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SUPPORTING DECISIONS

SPatial Deployment of offshore WIND Energy in Europe (WINDSPEED)

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Horizontal Key Actions

"Inventory of current and future presence of non-wind sea use functions"

WP3 Report D3.1

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Inventory of current and future presence of non-wind sea use functions

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Summary

This report is part of 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 deliverable D3.1 the first of three deliverables in the work package:

- 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

An overview is generated of the non-wind sea use functions currently at stake in the WindSpeed study area. The list of sea use functions is not exhaustive but does include the most important use functions, both when judged economically or by the size of area that they claim. These non-wind sea use functions include

- 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 sea use function should be quantified if possible. In addition to the current situation the future trend is of importance. E.g. the extent to which expansion of their claim on North Sea space can be expected, and the preferred regions where this expansion is likely to occur should 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. This topic is dealt with in a separate report (Van der Wal *et al.* 2009).

Regarding the future development of non-wind sea use functions an attempt is made to arrive at the following: either a yearly growth rate or growth function to be able to calculate values for the target years or fixed estimates for the target years: 2020 and 2030. The aim is to arrive

at realistic default values, from which optimistic and pessimistic values[1] can be derived for use in scenario studies to be carried out in work package 6.

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 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 maintain a safe distance between ships.

For the purpose of the WindSpeed project spatial data is also gathered for use as building material for the Decision Support System (DSS) that is part of the project. 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 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 reason to undertake this effort is a target set by the European Union in the new Renewable Energy Directive to cover 20% the European energy demand with renewable energy by 2020. Wind energy including offshore is expected to contribute a major part to this objective.

Many datasets have been identified and collected for the non-wind sea use functions. The availability of these was very different for each of the countries. It turned out that for most datasets, the information available in the national datasets was very different, and not standardized. This led to an unforeseen extra effort in making the collected data usable for the DSS: harmonizing the datasets so that they can be merged into a final dataset where the same information is available for all countries.

In a number of cases the available datasets are possibly in need of extending. This means that the present information on features is insufficient to be able to apply all desired calculation rules or refinements thereof. One example of this comes from oil and gas platforms. It appears desirable to have knowledge of which platforms are normally manned and which have a helipad. Such information is useful as helicopter access to a platform requires a wider area free of obstruction than is the case for shipping.

The description of future developments is feasible without quantifying them exactly; however adding quantities or growth rates is much more difficult. For developing scenarios assumptions have to be made and described, then from this further development is possible. Starting with a ‘realistic’ estimate a base case can be defined, after which optimistic and pessimistic values can also be applied.

The following three tables summarise the results of the inventory and the expected future development. Table I gives for each sea use function the required area (km^2) and a percentage (either relative to the WindSpeed area =WS or the North Sea =NS). For reference purposes the total area for both WindSpeed and North Sea are included as well. Both dredging and radar interference have not been included in this and the following tables. Dredging is not

[1] Please note that optimistic can mean both growth or shrinkage depending on point of view or perception, and vice versa for pessimistic.

relevant to WindSpeed as a separate activity, as the locations completely overlap with shipping. Radar interference has not been included as the dataset only covers British waters and no data is available for the remaining part of the WindSpeed study area.

Table I Summary table showing required area (km2) and percentage of area

Sea use function		Area (km2)	Percentage	
Shipping	1	69000	14	WS
Oil and gas extraction		62000	10	NS
Fisheries		447900	100	WS
Cables	2	36500	6	NS
Pipelines	2	30000	5	NS
Military activities		59500	13	WS
Sand extraction		8350	2	WS
Nature conservation	3	106000	24	WS
WindSpeed		447900		
North Sea		610750		

Notes:
[1] combined routes and very high and high shipping density, low end estimate
[2] including 500m maintenance/safety zone on either side
[3] including designated, proposed and draft marine protected areas, including the Wadden Sea

Please note that the results for shipping (Table I) are a low end estimate, a still to be determined part of the medium category in the shipping density dataset will have to be added to this estimate. Only by including some of this category as well, will a network of shipping network be possible connecting relevant ports, while at the same time meeting the requirement of not causing excessive increases in the distance that ships must travel from port to port.

In Table II the most important driving forces towards either an increase or a decrease are listed for each sea use function. The strongest driving force(s) is indicated by using a bold typeface.

Finally Table III gives a concise overview of the expected future development of each sea use function. The expected development is given either as a yearly growth rate, an expected number by each target year or a relative size for each target year. For military activities no overall change is expected, but it may be possible to relocate military areas. By relocating desirable locations for developing offshore wind energy can be freed. No estimate has been made on the development of nature conservation. The present estimate already includes proposed as well as draft marine protected areas (MPA). It remains to be seen whether all of these will eventually be fully designated. The estimate is therefore already very conservative and fairly high. On the other hand the underlying legislation for Natura 2000 is presently not very well developed for the marine environment. An adjustment to remedy this shortcoming will most likely require more MPA to be designated, if and when it is made.

Table II Summary table of driving forces

	Driving force towards	
Sea use function	**Increase**	**Decrease**
Shipping	**Economic growth, requires increased transport capacity**	Increasing vessel size
Oil and gas extraction	Possibility of exploiting new finds in the area, re-use as carbon storage facility	**Depletion of oil/gas fields**
Fisheries	-	**EU Common Fisheries Policy and related legislation (combat over-fishing)**
Cables	**Economic growth, requires increased transport capacity (phone, data)**	-
Pipelines	**Development of new finds**	Depletion of oil/gas fields
Military activities	Terrorist threats, piracy	Global economic development
Sand extraction	**Economic growth, depletion of terrestrial resources, climate change/sea level rise**	-
Nature conservation	**Increased political and societal attention for nature conservation**	Economic restraints

Table III Summary table of future development

Sea use function	**Expected development**	**Unit**
Shipping	1% yearly increase	number of vessels
Oil and gas extraction	2010: 750 2020: 303 2030: 100	number of platforms
Fisheries	2010: 100% 2020: 90% 2030: 85%	relative size fishing effort (fishing days)
Cables	1% yearly increase	cable length
Pipelines	0.2% yearly increase	pipeline length
Military activities	no change overall, possible to relocate	area
Sand extraction	5% yearly increase	area
Nature conservation	increase, size not determined	area

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 [2]. 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.

[2] 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 (this report)

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

2 Overview of non-wind sea use functions including scenarios for their development in the period up to 2030

The identified non-wind sea use functions include the following:

- Shipping
- Oil and Gas extraction
- Fisheries
- Cables and Pipelines
- Military Use
- Nature conservation
- Sand extraction (as well as gravel)

This list is not exhaustive but does include the most important use functions, both when judged economically or by the size of area that they claim.
Each of these sea use functions has a dedicated section describing its currents use and future developments.

2.1 Shipping

2.1.1 Current use

Shipping on the North Sea comprises route bound shipping and non-route bound shipping. Route bound shipping takes account of slightly more then 50% of the total shipping movements. Route bound shipping includes ferries, cargo shipping, tankers, bulk transportation, and container shipping. Non-route bound shipping includes particularly fisheries, offshore supply vessels, and recreational shipping[3]. Shipping activities associated with fisheries are dealt with in section 2.3.

The North Sea is densely trafficked, with the highest densities occurring in the international routeing system (Vessel Separation System or VSS) between the United Kingdom and the Netherlands (Figure 1). This international routing system is controlled by the International Maritime Organisation (IMO). In the VSS ships congregate to access the harbours of Rotterdam, Amsterdam and Antwerp (in Belgium). Simultaneously many ships use the same VSS to reach ports in the United Kingdom and Germany as well as en route to destinations in Scandinavia and the Baltic. To the south the IMO routeing system extends into the English Channel and out towards the Atlantic Ocean. The global distribution of ports dictates that most vessels move in and out of the North Sea through the English Channel. Other routes are used to safely and smoothly guide traffic to and from the coast and harbours. Outside the routeing system ships usually travel in straight lines towards their destination, as is clearly visible from the patterns in shipping density (Figure 1).

A 2 nm separation is suggested based on a shipping safety study in relation to OWP by DNV (2008). Also Verkiel (2008) uses the same 2 nm safety distance, but includes an explanation

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[3] http://www.noordzeeloket.nl

of the logic behind this value. This explanation takes factors into account such as ships characteristics, required deviation from a ships original course to clearly indicate to the other ship that evasive action to avoid a collision has been taken, representative speeds and time requirements. The same source recommends a 4 nm safety distance around anchorage areas, mainly because the anchoring manoeuvre needs be performed against the combined influence of wind and current and at low speeds.

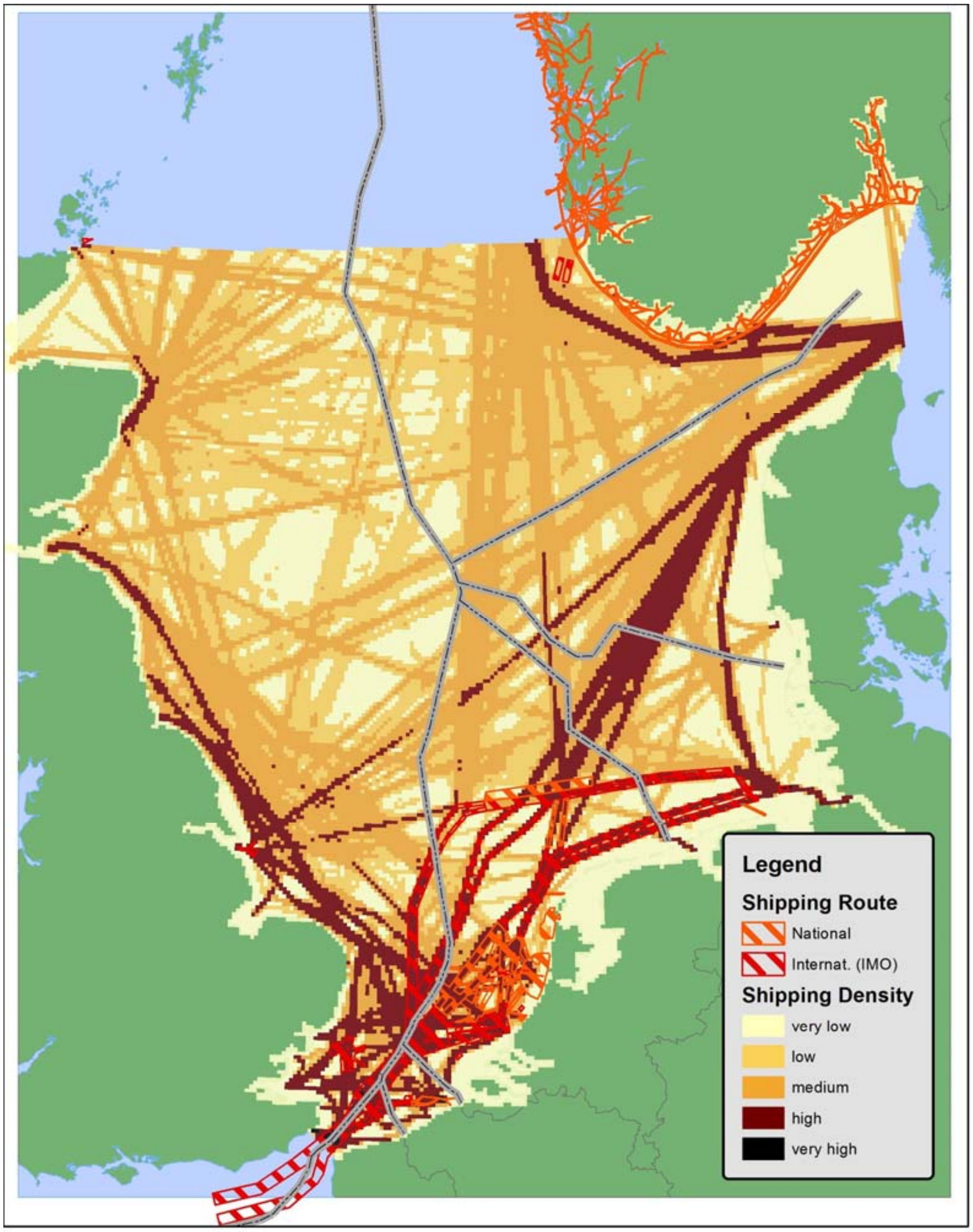

Figure 1 Shipping routes and densities

A map of the WindSpeed area showing the location of IMO and other shipping routes as well as shipping densities is shown in Figure 1. The importance of shipping on the North Sea should be clear from this picture. High density areas of shipping connect the ports. The total area occupied by shipping routes is 28 500 km^2 or around 6% of the North Sea. In Table 1 the area used and percentage for each category identified in the shipping density map is listed. From this it becomes clear that in addition to the shipping routes, which coincide with the categories very high and high, 40 000 km^2 or 8% of the North Sea is intensively used by shipping. Within this area a ship is present at least once a week upto once a day. For the category ‘very high’ this is more than one ship per hour per square nautical mile. More background on the shipping density map can be found in Anatec (2008).

Table 1 Shipping density by category expressed as km2 and percentage of the WindSpeed area. (Source: Anatec, year=2008)

Category	n ships / nm2		Area (km2)	
very low	<12	< 1 /month	122 600.0	26%
low	13-52	> 1 / month	121 600.0	26%
medium	53-365	> 1 /week	160 800.0	34%
high	366-8760	> 1 /day	68 400.0	14%
very high	>8761	> 1 /hour	500.0	0.1%

The North Sea is heavily used by shipping with 260,000 ship movements per year. Transport to and from Dutch sea harbours are involved in 42% of these shipping movements. The economic value of shipping including transhipment is high for the Netherlands and amounted to €25 billion in 2004 (Ministerie Verkeer en Waterstaat, 2008a). By volume of freight transhipped per country the importance of the ports and the ships that make use of them can be estimated from Table 2.

Table 2 National totals of freight (Mt) transshipped in the ports of Germany, the Netherlands, Belgium and the United Kingdom.
Sources:
1 Havenraad (www.havenraad.nl/feitenencijfers),
2 Brititish Ports Association (www.britishport.org.uk).

Freight in Megatonnes		2001	2002	2003	2004	2005	2006	2007	2008
Germany	1	183	187	198	215	230	246	256	260
Netherlands	1	425	442	437	472	493	513	540	562
Belgium	1	190	195	204	217	224	239	258	267
United Kingdom	2						600		

Presently there is not much seasonality in the shipping across the North Sea, although some differences are likely. Demand for food and consumer goods should be fairly constant, an increased need for fuels in winter is likely to push shipping up in this period; however this will probably be counteracted, at least in part, by ports in the Baltic becoming inaccessible due to freezing.

Analysis of vessel traffic data on the North Sea shows that the average number of ships has slightly decreased over the last decades (DNV, 2008). Most likely this is a result of the expansion in size per ship. Busier deep water routes in recent years are another consequence. This accounts for the route bound shipping activities. Offshore supply shipping is likely to increase as an increasing number of smaller platforms will be used in future. In recent years this shipping activity has increased by 3% (Slijkerman et al., 2008).

2.1.2 Future developments

Shipping activity and distribution is likely to change. Changes may result from climate change e.g. in case the polar ice sheets in the Arctic recede sufficiently to allow ships passage then this will be attractive for transport between Europe and the far East and the western USA. Other causes, such as shifts in global economic patterns i.e. emerging markets in India and China, may result in increased shipping of goods.

From 2004 to 2015 shipping movements may increase with 14 to 31%. The current capacity of the shipping infrastructure is sufficient to handle the shipping up to 2015. Recreational shipping is also expected to increase in the future. After 2015 shipping infrastructure may have to be adjusted in order to cope with the diversity and characteristics of ship types and the increased number of shipping movements. Fisheries and oil shipping may decrease whereas liquid gas (LNG), bio fuel and container shipping will probably increase (Ministerie van Verkeer en Waterstaat, 2008a). Verkiel (2008) has ship traffic increasing by 45% or more between 2003 and 2033. Also Dr. Jansen (PLANCO, 2007) in a study on harbour development focusing on German ports for the PlanCoast-project[4] presents yearly growth rates for North Sea ports of around 4 percent on average based on the amount of cargo handled. With most of the expected growth resulting from increased handling of containers. The British Ports Association[5] also clearly indicates the economic importance of the ports and the expectation of continued growth into the future. Also these projections are for handled cargo. For our purpose number of vessels is more relevant as this dictates the intensity of shipping out at sea. The number of shipping movements has been decreasing over the last decade at least, however at the same time the average ship size has increased. Combined cargo handling capacity has increased. In the future it is expected that ship sizes will increase further, this growth is however likely to decrease. After all there is a limit to the size to which shipping channels and other port infrastructure can grow.

A final estimate for projecting the density of shipping into the future is a 1% yearly growth rate for the number of vessels. This figure matches closely with both Ministerie van Verkeer en Waterstaat (2008a) as well as Verkiel (2008). A yearly growth rate of 1.25% would exactly match the numbers quoted by these sources. In the WindSpeed estimate the expected growth by cargo handled is compensated by increased ship size. In recent years increased ship size has effectively allowed a smaller number of vessel movements to accomplish a growth in cargo handled. However, as constraints apply on the physical size of ships and on the possibilities for ports to adapt, a modest increase in the number of vessels is our best estimate. Relative to 2010 as a base year set to 100% a 1% yearly growth rate would accumulate to increase an extra 10% by 2020 and add another 12% by 2030. The compound increase of 1% only showing a discernable difference beyond 2020.

2.2 Oil and gas extraction

2.2.1 Current use

There are approximately 500 production platforms located on the North Sea within the WindSpeed study area (Figure 2). From the Doggerbank area southward most platforms produce gas. North of the Doggerbank oil is the dominant product. Production and housing

[4] http://www.plancoast.eu/

[5] http://www.britishports.org.uk

platforms that rise above the sea surface can have associated subsurface structures in the vicinity. A distinction is made between surface infrastructure, typically a production platform, subsurface infrastructure which will most often be a well head production unit on the seabed and other infrastructure, e.g. a floating production, storage and offloading vessel (FPSO).

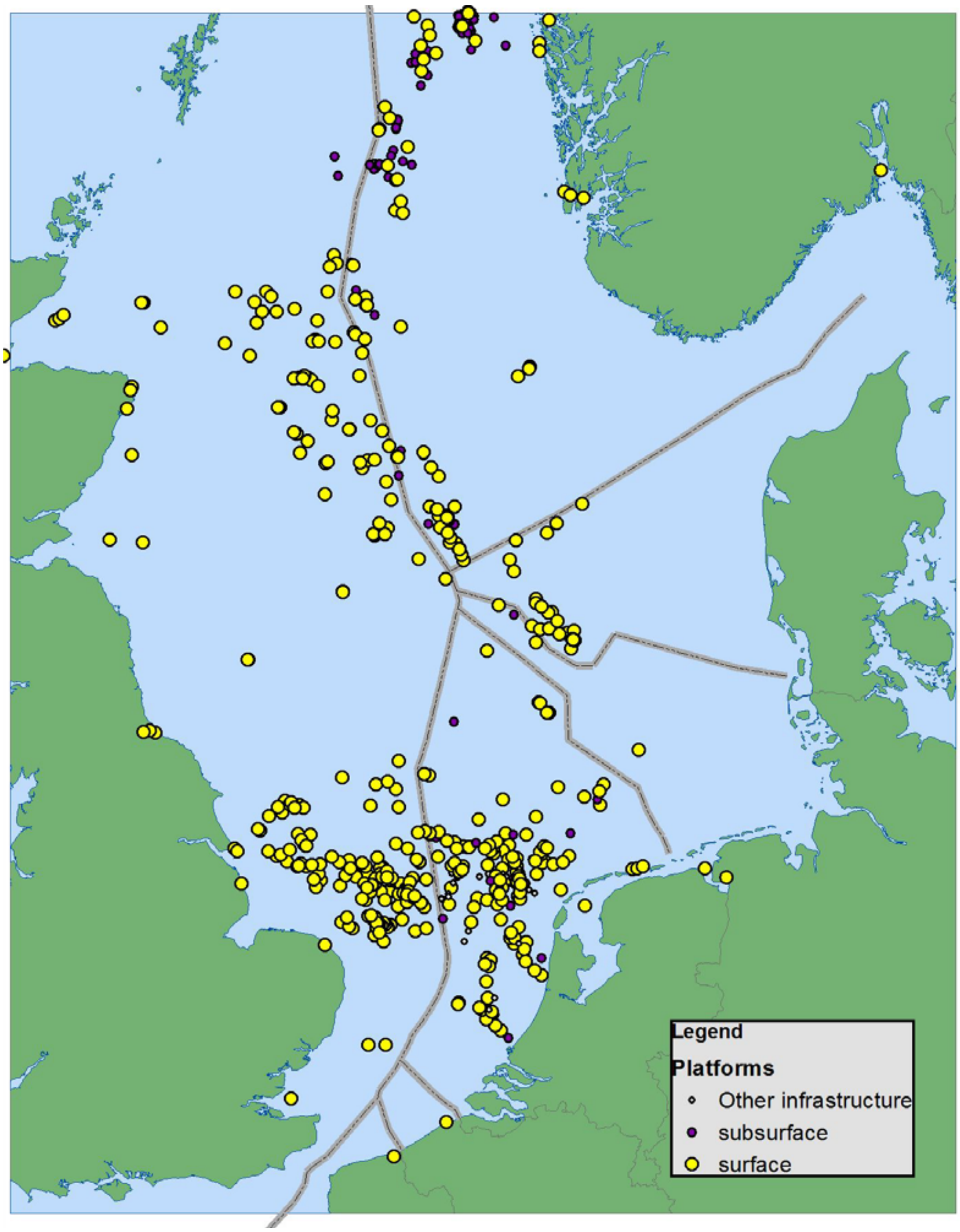

Figure 2 Offshore Oil and Gas installations

Extracted gas and oil is usually transported to shore via pipelines, sometimes via shuttle tankers (oil). Around the platforms a safety zone of 500m is defined in which no shipping is allowed (excluding standby vessels and supply ships). This safety zone is defined in accordance with the United Nations Convention on the Law of the Sea (UNCLOS), and is effective globally. Offshore platforms often have a helicopter platform to allow personal quick and easy access to the installation, also in heavy weather conditions. Because of this helicopter access a safety zone of upto 5 nm is advisable, also to ensure the possibility of evacuating personal in case of an emergency. The visual impact of the surface infrastructure (yellow dots) in Figure 2 is close to that of 5 nm safety zones around each platform. This would result an area of a 62000 km^2 or about 10.2 % of the North Sea area. This spatial claim is already mitigated by overlapping safety zones from platforms located close together. The actual claim is expected to be smaller as not every platform is fitted with a helicopter platform. The area taken up by the 500 m shipping safety zones is 330 km^2 or less than 0.1 %.

In the Netherlands the total annual oil and gas profit is approximately 5 billion euro. There are 143 production units, consisting of 92% gas production and 8% oil production (Ministerie Verkeer en Waterstaat, 2008a). Oil and gas UK (2009) report an annual production for 2008 of 549 million barrels of oil, satisfying almost all domestic consumption (97%) and 68 billion cubic metres of gas which satisfied about three quarters of consumption. For Norway (NPD, 2009) production numbers for 2008 are 772 million barrels of oil and 99 billion cubic metres of gas.

The British and Norwegian sections hold most of the remainder of the large oil reserves. It is estimated that the Norwegian section alone contains 54% of the sea's oil reserves and 45% of its gas reserves. More than half of the North Sea oil reserves have been extracted, according to official sources in both Norway and the UK[6].

Offshore production of oil and gas is not subject to seasonal variation.

2.2.2 Future developments

The number of active platforms is expected to decrease as the production of many fields is in decline. A relatively small number of new hydrocarbon deposits may be discovered and taken into production. An exact trend depends on fuel prices, and investments. Counter to this the number of platforms may also increase towards 2020 or 2030 as increasingly smaller fields will become economical to exploit. This new production infrastructure may take the form of sub-sea facilities linked to existing platforms or could be implemented as mono-pile based small structures. Such platforms are coming into use today, as a cross-fertilisation between offshore wind turbine technology and oil and gas offshore technology. Please note that this has the potential of bringing the oil and gas industry into larger conflict with sea mammals if they use pile-ramming as installation technique for mono-pile production platforms.

During exploration and installation procedures drilling vessels and or platforms will need to be able to navigate and operate in the area and a combination with an OWP on or very near such a site is not desirable.

However, the difficulty in planning OWP lies in the uncertain locations of future finds of oil and/or gas deposits. These locations are not known and if such information exists it is treated as highly confidential by the industry and is unavailable.

[6] http://en.wikipedia.org/wiki/North_Sea_oil

A future trend that has to be signalled is the possibility that offshore platforms may be used as carbon sequestration facilities (carbon storage) rather than removing them from the marine environment. This may result in a given platform staying at a location for a few decades longer. The time a platform remains can either be governed by the technical lifespan of the platform e.g. limited by corrosion making the structure unsafe or by the storage capacity of the field underneath.

In the Dutch EEZ a limited number of new production locations are expected up to the year 2020. Developments depend on several factors, including the oil price. It is expected that the exploitation of the majority of the current production fields will end between 2020 and 2030 (Ministerie Verkeer en Waterstaat, 2008a). Similarly in the UK and Norway new developments are expected to come online in the upcoming years, a development in line with that in recent years (NPD, 2009; Oil and Gas UK, 2009).

Decommissioning in Norway follows the main rule that when petroleum activity ceases, everything must be cleared and removed (NPD, 2009). To date, the Ministry of Petroleum and Energy has approved more than ten decommissioning plans. Both national and international regulations apply when the government reaches a decision regarding disposal of an installation on the Norwegian continental shelf. Disposal or decommissioning of facilities is regulated by the Petroleum Act of 1996. In addition to this Act, Norway's obligations under the OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic) also apply. As a general rule, pipelines and cables may be left in place provided they do not cause an obstruction or present a safety risk for bottom fishing. Costs of burial, covering or removal are taken into consideration when deciding to leave a cable in place. A licensee is required to submit a decommissioning plan two to five years prior to expiration or relinquishment of a production licence or the use of a facility is terminated permanently. The decommissioning plan must consist of two main parts, a disposal plan and an impact assessment. The impact assessment provides an overview of the expected consequences of the disposal, such as environmental consequences. The disposal plan is assessed by the Ministry of Petroleum and Energy and the Ministry of Labour and Social Inclusion (safety aspects).

Also in the UK the first decommissioning of platforms has already taken place (Oil and Gas UK, 2009). Expected dates for cessation of production for British fields are for around 15 fields per annum up to 2020, decreasing towards around 5 towards 2030, based on statistics provided by DECC. These offer a conservative perspective, because it excludes the potential development of further reserves in and around each field and from new exploration activity. If industry succeeds in bringing further reserves into production from both existing and new fields in the longer term, decommissioning could be delayed by 10-15 years in many infrastructure systems. Extending the life of infrastructure allows more reserves to be recovered from existing fields and any developments arising from new exploration drilling. Once infrastructure is decommissioned and removed, nearby exploration potential becomes very expensive to develop, thus reducing ultimate recovery of reserves.

Regarding future development in the oil and gas industry offshore, the sector would prefer to have the planning of OWP take into account areas where hydrocarbon deposits may be discovered in the future. This stance was first presented to WindSpeed on the national stakeholder workshop for Belgium and the Netherlands; it is also included in a paper from the International Association of Oil & Gas Producers (OGP, 2009). The major difficulty in implementing this desire lies in the confidential nature of the required data. The companies involved have high financial stakes in keeping such information from their competitors. The marine spatial planning process as WindSpeed is trying to implement specifically for OWP can therefore not make use of such data. A possible work-around that could be attempted is that the sector agrees to share information first with each other and than with third parties on areas where they feel confident that no new hydrocarbons are to be found. These areas can then be used as preferential zones for zoning OWP.

To arrive at numbers of oil and gas installations still present by 2020 and 2030 an estimate can be based on the data from Oil and Gas UK (2009), these results in annual decommissioning rates of 5% upto 2020, decreasing to 2% by 2030. An intermediate value of 4% decommissioning per year for the period upto 2025 is made here. When applied for the whole North Sea area the initial number of installations is 750, including both surface and subsurface types, for 2010. Applying these fixed annual decommissioning rates the number of installation remaining by 2020 is 303 and only 100 by 2030. These numbers are listed in Table 3.

Table 3 Estimated Number of Oil and Gas installations present in the North Sea area for 2010 (initial), 2020 and 2030

Year	**Number of installations**
2010	750
2020	303
2030	100

Extrapolating British estimates across the entire North Sea area seems reasonable considering that the oil and gas fields in exploitation elsewhere in the area share many characteristics. The exploitation started at roughly the same time, the companies have access to much the same technologies and will be the same internationally operating companies in many cases. It stands to reason that similar decommissioning rates should apply. These assumptions appear valid based on a published map in Ministerie van Verkeer en Waterstaat (2008b) supplied by NOGEPA, which shows a much smaller expected infrastructure for oil and gas for 2020. Another source of confirmation is available from Decomplatform.com[7] where a decommissioning map for NW Europe can be found, which has data from UKOOA, OLF, NOGEPA and OPL. There as well the number of installations expected to last beyond 2020 is low.

2.3 Fisheries

2.3.1 Current use

Fisheries are a well-known and wide-spread sea use function on the North Sea. Fishermen choose to fish with different fishing gears and vessel sizes, resulting in different fish species being targeted and different preferences on where to fish. In most countries the majority of fishing vessels is relatively small and light gears are used by such vessels; they will also prefer to be active in in-shore areas. These fisheries are not likely to come in to conflict with OWP, in many cases it may even be possible for them to operate inside OWP.

[7] http://www.decomplatform.com

For the purpose of WindSpeed the focus has been on fisheries that are likely to conflict with OWP. These are the fisheries using large and powerful vessels in combination with large and often heavy fishing gears. Fisheries research institutes where requested for data on vessels operating with engine sizes over 300 hp and using beam trawls, otter trawls and pelagic trawls. Specifically the beam trawl is of concern as this is a heavy, bottom-touching gear that could snag on a cable inside an OWP. Otter trawls are also operated close to the seabed and in some risk of catching a cable. Pelagic trawls are large nets mostly operated from large ships and their size is possibly a problem when operating in or near an OWP. For the WindSpeed project we have limited the fisheries fleets to those of the countries bordering the study area: the United Kingdom, Norway, Sweden, Denmark, Germany, the Netherlands and Belgium. It should be noted that fishing vessels from other countries are active on the North Sea, such as e.g. France and Spain. These foreign fleets are not expected to have a large impact on the distribution of fisheries effort across the North Sea.

In Norway fisheries has historically been a strong part of the economy, today it forms the third most important export after oil/gas and metals (Statistics Norway, 2009). Total revenue is nearly € 1500 million or around 4.5 % of national exports for 2008. The fleet has lost over 50% of its numbers since 1995 and in 2008 less than 7000 vessels where active (Fiskeridirektoratet, 2009). The largest decrease is in the smallest category of vessels, less than 10 metres in overall length. Roughly $1/7^{th}$ of these vessels are based in the part of Norway that is included in the WindSpeed study area. The decrease in fleet size has been visualised in Figure 3, which has data for all the countries in the WindSpeed area. For Norway two different time series are shown: one for the whole country -marked Norway (all)- and one for the portion of the fleet registered within the study area –marked Norway (WS).
Also the fleets in the other countries are shrinking in size (Figure 3). The data on which Table is based is published on the Fisheries website of the European Commission[8]. Numbers of vessels in the fleets are already in decline for over 10 years, and for most fleets also the average size and engine power of the vessels is past its maximum value. Please note that the average vessel in Belgium and the Netherlands is considerably larger than in the other countries. This size difference stems mostly from a large number of small vessels (< 10 to 12 metres) in the other fleets.

[8] http://ec.europa.eu/fisheries/fleetstatistics

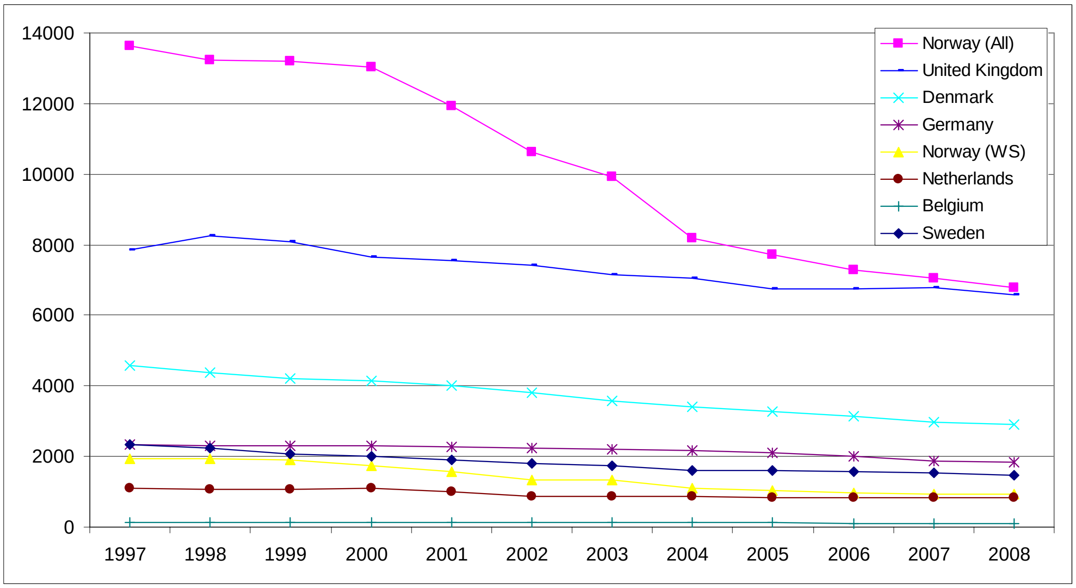

Figure 3 Fleet sizes (number of vessels) for the countries in the WindSpeed study area for the period 1997 thru 2008. Norwegian data from Fiskeridirektoratet, remaining countries EC Fisheries website

Table 4 Fleet sizes in numbers, tonnage and engine power for Belgium, United Kingdom, the Netherlands, Germany, Denmark, Norway and Sweden. Data from the European Commission, Fisheries website8, except for Norway which comes from Fiskeridirektoratet.

Country	**Fleet size 2008 number**	**Relative size 2008 re 1997**	**Average Tonnage (GT)**	**Average power (kW)**
BE	100	68%	189	594
NL	829	74%	194	462
UK	6554	84%	31	126
DE	1812	78%	36	85
DK	2898	63%	25	93
NO	6790	52%	16	183
SE	1474	63%	28	141

The Belgian fleet is small and homogeneous: most vessels use beam trawls. The main target species in terms of landing volume are flatfish (plaice, sole and lemon sole), cod and crustaceans, mainly caught in the North Sea, but other fishing grounds (the Irish Sea, the eastern English Channel and the Celtic Sea) are equally important. Around 12% of the catch is landed in foreign, mainly Dutch, ports.

The UK fishing fleet consists of around 6500 vessels. The majority of these vessels are rather small (77% less than 10 metres) and fish mainly inshore with passive gear. All vessels are highly mobile around the UK coast. Around a third of these are demersal and nephrops trawlers based mostly on the East coast of England and Scotland and fishing in the North Sea and West of Scotland areas. A further 25% are beam trawlers based on the East coast of England and Scotland and fishing mainly in the North Sea, or based on the South Coast of England fishing mainly in ICES Area VII. A further 10% also fish in Area VII based out of

Wales and the South West of England, using mainly long-line gear. Of the remainder, 10% are pelagic vessels based primarily in Scotland, with the others being either shellfish boats based in the South of England or vessels engaged in distant water fisheries.

A map of the ICES areas referred to above is given in Figure 4. The WindSpeed study area coincides largely with the areas IVa, IVb, IVc and IIIa.

The Dutch fishing fleet consists mostly of beam trawlers and freezer trawlers. The main target species for the larger beam trawlers are sole, plaice and other flatfish, while small vessels target shrimp. All these species are mainly caught in the North Sea. The fish is landed fresh. The most common fishing method is beam trawl. For the 16 freezer trawlers herring, sardinella, horse mackerel, blue whiting and mackerel are the main species. The freezer trawlers fish in the EU and in West African waters and all catches are landed frozen.

The German fleet is composed of roughly 2000 vessels, accounting for just 2.3% of the Community fleet in vessel numbers (3.2% in tonnage and 2.2% in engine power). A large proportion of this number (more than 1 600) are small coastal vessels (<12 metres in length), primarily active in the Baltic Sea. Most of the other vessels are trawlers fishing for demersal and pelagic species and flatfish in the North Sea and in the Baltic. Only 26 vessels over 12 metres in length use passive gear. In the ten years since 1996 the number of vessels (-15%) and the capacity (-15% in GT, -8% in kW) of the German fleet have constantly decreased.

The Danish fishing fleet numbers over 3000 vessels. The main components of the Danish fishing fleet are trawlers of small to medium size, purse seiners, Danish seiners and gill-netters; together, these vessels account for 83.8% of revenue. The figures for the whole fleet also include different types of multi-purpose vessels, beam trawlers, shrimp trawlers, mussel dredgers and vessels using fixed gear.

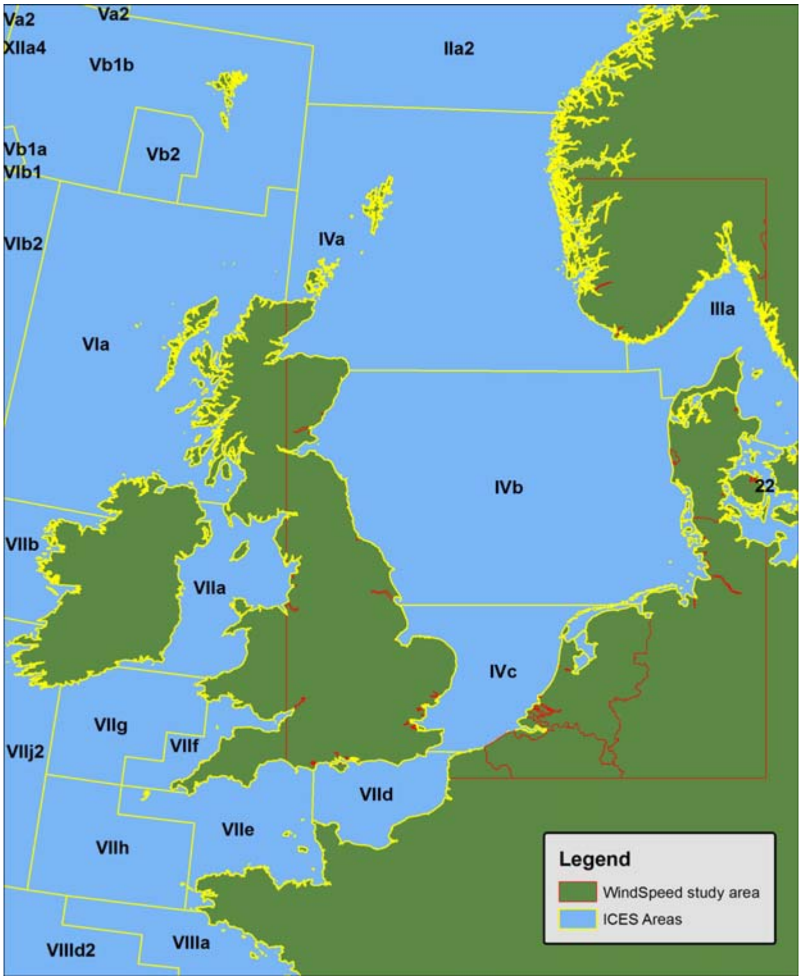

Figure 4 ICES areas in and around the WindSpeed study area

EuroStat (2007) has statistics on the value of the fisheries for each country, including Norway. These values are given in Table 5 and clearly show that fisheries have an important economic value. Especially for Norway fisheries are an important part of the economy.

Table 5 Value of fisheries in millions of Euro's for the years 2005 and 2006 for the EU 15 and the WindSpeed countries.

Country	**2005**	**2006**
EU 15	5894	6687
BE	80	93
UK	536	680
NL	310	336
DE	122	113
DK	442	446
NO	1608	1611
SE	106	117

General

In the European Union, fisheries data are collected for inspection purposes. Fishermen fill in their logbooks on a daily basis and register their catch, gear used and statistical rectangle where they have been fishing. These data can be used to map fishing effort on the North Sea.

Resolution of data

It is important to realize that these data actually have a too low resolution to realistically map effort: both in space and time. The spatial resolution is on a level of statistical ICES rectangles, which are approximately 30x30 nautical miles. In reality, fishermen operate in much smaller areas, see Figure 5: for an example of effort distribution based on satellite data (VMS) for the Dutch beam trawl fleet. A spatial pattern with a preference to fish fairly close to shore can be seen. This preference is a likely result of balancing fish catches with fuel costs. Other areas that are fished are north of Jutland, Denmark and along the edge of the Norwegian trench. The Doggerbank appears to be avoided. The temporal resolution of the data is on an annual basis, averaged over the period 2005-2007. In other words, no seasonal patterns are included. Throughout the year the fishing fleets adjusts it choice of location to the availability of fish. Published maps similar to Figure 5showing detailed distributions of fishery effort based on detailed analysis of VMS-data are available for the British fishing fleet (Mills *et al.*, 2007) and for the German EEZ (Fock, 2008). More examples may exist for other countries.

It would be most suitable to use VMS data for all international fleets in order to get more reliable fisheries maps. However, VMS data are difficult to obtain, mainly due to privacy legislation.

A choice was therefore made to request fishery effort data as days spent at sea per ICES block from all partner countries, as well as Sweden and France, which would avoid the issues involved with the VMS data. The request was honoured by all countries, with the exception of France.

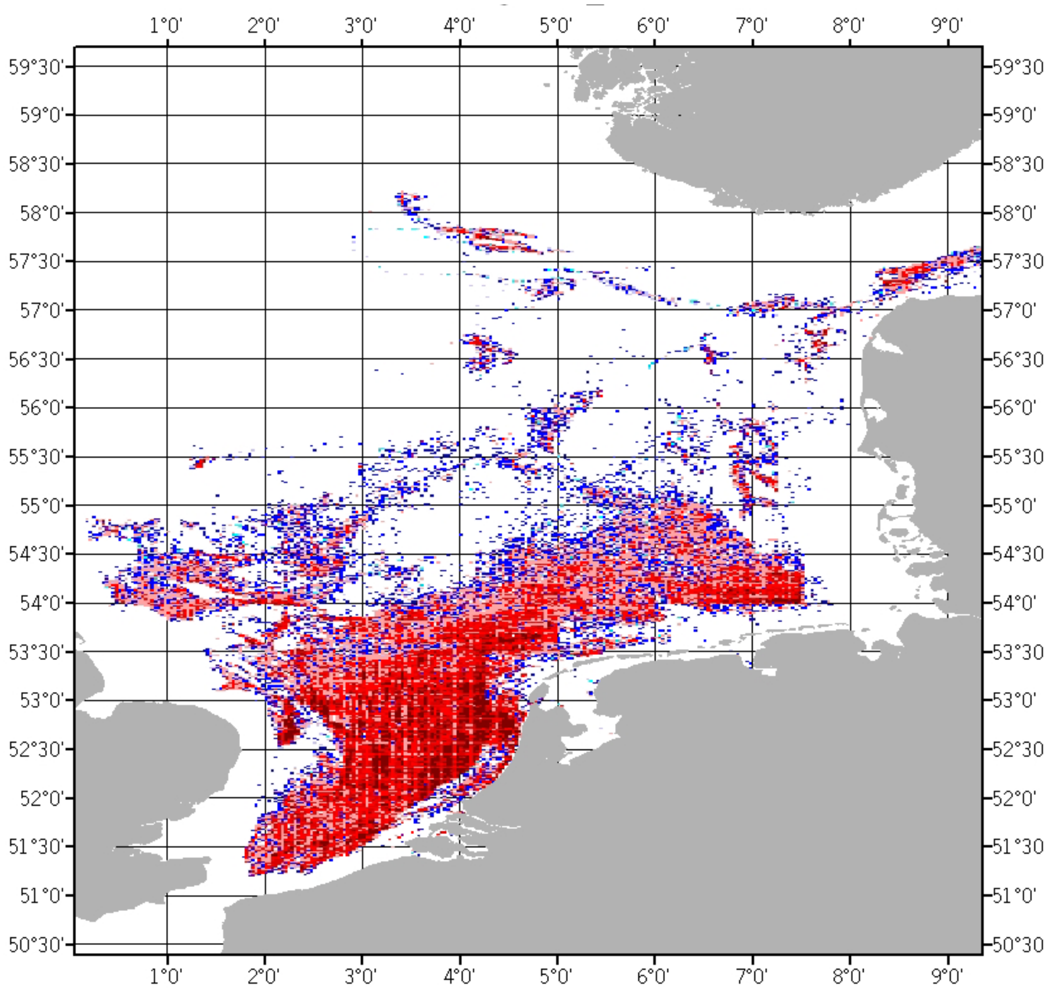

Figure 5 *Example off small scale spatial patterns in distribution of fisheries. Annual effort distribution pattern for the Dutch beam trawl fleet in the period 2004-2006. The underlying grid represents ICES rectangles of ~30x30 nautical miles. Low effort areas show in hues of blue, high effort areas show up in reds.*

For each of the countries for which ICES block effort data was received a map showing the geographical distribution and intensity of the effort is available in Figure 6 or Figure 7.

Please observe that the Norwegian number of days is considerably lower than that of the other countries. This is possibly the result of the selected fishing gear types, which are for demersal fisheries a type that could be of only limited importance for the Norwegian fleet within the study area. This is a speculative explanation. Similarly the received Swedish data were expressed as hours of fishing effort, which has been converted to days at sea by applying an appropriate conversion factor. For this a factor has been applied based on an analysis of the Dutch fleet as published by Piet *et al.* (2007). The most appropriate conversion was 16.3 hours of fishing per day, which is for large vessels (>300 hp). This matches with data from the EC on the Swedish fleet, which has an average power rating of over 500 hp in recent years for vessels using towed gear types.

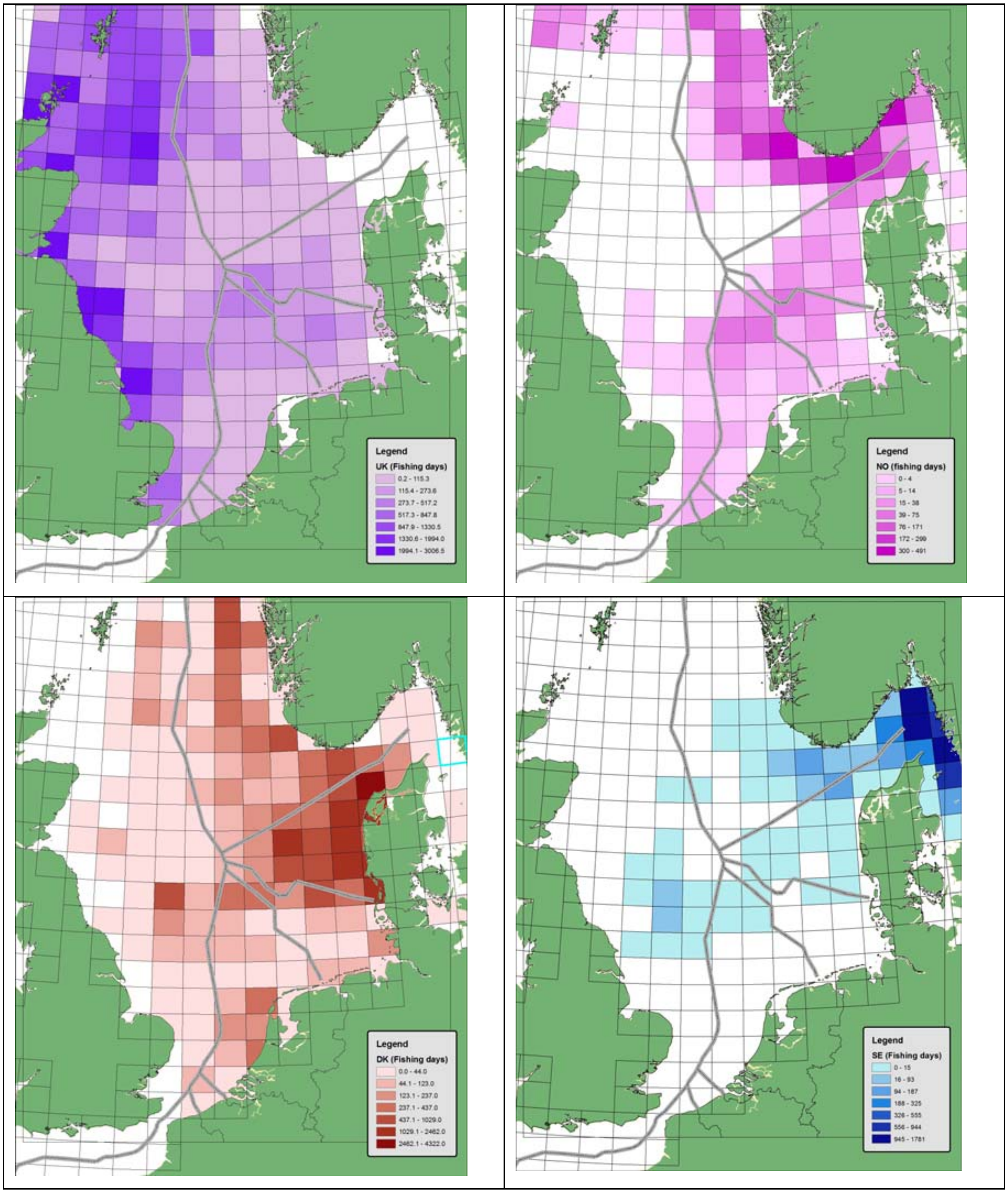

Figure 6 Fishery effort per ICES-block for United Kingdom, Norway, Denmark and Sweden

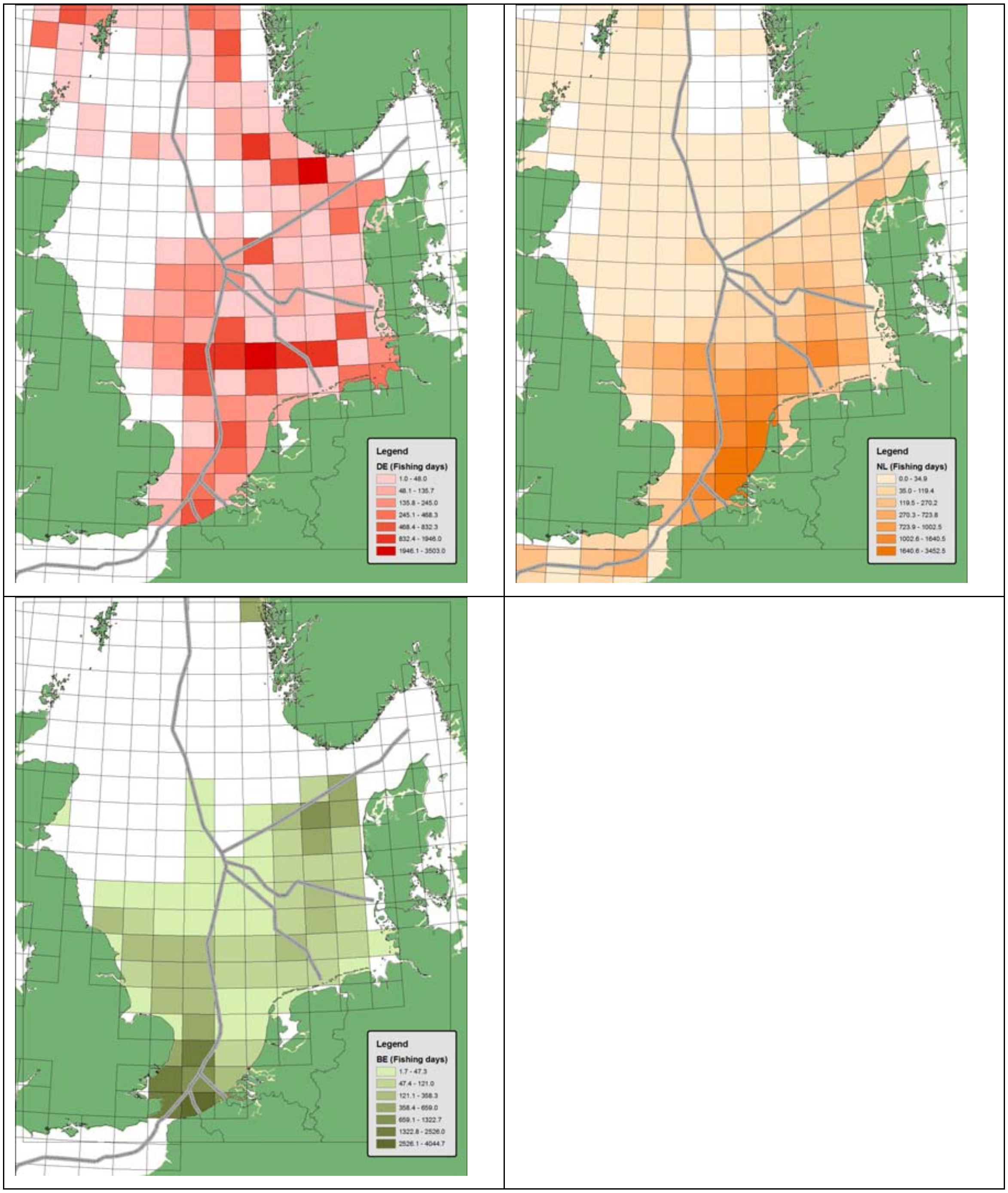

Figure 7 Fishery effort per ICES-block for Germany, the Netherlands, and Belgium

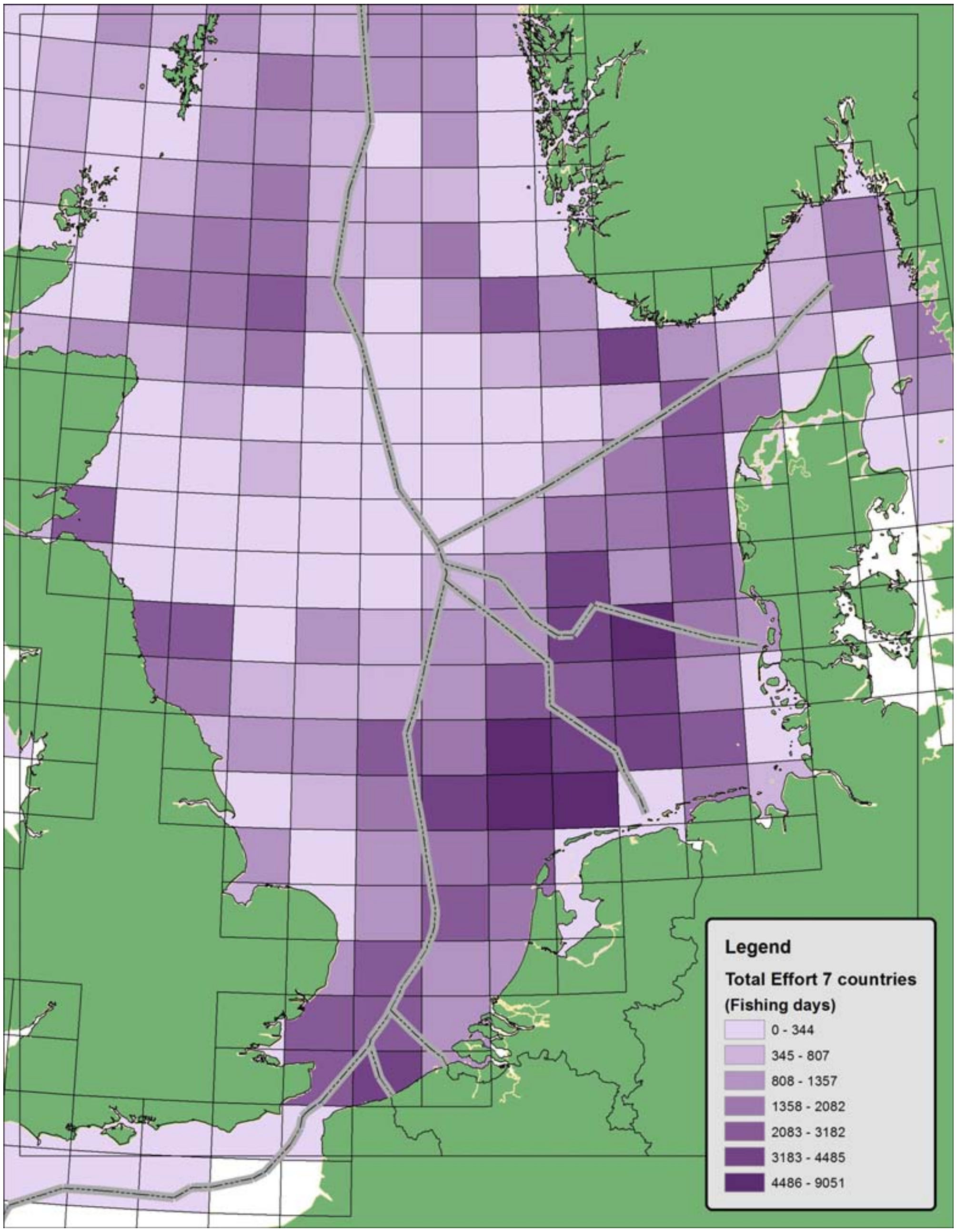

Figure 8 Fishery effort per ICES-block, Total for 7 countries (UK, BE, NL, DE, DK, SE, NO)

The northern part of the central North Sea appears to be relatively unimportant (Figure 8) to the fisheries of these countries. However the data underlying this map has a bias, it does include time (days) spent at sea while travelling (steaming) to the fishing grounds, ICES-blocks near home ports therefore appear more important than would be purely based on fishing activity.

On the topic of making the calculation rule for fisheries based on economical value, (Buisman, pers.comm. and Van Oostenbrugge, pers.comm) the Agricultural Economics Research Institute (LEI) has considered how to achieve this based on the presently available dataset and judged that these are not suitable for such a purpose. Analysis of both logbook and landings data from fishery vessels are some of the required ingredients that are missing. This is a difficult problem to solve, because these types of data are much more detailed in nature than the ICESblock effort data. As a result a match between them cannot be made. VMS-data is sufficiently detailed, but once combined with the logbook and landings data too sensitive while containing private details to be shared internationally. LEI has prepared a dataset where combined VMS/logbook/landings data has been aggregated to ICESblock level, to average annual values for the period 2004-2008. Vessel data on location and composition of the catch has been combined with monthly fish prices (per major species), resulting in accurate estimates for Value (in Euros) per ICES block. The original spatial resolution for this data is the same as in Figure 5. The resulting economical value map for the Dutch fishing fleet is presented as Figure 9. The same gear types (beam trawls and demersal trawls and seiners) have been included as in the effort maps (Figure 6 thru Figure 8). These two gear types are two of most important gear types for the Dutch fishing fleet (Table 6). These results are limited to the Dutch fleet as that is the only fleet for which sufficient access to the data was available. Both LEI and IMARES are involved with partners abroad to improve the international availability of fishery effort and economical value datasets, e.g. by having nationally producing maps or datasets like Figure 9 and sharing the result which is no longer sensitive.

Table 6 Annual value (Euro) per gear type for the Dutch fishing fleet over the period 2004-2008

	Euro
Aquaculture & inland fish	4 000
Beam trawl	219 505 000
Demersal trawls and seiners	15 634 000
Dredges	3 600 000
Drift nets and fixed nets	394 000
Gears using hooks	68 000
Passive gears	2 169 000
Pelagic trawls and seiners	21 121 000
Polyvalent gears	1 242 000
Purse seiners	92 000
Total	**263 828 000**

It is unfortunate that the available data cannot be used to implement an economical calculation rule. The choice made by the WindSpeed project to attempt this with coarse data with a low spatial resolution was based on expected data access issues with higher quality datasets. This view was reinforced as correct by the fact that no comments were received on this during the series of national stakeholder workshops held during April and May of 2009. Nowhere comments were received to the effect that the e.g. access to higher quality data would be possible.

By comparing the available maps for the Dutch fleet: Effort (Fishing days) top right-hand corner of Figure 7 and Economical value (Euro) Figure 9, the following can be seen. The large-scale distribution of effort and value are similar, though the highest value appears to shift closer to shore. This is seen most clearly in the German EEZ. On the assumption that the same similarity in distribution is present for the other fleets fishing within the WindSpeed study area the combined effort map (Figure 8) is judged as fit for purpose.

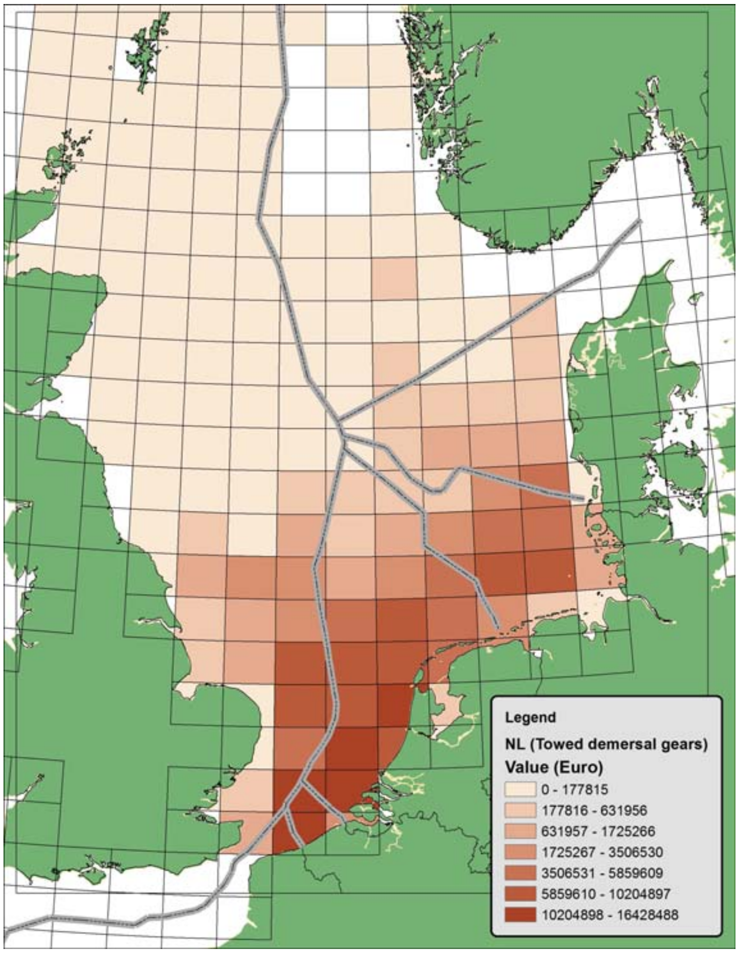

Figure 9 Value in Euros per ICESblock for the Dutch fishing fleet, using towed demersal gears. Average annual values calculated for the period 2004-2008

2.3.2 Future developments

In the coming ten to twenty years, several changes are expected in the fisheries on the North Sea. There are many factors influencing the fisheries: European Council (EC) policy, sustainability labels, energy prices, fish prices, fish availability, climate changes, etc.

EC policy on fisheries is described in the Common Fisheries Policy (CFP), aiming to ensure sustainable exploitation of living aquatic resources[9]. The main measures used in the management of fisheries are: reduction of fishing effort, together with limitation of catches and technical measures for reduction of by-catch and discards. For the North Sea fisheries effort reduction means a decrease in the number of fishing vessels and a reduced allowed number of days at sea. Presently the European Commission is busy reviewing the CFP (EC, 2009) pointing out that while important initiatives have been taken to make EU fisheries more sustainable, important problems remain.

[9] http://ec.europa.eu/fisheries/cfp_en.htm

More and more fisheries aim for a **certificate** e.g. Marine Stewardship Council (MSC) stating that their fish is caught in a sustainable manner. Such a certificate helps the fishery to be accepted by society and to improve marketing possibilities. Certification processes stimulate the fisheries to operate in a more environmentally friendly way, e.g. with minimized by-catch, discarding and bottom contact. Another point to consider is the that of marine protected areas (MPAs), where restriction may be applied to fisheries. However by selecting a sustainable fishing technique and/or having a certification fishermen may be allowed to catch fish inside MPAs.

Energy prices (or more specifically: fuel prices) are an important driver for fisheries. High energy prices stimulate fishers to use less energy, in other words; use lighter gear to reduce the energy needed to tow the gear; and to fish closer to port to reduce the required fuel for reaching fishing grounds. It might result in a fleet that uses different types of gear, and perhaps more passive (standing) gear in stead of actively towed gear.

Climate changes might lead to alterations in abundance and distribution of various species in the North Sea. As a consequence, the species that are currently might not be as abundant in ten or twenty years. This will affect targeting behaviour of fishers. **Fish availability** and **fish prices** are important factors determining targeting behaviour. It is difficult to foresee which species will be most attractive for fishers in future. A trend that might be expected is an increased interest in a wider variety of species. Fishing for bulk will probably be less interesting, while fishing for (local) high quality species might be more profitable. That will induce the fleet to be more flexible in using gears and visiting different fishing grounds. A smaller scale fishery might be the result.

The Dutch North Sea fishery is currently under pressure due to several reasons: high energy use, reduced fish catch opportunity, economic overcapacity, public pressure to convert the fishery to sustainable methods, increased spatial claims by other sea use functions. The economical value of fisheries on the Dutch EEZ is expected to decrease with 8 to 50% in the period 2005 to 2015. Besides there are chances to develop sustainable fishery using ecolabels. The Dutch fishery policy is mainly determined by the European Common Fishery Policy (Ministerie Verkeer en Waterstaat, 2008a). Much the same will be true for Belgium, UK, Germany, Denmark and Norway. See also the fleet descriptions and historical data included at the beginning of section 2.3.1.
Van Densen (2009) gives an overview of 50 years fisheries management in the North Sea and shows that fish landings have now decreased to levels that are similar to those in the 1950's and before. Fishing mortality one important parameter to judge whether fishing pressure is at acceptably low levels, is also shown to have decreased considerably over the last two decades. This is also the result of scientific advice on Total Allowable Catch (TAC) being followed relatively well. Admittedly the final necessary improvements have only been reached in the last few years, but the efficiency and success of the present fisheries management is demonstrated for the North Sea. In other areas such as the Baltic Sea and the Mediterranean Sea the results of fisheries management appear to be less positive, which was seen as the main reason for continued negative communications on fisheries and fisheries management.

Summary of expected future of the North Sea fishery

Expected trends in the fishery are:

- effort reduction: less vessels, smaller vessels, less days at sea
- reduction of by-catch and discards of unwanted species: avoidance of areas and periods with high amounts of by-catch and discards, technical adjustments of fishing gear
- sustainability becomes even more important: fishing techniques and behaviour will be (as far as possible and acceptable) adjusted to the demands of society/NGOs
- energy use will be reduced as much as possible: the fleet might stay closer to port and active gears might be replaced by passive gear (requiring different fishing areas and strategies)
- fishing for quality, not for quantity: targeting of a wider variation of marine species, better adjusted to availability of species and the demands of consumers

Deriving from the data above there is little information available on the expected future development of fisheries. Consensus is that a further reduction is required, as many fish stocks are presently still over-exploited a suggested reduction to use for the target years 2020 and 2030 needs to be derived. However as Van Densen (2009) points out in the case of the North Sea the reduction needed there is not very large anymore. Based on the suggested range of decrease for 2015 and the observations on the results of fisheries management in the North Sea the following numbers are selected for use as defaults in the WindSpeed DSS: a decrease of fishery effort of 10% by 2020 and an additional decrease of 5% by 2030.

2.4 Cables and pipelines

2.4.1 Current use

There are numerous cables and pipelines to be found on the North Sea seabed. In this section cables will be covered first and pipelines next.

Cables in the North Sea are either power cables (electricity) or telecommunications cables. Power cables have been laid to connect countries with each other for purposes of supplying cheaper electricity as well as achieving a reliable power supply. Telecommunication cables typically carry phone conversations and are part of the Internet infrastructure. Recently laid telecommunications cables are likely to be fibre optics.

United Nations Convention on the Law of the Sea (UNCLOS) has defined a maintenance zone of 500 metres on either side of cables. This value is generally respected globally and certainly within the WindSpeed area. The reason to designate a safety or maintenance zone is to avoid disruption of service by e.g. fishing vessels or anchoring ships breaking a cable and to ensure access to the cable for maintenance vessels.

Cables are an integral part of an OWP. A cable is connected to each turbine. Often connecting to a central transformation platform but other configurations are also possible. All these connecting cables make that the entire OWP is to be considered a zone where activities that pose a risk to a cable should keep out. From the OWP a high voltage cable goes to shore, this can be either a single cable connection to shore or be part of an interconnector infrastructure. On the topic of grid infrastructure more information is available from Korpås and Van Dyken (2009).

At the Danish WindSpeed stakeholder workshops it was pointed out that in Denmark many cables are buried sufficiently deep or are protected with concrete layers above to allow fishing vessels to safely operate on top of cables. Also fishing is not always prohibited within OWP in Denmark when cables are seen as sufficiently safeguarded against damage. In this case, the Danish situation may also be influenced by local conditions, with the possibility that these circumstances are mostly based on the experience with relatively small fishing vessels and light gear types operating in the inner Danish waters.

The spatial distribution of cables is presented in Figure 10. Especially the southern part of the North Sea between the United Kingdom, England more specifically, to the west and, Belgium, the Netherlands, Germany and Denmark to the east has many cables crossing the area. Most cables are used for telecommunication purposes. Umbilical cables are only shown in the Dutch sector, but should also be present elsewhere in association with oil and gas platforms. This category is however not included in the other available datasets. Umbilical cables link offshore installation together and are used for communication and operation purposes ; an umbilical cable may carry both power and communication signals to operate an underwater production facility from a nearby production platform. The relative scarcity of electrical cables crossing the North Sea is partly the result of insufficient technology until recently. The relatively short cables connecting Netherlands and Belgium with the United Kingdom are carrying high voltage AC. This technology is unsuitable for long distance transport due to high losses. Also the short cables shown between northern Denmark and Norway, shown in brown on the map, use the same technology to transport electricity. The long cable cutting across the North Sea from southern Norway to the Netherlands is of a new type. Here high voltage DC technology is used and this makes it possible to transport electricity efficiently and with low losses over longer distances. More cables of this type are expected to be laid in the future, possibly in association with the large scale development of offshore wind energy, e.g. as an offshore electricity grid. More on this topic can be found in Korpås and Van Dyken (2009).

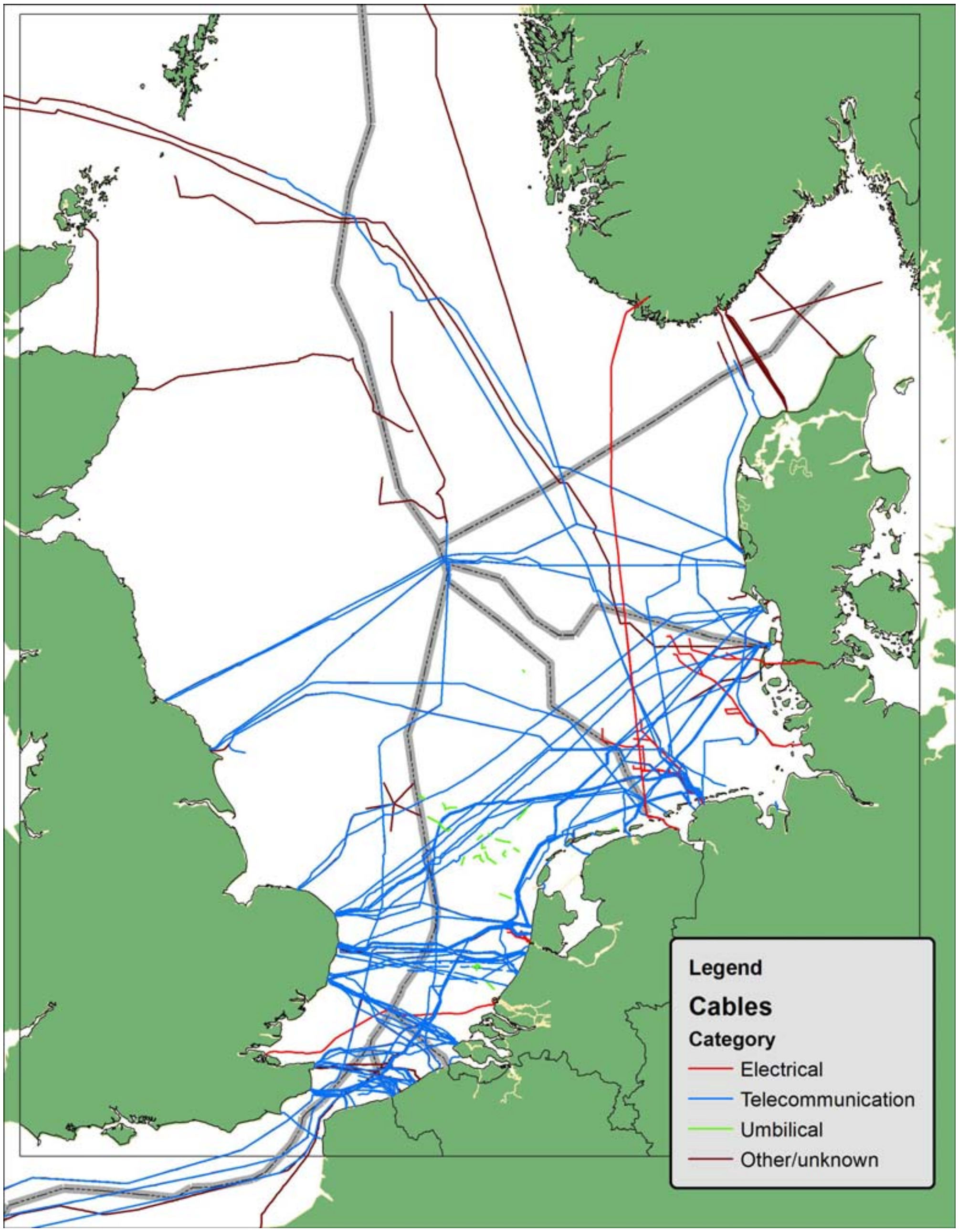

Figure 10 Cables in the North Sea

Table 7 Cables in the North Sea, by category, area taken up by a 500m maintenance/safety zone in km2 and expressed as a percentage of the North Sea area

Cable Category	**Area km^2**	
Electrical	1367	0.2%
Telecommunication	17275	2.8%
Umbilical	186	0.03%
Unknown	17680	2.9%
Total	**36508**	**5.9%**

In Table 7, for each category of cable, the area used by the cable and associated maintenance zone is shown, expressed both as square kilometres and as percentage of the North Sea area. Telecommunication cables and cables for which the function is presently unknown are the major categories. In total about 6% of the North Sea area is inaccessible to OWP as a result of the presence of cables and associated safety zones.

Similar to cables are pipelines of which there are a fair number in the North Sea. Many pipelines connect the facilities for offshore oil and gas production together and run on from there to the coast.

As with cables a safety zone is defined around pipelines to protect the pipeline from damage. In the case of pipelines transporting oil or similar products, this protection is also of great importance for protecting the environment. The width of the zone is 500m to either side of the pipeline, and is also based on UNCLOS.

Table 8 Pipelines in the North Sea, by product transported, area taken up by a 500m maintenance/safety zone in km ^{2} and expressed as a percentage of the North Sea area

Pipeline for	**Area km^2**	
Gas	13328.1	2.2%
Oil	3785.4	0.6%
Oil + Gas	2025.3	0.3%
Other	2293.7	0.4%
Water	330.1	0.1%
Unknown	8014.4	1.3%
Total	**29777**	**4.9%**

The majority of pipelines present in the North Sea transports gas (Table 8), the second most important group being those with a (presently) unknown function. The total percentage of the North Sea area taken up by pipelines and the associated safety zones is 5%.

Since the introduction of oil and gas extraction from the North Sea, a maze of pipelines has been established (Figure 11). Most pipelines carry gas, others oil and can be distinguished in the map. Some, mostly short, stretches of pipeline carry water. In a number of cases this can be drinking water being supplied from the main land to an island. Most other pipelines carrying water are associated with oil and gas platforms. As a by-product these wells also produce water, often very salty and too rich in hydrocarbons to be safe to discard to the sea.

This produced water is re-injected into the field, which both helps in minimizing the environmental impact and maximizing the recovery of hydrocarbons from the field.

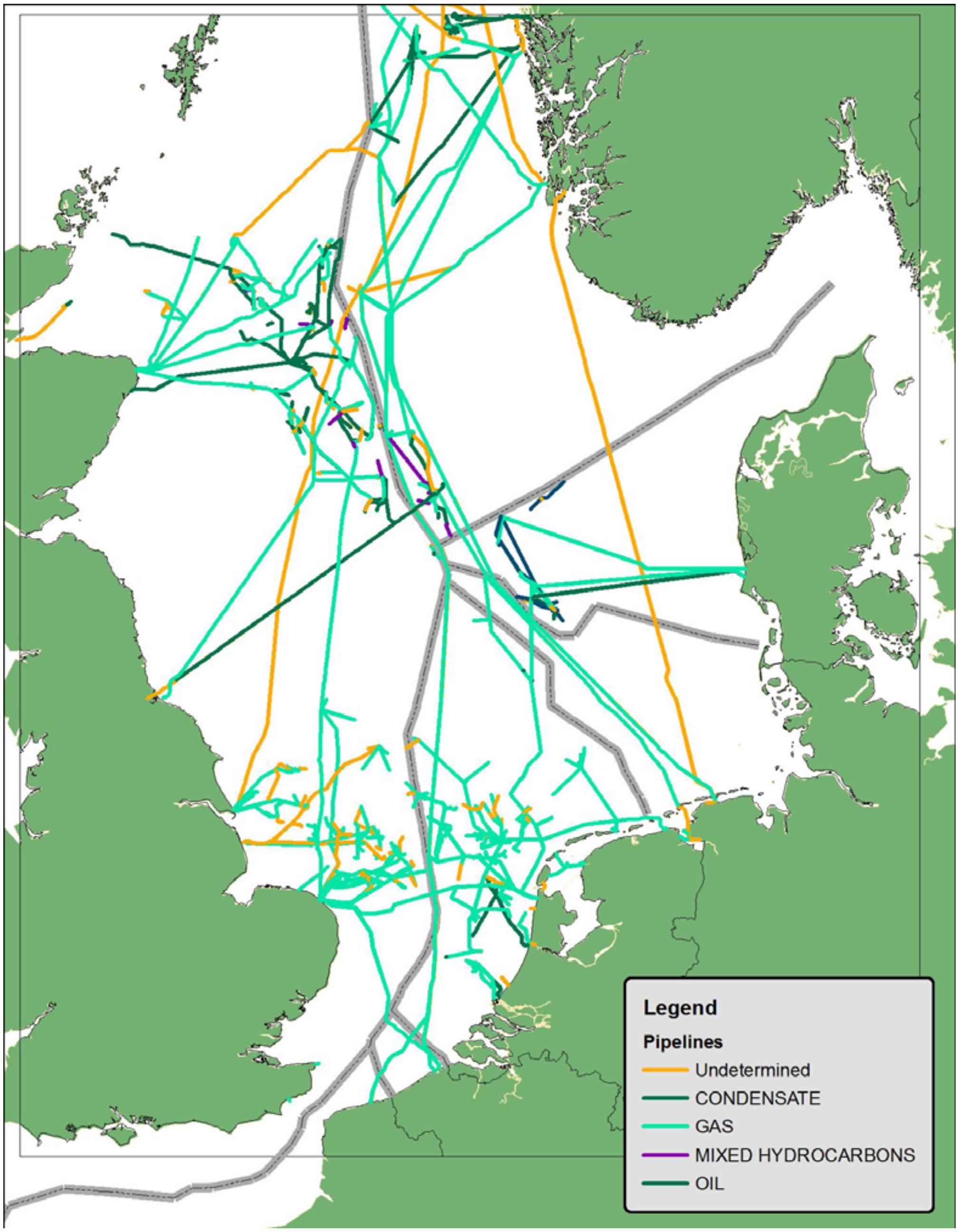

Figure 11 Pipelines in the North Sea

2.4.2 Future developments

Optical fibre cables are likely to increase as internet demand is increasing. However, the exact increase will depend on new techniques as well. Also power cables are likely to increase as the development of offshore wind energy parks will require cables to transport produced electricity to shore. A factor to consider in this respect is the unpredictable nature of wind energy, which results in an increased need for interconnection of national power grids. This will aid in shunting the available power to the locations where it can be put to its best use.

Pipelines, are most likely to increase, as companies are focusing on smaller platforms (= producing oil and gas from smaller –previously unprofitable- deposits. The actual platforms required may not be that much smaller in future. The length of pipeline required will be small. Small fields will only be developed and taken into production when connecting to existing infrastructure nearby is possible. In locations where no such infrastructure is available the development will require the use of a floating production, storage and offloading vessel or FPSO and tankers will be used to transport the product to a receiving port.

In the Dutch pre-policy Document (Ministerie Verkeer en Waterstaat, 2008a) on the North Sea it is described that opening up of the European electricity market has caused an increase in the demand for international power supply links (interconnectors). At present, the Netherlands has an interconnector across the sea, a cable between the Netherlands and Norway (NorNed cable), shown in Figure 10. Another interconnector is currently under construction between the Netherlands and the UK (BritNed cable). The construction of wind farms at sea will generate an additional need for power cables between the wind farms and the Dutch coast. The government is exploring possibilities for so called 'sockets at sea' for the benefit of large-scale wind farms. In addition the building of new international gas pipelines will have to be taken into account. Bundling of cables and pipelines and reduction of safety zones and maintenance zones are aimed for (Ministerie Verkeer en Waterstaat, 2008a).

Based on the information presented above the following figures are suggested for yearly growth rates to be used in the DSS.

For cables a yearly increase of 1% is suggested as a base figure. With an installed base of over 80000 km of cable a yearly increase of 1% amounts to 800 km of cable. For cables the location where these are likely to be laid will depend on the purpose. Telecommunication cables are very likely to be required to add capacity between locations that are already connected and therefore are expected to be laid parallel to existing cables. Most of the increase for the category of electrical cables will be associated with development of offshore wind energy and are the subject of study of other WindSpeed work packages.

For pipelines a yearly increase of 0.2% is suggested. With over 50000 km of pipeline present in the area, this would amount to 100 km of pipeline laid each year. The location where this new pipeline is expected to appear is in close association to existing hydrocarbon infrastructure.

2.5 Military activities

2.5.1 Current use

Military activities include port activities, open water ship and submarine activities, construction and upkeep of the fleet, underwater disposal of weapons and munitions (fishery protection patrols by the respective navies), and manoeuvres and firing exercises. Firing exercises are held within clearly identified zones.

Military activities can lead to disturbance of wildlife and interfere with other uses of the areas involved. At the end of the First and Second World Wars in most of the (OSPAR) Regions considerable quantities of arms and munitions were dumped at sea including considerable quantities of chemical warfare materials (e.g. mustard gas and different arsenic-containing types of munitions) (OSPAR Commission, 2000).

The main usage categories that can be distinguished within the group of military uses of shore are the following:

- shooting ranges;
- flying zones;
- mine testing areas;
- submarine exercise areas;
- former munitions dumping sites.

The last category is the most problematic for an OWP, as the dumped materials are hazardous and removal is therefore dangerous. As these areas are well known and take up only a limited part of the North Sea they will be treated as exclusion zones as far as OWP are concerned.

As illustrated in Figure 12, there are exercise areas off the eastern coast of England and around the Firth of Forth and Ireland. In front of the Dutch coastline (Wadden Sea and North Sea) several military areas are located. Also of the German, Danish and Norwegian coast military exercise areas exist.

The presently known number of military use areas per country are listed in Table 9. The table lists total area in square kilometres with military use per country and the percentage this is of the national EEZ (as far as the EEZ coincides with the WindSpeed study area).

Table 9 Military use areas per country, number and total area in km2 and as percentage of the WindSpeed by EEZ, including totals.

	UK	**NO**	**DK**	**DE**	**NL**	**BE**	**Total**
No.	43	7	6	17	25	11	
EEZ km2	194600	85700	58300	41300	64400	3500	447900
Area Mil (km2)	31400	3100	1400	17000	5800	800	59500
%WindSpeed/EEZ	16%	4%	2%	41%	9%	23%	13%

The United Kingdom and the Netherlands have percentages in a similar range as the total for the whole area. For Germany (41%) and Belgium (23%) the relative area of the EEZ having a military use is higher than average. For Denmark and Norway the percentage value are considerably lower, this may however relate to the fact that no specific datasets from these countries on military use are available. With additional data from these countries the number and total area with some type of military use is likely to increase. For the whole WindSpeed area the relative area having some type of military use is 13%.

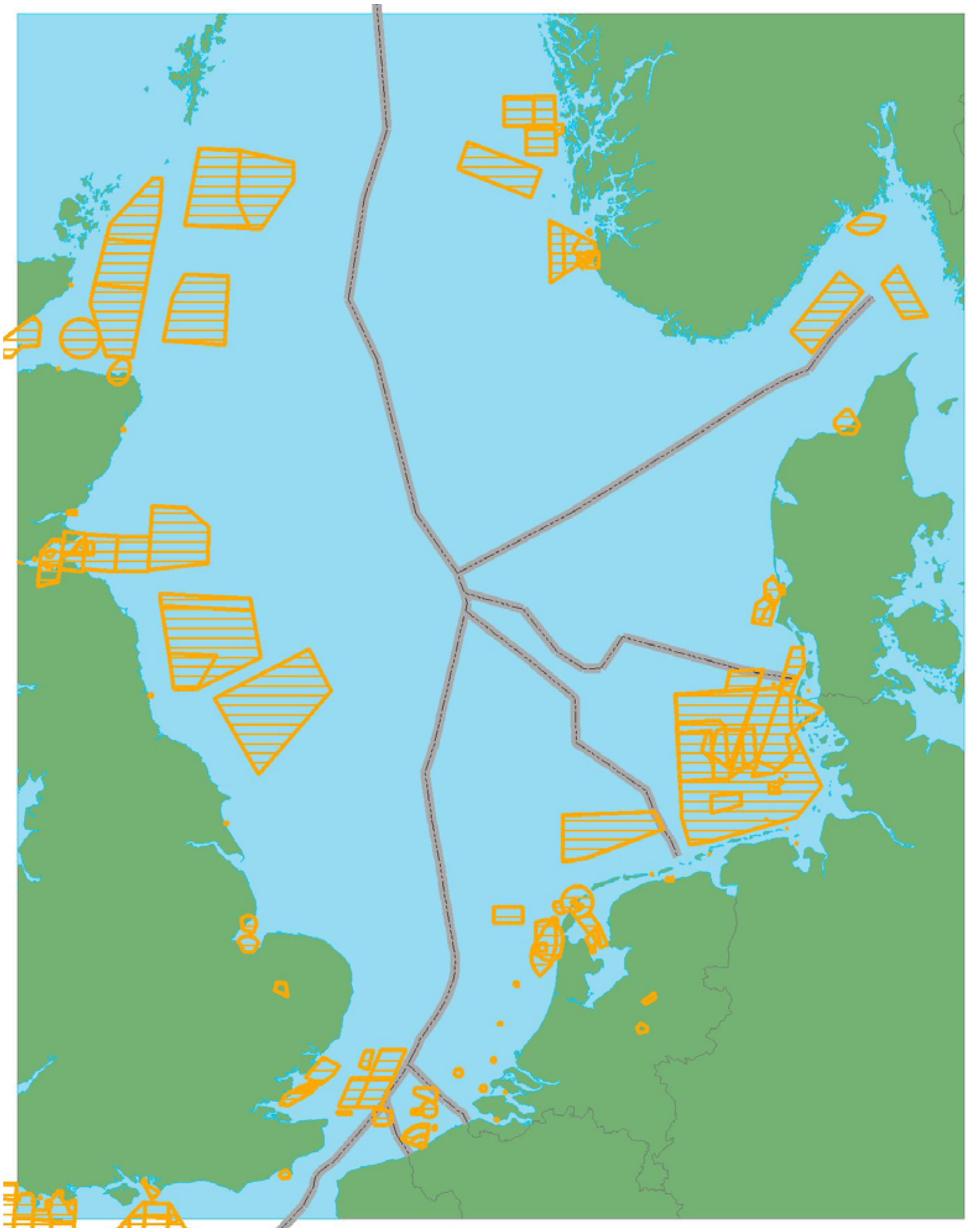

Figure 12 Areas with known military use within the North Sea

2.5.2 Future developments

The use of military areas in the Dutch Continental Shelf (DCS) will most probably not change much in upcoming years. This is unknown for the other countries. Attempts have been made to get access to such information, but these have been to no avail.

In the Netherlands the policy is to train different types of defence activities and test resources, to be able to do this training grounds of sufficient size at sea are needed to ensure the national safety of the Netherlands. The aim of spatial defence policy is to ensure that sufficiently large defence areas are available for military activities in the Netherlands, including those in the North Sea. In 2004, the defence grounds were laid down for a period of ten years in the Second National Structure Plan for Military Areas. Shared use of these areas is permitted where this is compatible with military training taking place there. Reference is made to the Mining Regulations for an exact delineation of these areas (Ministerie van Verkeer en Waterstaat, 2008a).

It may also be worthwhile to consider the fact that all countries are members of the North Atlantic Treaty Organization (NATO)[10], and as such have a long history of amongst other things exercising together and sharing training facilities. On NATO's agenda are topics such as 'adapting its forces and developing new, multinational approaches to deal with terrorism, failed states and other security threats such as weapons of mass destruction'.

Based on the above it seems wise to expect the military claim for space in the North Sea area to remain constant. However as there is a need to adapt, possibilities may exist for areas of prime interest for developing OWP to be made available, as other locations may prove to be more or equally suitable for the future requirements of the military.

2.6 Sand extraction

2.6.1 Current use

Minerals are extracted from the sea bed of the North Sea; these are mainly sand and gravel. Sand extraction accounts for the bulk. Sand can be extracted from dredged navigational routes, and the shelf itself. Thus far nearly 40% of sand extracted in the Netherlands originated from dredged routes[11]. Annually around 25 million m^3 sand is extracted in the Netherlands in recent years. Nearly half of the amount of sand is for reclamation purposes, the other near half is used for beach nourishment, leaving a modest 5% or thereabout for construction sand.

In Denmark sand is extracted from the sea floor for reclamation, construction (i.e. use in building materials such as concrete) and for shore and beach nourishments. The relative proportions are not constant, but can be typified as roughly equal. The Danish sand extraction is just over 6 million m^3. Belgium also has sand extraction areas. From these a fairly modest volume of circa 1.5 million m^3 is extracted annually. It is used for either reclamation or construction.

In the United Kingdom relatively large amounts of sand (and/or gravel) are extracted, with a national annual total nearing 13 million m^3. Please note that this number includes materials extracted outside the WindSpeed study area. Material intended for construction accounts for 90% or more of the British aggregate production, some 5% is used in beach nourishment, leaving a few percent for reclamation uses.

[10] http://www.nato.int
[11] http://www.noordzeeloket.nl/activiteiten/oppervlakte_delfstofwinning/algemeen/ (in Dutch)

In Germany sand and gravel are extracted in low, but increasing, amounts with 0.8 million m^3 in 2005. Here around 15% is for construction purposes, the remaining 85% being used for beach nourishment. In Norway there is no sand extraction like in the other countries, in some years silica sands -for use in glass manufacturing- are reported as extracted from the North Sea in amounts of 0.10 to 0.15 million m^3. The numbers presented so far have been taken from Sutton and Boyd (2009). From this same source Figure 13 has been drawn, showing the irregularly increasing amount of sand extracted from the North Sea for the period 1992 thru 2005.

The major purpose of sand and gravel extracted from the seabed is for construction purposes, such as use in concrete for buildings, road building etc. However in all countries beach replenishment occurs to some extent.

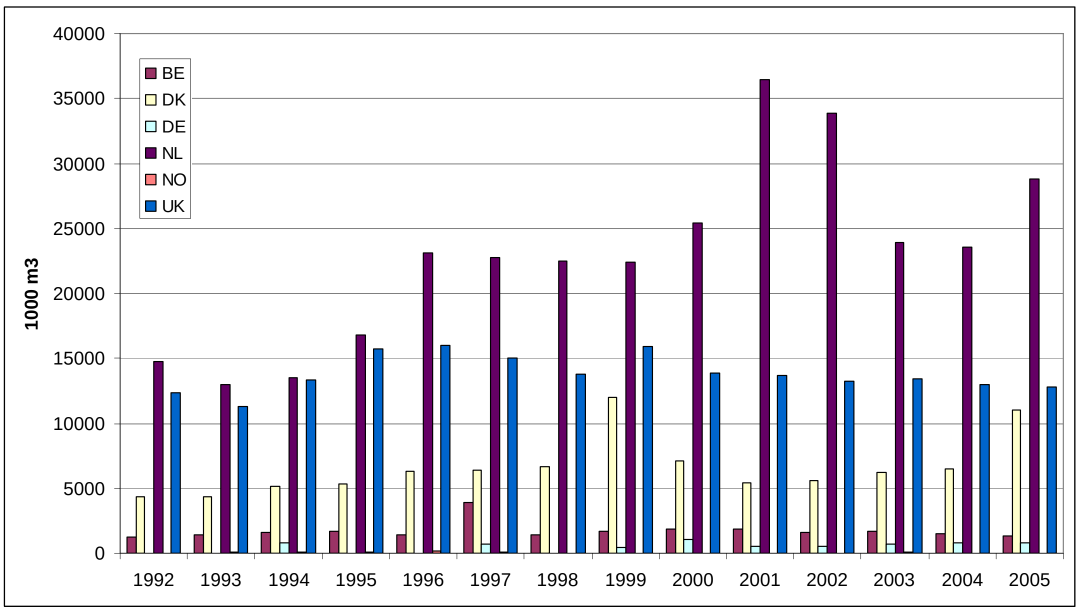

Figure 13 Sand extraction per country in the WindSpeed study area for the period 1992 thru 2005. Source: Sutton and Boyd, 2009

In Figure 14 the known sand extraction areas for Denmark, Germany, the Netherlands, Belgium and the United Kingdom are shown. In some areas the extracted material is mostly gravel. In the figure, areas with active extraction are distinguished from those with uncertain status. Uncertain status includes areas that are available for prospecting and those that have a granted permit for development or mining but are not presently active. The amount of square kilometres in use for sand extraction or dredging is given in Table 10. Expressed as percentages of the WindSpeed area sand extraction is present in 2% and dredging in 3% of the area. Dredging of navigational routes has been included in both Table 10 and Figure 14 because it provides part of the required amounts of sand extracted from the sea bed.

Table 10 Sand extraction activities and dredging (for navigational purposes) area in use (km2) and percentage of WindSpeed area

Category	Area (km2)	%% of WindSpeed area
Sand extraction	8350	2%
Dredging	12169	3%

In The Netherlands sand extraction is only permitted outside the -20 m line. This national constraint is influenced by the low lying location of the Dutch coast relative to sea level. Elsewhere coastal erosion, if and where it occurs, is of large concern but only for local communities. In the Netherlands large areas are at risk including densely populated areas.
In all cases the geological and physical characteristics of the deposits determine whether an area of sand or gravel is of interest for use as e.g. building sand. This includes not only particle sizes but also the particle size distribution. For some purposes material with a narrowly defined band of particle sizes is desirable in other cases a broad spread is what is required.

When licensing, the authorities in most countries also consider the intensity with which an area is mined and whether the licensed area is unique within the wider surrounding area. In case an area with a unique coarse type of gravel is considered for aggregate extraction, nature conservation is but one of the aspects that is considered when deciding whether an application can be granted or not. Usually a permit contains limitations regarding the area that can be mined and the volume to be extracted. The permit is limited to a number of years for which it is valid.

As sand extraction is an economical activity data has been collected to assess the possibility of assigning economical value. Data was found for Belgium (Zeegra, 2004), Germany (WBN, 2009), the United Kingdom (Highley *et al.*, 2007) and the Netherlands (Ministerie van Verkeer en Waterstaat 2008a) based on what should be the turnover. The resulting values were found to be widely different and using these figures would clearly not give a reliable valuation of economical value. The inclusion of prospective areas in the dataset on sand extraction and the question of how to properly valuate these, is further reason to refrain from pushing this topic any further.

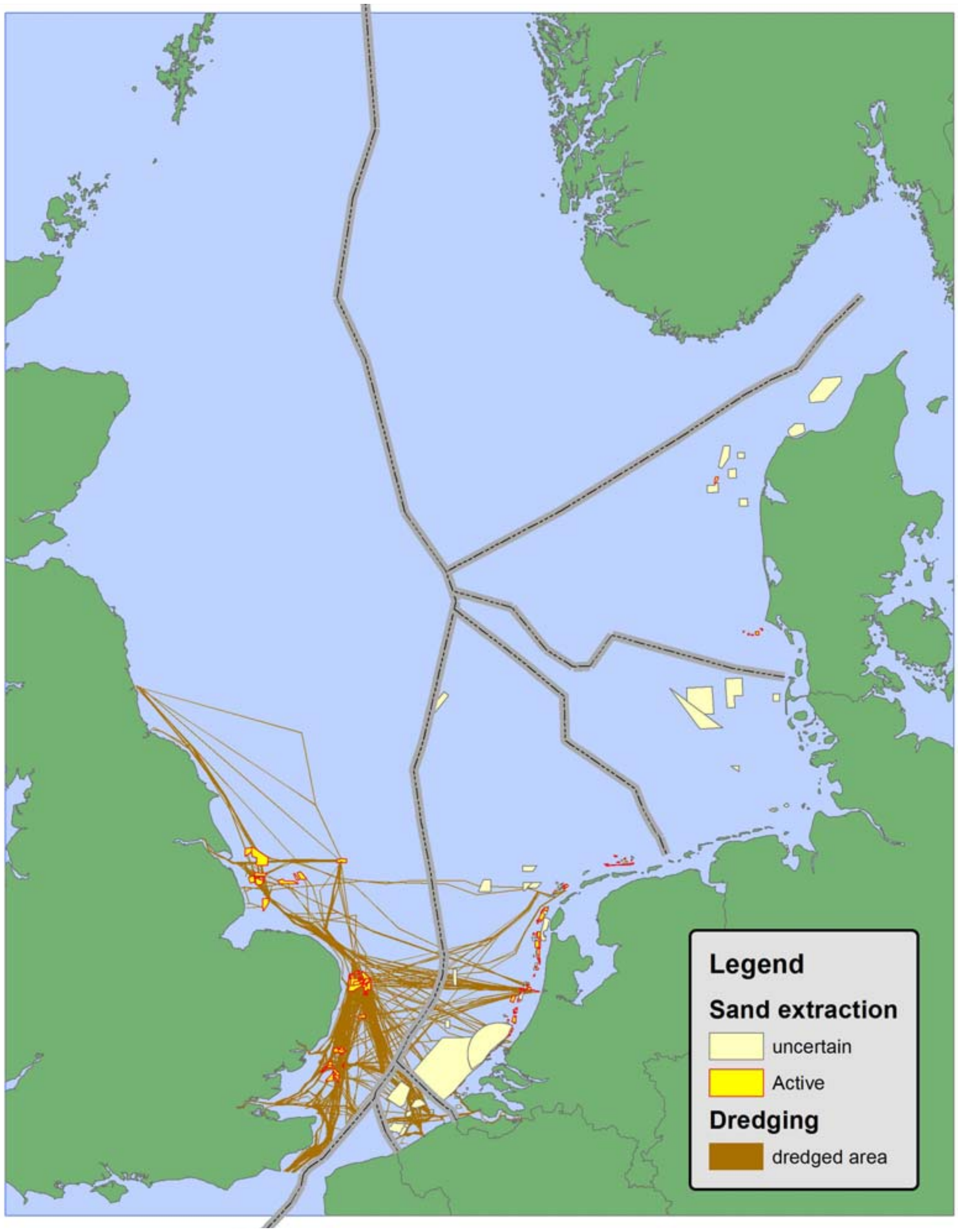

Figure 14 Sand extraction (related) areas in the North Sea, as well as areas where navigational dredging occurs.

2.6.2 Future developments

Since the planning for shore and beach nourishments are increasing, sand extraction increases as well in upcoming years. Reclamation sand needed for 'Maasvlakte 2'[12], accounts for an extra 300 million m^3 in the coming years. This equals an extraction area of $15km^2$. By 2020 the project should be finished and the increased demand for this project will have stopped. Known deposits of suitable construction sand have been identified and this area is included on the maps. However as these deposits are lying several metres deep, covered by other materials, economical extraction is only possible if the overlying materials can also be exploited e.g. as reclamation sand. Among the countries surrounding the North Sea, the Netherlands is taking the largest quantities of sand from the sea. This is approx. 25 million m^3 sand per year[11]. In 2004 the added value and production value of sea sand extraction was 11.9 and 49.7 million euro per year, respectively. In 2015 these values will have increased up to 21.1 and 91.1 million euros, respectively (Ministerie Verkeer en Waterstaat, 2008a).

In Denmark, Germany, Belgium and the United Kingdom, an increased demand for sand and gravel from the North Sea may be expected. The availability of these resources from quarries on land is likely to be limited and many may already be depleted. Also there is a steady if not increased demand for building purposes and as well as for coastal defence. Sea level rise as a result of climate change can be expected to further increase the demand for sand for coastal defence. Associated with increased trade by larger ships infrastructural works on developing new harbour facilities may also increase demand for sand. On the other hand with increased ship sizes the required depths for shipping routes will also increase. From the material dredged these routes at least some of the expected increased demand for sand (and/or gravel) can possibly be met.

Based on the above mentioned figures and a baseline yearly increase percentage of 5% is suggested. This growth rate in line the historical increase by Belgium and the Netherlands based on data from Sutton and Boyd (2009) starting in 1988 resp. 1974. It is also explainable from the following reasoning. A healthy economy is expected to grow ca. 3% on a yearly basis. On top of this the expected increase for sand extraction is adjusted upwards by 1% twice to account for the following: 1) an increased demand for marine aggregates as land-based deposits become depleted and 2) an increased demand for marine sand for coastal defence as a results of sea level rise.

Relating this estimate to historical data from Sutton and Boyd (2009) for Denmark, Germany and the UK, the picture is different for each country. In the United Kingdom sand extraction seems relatively constant since 1992 at around 13 million m^3. This constancy is the exception. In Denmark a low growth rate of around 2% matches with historical data starting in 1978. For Germany the North Sea is a relatively new area for sand extraction, as previously the Baltic Sea was preferred. Since 2001 the North Sea appears to have become an established production area for Germany and has shown a yearly growth of around 8% until 2005. Also from this data an increase per year of 5% annually is conceivably a representative value.

[12] Maasvlakte 2 is a large construction and land reclamation project where the Port of Rotterdam is extended with an area of about 20 km2, enlarging the port's capacity by around 20%. This extension is seaward or to the west from an earlier Maasvlakte project. For more information the project website can be found at: http://www.maasvlakte2.com/en/index/.

2.7 Radar interference

2.7.1 Current use

Interference of wind turbines with radar systems both for civil and military aircraft is an issue across the WindSpeed study area. For the UK detailed maps are available on this topic. Also shore-based and ship-side navigational radar systems are susceptible to radar interference. On the other hand improvements made in radar technology have helped to decrease the severity of the problem and also other mitigation options are possible e.g. by having additional radar systems installed to improve the capability of e.g. air traffic controllers to ‘see’ behind wind turbines.

Figure 15 shows the British radar interference data for wind turbines with a blade tip height of 140 metres. This is the largest size for which NERL plc has performed calculations and has been selected for this map as this is closest to the size of wind turbine used in offshore wind energy developments identified by WindSpeed. The actual size and shape of the interference areas is an interaction between the location of the radar installation in the landscape and the position of the wind turbines. There is no easy method of estimating this for the other countries without detailed knowledge of the radar infrastructure.

2.7.2 Future developments

As already stated, radar interference by wind turbines is an issue where technological progress has been made in recent years. The extent to which this still needs to be an issue is therefore debatable. The safety concerns should however be taken seriously. After all not only does this touch the safety of members of the public travelling by airplane or ships, it also touches on matters of national security and defence. Also the safety of workers in the offshore oil and gas industry who are routinely transported to and from their places of work by helicopter needs to be considered with regard to radar interference.

Air traffic and shipping are activities that are expected to increase in the future. Resulting from this an increased need for accurate and reliable surveillance by using radar and other observation techniques is to be expected.

When siting OWP attention should be paid to reduce conflicts with radar systems as much as possible.

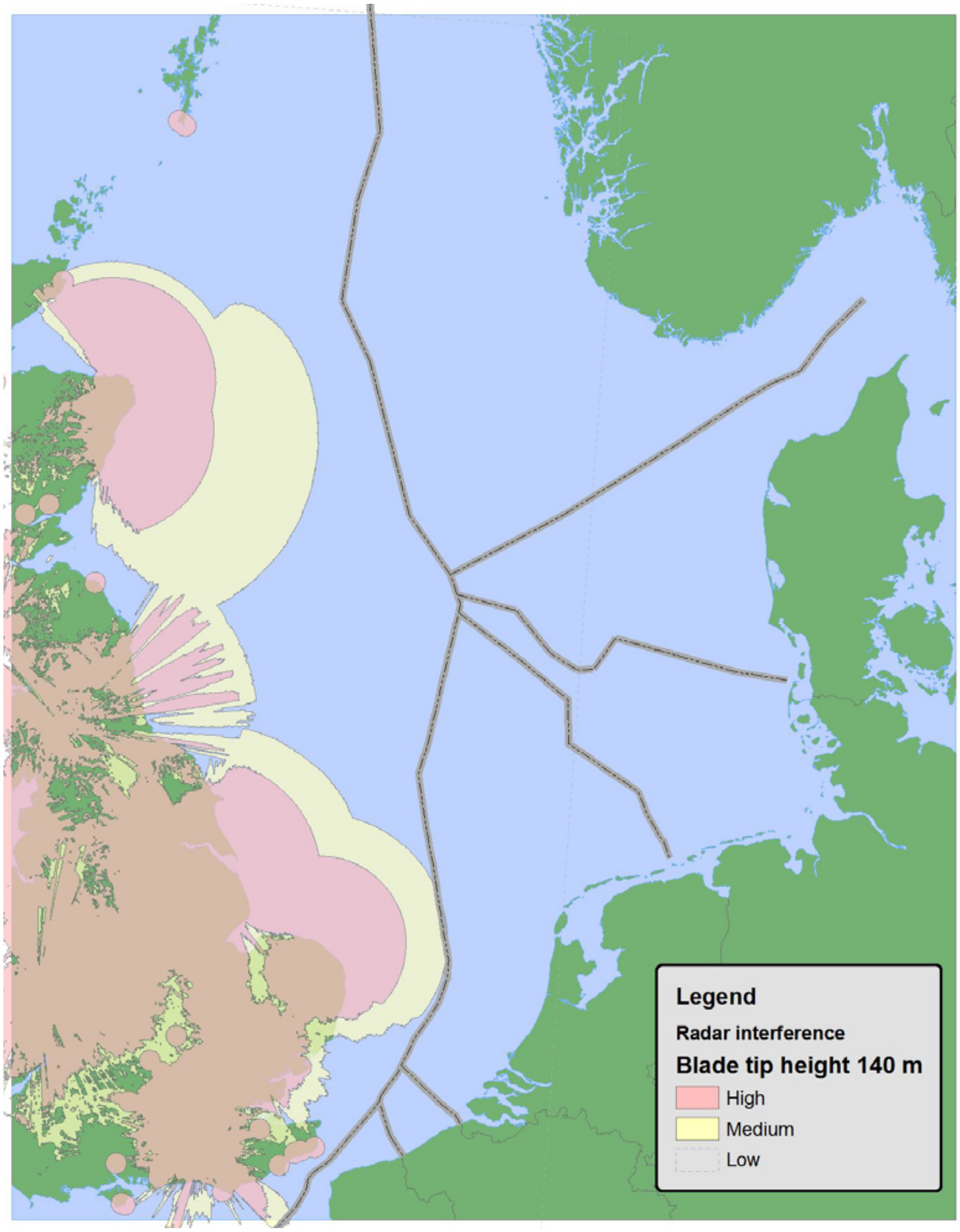

Figure 15 Map showing the areal extent of radar interference from wind turbines with a blade tip height of 140 m. for the United Kingdom.

2.8 Nature conservation

2.8.1 Marine ecosystem

The North Sea is a highly complex and open marine ecosystem, shallow and rich in nutrients. The area is a breeding ground for fish and important as a migratory route and wintering place for several species of bird. There is a growing concern about the effect of increased human activity on the marine ecosystem. Marine biodiversity is under increasing pressure, and natural resources are being depleted and special attention is being paid to growing spatial pressures.

In the next sub sections attention is given to important representatives of the marine ecosystem: protected areas, sea birds, sea mammals, fish and benthos.

2.8.2 Marine protected areas

For nature conservation in the marine environment all countries have designated sea areas that should be treated as some type of reserve. The actual regime (what is protected by what measures and/or restriction) may differ between the countries even where the reasons for designation are the same and often based on European legislation.

The two most important pieces of European legislation relating to nature conservation are the Habitats Directive and the Birds Directive. Member States are required to implement these directives in national legislation. A Special Area of Conservation (SAC) is an area designated for reasons outlined in the Habitats Directive. A Special Protection Area (SPA) is based on the Birds Directive. These SAC and SPA may overlap and together underpin a European network of protected areas known as Natura 2000. Countries can also protect additional areas by national laws.

A compilation of nature conservation areas, both designated and proposed, within the WindSpeed study area is given in Figure 16. The total area of sea covered is 106000 km^2 or 23.6 % of the WindSpeed area. The level of protection already in place in the Wadden Sea is such that it should be regarded as a No-Go-area for OWP.

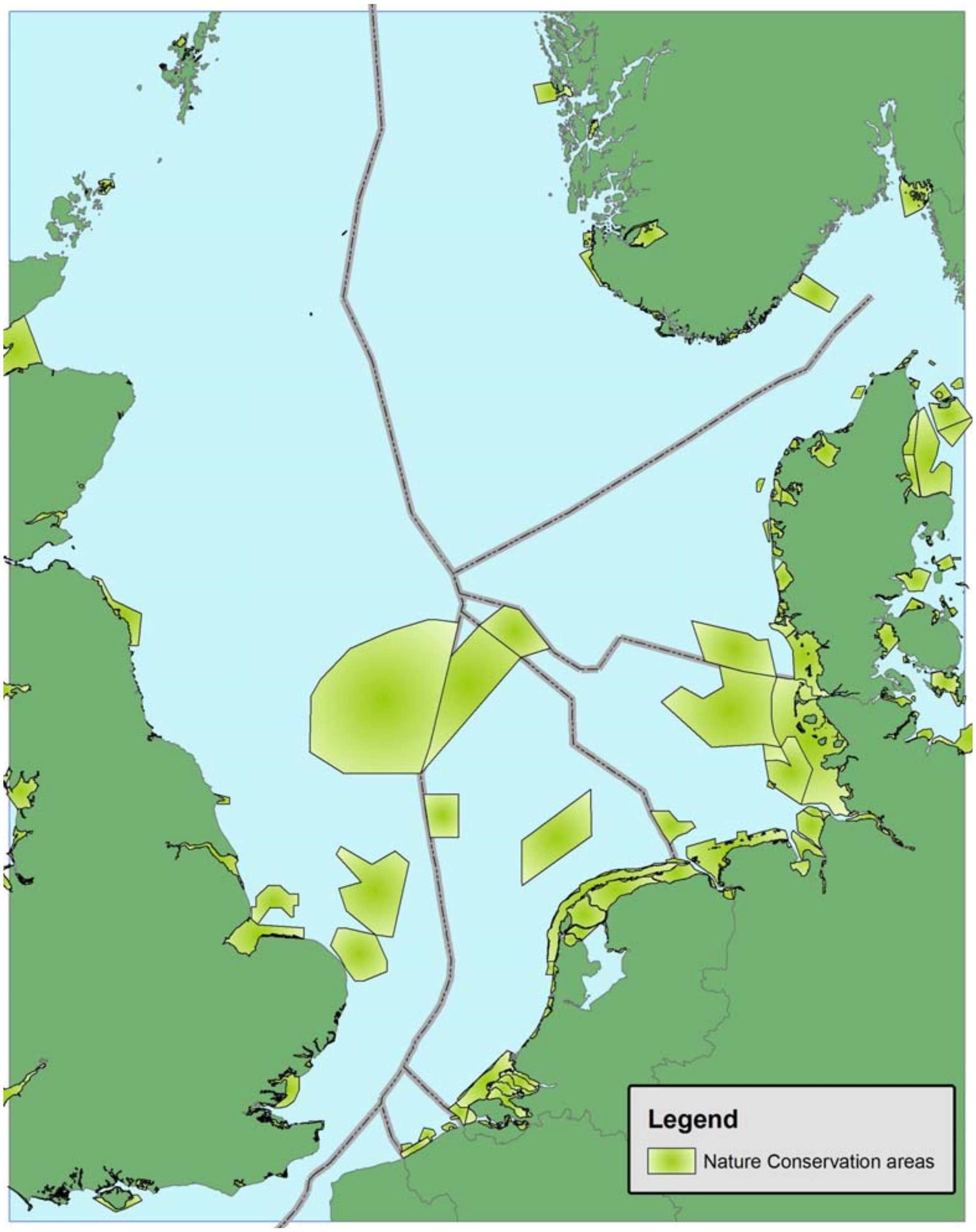

Figure 16 Nature conservation area

2.8.3 Sea birds

Impacts of OWP on birds depend on their location on the North Sea and will vary depending on the time of year. The majority of the sea bird species are much more abundant near shore than further away from the coast. A bird-OWP vulnerability map for the entire Central and Southern North Sea will be developed within the project. For the North Sea region along the Dutch coast such a map has already been developed.

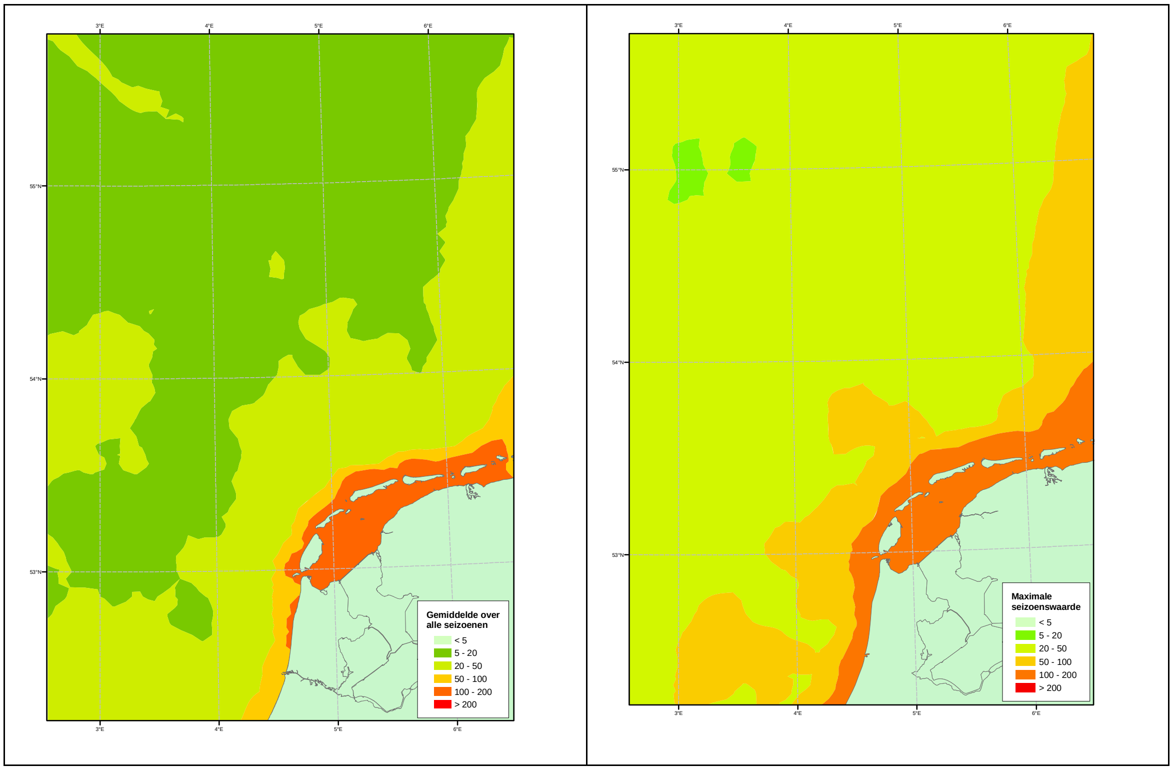

Figure 17 Exampled of bird value maps for the Dutch part of the North Sea (left side: average values across all seasons; right side: maximum values over the year).

Work is progressing towards achieving a map of the WindSpeed study area similar to what can be seen in Figure 17. The method employed builds on work by Garthe S. & O. Hüppop (2004) and combines a species-specific wind turbine sensitivity index (WTSI) with count data on the number of birds present in an area. The WTSI has already been calculated for the 33 most numerous species in the Dutch sector of the North Sea, and takes nine factors into account:

A manoeuvrability in the air
B usual flight height of a species
C amount of time spent flying
D a measure relating to how active a species is during the night
E sensitivity to disturbance by ships
F a measure for a species flexibility regarding choice of habitat/area
G total biogeographical population size
H normal survival rate for adult birds
I status according to “European Threat and Conservation Status” (Tucker and Heath, 1994).

2.8.4 Sea mammals

The group of sea mammals includes the following species:

- Common seal (*Phoca vitulina*),
- Grey seal (*Halichoerus grypus*)
- Harbour porpoise (*Phocoena phocoena*).

These three species are relatively common and are well-studied (to some extent) within the WindSpeed area. Other whales and dolphins do occur within the area, but most of these only stray into the North Sea on an irregular basis. With the possible exception of the Minke whale (*Balaenoptera acutorostrata*); these other species are too rare to be included in the WindSpeed study. On the Scottish coast otters (*Lutra lutra*) are active along the seashore in some areas. These animals however appear to occur mostly on the western coast of Scotland, outside the WindSpeed study area.

As an example of the distribution and density of two of these species maps derived from the OBIS-Sea map-database (dating back to 1994) are given in Hammond *et al.* (2002). These maps are presented in Figure 18. Please note that the Harbour porpoise has shown a more southerly distribution in recent years.

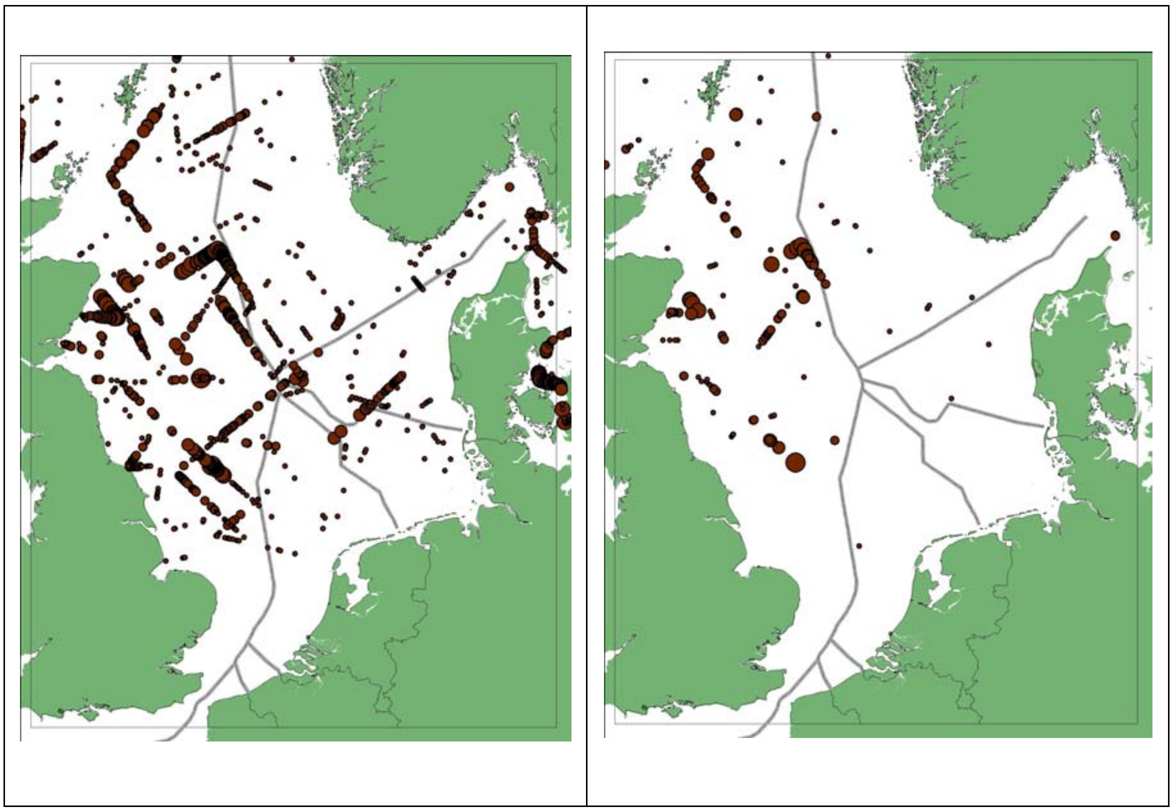

Figure 18 Distribution of Harbour porpoise (Phocoena phocoena) (left) and Minke whale (Balaenoptera acutorostrata) in the North Sea area (Hammond et al., 2002)

2.8.5 Fish

To assess which areas of the North Sea are of more value for fish from an ecological point of view, we have opted for maps based on several years of surveying fish species with benthic gears as reported in Ter Hofstede *et al.*(2005) who focussed on 'natural value'-maps for fish.

The first map (Figure 19) is a map showing species richness, where the number shown has been standardised to account for different levels of sampling density across the North Sea.

The result is a striking pattern, where the Scottish waters, the south-eastern North Sea and the Skagerrak/Kattegat area clearly show a higher number of fish species than the eastern part of the northern and central North Sea. Real hotspots with over 50 species occur at the entrance of the Skagerrak, close to the English coast and near Scotland. The central part of the North Sea around the Doggerbank is relatively poor in species.

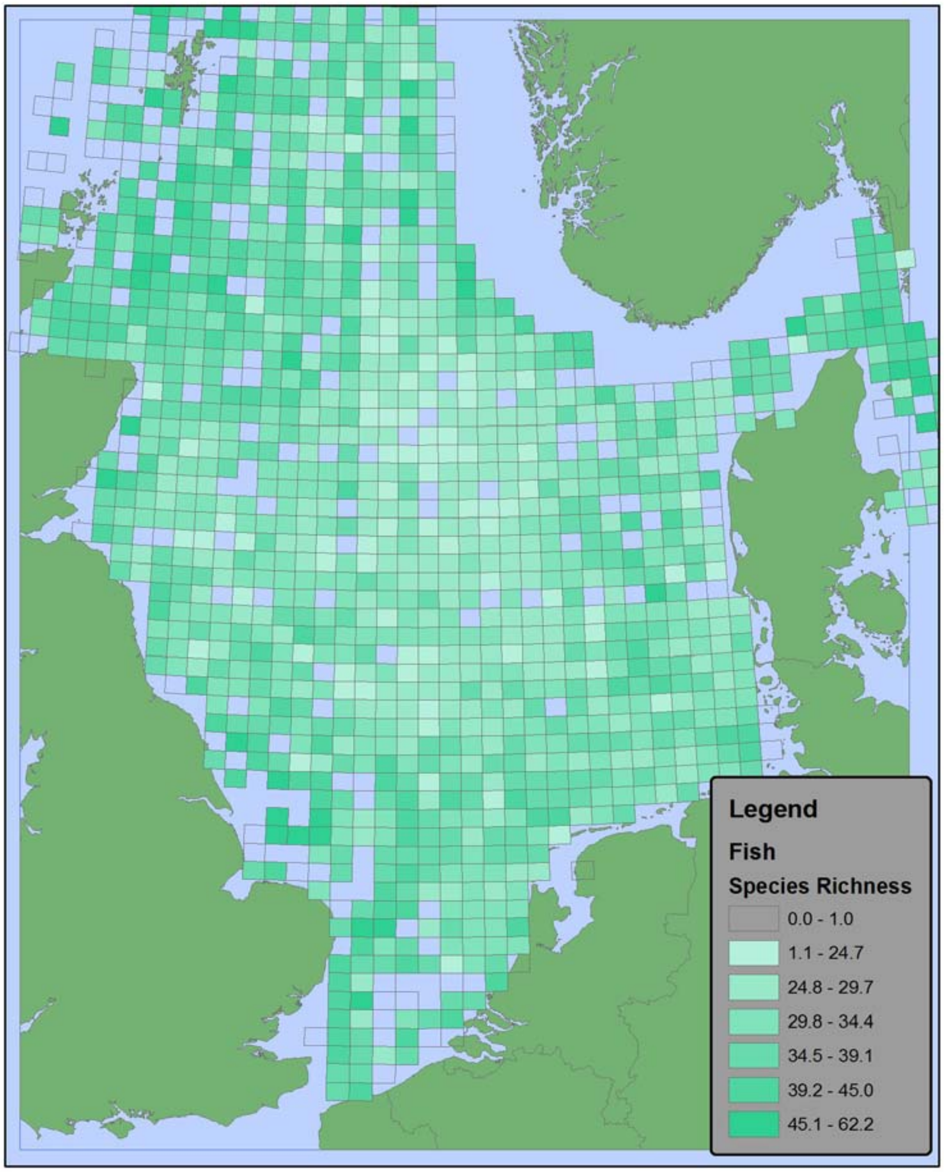

Figure 19 Species richness for fish

The second map (Figure 20) attempts to visualize rareness of fish species. Since the concept of rareness combines two very different aspects: numerousness and geographic limits to a distribution, it can be cumbersome to depict properly and it is prone to artefacts. The values shown in the map are specific for both the total number of species (i.e. 91) and the location. Each cell is given a value representing its contribution to the accumulated rareness across the entire area. The sum of all squares is one thousand. A higher value signifies that higher numbers of rare species have been caught in a location relative to the rest.

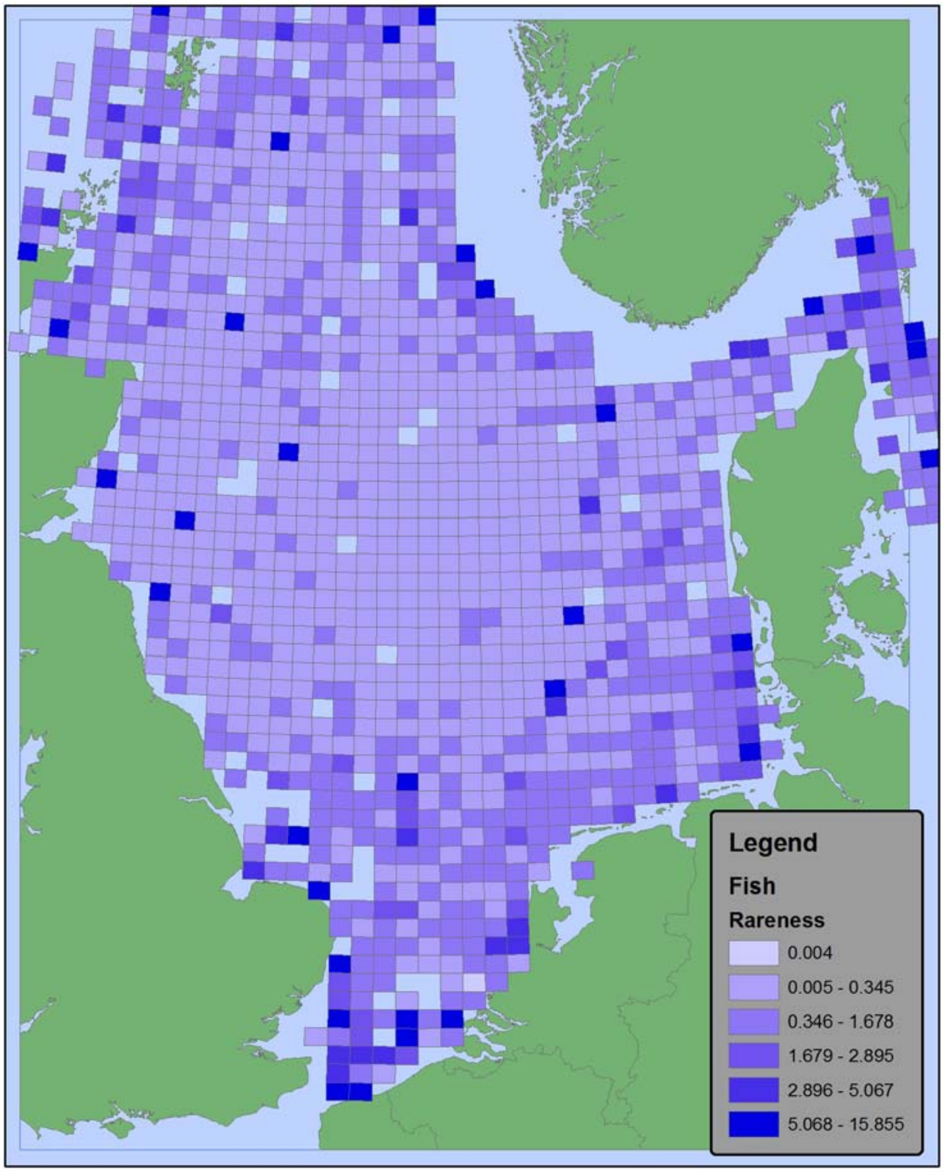

Figure 20 Rareness of the fish community

Rare species are mainly found in the southern North Sea, in the northern Scottish waters, in the Kattegat and along the continental shores. A possible explanation for this patterns is that species that are ‘rare’ for the North Sea as a whole are actually occurring at the edges of their natural distribution, which is mainly located outside the North Sea. Southern species could be rarefying the fish community towards the English Channel whereas northern species do so at the northern edge. Similarly relatively high scores for rareness along the coast may arise from the local occurrence of coastal species. These species need not be exceptionally rare within their coastal distribution, but are so on the scale of the whole North Sea.

2.8.6 Benthos

For the benthic communities occurring in the WindSpeed area, a mosaic map of the area has been implemented (Figure 21). It combines data from the MESH-study for EUNIS level 3 habitat map (Coltman, Golding and Verling, 2008) units with predicted habitats map generated as part of MESH for the EEZs of Belgium (Degraer *et al.*, 2008) and the Netherlands (Van der Wal *et al.*, 2010). The MESH study area overlaps with WindSpeed for the British, Belgian and Dutch sectors of the North Sea. For the German sector a similar predicted habitat map by Pesch *et al.* (2008) is available and has been used. For the United Kingdom the Seabed Landscape map (Connor *et al.*, 2006) was also taken into account. For the Danish and Norwegian sectors no habitats maps were identified. Here a more broad scale map from the North Sea Benthos Program was relied upon (Rees *et al.*, 2007). Also considered in this map is a published map on different water masses that can be distinguished within the North Sea (Ehrich *et al.*, 2009). As the nature of the substrate (hard or soft, coarse of fine) has a strong influence on benthic community composition, a seafloor geology map (OSPAR Commission, 2009) has also been included as a good proxy for assessing benthic biodiversity. The WindSpeed project may choose to update the present benthic value map when improved or new data becomes available at a later stage in the project.

The map as shown in Figure 21 shows the lowest benthic value, in the sandy and shallow waters along the eastern side of the North Sea. Here the sandy sediment and generally high dynamics resulting from tidal currents and wind driven waves (from storms) disturbing the sea floor is limiting biodiversity. Judged to have somewhat higher value is the central North Sea, to the north and west of the Dogger Bank. Here sandy sediments are also prevalent but with larger water depths the disturbance of the sea floor is lower. High values are awarded to the area from the English Channel north along the coast of southern England, the Dogger Bank area and an area just north of Scotland. Here conditions combine in different ways, but in each location this does result in higher biodiversity than elsewhere. The highest category is awarded to an area covering the Oyster Grounds and surrounding areas with silty sediments and an area with similar bottom conditions (though deeper) between Scotland and Norway. The Norwegian trench which has silt or clay as sediment is not included in this highest category. The large depth and associated low temperature near the bottom are thought to be of higher impact on the biodiversity than the sediment type and therefore it is included in the medium benthic value category.

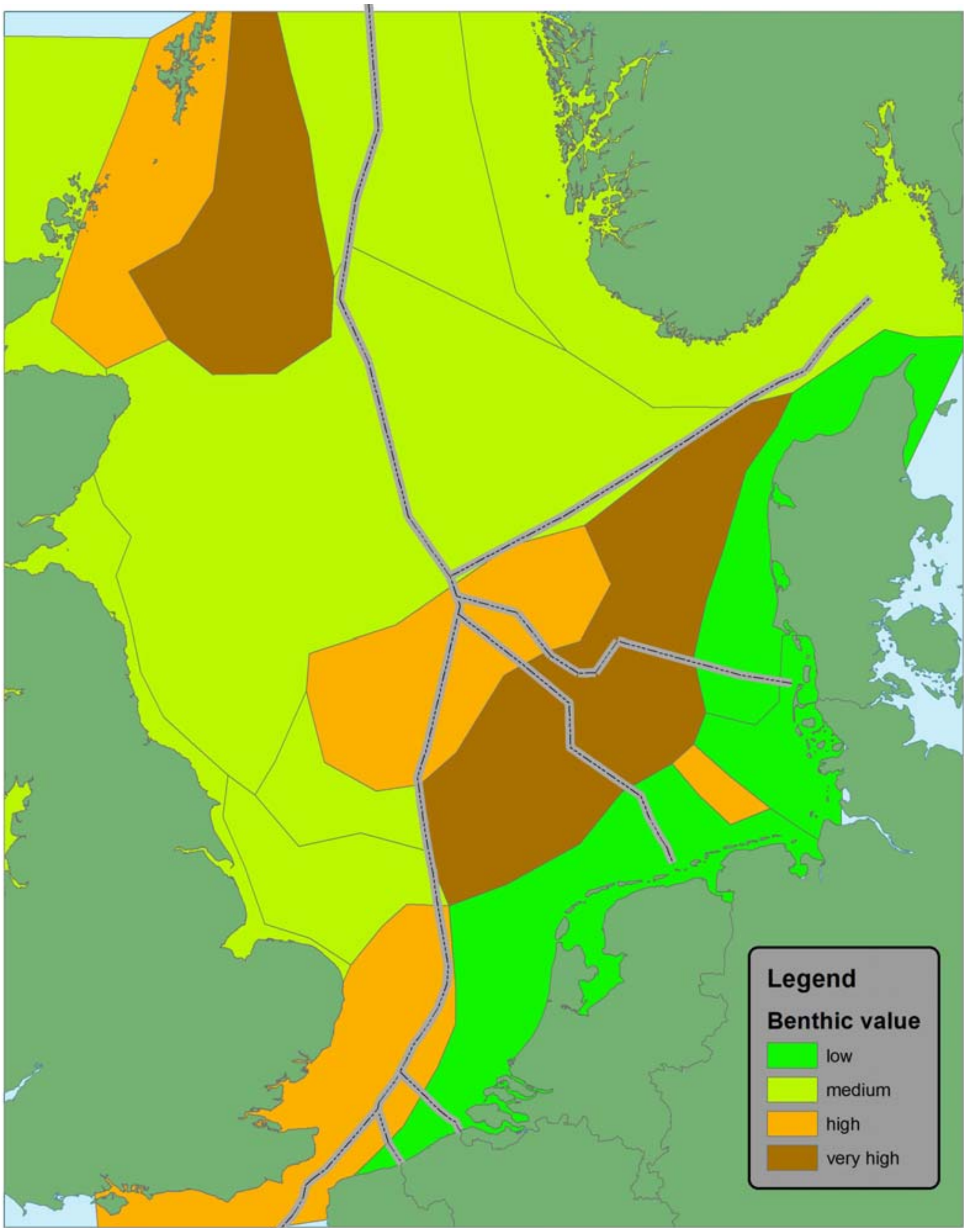

Figure 21 Map showing benthic value across the WindSpeed area in four classes

Although coarse this map is thought to suffice as benthic communities tend towards less diversity in colder and deeper water (ICES 2004). Another factor to take into account is the fact that also benthic species are mobile. A community encountered in one location in one year may not be present there the next, even when the adult animals only have limited capabilities for movement, the larvae of nearly all species are pelagic for at least some days and will travel with tidal and wind driven currents.

The sustainable development of the marine system is formulated in the 'Blue Book' An Integrated Maritime Policy for the European Union (EC, 2007), and the sustainability of the Common Fisheries Policy (EC, 2009), in addition to areas designated pursuant to the Bird and

Habitats (incl. Natura 2000). The Marine Strategy Framework Directive came into force in 2008 and follows the regulations and commitments of OSPAR, and obliges member states to achieve a sustainable balance between economic growth and ecology of the marine system. Key premises are the precautionary principle and the ecosystem approach. Marine spatial planning is regarded as an important tool for arriving at a sustainable use that is in balance with the marine ecosystem (Ministerie Verkeer en Waterstaat, 2008a).

2.8.7 Future developments

The present dataset already includes a number of nature conservation areas that are presently not officially designated. Some areas have already been proposed, while others are only in a draft stage. By already making these areas part of the WindSpeed dataset on nature conservation, we have already taken most of the possible future development into account. The Natura 2000 network is based on both the Birds Directive and the Habitats Directive, both of which may undergo future adaptation e.g. to include more marine species or habitats. As a result additional marine protected areas (MPA) may be designated in the future, to extend the Natura 2000 network.

2.9 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.

A very important result of the workshops has been that although general rules apply to the marine spatial planning of OWP, these are not set in stone. Most often when a specific OWP is planned somewhere, negotiations are opened with third parties to find an optimal solution for that particular OWP. Unfortunately this does not help the WindSpeed project much; such outcomes are unpredictable and cannot be implemented in calculation rules and the DSS.
The best aim is for a tool with general rules that identifies good locations where OWP could be developed. This helps to get the bigger picture. Hopefully the outlined process of negotiation will help to develop allocate more space to OWP than calculated using the DSS as additional room may be found at that later stage.

3 Conclusions

This report is the first of three deliverables and gives an overview of non-wind sea use functions and their future development upto 2030. The remaning deliverables are an analysis of positive and negative interactions between offshore wind and other use functions (Van der Wal *et al.*, 2009) and 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.

Many datasets have been identified and collected for the non-wind sea use functions. The data availability was very different for each of the countries, though in most cases the project was successful. It turned out that the information available in the national datasets was very different, and not standardized. This led to an unforeseen extra effort to make the collected data usable for the DSS: harmonizing the datasets so they all can be combined into a final dataset where for all countries the same information is available for each feature. Here a feature is terminology denoting e.g. a nature conservation area or an oil platform.

In a number of cases the available datasets possibly need to be extended. This means that the present information on features is insufficient to be able to apply all desired calculation rules or refinements thereof. One example are the oil and gas platforms. It appears desirable to have knowledge of which platforms are normally manned and which have a helipad. E.g. if all manned platforms have a helipad this can be used when adding this information to the datasets. Such information is useful as helicopter access to a platform requires a wider area free of obstruction than is the case for shipping.

The description of future developments is feasible without quantifying them exactly; however adding quantitative growth rates is much more difficult. To develop scenarios, assumptions have to be made and described. From these basic assumptions scenarios can be developed. Starting out with a 'realistic' estimate a base case can be defined, after which optimistic and pessimistic values can also be applied.

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 have stronger claims on space at sea than OWP do:

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

Only shipping lays claim to a large area. However also oil and gas extraction may turn out to also claim a large area. This depends on the number of platforms that require helicopter access, with an exclusion range of ca. 5 nautical miles covering nearly 300 km^2 for a single platform. In relation to Military Use, the outcome is difficult to predict. Historically and politically the requirements of the armed forces for areas to practice have been very highly regarded. In the present day the threat of terrorism and the increased occurrence of acts of piracy help to strengthen such claims. It remains to be seen whether offshore wind energy is perceived by society and politicians as sufficiently attractive and rewarding as a source of renewable energy to be successful in laying claim to areas presently in use by the armed forces. Displacing military use to other locations will give rise to new conflicts with other sea use functions. On the other hand recent changes in the role of the military may also mean that they have new requirements. Requirements that may mean that they require less space at sea or that other area can be selected that better suits their purposes.

With respect to fisheries and sand extraction calculation rules based on economical value generated by these activities can be applied. As such a fair method of weighing these activities against each other can be made. Fisheries have been decreasing considerably over the last decade (and longer) and are expected to decrease even further in the future. The majority of commercial fish stock is still being overexploited and less fisheries is the only way to resolve this. Van Densen (2009) points out that for the North Sea fisheries management has been successful. On the basis of this only moderate decreases in fisheries are foreseen for the North Sea in the future. With a decreasing fishery, the availability of fish on the market may drop, which may financially offset the outcome as it will probably push fish prices up. Here the complexities of fisheries policies comes into view, because to effectively protect fish stock from overfishing measures must be in place to prevent increased fish stocks and/or fish prices to attract new fishing vessels.

Sand extraction is another 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 Sources of data

4.1 Shipping

Shipping route data has been collected and collated for the complete WindSpeed area, based on data supplied by the following agencies/authorities:

- United Kingdom
  Anatec UK Ltd (www.anatec.com) by way of Garrad Hassan (ww.garradhassan.com)
- Germany
  Bundesamt für Seeschiffahrt und Hydrographie / Federal Maritime and Hydrographic Agency (www.bsh.de) CONTIS or Continental Shelf Research Information system
- Netherlands
  Rijkswaterstaat, as part of the Ministry of Transport Public Works and Water Management (www.noordzeeloket.nl in Dutch)
- Belgium
  Beheerseenheid van het Mathematisch Model van de Noordzee / Management Unit of the North Sea Mathematical Models (www.mumm.ac.be)
- Norway
  Kystverket / Norwegian Coastal Administration (www.kystverket.no)

These datasets have been combined into a harmonized dataset for WindSpeed. Based on the web mapping service (WMS) available from the German authorities BSH, IMARES is confident that no major shipping routes are missing for Denmark.

Data on shipping density (or intensity) was available for the Netherlands (source: Rijkswaterstaat). This datasets has insufficient cover of the WindSpeed area. Garrad Hassan has supplied a more recent dataset covering the WindSpeed area, by contracting Anatec Ltd.

4.2 Oil and Gas extraction

Data is available the following countries and agencies/institutions is used:

- Norway
  Oljedirektoratet / Norwegian Petroleum Directorate (www.npd.no)
- Denmark
  Farvandsvandsvæsenet / Danish Maritime Safety Organisation (www.frv.dk) and Kort- og Matrikelstyrelsen / National Survey and Cadastre (www.kms.dk)
- United Kingdom
  Crown Estate (www.crownestate.co.uk) and Department of Energy and Climate Change , Oil and Gas (DECC Oil and Gas, www.og.decc.gov.uk)
- Netherlands
  Rijkswaterstaat, as part of the Ministry of Transport Public Works and Water Management (www.noordzeeloket.nl in Dutch)

The Dutch dataset also covers the German sector. This has been verified with the web mapping service (WMS) of the BSH.

4.3 Fisheries

Restrictions to data use

The data can only be used for making effort maps in the WINDSPEED project. It is not allowed to use them for other purposes. All institutes that provided data for the fisheries maps should be mentioned where the data are presented and in the acknowledgements of the present report:

- Germany
  Johann Heinrich von Thünen-Institut / Federal Research Institute for Rural Areas, Forestry and Fisheries (www.vti.bund.de)
- Scotland
  Fisheries Research Services, since 01-04-2009 part of Marine Scotland, a Directorate of Scottish Government (www.scotland.gov.uk/marinescotland)
- England & Wales
  Centre for Environment, Fisheries and Aquaculture Sciens (Cefas, www.cefas.co.uk)
- Belgium
  Instituut voor Landbouw- en Visserijonderzoek / Institute for Agricultural and Fisheries Research (ILVO, www.ilvo.vlaanderen.be)
- Denmark
  Danmarks Tekniske Universitet, Institut for Akvatiske Ressourcer / Technical University of Denmark, National Institute for Aquatic Resources (DTU-Aqua, www.aqua.dtu.dk)
- Norway
  Havforskningsinstituttet / Institute of Marine Research (IMR, www.imr.no)
- Sweden
  Fiskeriverket / Swedish Board of Fisheries (www.fiskeriverket.se)
- Netherlands
  Institute for Marine Resources & Ecosystem Studies (IMARES, www.imares.wur.nl)

4.4 Cables and pipelines

Regarding cables MUMM has released data for Belgium and Rijkswaterstaat has a dataset that covers the Dutch part as well as the German and Danish sectors. Also the British sector appears to have some cover. However there is a clear scarcity of cables in the northern British waters. In the Norwegian sector some cables come to an end well away from shore and another data gap is apparent. An additional source of data on the location of cables has been found. This is the Kingfisher program for the United Kingdom and an associated program on cable awareness for fishermen for Denmark. From these programs dataset are available e.g. on CD for use with navigation systems. By conversion of these datasets the missing cables have been added to the WindSpeed dataset.

- Belgium
  Beheerseenheid van het Mathematisch Model van de Noordzee / Management Unit of the North Sea Mathematical Models (www.mumm.ac.be)
- Netherlands
  Rijkswaterstaat, as part of the Ministry of Transport Public Works and Water Management (www.noordzeeloket.nl in Dutch)

- Germany
  Bundesamt für Seeschiffahrt und Hydrographie / Federal Maritime and Hydrographic Agency (www.bsh.de) CONTIS or Continental Shelf Research Information system
- United Kingdom, Denmark
  Kingfisher Information Service – Cable Awareness (www.kisca.org.uk)

Data available on the location of pipelines is available from the following sources:

- Norway
  Oljedirektoratet / Norwegian Petroleum Directorate (www.npd.no)
- Denmark
  Kort- og Matrikelstyrelsen / National Survey and Cadastre (www.kms.dk)
- Germany
  Bundesamt für Seeschiffahrt und Hydrographie / Federal Maritime and Hydrographic Agency (www.bsh.de) CONTIS or Continental Shelf Research Information system
- United Kingdom
  Data received via Garrad Hassan (www.garradhassan.com)
- Belgium
  Beheerseenheid van het Mathematisch Model van de Noordzee / Management Unit of the North Sea Mathematical Models (www.mumm.ac.be)
- Netherlands
  Rijkswaterstaat, as part of the Ministry of Transport Public Works and Water Management (www.noordzeeloket.nl in Dutch)

4.5 Military use

For military use data was available from three different sources:

- Rijkswaterstaat which provides some knowledge not only for the Dutch sector, but also has data on the other countries within the WindSpeed study area.
- A UK (Ministry of Defence via Garrad Hassan) dataset adds some exercise areas east of the Thames Estuary and in the Firth of Forth.
- A dataset for Belgium (MUMM) adds a number of areas used for military purposes in the Belgian sector.

For Germany, Denmark and Norway no national datasets have been collected so far. Based on the experience with the UK and Belgium it would seem probable this having such datasets available will increase the number of areas that are used for military exercise. Coverage of the German EEZ regarding military uses should be relatively accurate. The WMS-service of the BSH showed large areas designated as having several types of military use and this source of data was used to digitize these for use in the WindSpeed project.

- Netherlands
  Rijkswaterstaat, as part of the Ministry of Transport Public Works and Water Management (www.noordzeeloket.nl in Dutch)
- United Kingdom
  Data received via Garrad Hassan (www.garradhassan.com)

- Belgium
  Beheerseenheid van het Mathematisch Model van de Noordzee / Management Unit of the North Sea Mathematical Models (www.mumm.ac.be)

4.6 Sand and gravel extraction

The data presented has been gathered from MUMM for Belgium, Danmarks Miljøundersøgelser, Aarhus Universitet and By- og Landskabsstyrelsen, Miljøministeriet for Denmark, BSH-Contis for Germany and Rijkswaterstaat for the Netherlands. Only for the Netherlands is it clear which are the currently active areas. For Belgium and Denmark the data should interpreted as the maximum extent of sand extraction in these countries. In the case of Denmark some areas may also be available for extraction of coarser material (gravel, cobble or boulder).

Sand (and gravel) extraction are also known to take place in the British section of the North Sea, but presently no datasets have been identified. Some statistics and visual material is available from the Crown Estate (www.thecrownestate.co.uk/marine_aggregates) as well as the British Marine Aggregate Producers Association (www.bmapa.org).

- Belgium
  Beheerseenheid van het Mathematisch Model van de Noordzee / Management Unit of the North Sea Mathematical Models (www.mumm.ac.be)
- Denmark
  Danmarks Miljøundersøgelser, Aarhus Universitet / National Environmental Research Institute, Aarhus University (www.dmu.dk) and By- og Landskabsstyrelsen, Miljøministeriet / Agency for Spatial and Environmental Planning, Ministry of the Environment (www.blst.dk)
- Netherlands
  Rijkswaterstaat, as part of the Ministry of Transport Public Works and Water Management (www.noordzeeloket.nl in Dutch)
- Germany
  Bundesamt für Seeschiffahrt und Hydrographie / Federal Maritime and Hydrographic Agency (www.bsh.de) CONTIS or Continental Shelf Research Information system

4.7 Radar interference

A GIS dataset is available for the United Kingdom from the website of the British Wind Energy Association (BWEA, http://www.bwea.com/aviation/nats.html); it has been made available by the NATS En Route PLC. This company is responsible for the safe and expeditious movement in the en-route phase for aircraft operating in controlled airspace in the UK.

5 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.

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

Signature:

Date: 09-12-2009

Approved: J.H.M. Schobben MSc.
Head of the Department of Environment

Signature:

Date: 09-12-2009

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