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Horizontal Key Actions

"Identification and analysis of interactions between sea use functions"

WP3 Report D3.2

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Identification and analysis of interactions between sea use functions

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- Wageningen ***IMARES*** conducts research providing knowledge necessary for the protection, harvest and usage of marine and coastal areas.
- Wageningen ***IMARES*** is a knowledge and research partner for governmental authorities, private industry and social organisations for which marine habitat and resources are of interest.
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Summary

This report reports on Work Package 3 of the WindSpeed project, which has four tasks:

- Task 3.1: Inventory and description (including economic value if possible) of non-wind sea functions currently at stake in the area
- Task 3.2: Inventory of development scenarios for these functions up to 2030, including resulting spatial claims
- Task 3.3: Inventory of known positive and negative interactions between offshore wind and other functions
- Task 3.4: Translation into calculation rules

This report is the second deliverable of the work package (D3.2) which has three deliverables:

- D3.1. Overview report of non-wind sea functions currently at stake in the area, including scenarios for their development in the period up to 2030
- D3.2. Report with an analysis of positive and negative interactions between offshore wind and the other use functions of the North Sea
- D3.3. A set of calculation rules for the interactions between offshore wind and other use functions, in a database or other digital format

Progressing from the inventory of the non-wind sea use function currently at stake in the WindSpeed study area (Van der Wal *et al.*, 2009), this report focuses on the interactions – both positive and negative- between offshore wind energy and the non-wind sea use functions. The non-wind sea use functions include the following:

- shipping,
- oil and gas extraction,
- fisheries,
- cables and pipelines,
- military activities,
- sand extraction,
- radar interference and
- nature conservation.

Some sea use functions can co-exist without substantial negative effects. Other combinations are problematic or even impossible and should be avoided. Therefore the interactions of the sea use functions are of importance. For example, it is clear that offshore wind parks (OWP) will compete for space with functions like shipping routes and military areas. On the other hand, OWP may have synergetic effects with infrastructure for offshore oil and gas extraction, and possibly with aquaculture.

Sea use functions interact with each other. The initial interaction between many uses will be a negative one as each lays claim to an area for its own purposes. From here the intensity and fashion in which use functions interact can be studied further. The most negative interaction would be for a use function to fully block other use functions from a given area all of the time: it requires exclusive usage rights. In many cases the problem is far less severe. In some cases the possibility of positive interaction exists, conditions for a given use function may improve if another function is also present. An example could be locating aquaculture facilities within the boundaries of an offshore wind energy park. The wind turbines (or some of them) could be used as mooring points for the aquaculture infrastructure. As the OWP is generally a no-go zone for shipping its presence helps to protect the aquaculture facilities.

These at the same time make the area less desirable to enter with ships as they make navigating more difficult and so help to strengthen exclusion of shipping from the area.

Many of the sea use functions are forms of human use of the marine environment; they do however from our point of view also include the natural values that together form the marine ecosystem. To take the claim made by sea mammals, birds, fish and benthic organisms into account, the aim is to include datasets on biodiversity (species richness) for each of these groups. All the human use functions interact with each other by claiming some areas, but they also compete with each other on the basis of economical and political importance and societal perception.

It makes sense in this respect to realise that many use functions are conditionally compatible. They do not necessarily exclude one another or form natural partners, but they can be put together provided some conditions are met.

The most important interactions to deal with are those relating to OWP and the other sea use functions. A choice has been made to include the remaining interactions as well. All these interactions have been summarised as a matrix in Table 1 (which can be found in section 2.3). This matrix not only illustrates the fact all sea use functions are in competition with each other for space at sea. It will also help to understand the carry-over effect of awarding space to OWP in favour of some other function. When a combination of uses cannot be made then the displaced activity will either have to be discontinued or it will have to be given a new location. A new location where some other function also has a claim and forcing these together will have consequences.

An interesting observation is that there are two sea use functions that have almost exclusively negative interactions, whereas the remaining sea use functions also have at least some positive interactions. The two use functions that are apparently most difficult to combine with others are: OWP and Oil and Gas Extraction. Both have in common that they are focused on supplying energy.

The analysis of positive and negative interactions of OWP and other sea use functions shows, that similar to Oil and Gas extraction, OWP are more difficult to combine with other uses than those are with each other. Regarding priorities, as they are based mostly on economic considerations, the following sea use functions presently have stronger claims on space at sea than OWP do:

- Shipping;
- Oil and Gas extraction;
- Cables and Pipelines.

1 Introduction

1.1 Work package 3

In order to assess the suitability of locations on the Central and Southern North Sea for wind parks present sea use functions should also be taken into account. These sea use functions comprise shipping, oil and gas extraction, fisheries, cables and pipelines, military activities, sand extraction, radar interference and nature conservation. Information on the spatial distribution and the extent of each use function should be quantified if possible. Apart from the current situation, the future trend in these use functions is also of interest. E.g. the extent to which expansion in their claim on North Sea space can be expected, and the preferred regions for this expansion must be identified. Some sea use functions can co-exist without substantial negative effects. Other combinations are problematic or even impossible and should be avoided. Therefore the interactions of the sea use functions are of importance. For example, it is clear that Offshore Wind Parks (OWP) will compete for space with functions like shipping routes and military areas. On the other hand, OWP may have synergetic effects with infrastructure for offshore oil and gas extraction, and possibly with aquaculture.

The WindSpeed project will make the different claims of human activities on the North Sea spatially explicit. These activities include those related to offshore wind energy production, but also a number of non-wind or other sea use functions. To this end IMARES has collected data on these other sea use functions. We have gathered data from several national institutions, with a good deal of help from our project partners in identifying the best available sources.

The WindSpeed project aims to develop a roadmap defining a realistic target and a development pathway up to 2030 for offshore wind energy in the Central and Southern North Sea (www.windspeed.eu). To achieve this roadmap spatial data on where these activities occur and if possible with what intensity is needed. This data can then be used as building material to feed into the DSS or Decision Support System that is also part of the project plan. This GIS-based tool will show a spatial representation of offshore wind energy potential in relation to non-wind sea functions and environmental aspects. The tool will also facilitate the quantification of trade-offs between electricity generation costs from offshore wind and constraints due to non-wind sea functions and nature conservation.

One of the main reasons to undertake this effort is a target of 20% share of renewable energy in the European energy supply by 2020 as set by the European Union in the new Renewable Energy Directive [1]. Wind energy including offshore is expected to contribute a major part to this objective.

Next to datasets on human activities data, has been gathered on the location of different types of nature conservation areas and natural values in the marine area.

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1 DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (published in OJ 140, 05.06.09, p. 16).

Regarding the future development of other sea use functions an attempt is made to arrive at the following: a yearly growth rate or growth function to be able to calculate values for the target years or fixed figures for the target years 2020 and 2030. The first aim will be to arrive at realistic or most probable values, from that optimistic and pessimistic values can be derived for use in scenario studies. Please note that optimistic may denote growth or shrinkage depending on point of view or perception, and vice versa for pessimistic.

To achieve a spatial representation of the situation in the target years allocation functions are presently seen as the best way forward. An allocation function for e.g. shipping would assign the majority of change (growth or shrinkage) to occur in the areas where shipping is at its densest in the present situation, being the designated international shipping routes and the shortest (straight) line routes that connect these and destination harbours. At some point this density increase will have to be limited as safety concerns (collision risk) will force ships to spread wider into less heavily used areas to keep a safe distance between ships.

At the moment there very few published and accessible methods to assess the introduction of wind farms in the context of other sea use functions. Several examples can be mentioned where most often a government institution has made a methodical analysis of their EEZ to identify how and where it would be best to incorporate offshore wind energy into the fabric of existing and competing sea use functions. For Belgium Le Bot *et al.* (2003) have a well-documented example, also a Danish study on future wind energy development towards 2025 (ENS, 2007) has been documented in detail. However the publication including these details is only available in Danish. A study commissioned by the Dutch Ministry of Transport, Public Works and Water Management was performed by DNV focussing mainly on the topic of shipping safety and offshore wind energy, which also employed GIS-technology (DNV, 2008). In the United Kingdom, the Crown Estate has a GIS-based system called MaRS or Marine Resource System under development to facilitate strategic and integrated decision making for the marine environment. From the perspective of the WindSpeed project these are all attempts to find good national solutions, where our aim is to improve on this by introducing an international view. To achieve this a methodological framework for the quantification of the (economic) impacts of the interactions between other sea use functions on the deployment of offshore wind farms will be developed in the Windspeed project. The results of this analysis of interactions will then be translated into calculation rules for the GIS-based modelling tool to be developed in WP4.

1.2 Tasks

The four tasks of this work package are described below.

Task 3.1: Inventory and description (including economic value if possible) of non-wind sea functions currently at stake in the area

The present use functions in the Central and Southern North Sea will be quantified. The use functions comprise shipping, oil and gas extraction, fisheries, cables and pipes, defence activities and nature conservation. Key information sources will be recent state-of-the art surveys. The countries of concern are all involved in this database. The authorities of these countries will be approached with a request to relinquish and allow the use of this kind of information.

Task 3.2: Inventory of development scenarios for these functions up to 2030, including resulting spatial claims

Apart from an inventory of current uses, indicative scenario projections will also be made for future claims of non-wind energy uses of the sea. This will be mainly based on sectoral projections. Where relevant, these scenarios will be attributed to more general scenarios, such as the DGTREN scenarios for energy and transport. IMARES has collected information related to nature conservation areas, marine ecology functions, fisheries and environment. Garrad Hassan and SINTEF have collected information for shipping and electricity infrastructure respectively. This data will be used for developing the DSS tool and for scenario analysis.

Task 3.3: Inventory of known positive and negative interactions between offshore wind and other functions

Information on negative and positive effects of offshore wind on other use functions is collected from literature and stakeholder meetings. Global information on interactions of a sea use function on another sea use function is often available or can be easily derived. However quantitative information is often lacking. Data on the effects of existing wind parks on nature is scarce but much will come available during this and the following years. Monitoring data of the presence of birds, sea mammals and fish in the vicinity of OWP and far away from OWP but in comparable areas may reveal the impact of the OWP on nature. Various OWP life stages should be taken into account: construction phase, use phase and decommissioning phase as it can be expected that the impacts may be quite different.

It is expected that the most important natural limitation on potentials for wind turbine parks are the cumulative effects on birds and sea mammals. Two aspects are of importance in order to assess cumulative effects for a certain issue. The first is basic information on nature values; for instance the distribution and ecology of species. The second important aspect is formed by the methods to integrate the impacts of simultaneously occurring activities. An other possible effect of wind turbine parks that needs to be assessed is a possible positive influence of OWP resulting from the sanctuary effect on groups like birds, fish and benthic organisms.

The effects of wind parks on nature can be adequately assessed for sea birds. The distribution and abundance of all sea bird species is known for each square km North Sea for every month. IMARES has developed an integration method to develop a wind park sensitivity map. The same type of sea bird sensitivity map for the Dutch Continental Shelf can be made for oil pollution, shipping activity and fishing activity. For the latter, positive effects are also possible.

Also the interactions of offshore wind with the other use functions of the North Sea will be analysed. We expect the complexity of these interactions to be somewhat lower than the interactions between offshore wind and marine ecology. As mentioned, both negative interactions will be analysed (e.g. safety zones between shipping routes and wind parks, and consequent increases in travel distances for ships), as well as positive (e.g. using offshore oil and gas facilities as hubs for the electricity distribution infrastructure. For these functions, interactions will also be related to future developments. For example, the future decommissioning of oil and gas platforms may have major consequences for future wind parks in these areas.

Task 3.4: Translation into calculation rules

Calculation rules describe the spatial use and in some cases also the intensity of use depending on certain factors like location, time, presence of another use function, economic profit etc.. The preferred format of a calculation rule is a quantitative relationship and if relevant also in an economic value. This is not always possible because this depends on the kind of information for a use function that is available concerning development or preferred and claimed space or interactions with other use functions.

1.3 Deliverable(s)

The deliverables of the work package are:

D3.1. Overview report of non-wind sea functions currently at stake in the area, including scenarios for their development in the period up to 2030 (Van der Wal *et al.*, 2009)

D3.2. Report with an analysis of positive and negative interactions between offshore wind and the other use functions of the North Sea (this report)

D3.3. A set of calculation rules for the interactions between offshore wind and other use functions, in a database or other digital format

1.4 Stakeholder involvement

The WindSpeed project has held a series of national workshop during the spring of 2009 to attract input and comments from stakeholders. Stakeholders were invited to attend including representative of authorities, non-governmental organisation, industry organisations etc.

The workshops were very helpful, and confirmed that our approach is valid. No important sea use functions where identified that should be added to our list. The audience was helpful in identifying sources and alternatives for missing datasets and helped the project considerably. Discussions on the interactions between sea use functions based on Table 1 were fruitful and led to several improvements being made.

2 Analysis of positive and negative interactions between offshore wind and the other sea use functions of the North Sea

2.1 Interactions between sea use functions

Within the mindset of the WindSpeed project sea use functions, such as shipping or offshore wind energy interact with each other. The initial interaction between many uses will be a negative one as each lays claim to a certain area for its own purposes. From this initial position the intensity and manner in which sea use functions interact can be developed further. The most negative interaction would be for a use function to fully block other use functions from a given area all of the time: it requires exclusive usage rights. In many cases the problem is far less severe. Often there are options available to ensure that different sea use functions can have access to the same area, but some rules may have to be adhered to by all parties involved. Then in some cases possibilities exist for positive interaction, conditions for a given sea use function may improve if another function is also present. An example could be locating aquaculture facilities within the boundaries of an offshore wind energy park. The wind turbines (or some of them) could be used as mooring points for the aquaculture infrastructure. As the OWP is generally a no-go zone for shipping its presence helps to protect the aquaculture facilities. These at the same time make the area less desirable to enter with ships as these make navigating more difficult and so help to strengthen exclusion of shipping from the area.

Many of the sea use functions that are considered are forms of human use of the marine environment; they also include the natural values that together form the marine ecosystem. To take the claim made by sea mammals, birds, fish and benthic organisms into account, the aim is to include datasets on biodiversity (species richness) for each of these groups. In order to more clearly specify the ways in which offshore wind energy interacts with the marine biological system and how this interaction changes with the different stages (construction, operation, decommissioning) this topic is developed further in 2.2.

All the human use functions interact with each other by claiming some areas, but they also compete with each other on the basis of economical importance, societal perception and political importance.

It makes sense in this respect to realise that many use functions are conditionally compatible. They do not necessarily exclude one another or form natural partners, but they can be put together provided some conditions are met.

The interactions are often summarized in tables or matrices such as those presented by Forkink *et al.* (2004), Glaeser *et al.* (2004), PlanCoast (2008). The WindSpeed matrix of interactions is presented in section 2.3. The interactions that offshore wind energy parks, as summarised in the matrix, are detailed in subsection 2.3.1. For the non-wind sea use functions the interactions amongst these are detailed in subsection 2.3.2.

2.2 Effects on the marine ecosystem

Human use of the marine environment will result in effects on the marine ecosystem. By quantifying these effects it becomes possible to weigh the effects of several combined use functions on the marine environment. This process can help in deciding what route to take in a given situation.

As WindSpeed focuses on offshore wind energy, the effects on the marine ecosystem of first constructing, then operating and finally decommissioning an OWP are treated in the following paragraphs. It should be clear however that also the other sea use functions have similarly complex and numerous ways of interacting with the marine ecosystem.
Also shipping and fisheries use vessels that are visible and cause a disturbance, they produce noise etc.

2.2.1 Installation or Construction phase of OWP

The construction phase of an OWP is the most problematic from several points of view. Placing the structures leads to much shipping activity in the area, and many disturbances of wild life will occur. Also the associated vessel movements will influence fishing, commercial and recreational vessels. This increase in traffic will have an associated safety risk. The risk area extends beyond the area where the OWP is being constructed to the shipping lanes to and from the ports from which the supplies are transported. Even in the ports increased activity will carry an increased risk with it.

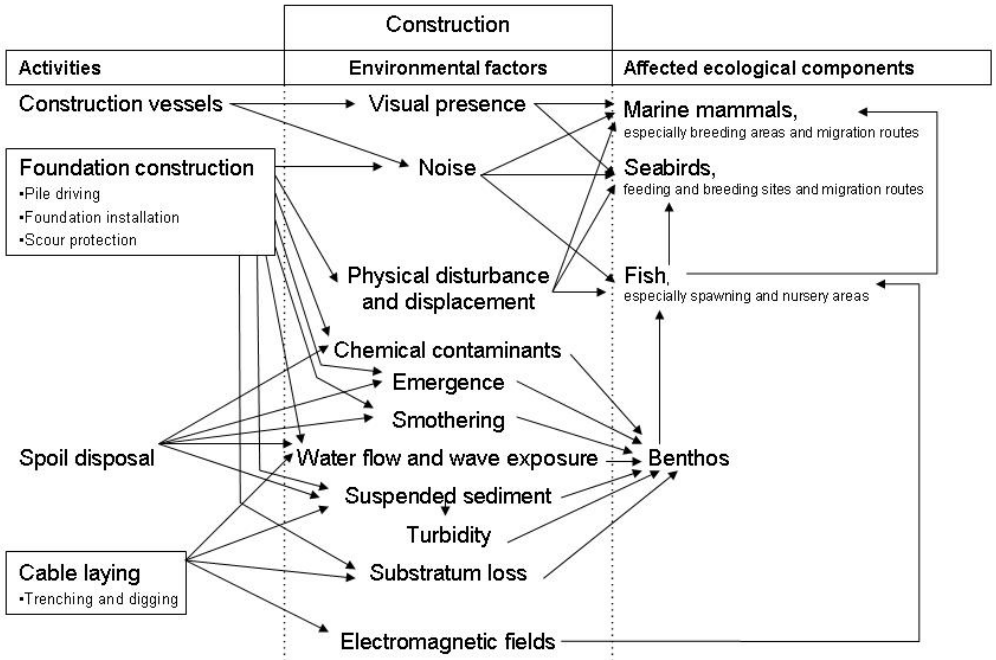

Figure 1 Scheme showing activities, environmental factors and affected ecological components associated with the construction of an OWP (according to Hiscock et al., 2002 and Michel et al., 2007)

Many activities associated with the construction of an OWP can affect ecological components along different routes. An illustration of this is given in Figure 1. One of the major impacts of OWP construction on the environment is the impact that pile-ramming has on marine wild-life. Sea-mammals (like seals and dolphins) are animals with acute hearing senses. They can suffer hearing loss from the very loud noises (>190 dB) that arise from pile-ramming. Besides permanent hearing loss the sound can be loud enough to kill. Also fish may be killed by noise, e.g. by shock waves rupturing the swim bladder. Some fish species also produce sound to e.g. defend a territory or breeding location.

As the wind industry has picked up on this topic, alternative quieter technologies are being developed like vibrating or screwing a mono-pile into position. Alternative foundation technologies can be selected, not only for technological considerations but also the presence of susceptible wild life may influence the choices made.

Many of the impacts of constructing an OWP are mitigated to a small extent by the fact that they last only for a relatively short period of time. By timing these activities so they do not coincide with the presence of (very) susceptible ecological components, much can be gained. Also quite often work is only progressing on a single (or just a few) turbine(s), limiting the affected area.

2.2.2 Use or operation of OWP

During the operational phase the wind park has less (Figure 2) impacts on the environment. Most of these impacts are present all the time, i.e. permanent.

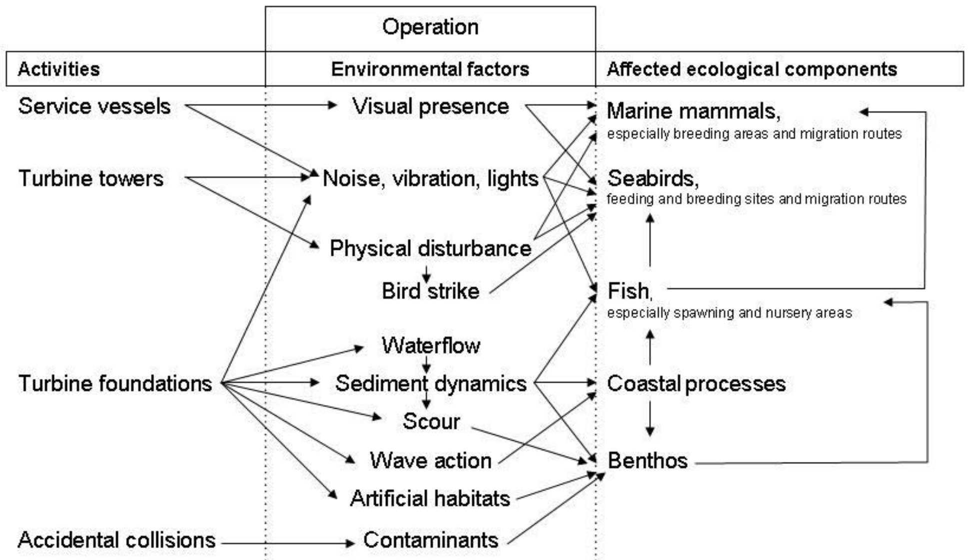

Figure 2 Scheme showing activities, environmental factors and affected ecological components associated with the operation of an OWP (according to Hiscock et al., 2002 and Michel et al., 2007)

2.2.3 Decommissioning of OWP

Like other offshore infrastructure such as oil and gas platforms wind turbines and OWP have a limited lifespan. This limit may arise from economical factors, such as rising maintenance cost causing the OWP to be no more economically viable, but may also stem from technical sources. When this occurs a good assessment is required to decide what best to do with the wind park at that time. Can it be left in place and decay, with possible detrimental effects on e.g. the environment or on shipping safety, or should it be removed. If removal is chosen, what technology should be deployed to achieve this in a safe and environmentally sound fashion.

Also to consider are the aspects of re-powering. In many cases the operator of an OWP is planning from the outset for the foundation structure to outlast the generator and blades. When e.g. after two decades the maximum lifespan of the technological parts is reached, these may be replaced by newer technology. This will come at a cost, but will most likely also result in more power being generated as the technology will have improved during this time. The extra vessel movements associated with a repowering operating, to first remove the old part and then to fit the new parts, will lead to similarity with the initial construction phase from an environmental point of view, but also e.g. for shipping safety. It is only the placement of the mounting structure and the placement of cables that can be skipped. And even the cabling may have to be renewed either to cope with wear and damage already sustained or because it is required to either deal with the increased amounts of power generated or to improve the total efficiency of the OWP by cutting back on transmissions losses by replacing old with new and improved technology.

2.3 Matrix of interactions between sea use functions

The matrix below (Table 1) shows the possibility of co-existence of sea use functions. It reveals that some combinations of sea use functions can co-exist without hindering each other. Apparently conflicts will not occur for these combinations. Other combinations can not use the same space. However a distinction can be made between the ones for which a co-existence can be achieved after adaption and the ones for which this is not possible. The latter exclude each other.

Table 1 Assessment of the interactions between two sea use functions.

Green √	No problem
Yellow < ^ O	no (or limited) possibility of co-existence Symbol (< or ^) points to the use function that will prevail. O signifies that prevailing use function is uncertain.
Blue ~	Co-existence is possible under certain conditions.

	OWP	Sand Extraction	Nature (protected)	Cables & Pipelines	Fisheries	Military Use	Oil & Gas	Shipping
Shipping	< routes	√	~	√ anchoring	√ routes	~	^	√
Oil & Gas	<	<	^	#	<	<	*	
Military Use	O priorities	~	~	√	√	√		
Fisheries	^ **1**	√	<	^	√	1 outside prime fishing areas		
Cables & pipelines	< 2	<	√	*	2 existing and in use cables & pipelines			
Nature (protected)	~	~	√					
Sand extraction	^	~						
OWP	*	* First come first served. Additional activities will have to negotiate						

A comparable way of classification of the co-existence of sea use functions has been used by Forkink et al. (2004) in their study on the development of an integrated cost-benefit method for multi functional spatial use in the North Sea and the coastal zone. The extent of conflict between use function groups was classified in:

- No conflict
- Minimal conflict
- Conflict requiring adaptation
- Conflict requiring regulation

This is a major part of the use functions also relevant for WINDSPEED. We will elaborate on this and compare the outcome with the one described above in this section.
It should be noted that PlanCoast (2008) stress the importance of regional differentiation when assessing spatial needs, impacts and compatibilities. Specific environmental, economic or socio-political circumstances may apply and give rise to differences in relative significance of pressures and/or priorities awarded to use functions.

The rationale behind each cell in Table 1 will be discussed, starting with the column of the OWP, and working down and to the right. The most important interactions to deal with are those relating to OWP and the other sea use function, a choice has been made to include the remaining interaction as well. This not only illustrates the fact these other sea use functions are also in competition with each other for space at sea. It will also help to understand the carry-over effect of awarding space to OWP in favour of some other function. When a combination of use cannot be made then the displaced activity will either have to be discontinued or it will have to be given a new location where it can continue. A new location where perhaps some other function also has a claim and forcing these together is also likely to have consequences.

An interesting observation from Table 1 is that there are two use functions that have almost exclusively yellow cells, whereas the remainder has at least some green cells. The two use functions that are apparently most difficult to combine with others are: OWP and Oil and Gas Extraction. Both have in common that they have fixed positions and safety zones and are focused on supplying energy.

2.3.1 Interactions between Offshore Wind Parks and non-wind sea use functions

The next eight sections specify in detail the manner in which an offshore wind park has an interaction with another sea use function. The order in which the sea use functions are treated follows that of the matrix of interaction as presented in Table 1.

2.3.1.1 OWP and Shipping

Shipping is globally and economically a very important activity. It also has very strong historical claims to use of the sea, something which is strongly regulated by UNCLOS, the United Nation Convention on the Law of the Sea. Safety of mariners working on ships is also an important aspect that needs to be considered.

The IMO has set out a system of shipping lanes and separation zones in part of the North Sea; these are internationally adopted and can be revised. This revision is a lengthy process and as such the basic assumption is to treat the existing system as fixed. Nationally each country has shipping lanes that are also of importance, these can often be adapted more easily than the international routes. To account for the fact that many ships do not need to follow the shipping routes, the WindSpeed project also makes use of a map showing shipping density.

Shipping routes (IMO and national) are treated as no-go zones for OWP, along with a safety zone outside the shipping route. With this safety zone sufficient space should be available between shipping routes and OWP, to allow a ship to safely turn even under unfavourable weather conditions. When looking for possible space for OWP the lowest density of shipping areas will be favoured, keeping in mind that ships must remain able to reach their desired destinations without unreasonably long detours. The issue of interference of wind turbines with radar systems must also be considered when locating an OWP near shipping routes or ports.

As a newcomer offshore wind energy will have to respect, at least to some degree, the historically strong position of shipping. The high desirability of a sustainable energy supply should give offshore wind energy sufficient strength to successfully stake claim.

2.3.1.2 OWP and Oil and Gas

Again this is a very high value activity to society. Certainly for the near future this is economically still very important, however bearing in mind that a more sustainable energy supply is required some concession from the oil and gas industry may be expected. Please bear in mind that oil and gas companies are also active in offshore wind.

Where presently oil and/or gas platforms are located no OWP should be planned in the near future. Also it might be advisable not to plan large OWP in areas where hydrocarbon deposits are expected. However knowledge of future oil or gas finds is not available to the WindSpeed partnership, as a result we are not capable to plan for this contingency.

Other aspects to consider when planning OWP near oil and gas platforms are requirements for access to the platforms, not only with vessels that supply equipment but also with helicopters. All of these need space to operate and navigate safely.

2.3.1.3 OWP and Military use

The military make use of large areas of the sea for different purposes. Depending on what use is made of an area, a combination with offshore wind energy may or may not be possible. Also it would be open to negotiation with the military and within the political arena, whether some areas may be better used for offshore wind energy rather than for their present military use. One may choose to set different priorities.

A few broad categories of military use can be distinguished and are well known to the marine community as they are marked on navigational charts. These categories may be treated differently with respect to their compatibility with OWP.

- Shooting ranges; these generally do not combine with OWP. However these maybe relatively easy to renegotiate to allow for an OWP to be constructed in the area. On the other hand many are situated close to shore where an OWP may not be desirable for social and/or nature conservation concerns.
- Flying zones; these zones are often large and situated on the open sea. They may combine well with OWP provided they are not intended for exercises with low altitude flying or sea-air combat excercises. Otherwise aircraft will usually operate well above the height of the wind turbines and there should not be a problem with having an OWP there as well. The topic of radar interference may come into play here and prevent wind turbines from being considered a compatible use of space.

- Mine testing areas, also including areas for exercising with submarines and torpedoes; these cannot be combined with an OWP. Navigating the ships and submarines and targeting exercises will exclude wind turbines from such an area. The only option would be to negotiate and when possible relocate a given military area in favour of an OWP based on e.g. high economic value.
- Former munitions dumping sites; once more this is a use that is probably best not to combine with OWP or most other sea use functions. The dumped ammunition is a threat to the wind turbines or at least to the vessels and personnel installing them. These site are relatively few and do not cover much space. WindSpeed suggest leaving these locations unchanged.

2.3.1.4 OWP and Fisheries

How well fisheries and OWP go together depends on the type of fishery. Wind turbines require cables to bring the produced electricity to shore. These cables are at risk from fisheries that use heavy towed gears from powerful vessels. A mutual risk though as snagging the gear on a cable may also capsize or sink a vessel to name but a few possible scenarios. Generally it would seem advisable not to combine fisheries with an OWP. However locally fishermen and OWP operators may be able to reach agreement about allowing fishing vessels using suitable fishing gear into an OWP.

In case an OWP is designated a no-go zone for fisheries, it will de-facto turn into a no-take zone and thus a type of nature conservation area. The local community of benthic organisms such as molluscs, sea stars, worms and fish may develop into a more natural one. After a number of years the OWP could turn in a source area supplying the surrounding area with food items and fish. For most commercially fished species of fish a single OWP is not very likely to make much of an impact on fish stocks, especially pelagic (schooling) fish species such as herring, mackerel and whiting require far larger areas and roam much more widely through the seas.

A number of well known fishing grounds exist within the North Sea, WindSpeed has identified these and by assessing fishing effort from statistics available as ICES-blocks for all six countries involved as well as Sweden. By combining fishing effort with economical data on the value of the fisheries of each country, national effort data can be converted into economical value. These national economical values can finally be combined into an aggregated fisheries value map for the whole WindSpeed area. OWP should then preferably go into those areas with the least value for the fisheries.

Treating each OWP as a generic no-go area for all types of fisheries may prove to be too coarse an approach. However for the WindSpeed approach using a DSS to work, a system based on categories of fishing vessels and gear types that are allowed to operate inside an OWP using clear rules will have to be available. It would be feasible to implement such a system with rules differing by country. When decisions are made on a case-by-case basis after the OWP has been constructed this will be impossible to take into account.

2.3.1.5 OWP, Cables and Pipelines

Existing cables, such as electrical and telecommunications cables and existing pipelines that bring oil and gas to shore will have to be treated as no-go zones for wind turbines. The main reason for this is that the owner or operator of such infrastructure must have access to the area with vessels to perform maintenance operations. Conversely the cables required by wind turbines may come into conflict with existing infrastructure when installing them.
When selecting zones for OWP care should be taken that options are kept open for new cables and pipelines to be installed, e.g. for future development of larger OWP further offshore and from which the electricity will need to be brought to shore.

2.3.1.6 OWP and Nature

Nature means two different things in this context.

Firstly there is the way in which nature conservation areas, mainly Natura2000, interact with possible OWP. The most important point here is that Natura2000 does not state that a given human activity (OWP or otherwise) is not possible within the conservation area. However the burden of proof showing that an activity will not cause harm to the values to be protected lies fully with those undertaking the activity. Basically the suggestion made for the combination with OWP is that initially offshore wind energy should best be kept outside nature conservation areas. Which nature conservation areas go together better with OWP depends on the values that need to be protected. Goals that are defined on the basis of birds species or sea mammals would typically be more problematic for an OWP than those aiming to protect benthic communities or fish species.

Secondly use will be made of a series of ecological valuation maps, showing which areas are more or less valuable for four groups of species: sea mammals, birds, fish and benthos. Higher species numbers (per unit area) would make an area more precious. These maps should ideally show concentration of high value where nature conservation areas are already in place. But by having them as an extra we will also be able to accommodate areas of high natural value, that are (still?) outside nature conservation areas.

A large source of difficulty when dealing with biology (species, ecology) is the fact that it is subject to natural variation due to amongst other weather conditions. As a result an area may be very rich in some species for a number of years and then suddenly become far less important or vice versa.

2.3.1.7 OWP and Sand extraction

Sand extraction and gravel extraction are important to society as it supplies us with building material for roads and houses etc. It has significant economical importance. For this industry clear distinctions are made between different types of resource. In many cases a company extracting sand from the sea bed will have prospected an area to find where the desired type of sand is available. After that permits will have to be acquired to mine the resource. Such permits are usually valid for a limited period (several years) for a given area within which a set volume of sand may be mined. Often restrictions apply on how deep an area may be mined.

The authorities granting mining permits are often also required to consider natural values in an area. When e.g. allowing the extraction of a coarse gravel, this is a limited resource that also has its own typical ecology associated with it. Once extracted this value will be lost for ever.

OWP should best not be located in areas where aggregates (sand and/or gravel) are extracted from the seabed. This is most likely a case of limited conflict; most aggregates are won fairly close to shore, whereas a tendency exists to locate OWP further offshore.

2.3.1.8 OWP and other OWP

Cleary an OWP cannot occupy the same area as another OWP. However when considering OWP in marine spatial planning it makes sense to plan ahead. OWP should not be located so that they are placed awkwardly and hamper the future development of others. This will have to deal with access to sites where the on-shore grid is accessible and has sufficient capacity to handle the available power. The basic premise is first come first served. Additional activities entering the area at a later date will have to negotiate for their entry.

2.3.2 Interactions between the non-wind sea use functions

In this section all 27 interaction between the non-wind sea use functions are treated in detail. This includes interaction with the same sea use function.

2.3.2.1 Sand extraction and shipping

Sand extraction and associated activities takes place with ships that are immobile while mining and as such may pose an obstruction to shipping. In most cases however aggregates are won in areas outside shipping routes and there will be no conflict.

In the case of the related activity of dredging (e.g. of shipping routes) conflict is more likely to occur. However dredging is often done to keep shipping routes navigable for ships. In case a channel has to be dredged for shipping and the material at that location is suitable as e.g. building material the activity of dredging becomes coincident with sand extraction. Otherwise the dredged material will have to be disposed at some other suitable location.

2.3.2.2 Sand extraction, Oil and Gas

Sand extraction cannot take place where an oil or gas platform is located. The platform will in most cases be seen as taking priority over sand extraction. If a hydrocarbon deposit is discovered in an area with active permits for aggregate extraction, it seems likely that such a permit will not be extended.

2.3.2.3 Sand extraction and Military use

Sand extraction and military use do not combine well under all circumstances. Areas where the military may have explosive material lying on the seabed, such as in the unsafe sectors of shooting ranges, mining and torpedo exercise areas and munitions dumping locations are not suited for sand extraction. The risk to the miners would be too great. In areas where no such dangers are present, sand extraction can be combined with military use. Extraction activities may have to be limited in time so as not to coincide with military exercises.

2.3.2.4 Sand extraction and Fisheries

This is seen as a combination that does not cause concern. In areas with active sand extraction, fishermen can be active simultaneously. The fisheries vessels can easily navigate to avoid conflicts with the mining vessel.

2.3.2.5 Sand extraction, Cables and Pipelines

Cables and pipelines are the priority activity in this case and the competent authorities will not issue permits for sand extraction to occur in areas where cables and pipelines are located.

2.3.2.6 Sand extraction and Nature

Sand extraction and natural values are not optimal partners. Much will be handled by the competent authorities when granting a permit. Where important natural values are located on the seabed or downstream (currents and tidal movement of the water) from an extraction site these can be threatened by the extraction. This may arise from direct physical disturbance or from sediment becoming suspended in the water column and thus increasing the turbidity of the water. In turbid waters macro-algae may suffer from low light conditions or sensitive bottom-dwelling organism may become buried when settling sediment amounts are higher than they can cope with.

On the other hand ideas are being developed to create new or more diverse habitats on the seabed by selectively mining and shaping deposits. An example of this is the 'Building with Nature'-project (http://www.ecoshape.nl).

2.3.2.7 Sand extraction and other sand extraction

This is not a combination that is likely to cause problems. Potential conflicts will be handled by the competent authorities when granting permits. Different licensees may be able to operate in areas close together.

2.3.2.8 Nature and Shipping

Nature conservation areas and shipping can be combined upto a certain degree. Areas near ports where shipping density is very high and where shipping is constricted into narrow shipping channels do not go together well with nature conservation areas and high natural values. The ships provide a visual disturbance to birds and are a source of considerable noise, also underwater. Not only is a ships propeller a source of noise, also the engines and pumps operating in a vessel are audible outside the ship. In many ships the engines are mounted directly to the ships hull, as opposed to e.g. car engines which are fitted on engine mounts that absorb much sound and vibration. In this way considerable noise levels can be reached in the water column affecting sea mammals, diving birds, fish etc. Another aspect of shipping that needs to be controlled with respect to nature conservation is pollution. Although admittedly most ships nowadays are operated in an environmentally-friendly fashion with minimal discharges to the sea, in areas with high shipping densities even small amounts of per-ship pollution may result in total pollution levels that are detrimental to nature conservation goals in nearby areas.

2.3.2.9 Nature, Oil and Gas extraction

Nature conservation is not the most likely winner in a conflict with oil and gas extraction. However within the WindSpeed study area and elsewhere the environmental awareness of the oil and gas companies is such that they will go a long way to avoid environmental damage. This awareness is strengthened by legislation and controls by the national authorities. Within the boundaries of a designated nature conservation area oil and gas extraction activities will either not be allowed or be subjected to stringent environmental requirements set out in permits in order to safeguard the conservation goals.

2.3.2.10 Nature and Military Use

Military use of the marine environment is often not very harmful to present natural values. However mining exercises and some sonar systems can be very dangerous to wild life and can even be lethal in some cases. Such activities should not be combined with nature conservation areas. Other military use may go fairly well together with nature conservation goals, especially where a low intensity of military use deflects other use functions away from an area and as a consequence making such an area a haven where wild life can escape human pressures.

2.3.2.11 Nature and Fisheries

Fisheries are clearly a form of existing use and as such are not influenced by the mere fact that an area has been designated a nature conservation area. Unless specific measures are taken that put limits on what fisheries can do in a Natura2000-area, fisheries can continue as usual.

How important it would be to put limits on fisheries depends on the nature conservation goals within an area. If fish species, sensitive benthic habitats or benthic species are to be preserved it would make good sense to oust fisheries from the area or to ban the use of (heavy) towed bottom gears. For areas aimed at conserving sea mammals or birds the presence of fisheries in an area may be less problematic. The most important conditions to meet in those cases would be a sufficiently low intensity of fisheries so that the species are not disturbed and sufficient food resources remain in the area. It may be that restrictions need to be applied during some periods, e.g. when sea mammals have calves or pups in an area or when breeding birds need optimal access conditions to a foraging area to be able to successfully rear their young.

2.3.2.12 Nature, Cables and Pipelines

These make relatively good partners. The disturbance caused when a cable or pipeline is installed in an area, is limited to a narrow band. Often the trench in which they are laid is only a few metres wide. Lateral migration of benthic organism allows for good possibilities for recovery afterwards. When a cable or pipeline is present and as a result fisheries or sand extraction is kept away from such a site, this will be beneficial to the development of natural values. In a nature conservation area it would not be too problematic to allow for a new cable or pipeline to be laid.

In the case of cables some concerns exist surrounding the possible effects of magnetic fields occurring around high voltage electrical cables. This could possibly disturb migration routes of organism that orient themselves using the earth's magnetic field. The technology choice made is also of influence here. For short stretches high voltage alternating currents (HV-AC) can be used. This is existing and well-proven technology, magnetic effects will alternate the. Thus these are not likely to severely disturb organisms. For longer distances, e.g. interconnectors such as the NorNed-cable high voltage direct current (HV-DC) must be used. This is necessary as HV-DC is much less susceptible to transmission losses as compared to HV-AC. However a DC-cable will generate a stable magnetic field and is therefore much more likely to cause disorientation in organisms. Actually occurring fields strengths are very susceptible to the configuration used. Andrulewicz, Napierska and Otremba (2001) indicate that for a HVDC-cable in the Baltic the field strength is well above the earth's magnetic field, but that this drops to values well below the natural strength within 20 metres. Öhman, Sigray and Westerberg (2007) give some more examples with fairly limited scopes and indicate that with the technology choice made for the NorNed-cable, a single two-core cable, the emitted magnetic flux is lower than with other options, but not zero.

Another possible but localised effect of both cables and pipelines is increased temperature of the seafloor next to the cable or pipeline.

2.3.2.13 Nature and Nature

This is typically a no-conflict combination, although there exists the theoretical possibility of conflicting environmental requirements from species that are all be desirable to conserve. In most cases once an area has been designated as a nature conservation area, choices will have been made on what are the most important values to protect in that area. Other species and/or habitats are likely to benefit from these choices.

2.3.2.14 Cables, Pipelines and Shipping

Cables and pipelines are not affected much by shipping. Under normal operating conditions they are safely positioned on the seabed while the ships float on the water surface and stay well clear from the bottom. Only in accidental situations when a ships runs aground on top of a cable or pipeline is damage likely to occur. Such situations need not be considered within the scope of the WindSpeed project. The only normal activity for a ship that may cause damage to cables or pipelines is anchoring. An anchor catching on a submarine power cable may damage or break the cable and thus cause a disruption to the power supply. It also poses a hazard to the ship, as the electricity may give rise to fire on board or injury to seamen. For this reason cables and pipelines are marked on navigational charts and ships will avoid anchoring in these areas.

2.3.2.15 Cables, Pipelines, Oil and Gas extraction

Cables and pipelines generally do not go well with oil and gas platforms. However almost all platforms are linked with at least one pipeline, that takes the oil or gas to land. New cables and pipelines will normally be placed such that they avoid existing oil and gas platforms as much as possible. Conversely a new platform will be situated such that it does not cause conflict with cables and pipelines from third parties that are already in place.

2.3.2.16 Cables, Pipelines and Military Use

Cables and pipelines and military use go well together under normal conditions. They can coexist within the same area. The military will take proper care not to damage existing infrastructure, and companies installing new cables and/or pipelines will have to take military use of the area into account. This may cause them to avoid some areas, to bury the cable or pipeline sufficiently deep to avoid damage from military activities or to negotiate with the military users to adjust their use of the area in favour of the cable/pipeline.

2.3.2.17 Cables, Pipelines and Fisheries

Fisheries will give way under most circumstances. They will avoid to fish where (susceptible) cables and/or pipelines are located. Or they can adjust the fishing direction to minimise risks. To this end, though not exclusively so, cables and pipelines are indicated on navigational charts. In addition to this, schemes are in place that make it easier for fishermen to know the location of cables. The Kingfisher Information Service – Cable Awareness operates a website at http://www.kisca.org.uk where data on the location of cables in the seas around the UK, including all of the WindSpeed study area is available. Formats include paper charts and PDF files, but also digital formats for several types of fishing plotters, which are computerised systems fishermen use to navigate with.

2.3.2.18 Cables, Pipelines and other Cables and Pipelines

In areas near ports and thus also industrial sites and cities, cables and pipelines often come closer together. After all this is where much of the electricity and telecommunications signals is destined to arrive, and similarly for oil and gas carried by pipelines. Here conflicts may arise when new cables or pipelines must be added. However the situation is controllable. After all newcomers will have to apply for a permit from the authorities before proceeding and sufficient safeguards will be put in place to ensure safe and continued operation for cables and pipelines already in operation. Newly installed infrastructure will have to be implemented in such a way that this is possible. How to achieve this will also be subject to negotiations between all parties involved. The basic premise is first come first served. Additional activities entering the area at a later date will have to negotiate for their entry.

2.3.2.19 Fisheries and Shipping

Fisheries are not severely influenced by shipping, with the possible exception of very busy shipping lanes. The sea outside shipping routes is presently free for fishermen to trawl (or fish using other types of gear). Fishermen will have to abide by navigational rules when operating in or near shipping routes. These constraints are likely to cause fishermen to prefer fishing outside shipping routes, but the intensity of the traffic will also be considered. At the spatial scale at which WindSpeed is considering fishing effort (ICES-blocks) the level of detail is so low that the influence of shipping on fisheries can not be distinguished.

2.3.2.20 Fisheries and Oil and Gas extraction

These are already regulated, fishing vessels as well as other ships are not allowed to go within 500 metres from oil and gas platforms. This is a measure to reduce the risk of collision. A clear risk to personnel working on a platform but also for fishermen on a fishing vessel.

2.3.2.21 Fisheries and Fisheries

Fisheries can combine well with each other. Many vessels can safely operate within a given area, possibly using different gear types and target species, as long as collisions are avoided.

2.3.2.22 Military use and Shipping

This combination has limited possibilities for combining. However presently there is not much conflict as each has their own designated areas, especially where the specific military use does not combine with other uses, such as shipping. On the other hand, most areas that are designated for military use are available to shipping for most of the time. Only during exercises which are made known to the general public, such as seamen, by publication from national hydrographic offices usually entitled ‘Notice to Seafarers’ or something similar. Unsafe areas of shooting ranges are listed in these publications including the period(s) when actual shooting practice is done, also e.g. a planned explosion of an old mine is warned for. The military will also monitor with radar for vessels entering the area and where necessary issue warnings by radio and/or other means when vessels stray into an unsafe area.

An ammunition dump site is not a problematic location for shipping, ships can safely pas overhead of such a location.

2.3.2.23 Military use, Oil and Gas extraction

In the present situation these uses are not in conflict. Military use of the sea is not made in areas where oil and gas deposits have been discovered. In case hydrocarbon deposits are found in an area designated for military use, it would seem likely that a solution will be found that allows for the hydrocarbons to be recovered. This may take the form of a small cut-out area being freed from the military designation, or that the military for the time period required for exploiting the hydrocarbon deposit relinquishes its claim on the area (or part thereof).

2.3.2.24 Military use and other military use

From the perspective of the WindSpeed project there are not many difficulties to be expected with combined military uses within the same area. It should however be clear that some forms of military use may not go together well. In these cases internal coordination within the military on who is allowed to perform which activity at what location and at which time will most likely be sufficient. Also in the present situation areas with different and not fully compatible military use overlap and this does not cause problems.

2.3.2.25 Oil and Gas extraction and Shipping

The oil and gas platforms are a use of the sea that is very important to society. Many have a large compliment of personnel working on them and with the risk of fire and explosion they form a high risk environment. This is also part of the reason why UNCLOS has set exclusion zones around oil and gas platforms of 500 metres where shipping is not allowed. This zone is guarded from the platform as well as from a standby vessel. Standby vessels patrol this safety zone and will warn ships if they are in danger of passing too closely to the platform. Ships that infringe on the safety zone also risk being fined or in some cases even more severe penalties. By maintaining this safety zone ships and platforms are protected to a large extent from collisions and the subsequent risks. A collision with a platform also carries significant risk to the ship, which is likely to get damaged or may even sink. In cases where such a ship carries a cargo with toxic or otherwise hazardous compounds there also is a risk to the environment.

2.3.2.26 Oil and Gas extraction and other Oil and Gas extraction

This is a possible combination. The licensing system ensures that usually only one company is active with the exploitation of a given hydrocarbon deposit. Already new wells and other infrastructure are regularly added in the vicinity of existing platforms to better exploit and recover the hydrocarbons from such a field. Where different companies are involved, which e.g. could occur where a hydrocarbon field is accessible from different licensed areas, existing rules and regulations will be sufficient to regulate this in a proper fashion. The basic premise is first come first served. Additional activities entering the area at a later date will have to negotiate for their entry.

2.3.2.27 Shipping and other Shipping

This is generally an unproblematic combination. Ships can navigate and avoid each other. With increased ship traffic in areas near ports, there exists a risk for congestion. This may create unsafe situations where ships could come too close together to navigate safely. Authorities will have to keep abreast with the development here and when necessary take appropriate action. Such action could be to widen designated shipping lanes, more strictly regulate which types of vessel are allowed to use what areas, add new areas for ships to anchor. Anchoring areas are important as this is where ships may be forced to wait for some time in case that no space is available in port. Please note that in many cases for large commercial vessels slots for loading and unloading in port are planned several days ahead with often only some hours of leeway. This planning is also used by the ships; they throttle the engine to achieve the required travelling speed to catch their designated slot. In this way fuel is saved and the ship can be operated economically. The constraints on available quay space are less stringent for smaller vessels and they may operate on a looser schedule.

Please note that here we also touch on a topic where marine spatial planning touches with terrestrial spatial planning. Requirements for space at sea are influenced by how efficient ports can operate, which also has to do with their capability to process cargo which also needs transport on the landward side.

3 Conclusions

Three deliverables are part of WindSpeed work package 3:
1) an overview of non-wind sea use functions and their future development upto 2030 (D3.1, Van der Wal *et al.*, 2009);
2) an analysis of positive and negative interactions between offshore wind and other use functions and (this report)
3) a set of calculation rules specified in such a way that they can be implemented in the Decision Support System (DSS). This DSS is a deliverable of another work package of the WindSpeed project, led by DLR.

The analysis of positive and negative interactions of OWP and other sea use functions shows, that similar to Oil and Gas extraction, OWP are more difficult to combine with other uses than those are with each other. Regarding priorities based mostly on economic considerations, the following sea use functions presently have stronger claims on space at sea than OWP do:

- Shipping;
- Oil and Gas extraction;
- Cables and Pipelines.

Fisheries is human activity carried out at sea with a long tradition and clear economic value. It therefore has a strong claim regarding its use of large areas of the sea. On the other hand fisheries have been decreasing for at least a decade and are expected to decrease even further in the future. This expectation is mainly based on the global state of many fish stocks that are over-exploited. With respect to the interaction of fisheries with OWP fishermen should not loose access to prime fishing grounds. Allowing fisheries inside OWP is not an option, especially not when heavy bottom-touching fishing gear is used. With OWP becoming no-take-zones for fisheries, fishermen loose access to these areas. It may turn out that they are compensated for this by OWP becoming source areas and help keep fish stocks up in the surrounding area. For a final decision on the positive or negative balance of OWP vs. fisheries the results from on-going and future monitoring research will have to be evaluated.

Sand extraction is an activity that has clear economical value to society. As availability of terrestrial sources of sand and gravel are declining, increased interest for exploitation of marine sources is to be expected. With respect to OWP it would seem likely that some developments in prime locations may be favoured over sand extraction, but it might not be acceptable to have OWP exclude sand extraction from the seas.

Nature conservation is the final sea use function to discuss that competes with OWP for space at sea. Most marine nature conservation areas have been designated as part of Natura2000 and as such this does not definitively exclude an OWP from the same area. However, the burden of proof showing that the wind turbines do not endanger the conservation goals for the area lies solely on the side of the OWP. Bearing this in mind the expectation is that the preferred option will be to locate OWP outside nature conservation areas. If the spatial requirements for offshore wind energy cannot be completely met outside nature conservation areas, it is possible to device prioritization rules based on the conservation goals. Conservation goals such as birds and sea mammals, especially harbour porpoise and other cetaceans, are strong arguments against having OWP in the same area. Also some habitats are possibly rather sensitive for the changes induced by wind turbines nearby, these would also have to be given low suitability values for OWP.

After collecting and analysing the data on all the non-wind sea use functions, their expected future development and the interactions, calculation rules have been defined for implementation in the DSS. From this we should learn whether the present datasets and calculation rules allow for sufficient space to be allocated for OWP to reach the sustainable energy goals of the European Union and the partner countries while also taking all other interests into account. If this is not the case improvements to the spatial datasets or the calculation rules may help to find more space for offshore wind energy. These improvements can be targeted to address the issues that were found to be most restrictive to the development of offshore wind energy in the North Sea.

4 Quality Assurance & Justification

IMARES utilises an ISO 9001:2000 certified quality management system (certificate number: 08602-2004-AQ-ROT-RvA). This certificate is valid until 15 December 2009. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Environmental Division has NEN-AND-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 27 March 2009 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation, with the last inspection being held on the 5th of October 2007.

Rapport C132/09

The scientific quality of this report has been peer reviewed by the a colleague scientist and the head of the department of Wageningen IMARES.

Approved: Prof. dr. H.J. Lindeboom
Board of directors - Science

Signature:

Date: 09-12-2009

Approved: J.H.M. Schobben MSc.
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Signature:

Date: 09-12-2009

5 References

Andrulewicz Eugeniusz, Dorota Napierska, Zbigniew Otremba (2001): The environmental effects of the installation and functioning of the submarine SwePol Link HVDC transmission line: a case study of the Polish Marine Area of the Baltic Sea, Journal of Sea Research, Volume 49, Issue 4, Proceedings of the 22nd Conference of the Baltic Oceanographers (CBO), Stockholm 2001, June 2003, Pages 337-345

Baptist H.J.M. & P.A. Wolf 1991. Vogels monitoren per vliegtuig. Sula 5(1): 16-23.

BirdLife International. 2004. Birds in the European Union: a status assessment, Wageningen, The Netherlands, http://birdsineurope.birdlife.org.

Garthe S. & O. Hüppop 2004. Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. J. Appl. Ecology 41: 724-734.

Glaeser, Bernhard, Kira Gee, Andreas Kannen, Horst Sterr (2004): Auf dem Weg zur nationalen Strategie im Integrierten Küstenzonenmanagement – raumordnerische Perspektiven. Informationen zur Raumentwicklung Heft 7/8.2004

Lindeboom H., J. Geurts van Kessel & L. Berkenbosch. 2005: Gebieden met bijzondere ecologische waarden op het Nederlands Continentaal Plat, RIKZ-rapport 2005.008; Alterra-rapport nr. 1109, april 2005.

Öhman, M.C., Sigray, P., Westerberg, H. (2007): Offshore windmills and the effects of electromagnetic fields on fish. Ambio, 36 (8), pp. 630-633.

PlanCoast 2009: Handbook on Integrated Maritime Spatial Planning >Experience >Tools & Instruments >Case studies from the INTERREG III B CADSES Plancoast Project, Angela Schultz-Zehden, Kira Gee, Katarzyna Scibior, s.Pro, Berlin, April 2008.

Tasker M.L., P. Hope Jones, T.J. Dixon & B.F. Blake 1984. Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101: 567-577.

Van der Wal, J.T. , F.J. Quirijns, M.F.L. Leopold, D.M.E. Slijkerman, R.H. Jongbloed (2009): Inventory of current and future presence of non-wind sea use functions , WindSpeed D 3.1, IMARES report C131/09, IMARES, IJmuiden, The Netherlands

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