and habitat loss, attraction and use as resting area
	Physical presence and collision risk	Mortality, especially in nights with poor visibility
	Wake of turbines	Damage, mortality
	Physical presence and visibility	Permanent habitat loss (sensitive species) or change, avoidance behaviour, disturbance of resting, feeding or wintering areas, barrier effect, fragmentation of associated areas (e.g. feeding and resting areas)
	Shading effect and light reflection	Avoidance, barrier
	Operational noise (air)	Avoidance by some species
	Operational noise (water column)	Avoidance
	Introduction of artificial hard substrate	Disturbance of feeding, resting, wintering areas, habitat loss; Indirect beneficial effect due to increased food species availability, attracted by area (probably few birds profit from this)
	Indirect due to impacts on food resources	Reduced food resources; Pollution of food resources and water (due to release of harmful substances)
	Increasing boat and air traffic	Habitat loss, disturbance of resting, feeding or wintering areas, avoidance, stress, increased flying-off and reduction of biological fitness; Emissions

	Physical presence as safety risk for fishing boats	Higher fish abundance and new species likely, so increasing food availability
	Release of harmful substances due to accidents, ship collision or from turbines	Mortality, damage, habitat loss, destruction of feeding and resting areas
Bats	Physical presence and collision risk	Mortality
	Physical presence	Attracted by installation, new habitat, resting and feeding area; Avoidance and habitat loss Barrier effect;
	Ultrasound emission	Disturbance of orientation
Zooplankton	Decreasing food resources (when phytoplankton effected negatively)	Mortality
	Shading effect	Avoidance
	Increasing ship traffic	Damage and mortality due to pollution
	Water quality (e.g. oxygen deficit and germs)	Damage of organisms and mortality
	Release of harmful substances due to accidents, ship collision or from turbines	Mortality, damage, habitat loss
Phytoplankton	Sediment turbidity, stripes of turbidity, smothering of water	Decreasing light transmission and reduction of photosynthesis, temporary habitat loss
	Shading effects	Reduction of photosynthesis
	Water quality (e.g. oxygen deficit and germs)	Damage, mortality
	Release of harmful substances due to accidents, ship collision or from turbines	Mortality, damage, habitat loss
Macrophytes	Sediment turbidity, stripes of turbidity, smothering of water	Temporary habitat loss, reduction of photosynthesis
	Change of sediment composition and flow regimes	Permanent habitat loss, alteration of plant community composition
	Sealing of seabed	Permanent habitat loss
	Introduction of artificial hard substrate	Alteration of plant community composition, habitat loss or new habitat
	Release of harmful substances due to accidents, ship collision or from turbines	Mortality, damage, habitat loss
Human beings	Physical presence as safety risk for fishing boats	No fishing, with an effect on the resource fish
	Pollution due to accidents and release of harmful substances	Human health (over food chain)

	Accidents, increasing risk of ship collision	Human health and life
	Noise emission while construction	Health
	Visibility	Loss of recreation area

Table 2.2.6-1 Impacts of offshore wind farms on protected assets and their sources

Chapter III: Offshore wind farm projects in Germany

Within this chapter the environmental impacts addressed within the documents of the German offshore wind farm “MEG Offshore I”, acting as a base for information based decision-making, are introduced. First, a general overview of the legal base within the licensing process including important laws as well as guidelines regarding environmental protection is given. Also the most important steps, documents, stakeholder and public bodies influencing the decision-making of the procedure from the start document till the authorisation are introduced shortly. These information help to understand the choice of the documents EIS and licensing text analysed to show which impacts are addressed and are most important for the decision-making. On other hand, as the EIA is influenced by social and political pressure (Arts, 2004) and is a non-autonomous instrument (standards and requirements are defined by national law) these information are crucial for understanding on which base and by whom the decisions are made.

These documents are part of the German permit system for large projects which requires a license and is, besides others, used to address impacts of large projects. Before the license can be given, different steps have to be taken, stakeholder involved and documents made considering, e.g., environmental impacts of the project (BSH, 2010). The licensing text is the end document of this procedure. The main decisions of the authorisation procedure, issues taken into consideration and requirements given are summarised in this text. An important document supporting the final decision is the EIS. It is nowadays the instrument most valuable addressing environmental impacts directly (Köller et al., 2006).

After giving an overview of the decision-making base for offshore wind farms in Germany, the EIS and licensing text of the German project are shortly introduced, including the contents and their relation. A short introduction of the project “MEG Offshore I”, taken as the German example to be analysed, including some important data about the project follows. Afterwards, the results of the content analysis (see annexe, evaluation table) of the EIS and the licensing text of the German offshore wind farm “MEG Offshore I” will be discussed. The content analysis looks at the documents focusing on which impacts on the marine environment are assessed and the level of detail they are discussed. The method used for the analysis of the documents is explained in the annexe. In this chapter, mainly the impacts identified in the evaluation table (annexe) as discussed and discussed partly (analysis table, rank 1 and 2) are taken into account, as they are important for the decision-making. Due to the high value given to the EIS for the decision-making in the licensing process the intensively discussed issues (rank 1) are seen as highly relevant to the decision-making process and the issues discussed less intensive (rank 2) as relevant. The ranks 3 and 4 of the evaluation table (annexe) are not considered here.

Besides assessing possible impacts and their sources, the documents assess cumulative effects and contain recommendations and requirements of mitigating measures to soften negative impacts. These issues are not considered within the analysis table, but will be discussed within this chapter. Furthermore, a short look on impacts addressed within the area specific assessment, considering effects on Natura 2000 areas, is taken.

Cumulative effects are not taken into consideration in the evaluation tables (annexe), as they can not be easily related to the impacts or sources of impacts written in the table. Cumulative effects are caused by different sources. They are discussed within this chapter as they are very important to take into account for decision-making. The construction, operation and removal of a single offshore wind farm might not affect the marine environment in a way which would justify a rejection of a permit, but the adding up of many offshore wind farms or with other activities or uses in turn can have negative effects and lead to a rejection of the permit.

3.1 Decision-making base

3.1.1 Legal base and standards

The German *Federal Maritime Responsibilities Act* (Seeaufgabengesetz) implemented by the *Marine Facilities Ordinance* (Seeanlagenverordnung, SeeAnlV) builds the base for the authorisation procedure of offshore wind farms in the EEZ (BSH, 2010). Within this approval procedure it needs to be proved that the project (1) “does not impair the safety and efficiency of navigation, [and] (2) is not detrimental to the marine environment” (SeeAnlV §3). The endangerment of the marine environment is specified and defined within this ordinance as “pollution of the marine environment" due to UNCLOS (article 1, paragraph 1 (4)) or the endangerment of birds migration (§3 SeeAnlV). If a project affects the marine environment negatively, suitable measures need to be available to limit the impacts to a certain period of time, prevent or compensate negative effects. Furthermore, the project needs to (3) go conform with the interests of spatial planning (targets and principles of marine spatial planning, Federal Spatial Planning Act & EU Directives) and other main issues of public interest (e.g. resource exploration) (SeeAnlV §3). Due to Köller et al. (2006), the Federal Maritime Responsibilities Act and *Marine Facilities Ordinance* also implements other international conventions, like OSPAR and the Helsinki Conventions, into national law.

An important tool to prove the marine environment and its protected assets are not impaired strongly is the environmental impact assessment (EIA) introduced above. It is put into praxis by the European EIA Directive and implemented into national law by the *Environmental Impact Assessment Act* (UVPG – Gesetz über die Umweltverträglichkeit). The UVPG requires an investigation, description and evaluation of direct and indirect impacts of a project on the protected assets described above (chapter 2.1). If more than 20 turbines are installed as part of the project, an EIA is obligatory (EIA Directive & UVPG, Annex 1, no. 6). The applicant needs to assess and prognosticate possible impacts on the marine environment in the project area (BioConsult SH, 2008). Furthermore, it defines the general contents of an EIA.

The contents is described more detailed in the guideline *“Standards for the Environmental Impact Assessment”* (StUK - Standarduntersuchungskonzept) developed by the BSH in cooperation with experts.

The *Federal Nature Conservation Act (BNatSchG - Bundesnaturschutzgesetz)* is implementing the European Habitats and Birds Directive into national law. §38 requires the designation of Natura 2000 areas, projects to be proved on their compatibility with the development goals of the designated Natura 2000 areas. According to §56 para. 1 regarding the protection of species and habitats in the EEZ, the Federal Agency for Nature Conservation (BfN) checks if the project is violating prohibitions regarding the protection of species and habitats and, when indicated, if exceptions are admissible. The impacts on the environment need to be compensated, stated within §15 about the impact regulation

(Eingriffsregelung), but the paragraph is not applicable for offshore wind farms approved before 01.01.2017 (BSH, 2010). The BSH formulated in collaboration with the BfN a guideline for the execution of the impact regulation under the Federal Nature Conservation Act in the EEZ, called “Leitsätze für die Anwendung der Eingriffsregelung in der AWZ” (BSH, 2010).

An important instrument to coordinate uses, and ensure the concentration of construction of turbines within designated areas and therewith protect more sensitive areas (e.g. Natura 2000, Marine Protected Areas) is *marine spatial planning*. The *Federal Spatial Planning Act* – the territorial planning law – was extended with the act of June 24th 2004 to the EEZ and allows therewith a development of maritime spatial planning. Surface water, water column and sea bed - all part of MSP - are covered with it. With the marine spatial plan, the German North Sea area is divided into different zones with different activities (European Commission, 2008).

The extension to the EEZ enables a better co-ordination of the different economic and scientific uses with the goal of ensuring safety and efficiency of navigation and a marine environmental protection. Due to §18a Federal Spatial Planning Act (of August 18th 1997), introduced by the act of June 24th 2004, the Spatial Plan for the EEZ of the North Sea was drawn in the form of an *Ordinance on Spatial Planning in the German Executive Economic Zone in the North Sea* of September 21st 2009 (BMVBS, 2009). A map shows the different uses divided into areas of priority and reservation for offshore wind energy farms as well as shipping, pipelines, submarine cables and marine scientific research and gives information about cable or pipeline corridors, areas of nature conservation, exploitation of sand, gravel or gas, military use and offshore wind farms (BSH, 2009a). A text part explains targets and principles of spatial planning in the EEZ as well as the base the plan is build on, it justifies the choices of targets and principles and gives an overview of the legal background (BMVBS, 2009a). Furthermore, an environmental report for the German EEZ in the North Sea was made as a base for the spatial plan (BSH, 2008). Impacts are not getting addressed directly, but mitigated as areas are designated for nature conservation where other activities opposed to the protection or development targets are prohibited and special areas for construction of wind farms identified. This plan bases on an SEA, also containing a description of environmental impacts expected.

Addressing environmental impacts

Legislations and standards used are having consequences for the way impacts are getting addressed. They are forming the statutory framework making sure impacts are taken into consideration for the decision-making and are getting assessed as well as asking for measures to be taken. Also stakeholder involved and having a saying within the decision process, which are introduced later on, are defined. But legislations do not give specific rules, guidelines or criteria about how to evaluate impacts or about when exactly can a project not be permitted because of its significant environmental impacts. The realisation and ways to evaluate impacts are in the end up to the evaluator and the responsible authority.

First of all, the *Marine Facilities Ordinance* ensures environmental impacts are taken into consideration and a permit can be rejected if the project harms the environment significantly. But this *Marine Facilities Ordinance* does not define or give criteria for defining at what point a project is detrimental to the marine environment: when does it harm the environment significantly? Due to Peters et al. (2008), also the *"Standards for the Environmental Impact Assessment"* give rules for the description of assets but not for the evaluation, which is up to the evaluator. For the evaluation of impacts on protected assets criteria are used which are also defined by the evaluator of the EIS. Besides the evaluator, other experts are reviewing the work and give requirements for an improvement. The *Marine Facilities Ordinance* is also a frame for the application of mitigating measures by stating that suitable measures are needed to minimise or avoid negative impacts.

The *Environmental Impact Assessment Act* is an important base to ensure impacts are assessed, written down in a document and, hence, are known and implemented into the decision. The EIA Act (§ 2) asks for an overall final assessment, assessing the endangerment of the protected assets. The way of doing it is again up to the evaluator (Peters et al., 2008). The European EIA Directive, building the base for the *Environmental Impact Assessment Act,* defines protected assets to be assessed, but no further criteria about the evaluation of impacts are given. Which also has to be mentioned is that the definition of protected assets by the EIA Directive as well as the definition of the *"Standards for the Environmental Impact Assessment",* giving criteria for how to describe assets within the project area, are already political choices. So, legislation is also indirectly limiting. Due to the *Federal Nature Conservation Act,* also compensation is necessary, which is due to political decisions not necessary for the wind farms approved before 01.01.2017. The political pressure on building offshore wind farms is high, hence, there is a danger of overlooking impacts and violating basic regulations, like the necessity of compensating damages of the environment. Special rules are made up by the responsible authority for the compensation within the EEZ. The *Federal Nature Conservation Act* also implements the Habitats and Birds Directives into national law and therewith identifies protected species and habitats which are getting a special attention within the documents supporting the decision-making about the environmental compatibility of the project.

The *Ordinance on Spatial Planning in the German Executive Economic Zone in the North Sea*, as mentioned, does not address impacts directly but protects special areas of high value and, hence, mitigates negative impacts within this areas.

More information about German standards for the realisation and use of offshore wind farms can be found on the following web page:
http://www.naturschutzstandards-erneuerbarer-energien.de/index.php/ergebnisse/offshore-windenergie/stand-der-standardisierung, 29.03.2011

3.1.2 Role of EIS and licensing text for the decision-making

For planning and authorisation of large projects in the German EEZ a permit system with different instruments is used which are, according to Köller et al. (2006, p.307), "having the task of ascertaining the impact on the marine environment caused by the construction, installation and operation of offshore wind farms, and of integrating this information into the decision-making process on the authorisation of such projects". The most important instruments are the EIA (result: EIS) and the authorisation procedure (result: licensing text).

The *EIA* is done to get a broad overview of possible impacts of the project on the marine environment and its protected assets, hence, for having a good base to decide about the effects which need to be considered for the decision about the environmental compatibility of the project and therewith its permit. So what does the EIS contain? The structure of the German EIS contains a description of the project including the location, technical data of the wind turbines, foundation, cabling, about construction, operation and removal, including a time plan. Alternatives to the planned wind farm are also discussed, but very shortly. A description of impacting factors during the construction, operation and removal of the wind farm is given. Other present and planned uses and activities are outlined and evaluated which is, with regard to impacts on the marine ecosystem, necessary to assess possible cumulative effects of these activities with the planned wind farm. Furthermore, present environmental conditions of the protected assets in the affected area are described and evaluated and a prediction of the environmental development without the realisation of the planned project is given. An important part is the assessment of impacts of the project which can be expected on the marine environment and its protected assets: soil and sediment, water, air and climate, phyto- and zooplankton, benthos, fish, sea birds and mitigating birds, marine mammals, bats, landscape as well as human beings and their health. It contains an evaluation of impacts caused by the different project phases, including cumulative effects. Gaps of knowledge causing problems in forecasting changes and negative impacts by the project is also an important issue to be mentioned, as an EIS is also a base for further research to close gaps of knowledge. Another essential point is the description of possible measures to mitigate negative impacts (BioConsult SH, 2008). Some activities, e.g. pile driving, have such significant negative impacts on protected assets that without any mitigating measures the project could not be authorised due to species conservation policies, like the European Habitats Directive article 12 (BioConsult SH, 2008a). Also planned monitoring activities of the construction phase, operational phase and during the removal of the wind farm are outlined which ensure that significant impacts are recognised and that further experiences about the effect on wind farms on the marine ecosystem can be made.

When asking the question about the impacts addressed within the decision-making process, choosing the EIA as one important instrument for decision-making, it needs to be clarified how the decision about the contents of the EIA is made. Not all impacting factors and protected assets can and need to be studied into detail. The art is to find a balance between make the EIA efficient, but take into account all affected assets and important impacting factors (Köller, 2006; Peters et al., 2008). This is a hard task as, like already mentioned, there are large gaps of knowledge about the marine ecosystem and effects of offshore wind farms on it. In the German case, different studies were made trying to define impacts and affected protected assets to be addressed within the decision-making process and how to address them (Köller, 2006; Peters et al., 2008). One of the first was made by Peters et al. (2008) with the goal to identify which protected assets are affected by impacts and need to be taken into consideration within the EIA and decision-making process. Also a concept for the evaluation of the significance of impacts was made up. To develop a standard concept for the evaluation of impacts in the EIA and for the development of final evaluation described in the licensing text they also had a look at different EIS and licensing texts.

For the development of EIAs, the BSH developed in cooperation with experts the "Standards for the Environmental Impact Assessment" with guidelines specifying issues to be assessed and how to be assessed (BSH, 2010).

The *licensing text* contains an own description and evaluation of the current environmental status of the project area, its initial level of pollution and possible impacts caused by the project. Possible affected protected assets soil or sediment, water, climate, landscape, cultural heritage, human beings, flora, benthos, fish, marine mammals, avifauna including sea birds and migrating birds, as well as bats and inter-action between the factors. The final result of the EIS, in this case the environment compatibility, is mentioned roughly in the end. According to Peters at al. (2008), the licensing text is an independent survey, the results of the EIA are only taken into account partly. For this reason Peter et al. (2008) ask for a better compatibility of EIS and licensing text also to make it more efficient.

An area specific assessment about effects on Natura 2000 areas is a part of the EIA. In this report the most significant known effects on Natura 2000 areas and its protected assets are evaluated here. It needs to be ensured the project is not contradictory to aims and targets of this network of protected areas (BioConsult SH, 2008b).

3.1.3 Permit procedure: steps and stakeholder

Following, an overview is given about the steps taken within the licensing process, important for decision-making, including the final decision about the environmental compatibility of the project. Also interesting in this context is who influences this decision. The role of public bodies and other stakeholder, like different groups of interest, experts or the public is also explained briefly below. Figure 3.1.3-1 gives an overview of different steps taken, their outcomes and stakeholder involved.

Responsible bodies and stakeholder

The Federal Maritime and Hydrographic Agency (BSH - Bundesamt für Seeschifffahrt und Hydrographie) is responsible for the approval of offshore wind farms within the EEZ. Within the 12 nm zone, the Federal States (Länder) are in charge for permissions (BSH, 2005). In this thesis the approval procedure within the EEZ is relevant, as “MEG Offshore I” is located in the German EEZ. The responsible authority of a federal state has to be involved as the electric cable have to be laid through their area to connect it to the power grid at the mainland. The BSH also checks whether the marine environmental features to be protected are endangered by the project (BSH, 2010).

The Water and Shipping Directorate North (Wasser- und Schifffahrtsdirektion Nord, WSD Nord) is responsible for the Baltic Sea and eastern North Sea, the Water and Shipping Directorate North-West (WSD Nord-West) for the north-westerly part of the North Sea. The directorate has a veto right on the permit given by the BSH (Zeelenberg, 2005).

The Federal Agency for nature Conservation (Bundesamt für Naturschutz, BfN) is responsible for proving if the project violates prohibitions regarding the protection of species and habitats and, when indicated, if exceptions are admissible (BSH, 2010).

Third stakeholders involved within the decision-making process are governmental bodies, groups of interest like fishery, shipping, nature protection, from the energy sector, as well as the local directorates and citizens (Zeelenberg, 2005).

The project owner - a private company - has to deliver the necessary documents, like the application including a detailed description of the project and the area, studies about risks for navigation and the environment (BSH, 2010).

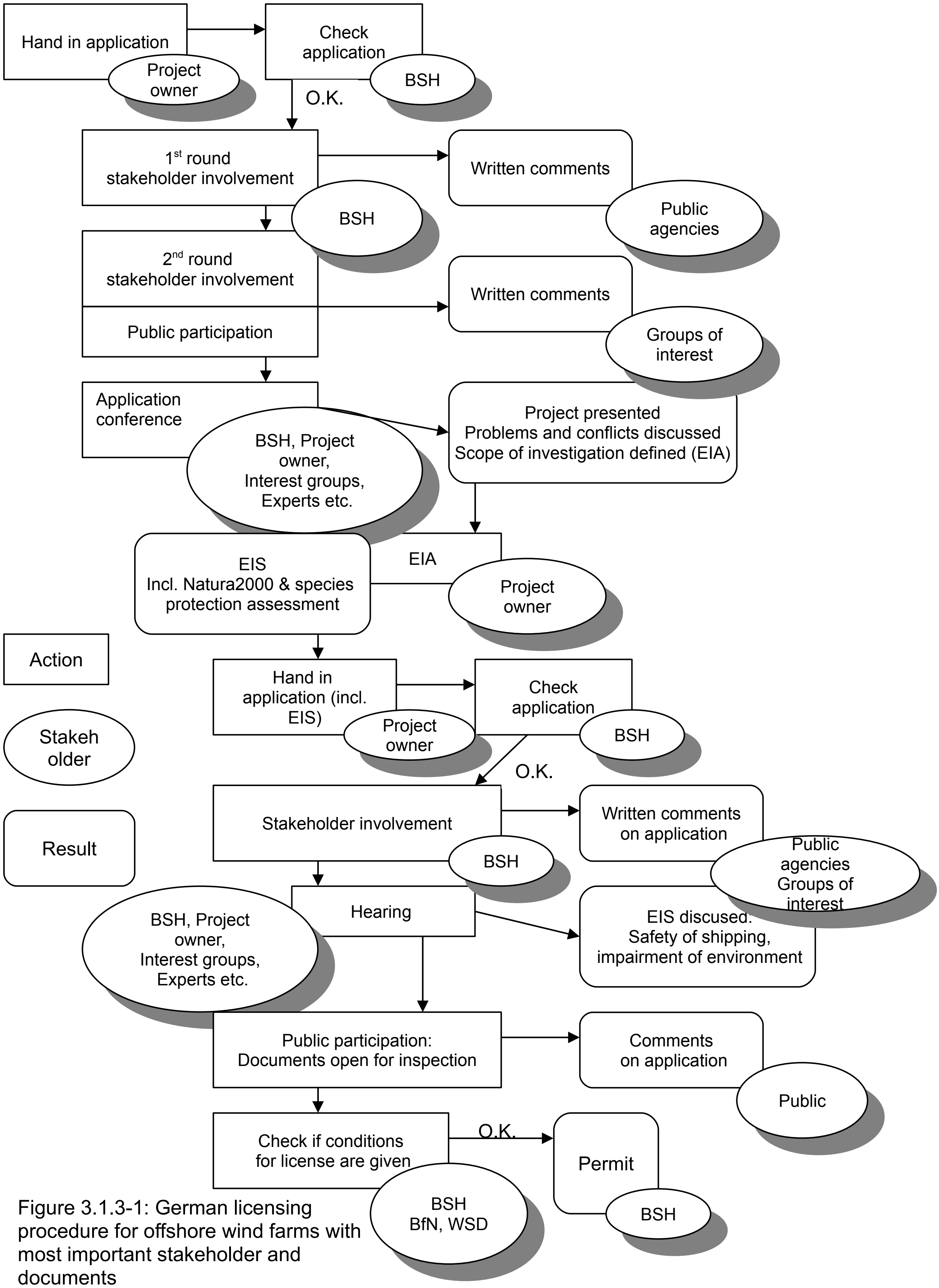

Figure 3.1.3-1: German licensing procedure for offshore wind farms with most important stakeholder and documents

Phases within the licensing procedure

According to the Marine Facilities Ordinance and BSH (2010) and shown in figure 3.1.3-1, the procedure runes like described following: The procedure starts with handing in the planning application. The BSH checks the application documents of completeness, if necessary the project owner has to work them over again. After an “okay”, the BSH initiates a first round of stakeholder involvement, sending the application to public agencies, e.g., regional Waterways and Shipping Directorates (WSD), the mining authority, the Federal Environmental Agency (BMU) and the Federal Agency of Nature Conservation (BfN) and requests for a written comment. After the evaluation of the written comments of public agencies involved, the BSH starts a second round of stakeholder involvement (2. Beteiligungsrunde, Interessensverbände). Different groups of interest are getting informed, e.g., nature protection organisations, fishery or shipping. At the same time a public participation by publishing the project initiative in newspapers takes place, the inspection of the planning documents is possible. Also an early involvement of coastal states is important, as they are responsible for the permission of land feeder cables which conduct the electricity from offshore wind farms through the territorial sea to onshore substations and the electricity grid.

As a next step an application conference follows, where the applicant (project owner) can present the project. Problems and conflicting issues are addressed and discussed and the scope for investigations of negative effects on the marine environment, in form of an EIA, gets defined. Based on these advisements, StuK and environmental studies, the applicant makes or rather commissions experts with the execution of an EIA. Also a risk analysis, not mentioned in the diagram below, regarding the safety of navigation, calculating the probability of ship collision with wind turbines has to be done.

After receiving the application documents, including the EIS, area specific assessment, risk analysis and other surveys, the BSH checks them and sends the documents to stakeholders to give an opportunity for a commentary. A hearing, an other discussion round with involved stakeholders, follows where the safety of navigation as well as the impairment and protection of the marine environmental feature and other issues affected are getting addressed. Public participation happens in form of a newspaper article and the possibility of inspecting and commenting the documents.

The BSH checks if the conditions for a license are given, also the BfN and WSD are involved. First, the BSH is checking, inter alia, whether the marine environmental features to be protected are endangered by the project, if compensating measures or financial measures for compensation are necessary and in which form (based on “Leitsätze für die Anwendung der Eingriffsregelung in der AWZ”). After, the WSD proofs the safety and efficiency of shipping and navigation. The BfN proofs, based on the EIS, if the project violates prohibitions regarding the protection of species and habitats and, when indicated, if exceptions are admissible (BSH, 2010). Finally, if all requirements are met a permit is given by the BSH and proofed by the WSH, which has a right to veto (Zeelenberg, 2005).

3.2 The project “MEG Offshore I”: area and data

The offshore wind farm “MEG Offshore I” analysed below is located in the German North Sea. Figure 3.2-1 shows the location including the coordinates and other planned or already realised offshore wind farms.

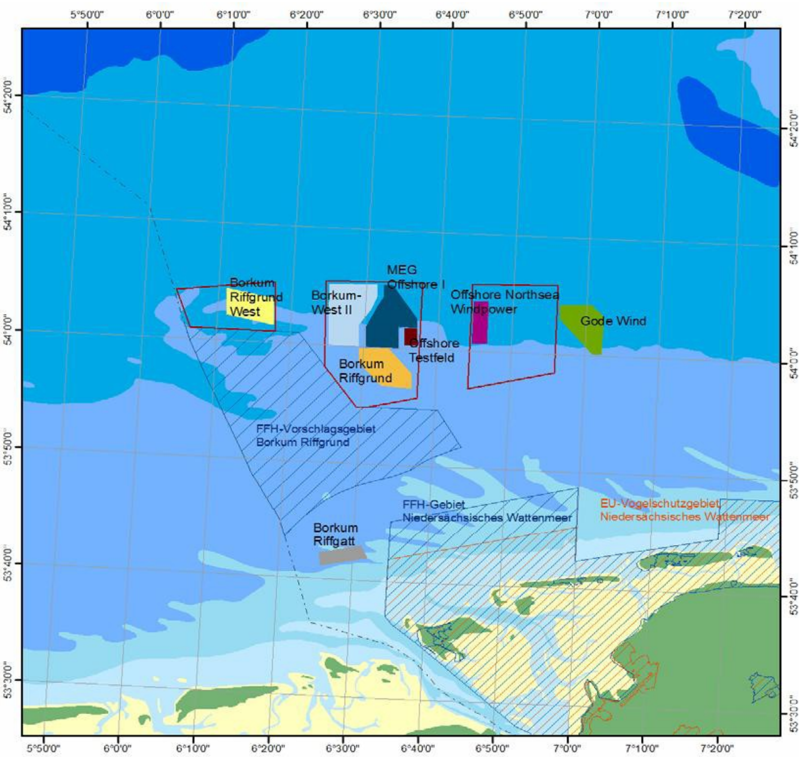

Figure 3.2-1: Location of offshore wind farm MEG Offshore I and other planned offshore wind farms north of the Lower-Saxony coast (BioConsult SH, 2008)

The location is about 45 km north of the East Frisian Island Borkum, in an area of about 46 km² in size with a water depth of 27-33 meter. The location is within one of the priority areas for offshore wind energy according to the Spatial Plan for the EEZ in the North Sea. The next Natura 2000 areas are Borkum Riffgrund in the south of the wind farm and the Wadden Sea. Furthermore, as effects of offshore wind farms on the environment due to a lack of experiences with this young technology are not fully predictable yet, the wind farm is limited to 80 turbines due to regulations by the BSH. The distance between the turbines is 880-1000 meter, steel tripods build the foundation. More information about technical data of the wind turbine and submarine electric cable can be read in the EIS (BioConsult SH, 2008).

3.3 Analysis: Addressing impacts of 'MEG Offshore I'

The analysis concentrates on impacts assessed within in the EIS and the licensing text, as these documents give an overview of impacts important for decision-making. But also two other important documents, which are used in the light of assessing potential impacts on the marine environment, get considered here. These documents are impact studies regarding impacts on Natura 2000 areas and the protection of species and their habitats, due to the Habitats Directive, article 12. They are part of the EIS and, therewith, also important for an information based decision-making.
Following, the questions about impacts addressed and important for decision-making, protected assets affected, measures used to mitigate impacts and cumulative effects are getting answered.

3.3.1 EIS

a) Impacts

Table 3.3.1-1 below gives an overview of the mainly considered impacts and their sources on protected assets in the North Sea within the EIS of the German offshore wind farm “MEG Offshore I”. This table results from the evaluation of the document. The method used is described detailed in the annexe, the complete evaluation table can also be found in the annexe. The issues listed in the table are discussed quite detailed in the document and are interpreted as important for the decision-making.

Issues listed under "primary focus" are impacts on protected assets discussed detailed in the document (evaluation table: rank 1), the impacts listed under "secondary focus" are important and discussed, but not discussed very detailed (evaluation table: rank 2).

Assets	Primary focus	Secondary focus
Water		Suspended sediments in water body and stripes of turbidity causing turbidity and smothering of the water due to construction activities, e.g. dredging, pile driving and cable laying
		Less swell, but a higher turbulence at water surface leading to a stronger steering of the temperature stratification due to physical presence
		Increasing risk of pollution by ship collision
Seabed		Suspension of sediments and stripes of turbidity due to construction activities, like dredging, pile driving, cable laying
		Sealing of sea ground by introduction of artificial hard substrate and the demand of space
		Change of sediment dynamics (erosion and sedimentation), sediment composition and structure, morphology and development of scour pits and tails, sediment turbidity and as a result of this the release of harmful substances due to physical presence and therewith changing hydrodynamics
		Increasing temperature of sediment and pore water caused by operating submarine electric cable
		Increasing risk of pollution due to ship collisions
Benthos		Endobenthic organisms laid open, epibenthic organisms covered causing mortality, damage, habitat loss due to re-suspension and relocation of sediments
		Introduction of artificial hard substrate causing a permanent habitat loss and mortality, new habitat for new species, a shift of community composition, increased biomass, biodiversity and abundance at the piles
		Electromagnetic fields caused by electric cable could damage individuals, possible responses of cancer (lack of knowledge)
		Physical presence as safety risk for fishing boats leading to protection against bottom trawling and indirect a higher predatory pressure

Fish	Sediment turbidity, re-suspension, sedimentation causing a damage, dislocation, temporary habitat loss (especially pelagic fish), damage to fish eggs and spawning grounds	Introduction of artificial hard substrate leading to a new habitat, attraction of fish and new species, change of community composition, serving as nursery area and protection from predators, the availability and diversity of prey organisms changes and increases
	Construction noise and vibration especially while pile driving causing stress, behavioural effects, injury, mortality from gas embolism, impair sense of hearing, deafness, impair survival, dislocation and temporary habitat loss, masking effect, damage and elimination of fish spawn and larvae	Vibration and noise emission into the water body during operation causing a habitat loss, dislocation, barrier effect, behavioural effects, stress, masking by noise (pray, enemies, intra-specific)
		Light reflection and shading effect from rotor blades can lead to avoidance of some species
		Physical presence as safety risk for fishing boats making the area to a refuge from intense fishing, regeneration area allow a recovery of stock, development of natural age structure
Marine mammals	Construction noise especially pile driving, but also boat traffic, cable laying and removal leads to a temporary habitat loss, fragmentation, behavioural change, avoidance, temporary or permanent physical damage like hearing damage impair survival, loss of individuals, disturbance of intra-specific communication due to masking by noise therewith reduction of reproduction rate	Increasing boat and air traffic having species-specific effects, like change of behaviour, stress and avoidance
	Vibration and noise emission into the water body during operation causes a barrier effect to mitigating marine mammals, fragmentation of resting, hunting and reproduction areas, changed behaviour, disturbance and permanent habitat loss possible, masking effect and disturbance of intra-specific communication	
Mitigating birds	Increased collision risk especially in nights with poor visibility causing higher mortality due to the physical presence	Due to noise emission while pile driving an avoidance of the area is expected
	Physical presence and visibility cause a barrier effect and fragmentation of migratory routes, avoidance or flying around costs energy and reduces fitness	Visual effects of construction and maintenance leading to a temporary habitat loss of species sensitive to this impact, avoidance, flying around the area and reduction of fitness
	Facility illumination increases the collision risk, attracts some species, flying around the facility costs extra energy (mortality possible)	Increasing boat and air traffic leading to habitat loss, loss of feeding and resting area; stress, more flying-off causing reduction of biological fitness
Sea birds	Visual effects of construction works cause avoidance, temporary habitat loss, feeding, resting and wintering areas can be affected	Physical presence and visibility cause disturbance of resting, feeding or wintering areas, barrier effect, fragmentation of associated areas, e.g. feeding and resting areas

	Physical presence and visibility causing permanent habitat loss (sensitive species) or change, avoidance behaviour	Increased collision risk especially in nights with poor visibility causing higher mortality due to the physical presence
	Increasing boat and air traffic leading to habitat loss, disturbance of resting, feeding or wintering areas, avoidance, stress, increased flying-off and reduction of biological fitness	Light reflection and shading effect from rotor blades can lead to avoidance and barrier effects
		Emissions due to increasing boat can harm birds
		Higher fish abundance and new species likely, so increasing food availability due to physical presence as safety risk for fishing boats
Bats		Physical presence can lead to an increasing mortality by collisions with the turbines
Not further discussed are: Zooplankton, Fauna, Human beings, Air and Climate		

Table 3.3.1-1: Mainly considered impacts and their sources on protected assets in the North Sea within the EIS of the German offshore wind farm 'MEG Offshore I'

Within this EIS the main focus lays on the impacts on fish, marine mammals, sea birds and migrating birds. The two main issues regarding the impacts on *fish* are damage and dislocation, habitat loss of fish due to re-sedimentation and stripes of turbidity while construction and noise emission and vibrations into the water body while pile driving causing stress, injury, impairing the survival, mortality, damage and elimination of fish spawn and larvae. Probably mostly discussed in detail are the effects of noise emissions during pile driving on *marine mammals.* But also sounds and vibrations emitted into the water body while operation and their effects: barrier effects, fragmentation of associated areas, habitat loss, masking-effect, disturbance of intra-specific communication are considered. Regarding effects on the *avifauna*, visible effects due to construction works or physical presence leading to a temporary or permanent habitat loss, especially for sea bird species sensitive to this disturbing impact, like loons. They avoid the area and feeding, resting and wintering areas can be affected. Also increasing boat traffic causing flying-off and, hence, a reduction of the biological fitness is taken into account within the EIS. In case of mitigating birds it is mainly discussed how they are affected by the increasing collision risk causing higher mortality rates and the possible impairment on the birds migration and whole populations. In this context the facility illumination attracting birds and increasing the collision risk is considered and described detailed. Another important point within the EIS is the physical presence of the wind farm and the barrier it builds for bird migrations. Birds often avoid passing through wind farm by flying around which increases the way and, hence, has negative effect on their biological fitness. Water, seabed, benthos and bats are considered secondarily. Effects on the protected assets fauna, human beings, air and climate are neglected.

b) Cumulative effects

Cumulative effects of the different impacts of the wind farm due to construction, maintenance, operation and removal are not taken into account by the matrix developed for evaluation, as their consideration is quite complex. But as they are crucial to decision-making, they are getting attention in this part of the content analysis.
In the EIS cumulative effects are taken into account very roughly for every protected asset defined by the EIA Directive. Only cumulative effects of the planned offshore wind farm with other offshore wind farms are considered within the EIS of “MEG Offshore I”. Other activities and uses which could cause further impacts cumulating with impacts of the planned wind farm are not taken into consideration.

Protected asset	Cumulative effects	Focus in EIS
Water pollution	The risk of ship collision with a wind turbine increases with the amount of wind farms	secondary
Fish	Positive cumulative effect due to fishing ban and introduction of artificial hard substrate in areas where offshore wind farms are connected	secondary
Marine mammals	Pile driving when at the same time at different wind farms. Big radius from the source of noise, so can overlap with other noise	primary
Sea birds	Habitat fragmentation and barrier effect. Physical presence of many offshore wind farm can cause a large habitat loss of species sensitive to this impact and avoid the areas spaciously. Attention paid here to one species, the loon	primary
Mitigating birds	Global influence as collision risk and therewith an increasing mortality can have serious negative impacts/ influence on the populations affected.	primary
	Offshore wind farms can be a barrier for mitigating birds as they often show an avoidance of the offshore wind farms and fly around the wind farm. Many wind farms can result in a summation of many small extra way to a change of the route leading to a long way around.	primary

Table 3.3.1-2: Cumulative effects on protected assets taken into account in the EIS

The cumulative effects taken into account in the EIS are mainly effects which are discussed quite intensive in the EIS, so impacts which could be relevant for the decision about the environmental compatibility in the end. Therewith, mainly significant impacts get studied, focused on if they are adding up with other impacts of other wind farms and become to significant to permit the project.

One significant impact is the noise emission while pile driving. Figure 3.3.1-1 shows the radius of different noise emission while pile driving. It can be seen how the area is affected by construction activities. Cumulative effects of pile driving within one wind farm are shown as well as other wind farms close by which also impair the area during pile driving.

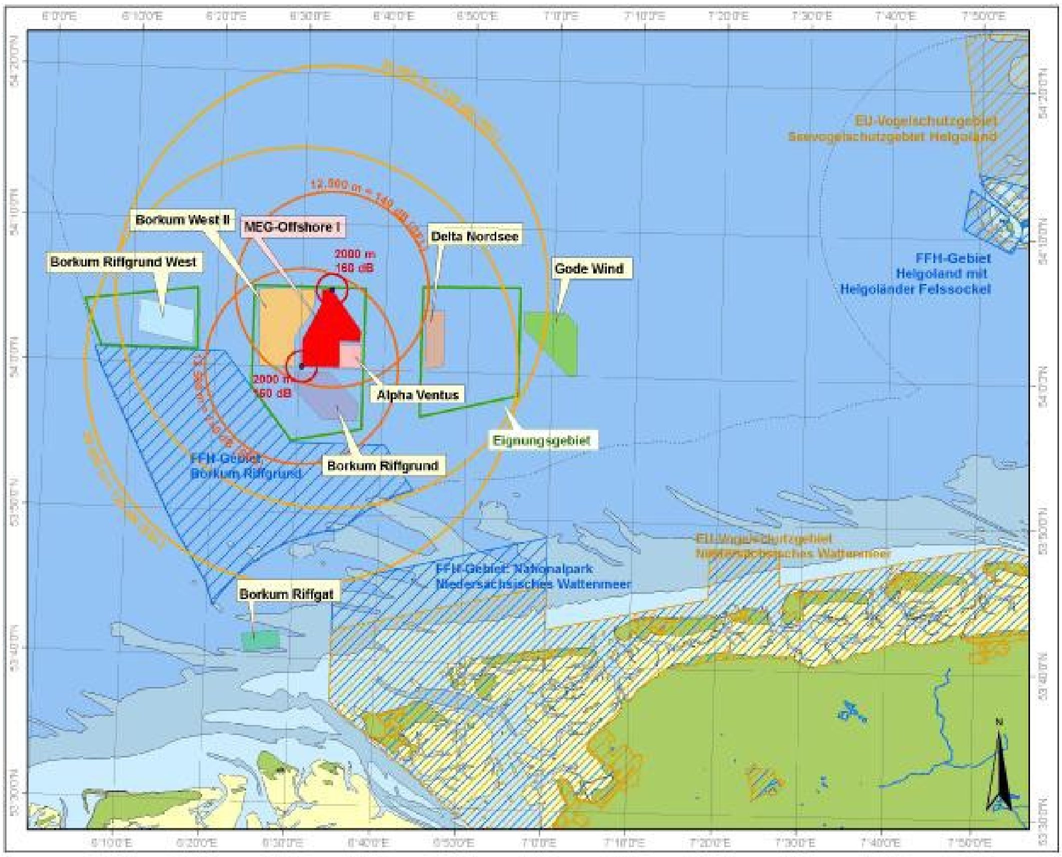

Figure 3.3.1-1: Predicted noise radii for pile driving at “MEG Offshore I” (BioConsult SH, 2008)

c) Measures

Measures and requirements discussed in the EIS are mitigating ones. The compensation of impacts within the areas is not yet necessary in Germany. The offshore wind farms approved after 01.01.2017 will have to define compensating measures.

Mitigating measures addressing different impacts, like noise emission, pollution, habitat loss or disturbance, are the following ones:

Water pollution

- To minimise the release of harmful substances choose anti-corrosion colour long lasting and as environmentally friendly as possible
- Prohibiting sewage and waste dumping
- Ensure avoidance and minimisation of release of harmful substances due to corrosion, accidents, failure of turbines

Noise emission (marine mammals, partly fish)

- Measures to displace animals before construction by a „soft start“ of pile driving and using acoustic disturbing signals (e.g. „Pinger“ and „Sealscarer“);
- Measures to reduce noise emission by covering pile into foamed plastic or similar material as air barrier suitable to reduce sounds in the water body
- Definition of a limiting value (UBA: 160 dB (SEL) 750m from source)

Collision risk, attraction (birds)

- Keep corridors (3 km) between wind farms open allowing birds to pass
- Use of light which reduces attraction of birds (like white flash light, or reduced red spectral component), reduce illumination to minimum

Disturbance, habitat loss (birds)

- Keep construction phase short, preferably not while main resting time (May – September), but the requirement are not seen as necessary
- Build wind farm compact to use minimal space

Space, habitat loss

- Reduce space needed to minimum

Disturbance of the seabed

- Use of hollow tubes contributing to the minimisation of compaction and dislocation of sediments while construction of the foundation

The measures listed above are addressing the most significant effects, discussed quite detailed in the EIS, like minimising noise emissions due to pile driving and their effects on marine mammals. Also the collision risk of migrating birds can be minimised by leaving corridors between wind farms open and decrease the illumination to minimum or prohibit the use of light which attracts the birds. Water pollution can be minimised by keeping the release of harmful substances low and prohibiting waste dumping. Furthermore, the space the offshore wind farm takes up can be reduced to a minimum to keep the affected area small and protect habitats.

3.3.2 Area specific assessment study: Natura 2000 and protection of species

The area specific assessment study stands in this case for the "Natura 2000 – Verträglichkeitsprüfung" and the "Artenschutzrechtliche Prüfung" which are part of the EIS. These documents describe and evaluate impacts on Natura 2000 areas and its protected assets. The evaluation bases on requirements of the Habitats Directive and an assessment of birds affected as asked for in the Birds Directive.

In Table 3.3.2-1 impacts described in the Natura 2000 environmental compatibility study (BioConsult SH, 2008b) are listed. Described within the documents are the impacts which could harm protected assets, Natura 2000 area and are contradictory to its targets and aims. Protected assets described here are marine mammals, sea birds and mitigating birds. The focus lays on most significant impacts which could increase the mortality, disturb animals or their habitats.

Protected asset	Impacts	Cumulative effect
Marine mammals	Noise emissions while construction, pile driving	Planned offshore wind farm with other offshore wind farms
	Noise emission while operation of wind farm, habitat loss and barrier effect of migration routes	No
Sea bird	Avoidance of the wind farm area while construction and operational phase and therewith habitat loss of sea bird species sensitive to the presence, including facility illumination	Planned offshore wind farm with other offshore wind farms
Migrating birds	Barrier effect forcing birds to fly around the wind farm which leads to a reduction of the biological fitness	Planned offshore wind farm with other offshore wind farms

Table 3.3.2-1: Impacts and cumulative effects described in the Natura 2000 environmental compatibility study

Cumulative effects of the planned offshore wind farm with other offshore wind farms are also taken into account. The focus lays on noise emission while pile driving and barrier effects on marine mammals, habitat loss, collision risk and barrier effects on birds (BioConsult SH, 2008b). Cumulative effects with other activities or uses which are, according to Peters et al. (2008), quite important to give a statement about the environmental compatibility of the project are left out.

Table 3.3.2-2 shows protected assets and impacts addressed within the species conservation study, called “Artenschutzrechtliche Prüfung”, which have to be proven according to the Habitats and Birds Directives (BioConsult SH, 2008a).

Protected assets	**Habitats Directive**
Fish	Increasing mortality due to pile driving
Marine mammals	Increasing mortality due to pile driving
	Disturbance due to pile driving
	Disturbance of their resting and reproduction areas due to pile driving
Bats	Increasing mortality due to collision with turbines
	Birds Directive
Migrating birds	Collision risk and increasing mortality
	Barrier effect due to construction and physical presence of the wind farm
	Illumination attracts migrating birds and disturb them from continuing their directed flight, energy loss and mortality of smaller birds possible
Sea birds	Disturbance due to construction (illumination, noise and ship traffic) and operation and hence avoidance and habitat loss, loss of resting area and wintering area

Table 3.3.2-2: Impacts considered in the area specific assessment study for “MEG Offshore I” due to requirements of the Habitats Directive and the Birds Directive

The focus is again on marine mammals, birds and fish, but also on bats as many bat species are endangered and protected by the Habitats Directive. According to this directive, prohibited are the elimination or disturbance of protected species and their habitats. Especially pile driving endangers animals and habitats, causing damage, disturbance, an increasing mortality and temporary habitat loss. Also sea birds suffer a permanent habitat loss, due to disturbing effects of the wind farm, migrating birds and bats are affected due to an increasing collision risk with the rotating rotor blades.

Within this assessment, cumulative effects or measures are not mentioned.

3.3.3 Licensing text

a) Impacts

Table 3.3.3-1 shows the mainly considered impacts on protected assets and their sources in the North Sea within the licensing text of the German offshore wind farm "MEG Offshore I". It results, like the EIS, from an analysis of the mentioned document and is described in the annexe. The base for this table, the evaluation table, can be found in the annexe as well.

Assets	Primary focus	Secondary focus
Water		Water pollution caused by the impacts of ship collisions
Seabed	Change of sediment dynamics (erosion and sedimentation), sediment composition and structure, morphology and development of scour pits and tails, sediment turbidity and as a result of this the release of harmful substances due to physical presence and therewith changing hydrodynamics	
Fish	Construction noise and vibration especially while pile driving causing stress, behavioural effects, injury, mortality from gas embolism, impair sense of hearing, deafness, impair survival, dislocation and temporary habitat loss, masking effect, damage and elimination of fish spawn and larvae	Vibration and noise emission into the water body during operation causing a habitat loss, dislocation, barrier effect, behavioural effects, stress, masking by noise (pray, enemies, intra-specific)
Marine mammals	Construction noise especially pile driving, but also boat traffic, cable laying and removal leads to a temporary habitat loss, fragmentation, behavioural change, avoidance, temporary or permanent physical damage like hearing damage impair survival, loss of individuals, disturbance of intra-specific communication due to masking by noise therewith reduction of reproduction rate	
	Vibration and noise emission into the water body during operation causes a barrier effect to mitigating marine mammals, fragmentation of resting, hunting and reproduction areas, changed behaviour, disturbance and permanent habitat loss possible, masking effect and disturbance of intra-specific communication	
Migrating birds	Increased collision risk especially in nights with poor visibility causing higher mortality due to the physical presence	Facility illumination increases the collision risk, attracts some species, flying around the facility costs extra energy (mortality possible)
	Physical presence and visibility cause a barrier effect and fragmentation of migratory routes, avoidance or flying around costs energy and reduces fitness	

Sea birds	Physical presence and visibility causing permanent habitat loss (sensitive species) or change, avoidance behaviour	
Not further discussed are: Benthos, Zooplankton, Bats, Fauna, Human beings, Air and Climate		

Table 3.3.3-1: Mainly considered impacts on protected assets and their sources in the North Sea within the licensing text of the German offshore wind farm "MEG Offshore I"

The focus within the licensing text and therewith on issues important to the decision-making of the project authorisation lays on effects on the seabed, fish, marine mammals and mitigating birds. Discussed quite detailed are changes in *sediment* dynamics, composition and structure, development of sour pits and tails and a release of harmful substances caused by changing hydrodynamics due to the physical presence of a wind farm. A focus lays also on noise emission during pile driving and their effects on *fish* and *marine mammals*. The fish fauna suffers stress, injury, impairment of the sense of hearing, deafness, impairment of the survival, mortality, temporary habitat loss, furthermore, fish spawn and larvae are getting eliminated or damaged. Effects on marine mammals discussed are physical damage, especially their hearing system, habitat loss impairing their survival, masking effects and disturbance of intra-specific communication. Also the noise emission during operation as a source of impact and their effects, like barrier effects or habitat loss, are important issues considered in the licensing text. Some *sea bird* species, here especially one endangered species the loon, sensitive to the effects of the visibility and physical presence of the wind farm can suffer a permanent habitat loss. Another important issue regarding impacts on *mitigating birds* are the possible barrier effect, forcing the birds to fly around the wind farm as well as the increasing collision risk with turbines and rotor blades. The effects of the facility illumination, increasing the risk of collision, is discussed secondary.

Furthermore, secondary considered are effects on the water quality as well as other impacts on migrating birds and fish. *Fish* can be harmed by vibrations and noise emission into the water body while operation. *Water* pollution in case of a ship collision with a turbine has fatal consequences for the environment and its protected assets. Hence, a risk analysis is obligatory as a part of the application documents. Effects on benthos, zooplankton, bats, fauna, human beings, air and climate are not discussed further within the licensing text.

b) Cumulative effects

Taking into account cumulative effects is also part of the licensing text. Like in the EIS, only the effects of other offshore wind farms which are build, permitted or in the final phase of the permission process are considered here. Impacts due to other activities or uses adding up with impacts of the planned wind farm are left out. For the permission of "MEG Offshore I", 7 wind farms are taken into account to assess possible cumulative impacts. The cumulative effects addressed in the licensing text are listed below.

Protected assets	Cumulative effects	Focus in EIS
Marine mammals	Noise emission during pile driving of different offshore wind farms within the same period of time	primary
Mitigating birds	Collision risk causing increasing mortality	primary
	Barrier effect forcing birds to fly around wind farms. Energy loss and impair their survival and reproduction rate	primary
Sea birds	Habitat loss of one species, the loon, during operation	secondary
	Endangerment and environmental burden by pollution, overfishing, tourism and other activities	

Table 3.3.3-2: Cumulative effects on protected assets considered in the licensing text

Within the licensing text cumulative effects are hardly considered. Nevertheless, first steps are made, for instance, to assess cumulative impacts of different offshore wind farms on marine mammals due to noise emission during pile driving. A study was made to assess cumulative impacts of the expected noise emissions. These effects are hard to predict due to a lacks of detailed knowledge about the specific influences of noise on marine mammals (other noise sources not mentioned here). To minimise or avoid cumulative effects the authority BSH coordinates building activities of projects in adjacent areas. Important, especially in the light of cumulative effects, is the increasing collision risk causing an increasing mortality and barrier effects forcing birds to fly around the wind farms leading to an energy loss and impair their survival and reproduction rate. Also discussed and evaluated is the habitat loss of sea birds, here especially of one species (the loon), during the operational phase, including cumulative effects with ship traffic. It is discussed quite intensive within the permit procedure and is therewith important for the decision-making. Also a database gets created to evaluate, qualitative as well as quantitative, the habitat loss of loons due to cumulative effects of offshore wind farms. Moreover, a damage and disturbance of breading areas of sea birds is mentioned but not seen as significant. Mentioned, but not discussed as possible cumulative effects are the endangerment of sea birds and environmental burden by pollution, overfishing, tourism and other activities. Also the problem of the initial level of pollution by ship traffic and military use is mentioned in the licensing text, but not discussed in the background of negative cumulative effects. Cumulative effects with these pre-loads leading to barrier effects or a disturbance are seen as insignificant and are not discussed further. Cumulative effects on mitigating birds by the physical presence of offshore wind farms are also discussed but not seen as significant.

c) Measures

Measures required in the end are limited to mitigating measures. As mentioned above, a compensation is necessary for offshore wind farms approved after 01.01.2017. The measures addressing different impacts are binding:

Water pollution

- To minimise release of harmful substances choose anti-corrosion colour long lasting and as environmentally friendly as possible
- Prohibiting sewage and waste dumping
- Ensure avoidance and minimisation of release of harmful substances due to corrosion, accidents, failure of turbines
- Introduction of harmful substances while construction, maintenance and operation and waste dumping is prohibited

Noise emission, pile driving (marine mammals, fish)

- Measures to displace animals before construction by using acoustic disturbing signals (e.g. „Pinger“ and „Sealscarer“) and a „soft start“ of pile driving
- Measures to reduce noise emission by covering pile into foamed plastic or similar material (as air barrier suitable to reduce sounds in water) or use of bubble curtains
- Definition of a limiting value (UBA: 160 dB (SEL) 750 m from source and maximum value Lpeak of 180 dB)
- Best available technology (e.g. for pile driving)
- Survey; Monitoring and evaluation while pile driving

Birds collision, attraction

- While times of high bird migration rates consider to switch off turbines or use measures to repel birds from wind farm
- Minimal use of illumination while construction and operation

Avoid high temperature and electromagnetic fields

- Limiting value of maximal 2 K temperature increase of the sediment in 20 cm depth; minimal cable depth of 1 m
- Keep the submarine electric cable 0,6 m under the seabed, regular inspections necessary

Further

- Evaluation and monitoring Programme while construction and operation (of habitat use of birds (here: loon), database)
- Removal (partly) of the wind farm in the end of operational time
- Use of state of the art technology to ensure emissions of harmful substances, noise and light are limited while construction and operation

3.4 Results: Addressing impacts of "MEG Offshore I'"

Following, the results of the document analysis as well as the area specific assessment and cumulative effects which are not considered within the content analysis (see annexe) are shown. The text addresses the question about: which impacts, currently discussed, are crucial for the decision-making and which are taken into consideration when coming up with requirements and measures for construction and operation of offshore wind farms? Which requirements and measures are used to avoid or minimise negative impacts? And which requirements are set on the contents for the EIS and the licensing text: What is getting considered? Which protected assets have to be taken into account?

3.4.1 Impacts

Taking into consideration the EIS, including an area specific assessment Natura 2000 and species protection, and the licensing text, which are the main documents assessing the impacts offshore wind farms cause on the marine environment and serving as a base for information based decision-making, the main focus lays on negative impacts on the protected assets fish fauna, marine mammals, migrating birds and sea birds. More specific, the main impacting factors looked at in the light of an environmental compatibility of the project are (1) the noise emission while pile driving on fishes and marine mammals, (2) emission of noise and vibration into the water body while operation affecting marine mammals and partly fishes, (3) the collision risk for migrating birds with rotor blades, (4) the barrier effect of the wind farm on migrating birds and (5) the habitat loss of some sea bird species due to the visibility of the wind farm causing disturbance and an avoidance of the area.

Environmental impact statement

Within the EIS, results of the EIA are summarised including a broad assessment of possible impacts on the marine environment. The content of the EIA bases on the guidance “StUK”, the results are reviewed by the authority and discussed in hearings with experts and was laid open for public inspection. Finally, mainly addressed are effects of construction and operation or rather the physical presence of the offshore wind farms on the protected assets fish, marine mammals, sea birds and migrating birds, as shown in table 3.4.1-1.

EIA Directive	**North Sea**
Fauna	Birds, marine mammals, fish, bats, zoobenthos, zooplankton
Flora	Phytoplankton, phytobenthos, macrophytes
Soil, water	Seabed, sea water, flow-changes (sediment structure, hydrodynamic)
Air, climate	Air, climate
Human being	Human health and life
Interaction between mentioned factors	Interaction between mentioned factors

Table 3.4.1-1: Protected assets defined in EIA Directive (left) and assets relevant for offshore wind farm projects in the North Sea (right) taken into account in the German EIS “MEG Offshore NL1” (grey marked)

Effects caused by noise emissions while *pile driving* are the most discussed and, according to the current state of knowledge, probably most significant factors impairing protected assets. In the EIS especially assessed in this regard are *marine mammals* and the effects known and feasible to occur causing injury or even the death of single individuals. Vibrations and sounds emitted during operation which can, e.g., cause a barrier on the mitigation route, fragment important habitats or a habitat loss are discussed. This effects are unlikely, but as there are not many experiences regarding effects of wind farms it can not be excluded and attention needs to get paid to this issue.

Impacts on *fishes* are also considered, the main focus lays on negative impacts due to an increasing sediment turbidity and emission of noise and vibration into the water body while construction, especially pile driving.

In the case of effects on *migrating birds*, the collision risk with rotating rotor blades, the facility illumination attracting or disturbing birds and increasing the collision risk additionally as well as the barrier effect offshore wind farms cause are assessed.

The primary discussed impact on *sea birds* is the permanent habitat loss of species sensitive to the disturbance offshore wind farms cause on a large scale due to their visibility and the disturbance the shading and illumination raises. These factors are also important within the licensing text and the Natura 2000 and species protection assessment, as shown below. Other impacts important to consider are visual effects by the construction works and the stress and disturbance the increasing ship traffic brings on.

When *comparing these impacts on protected assets and their sources with the impacts found in the literature*, it stands out that some aspects are not taken into account. The EIS concentrates on the most significant and feasible impacts as defined, inter alia, in the application conference and the StUK. Missed out are closer evaluations of effects on the fauna, human beings, air and climate. Also not taken into consideration are often indirect impacts, like negative impacts of an increasing biomass due to the introduction of artificial hard substrate. It can harm the water quality, as due to increasing biological processes an oxygen deficit can occur which again can damage benthic organisms or fish species.

Also effects on fish larvae due to pile driving, which can be very significant, are only mentioned briefly. Indirect effects on other species, like birds and marine mammals, due to an increasing mortality of fish larvae are not considered.

Missed out in the EIS, but discussed in literature are also that vibrations during operation can change sediment characteristics and lead to a habitat loss of benthic species sensitive to this effect. Furthermore, withdrawal of cooling water and introduction of heated water leads to a damage or mortality of eggs and larvae of fish and benthic species (Schuchardt et al., 2009). Epibenthic fish species suffering damage or a habitat loss caused by impacts on the seabed, like sealing and construction activities, or an increasing temperature due to the operating submarine electric cable of the wind farm. Also the removal of artificial hard substrate, whose introduction is supposed to have positive effects on fishes, is not considered at all.

Besides the noise emissions of pile driving, the operation of the turbines or increasing boat traffic there are no further impacts on marine mammals mentioned. One issue found in the literature is a possible (even if unlikely) impairment of mitigating marine mammals due to electromagnetic fields emitted by the submarine electric cable of the wind farm. Also further impacts due to construction or the presence, as well as the removal of the wind farm are not mentioned in the EIS. But in the same way, regarding marine mammals, the studies are focusing on negative effects by pile driving.

Effects on birds found in the literature but not discussed in the EIS are: the wakes of turbines which could catch birds and harm them and indirect impacts due to the release of harmful substances from wind farms or due to ship accidents. Especially for sea birds, the noise emissions into the water body harming diving birds as well as the introduction of artificial hard substrate causing beneficial effect to probably a few birds due to an increasing availability of food species are discussed in literature and missed out in the EIS.

Furthermore, possible impairments of bats are discussed quite roughly, only the collision risk is mentioned briefly. Also as there is not much known about the effects of offshore wind farms on bats further investigation is necessary. The literature discusses, as mentioned in chapter 2, impairments due to ultrasound emissions which could disturb the orientation sense of bats.

Concluding, quite a lot of impacts are missed out, but it has to be said that it is also not necessary to mention all impacts. The EIA needs to be doable, impacts with are not very significant and do not influence the decision-making are left out. The EIA is a tool for an information based decision-making. Besides this, further research projects and studies are made which are necessary to gather knowledge about possible impacts. Therefore, it is important that an EIA takes into account new literature, results of research projects and is based on the current state of knowledge.

Area specific assessment: Natura 2000 and species protection

Marine mammals, fish, bats, mitigating birds and sea birds are considered within the area specific assessment. The impacts described here are similar to the main ones described in the EIS and the licensing text. A main difference is that the area specific assessment assessing the impairment of protected species also takes into account bats which normally find rarely any attention within other documents. Regarding bats, here the collision risk especially with rotating rotor blades and hence an increasing mortality is discussed.

Licensing text

Finally focused on in the licensing text and, hence, important for the decision-making are the following issues:

Like in the EIS, the most detailed impact discussed is the pile driving causing noise emission into the water body and injury or elimination of *marine mammals*. Also *fishes* are affected significantly by this impacting factor. Marine mammals also impacted by vibration and noise emission while operation of the wind farm, no significant impact expected, but due to a lack of knowledge can not be excluded and needs to be observed. This impact on fish also briefly discussed, but not habitat loss expected, as the wind farm brings many positive changes due to fishing ban, increasing biomass due to introduction of artificial hard substrate.

Migrating birds barrier effect. increasing collision risk. Discussed partly in this context also effects caused by the facility illumination as it can attract birds or disturb them that they fly into the wind farm and risk of collision increases.

The habitat loss of *sea birds* due to visibility and disturbance is discussed quite detailed as this can be a significant impact especially to one species sensitive to disturbance, the loon. More research will be done in future to enable an evaluate of specific long term impacts as many wind farms build, effects add up, more habitats get lost.

Sea bed due to the physical presence changing hydrodynamics, causing change of sediment dynamics, sediment composition and structure, development of scour pits. The assessment of these changes is part of different studies. Changes over a large scale are not expected.

Furthermore, discussed casually is *water* pollution and in this context the risk of ship collisions with the wind turbines, especially a pollution by oil spills in case of a shipping accident. This issue is quite important to consider as the impacts on the marine environment would be in case of an accident very significant and far-reaching over a long-term.

According to Peters et al. (2008), the licensing text is an own assessment, taking into account the results of the EIS. Looking at the documents of “MEG Offshore I”, the results of the EIS are not summarised in the licensing text, but according to it, taken into consideration for the decision. They are further quite conform to the results of the licensing text. Primary focused on in both documents are (1) noise emissions while pile driving on marine mammals and (2) fish fauna, (3) the effects of operational noises and vibrations on marine mammals, (4) the increasing collision risk of migrating birds with the turbines, (5) the barrier effect of wind farms for mitigating birds and (6) the physical presence and visibility of the wind farm causing disturbance and habitat loss of sea birds.

Considered in the licensing text, but only discussed partly in the EIS are the effects on the seabed due to the sediment dynamic resulting from the physical presence of the wind farm which causes changing hydrodynamics. On the other hand, effects on the fish fauna due to an increasing sediment turbidity as well as visual effects of the construction works and an increasing boat and air traffic in the area on sea birds causing disturbance and a habitat loss are discussed quite broad in the EIS but not mentioned in the licensing text.

The results of the EIS are insofar taken into account as it approves the environmental compatibility of the project. Due to the licensing text, attention needs to be paid especially to the protected assets water and seabed and an introduction of harmful substances or energy as this could be a reason for rejection.

3.4.2 Cumulative effects

Cumulative effects are considered very roughly. The focus of all documents considered lays on cumulations of the planned wind farm with other offshore wind farms. Further activities or uses which could influence the protected assets negatively are not considered. Most of the impacting factors addressed when assessing cumulative effects are the most significant ones considered in the documents. A close look has been taken at cumulative effects of pile driving on marine mammals and the habitat loss of some sea bird species, rising with the amount of offshore wind farms installed. Many offshore wind farms are planned or already permitted and get build within the next years, hence, besides these effects also other cumulative effects have to be assessed and taken into consideration.

Environmental Impact Statement

The cumulative effects assessed in the EIA are listed in table 3.3.1-2 above, covering six impacts which could add up to a more significant impairment on the protected asset: (1) effects of ship collision on the *water* quality, (2) positive effects on *fishes* due to a fishing ban and introduction of artificial hard substrate, (3) noise emission while pile driving on *marine mammals*, (4) habitat loss, fragmentation and barrier effect on *sea birds* due to the physical presence of the wind farm, (5) the collision risk of migrating birds with rotor blades and (6) the barrier effect of wind farms for migrating birds. A method for the evaluation of cumulative effects in the EIS is not explained.

Natura 2000 assessment

The Natura 2000 assessment solely mentions cumulative effects of offshore wind farms (1) on *marine mammals* due to pile driving, (2) the habitat loss of *sea birds* due to disturbing effects of the visibility of wind farms and (3) the barrier effect of wind farm for *migrating birds*.

Licensing text

Within the licensing text cumulative effects on marine mammals, sea birds and migrating birds are taken into account. Important for the decision-making are cumulative effects on marine mammals by pile driving and on sea birds due to the habitat loss caused by disturbing effects of the wind farm. The consideration of noise emissions while pile driving on marine mammals gets a special attention, as this causes a significant impairment of the animals. A study was made evaluating the impacts of the planned wind farm and other planned or permitted offshore wind farms build within the next years, but - as a method is missing to assess the cumulative impacts and detailed knowledge about the impact of noise emission on marine mammals is limited - with uncertainties regarding the results (BSH, 2009). Moreover, other sources of noise are not considered further. For the assessment of cumulative effects regarding the habitat loss of sea birds during the operational phase a database and method is just getting developed. In this context cumulative effects with ship traffic and military use are mentioned but not further discussed as they are not seen a significant, the focus lays on cumulative effects caused by offshore wind farms. Further cumulative effects mentioned but not seen as significant are listed in table 3.3.3-2.

Summing up, it can be assessed that cumulative effects within the documents are partly addressed but are not doing justice to the complexity of this topic. Which makes the assessment of cumulative effects hard is that a method to assess them is missing. The evaluation of cumulative effects is a very complex field, missing databases and gap of knowledge, often about basic factors, make it sometimes impossible. As the assessment of cumulative is very important and should be crucial for the decision-making, a method needs to be developed to improve the current praxis. The questions to be asked are: how to consider them? In which state of the planning process could they be considered best? These questions will be addressed briefly in chapter VI.

3.4.3 Measures

Environmental Impact Statement

Mitigating measure in the EIS are mainly addressing significant impacts on birds, the fish fauna and marine mammals, as well as the habitat quality by introducing measures prohibiting water pollution. Several measures are required addressing the noise emission due to pile driving, they displace the animals before pile driving, reduce noises and define a limiting value of maximal 160 dB in areas about 750 m from the source. Other measures aim to avoid water pollution by, e.g., prohibiting sewage and waste dumping, minimise the habitat loss and collision risk of birds and keep the disturbance of seabed and therewith effects on benthic organisms minimal. To minimise the risk of collisions with the rotor blade and keep the barrier effect to mitigating birds small, corridors of about 3 km between the single wind farms are hold free which should allow the birds to pass through. The minimal use of white flash light or other light, reducing the attraction of birds, is also suggested within the EIS.

Within the area specific assessment, about impacts on Natura 2000 areas and species protection, measures are not mentioned.

Licensing text

The licensing text requires partly additional or stricter measures compared to the ones mentioned in the EIS. Mitigating measures to avoid significant negative impacts on marine mammals and fishes due to noise emission while pile driving, on migrating birds due to the collision risk with rotor blades or impacts on organisms due to electromagnetic fields and increasing temperature caused by operating submarine electric cable are mainly addressed. Additionally, the use of the best available technology for and a monitoring while pile driving and a limiting value of 160 dB in areas about 750 m from the noise source are required. These measures and partly additional ones are necessary as tripod foundations are used, hence, it needs to be responded to a long time span of noise emission, especially because it is possible that pile driving activities extend into periods of the year with a high abundance of harbour porpoises (BSH, 2009). Suggestions for further measures are given in chapter V and VI by comparing measures required in The Netherlands and Germany.

Taking into account the high collision risk of mitigating birds, especially in nights with poor visibility, the BSH is free to switch off turbines in times with high bird migration rates or use measures to repel the birds. To switch off the turbines is probably the best way to protect birds from colliding with the rotating rotor blades, as they are especially endangered by these, but to consider switching off the turbines does not mean there is a need to switch them off. In nights with poor visibility and high birds migration it must be obligatory to switch off the wind turbines. The measure suggested in the EIS of using light reducing the attraction of birds did not get applied in the end. Also discussed within the EIS and not addressed in the licensing text is to limit the construction period to a short time, preferably not within the main resting times between May and September. But it should be mentioned that this requirement is in the EIS finally seen as not necessary as the construction happens punctual and the construction is due to practical reasons mainly limited to the summer time.

Also the problem of water pollution gets addressed by prohibiting sewage, waste dumping and specifically the introduction of harmful substances while construction, operation, maintenance. To avoid environmental pollution the removal of the wind farm after the end of the operational time is obligatory.

Furthermore, an evaluation and monitoring programme while construction and operation is obligatory to monitor and ensure it has no significant negative impacts as well as to gather new knowledge of changes offshore wind farms cause having negative impacts on the marine environment.

Chapter IV: Offshore wind farm projects in The Netherlands

In this chapter, environmental impacts addressed within the documents of the Dutch offshore wind farm “BARD Offshore NL 1” and therewith taken into consideration within the decision-making about the realisation of the project are described. First, different aspects including the legal background, like laws and guidelines, influencing the consideration of environmental impacts, steps taken within the licensing procedure as well as stakeholder influencing and making decisions are outlined roughly. Also a brief insight into the content and structure of the Dutch documents analysed, EIS and licensing text, is given. This especially helps understanding the choice of the documents analysed. The EIS and licensing text are the most important documents assessing and taking into consideration the environmental impacts of a specific project. All impacts considered can be found here, impacts important for the decision are discussed detailed (Köller et al., 2006).

When planning large projects in The Netherlands a permit system is used which requires different steps to be taken and documents to be considered, e.g., environmental impacts of the project (Noordzeelokket, 2010). The final document is, like in Germany, a licensing text containing, besides general information and data of the project, environmental impacts of the projects which are significant and important for the final decision-making about the project authorisation. Also stated here are requirements to be met and measures to be taken avoiding and minimising these negative impacts. The other important document required for a license, assessing impacts on the environment, supporting the decision about the environmental compatibility of the project and therewith about the authorisation is the EIS (Rijkswaterstaat Dienst Noordzee, 2006). Like in the German case study in chapter III, these two documents of the Dutch case study are analysed, based on the evaluation table (annexe), within this chapter. The method is described in the annexe, also detailed results of the content analysis of the documents can be found in an evaluation table in the annexe. The intensively discussed issues (rank 1 of the evaluation table) are seen as highly relevant to the decision-making process and the issues discussed less intensive (rank 2 of the evaluation table) as relevant. The ranks 3 and 4 of the evaluation table are not considered here.

Following, after giving a brief overview of the most important project data of “BARD

Offshore NL 1", the most important results of the analysis are discussed. The focus lays on impacts discussed intensively or discussed partly (evaluation table, rank 1 and 2) in the documents. Furthermore, cumulative effects, measures taken to minimise or avoid negative impacts discussed within the documents and impacts addressed within the area specific assessment study "Passende beoordeling", which is not considered in the evaluation table, are discussed. Although the documents "Passende beoordeling" and cumulative effects are not considered within the evaluation table, they are important for the decision-making. The document is considered in the table inasmuch as the assets protected by this site are considered, the detailed outcomes, influencing the decision as well, are outlines within this chapter. Cumulative effects are not taken into consideration in the table. They can not be easily related to the impacts or sources of impacts written in the table, as they are caused by different sources, also not only wind farms. But cumulative effects are still very important for decision-making. Even if a single offshore wind farm does not harm the environment significantly, allowing a licensing of the project, the adding up of impacts caused by many offshore wind farms or other activities or uses in turn can have significant negative effects and lead to a rejection of the permit. Therefore, cumulative effects are important to consider and will be discussed within this chapter.

4.1 Decision-making base

4.1.1 Legal base and standards

An overview of all relevant international and national acts and policy documents is given in the "Startnotitie Milieueffectrapportage BARD Offshore NL 1" (BARD Engineering GmbH, 2006).

The *Public Works Act (Wbr - Wet beheer rijkswaterstaatwerken)* is the main instrument regulating spatial and environmental claims within the EEZ (De Graaf, 2008) and the legal base for the authorisation of offshore wind farms. This act regulates the licensing process within the territorial sea and the EEZ where the Spatial Planning Act, regulating the national planning policy, is not executive anymore. The act itself does not imply any spatial goals, it focuses on the licensing of single project proposals within the North Sea outside a 1 km zone and refers to other acts and spatial plans (Zeelenberg, 2005). The Public Works

Act also does not take into account environmental impacts directly, but it requires an environmental impact assessment (EIA; in Dutch: m.e.r.) containing an assessment of potential environmental impacts of the planned project and showing alternatives. Its result, the environmental impact statement (EIS; in Dutch: MER), is an important part of the application of a project and an important base for taking into account environmental impacts within the decision-making (Storz et al., 2009).

The “*Beleidsregels inzake toepassing Wet beheer rijkswaterstaatswerken in de exclusieve economische zone*“ (called wbr beleidsregels) came into force at the 21 of December 2004 with the goal to support the development of offshore wind farms (Storz et al., 2009). As until 2004 no license for an offshore wind farm could be submitted, this ordinance was made up containing mainly procedural rules for the application of wind farm projects within the EEZ and defines requirements (Zeelenberg 2005). Due to Wbr beleidsregels, permission is not given to projects if the size of one offshore wind farm extend an area of 50 km² which is a reaction to the lack of knowledge about possible environmental impacts of offshore wind farms. The installation of wind farms is allowed in the whole EEZ, except areas reserved for other specific uses, like sand extraction or nature conservation (Storz et al., 2009). Permission can be given if (a) the efficient and safe use of the North Sea is still ensured, including safety of navigation, (b) it is not contradicting to the national spatial strategy (Nota Ruimte) and (c) takes into account other national acts, like Natuurbescherminswet 1998, Flora- en faunawet, Wet milieubeheer (Ministerie van Verkeer en Waterstaat, 2009). Even though the Dutch government pays attention to these acts for nature conservation, according to de Graaf (2008), they are not yet extended to the EEZ, hence, there is no obligation to apply these acts. According to Wbr beleidsregels article 6 (1) also measures have to be taken to avoid and minimise negative impacts on the environment as good as possible. Significant negative impacts which can not be avoided or minimised by mitigating measures have to be compensated (Rijkswaterstaat Dienst Noordzee, 2006).

As defined in the Wbr beleidsregels, effects on the environment, which includes effects on the nature (Article 1 (2)), have to be taken into consideration. In this light, according to the EIA Directive, an EIA has to be done. Paying regard to the Habitats and Birds Directives, it also needs to be ensured that no significant negative impacts are contradicting to targets of Natura 2000 areas or impairing their protected assets.

According to the *Environmental Management Act (Wet milieubeheer -Wm),* based on the Besluit milieueffectrapportage 1994, the construction of offshore wind farms within the EEZ requires an EIA. The act also defines issues which have to be included in the EIS and describes the procedure to be taken (Ministerie van Verkeer en Waterstaat, 2009). Guidelines about the contents of an EIA for offshore wind farm projects were made up by the EIA Commission in 2005 (Commissie voor de mer, 2006). *The Besluit milieueffectrapportage* (Besluit m.e.r.) contains more detailed specifications about when an EIA has to be made.

Another instrument to protect the environment and coordinate the many different uses and activities in the North Sea area is *marine spatial planning*. Especially the two following policy documents are relevant for offshore wind farms taking into account spatial development goals (Zeelenberg, 2005).

The *National Spatial Strategy (Nota Ruimte)* describes the spatial conditions in The Netherlands. It does not declare special areas for the development of offshore wind farms, but excludes areas, e.g., important to nature protection or shipping routes. It excludes, for instance, the installation of wind farms within the Wadden Sea and other Natura 2000 areas. The areas left are potentially suitable for offshore wind farms (Zeelenberg, 2005). Further, this plan sets the goal of an energy production by offshore wind energy of 6000MW until 2020 and defines the installation of wind farms in the EEZ of urgent public interest. For the EIS this means that the necessity of offshore wind farm projects does not need to be proven, but significant negative impacts on the environment need to be excluded (Storz et al., 2009).

The *Integral Management Plan North Sea 2015* (IMPNS 2015) is, as the name says already, a spatial management plan particular for the Dutch North Sea area. It is based on the National Spatial Strategy (Nota Ruimte) and aims to manage, using an inter-sectoral approach, all activities and interests having a claim on the North Sea area, it defines development goals to support decision-making by a framework. It includes an overview of suitable locations for offshore wind farms and defines their installation to be of urgent, public importance (Zeelenberg, 2005).

<u>Addressing environmental impacts</u>

The legislation and standards described above are building a base ensuring environmental impacts caused by the project are assessed sufficiently and taken into consideration during the decision-making process. The laws itself do not specify criteria or rules about how to evaluate impacts and when to reject a license for a wind farm. The legislation gives a frame ensuring impacts are getting assessed, play a role for the decision-making and measures are taken minimising or avoiding negative impacts. Impacts addressed and measures taken are getting specified by additional guidelines and standards or within the process by stakeholder, evaluator or the authority. An important body in this context is the EIA-Commission giving advises and formulating standards for the EIA contents. Also not specified within laws are criteria defining when a project harms the environment significantly and, hence, a license can not be given. In the end decisions about criteria defining how to assess which impacts and when to reject a project license are made by the licensing authority, experts, the evaluator of the EIA and other stakeholder. The authorities which can take action and make decisions gets also defined by the different laws.

Regarding the addressing of environmental impacts, an important act is the *Public Works Act (Wbr)*, especially the *Wbr beleidsregels*. It builds the legal base of the licensing system, regulating different activities, by require documents and steps to be taken to address impacts on the environment, assess them, ensure they are getting discussed, reviewed by experts and are therewith a base for an information-based decision-making. As mentioned, criteria about how to address which impacts are not taken into consideration within this law. An important tool in this context is the EIA, assessing impacts on the environment caused by the project. On national level the *Environmental Management Act* and the *Besluit milieueffectrapportage* build an important legal base, defining which projects require an EIA and define the contents. In case of offshore wind farms, the contents gets specified by the EIA Commission by developing basic guidelines and giving additional advices for every single project. The EIA Commission, described below, has an important role in the Netherlands ensuring environmental impacts are getting addressed sufficiently.

The *Wbr beleidsregels*, furthermore, are also responding to the lack of knowledge about possible effects of offshore wind farms by restricting the area of an offshore wind farm to 50 km². It also asks for measures to be taken to avoid, minimise or compensate significant negative impacts on the environment. More specified are these measures within the final licensing text made by the licensing authority, advised by experts. Above all, the Wbr beleidsregels do not explicitly forbid the authorisation of projects which are detrimental to the environment, but other national laws have to be taken into account which includes national nature conservation laws as well as the European Habitats and Birds Directives. According to De Graaf (2008) these laws are not extended to EEZ yet, according to the Ministerie van Verkeer en Waterstaat (2009) taken into account. With these European Directives endangered species and habitats are protected and projects harming these species and their habitats significantly can not be authorised.

Spatial planning does not address impacts directly. It rather protects the marine ecosystems and avoids negative effects indirectly by designating nature protection areas, Natura2000 areas and keep other, harmful activities out of the area. Areas which are suitable for offshore wind farms are not identified explicitly, but the expansion of wind energy within the EEZ is a main goal. Hence, the *Integral Management Plan North Sea 2015,* based on the *National Spatial Strategy (Nota Ruimte), protects* on one hand the environment by defining goals for nature protection and designating nature protection areas. On the other hand it also defines goals for the expansion of offshore wind farms. Therefore, the political pressure on the installation of offshore wind farms can have negative effects on addressing environmental impacts comprehensively. Negative impacts on the environment or their significance can be overlooked easily to enable the construction of many offshore wind farms.

4.1.2 Role of EIS and licensing text for the decision-making

In The Netherlands a permit system is applied for large projects like offshore wind farms (Ministerie van Verkeer en Waterstaat, 2009). Within the planning and permit procedure different instruments are in use important for considering environmental demands. One important tool is the EIA (result EIS), described above. Quite special in The Netherlands is the EIA Commission, e.g., giving advises and making guidelines for the development of every EIA for offshore wind farms. A part of the EIA is also an area specific assessment, called “Passende Beoordeling”. An other important instrument to ensure environmental demands are taken into account is the permit procedure (result licensing text). The final licensing text, written by the authority, also includes impacts on the marine environment, summarising the most important ones considered in the light of the decision-making (Ministerie van Verkeer en Waterstaat, 2009).

Within the EIS the results of the Environmental Impact Assessment are stated. It aims to give a broad overview of impacts expected from the construction, operation and removal of the offshore wind farm and therewith supporting an information based decision-making about the environmental compatibility of the project. The EIS contains a description of the current environmental status and an assessment of possible impacts on the different protected assets defined for the North Sea, based on the definition within the EU EIA Directive. A strength is the broad scale of alternatives discussing the best alternative (ecological and economical) minimising negative impacts on the environment. Different options influencing the environment differently are discussed, they include the arrangement and number of the turbines as well as the distance between them, their colouring or the size of rotor blades. Furthermore, mitigation and compensation measures, discussed later, are listed. Also standards for the Monitoring and Evaluation Programme are defined. This programme aims to provide knowledge about impacts while the construction and operation phase to compare them with predicted impacts and fill gaps of knowledge. When a wind farm is build in a sensitive area, specific impacts on protected assets and characteristics on this area need to be monitored and evaluated. Another important point is addressing gaps of knowledge and uncertainties within the EIS, also as a base for further research (Storz et al., 2009).

The decision about the contents is basically made, as mentioned above, by the EIA Commission (Commissie voor de milieueffectrapportage, 2009). Guidelines are developed by this body on which base specific guidelines are defined for every project by the EIA Commission, advisor, the authority, including comments by the public on these guidelines (Rijkswaterstaat Directie Noordzee, 2006).

The licensing text summarises the most important outcomes of the EIA and the “Passende Beoordeling”. It further takes into account advises and comments given by the EIA commission regarding the EIA, final advisements and statements are given by the licensing authority. The final decision drawn here follows after weighting up impacts and stating requirements which have to be met. The requirements include mitigating measures to avoid significant negative impacts on the marine environment and its protected assets as well as regulations for the obligatory Monitoring and Evaluation Programme. Effects on the ecosystem are only one point of the licensing text, which also takes into account effects on ship and air traffic as well as military areas.

A “Passende beoordeling” was recommended by the EIA Commission to assess if the installation of the offshore wind farm alone and due to cumulative effects with other wind farms have adverse effects on Natura 2000 areas and its protected assets. In a consultation at the 8th July 2008 the authority (Ministrie van Verkeer en Waterstaat) and the energy sector came to the conclusion that a “Passende beoordeling” needs to be part of the application of an offshore wind farm and a part of the decision-making base (Ministrie van Verkeer en Waterstaat, 2009). The legal background for the necessity of this survey build the European Habitats and Birds Directive.

4.1.3 Permit procedure: steps and stakeholder

<u>Responsible bodies and stakeholder</u>

As the Dutch state is owner and authority of its territorial zone (except 1 km zone) and the EEZ, the Ministry for Transport, Public Works and Water Management, more precisely the North Sea Directorate (DNZ, Rijkswaterstaat Directie Noordzee), is responsible for the approval of offshore wind farm projects (Zeelenberg, 2005).

Municipalities and provinces are not involved in the planning and licensing process within the EEZ, their responsibility is limited to the mainland and the 1 km zone from the shore. In case of offshore wind farm projects they need to be involved as they are executing authority for the 1 kilometre zone which the electricity cable have to cross (Zeelenberg, 2005).

The Dutch EIA Commission is an important body to ensure possible negative impacts on the environment are taken into consideration. It establishes guidelines for the EIA, checks the result, gives advice regarding the assessment of impacts and formulates suitable requirements and measures to soften these impacts. Based on article 7.14 Wet milieubeheer, the EIA commission gives advises regarding guidelines for the EIA (Commissie voor de milieueffectrapportage, 2006).

Beside these bodies, other third parties are involved while EIA and PWA procedure having a voice in the decision-making process. Included are governmental bodies, interest groups (like fishery and nature protection), private parties for offshore technology and the energy sector, pressure groups (mostly local ones) and citizens (Zeelenberg, 2005).

The project owner is responsible for the realisation of the project, including the project planning, the development of documents required for the approval of the application and later for the construction, maintenance and removal (Ministerie van Verkeer en Waterstaat, 2009).

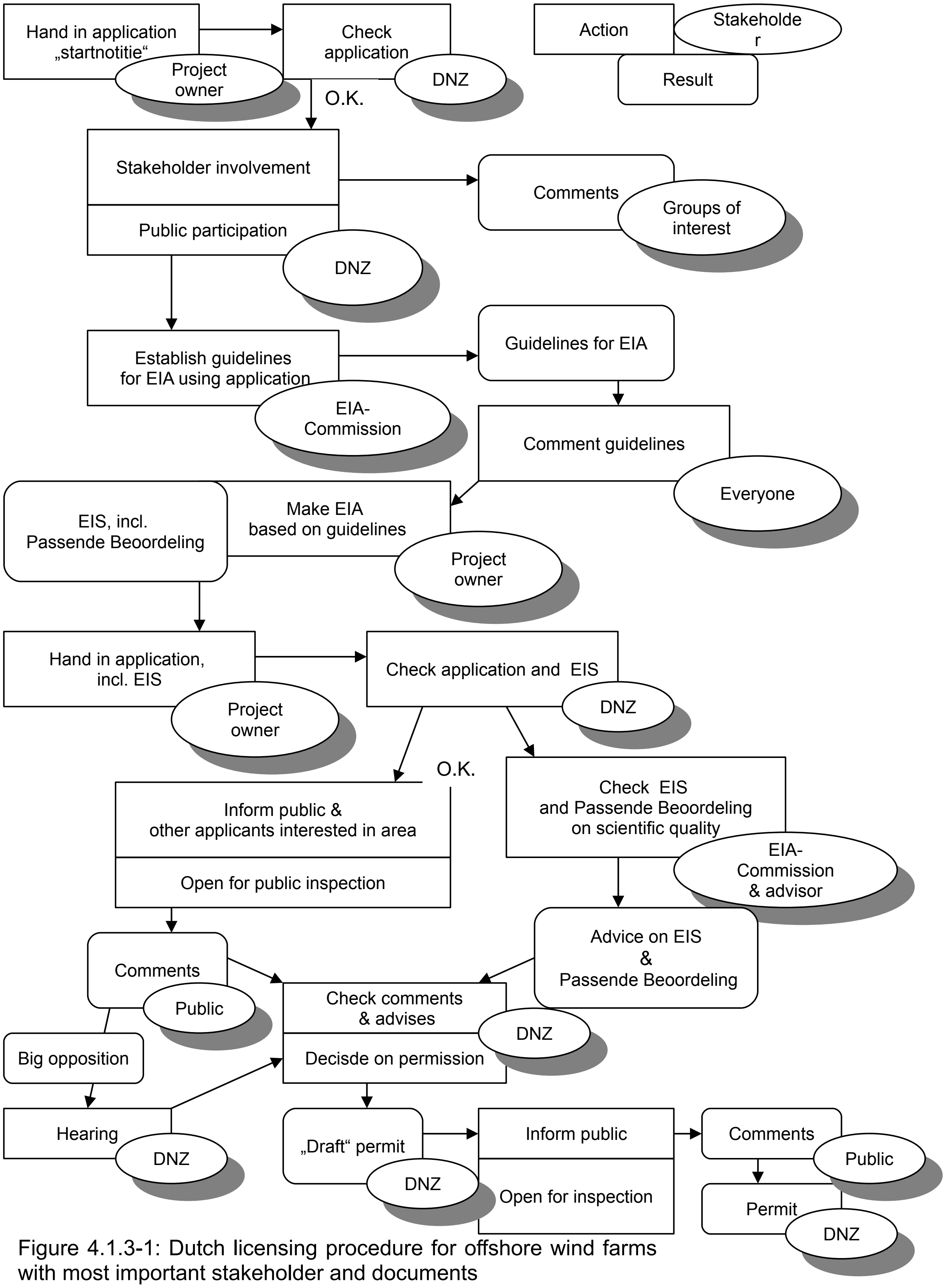

Figure 4.1.3-1: Dutch licensing procedure for offshore wind farms with most important stakeholder and documents

Phases within the licensing procedure

Based on the Wet beheer rijkswaterstaatswerken (Wbr) a permission is obligatory for the installation and operation of offshore wind farms. To obtain a permission the following procedure, including the procedure of an environmental impact assessment, has to be followed.

The procedure starts with the applicant handing in a starting document, the “Startnotitie MER”, at the Ministry for Transport, Public Works and Water Manage, more precisely the North Sea Directorate (DNZ, Rijkswaterstaat Directie Noordzee). The “Startnotitie” describes the location and technical details of the project and the next steps to be taken. The DNZ checks the document on completeness and asks for improvement if necessary.

As a next step, the DNZ sends the “Startnotitie” to the advisers and the EIA-Commission whom establish, based on these documents, guidelines for the content of the final EIS (Commissie voor de milieueffectrapportage (2006) & Wet milieubeheer, art. 7.14, 1 & 2). Rijkswaterstaat informs the public via newspaper about the planned project (Algemene wet bestuursrecht, art.3:12). According to Wet milieubeheer article 7.14, 4 every person gets the opportunity to give comments on guidelines for the content of the EIS. Finally, Rijkswaterstaat discusses the guidelines with the applicant.

The following EIA needs to be made by the applicant, usually commissioning experts with this task, based on the mentioned guidelines. Also part of the EIA is the “Passende beoordeling” taking into account impacts on Natura2000 areas and its protected assets. While making the EIA, the document can be handed in for a first check at Rijkswaterstaat. By making an EIA the applicant has no claim on the location. It is possible that at the same time other applications for the same area is running.

The application with the final EIA report, the EIS, has to be handed in at the Ministry for Transport, Public Works and Water Management. The Ministry proves the content and sends a copy to the advisor and the EIA-Commission which are proving the scientific quality of the assessment (Rijkswaterstaat Dienst Noordzee, 2006). The EIA-Commission gives another advise regarding the content of EIS and the “Passende beoordeling” (Commissie voor de milieueffectrapportage, 2009).

Rijkswaterstaat checks if the EIS and the application are permissible or if an improvement is necessary. As far as the application and EIS are acceptable, the applicant as well as other applicants interested in the area are getting informed. It also gets publish in a newspaper. A copy of the EIS gets send to the EIA-Commission and the advisers (7.20,1). The application and EIS are now open to public inspection (3:11,4 & 3:16,1), everyone can read it and formulate a written or oral comment. If a big opposition against the project occurs, Rijkswaterstaat can invite parties involved for a hearing to discuss the different issues. Comments can only be given on points of article 7.10 and 7.11 or because of an inaccuracy of the report (Rijkswaterstaat Dienst Noordzee, 2006).

While permit procedure, municipalities and provinces also need to be involved as they are executing authority for the 1 kilometre zone which the electric cable have to cross. This environmental permit and permission bases on the Spatial Planning Act (Zeelenberg, 2005).

After proving the comments of advisers, the EIA-Commission, Rijkswaterstaat and other interest groups, a decision is made on the permission of the project (Rijkswaterstaat Dienst Noordzee, 2006). Important for the decision-making are outcomes of the EIA, technical and financial issues which have to be met as well as other users interests in North Sea area (Zeelenberg, 2005). The licensing text is open for public inspection for 6 weeks and made public in newspapers. Again, comments on the permit are possible before the final decision on the permit is made (Rijkswaterstaat Dienst Noordzee, 2006).

4.2 The project “BARD Offshore NL1”: area and data

“BARD Offshore NL 1” realised by BARD Engineering GmbH is located 66 km off the Dutch North Sea coast and 56 km north of the islands Schiermonnikoog and Rottumerplaat within the Dutch EEZ. The project area is located 600 m from the next Natura 2000 area Borkum Riffgrund, which finds therefore special attention.

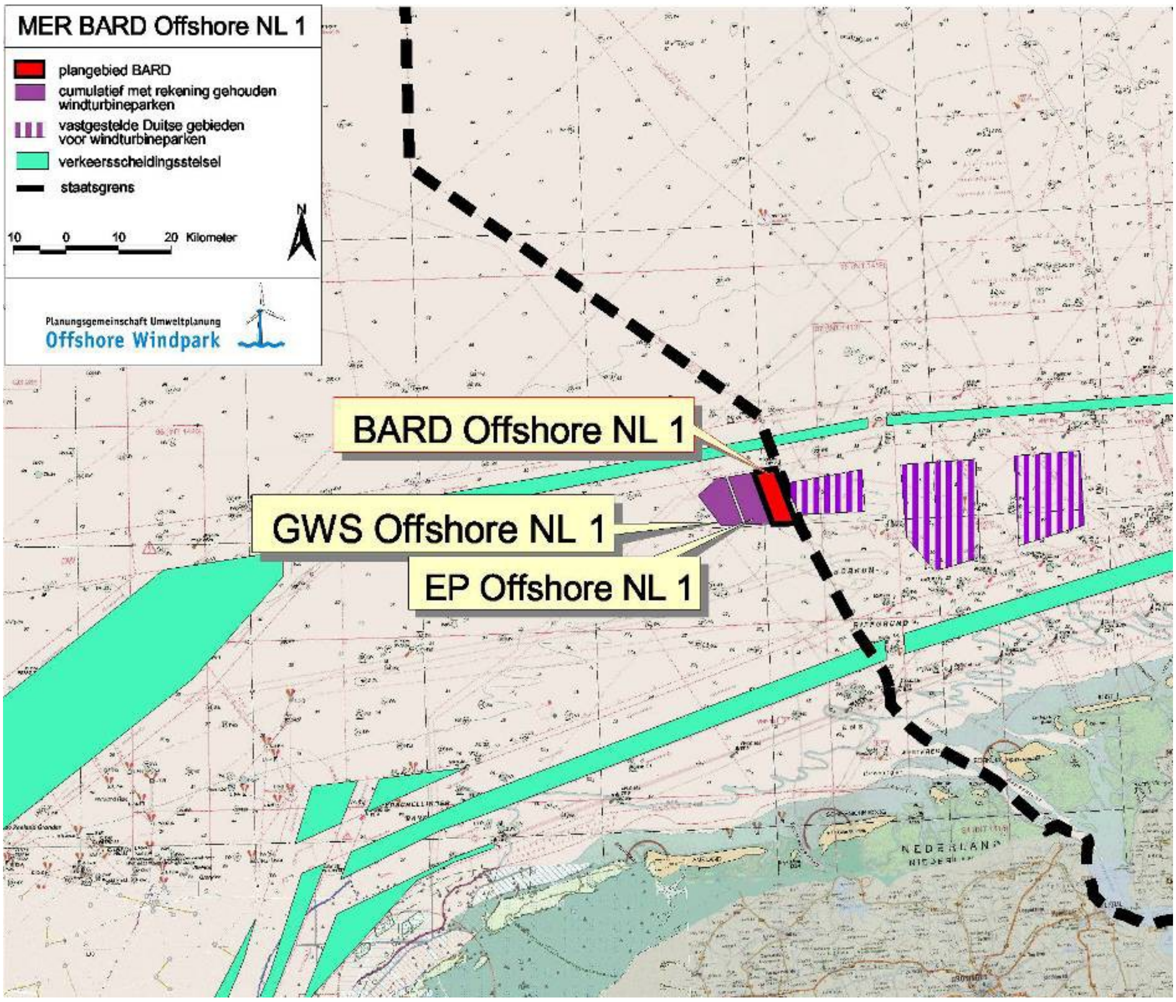

Figure 4.2-1: Location of “BARD Offshore NL 1” (red) and offshore wind farms (purple) close by (Storz et al., 2009)

78 wind turbines of 5 MW are installed within the project area of about 44,66 km² in size and within a water depth of 29-33 m. The distance between the turbines is about 870-900 m, they are placed on tripile foundations. The electricity produced will be conducted through submarine electric cable to the mainland. About 80 km of cabling are laid within the wind farm area in a depth of 1 m under the sea ground. Further information about technical data of this wind farm can be found in the applications and environmental impact assessment (Storz et al., 2009).

4.3 Analysis: Addressing impacts of “BARD Offshore NL 1”

In this chapter an overview of the most important outcomes of the document evaluation is given. Effects on protected assets as well as cumulative effects and measures to mitigate negative impacts found in the EIA and the licensing text of “BARD Offshore NL 1” are considered. The so called “Passende beoordeling”, an area specific assessment, is not analysed within the document analysis (see annexe) but will be considered here, as its outcomes are crucial to the final decision-making (Ministerie van Verkeer en Waterstaat, 2009).

But there are further documents which need to be taken into consideration when talking about impacts on the marine environment. In The Netherlands advices by the EIA Commission regarding the EIA are important, the most important outcomes are summarised in the licensing text. For the project “BARD Offshore NL 1” a survey about effects of construction on seals has also been made (Ministerie van Verkeer en Waterstaat, 2009).

4.3.1 EIS

a) Impacts

According to the Commissie voor de milieueffectrapportage (2009) the EIS of “BARD Offshore NL 1” does not contain all information available due to the state of knowledge. The information delivered are still sufficient, as the EIS contains the most important data and is completed by another 17 EIS made for other offshore wind farm projects in the same time period.

Table 4.3.1-1 gives an overview of the impacts on protected assets and their sources mainly discussed within the EIS of the Dutch offshore wind farm “BARD Offshore NL 1”. This table results from the document evaluation, the whole results can be read in the annexe. For an explanation of the method used see the description in the annexe.

Assets	Primary focus	Secondary focus
Water	Physical presence causes a change of hydrodynamics mainly on a small scale with local current speeds; changes are minimal on a large-scale	Suspended sediments in water body and stripes of turbidity causing turbidity and smothering of the water due to construction activities, e.g. dredging, pile driving and cable laying
	Operating electric cable increase the water temperature and can lead to a release of harmful substances	Re-suspension of sediments can lead to a release of nutrients and harmful substances and an oxygen deficit
		Less swell, but a higher turbulence at water surface leading to a stronger steering of the temperature stratification due to physical presence

Seabed	Changing hydrodynamics due to the physical presence change sediment dynamics (erosion and sedimentation), composition and structure, morphology, sediment turbidity, scour pits and tails and can lead to a release of harmful substances from the sediment	Sediment turbidity, erosion and relocation of sediment, compression of soil, strong disturbance of sediment, changing sediment structure and composition (heterogeneous), morphology, stripes of turbidity caused by construction activities, like dredging, pile driving, cable laying
		Dredging (foundation, cable laying) disturbs the seabed by shifting sediments
		Increasing temperature of sediment and pore water and a release of harmful substances (due to increased temperature) caused by operating submarine electric cable
Benthos	Introduction of artificial hard substrate causing a permanent habitat loss and mortality, new habitat for new species, a shift of community composition, increased biomass, biodiversity and abundance at the piles	Endobenthic organisms laid open, epibenthic organisms covered causing mortality, damage, habitat loss due to re-suspension and relocation of sediments
		Dredging and sediment shift eliminates and damages organisms by mechanical pressure and laying open or cover them
	Physical presence as safety risk for fishing boats leading to protection against bottom trawling and indirect a higher predatory pressure	Physical presence and changing sediment flux, composition, structure and morphology, esp. scour pits and a release of harmful substances from the sediment leading to a habitat loss, new species and an accumulation of harmful substances in organisms
		Increasing sediment temperature due to operating electric cable causing an alteration of endobenthic community, damage of individuals, non-residential species and released harmful substances from sediment accumulate in organisms
		Electromagnetic fields caused by electric cable could damage individuals, possible responses of cancer (lack of knowledge)
Fish	Sediment turbidity, re-suspension, sedimentation causing a damage, dislocation, temporary habitat loss (especially pelagic fish), damage to fish eggs and spawning grounds	Dredging and sediment shift (introduction of cable) causing a temporary habitat loss, damage of epibenthic fish species
	Introduction of artificial hard substrate leading to a new habitat, attraction of fish and new species, change of community composition, serving as nursery area and protection from predators, the availability and diversity of prey organisms changes and increases	Changing sediment flux, composition, structure, morphology and a release of harmful substances from sediment due to physical presence and changing hydrodynamics cause a habitat loss of some sensitive species
	Construction noise and vibration especially while pile driving causing stress, behavioural effects, injury, mortality from gas embolism, impair sense of hearing, deafness, impair survival, dislocation and temporary	Light reflection and shading effect from rotor blades could cause avoidance of the area by some species

	habitat loss, masking effect, damage and elimination of fish spawn and larvae	
	Construction noise and vibration have negative impacts on fish larvae causing a high mortality, damage, negative effect on development	Illumination can be beneficial for fish praying by visual perception, fish can be attracted by light, some species avoid it
	Vibration and noise emission into the water body during operation lead to habitat loss, dislocation, barrier effect, behavioural effects, stress, masking by noise (pray, enemies, intra-specific)	Electromagnetic fields emitted by submarine electric cable have a behavioural and barrier effect on electro-sensitive fish, an effect on migration and orientation is possible but unlikely (gaps of knowledge)
	Physical presence as safety risk for fishing boats making the area to a refuge from intense fishing, regeneration area allow a recovery of stock, development of natural age structure	
Marine mammals	Construction noise especially pile driving, but also boat traffic, cable laying and removal leads to a temporary habitat loss, fragmentation, behavioural change, avoidance, temporary or permanent physical damage like hearing damage impair survival, loss of individuals, disturbance of intra-specific communication due to masking by noise therewith reduction of reproduction rate	Electromagnetic fields can have a barrier effect and cause disturbance of small- and large-scale orientation (gap of knowledge)
	Vibration and noise emission into the water body during operation causes a barrier effect to mitigating marine mammals, fragmentation of resting, hunting and reproduction areas, changed behaviour, disturbance and permanent habitat loss possible, masking effect and disturbance of intra-specific communication	
Migrating birds	Increased collision risk especially in nights with poor visibility causing higher mortality due to the physical presence	Due to noise emission while pile driving an avoidance of the area is expected
	Physical presence and visibility cause a barrier effect and fragmentation of migratory routes, avoidance or flying around costs energy and reduces fitness	Visual effects of construction and maintenance leading to a temporary habitat loss of species sensitive to this impact, avoidance, flying around the area and reduction of fitness
	Facility illumination increases the collision risk, attracts some species, flying around the facility costs extra energy (mortality possible)	Wakes of turbines cause damaged, reduction of fitness or death to birds caught by them
Sea birds	Physical presence and visibility causing a permanent habitat loss (sensitive species) or change, avoidance behaviour, disturbance of resting, feeding or wintering areas, barrier effect,	Visual effects of construction works cause avoidance, temporary habitat loss, feeding, resting and wintering areas can be affected
		Noise emission during construction leading to an avoidance or flying around which costs energy and

	fragmentation of associated areas, like feeding and resting areas	reduces fitness, habitat loss
	Light reflection and shading effect from rotor blades can lead to avoidance and barrier effects	Increased collision risk especially in nights with poor visibility causing higher mortality due to the physical presence
		Wakes of turbines cause damaged, reduction of fitness or death to birds caught by them
		Introduction of artificial hard substrate can result in a disturbance of feeding, resting, wintering areas, habitat loss, indirect beneficial effect due to increased food species availability, attracted by area (probably few birds profit from this)
Not further discussed are: Zooplankton, Bats, Fauna, Human beings, Air and Climate		

Table 4.3.1-1: Mainly considered impacts on protected assets in the North Sea and their sources within the EIS of the Dutch offshore wind farm “BARD Offshore NL 1”

The main focus of this Dutch EIS lays on negative impacts on birds, fish fauna and marine mammals, but also some impacts on the benthos, the seabed and water quality are discussed intensive.

Important to consider and discussed intensively are the significant impacts of noise emission during construction works, especially during pile driving, on *marine mammals*. It causes, inter alia, a temporal habitat loss, disturbance of intra-specific communication and, very important to consider, the loss and damage on individuals, like hearing damage impairing their survival. Also discussed are emissions of noise and vibration into the water body during operation of the wind farm as a barrier effect, disturbance, avoidance, habitat loss and fragmentation of resting and hunting areas can not be excluded.

The construction noises are also taken into account for the *fish fauna* causing habitat loss, strong injury, deafness or even mortality. Also considered in this context is the high mortality of *fish larvae* due to the noise emission by pile driving. Fish and fish larvae suffer a habitat loss and damage due to an increased sediment turbidity and re-suspension during construction as well as emission of noise and vibration into the water body during the operation of the wind farm which are other important aspects of the EIS. Negative as well as positive effects on fishes due to habitat changes with the introduction of artificial hard substrate and positive aspects of the safety related fishing ban are discussed intensively.

Mitigating birds are on an increased collision risk, especially with the rotor blades. Facility illumination, having a drawing effect and increasing the collision risk are discussed quite intensive as well as the barrier effect forcing migrating birds to fly a circle around the wind farm. The habitat loss due to the avoidance of the wind farm area by sensitive sea bird species is another impact which can, depending on the species affected, have consequences to be weighted up. Avoidance, disturbance, e.g., of feeding grounds and habitat loss are also due to the light reflection and shading by the turbines.

In particular the *benthos* is affected by changes caused by the introduction of artificial hard substrate and the fishing ban within the wind farm area. Part of the EIS is the consideration of how the habitat changes and its positive as well as negative impacts on benthic communities. The change of hydrodynamics due to physical presence of the wind farm and related changes of sediment dynamics, composition, structure, and the development of scour pits, having again a direct impact on the benthic community, are also described. Effects by submarine cable, especially increasing temperature in the vicinity of the submarine electric cable and a related release of harmful substances from the sediment also change habitats.

Not mentioned or discussed further are impacts on zoobenthos, bats, fauna, human beings, air and climate.

b) Cumulative effects

The EIS “BARD Offshore NL 1” considers, related to the protected assets, different scenarios of cumulative effects:

- interaction of the planned offshore wind farms with other offshore wind farms
- interaction of the planned offshore wind farms with other authorised wind farms (OWEZ, Q7, Nördlich Borkum)
- temporal and spatial cumulative effects
- interaction of the cable system of the planned wind farm with other cable systems
- interaction with other planned projects in the area of Eemshaven
- interaction with other activities (defined in Bijlage 4, Tabel 7 Directive Rijkswaterstaat Nordzee, 2006)
- clustered and fragmented/ splintered scenario

The other activities taken into account within this EIS which also can have an influence on protected assets are mining, mineral and sand extraction, dredging of sea ground, military use, shipping, fishery, shell extraction, air traffic and the "Tweete Maasvlakte" (extension of the harbour Rotterdam). The table below gives an overview of the cumulative effects addressed.

Protected assets	**Interaction of "BARD Offshore NL 1" with:**	
	other offshore wind farms	**other activities and projects**
Migrating birds	Barrier effect forcing migrating birds to fly around the wind farms which reduces their fitness	Barrier effect
	Collision risk	Facility illumination attracting birds
Sea birds	Habitat loss for birds sensitive to disturbance by physical presence	Habitat loss, visual effects and noise emission due to use of machines and shipping
		Temporal habitat loss and disturbance of breeding birds
		Sediment disturbance have effect on diving sea birds
		Facility illumination attracting birds
		Demand of space
Marine mammals	Noise emission during pile driving causing health threat, disturbance and barrier effect (affecting migration routes)	Noise emission (construction, seismic studies, shipping, dredging, machines) causing health threat, disturbance habitat loss, barrier effect
	Noise emission during operation causing disturbance and avoidance of the area, barrier effect	
Fish	Noise emission while pile driving causing health threat	Noise emission while pile driving causing health threat
	Sediment turbidity causing health threat	Sediment turbidity causing health threat
	Habitat loss as sea ground gets lost with introduction of artificial hard substrate (erosion protection)	Habitat loss due to disturbance or barrier effect on migrating routes
	Safety related fishing ban, higher biomass, refugee area and attraction of fish	
Fish larvae	Mortality due to noise emissions by pile driving	

Benthos	Habitat loss due to sealing of soft bottom seabed (foundation, erosion protection)	Habitat loss due to a change of the habitat
	Hydrodynamic changes and habitat loss	
	Increasing temperature along the cable	
	Introduction of artificial hard substrate increasing biomass, but also sealing of seabed and habitat loss	
	Safety related fishing ban, refugee area, increasing biomass	
Geomorphology/ Hydrodynamics	Cable laying and introduction of artificial hard substrate causes change of geomorphological structures and sediment structure	Change of hydrodynamics and hence change of sediment composition
	Interaction of submarine cable of “BARD Offshore NL 1” with:	
	other cable	**other activities**
Sea birds	Cable laying in Wadden Sea area cause disturbance, temporal habitat loss of breeding birds	Projects in Eemshaven: construction works have negative impacts/ disturb breeding and pleisterend birds causing a temporal habitat loss
Marine mammals	Cable laying in Wadden Sea area causing acoustic and visual effects on seals and hence a disturbance	Disturbance of seals over a big area as dredging activities in Eemshaven and cable laying overlap
	Operating phase, magnetic fields and increasing temperature of the sediment close to the cable can occur if the distance between the cables is not big enough	
Fish	Construction of more cables at the same time causing disturbance and avoidance of a big area	Magnetic fields cumulating with NorNed-cable causing avoidance of the area by some species
	Operation of the cable, magnetic fields building a barrier, disturb fish species sensitive to electromagnetic fields. Not much known about it, but possible if not enough space between cables.	
Benthos,	During cable laying due to dredging, if more at the same time, affected area is bigger and therewith the negative effect on benthos	Dredging of the Ems causing an increasing sediment turbidity

	Dredging causes sediment turbidity which can lead to an impairment	
Geomorpholigy, Hydrodynamics		Dredging of the Ems causing an increasing sediment turbidity
		Change of geomorphology and sediment shift due to sand extraction and other dredging activities

Table 4.3.1-2: Cumulative effects considered within the EIS of the Dutch offshore wind farm "BARD Offshore NL 1"

The scale of cumulative effects studied in the EIS is compared to other documents quite broad. Effects of the planned wind farms including the submarine cable with other wind farms as well as other activities and uses on birds, marine mammals, fish, fish larvae, benthos, geomorpholigy and hydrodynamics are getting addressed here. Discussed intensive are cumulative effects on birds, marine mammals and the fish fauna. The cumulative effects of several offshore wind farms causing habitat loss, collision risk and a barrier effect on birds are evaluated quite sufficient with a focus on species affected strongly. Effects by other activities are also discussed shortly. Also cumulative effects of wind farms during pile driving on marine mammals and fishes are due to their significance discussed intensive.

c) Measures

The measures suggested within the EIS are focusing on mitigating measures to avoid and minimise negative impacts on the environment. Compensating measures are not applied here, they are according to the directive (Rijkswaterstaat Nordzee, 2006) necessary if significant negative impacts are expected. The following effects are addressed by different measures listed below:

Disturbance of the seabed (also benthos):

- Make a survey of the cabling at least ones per year, ensuring cable are not laid open. Important to keep cable under the seabed to keep the temperature and electromagnetic fields emitted by submarine electric cable low.
- Avoid dredging and flush cable into the seabed instead to avoid removal of sediment

Noise emission (marine mammals, fish)

- „Soft start“ for pile driving, means start pile driving with less energy and increase it slowly
- Use of measures to displace animals before construction by using acoustic disturbing signals, e.g. „Pinger“
- Measures to reduce noise emission, like bubble curtain around the foundation and pile
- No pile driving while marine mammals in the vicinity (radius min. 100m) of the construction side; control if marine mammals in vicinity (using sonar and visual)
- Avoidance of construction activities in month with high abundance of marine mammals in the area
- Avoidance of construction activities while moult period of seals and calving and suckling periods of seals and porpoises
- Within a radius of <15km the foundation works of only one offshore wind farm can be done at the time

Birds collision, attraction:

- Keep collision risk low by the arrangement of the turbines adapted to the main birds migration route, corridor of 800 m between turbines, turbines in a row behind each other, ensure visibility by optimal shading
- Switch off turbines in nights with high migration rate to keep collisions risk low
- Harmonise the arrangement of wind farms (national as well as cross-border) adapted to the main birds migration route and in a straight line behind each other
- Reduce illumination to minimum, avoid direct radiation; apply short-coloured, flashing light or flashing light signals with longer intervals; green light instead of red or white light

Disturbance, habitat loss (birds)

- Avoid building activities and cable laying in month with high presence of birds and during breeding season; locate offshore wind farms at least 56 km off the coast and islands to avoid negative effects on breeding birds

- Within the offshore wind farm area other activities are forbidden, like ship traffic, to avoid or minimise further impacts

Avoid high temperature and electromagnetic fields

Make a survey of the cabling at least ones per year, ensuring cable are not laid open. Important to keep cable under the seabed to keep the temperature and electromagnetic fields emitted by submarine electric cable low.

Cumulative effects:

- For offshore wind farms close by other times for constructions need to be applied (sediment disturbance and noise)
- Within the offshore wind farm area other activities are forbidden, like ship traffic, to avoid or minimise further impacts
- Large distances between turbines to avoid negative acoustic and visual effects
- Bundling of cabling with other existing cable
- Keep distance between different cable routes to avoid cumulative effect of increasing temperature and electromagnetic fields
- Cable laying of the wind farms not at the same time to avoid cumulative effects of noise emission

Further

- Use of external power sources as anti-corrosion protection and reduce therewith the introduction of harmful substances
- Use of three-phase current cable and a place them in at least 2 m depth into the ground to minimise electromagnetic fields
- Avoidance of construction works and cable laying during reproduction periods of birds and marine mammals

Locate offshore wind farm outside of conservation areas, like NCP or Natura2000

4.3.2 Area specific assessment study: Natura 2000

Within the area specific assessment "Passende beoordeling" of "BARD Offshore NL 1" attention is paid to impacts on Natura 2000 areas and their protected assets fish larvae, marine mammals and sea birds as well as colony birds and mitigating birds (Arends et al., 2009). These impacts and cumulative effects are listed in the table below.

Protected assets	Impacts	Cumulative effect
Fish larvae	Increasing mortality of fish larvae while pile driving and therewith negative effect on "nursery" area	Planned wind farm with other offshore wind farms
Marine mammals	Impacts due to construction noise, barrier effect, temporary or permanent hearing damage, temporary habitat loss	Planned wind farm with other offshore wind farms
	Impacts due to operational noise, barrier effect, habitat loss, disturbance, physical damage	Not mentioned
	Indirect effects due to impacts on fish larvae leading to a decreasing availability of pray fishes with effects on the fitness	Planned wind farm with other offshore wind farms
Birds	Collision risk with turbines, especially rotor blades	Planned wind farm with other offshore wind farms
	Avoidance of the park with habitat loss and barrier effect	Planned wind farm with other offshore wind farms
	Indirect effects due to impacts on fish larvae leading to a decreasing availability of pray fishes with possible negative effects on the breeding success in areas with breeding birds depending on fish as the main pray	Planned wind farm with other offshore wind farms

Table 4.3.2-1: Impacts on protected assets and cumulative effects within the area specific assessment

Besides the impacts of the single offshore wind farm, cumulative effects are considered within the area specific assessment. Effects on two Natura 2000 areas and its protected assets birds, marine mammals and fish larvae are evaluated, taking into account cumulations between the planned wind farm and other wind farms as well as other two projects, the "Tweete Maasvlakte" and sand extraction. Evaluated are, as shown in Table 4.3.2-1, the increasing collision risk of mitigating birds and specific colony bird species with an increasing number of wind farms, an adding up of habitat loss of colony and sea birds and of noise emissions due to pile driving and operating turbines. Furthermore, effects on juvenile fish, fish larvae and the function of nursery areas as well as indirect effects on birds and marine mammals due to increasing fish larvae mortality and therewith reduction of food resources.

4.3.3 Licensing text

a) Impacts

The mainly considered impacts on protected assets within the North Sea addressed within the licensing text of the Dutch offshore wind farm "BARD Offshore NL 1" and their sources are listed in table 4.3.3-1. It bases on the results form the document analyses which result, the evaluation table, can be found in the annexe.

Assets	Primary focus	Secondary focus
Fish		Construction noise and vibration especially while pile driving causing stress, behavioural effects, injury, mortality from gas embolism, impair sense of hearing, deafness, impair survival, dislocation and temporary habitat loss, masking effect, damage and elimination of fish spawn and larvae
		Construction noise and vibration have negative impacts on fish larvae causing a high mortality, damage, negative effect on development
Marine mammals	Construction noise especially pile driving, but also boat traffic, cable laying and removal leads to a temporary habitat loss, fragmentation, behavioural change, avoidance, temporary or permanent physical damage like hearing damage impair survival, loss of individuals, disturbance of intra-specific communication due to masking by noise therewith reduction of reproduction rate	Indirect effects due to impacts on food resources, here fish larvae
Migrating birds		Increased collision risk especially in nights with poor visibility causing higher mortality due to the physical presence
Sea birds		Physical presence and visibility causing a permanent habitat loss (sensitive species) or change, avoidance behaviour, disturbance of resting, feeding or wintering areas, barrier effect, fragmentation of associated areas, like feeding and resting areas
		Indirect effect due to impacts on food resources, here fish larvae

Not further discussed are: Water, Seabed, Benthos, Zooplankton, Bats, Fauna, Human beings, Air and Climate

Table 4.3.3-1: Mainly considered impacts on protected assets in the North Sea and their sources within the licensing text of the Dutch offshore wind farm “BARD Offshore NL 1”

The licensing text mainly summarises the most important outcomes of the EIS, the “Passende beoordeling”, the advice by the EIA Commission and the authority. It focuses very strong on impacts on migrating and sea birds as well as marine mammals, fishes and fish larvae. Assessed quite detailed, also in the EIS, and important for the final decision-making are the effects of pile driving on marine mammals as the noise emissions have significant effects on the animals impairing their survival. A secondary focus lays on negative effects on fish, marine mammals, migrating and sea birds. Adult fish but especially fish larvae are sensitive to the noise emissions caused by pile driving. Adult fish suffer in the vicinity of the source of noise habitat loss, injury or deafness impairing their survival. As fish larvae can not escape from the construction side, the result is a high mortality with effects on marine mammals and sea birds praying fish. Sea bird species sensitive to the disturbance caused by the presence and visibility of the wind farm are avoiding the area and suffer habitat loss and disturbance or fragmentation of feeding and resting areas. Also considered is the collision risk of migrating birds in nights with poor visibility causing an increasing mortality.

The effects on water, seabed, benthos, zooplankton, bats, fauna, human beings, air and climate are not considered and or only shortly mentioned and get therewith not an important role as a decision-making base.

b) Cumulative effects

In the licensing text cumulative effects are summarised which are discussed in the EIS and the area specific assessment. Also effects mentioned in the advice of the EIA Commission and given by the authority are taken into account.

Protected Assets	MER	Area specific assessment	Authority
Fish larvae			Mortality of fish larvae on large scale due to pile driving
Marine mammals		Barrier on migration routes and decreasing habitat quality (of seal) due to cumulative effects of operational noises with other activities	Temporal habitat loss, including areas of praying due to construction noises
		Noise emission while pile driving	Noise emission during pile driving cause negative effects
		Availability of food resources due to increasing fish larvae mortality	Increasing mortality has effects on marine mammals dependent on fish as food resource
			Habitat loss of marine mammals due to operational noises
Migrating birds	Collision risk with turbines	Collision risk with turbines	Collision risk with turbines
Sea birds	Habitat loss due to avoidance of the wind farm area		Effects on breeding success of birds dependent on fish as food resource due to increasing mortality of fish larvae

Table 4.3.3-2: Cumulative effects considered within the licensing text of the Dutch offshore wins farm “BARD Offshore NL 1”

Cumulative effects mentioned are mainly conform with the impacts focused on in the licensing text. Addressed are (1) the increasing mortality of fish larvae due to pile driving and its effects on birds and marine mammals mainly praying fish and (2) effects on marine mammals due to noise emissions while pile driving and noises during operation of the wind farm and the wind farm as a barrier effect within migrating routes. Furthermore, (3) the collision risk of mitigating birds with rotor blades and a permanent habitat loss for sea birds is taken into account and (4) the noise emission while pile driving is a very significant impact to pay attention to, especially when addressing cumulative effects. If all offshore wind farms considered in the analysis get build within the same time period, it would cause significant negative impacts, especially on seals, on a large-scale. Not considered as a very significant impact is the habitat loss of marine mammals due to operational noises. But in a worst case scenario considering a cumulative effect of many offshore wind farms, this impact can cause significant negative impacts on marine mammals (Ministerie van Verkeer en Waterstaat, 2009).

c) Measures

Looking at mitigating measures taken, most are avoiding negative impacts due to noise emission during pile driving. To reduce negative effects especially on fish larvae, marine mammals, breeding birds and avoid indirect impacts on birds and marine mammals due to an increasing mortality of fish larvae, the following measures are to be taken:

- Measures to displace animals before construction by using acoustic disturbing signals (e.g. „Pinger“ and „Sealscarer“)
- Technical measures to reduce noise emission. The first 20 m depth pile brought into the sea ground by vibrations („intrillen“) which reduces noise emissions of about 15-20 dB compared to pile driving
- Pile driving methods: in groups of eight, first pile driving, after turbines are getting installed which makes a phase with less noise emissions possible
- Starting pile driving with a „soft start“ and increase it, animals have time to leave the area
- While sensitive periods 1st January- 1st July pile driving forbidden
- Pile driving in only one wind farm per season (July - December) allowed (esp. to reduce effects on marine mammals in Borkum Riffgrund)

Other measures are addressing the increasing risk of birds colliding with rotating rotor blades, like

- switch off turbines in nights with high birds migration rate

and ensure the wind farm is getting removed after use:

- Removal of the wind farm in the end of its operating time within 24 month

Further requirements are helping to close gaps of knowledge:

- Survey of the seabed after removal of wind farm to proof the sea ground is in its original, natural condition without any residues.
- Monitoring and Evaluation Programme to close gaps of knowledge

4.4 Results: Addressing impacts of “BARD Offshore NL 1”

Discussed following are first of all the results of the document analysis, but also impacts assessed within the area specific assessment as well as cumulative effects which are not considered within the analysis (see annexe) are taken into account. Answered are the question about which impacts are currently discussed, are crucial for decision-making and which are taken into consideration when coming up with requirements and measures for construction and operation of offshore wind farms? Which requirements and measures are used to avoid or minimise negative impacts? And which requirements are set on the contents for the EIS and the licensing text. What is getting considered? Which protected assets have to be taken into account?

4.4.1 Impacts

When taking together the main documents for an information based decision-making - the EIS, including the area specific assessment 'Passende beoordeling', and the licensing text - the main focus is on negative impacts on fishes, fish larvae, marine mammals, sea and migrating birds.

Environmental impact statement

The Dutch EIS discusses impacts quite broad. The content bases on advises given by the EIA Commission, the done EIS has been reviewed by these commission, advisor and laid open for public inspection. The result contains a description of the impacts on water, seabed, benthos, fish, fish larvae, marine mammals, sea birds and migrating birds due to construction and operation of the wind farm, but also maintenance works and removal. The impacts due to removal are similar to these of the construction phase, but not really discussed. This additional burden can add up with other impacts of other phases and could lead to a significant impairment of the marine environment. For assets and impacts analysed further alternatives which are more economically and environmentally friendly are weight up.

EIA Directive	**North Sea**
Fauna	Birds, marine mammals, fish, bats, zoobenthos, zooplankton
Flora	Phytoplankton, phytobenthos, macrophytes
Soil, water	Seabed, sea water, flow-changes (sediment structure, hydrodynamic)
Air, climate	Air, climate
Human being	Human health and life
Interaction between mentioned factors	Interaction between mentioned factors

Table 4.4.1-1: Protected assets defined in EIA Directive (left) and assets relevant for offshore wind farm projects in the North Sea (right) taken into account in the Dutch EIS “BARD Offshore NL1” (grey marked)

Discussed very intensive are the collision risk of mitigating birds and different factors influencing it, negative effects on marine mammals, fish and fish larvae due to noise emissions while pile driving and the habitat changes due to the introduction of artificial hard substrate and the effects on the fish fauna.

Comparing the impacts on protected assets and its sources to the issues discussed in literature, the most significant changes and impacts are assessed. But there are also impacts not mentioned at all, which are not seen as significant and important to decision-making or are just overseen.

Regarding impacts on protected assets, not mentioned at all within the EIS are effects on bats, zooplankton, phytoplankton (only mentioned briefly), macrophytes, human beings and air. Also effects on the climate are not looked at, but they are indirectly mentioned as offshore wind farms are having a positive effect on the climate by decreasing CO2 emission when replacing coal-fired power plants.

Effects on the fauna are besides the mentioning of negative effects on phytoplankton by sediment turbidity and smothering of the water not even mentioned. Risks human beings are bearing are not addressed directly. These risks are anyway predominant, indirect ones due to the safety of shipping, air traffic or construction works and over the food chain. These impacts on human beings can also be addressed differently as humans, the public, are directly involved into decision-making. Documents need to be made public and everyone has the possibility to rise an objection to the decision.

One issue definitely missed out are the effects on bats. According to Bach & Rahmel (2008), migrating bats were observed over the North Sea, also in Borkum Riffgrund. A problem is the missing knowledge about mitigating routes of bats and effects of offshore wind farms on them. As explained in chapter 2, the collision risk with rotating rotor blades is quite high and, besides this, bats can be harmed or disturbed by ultrasound emissions from the turbines or due to a barrier effect. Bats are also important to take into account, as many species are endangered and, hence, protected by the EU Habitats Directive.

Factors harming the water quality, like the increasing ship traffic polluting the sea water and seabed or effects of the increasing biomass at the piles of turbines, are causing an increasing biological activity which can lead to an oxygen deficit. These factors are also not mentioned. The pollution by lightly more ship traffic is negligible small, however, it is one of many factors polluting the sea adding up with the time which can (not necessarily) end up in a significant impairment of the marine environment. The effects of the release of harmful substances further affects birds and marine mammals. Regard also is not paid to effects caused by the withdrawal of cooling water and the introduction of heated water damaging fish and benthos, eliminate their eggs or larvae. Due to this, possible but very unlikely is a shift of community, the distribution and density. But as the North Sea water with its tides is quite turbulent, the water gets mixes very fast and the effects are not very significant (Schuchardt et al., 2009).

Area specific assessment

Within the area specific assessment considering impacts on Natura 2000 areas the focus lays only on effects on marine mammals, fish larvae, migrating birds and sea birds due to the construction and physical presence of the wind farm. No other assets and sources of impacts are looked at. The impacts considered here are quite similar to the impacts discussed within the licensing text.

The licensing text

The licensing text is no own assessment, it rather takes into account the results of the EIS, the area specific assessment, advices of the EIA Commission, objections by different groups of interest, public bodies or others, like private persons. Furthermore, the licensing authority gives advises, statements and sets requirements after reviewing the documents.

The impacts addressed in the licensing text, building the base for the decision-making, go by with impacts mainly focused on in the EIS, but especially in the area specific assessment 'Passende beoordeling'. All impacts discussed within the area specific assessment and the most significant impacts described in the EIS are considered here. These impacts are (1) the construction noise on fish and fish larvae due to pile driving, (2) indirect effects on marine mammals and birds depending on fish as a food resource due to the increasing mortality of fish larvae during pile driving, (3) negative effects on marine mammals due to noise emissions while pile driving, (4) an increasing collision risk for migrating birds and (5) the habitat loss of sensitive bird species due to the visibility of the wind farm. Further impacts on protected assets are not mentioned or somehow taken into consideration.

Issues discussed in the licensing text are also focused on in the EIS, except indirect impacts on birds and marine mammals dependent on fish as a main food resource due to an increasing mortality of fish larvae. This has been recognised in the “Passende beoordeling”.

4.4.2 Cumulative effects

The assessment of cumulative effects is a challenge and, due to Zeelenberg (2005), a big concern as they are often not addressed sufficiently within documents and procedures, like the EIA, building the base for the decision-making about the environmental compatibility of a project. Within the EIS “BARD Offshore NL1” efforts are made to assess these cumulative effects which are compared to other documents assessed quite broad (see table 4.2.3.1-1).

Cumulative effects of the planned wind farm and its submarine electric cable with other offshore wind farms, cable, activities and uses are assessed. Additionally, temporal and spatial aspects are taken into account and different scenarios, a clustered and a splintered one, are helping to evaluate cumulative effects more detailed.

The licensing text summarises the most important cumulative effects of the EIS, advices by the EIA Commission and the authority and the area specific assessment “Passende beoordeling”. It concentrates on the main aspects regarding cumulating effects. Addressed within this documents are (1) the noise emissions during pile driving on fishes, fish larvae, marine mammals, (2) the collision risk of migrating birds, (3) the avoidance of the wind farm area and hence habitat loss of sea birds (especially Kleine mantelmeeuw, Jan van Gent, Nordsee stormvogel and Aalscholver) due to physical presence and visibility of the wind farm, (4) operational noises causing a barrier and decreasing the habitat quality (especially for seals) and (5) indirect impacts on marine mammals and birds dependent on fish as food resource due to an increasing mortality of fish larvae.

4.4.3 Measures

The measures taken here are mitigating only, compensating or adaptation measures are not mentioned.

Environmental Impact Statement

Within the EIS a lot of measures to avoid or minimise negative impacts on the environment are suggested. These measures address impacts on benthos, fish fauna, mitigating birds, sea birds, marine mammals as well as cumulative effects. The main focus lays on mitigating measures addressing the effects of noise emissions while pile driving on the protected assets marine mammals and fish as well as negative effects on birds and negative impacts due to cumulative effects. Effects on fish larvae can not be mitigated easily as they are not mobile and, hence, can not escape from the building site. Further, fish larvae or spawn are very sensitive to noise emissions, suffering damage and mortality with 20 dB over the natural background noises (Storz et al., 2009). A technique which can buffer the noise so well is not available yet, but other measures could be taken, like the avoidance of pile driving during the main spawning season. Regarding noise emissions on marine mammals the measures suggested are quite strict as it involves, for example, a prohibition of pile driving in sensitive periods, like moult period of seals or calving and suckling periods of seals and porpoises. Also the restrictions suggested as a reaction on negative effects on birds are strict, as construction activities in periods of high presence of birds and during breeding periods should be stopped for that time. Further, the operation of turbines will be stopped in nights with high birds migration. Also measures to keep cumulative effects of cable, turbines or construction works low are suggested. Another measure is adapting the arrangement of the turbines as well as the different wind farms to the main birds migration route to minimise the collision risk and build corridors allowing birds to pass though and therewith also address the barrier effect.

Licensing text

The measures taken finally to avoid or minimise negative impacts are specified in the licensing text. They are predominantly addressing negative impacts of noise emissions due to pile driving on marine mammals, but also fish and fish larvae. Different tools and a “soft start” method are used to ensure marine mammals but also fishes can escape and are no in the vicinity of the construction site while pile driving. Furthermore, a pile driving method is developed to reduce noises to a minimum level and a minimum of time. It includes bringing the pile into the sea ground partly by vibrations which reduces the noise emissions and a schedule for pile driving ensuring periods of less noise emissions. Very strict measures are the prohibition of pile driving between 1st January and 1st July as these are very sensitive periods for mammals, like to moult season for seals and calving time of harbour porpoises. Furthermore, in the season from July until December pile driving is only allowed within one wind farm, in the case of “BARD Offshore NL 1” this measure is especially taken to protect marine mammals in the German Natura 2000 area “Borkum Riffgrund”. These limiting measures for pile driving also have positive effects on the fish fauna. Also strict and necessary is the requirement of switching off turbines in nights with high bird migration rates to minimise the collision risk, as the risk of colliding with rotating rotor blades is very high. Another issue to avoid pollution is the obligatory removal of the wind farm after the operational time.

Other measures are taken with the aim of gathering more knowledge about effects of offshore wind farms on the marine environment and to close gaps of knowledge to ensure an improvement of future impact assessments for offshore wind farms. Very important in this regard is the Monitoring and Evaluation Programme. But also a survey of the seabed after the removal of the wind farm has to be made to proof the condition of the sea ground and gather knowledge about long-term effects even extending the time of operation and physical presence.

Chapter V: A comparison of The Netherlands and Germany

As offshore wind energy is a young field, still many experiences have to be gathered. Especially as offshore wind farms are expanding, safeguarding the energy supply in future, it is important to gather knowledge to predict possible effects on the marine environment and improve the current praxis addressing them. The consideration of impacts possibly caused by the planed project within the decision-making as well as the improvement of measures are very important to ensure the marine environment does not get harmed significantly. Therefore, based on the project “MEG Offshore I” in Germany and the Dutch project “BARD Offshore NL 1” as two examples, the praxis of both countries is getting compared aiming to improve the current praxis.

Following, standards, impacts, cumulative impacts and measures taken are compared and discussed. The legal base and standards used in both countries are compared briefly, but the main focus lays on environmental impacts. Impacts, already described in chapter III and IV, which are mainly discussed within the documents and, hence, crucial for the decision-making within the two projects are getting compared. Also requirements and measures taken including the impacts and assets addressed by the measures will be compared. Based on this comparison, suggestions for new measures and impacts to be addressed will be given in chapter VI. Besides measures and impacts, cumulative effects which are important to take into account for decision-making, but are often not addressed sufficiently are finding attention. These effects are hard to assess as a method is missing helping to take into account all issues influencing these effects. So, how are cumulative effects assessed in the different countries?

A more general question addressed here is: what can the countries learn from each other? The comparison and discussion within this chapter serves as a base for giving suggestions in chapter VI. It also supports the exchange data and knowledge about impacts and gives new inspirations for measures and standards to help improving the praxis by, as it was called at the beginning, looking “over the rim of the own tea cup”.

Therefore, this chapter points out the most important and significant impacts expected and see if there are significant differences in the impacts addressed or if some are even left out. These differences are quite interesting to point out as standards saying which are the main impacts and how to mitigate them are not yet existing. Also possible improvements are discussed here aiming to improve the knowledge and minimise negative impacts. Gaps in addressing impacts, cumulative effects and measures taken are shown. Also as both countries are member states of the EU, it can be seen how they deal with the regulations in praxis.

And which requirements are set on the contents for the EIS and the licensing text. What is getting considered? Which protected assets have to be taken into account?

5.1 Standards

Both countries use a licensing systems with different procedural steps to be taken, the involvement of stakeholder and development of documents, e.g. EIS and licensing text, as results of different studies and a base for discussion and an information based decision-making. Regarding the involvement of stakeholder, both countries involve public bodies, groups of interest and the public. The documents summarising decisions or serving as a base for further decisions are open for inspection to everyone and everyone has the possibility to make comments on the documents. These comments also have to be taken into consideration for the decision-making regarding requirements, measures to be taken or even the environmental compatibility of the project. Guidelines as well as the scope of investigation (e.g. time, area, protected assets, impacts) for the EIA is in The Netherlands mainly made by the EIA-Commission. Other public bodies, groups of interest and public have the chance to give comments on this guidelines. The EIA-Commission is besides two other advisers also responsible for checking the quality of the EIS at a later state of the procedure. In Germany guidelines for the EIA are made by the public authority, the BSH, in cooperation with other experts. The so called *“Standards for the Environmental Impact Assessment”* contain rules for the description and assessment of protected assets, but do not contain criteria or a method (e.g. including a standardised evaluation matrix) for the evaluation of impacts. This is in Germany as well as in The Netherlands up to the evaluator. The scope of investigation gets defined by the BSH and other stakeholder, like research institutes and other experts and groups of interest discussed during an initial Scoping. In contrast to The Netherlands the public gets involved at a later state when the EIS is done and open for inspection. The done EIS gets in The Netherlands checked by the licensing authority, advisers and the EIA-Commission on completeness and scientific quality. In Germany a hearing is made giving the possibility to discuss the quality and contents as well as necessary improvements of the EIS involving the project owner, public agencies, the licensing authority, groups of interest and, especially, experts for research institutes.

Legislation in both countries builds a framework for addressing impacts and protecting the environment. Within the acts it is stated that impacts have to be addressed and avoided or minimised as far as possible, but more specific criteria about how to address which impacts or when to reject a license are not defined. This is, like described above, up to the authorities, evaluator and other stakeholder. Comparing standards and legislation in both countries the following issues can be pointed out: In Germany, the *Marine Facilities Ordinance* explicitly mentions that the project can not be permitted if it is detrimental to the marine environment, including the avifauna. In the Dutch *Public Works Act* significant impacts on the environment are not directly mentioned, but it refers to national nature protection laws which have to be taken into account.

In both countries restrictions as a respond to partly significant impacts and, especially, the lack of knowledge regarding this impacts are made. In Germany an offshore wind farm can not consist of more than 80 turbines, in The Netherlands the wind farm area is restricted to a maximum of 50 km².

The respective acts in both countries also ask for measures to be taken, but it gets neither by the acts nor by other guidelines defined which measures have to be taken for which impacts. The final requirements and measures have to be specified for every single project, written down in the final licensing text. The decision about these requirements and measures is up to the licensing authorities in consents with other experts. In Germany the focus lays on mitigating measures, compensating measures are not getting applied for offshore wind farms approved before 01.01.2017. In The Netherlands mitigating measures are applied as well as compensation measures which are necessary if significant impacts can not be avoided by mitigating measures.

Regarding EU-Directives and, hence, the consideration of Natura 2000 areas and species protection, both countries are making obligatory studies evaluating how the different

Natura 2000 areas are affected by the project and if the impacts are conflicting with the development targets of the directives and accordingly to the areas. Paying regard to the Habitats and Birds directives, Germany is doing an assessment study about Natura 2000 areas and another study regarding special protected species which could be affected negatively. The Netherlands are doing one study, the “Passende beoordeling”, evaluating effects on protected assets and Natura 2000 areas.

Licensing text and EIS

In Germany the EIS assesses compared to the licensing text sources of impacts quite broad. The licensing text is an own survey referring to current studies and research projects and evaluating possible impacts on protected assets. It does not simply summarise the results of the EIS, other documents and hearing, although it takes into account these documents. One question also Peters et al. (2008) rises which should get addressed in further studies is if double work is done and if the procedure could be done more efficient.

In the Netherlands the EIS is comparable broad considering many different sources of impacts and discussing them relatively detailed. Striking within the EIS are also alternatives weighted up for every impact looking for the best alternative (environmental and economical). The licensing text includes the results of different documents (like the EIS, advices on the EIS and the Passende beoordeling), comments made on the documents, hearings and comments by the public authority. The licensing text is not an own survey like in Germany.

5.2 Impacts

Which impacts and sources of impacts on which protected assets are important for decision-making in Germany and The Netherlands? To answer this question it is necessary to have a closer look at impacts addressed in the licensing texts of the two projects “MEG Offshore I” authorised for the German EEZ and “BARD Offshore NL 1” for the Dutch EEZ.

The table below shows impacts and its sources discussed within the licensing texts. Factors only mentioned shortly in the document are not listed here. It gives a quick overview of impacts addressed both or only one of the licensing texts of both countries.

Protected assets	Germany	The Netherlands
Water	Water **pollution** caused by the impacts of **ship collisions**	**--**
Sea bed	Change of **sediment dynamics** (erosion and sedimentation), sediment composition and structure, morphology and development of scour pits and tails, sediment turbidity and as a result of this the release of harmful substances due to physical presence and therewith **changing hydrodynamics**	**--**
Fish	**Construction noise** and vibration especially while **pile driving** causing stress, behavioural effects, injury, mortality from gas embolism, impair sense of hearing, deafness, impair survival, dislocation and temporary habitat loss, masking effect, damage and elimination of fish spawn and larvae	**Construction noise** and vibration especially while **pile driving** causing stress, behavioural effects, injury, mortality from gas embolism, impair sense of hearing, deafness, impair survival, dislocation and temporary habitat loss, masking effect, damage and elimination of fish spawn and larvae
	Vibration and noise emission into the water body during **operation** causing a habitat loss, dislocation, barrier effect, behavioural effects, stress, masking by noise (pray, enemies, intra-specific)	**--**
Fish larvae	**--**	**Construction noise** and vibration during **pile driving** have negative impacts on fish larvae causing a high mortality, damage, negative effect on development
Marine mammals	**Construction noise** especially **pile driving**, but also boat traffic, cable laying and removal leads to a temporary habitat loss, fragmentation, behavioural change, avoidance, temporary or permanent physical damage like hearing damage impair survival, loss of individuals, disturbance of intra-specific communication due to masking by noise therewith reduction of reproduction rate	**Construction noise** especially **pile driving**, but also boat traffic, cable laying and removal leads to a temporary habitat loss, fragmentation, behavioural change, avoidance, temporary or permanent physical damage like hearing damage impair survival, loss of individuals, disturbance of intra-specific communication due to masking by noise therewith reduction of reproduction rate

	Vibration and noise emission into the water body during **operation** causes a barrier effect to mitigating marine mammals, fragmentation of resting, hunting and reproduction areas, changed behaviour, disturbance and permanent habitat loss possible, masking effect and disturbance of intra-specific communication	**--**
	--	Indirect effects due to impacts on **food resources**, here **fish larvae**
Mitigating birds	Increased **collision risk** especially in nights with poor visibility causing higher mortality due to the physical presence	Increased **collision risk** especially in nights with poor visibility causing higher mortality due to the physical presence
	Physical presence and visibility cause a **barrier effect** and fragmentation of migratory routes, avoidance or flying around costs energy and reduces fitness	**--**
	Facility illumination increases the **collision risk, attracts** some species, flying around the facility costs extra energy (mortality possible)	**--**
Sea birds	**Physical presence and visibility** causing permanent **habitat loss** (sensitive species) or change, avoidance behaviour	**Physical presence and visibility** causing a permanent **habitat loss** (sensitive species) or change, avoidance behaviour, disturbance of resting, feeding or wintering areas, barrier effect, fragmentation of associated areas, like feeding and resting areas
	--	Indirect effect due to impacts on **food resources**, here **fish larvae**

Not discussed	Benthos, zooplankton, bats, fauna, human beings, air and climate	Water, seabed, benthos, zooplankton, bats, fauna, human beings, air and climate

Table 5.2-1: Impacts discussed in the in licensing text, important for the decision-making

Comparing the main impacts addressed, differences between the two offshore wind farm projects in the two countries can be recognised.

In The Netherlands the main focus lays on effects by pile driving which has effects on marine mammals, fishes and fish larvae as well as indirect effects on sea birds. Especially (1) negative effects on marine mammals due to noise emissions while pile driving are evaluated quite intensive. Other negative impacts important for the decision-making are (2) the increasing collision risk for migrating birds, (3) the habitat loss of sensitive bird species due to the visibility of the wind farm as well as (4) the construction noise on fish due to pile driving. Moreover considered in the Dutch licensing text, but left out within the German decision are (5) indirect effects on marine mammals and (6) birds depending on fish as a food resource due to (7) the increasing mortality of fish larvae during pile driving.

In Germany more different impacts are discussed. A reason can be the structure of the licensing document. In The Netherlands it summarises the different documents and advices, in Germany the licensing text is an own assessment. Therefore, the main focus lays, like in the Dutch case, on negative impacts of (1) noise emission during pile driving activities on marine mammals. Also discussed in Germany, as well as in The Netherlands, are (2) effects of pile driving on the fish fauna, (3) collision risk of mitigating birds and (4) the habitat loss of some sensitive sea bird species. Impacts discussed in Germany which are *not considered in the Dutch project* are (5) the water pollution as a result of a ship collision, (6) a change of sediment dynamics, a development of scour pits as a result of the presence of turbines and, hence, changing hydrodynamics, (7) effects on fish and (8) marine mammals due to emissions of noise and vibration during operation, (9) the barrier effect on mitigation birds due to the physical presence of the wind farm and (10) the facility illumination disturbing, attracting and increasing the collision risk for migrating birds and costing them extra energy.

Some aspects listed above which are seen as important in one project, are sometimes not even recognised in the the other one. In the EIS, area specific assessment and the licensing text of “BARD Offshore NL1” effects on fish larvae due to pile driving noises are discussed as one of the more significant ones, causing increasing mortality rates, having further impacts on marine mammals and birds dependent on fish as their main food resource. The project documents of “MEG Offshore I” mentions negative effects on fish larvae and eggs marginal and does not pay any attention to this impact.

In turn, the EIS “MEG Offshore I” again sees the barrier effect by the physical presence of the wind farm on mitigating birds as well as the facility illumination increasing this risk and causing disturbance as a main impact to be discussed quite intensive and taken into account for decision-making. In the Dutch project EIS and area specific assessment “Passende beoordeling” this effect is discussed quite intensive, but within the licensing text it does not get addressed anymore and does not seem to be of relevance for the final decision-making. Also the effects of the emission of vibrations and noise into the water body during operation on marine mammals and the fish fauna are discussed intensive in the EIS “BARD Offshore NL 1” and its “Passende beoordeling”, but are not seen as significant and important for the final decision-making and, hence, are not mentioned in the licensing text. The licensing text “MEG Offshore I” assesses this effect definitely. Vibrations and noise emissions into the water body while operation are taken into account in the German project documents and are issue of further research in Germany, in The Netherlands these impacts are discussed quite intensive in the EIS but are not taken into consideration within the licensing text.

Having a look at the EIS and the area specific assessment, some assets listed in the EIA Directive are not taken into account. These are in Germany as well as in The Netherlands fauna, human beings, air and climate. The Dutch EIS and area specific assessment, as well as the licensing text, are also not considering bats at all. According to the EIS “MEG Offshore I” (BioConsult SH 2008), the North Sea area does not seem to have a high importance to bats as a habitat, but it is also not much known about migration routes of bats. However, migrating bats were observed over the North Sea (Bach & Rahmel, 2008) and as bat species are endangered, protected by the EU Habitats Directive, and can get impaired by the wind farm due to different factors and running a high risk of colliding with the wind farms, it should be part of the EIS discussing the specific risks.

The documents of both wind farm projects concentrate very much on negative effects on the fauna. Aspects like the pollution of the North Sea by the wind farm during construction, operation, maintenance and removal are also looked at, but secondarily. Also the impacts caused by the removal of the wind turbines are rarely looked at.

In general, the EIS of the Dutch project discusses many different impacts. Compared to this, impacts and its sources are discussed much shorter in the German project.

Compared with the list developed in chapter II containing impacts and its sources found in literature, quite a few effects are considered and partly discussed intensively. 34 % of the sources of impacts found in the literature are discussed (rank 1 & 2 of the evaluation table, see annexe) in the German project EIS “MEG Offshore I”. 7 % of the impacts (discussed in the literature) on different protected assets are discussed very detailed (rank 1), 21 % are partly discussed (rank 2). In the EIS of the Dutch project “BARD Offshore NL 1” 39% of the sources of impacts found in the literature were discussed (rank 1 & 2) and 14 % of the impacts (discussed in the literature) on different protected assets are discussed quite intensive (rank 1) and 25 % discussed partly (rank 2).

The licensing texts are focusing on the most important and significant impacts. Within the German project “MEG Offshore I” only 10 % of the sources of impacts found in the literature and listed in the evaluation table are discussed (rank 1 & 2). 4,5 % of these sources are discussed intensively (rank 1), 5,5 % are discussed partly (rank 2). The licensing text of the Dutch project discusses about 7,5 % of the sources of impacts (rank 1 & 2). 1 % of these sources found in the evaluation table are discussed intensive (rank 1), 6,5 % are discussed partly (rank 2).

5.3 Cumulative effects

Cumulative impacts are due to Zeelenberg (2005) one of the biggest concerns at the moment, as many proposals on the installation of offshore wind farms within the next years are handed in. Peters et al. (2008) criticise that cumulative effects are considered insufficient. This is also noticeable when reading the German and Dutch EIS and licensing texts. As it is already quite hard to predict an effect of a single source on a protected asset, the assessment of cumulative effects caused by different sources gets quite complex and is even harder and takes much more effort to do. Also as a method is missing until now to assess these cumulative effects.

According to Peters et al. (2008), the following issues are central to be defined for the assessment of cumulative effects:

(a) spatial scale
(b) temporal scale

(c) activities to be included: wind farm, other wind farms, other type of projects (pipeline, mineral extraction) and different uses (shipping, fishery etc.)
(d) impacts of the planned project on protected assets have to be included within the assessment of cumulative effects
(e) important interdependencies (of biotic and abiotic factors within the ecosystem or of human activities and ecosystem) affected by cumulative effects

The German EIS as well as the licensing text are considering cumulative effects roughly with a focus on effects caused by the installation and operation of offshore wind farms in the North Sea close to the planned wind farm. Further sources of impacts are not taken into account. The time scale considered for the investigation is also limited to the time of installation and operation of the wind farms. The method of how cumulative effects got assessed is not explained further.

The Dutch EIS considers cumulative effects more detailed and takes into account effects of other uses and projects, but it also can not do justice to the complexity of this issue. Different sources possibly causing impacts are considered, namely the planned offshore wind farm and its submarine electric cable and the interaction with other offshore wind farms, cable, activities (mining, mineral and sand extraction, dredging of sea ground, military use, shipping, fishery, shell extraction, air traffic and the “Tweete Maasvlakte”) and uses (projects in the area of Eemshaven) close by. The global aspect which can be important for mitigating species is, like in Germany, left out. Also temporal aspects are addressed. The amount of impacts addressed is comparable high, an overview gives table 4.3.1-2.

In the German project a close look has been taken at cumulative effects of pile driving on marine mammals and the habitat loss of some sea bird species, rising with the amount of offshore wind farms installed. Especially in the licensing text, attention is paid to the effects during pile driving on marine mammals. The study made focuses only on effects of wind farms installed at the same time, the cumulation of the effects over a longer time or the cumulation with other noise sources are not considered.

For considering cumulative effects in the EIA the focus lays on the following impacts which could add up to a more significant impairment on the protected asset: (1) effects of a ship collision on the *water* quality, (2) positive effects on *fishes* due to a fishing ban and introduction of artificial hard substrate, (3) noise emission while pile driving on *marine mammals*, (4) habitat loss, fragmentation and barrier effect on *sea birds* due to the physical presence of the wind farm, (5) the collision risk of migrating birds with rotor blades and (6) the barrier effect of wind farms for migrating birds.

Cumulative effects taken into account within the licensing text and, hence, for decision-making are listed in the table below.

Impacts	**Germany**	**Netherlands**
Noise emission during pile driving	yes (marine mammals	yes (marine mammals, fish, fish larvae)
Collision risk of migrating birds	yes	yes
Barrier effect for mitigating birds	yes	no
Habitat loss of sea birds due to avoidance of the wind farm area	Yes (one species, loon)	Yes (of 4 endangered birds)
Operational noises causing a barrier and decreasing the habitat quality	no	yes
Indirect impacts on marine mammals and birds dependent on fish as food resource due to increasing mortality of fish larvae	no	yes

Table 5.3-1: Comparison of cumulative effects considered within the licensing texts

5.4 Measures

The measures taken in both countries are mainly mitigating measures addressing different impacts trying to avoid or minimise the negative impacts they cause on the environment and its protected assets. Compensating measures are only getting applied in The Netherlands, if mitigating measures can not avoid or minimise significant impacts on the environment. The table below shows the different measures applied in Germany (“MEG Offshore I”) and The Netherlands (“BARD Offshore NL 1”) and the impacts they are addressing.

Impact addressed	Measure	Country
Water pollution	Anti-corrosion colour long lasting and as environmentally friendly as possible	DE
	External power sources as anti-corrosion protection and reduce therewith the introduction of harmful substances	NL
	Prohibiting sewage and waste dumping	DE
	Ensure avoidance and minimisation of release of harmful substances due to corrosion, accidents, failure of turbines	DE
	Introduction of harmful substances while construction, maintenance and operation and waste dumping is prohibited	DE
Noise emission (pile driving)	Measures to displace animals before construction by using acoustic disturbing signals (e.g. „Pinger“ and „Sealscarer“)	DE, NL
	Starting pile driving with a „soft start“ and increase it, animals have time to leave the area	DE, NL
	Survey; Monitoring and evaluation while pile driving	DE, NL
	Reduce noise emission by covering pile into foamed plastic or similar material or use of bubble curtains	DE
	Definition of a limiting value (UBA: 160 dB (SEL) 750 m from source and maximum value Lpeak of 180 dB)	DE
	Best available technology (e.g. for pile driving)	DE
	No pile driving while marine mammals in the vicinity (radius min. 100 m) of the construction side; control if marine mammals in vicinity (using sonar and visual)	NL
	Technical measures to reduce noise emission. The first 20 m depth pile brought into the sea ground by vibrations („intrillen“) which reduces noise emissions of about 15-20 dB compared to pile driving	NL
	Pile driving methods: in groups of eight, first pile driving, after turbines are getting installed which makes a phase with less noise emissions possible	NL
	While sensitive periods 1st January- 1st July pile driving forbidden	NL
	Pile driving in only one wind farm per season (July - December) allowed	NL
Birds collision, attraction	Minimal use of illumination while construction and operation	DE
	While times of high bird migration rates consider to switch off turbines or use measures to repel birds from wind farm	DE
	Switch off turbines in nights with high birds migration rate	NL
Avoid high temperature and electromagnetic fields	Limiting value of maximal 2 K temperature increase of the sediment in 20 cm depth; minimal cable depth of 1 m	DE
	Keep the submarine electric cable 0,6 m under the seabed, regular inspections necessary	DE

	Make a survey of the cabling at least ones per year, ensuring cable are not laid open	NL
Disturbance of seabed	Survey of the seabed after removal of wind farm to proof the sea ground is in its original, natural condition without any residues.	NL
	Use of hollow tubes contributing to the minimisation of compaction and dislocation of sediments while construction of the foundation	DE
Further	Removal of the wind farm in the end of its operating time	DE, NL
	Monitoring and Evaluation Programme to close gaps of knowledge	DE, NL
	Within the offshore wind farm area other activities are forbidden, like ship traffic, to avoid or minimise further impacts	DE, NL
	Locate offshore wind farm outside of conservation areas	DE, NL
	Use of state of the art technology to ensure emissions of harmful substances, noise and light are limited while construction and operation	DE, NL
	Other uses within the offshore wind farm area are prohibited	DE, NL

Table 5.4-1: Mitigating measures applied in Germany (yellow) and The Netherlands (green) and the impacts they are addressing

The mitigating measures listed above are used to avoid or minimise negative impacts of the offshore wind farms on different protected assets. Sometimes only one measure conduces to the minimisation of many negative impacts on one or more protected assets. The main direct impacts addressed by mitigating measures are (1) the noise emission due to construction works, especially pile driving, affecting fish fauna and marine mammals, (2) the pollution of the sea water, (3) the collision risk of mitigating birds and (4) attraction and disturbance of birds by the facility illumination as well as (5) negative effects by the submarine electric cable and (6) a disturbance of the seabed. By mitigating these impacts, further indirect impacts are also avoided or minimised.

Impacts addressed here are ones which could have quite significant effects on the marine ecosystem, like water pollution and noise emission. Also impacts by the submarine electric cable are going beyond the border of the wind farm and can cause cumulative effects with other cable, activities or uses. The collision risk, the effects of facility illumination and pile driving are discussed quite intensive in the documents, especially collision risk and pile driving are fundamental as they have significant impacts which ave to be mitigated.

Noise emission during *pile driving* and its direct, significant, negative effects on marine mammals and fish fauna including fish larvae is the most discussed impact within the documents of the two projects “MEG Offshore I” and “BARD Offshore NL 1”. Therefore, it is not surprising that many affords are made to minimise these impacts on marine mammals and the fish fauna. The Netherlands and Germany apply partly the same measures, like to displace mammals before pile driving by using disturbing signals or a “soft start” method, starting with less energy and increasing it. Other measures taken by the countries are quite different. In comparison, the measures required by the Dutch authority are much harder prohibiting pile driving in sensitive periods between the 1st January and 1st July, within the moult period of seals and calving and suckling period of porpoises and seals. Furthermore, the pile driving of only one offshore wind farm per season (July – December) is allowed. For the pile driving also a time plan is made up ensuring periods with less noise emissions and a method used to bring the pile the first 20 m into the ground with vibrations, causing less noise emission. Also stated within the licensing text is, it is necessary to control if marine mammals in the vicinity of the construction side (100 m) and not start with pile driving as long as this is the case. The German authority defined a limiting value of 160 dB (SEL) 750 m from the source and a reduction of noise emission by covering the pile into foamed plastic or similar material or the use of bubble curtains, as an air barrier is suitable to reduce sounds within the water body. This limiting value for noise emissions is quite important as, due to BSH (2009), harbour porpoises are suffering a permanent hearing damage from a value of 200 dB influencing their survival.

To prevent migrating birds from colliding with turbines or rather their rotor blades both countries consider to switch off the wind turbines: Germany in times with hight bird migration rates, The Netherlands in nights with poor visibility. Germany also considers measures to repel birds from the wind farm.

In the German licensing text a minimal use of *illumination* while construction and operation is required. Further measures which are actually existing, like different kinds of light used which can avoid the attraction of birds, are not mentioned. Although, a plan for the illumination still has to be developed, there are no further measures asked for in the licensing text. In the EIS of the German project these kinds of measures are discussed.

According to this, white flash light or reduced red spectral component and the reduction of illumination to the minimum reduces the attraction of birds and is suitable as a measure. The EIS of the Dutch project also schedules to reduce the illumination to the minimum. To avoid direct radiation, short-coloured, flashing light or flashing light signals with longer intervals can be applied. Another measure discussed in this context is the use of green light instead of red or white light to avoid the attraction and disturbance of birds and the negative consequences, but it does not get applied.

Furthermore, the use of the state of the art *technology* ensures a procedure as environmental friendly as possible. Also the *removal* of the wind farm after expanding is obligatory, but only partly. The BSH keeps the decision about the full or partly removal of the turbines open to weight up if the partly removal is in the end less harmful to the environment than the complete removal. The impacts of the removal of the wind farms are hardly assessed within both EIS.

Also important and required in both countries are further *surveys, monitoring and evaluation programmes* going along with the construction works, operation as well as the removal and assess long-term effects afterwards. An example is an obligatory survey of the long-term effects on the seabed after the removal of the wind farm. Additional, further research projects are necessary to build up databases and exchange knowledge, also between countries, and by exchanging knowledge learn from each other.

Cumulative effects are directly addressed by measures within the EIS “BARD Offshore NL 1”, which is not done in the EIS of the German project. As important as the assessment of cumulative effects is the development of measures and requirements minimising or avoiding cumulative effects. One example is the habitat loss of marine mammals due to operational noises of turbines. This impact is not seen as very significant, but a worst case scenario made by the EIS “BARD Offshore NL1” considering many offshore wind farms comes to the result that the impacts could add up to a significant impact on marine mammals. Therefore, large distances between the turbines are considered for this wind farm, named as a measure within the EIS. Another even more significant and obvious effect is the cumulative effect of pile driving at different locations at the same time. This could cause such significant impacts, especially on fish fauna and marine mammals, that it needs to be prohibited. Hence, as mentioned above, The Netherlands forbid pile driving for different wind farms within one season.

Chapter VI: Conclusion and recommendations

This thesis analyses and compares, based on two case studies, how environmental impacts of offshore wind farms are addressed within the decision-making process about the environmental compatibility of the project in Germany and The Netherlands. The chapter above evaluated the most important and significant impacts taken into consideration within the decision-making process and, hence, for the authorisation of the offshore wind farm projects “BARD Offshore NL 1” in the Dutch EEZ and “MEG Offshore I” in the German EEZ. Furthermore, the consideration of cumulative effects within the project documents is an important issue when assessing environmental impacts as well as mitigating measures and requirements addressing different impacts on protected assets. Besides this, an overview of the legal base and standards developed and used in both countries, steps taken and stakeholder involved is given. The differences in both countries are pointed out and discussed, showing quite a few similarities in the procedure of decision-making and addressing of impacts. But also striking differences and space for improvements, e.g., in the addressing of impacts seen as significant, cumulative effects and measures taken, are becoming obvious. The current challenges must be the gathering of data and exchange of knowledge to fill gaps and improve the praxis.

In this chapter, a conclusion, based of the comparison of the countries and with the findings in the literature, is drawn pointing out the main lacks and needs of improvement. In the end recommendations for an improvement of the praxis in both countries are given.

6.1 Gaps and space for improvements

Analysing the documents and looking at the different aspects: the standards, the impacts and cumulative effects as well as measures required, gaps and a need of improvement of the praxis in both countries can be seen.

These are, regarding the standards, a missing common method for the evaluation of the significance of impacts and criteria defining when the impacts are too significant and, hence, the project detrimental to the environment and needs to be rejected.

Analysing impacts assessed in both documents, striking differences between the impacts seen as significant and important for the decision-making can be seen. The decision about the contents of the EIA is taken by experts, public body and other stakeholder involved. Hence, the choice of impacts, sources of impacts as well as protected assets focused on is due to the interests involved and it seems that important impacts are easily overseen or ignored. Especially indirect impacts are often not or only briefly considered.

Also cumulative effects are assessed, but, when paying regard to the complexity, not sufficient. Due to a missing method and as the assessment is very complex, time- and cost- intensive, the analysis is limited to the most obvious sources and impacts. The proper consideration of cumulative effects and the development of a method to assess them is an important challenge. In this context, also a discussion is needed about: At which state of the planning process could the consideration of cumulative effects be useful?

The application and development of a compensation of impacts is necessary, as this is not the praxis yet. Also mitigating measures have to be improved, new ones developed and others have to be stricter.

A big problem is also the political pressure on the installation of the offshore wind farms. Offshore wind energy ensures the energy supply in future. The German and Dutch governments are aiming to expand wind farms within the North Sea area. Negative impacts on the marine environment will the tolerated and the danger of overseeing significant impacts should not be ignored. To make the decision about the project authorisation independent of the political will, the development of common standards and methods to assess impacts and criteria for the evaluation of the significance of impacts and the environmental compatibility of the project is necessary. Furthermore, strict mitigating and compensating measures are absolutely essential to protect the marine environment and, at the same time, enable a development of offshore wind farms.

a) Standards

First of all, guidelines and standards for making an EIA are existing in both countries. ***What is missing are a common method for the evaluation of the significance of impacts and criteria defining when the impacts are too significant and, hence, the project detrimental to the environment and needs to be rejected.*** The existing criteria of the Habitats and Birds Directives are one base, but are also not handled very strict. According to the area specific assessment and findings of the EIA the project causes, e.g., a disturbance of sensitive birds, an increasing mortality of birds due to a collision risk with the turbines, injury and disturbance of marine mammals and other significant impacts. Due to directive forbidden. But not seen as significant.

Nowadays, the decision about which impacts and assets to be addressed bases on standards and guidelines for the development of the EIA and its contents, but mainly on decisions made by the evaluator (making the EIA), the licensing authority, other experts and stakeholder. In The Netherlands the EIA-Commission defines the content of the EIA, reviewed by the licensing authority, the public and other stakeholder. In Germany in an initial “Scoping” the content for every project gets defined by authorities involved, experts and other stakeholder. But as the legislation addressing specifically offshore wind farms is quite young, still some issues have to be improved and developed. Regarding the consideration of environmental impacts, guidelines containing a standardised method for assessing impacts and criteria defining when impacts are too significant to permit the project are not existing. The decisions are mainly up to the evaluator of the EIA, as well as the licensing authority and other experts and stakeholder discussing the final EIS in a hearing or giving comments and recommendations.

b) Impacts

Taking a look at impacts assessed, quite some efforts are made to evaluate them: an EIA is made, as well as other studies and surveys. Until the authorisation of the project many aspects are getting considered, inter alia, to safeguard the environment does not get harmed significantly. Nevertheless, not all impacts known nowadays, but rather a choice of the most striking impacts are assessed, as the EIA would be an enormous project on its own, it still needs to be doable and efficient. ***But when comparing the documents, the foci on impacts seen as significant and important for the decision-making in the end, is quite different***. ***Hence, it can be discussed, if important impacts are overseen in the EIS of the projects. Also indirect impacts are often not or only briefly considered.*** Gaps of knowledge make the prediction hard. But besides this, the decision about impacts seen as significant and important for the decision-making is also always a choice made by people involved. This lack of knowledge needs to be stuffed and common standards need to be developed.

Which are the main differences between the impacts addressed? As a main factor for decision-making about the authorisation of the project in The Netherlands the increasing mortality of fish larvae due to pile driving is discussed. Resulting form this, further indirect effects on marine mammals and sea birds depending on fish as a main food resource are take into account. In the German project documents EIS and licensing text these impacts are not even mentioned. On the other hand, barrier effects on mitigating birds by the physical presence of wind farms and the facility illumination are important in the German project. These impacts are discussed in the Dutch EIS, but are neglected for the final decision in the licensing text. Also within the "Passende beoordeling" assessing impacts on protected species and habitats protected by the Habitats and Birds Directives it is not taken into account. Furthermore, water pollution and effects on the seabed discussed in the German EIS and licensing text, import for the decision, is not taken into consideration in the Dutch project documents. Negative impacts on bats are discussed shortly in the German EIS but left out completely in the project documents of "BARD Offshore NL 1" build in the Dutch EEZ.

Many ***assets as well as impacts on protected assets are not taken into consideration*** as they are seen as insignificant or as they are not known sufficiently yet. For the decision-making about the environmental compatibility, both projects are mainly taking into account impacts on the marine fauna as well as the avifauna. Germany also assesses effects on the seabed and partly water pollution. The fauna, benthos, zooplankton, air and climate as well as human beings are partly assessed in the EIS but do not find consideration in the area specific assessment and the final licensing texts of both projects. Hence, these protected assets are partly considered within the whole decision-making process, but are not important for the final decision.

A main problem when assessing impacts of offshore wind farm are the gaps of knowledge. Missing experiences and lacks of basic knowledge about the marine ecosystems make the prediction of possible changes and positive as well as negative impacts on the marine environment and its protected assets quite difficult. A future challenges is to gather knowledge about impacts caused by offshore wind farms, especially long term effects, as it is due to a lack of experiences not much known. With the Evaluation and Monitoring Programme, which is obligatory in both countries, a big contribution can be done to collect experiences and improve the knowledge which can be used for future EIS and decisions. But also research programs are crucial, like the research project FINO in Germany (BSH, 2009).

c) Cumulative effects

Another problem is the consideration of cumulative effects. In both projects cumulative effects are considered, but are not doing justice to the complexity. Many sources of impacts are left out and cumulative effects only get considered very briefly.

Therefore, the assessment of cumulative effects is a challenge which needs to get addressed. The assessment is very complex and time intensive and missing methods as well as again the gaps of basic knowledge and knowledge about impacts caused by single sources make the prediction of effects a hard task. It gets even more complicated when taking into account the time and space. Impacts have to be considered on a regional and global scale, over a long-term and a short-term. The consideration is necessary but makes every single EIA again bigger, takes more time and financial resources, hence, ***cumulative effects do not get considered sufficiently. In this context a discussion is needed about: at which state of the planning process could the consideration of cumulative effects be useful?*** Coming back to the citation by OSPAR (2008, p.4) stated at the beginning: “At the scale of development in 2008, national and international controls are in place to ensure that the environmental impacts associated with offshore wind-farm developments are appropriately evaluated and managed. The main instruments are the Strategic Environmental Assessments and Environmental Impact Assessments”. Within the EIA cumulative effects on the regional level, more specific of every project can find consideration. But to address cumulative effects, for instance, on a global scale the SEA of Spatial Plans defining and regulating the use of the North Sea and the EEZ could be more appropriate. This way cumulative effects are already addressed at an early stage of planning when making up spatial planes, like in Germany, defining areas for an offshore wind farm development. In Germany, specific areas for offshore wind farms are designated based on an environmental report which ensures that effects on the environment are addressed in an early phase. This report could also implement a first assessment of cumulative effects, for instance on the global scale. An example is: If offshore wind farms are located in a special area which impacts does it cause and can they add up with other impacts caused in other countries?

The German project EIS considers cumulative effects roughly. The focus lays on cumulations with impacts of other offshore wind farms in the North Sea close by installed and operating during the same time period. Other sources of impacts like other activities and uses are neglected. Also the impacts discussed resulting of the installation or physical presence of many offshore wind farms are few. Special attention is paid to the effects of noise emission while pile driving of more than one wind farm at the same time on marine mammals. As the effects are very significant, it is important that only one wind farm gets installed at the time. Discussed are the effects on the water quality in case of ship accidents, positive effects of offshore wind farm areas as refugee areas for fishes, the habitat loss of sea birds and barrier effect of mitigating birds due to physical presence and a high demand of space. Also the increasing collision risk of mitigating birds with the increasing amount of wind farms is discussed roughly.

Within *the Dutch project* documents cumulative effects are discussed more detailed. Cumulative effects of offshore wind farms, submarine electric cable, other activities (like sand extraction) and uses (projects in the area of Eemshaven) are considered. But also here the effects and their sources are only assessed on a regional scale, a broader scale which is especially relevant for mitigating species is missing. Many impacts on the protected assets benthos, geomorpholigy, hydrodynamics fish, fish larvae marine mammals and birds are addressed. Mainly discussed are cumulative effects of several offshore wind farms causing a habitat loss of sea birds as well as an increasing collision risk and a barrier effect on mitigating birds, special attention on species affected strongly. Like in Germany, also effects of pile driving of more than one offshore wind farms at the same time on marine mammals is assessed within the EIS.

d) Measures

To minimise significant negative impacts on the marine environment, mainly (in Germany only) mitigating measures are taken. ***To protect the marine environment as good as possible mitigating significant impacts is not enough***, especially as impacts can only be minimised, but not completely avoided by mitigating measures. ***Therefore, also compensating measures need to be part of the project. Like inland, the impacts caused by a large project, like the installation and operation of an offshore wind farm, as well as the value of the area harmed need to be assessed and compensated adequately. Furthermore, mitigating measures have to be improved, new ones developed and others have to be stricter.***

As offshore wind energy is an important source for the energy production in future, many offshore wind farms will be licensed and negative impacts will be tolerated. In this context, measures compensating but especially avoiding and minimising negative impacts and preventing the environment from severe damage are needed. The measures taken nowadays are mainly mitigating ones, avoiding and minimising negative impacts on the environment and its protected assets. Compensating measures are only getting applied in The Netherlands, in case mitigating measures can not minimise significant impacts sufficiently. Impacts on protected assets mainly addressed by different mitigating measures are (1) the noise emission due to construction works, especially pile driving, affecting fish fauna and marine mammals, (2) the pollution of the sea water, (3) the collision risk of mitigating birds and (4) attraction and disturbance of birds by the facility illumination as well as (5) negative effects by the submarine electric cable and (6) a disturbance of the seabed.

The measures required are partly very strict addressing quite a few impacts. Also striking is that the countries often apply different measures for addressing the same impact. This gives an input for making suggestions for new measures also as, especially when comparing the measures taken in both countries, it gets clear that they have to be improved and further measures have to be developed.

The most striking example is pile driving. In The Netherlands the measures especially for pile driving are quite strict also as it has, according to the state of knowledge, the most significant impact on protected assets. Within sensitive periods of marine mammals (January-July) pile driving is forbidden. Germany also takes several measures minimising this significant impact by defining a limiting value of maximal 160 dB in areas about 750 m from the source, which is not applied in The Netherlands yet. But as the time of pile driving could overlap with times of high abundance of harbour porpoises (BSH, 2009), Germany still needs to improve their measures addressing noise emission into the water body, for instance, by restricting the construction period to less sensitive with times, outside periods of a high harbour porpoise abundance.

Below, further suggestions for measures are given. Furthermore, a future challenge could be the development of common standards or guidelines defining or giving suggestions for measures to be applied addressing different impacts on different protected assets. This could also be a base for the exchange of knowledge between countries supporting the development of new measures. Apart form this, new measures have to be developed, especially technical ones. But the base for this development is a better knowledge about the changes and impacts offshore wind farms cause. Hence, common data bases gathering and exchanging knowledge about impacts and basic knowledge about the marine ecosystems and protected assets affected has to be supported and developed further.

6.2 Recommendations

The following **recommendations** for an improvement of the praxis of The Netherlands and Germany can be given:

a) Standards

To ensure an objective decision about the environmental compatibility of the project:

- Establish an independent commission deciding about the environmental compatibility of the project, e.g. the EIA-Commission. In Germany an EIA Commission would need to be developed; in The Netherlands more power, regarding decision-making, could be given to the commission.
- Development of a common method for the evaluation of the significance of impacts

and criteria for the evaluation of the environmental compatibility of the project. Based on existing EIS, these standards and criteria can be developed.

- The Netherlands: extend nature conservation acts to the EEZ

b) Impacts

Within the project documents there are partly big differences in addressing impacts which are quite significant and important for the decision-making. Impacts described in the documents of one project is sometimes completely missing in the documents of the other one. Also indirect impacts are often not or not sufficiently considered. To avoid missing out the assessment of significant negative impacts on the environment, the following recommendations can be made:

- Development of a common databases and the exchange of data, especially between countries, are important to win on knowledge and share experiences about impacts offshore wind farms cause.
- Development of standards defining basic impacts to be assessed (which could be more useful when more impacts are known)
- Development of common standards for the evaluation of impacts and their significance within the EIS.

For the fast development of common standards, methods and criteria (e.g., European wide) as well as a common databases, international research institutes as well as public bodies have to work close together.

Regarding special impacts not considered in the project documents, the German and Dutch project are missing out and should consider the following ones:
Germany:

- Consideration of effects on fish larvae and further impacts on marine mammals and birds depending on fish as food resource

The Netherlands:

- Consideration of impacts on bats, collecting of data about their occurrence and distribution
- Consideration of impacts on the sea bed and sources of water pollution

c) Cumulative effects

The assessment of cumulative effects is a challenge which has to be taken in future. To be able to assess them,

- a method has to be developed addressing cumulative impacts.
- A discussion is needed about: At which state of the planning process could the consideration of cumulative effects be useful? An assessment of cumulative effects could partly be done at an earlier state, like within the SEA of a spatial plan designating special development areas for offshore wind farms.
- An EU-wide collaboration for data exchange, which is important for assessment of cumulative effects, and an exchange of methods for the evaluation of cumulative effects would also push a fast improvement of the assessment quality.

d) Measures

Regarding measures, beside mitigating measures, compensating measures have to be developed and obligatory for every offshore wind farm. Mitigating measures alone can not avoid negative impacts on the environment, they rather minimise significant impacts. Pubic agencies are responsible to ensure mitigating as well as compensating measures, protecting the marine environment as good as possible, are taken.

But also the mitigating measures still have space for improvement. Also here public agencies are responsible for ensuring the marine environment is preserved from damage as good as possible. Both countries should think about an improvement of measures.

In Germany:

- Stricter measures for pile driving, e.g., think of prohibiting pile driving while high abundance or sensitive month of marine mammals; Prohibiting pile driving while marine mammals in the vicinity of the construction side; Allowing pile driving in only one wind farm per season; Time management for pile driving ensuring phase with less noise emissions; Technical measures to reduce noise emission, e.g., pile brought partly into the sea ground by vibrations
- For facility illumination using light which minimises the attraction and disturbance of birds, like green light

- Obligation to switch off turbines in nights of poor visibility and high bird migrations
- Compensation of significant impacts on the environment

In The Netherlands:

- Defining a limiting value for noise emission due to pile driving
- Defining a maximal value of temperature increase within the seabed due to operating electric cable
- Reduce noise emission by covering pile into foamed plastic or similar material or use of bubble curtains

To ensure the best available measures are taken,

- the exchange of knowledge, between researchers within one country as well as of other countries, about measures which can be taken to avoid and minimise negative impacts is important.
- The development of standards (e.g. EU-wide) defining measures to be taken addressing specific impacts could also force countries to take measures protecting the environment as good as possible.

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Annexe

A) Evaluation table

As mentioned, the matrix used for the content analysis of the documents is based on the table 2.2.6-1 which is the result of the literature research in chapter II. Its development and the choice of the impacts, their sources and protected assets taken into consideration is explained in chapter 2.6.

The EIS as well as the licensing text of the German offshore wind farm project “MEG Offshore I” and the Dutch project “BARD Offshore NL 1” are analysed, the results are shown in the evaluation tables below. The aim is to see which impacts and their sources and how detailed the impacts and impact sources are discussed within this documents. Assuming that EIS and licensing text are the most important documents informing and discussing about impacts on the environment and are the base for information based decision-making in the end (BSH, 2008; Köller et al., 2006; OSPAR, 2008), they allow some conclusions about the importance of different impacts for the decision-making. The weight of different impacts on the decision-making can be seen by the level of how detailed they are discussed within the documents.

A valuation system shown in table A-1 with ranks from 1 until 4 is used for evaluating how detailed the single impacts are discussed within the documents.

Rank	Level of detail
1	Mentioned and discussed
2	Mentioned and discussed partly
3	Mentioned (or partly mentioned) but not discussed further
4	Not mentioned

Table A-1: Valuation system

To distinguish between rank 1, 2 and 3 a qualitative approach is used. For distinguishing these different ranks it is important how detailed the sources of impacts and potential impacts on protected assets are described. As a guidance, the criteria shown and explained below are used.

The indicators used are orientated at criteria important in an EIS according to Peters et al. (2008). Further criteria were added which seemed to be important regarding impacts in most studies.

Criteria used for assigning to the level of detail:

References to authors and other research projects

Description of impacts in detail (qualitative) compared to other literature:

Numbers and facts

Specifically named species affected (where required)

Time (long-term, short-term)

Scale (large-scale, small-scale)

Secondary impacts

Impacts or impact sources can be classified as rank 1 when the impacts and respectively the sources of impacts are discussed very intensive, facts are according to the current state of knowledge and references to results and findings of other authors or research projects are given. The impacts are described detailed, containing information about species affected and how they are affected. Also important are details about the time and time period of impacts occurring as well as about the scale: when and for how long? Are the effects limited to the vicinity of the turbines, to the offshore wind farm area or are they having effects far beyond the borders of the wind farm? Also secondary impacts, if important, are mentioned.

Classified as rank 2 are impacts and impact sources if they are partly discussed and rank 3 if they are mentioned but the description does not go into detail about facts, species affected, or results of other research projects or surveys.

<u>NATURA 2000 and cumulative effects</u>

The effects on Natura 2000 sites are addressed in the table inasmuch as the assets protected by this site are considered. The results of the area specific assessments "Passende beoordeling" and "Natura2000 Verträglichkeitsprüfung" and "Artenschutzrechtliche Prüfung" are also addressed briefly later in chapter III, IV and V.

Cumulative effects are also not taken into consideration in the evaluation tables (annexe). They can not be easily related to the impacts or sources of impacts written in the table, as cumulative effects are caused by different sources. Nevertheless, they are discussed in chapter III, IV and V.

Non-plagiatism statement

By this letter I declare that I have written this thesis completely by myself, and that I have used no other sources or resources than the ones mentioned.

The sources used have been stated in accordance with the rules and regulations that are applied at the Faculty of Spatial Sciences of the University of Groningen. I have indicated all quotes and citations that were literally taken from publications, or that were in close accordance with the meaning of those publications, as such.

Moreover I have not handed in a thesis with similar contents elsewhere. All sources and other resources used are stated in the bibliography.

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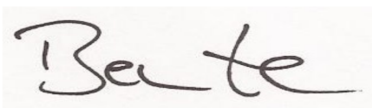
Granada, 25.07.2011



Place, Date   Annika Bente