Concerted action for offshore wind energy deployment (COD)

Overview of Environmental Impacts of Offshore Wind energy

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1 Introduction and Methodology

This report contains draft conclusions and recommendations from the overview on environmental issues of offshore wind energy.

1.1 Background

Eight European countries are undertaking a Concerted Action for Offshore Wind energy Deployment (COD), EC NNE5-2001-00633. The objective of this Concerted Action is to speed up the environmentally responsible implementation of offshore wind energy in the European Union by an early identification and possibly removing of non-technical barriers: legal, administrative, policy, environmental and grid infrastructure planning issues.

These non-technical issues need to be resolved to enable offshore wind energy to contribute to the EC's strategic goals and Kyoto objectives. The project aims to provide a harmonised European Offshore Wind Energy process for deployment, environmental impact analysis and for permission procedures for Offshore Wind Energy Farms.

One of the milestones and expected results of the project is a Harmonised Working Methodology (in the form of guidelines or standardised procedure for environmental impact assessment (EIA)) of offshore wind farms in the participating countries. In order to develop these guidelines publications on the environmental issues are collected and an overview is given.

This report is the result of an analysis of all publications on the environmental impacts of offshore wind parks, which have been collected and inserted into a database by the members of the COD working group.

1.2 Questions addressed

The idea behind the overview is to unveil and compare the already available body of reports on Environmental Research of offshore wind energy in a structured way. In this overview the following questions will be addressed:

- What kinds of studies have been published until now? (Chapter 2)
- What baseline studies have been done and what methodologies have been studied? (Chapter 3)
- What are the impacts of Offshore Wind Farms? (Chapter 4)
- What can be concluded from the reports in the database (Chapter 5)
- What recommendations are possible up to now? (Chapter 6)

Chapter 5 contains recommendations for the environmental research method to be used to obtain the most unequivocal results, the need-to-know information for baseline and effect studies for a good Environmental Impact Assessment and which environmental issues should be studied on a European rather than national scale in order to give reliable results and to optimise the use of available budget.

1.3 Structure of the database

The database has been designed in cooperation with the TU Berlin

The following explanations of database–terms enable a standardized analysis and a harmonised understanding of the outcome of relevant publications in the participant countries[1]. They are meant to help the participants to fill the appropriate information into the appropriate field of the database.

- **Potential influencing factors (of offshore wind farms).** A potential influencing factor can be viewed as a factor or some kind of stressor that may change or affect the environment. Potential disturbing factors result from the construction and operation of the wind farms. They can affect the environment; respectively they can affect the identified "subjects" (and thus "potential influencing factors" can cause environmental "impacts"). Examples for "potential disturbing factors": *noise/vibration (including sub-sea noise), barrier effects, visual intrusion (day-night), electromagnetism, sedimentation / turbidity, disturbing effects of construction/maintenance traffic* and *other*.
- **Subjects (of marine ecosystems)**. Subjects are those components of the marine ecosystem/environment which are potentially affected by the construction and operation of the wind farms. The selection of the relevant subjects is related to the specifications of the EIA-Directive and the kind and character of the projects. In the database under "subjects studied" are listed: *marine mammals, birds, bats, fish, zoo- and phytobenthos, soil/seabed, water (e.g. quality, flow), visual landscape, men (e.g. coastal inhabitants, tourists, etc.)* and *other*.
- **Environmental impacts:** Environmental impacts reflect how the environment (or the "subjects") changes after being affected by the "potential disturbing factors" (which are caused by the construction and operation of the wind farms). For example impacts could be: *the impairment/loss of the hearing ability of marine mammals*, *collisions of birds/bats*, *the habitat loss of a species, an change of the mortality rate of benthos species because of the coverage with sediments, changes in the migratory paths of birds, changes in the flight patterns, increasing risk of ship collisions (including follow-on impacts on the ecosystem)* etc.
- **Investigation methods:** Methods used to investigate the marine environment, i.e. subjects of protection and their interrelationship. Examples are: *ship-based surveys, radar based observations, aircraft surveys, porpoise detectors (POD), bottom trawling* etc.
- **Planning instruments:** Planning instruments are used to obtain information on subjects based on which decisions on the planning of offshore wind farms are made. Examples of these instruments are: *Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA), Habitats Assessment, spatial planning (e.g. criteria for identification of suitable areas for wind farms), protected areas, and avoidance and mitigation measures*.

[1] Terminology after Eccleston, Charles H. (2000): Environmental Impact Statements: a comprehensive guide to project and strategic planning: a total planning strategy integrating modern tools and techniques. John Wiley & Sons, United States.

The participating countries collect all important publications and information on research projects which refer to the use of offshore wind energy and which are closely connected to the aspects in the last paragraph. To get the collected information into the environment database 3 forms have to be filled, figure 1.:

Form I: general information *(one per publication / research project)*

Form II: A form to specify the content (subject) of the publication/study *(one or more forms per publication / research project)*

Form III: A form to specify other publication details, especially information on planning instruments / tools *(one form per publication / research project)* and – additional to that – information on environmental improvements (e.g. reduction of greenhouse gases), life cycle assessment of offshore wind farms, etc.

Per publication / research study the structure of the database can be visualised as depicted in figure 1:

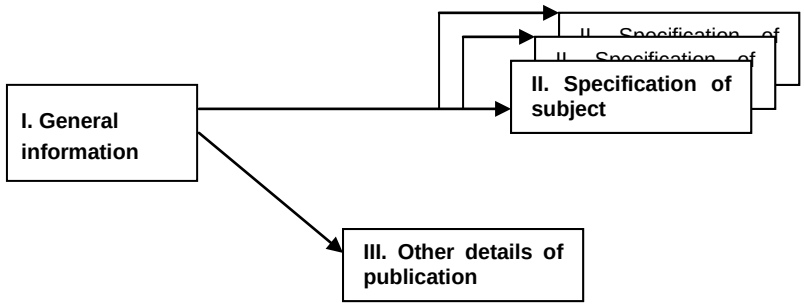

Figure 1 Visualisation of the structure of the database on environmental issues

The following aspects have to be considered when interpreting the results:

- the format of a database supports a standardized action; but still a range of interpretation in analysing the publications is possible;
- the database comprises only a selection of publications which are considered as relevant or important. Each country of the COD project has decided itself which publication is recorded and which not. These countries might have applied different criteria when selecting the publications.
- the database only shows a preliminary state. Additional publications and further results are expected in 2004 and 2005.
- actual results are momentarily confined to baseline studies/ generic research, monitoring and project related studies, i.e. EIAs. There is hardly any documentation of experience concerning other types of assessments (for instance SEA and Habitats Assessment) up to now.
- Studies or guidelines concerning delineation of protection areas (i.e. NATURA 2000 sites) and consequences for licensing offshore projects are not documented as well.

1.4 Methodology of environmental impact assessment applied to Offshore projects

Every project is emitting specific **effects** on the environment. The first step in analysis is to identify the relevant **influencing factors** that lead to effects on the environment (see figure 2). The influencing factors can be classified after their intensity.

Effects can be caused by physical presence of offshore wind facilities in all phases of the lifecycle (construction, operation and deconstruction).

The effects are to be evaluated whether they are positive or negative (damaging).

The evaluation of effects, which has to be carried out in every singular case, depends on

- the intensity of the influencing factors

- the sensitiveness of **subjects of protection**

The higher the intensity of influencing factors (correlating to the magnitude of projects), and the higher the sensitiveness of subjects of protection are, the higher there is a likeliness of **negative effects**. If there are negative effects we use the term **"impact"**.

In an EIA-study only those effects that are likely to be impacts have to be considered.

Identification of influencing factors and the likeliness of effects being impacts are considered in the Scoping phase of EIA-procedure.

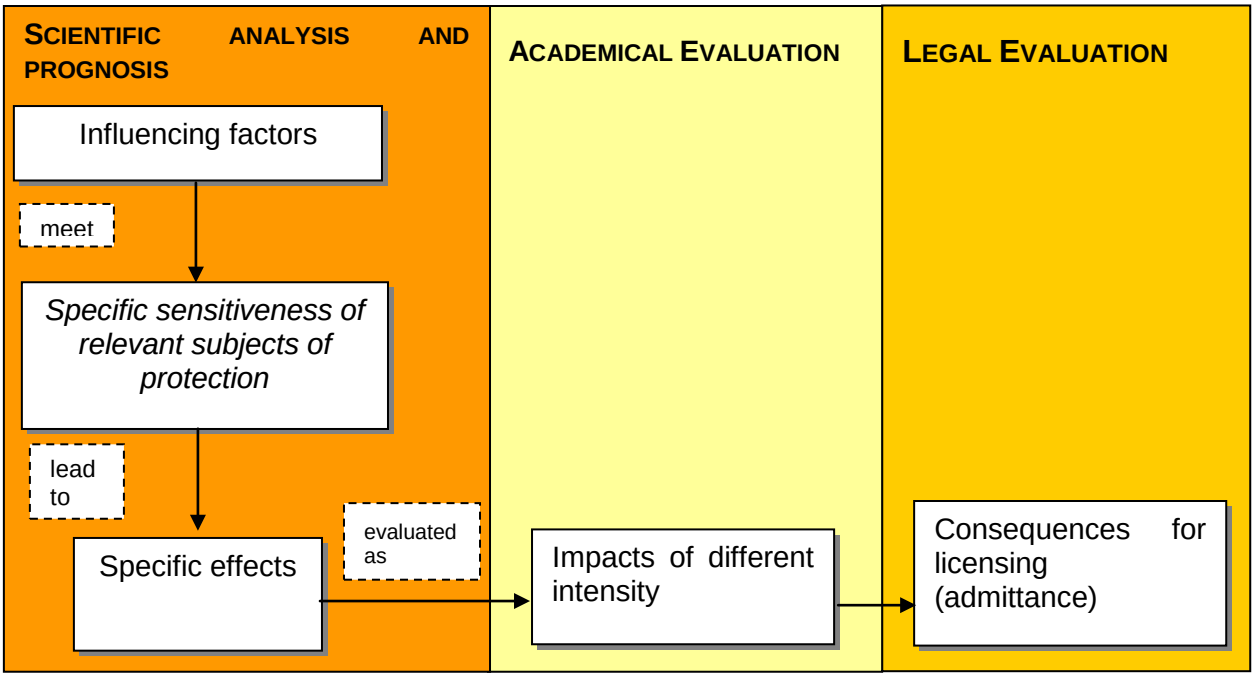

Figure 2: Methodology of analysis and prognosis of environmental effects caused by offshore wind facilities

There are different levels of knowledge about the effects and their interrelations:

- **Effects or interrelations *are likely***. In some cases there is generic research going on to find out how effects can be investigated and measured (see effects of sub sea noise on hearing ability of sea mammals).
- **Effects or interrelations do exist.** Up to now, there is an ***uncertainty about the intensity and relevancy*** for the decision making process.
- **Effects or interrelations do exist.** There are **indications of damage** (see bird collisions), but i.e. consistent limit values for the decision making process are still missing.

It has to be stated that there is a considerable lack of knowledge in judging the sensitiveness of relevant subjects of protection. For instance how do animals react? Do they react at all? At which level of effects one has to consider the effects as impacts/damages. Which level of impact would lead to refusal of permission for the implementation of an offshore wind park?

Beside lack of basic knowledge we have mainly a lack of consensual scales / ranges of standards for evaluation. For decision making processes and consenting, the latter is an important factor of restriction in offshore wind deployment.

1.5 Limitations

This report has several limitations, which should be kept in mind when referring to the results and interpreting the findings:

There is only a limited amount of data on environmental effects of existing offshore wind parks. The data differs between the various countries and is collected with various methodologies. Quite a few reports refer to other sources. This will be improved in time, when more publications are available. Only then a benchmark between various parks or countries can be carried out.

The authors have used reports from studies and inserted these in a database, thereby making the database a source of secondary information. Although all effort has been used to maintain accuracy and completeness, for a full understanding of a study, the entire research report in question should be used.

The Belgian publications on offshore wind energy have not been taken into account in this report.

2 What kinds of studies have been undertaken and which issues have been studied?

In this chapter questions about the publication of different kind of studies are addressed. What is the content of the studies? How many and what type of studies are inserted in the database? Which institutions have been involved in the studies; what was the duration of the studies and have much did they cost?

Before these questions can be answered, it is necessary not only to refer to the database, but consider additional information from each country as well. For three of the countries involved in this project (DE, DK and UK) the additional information is given[2].

Denmark

After realization of some smaller projects Denmark decided in the late 90's to establish large-scale demonstration projects for offshore wind energy based on recommendations of "The Offshore Wind Turbine Action Plan for Danish Waters". In this context an environmental programme has been initiated, which is a pre-condition for the approval of the demonstration projects. It includes environmental measurements and monitoring projects much more comprehensive than the EIA's. To set up the monitoring programme to investigate the effects of offshore wind farms on the marine environment the state provided about € 10 Mio. for five years. Up to now two of the five planned demonstration projects were realized.

The environmental monitoring which is currently carried out at the demonstration wind farms "Horns Reef" and "Nysted" comprises baseline studies over two years, monitoring during construction and monitoring over two years of operation. The surveys focus on sea and migrating birds, marine mammals, fish, benthic communities, hydrography / geomorphology and visual landscape. Also aspects like acoustic emissions, electromagnetism and socio-economic issues are taken into consideration. Thus, the state funded environmental monitoring at the Danish demonstration projects bears analogies with the monitoring in Germany which has to be carried out by the developers at their own expenses as part of the licensing.

No indications were found on the existence of generic research programmes in Denmark on offshore wind energy and the marine environment that are not project-related and therefore not liable to specific licensing conditions.

Germany

As in Germany the deployment of offshore wind energy became a political issue (see Strategiepapier der Bundesregierung), a national research program (ZIP; see D-002) was released, which allowed 4 Million € to several research institutes, aiming mainly on baseline investigation. The reports of the research projects are comparably few in number, but cover a wide range of themes, which had not been investigated up to now. For all offshore facilities, project related environmental assessments (EIAs) are generated. But these studies, which are part of the documents essential for ongoing licensing procedures, are *not* published and therefore not officially accessible.

[2] source: Elke Bruns and Ines Steinhauer (2004): Researdh Projects on Environmental Effects of Offshore Wind Energy in Europe; Review of Germany, Denmark and United Kingdom; TU Berlin

Apart from baseline studies and assessments, problems referring to planning instruments are dealt with, too. They aim at supporting the decision making process, i.e. selection of relevant data, evaluation methods, preparing of EIA-guideline, standardization of methods (both investigation and evaluation); designing protection areas (national and Flora and Fauna Habitat)

In Germany offshore wind facilities have not been constructed up to now. Monitoring studies (see BEOFINO – D-004) are concentrated on the research platform (see FINO; D-010 and, which has been erected in 2003.

United Kingdom

As part of the first round of consents for offshore wind farms The Crown Estate has established a trust fund based on the refundable financial deposits made by developers. The interests accruing are intended to support research purposes and administered by the COWRIE steering group. COWRIE (Collaborative Offshore Wind Research into the Environment) has identified four priority areas for generic research: the potential effects of electromagnetic fields from cables on fish, the comparison of bird survey methodologies, predicting the displacement of birds (especially Common Scoter) from benthic feeding areas and the potential effects of underwater noise and vibration on marine mammals. Respective research contracts have been awarded to institutes and work is in progress. Probably COWRIE will be extended for the second round of consents but no research projects have been specified or started yet. Beyond COWRIE there are also some R&D projects on offshore wind energy and the environment funded by the Department for Environment, Food and Rural Affairs (DEFRA).

The mentioned generic research projects are quite separate from the requirements on developers to undertake site investigations to inform the environmental impact assessments or site monitoring requirements. Detailed conditions apply to all construction licences for offshore wind farms regarding the implementation of environmental baseline and monitoring studies.

2.1 How many reports and publications have been captured in the database?

To understand the results of the overview, it is necessary to know something about the specific framework of each country influencing the research of effects on the marine environment caused by offshore wind farms. The analysed database contains 173 reports from six countries. Annex 1 contains the reference codes and titles of all publications in the database. The reference code reflects the country that inserted the publication into the database.

The publication years vary from 1994 to 2004. Most reports are published in 2002 (49), 2000 (42) and 2003 (41). For 12 projects a draft report or planning is available, because the project is in preparation or still in progress, table 1.

Most publications have been published in Denmark (83). The most recent reports are from Denmark and Germany. The database also contains 35 publications from the United Kingdom, 4 publications from Ireland, 14 from the Netherlands and 2 from Sweden.

Furthermore it should be noted, that this database doesn't contain publications that are confidential, because they are part of the licensing process. Therefore, the actual number of publications in for example Germany (30 projects in licensing process) is

larger than the total entered into the database. Other countries like DK and UK have a large number of publicised studies (EIAs) and - with COWRIE - also a national monitoring (DK) or research program (GB) which provides publications.

Table 1: Amount of reported studies, ongoing projects and year of publication

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	In progress/ planned	Total
UK			1		1	1	1	7	17	7			35
DE							1		3	16	3	12	35
NL						1	1		3	8	1		14
IRL							2		2				4
SE	2												2
DK						2	37	10	24	10			83
PO													
BE													
Total	2	0	1	0	1	4	42	17	49	41	4	12	173

The Belgian reports are not entered into this database. In Poland no publications are available at this moment. In Germany and the Netherlands, many research projects and studies are still in progress. The distribution of publications over the years shows an increasing interest in environmental issues in offshore wind energy.

2.2 What types of studies have been executed and are inserted in the database and what are the subjects of these studies?

The planning of an offshore wind farm consists of different phases, which coincides with the type of studies to be performed:

- Before a location for a park can be chosen, the **reference situation** has to be determined. This is done with so-called *baseline studies.*
- When the park is to be built, its' **expected** impact on the environment is studied by *Environmental Impact Assessments (EIA*). Some COD countries are in the process of formulating guidelines or Terms of Reference for these EIA's, some have already formulated these guidelines or Terms of Reference.
- After a wind-park has been built, its **effects** on the environment can be studied. These are called *effect studies*.

In the database, the publications on environmental issues of offshore wind farms are divided into six types, depending on the content of the publication:

- Baseline studies to determine the reference situation for relevant subjects;
- Environmental Impact Assessments in which the expected impacts of offshore wind farms on the environmental issues are studied;
- Guidelines or terms of reference on what has to be studied and how;
- Methodological studies: research into what method is best to use when studying certain environmental subjects like marine mammals, birds, fish, etc.;
- Effect studies to monitor the actual effects on the environment;
- Other kind of publications like monitoring programmes or planning, conference reports, protected areas, etc.

The distribution of the reports in the database shows that most publications are EIA's, table 2. There are a number of guidelines on what to study in such an assessment. These guidelines will be discussed in chapter 4. Many baseline studies have been executed as well. There are 8 effect studies available, mostly published in Denmark, because only Denmark has started with the installation of two offshore wind parks as a demonstration project. The monitoring programme of the demonstration project has been initiated and information on the effects of the construction activities is starting to be published.

Table 2 Kinds of reports in COD database.

Kind of report	Number in database
EIA or research project	61
Baseline study	58
Guidelines/Terms of Reference	18
Methodological studies	22
Effect studies	8
Other	39

In table 3 the environmental subjects are shown. The marine mammals and birds have been studied most extensively, followed by fish and benthos. Up to now, there is no data on bats available.

Table 3 Environmental issues discussed in the publications

	Mammals	Birds	Bats	Fish	Benthos	Men	Seabed	Visual landscape	Water	Other
EIA or research project	19	22	-	23	19	16	12	1	13	7
Guidelines/Terms of Reference	7	7	-	6	5	4	-	2	-	5
Baseline study	13	15	-	10	8	1	9	-	-	-
Methodological studies / Research into best method	9	5	-	1	-	1	2	1	-	3
Effect studies	3	3	-	1	1	-	-	-	-	-
Other	9	8	-	6	9	3	6	2	3	24
Total	60	60	-	47	42	25	29	6	16	39

The Netherlands and the United Kingdom have formulated guidelines or terms of reference for investigation methods respectively Environmental Impact Assessment. These guidelines point out on which environmental subjects the impacts of offshore wind farms should be studied. All mention mammals, birds, fish, and benthos as important research subjects. In Germany, a study of the ZIP-Program points out the following issues (Table 4):

Table 4: Subject of protection possibly affected by Offshore-Wind Facilities

Subject of protection EIA – Guideline	Subject of protection possibly affected by Offshore-Wind Facilities
Men	Men
Animals	Seabirds
	Migratory birds
	Marine mammals
	Fish
	Benthos
Plants	Subsea Macro-phytobenthos
Soil	Seabed, sediment structure
Water	Seawater, above all Quality

Subject of protection EIA – Guideline	Subject of protection possibly affected by Offshore-Wind Facilities
	Hydrology
Air	Air
Climate	Climate
Landscape	Visual landscape
Interactions	Interaction between subjects

It is observed that the distribution over subjects clearly mimics the species of most environmental concern: birds, mammals, and fish. This is logical since it is expected that offshore wind farms have the greatest (life threatening) impact on the population of these species. But although people highlight birds, mammals, and fish, offshore wind farms can be equally threatening to the population of benthos for instance, so all subjects should be studied.

The following effects on relevant subjects of protection are possibly relevant in decision-making process:

- Seabirds: Collision or displacement of seabirds
- Migratory birds: Collision and/or barrier effects caused by construction and operating noise
- Impairment and/or displacement of sea mammals by noise (construction and operating)
- Impairment and/or displacement of fish (turbidity; electromagnetic fields)
- Impairment and/or loss of benthos by smothering /burial
- Accidental pollution of sea (caused by ship collisions)
- Turbulence of thermal layering (esp. in Baltic sea) and water layer structure.
- Visual intrusion
- Interaction and cumulative effects

Besides the effects on the “biotic components of marine ecosystems” the effects of visual intrusion belong to those that could cause severe conflicts. Near shore sites are most likely to cause impacts that are relevant in licensing process. Nevertheless, effects of visual intrusion or methodology of investigation and prognosis of visual intrusion by offshore projects is not subject of actual research in those countries who fed the database up to now.

2.3 What kinds of organisations and institutions are involved in the studies?

To be able to give recommendations about the kind of institutions needed for research in the Offshore Wind Energy field, it is useful to know what kind of organisations are actually involved in the execution of the studies. The distribution of studies over different types of institutions is described in table 5.

The responsibility for the publications lies most frequently with universities/research organisations and engineering companies. Most of the institutions in the category 'other' are consultancies (11x), developers (4x) or trade organisations (4x).

Thesis: The type of institution dealing with environmental issues on behalf of offshore project is closely linked to the funding strategy of each country. The more offshore wind is a political topic of national importance, the more non-private institutions are concerned with investigations (see German Strategy paper). The more liberal / orientated to the market the policy is, the more studies are financed and performed by private investors / planning offices / consultancies.

There are some peculiarities per country, for instance a significant difference between Germany and the UK. In Germany, research is mostly undertaken by research institutes and universities or by nature protection agencies. In the United Kingdom on the other hand, engineering companies do a large part of the project related studies. In the Netherlands, environmental consultancies are doing most of the research.

What stands out as well is that little NGO's are carrying out the studies themselves.

Table 5 Type of institutions involved in the studies

Type of institution	DE	IRL	NL	SE	UK	DK	Total
research institute / university	19	1	3	1	2	48	74
engineering company / office	4	1	-	-	15	27	47
nature protection agency (governmental)	5	-	1	-	5	-	11
Licensing authority (for offshore wind farms)	3	1	-	-	1	-	5
non governmental organization (NGO)	-	-	-	-	1	-	1
wind energy promoting agency	-	-	-	-	1	-	1
national electric utility / power authority	-	-	-	-	-	5	5
other:	2	1	12	1	9	-	25
Total	33	4	16	2	34	80	169

2.4 What was the duration of the studies and what were the costs?

A study can be regarded effective or successful, when it delivers reliable results in an agreed or expected time schedule at reasonable costs. No data is available in the database on these items. In very few publications the duration or the costs of the study are mentioned.

3 What were the conclusions of methodological studies and the baseline studies?

3.1 What baseline studies have been executed and what are the results?

To be able to identify the changes of the environment caused by an offshore wind farm, the reference situation has to be known. Currently the COD database contains information on 12 baseline studies. Short summaries of the results from or the status of these studies are given in table 6. All Dutch baseline studies are still in progress.

- **Mammals:** The five German baseline studies on marine mammals (one in progress) have identified the distribution and density of some species in the North and Baltic Sea, but finish with the remark, that the results should be confirmed statistically and/or that in order to close certain areas for offshore wind, more research is needed. One publication focuses specifically on the areas "Kadetrinne" and "Fehmernbelt", which are very important for harbour porpoises in the Baltic Sea.

  The five Danish studies focus more on the behaviour and abundance of marine mammals throughout the year on the Horns Reef and Rødsand.

- **Birds:** A German and an English baseline study give maps showing the distribution of birds. In a German research project meanwhile a "sensitivity index for different seabird species" was developed[3]. Considering the distribution of species with a high sensitivity index, areas can be delineated, in which offshore wind farms should be excluded. Another German publication provides data on the population of some bird species in the North Sea.

  What stands out is the lack of information on migration routes of birds. There have been comprehensive studies in the North Sea and Baltic Sea, which help to identify some "hot spots". But changing flight conditions (wind, visibility, day or night) lead to varying behaviour and routes.

  The migrating and staging birds on and within the vicinity of the Horns Reef and Rødsand area have been studied extensively. The within-year and year-to-year variation of the most abundant species is known now, giving a good basis for the monitoring of the actual effects of an offshore wind farm on birds.

- **Fish:** The two German studies conclude that not enough data is available in fish to identify possible protection sites in the Baltic Sea. Danish publications describe the fish fauna as well and observe large fluctuations from year to year in abundance of the species.

- **Benthos:** A German study (D-016) analyses the habitat conditions for benthos species both in the reference situation in two locations in the Baltic Sea and on the piles of the research platform. Populations on both site contain endangered species and therefore, it is expected that a wind park will have a disturbing influence. The Danish studies on the demonstration location don't identify endangered species.

[3] Publication is in preparation (publishing in 2004).

- **Soil and seabed:** With nine different publications on soil and seabed, the Danish demonstration locations have been mapped sufficiently to conclude that regarding the soil and seabed, there is no objection to the construction of an offshore wind farm on those locations.

It is concluded that, with the exception of the Danish demonstration locations, insufficient data from baseline studies is available to predict the impact of offshore wind farms on the marine environment in any location of the North and Baltic Sea.

Table 6a Baseline studies on marine mammals

Reference	Results
COD-D-003	- Distribution, density and number of seabirds and harbour porpoises in the whole German North and Baltic Sea: The number of porpoises in the Baltic Sea decreases from west to east. This should be confirmed statistically. - First indications of areas which are of particular importance for harbour porpoises / which are highly used by harbour porpoises. - New knowledge regarding the use of space by seals.
COD-D-013	- Distribution of harbour porpoises mainly from south to north along coastline; Distribution area of grey and harbour seals from the coast to a depth of 35 m and a distance of maximally 50km from the resting area; but more data on this area needed. The distribution areas of porpoises and seals are the same. The small number of Harbour seals gives a special status
COD-D-014	- The abundance of harbour porpoises is much larger in the west of the Baltic Sea the in the east. A clear borderline between species from east and west exists. The Oderbank and 'Pommerschen Bucht' form the main points for the presence of harbour porpoises. The population in the Baltic Sea should be protected. In order to close certain areas for Offshore wind, more research is needed.
COD-D-019	- The two examined areas "Kadetrinne" and "Fehmarnbelt" are very important areas for the harbour porpoise in the German Baltic Sea. The investigation of the pattern of utilisation of habitats through harbour porpoises with acoustic methods (PODs) points out a frequent presence of harbour porpoises in the "Kadetrinne" and the associated nearshore area. Germany has a special responsibility for the continuity of the species in the Baltic Sea with respect to the total population (except for the Beltsee and Kattegat).
COD-D-030	- In progress
COD-DK-002	- Distribution of harbour porpoise in investigation area is linked to hydrography; high density area throughout the year over the eastern part of Horns Reef;
COD-DK-021	- It is obvious that the porpoise activity in the western part of the reef is lower in the winter period compared to July-October. We have explained this variation by variations in salinity and the frequency of westerly winds, which was higher in November-December compared to the summer and early autumn period. It is likely that monitoring data from several years may show a consistent seasonal pattern, and that the seasonal variation can be included into future analyses.
COD-DK-084	- Rødsand seal sanctuary is the most important haul out site in south-western Baltic during summer while it is less important to the harbour seals during February-March. However, two live grey seal pups were observed in late February-early March, which indicate that the sanctuary is very important to grey seals during spring.
COD-DK-086	- Harbour seals remained within 50 km of the tagging site year-round, while grey seals made extensive movements up to 850 km away from Rødsand to Sweden, Germany, Estonia and Latvia. The average Kernel home range (95% fixed Kernel) of the harbour seals was 394 km2 ranging from 237 to 709 km2,

Reference	Results
	whereas the corresponding Kernel home range was 130 times larger for grey seals namely 51,221 km2 ranging from 4,160 to 119,583 km2. All the tagged harbour seals stayed year-round in the Rødsand area, whereas, the grey seals on average only remained in the area for 17.8% (range: 2.6 - 58.3%) of the monitored time. Rødsand locality is more important for harbour seals than for grey seals.
COD-DK-087	- On 36 % of the days from April through August there are more than 20 seals on land at the time. This number could be higher as not all pictures from May through July have been transferred to NERI and analysed yet. In September there is only a maximum of 10 to 20 seals on land. From October to January there are many days without seals, but for 12 of those days with seals on land the number tends to exceed 20 seals. From February to March there have only been few days with seals present and only 2 - 10 seals at the time.
COD-NL-008	- In progress

Table 6b Baseline studies on birds

Reference	Results
COD-D-003	- Distribution, density and number of seabirds and harbour porpoises in the whole German North and Baltic Sea: The number of porpoises in the Baltic Sea decreases from west to east. This should be confirmed statistically. - Maps of resting bird distribution. - Development of a "windfarm sensitivity index" for resting seabirds.
COD-D-015	- Gavia stellata and arctica in North Sea: 13.700 individuals in winter and 8.600 in summer mainly along the coastline. - 'Basstoelpel' (Morus Bassanus) in North Sea: 1.500 ind. in summer. - 'Zwergmoewe' (Larus minutus) in North Sea:1.800 ind. in winter. - 'Sturmmoewe' (Larus canus) in North Sea: 58.400 ind. in winter
COD-D-030	- In progress
COD-DK-003	- Species with a high reproductive output and a correspondingly low annual survival rate will be less sensitive to added mortality than species with a high annual survival rate and a low reproductive output. Most of the species occurring in the wind park area belong to the latter category. - Flight altitude varies significantly between species (p.71), the assessment of collision risk during both day and night time is greatly hampered by the lack of fundamental knowledge of the behaviour of birds shown towards wind turbines and wind parks in general for the species in question. - Bottom fauna foraging birds are not frequently counted.
COD-DK-009	- Table with abundance on p.10. The Herring gull and the Common Scoter are most abundant. - Based on the distribution of the most abundant bird species recorded during 13 aerial surveys, there were no indications that the wind farm area was of any particular importance to the birds' exploitation of the Horns Reef area.
COD-DK-010	- Baseline abundance of bird species p.22. It is a continuation of the study period reported in COD-DK-009 till April 2002. - The within-year variation recorded in the most abundant species during the base-line study did not show any major deviation from what could be expected from comparison with the seasonal occurrence of these species at Blåvandshuk 1963-1999.
COD-DK-032	- (032 is a continuation of the study reported in COD-DK-009).Species and numbers recorded during the nine aerial surveys carried out between August 2000 and January 2002 are shown in Table 2. Bird species that are very

Reference	Results
	difficult to separate during aerial surveys are grouped, while a few observations of migrating non-marine bird species (e.g. shorebirds) are omitted. Based on the distribution of the most abundant bird species recorded during 16 aerial surveys performed during August 1999 - January 2002, there were no indications that the wind farm area was of any particular importance to the birds' exploitation of the Horns Reef area. Of species foraging on sessile benthic fauna (eider and common scoter), only small numbers were observed at Horns Reef.
COD-DK-052	- It was shown that more than 90% of the waterfowl migration consisted of Eiders. In general, ca 20% of the total waterfowl migration passed through the planned wind park area. During the autumn period app. 10% of the Cormorants, gulls and Eiders passed the wind park area within the critical rotor height (30-110 m). A 10 m lowering of the hub height will increase this percentage 6-8%.
COD-DK-069	- Although bird migration was partially deflected and concentrated along Gedser Odde, the radar data presented here showed that a substantial proportion of both the waterfowl and the terrestrial migrants crossed the wind farm area during their autumn migration. Visibility may play a significant role with regard to future potential responses of the birds migrating towards the wind farm. In one out of three social foraging events, several thousand cormorants moved through the wind farm area, a situation that could be critical in terms of risk of collisions with the turbines.
COD-DK-072	- (072 is a continuation of the study reported in COD-DK-069.) Observations at Gedser Odde have suggested that numbers of waterfowl may add up to 300,000 individuals. The base-line study has shown that between 37% (2001) and 49% (2000) of the waterfowl tracks registered by radar pass the eastern edge of the wind farm area. - Count surveys of staging, wintering and moulting waterfowl have shown that cormorants (up to 5,200 individuals) and moulting mute swans (up to 9,700 individuals) occur in internationally important numbers (> 1% of total population in the entire study area) on an annual basis. - Long-tailed duck and common scoter showed a preference for the wind farm area. Red-breasted merganser showed a preference for the wind farm area + a 275 m zone. - However, radar studies revealed that cormorants may undertake social foraging events during early mornings and in late afternoons. Social foraging flocks may hold 5,000 individuals and may occur inside the wind farm area. This behaviour makes cormorant a potential high-risk species with respect to collisions with the planned wind turbines, also because the species may be attracted by the turbine foundations, which may be used as roosting sites.
COD-DK-088	- (Continuation of DK-069 and DK-072). Despite the only four surveys, compared to seven in 2001, the number of observed long tailed duck, eider, common scoter and red-breasted merganser was strikingly similar between the two years of investigations. - Evidently, not all eiders, which pass through the wind farm area, are at risk of colliding with the turbine wings. The proportion of migrating eiders within the altitude range of the wings (30-110 m) was highly variable (10-53% land) and depended on wind conditions and season.
COD-IRL-005	- Previous studies considered the main potential impact on birds relate to collision, avoidance and habitat loss. Three of the five most significant species in the study area, the Manx shearwater, guillemot and razorbill are almost entirely restricted to the water surface or the air space well below 40m I.e the lowest point of the turbines. During the July off-peak, the birds are

Reference	Results
	largely flightless. Little gulls normally feed low over the water, but may fly higher when commuting between feeding and roosting areas. The red-throated diver tends to fly higher and it is difficult at this stage to assess how typical this is as much of the flight activity observed during the fieldwork may have been in response to disturbance by the survey boat.
COD-UK-050	- A series of maps shows the distribution of key bird species (groups) in 4x4 km cells, calculated as the number of birds encountered corrected for survey effort.
COD-NL-009	- In progress
COD-NL-010	- Results expected in 2004

Table 6c Baseline studies on fish

Reference	Results
COD-D-020	- Due to the few data no final judgement is possible concerning potential protection sites. With regard to the Annex II species of fishes the results of the investigations do not point out any emphasis of distribution for these species. The knowledge about occurrence and distribution is incomplete (except Alosa fallax).
COD-D-021	- The data did not allow identifying and implementing any Special Area of Conservation in the German EEZ for Alosa fallax.
COD-DK-005	- The description of the fish fauna in the Horns Reef area is based on eleven years trawl surveys carried out by the Dutch Institute for Fisheries Research. The most common species are dab, plaice, hooknose, whiting, dragonet and grey gurnard. A total of 42 different fish species are listed. The relative abundance of the ten most common species is given for three different areas within and outside the windmill area. These mean figures indicate some systematic differences among the three areas for species like plaice, hooknose, whiting and gobies. However, there have been large fluctuations from year to year in the abundance of the species. A high abundance of the brown shrimp is observed east of the windmill area.
COD-DK-007	- A total of 186 fish distributed in 14 species were caught in this preliminary survey. The most predominant fish species in the catches were whiting and plaice. On the basis of 6 gillnets (=samples) an average of 22.7 and 3.3 whiting and plaice were caught with a variability of 80% and 35% respectively.
COD-NL-006	- In progress
COD-NL-007	- In progress

Table 6d Baseline studies on zoo- and phytobenthos

Reference	Results
COD-D-016	- 77 species of macrozoo-benthos on Kriegers Flak with a density between 386 and 8.875 ind/m^2; - 69 species of macrozoo-benthos on Westlicher Adlergrund with a density between 750 and 21.250 ind/m^2; The populations in both sites contains endangered species. It is expected that the installation of an offshore wind park will have a disturbing influence on the zoo- and phytobenthos.
COD-DK-018	- Baseline study on benthos and seabed; The annexes describe the benthos characteristics.
COD-DK-035	- The most common species of shellfish on Horns Reef in both the Wind Turbine park and control area were brown shrimps (Crangon crangon) at an abundance of between 15,000 and 31,000 pr. km2. Syndosmya (Abra) alba a small bivalve was observed at an abundance of around 16,500 pr. km2 in the wind turbine park and around 2,500 in the control area. The clam (Spisula solida) were observed at an abundance of 1,300 pr. km2, which are much lower than observed in 1993, when the abundance were around 17,000 pr.

Reference	Results
	km2. Potentially a high abundance of S. solida may appear in the future, but how soon and how large is difficult to predict from the data compiled in this report.
COD-DK-066	- Epi-benthic communities of common mussels and brown filamentous algae attached to the mussels were developed in the southern part of the wind farm and along transects west of the wind farm. Common mussels appear to be scarce in the lagoon. The bottom vegetation consists of populations of eelgrass with a low shoot density in innermost section of the cable connection and attached algae on stones along the middle section of the alignment. Detached algae were abundant in the interior part of the lagoon.
COD-DK-068	- Common mussels (Mytilus edulis) were observed, but were only abundant at station 11 at pound net 2. At all other stations common mussels were absent or few and scattered. - At all stations detached and decaying filamentous macro algae were found. At 75% of the stations the algae were found between the sand ripples and covered <5% of the bottom, while at some stations along pound nets 1, 2 and 4 the algae covered 5- 25% of the bottom. At two stations along pound net 2 and four stations along pound net 4 larger occurrences of detached algae were observed covering 25 to 100 % of the seabed. At all stations the detached algae were lying loosely on the bottom. The algae were re-suspended and moved along the seabed as the frame of the photo sampler approached the bottom. This indicates a dynamic and temporary character of the algae.
COD-NL-005	- In progress
COD-NL-013	- Overview of benthic species in the NSW area and the two reference areas

Table 6e Baseline studies on soil and seabed

Reference	Results
COD-DK-018	- The annexes describe the sediment characteristics.
COD-DK-019	- Both in the wind farm area as well in the reference area the values for sediment characteristics indicate sediments to be very homogeneous and well sorted. Especially in the shallow part of the reference area, the fine sand is very well sorted, whereas a lower sorting index generally is found for coarser sand especially at wind turbine site M95. The general characteristic of the sediments is pure sand with an ignition loss of less than 1%.
COD-DK-035	- In both the control and impact area the weight fraction of Silt/clay + Very fine is smaller than 2% at all sample locations and thus clearly below the 6% limit above which sand eels would avoid the sediment.
COD-DK-042	- 12 anomalies have been investigated by NMU and concluded not to be of historical importance.
COD-DK-043	- It was concluded that the two identified potential archaeological objects weren't of historical interest.
COD-DK-060	- It is concluded that no potential resources is seized/destroyed when building the wind farm
COD-DK-066	- The seabed consists predominantly of sand. Stones are scattered and the coverage is below 25% at the wind farm and along the reference transects.
COD-DK-068	- A seabed consisting of pure sand with sand ripples dominated along four pound nets. At most stations no stones were observed. However, detached algae may cover minor stones. At some stations especially along pound nets 2 and 4 a few small stones and/or shells were scattered in the sand. Only at pound net 2, stations 2 to 11, significant amounts of gravel and small stones were seen mixed with the sand.
COD-DK-076	- On the basis of the photo sampling results between 75-100% of the windmill parks area and the bottom along the reference transects is estimated to be covered by sand. Stones of various sizes have been observed in the entire

	park, but the coverage is mostly <5%. Large stone concentrations covering 5-25% of the bottom are observed in the south-eastern part of the park as well as in the area closest to the coastal part of transect 2/3. Based on the geophysical measurements, 427 stones with a size between 1m and 2m were identified inside the investigated area of the park.

3.2 Which environmental research methods are the most effective?

There are 18 reports identified as methodological publications trying to determine which research method is suited for environmental studies on offshore wind energy. These reports all concern mammals or birds. Five of the nine German studies are still in progress or preparation. For one British study only a draft report is available.

For these methodological studies a short summary of the findings is given in table 6. From this table, the following observations are made:

- One German study concludes that for the research into harbour porpoises, it is best to use a combination of acoustic (PODs) and visual (aircraft) observations. This study recommends also improving the stationary use of PODs in the North and Baltic Sea. The use of PODs for the monitoring of harbour porpoises is recommended by the Danish studies as well. Besides the monitoring by PODs, the use of satellite telemetry and video registration has proven successful on a number of items. Furthermore, a functional measuring unit has been developed for hearing tests on seals and porpoises.
- A Dutch study concludes for researching disturbing effects on birds, the existing methods and resources fulfil all needs, but that a new method should be developed for researching collision victims of birds.
- Computer modelling: The use of spatial and temporal modelling techniques is most effective for the process of environmental impact assessment of offshore wind farms on birds (UK-054). For water movement there is a recommendation for monitoring of operational wind farms to validate or modify the computer modelling results (UK-009). A German publication uses calculation methods to predict the influence on sea currents and wave load as well. Computer modelling is also used to map under-marine banks in the North and Baltic Seas.
- For the analysis of the visual impact a photographic visualisation of the planned project from different viewpoints has to be given with addition schematic and graphical detailing and comparisons.

Table 6 Publications which study research methods

Reference	Method studied	Subject	Results
COD-D-003	aircraft-based surveys	marine mammals	Necessity of the combination of acoustic (PODs) and visual (aircraft) observations concerning harbour porpoises
	POD (porpoise detector, click detector)	marine mammals	Improvement of the stationary use of PODs in the North and Baltic Sea.
	sonic experiments	marine mammals	Formulation of a functional measuring unit for hearing tests to carry out with seals and porpoises. Training of seals and one porpoise for further investigations.
	telemetry	marine mammals	Improvement of telemetry equipment regarding functionality and animal protection.
COD-D-005		marine mammals	The research project is still in progress.
COD-D-013	aircraft-based surveys	marine mammals	
	other: coincidental counting's	marine mammals	
	telemetry	marine mammals	
COD-D-022	GIS supported computer modelling	seabed	With the developed method undermarine banks were mapped in the North and Baltic Seas. But due to differently dense data sets not all banks which are recognizable in a TIN visualisation were identified by the model and separated. For the delimitation of marine banks the spatial density of the measuring data should be 100 metre.
COD-D-024	sonic experiments	N/A	sound radiation: Development of a forecasting method for sound pressure levels with realistic results.
	calculations	water	- influence on sea currents: the currents in the area of the parks change, however, only around very few percent. Near by the foundations and piles there is an increase of the tidal and wave-conditional currents with the danger of formation of scour pits. - loads: wave loads have been calculated by use of extreme value analyses. These results entered in a computer programme for load and fatigue analysis at Monopiles, Tripoids and Jacket constructions. The programme is already used in planning of offshore wind parks.
COD-D-032	computer simulation	ship collisions	ongoing

Reference	Method studied	Subject	Results
COD-D-033	Validation of prognosis methods and measuring methods	sound emission	project in preparation
COD-D-034	Calculations	bird collisions and migration rates	project in preparation
COD-D-036	Landscape analysis	men	- Of importance for the impact assessment is the sensitivity of the representative viewpoints which should be described by topographical, utilization, environmental, structural and shape analytical criteria. - A main aspect of the landscape analysis is the photographic visualisation of the planned project from different viewpoints. Additionally schematic and graphical detailing and comparisons are necessary.
COD-DK-021	POD (porpoise detector, click detector)	marine mammals	The results of the power analysis indicate that with the entire available POD data a change in the order of 25 % should be detectable with the data obtained in the baseline study.
COD-DK-025	POD (porpoise detector, click detector)	marine mammals	The field deployment of PODs revealed large spatial differences at even small scales. For all indicators there were large spatial variations between the four investigated areas, but also large spatial variations between stations within areas (~10 nautical miles apart). Indicators derived from PODs deployed simultaneously at the same station were not significantly different. The pages 56 and on give recommendations on how to use PODs for monitoring harbour porpoises.
COD-DK-069	Calculations	birds	A method for estimating the frequency of collision is suggested.
COD-DK-070	satellite telemetry	marine mammals	In conclusion satellite telemetry has proven successful on a number of items including migrations, habitat use, home range identification as well as dive behaviour. However, additional tagging, longer survey periods as well as additional methods may add information with a higher spatial resolution on the local scale.
COD-DK-071	POD (porpoise detector, click detector)	marine mammals	This report describes the use of POD's as a tool to investigate potential effects on the harbour porpoises in the 'Rødsand'

Reference	Method studied	Subject	Results
COD-DK-087	remote video recording / photographs	marine mammals	The first period of video registration of the seals at Rødsand seal sanctuary has provided usable data for analysing the possible effects of the construction of the Nysted Offshore Wind Farm on the seals. Even with the problems in the starting phase of the video registration, it is concluded that the temporal amount of data achieved by this method exceed the data that can be cost-realistically collected by an observer. In behavioural studies the presence of an observer may have an effect on the animals and thereby bias the result.
COD-NL-002	radar-based observations / research on offshore platform / sonic experiments / video recording / photographs	birds	- for researching collision victims a new method should be developed. - for researching disturbing effects the existing methods and resources fulfil all needs
COD-UK-009	computer modelling	water	The studies are based on an assessment of short term impacts related to a set of idealised cases and supported only by theoretical considerations and should be validated by monitoring.
COD-UK-054	aircraft-based surveys; ship-based surveys; modelling;	birds	- Comparing the different research methods it is concluded that spatial and temporal modelling techniques are most effective for the process of environmental impact assessment. - Recommended census techniques for ship-based seabird surveys are strip-transects techniques with a snap-shot for flying birds, and incorporating the full behaviour module recording detailed information on species, sex and age where feasible, foraging behaviour, flying height, and precise numbers per unit area.
	aircraft based surveys; global positioning system		The advantages and disadvantages of using aircrafts, global position systems (GPS) or distance sampling for bird surveys in open offshore areas are given

4 What are the expected environmental impacts and actual effects of offshore wind farms?

In this chapter the expected impacts of offshore wind farms on environmental subjects are described. Because more data is available on the impacts on marine mammals, birds, fish, benthos and seabed, these subjects are discussed in separate sections. An overview of the in these sections described state of the art knowledge on environmental impacts of offshore wind farms is given in table 7 (p. 19/20). In the sections for birds and fish the measured effects are discussed as well. The expected impacts on subjects of which less information is available are combined and described in section 4.5. The last section of this chapter indicates mitigation measures that can be used to reduce or eliminate the expected impacts on the environment.

4.1 Expected impacts on marine mammals

The data on the impact of offshore wind farms on marine mammals during construction and operation are very limited. Only the Danish monitoring programme is producing some actual effects, measure during construction, but most of these publications are not yet available in this database. For the other countries hardly any quantitative monitoring data are available, only expectations and assumptions.

Influences of noise and vibrations

- The lack of data on the sensibility of marine mammals to noise and vibrations is explicitly mentioned in several Environmental Impact Assessments. Noise levels are expected to be at lower frequencies than those used by dolphins and porpoises for echolocation to hunt prey, so they should not be affected. Seals are unlikely to be sensitive to the noise produced by the turbines.
- The reaction of baleen whales is unknown in the absence of data regarding their audible sensitivity. However, it is possible that they will show a behavioural response to the low frequency sound wind farms are likely to produce because they are extremely sensitive to noise in the frequency range produced by wind turbines. The significance of this response will depend upon the proximity of wind farms to whale migratory routes. But there are no data available to proof these expectations. The full effects of offshore wind farms on marine wildlife; particularly mammals, fish and migratory fish behaviour and the ecology can only be usefully determined through further monitoring.
- None of the Environmental Impact Assessments study the impacts of noise and vibration (i.e. during construction) on the mortality or birth rate of marine mammals.
- During construction seals and cetaceans are likely to avoid the area. Curiosity could on the other hand lead to the opposite behaviour. Impacts arising from boat movements and installation of piles have therefore to be assessed in all sites known as sites frequented by seals or cetaceans. No impacts are predicted on seals and cetaceans during the operational phase.

Barrier effect

- An offshore wind farm may have an effect on the abundance of marine mammals because of reduced disturbance by fishery and increase of biodiversity because of existence of new communities on the poles.

- In Denmark, Horns Reef, loss of habitat will constitute a very small portion of the high density area or harbour porpoises.

Influence of electromagnetism

- The risks caused by electromagnetism are low to unknown.

Disturbing effects of construction/maintenance traffic

- Harbour porpoises are expected to be able to move to alternative feeding areas during the construction period
- Fast moving boats during construction are expected to disturb the mammals
- No investigations that are able to show in detail what effects the construction of a wind farm with 72 turbines on 23 km^2 will have on the population of porpoise, have been undertaken. It is assumed that the construction activities only will affect individual porpoise. The operation of the wind farm is assumed to be less disturbing and have an insignificant effect on the porpoise.
- In the summary of **effect study COD-DK-016** it is concluded that individual rammings had an effect on the acoustic behaviour of harbour porpoises on the reef, lasting up to 3-4 hours after end of each ramming operation. Furthermore there were more general effects on abundance and behaviour of the animals in the construction period. It is not clear, however, whether this change in behaviour is truly attributable to the construction or whether it is related to overall temporal variation. The data collected, indicate that harbour porpoises have been affected by the ramming operations both in terms of behaviour and abundance over a range of temporal and spatial scales, thus expanding the potential effects beyond what was suggested in the EIA.
- In the **effect study COD-DK-017** the resolution in positional information is not sufficiently high to allow for a detailed study of the effects of the construction phase on the tagged seals. It was observed however, that tagged seals moved across the reef also in the construction period. It is recommended that monitoring of the seals continues in the coming years with the wind farm in full operation in order to obtain more information on use of the reef by the seals and reactions to the wind turbines, especially at other times of the year than in the present study.
- **Effect study COD-DK-084** studied the effects of the construction work on seals, but because of seal epidemic it has not been possible to evaluate the effects so far. Based on the aerial surveys an estimated stock of about 200 harbour seals was observed to use the Rødsand area during the moult in late August 2002.

4.2 Expected impacts and effects on birds

There seems to be species-specific differences in the sensitivity of birds to wind turbines. One of the two monitoring studies available for this overview shows no deviation in the total numbers of birds observed, compared to the baseline studies.

Collision risk

- Effects of wind farms on birds depend on the height of the poles, the rotor diameter, the distance between turbines (preferably 1000 to 2000m), the total area of the wind park and the colour and the placing of the poles. The collision risks also correlate with the weather conditions. Bad sight due to rain or fog increases the risk significantly. Some environmental impact studies give

qualitative data on collision risks of birds against the turbines. But these data are not very reliable because of the little amount of data available.

- The implications of newer, larger turbines have to be studied.
- The Environmental Statements based on the English Environmental Impact Assessment estimate tens to hundreds of collisions a year for a wind farm of 9 turbines. Most of the assessments of impacts on bird species on the British proposed wind farms site have concluded that effects on the feeding, roosting, breeding or migratory behaviour of all bird species, or through bird disturbance or collision, will not be significant, due principally to the small numbers of birds recorded from the site.
- A Dutch publication (NL-012) on bird collisions calculate a maximum of thousand to thousands of mortalities extra per year, based on measurements on turbines on land for an area of 16 km^2 with 36 turbines.
- Species with a high reproductive output and a correspondingly low annual survival rate will be less sensitive to added mortality than species with a high annual survival rate and a low reproductive output. Most of the species occurring in the Horns Reef wind park area belong to the latter category. Therefore impacts on those bird species are expected. Flight altitude varies significantly between species, the assessment of collision risk during both day and night time is greatly hampered by the lack of fundamental knowledge of the behaviour of birds shown towards wind turbines and wind parks in general for the species in question.
- It is assessed that the collision risk will be at its highest in connection with the annual migration between areas used for breeding and wintering, and lowest for birds foraging on the wings. The number of collisions is expected to depend on the bird's manoeuvrability, and is likely to increase in situations with low visibility (during night and in foggy weather).

<u>Barrier effects</u>

- Three British studies find no direct loss of habitat and concluded that the risk for loss of habitat is mainly low, but medium to significant for Common scoters and Eiders.
- Little reliable data on the barrier effects of offshore wind farms are available.
- Giving reason for deviation of flight routes and obstruction of potential resting areas, offshore wind farms of large extent diminish foraging and resting conditions, which may decrease reproduction rates. The effect of diminishing unaffected areas has to be seen in the context of the overall intense use by fishery, military, traffic and so on. Up to now, the effects are not measured, predictions are uncertain.
- Migratory birds have been observed flying further away from the unit. One **effect study** concludes that there is reduced nocturnal flight activity near the wind farm and that the area with effect on flight movements lies up to 1500m outside the wind farm. The reduced nocturnal flight activity near the wind farm and low number of flight movements through the wind farm indicate that the farm might function as a flight barrier. Collision risk is reduced, because of avoidance of wind farm areas.

- Habitat loss is expected negligible; thus net habitat loss in the Horns Reef area is considered more likely to be the result of an avoidance effect than a result of direct habitat loss resulting from the turbine foundations.
- Physical changes of the habitat and disturbance effects on birds will mainly influence the staging, moulting and wintering waterfowl. If the birds completely abandon the Rødsand wind park area due to disturbance, the total habitat loss will make up a maximum of 2% of the whole study area. In a 'worst possible case' scenario (assuming that birds completely avoid the wind park area up to a distance of 4 km) it will affect 51% of Common Scoters, 46% of Red breasted Mergansers and 27% of Long-tailed Ducks in the whole study area. Of the remaining species a maximum of 14% of the individuals occurred within the 4-km zone. It is considered unlikely that disturbance effects from the construction work in the wind park area can be detected in the breeding colonies at Rødsand.
- The first Danish **monitoring study COD-DK-**010 shows that the overall numbers of all bird species recorded in the total Horns Reef study area during the period of construction did not deviate from the numbers recorded during the base-line years. Even though some species recorded within the wind farm area and the wind farm area +2 km and +4 km zones showed changes in their exploitation of these areas during the period of construction, statistical analyses did not find any consistent significant reductions in the observed bird numbers which indicate a disturbance effect from the construction activities.

Influence of noise and vibrations

- If construction activities (transport, construction work) are timed to avoid the breeding season there will be no significant impacts. In addition, with less fishing over the bank, the fish population might increase, so improving the food stock. Disturbance is expected at a noise level of 60dB, but this level is only measured on a small distance from the turbines (NL-004).

Disturbing effects of construction/maintenance traffic

- Cable laying is expected to disturb moulting birds

4.3 Expected impacts and effects on fish

Influence of noise and vibrations

- The risk for noise impacts on fish is estimated low, but more research on this subject is needed. There are not enough data available for reliable prediction of effects of noise on under water organisms. Noise and vibration is only expected to exceed ambient levels at very low frequencies and fish are expected to become accustomed to these noises.

Influence of electromagnetism

- The risks caused by electromagnetism are low to unknown. No impacts on the birth rate of fish caused by electromagnetism or other influences are described.
- The operation of the sub sea cable is not anticipated to have a significant impact. Electro-sensitive fish are unlikely to be impacted significantly as the electrical field generated by cables is minimised by insulation and burial, while migratory fish are unlikely to be impacted for the same reason. The risk of interruption of migration routes is low.

Barrier effect

- Sea life will be directly impacted only on areas utilised for construction activities, resulting in a loss of a very small area of seabed. Conversely, habitat will be created through colonisation of the turbine support structures and any associated scour protection, if utilised, resulting in small increases in species diversity and overall productivity.
- In the longer term, it is likely that the combination of reduced fishing activity and increasing habitat biodiversity will have a beneficial effect on fish populations in the area. With less fishing over the bank, the reproduction rates of fish might increase. Food stock and diversity of species are likely to be improved.
- The physically presence of the windturbines is estimated only to have short-term effect, sea life is expected to return to normal. The turbines may create a artificial reef and it is estimated they will attract other species of fish.
- The construction of the wind turbine park is not supposed to effect the sandeel population in the Horns Reef area because the impact area seems to constitute a small fraction of a larger area with sandeel habitat.
- A Swedish **effect study** (SE-002) finds an increase of fish within a radius of 400 m, no matter if the unit is in operation or not and a decrease within a radius of 200 m when in operation.

Changed water movement

- The construction phase can cause a disturbance and redistribution of sediments. The impact of this is low to medium. The risk is subject to timing and locality. An increased Suspended Sediment Concentration is predicted to cause, at most, a minimal impact on fish and shellfish resources within the study area. The resuspension of sediment will not affect fish in general, but would impact spawning fish such as herring, which lay their eggs in mats attached to the seabed.

Sedimentation/turbidity

- The suspended sediment concentrations resulting from the construction work are evaluated to be so small that they are unlikely to have a lethal impact upon juvenile and adult fish.
- It is estimated that the spill concerning the foundation of 'Nysted Havmøllepark' will not bring any particular reduction of the fish population in the area, but certain limitations of fishing must be expected, during the construction period.

Disturbing effects of construction/maintenance traffic

- It is not likely, that the noise from pile-driving will produce any other physical injuries to any of the fish species. Different species of fish have different hearing abilities and the reason for this is mainly differences in the physiology. In the frequency range from 1 Hz and 4 Hz, the average measured peak noise levels during the pile-driving impacts did not exceed the ambient (background) levels. For frequencies above 4 Hz the noise from the pile-driving impacts could clearly be seen. In the frequency range from 4 Hz to 100 Hz the sound pressure generally was at a level from 120 dB to 150 dB depending on both the frequency and the distance from the sound source.

- It is not likely, that the hearing of flounder, plaice, dab, turbot, sea scorpions, eelpout, sand eels and gobies, cod, whiting and silver eel will be harmed by the noise of pile-driving.
- The construction noise of an offshore wind farm at Rødsand may temporarily potentially affect the fish population in the area during construction and operation. Herring and sprat will probably show escape response as a result of pile-driving.
- It is likely that the construction activities, including the sediment spill, will stress the fish to such an extent that juvenile and adult fish will exhibit avoidance reactions.

4.4 Expected impact on benthos and soil & seabed

No data on the impacts on the mortality and birth rate of zoo- and phytobenthos caused by offshore wind farms are described. As already mentioned in paragraph 4.3 all Environmental Impact Assessments expect little effects on zoo- and phytobenthos, because of the reduced disturbance by fishery and increase of biodiversity, because of existence of new communities on the poles totally different from the community on the bottom. Whether these effects (i.e. bringing in species using hard substrates in areas of mainly soft substrate seabed) are evaluated as positive, depends on the singular case.

Disturbing effects of construction

- Data on the potential impacts on the benthic environment are not yet available or the impacts are considered to be low, with the exception of the following:
    - Damage to rare, endangered or threatened benthic species that are very localised in occurrence and with low population densities;
    - resuspension of contaminated sediments in localised, sediment 'sink', areas such as estuaries. Their relative significance of this impact would require consideration during project specific EIAs;
    - scouring or smothering by scour protection of biogenic reefs is considered to be a serious risk, because of their conservation interest and low capacity for regeneration.

- One British local EIA concludes that the maximum total volume of sediment that could be released during construction is approximately one thousandth of the level of sediment habitually in motion across the site. An assessment of the release of metals and other organic chemicals indicate very small increases in concentrations arising during construction, less than 10% of the background concentrations and well below environmental standards.
- Turbine installation will result in a seabed loss of 0.01% of the total wind farm area, which is considered to be low.

Electromagnetism

- Risks caused by electromagnetism are low to unknown.

Barrier effects

- The area of reclaimed sea bottom covered by establishing the Horns Reef wind farm, is expected to be less than 0.1% of the total area of the site.
- **Effect study COD-DK-079** shows that a fouling community of common mussels, barnacles and macroalgae has developed on the Rødsand turbines and the transformer station on concrete foundations and stones introduced in the wind farm in late 2002 and early 2003. The fouling community was not affected by the age of the substrates during the first reproductive season in 2003. During construction the biomass and abundance of invertebrates and the biomass of macroalgae on the shaft and stones was reduced at the transformer station compared to the turbines. The seabed work and the traffic have been more intense around the transformer due to additional deployment of connecting cables on the seabed. The associated sediment spill of the extra earthwork and re-suspension of sediment caused by the propellers of the ships may have hampered the settling and growth of organisms and reduced the biomass and abundance of the fouling community in the first reproductive season.

Changed water movement

- A change in turbulence might influence macrobenthos. According the a British Local EIA, the scour is estimated to form a cone of 30 m diameter, with a maximum depth of 1.34 m close to the monopile rising to the surrounding seabed within 15 m. However, the intention is to use scour protection in the form of artificial fronds, which will minimise the scour. This means that sediment movement is very localised and will not impact on other areas along the coast.
- The scale of the potential changes to the sediment regime (erosion/deposition patterns) is very much smaller than the natural changes that have been observed over similar timescales.
- It is assessed that the erection of a wind power plant at Horns Reef will cause no measurable influence on the environment with respect to hydrography and sediment transport.

Sedimentation/turbidity

- Violation of the sedimentation limits will only be local around the digging facilities of Rødsand. The limit will only be overrun for less than 10% of the digging time. Even for longer periods with constant southern wind it is expected that the sedimentation will not be > 60 g/m2/day only very close to the site. The results of the simulation show that the sediment will spread primarily to V and NNØ.
- Effects of the sediment spill on the bottom flora and fauna at 'Rødsand' is expected to be of local, short and minimum character, and without major effects.

Other influences

- An increased copper contamination of filter-feeding benthic animals can be expected as a result of the total annual discharge of 206 kg copper from the slip-rings in the wind turbines.
- It is concluded that during the construction potential sand/gravel resources are not expected to be seized.

Table 7. Overview of state of the art of knowledge on environmental impacts of offshore wind farms.

Subject Influencing factor	Marine mammals	Birds	Fish	Benthos/seabed
Noise and vibrations	Dolphins, seals and porpoises are expected to habituate. Whales expected to be sensitive to noise, but effects unknown Areas regularly frequented by marine mammals should be avoided. Insufficient data to proof expectations. Monitoring needed	Disturbance at small distance from turbines. Construction time avoiding the breeding season	Risk estimated low. Expected to become accustomed to low-freq noise levels.	Unknown
Barrier effect	Maybe positive because of reduced disturbance (fishery) in wind park area	Wind farms are flight barriers day and night. Higher losses to be expected in bad weather conditions. Loss of habitat limited, except for some species. Prediction of the effects of diminishing foraging and resting areas is difficult.	Colonisation of fish on support structures. Possible net increase in biodiversity and productivity, partly due to protection from fishery.	Unknown Fouling community of commom mussels, barnacles and macroalgae has been observed to develop on turbines and transformers station.
Construc-tion	Expected avoidance of construction area. In the singular case, repellents are necessary. Activities will only affect individual harbour porpoises. Harbour porpoises are affected by ramming operations in terms of behaviour and abundance.	Avoid construction during breeding season Overall numbers of all bird species recorded in total study area (DK) did not deviate from the numbers redorded during the baseline years.	Small loss of seabed area during construction Redistribution of sediments minimal effect on fish and shellfish Sealife is expected to return to normal. No significant effect on fish population. Suspended sediment concentrations are unlikely to have lethal impact on juvenile and adult fish. Noise from pile driving not likely to produce physical injuries to fish species Activities and sediment spill are likely to stress fish such to cause avoidance reaction	Localised effects on endangered species due to redistribution of (contaminated) sediments. Limited effect compared to background levels.

Subject Impact	Marine mammals	Birds	Fish	Benthos/seabed
Collision risks	None expected	Depends on height and diameter, color, and pole placement. Estimates 10-100 to thousands collisions /year. Impact of large turbines unknown Species with high reproductivity and low annual survival rate are less sensitive to added mortality than species with high annual survival rate and low reproducitivity At its highest in connection with annual migration between areas used for breeding and wintering. Number of collisions expected to depend on manoeuvrability and is likely to increase with decreasing visibility.	Unknown.	Not applicable
Electromagnetism	Unknown	Unknown	Unknown, likely to be low. Effects of subsea cables limited, when insulated and buried. Risk of interruption of migratory routes low	Unknown
Water movement	Unknown	Unknown	Redistribution and re-suspension of sediments expected with small effect on spawning fish (herring)	Very localised scour, which can be avoided using artificial fronds Erection at Horns Reef no measurale influence on environment with respect to hydrography and sediment transport

4.5 Expected impacts on other environmental subjects

Bats

- As a side effect of investigating bird collisions, bats were found in singular cases. There is no data available on the amount of affected bats.

Marine invertebrates

- No adverse impacts on marine invertebrates are expected by the noise and vibration generated by turbines.

Water

- The construction, operation or decommissioning of the wind farm is not anticipated to result in any impact on hydrography (water levels, tidal currents and waves). The effects are only noticeable close to the poles and the changes in wave height are negligible and in the order of about 0.10m. And although the presence of the turbines will decrease the flow locally behind each monopile, this effect will not extend beyond the development area. All changes are within the natural dynamics of the sea.

Men

- Environmental damages caused by ship collisions.
    - Two Dutch studies and three British studies give quantifications for the collision risks of boats. The calculated collision chances vary for once every 11 or every 1.823 to 23.169 years (NL), depending on the kind of boats to one additional collision per 145, 2.778 or 34.014 years (UK).
    - The highest contribution in terms of risk of collision is associated with fishing vessels.
    - It should be noted that in case of a collision of oil vessels, the effects can be catastrophic.
- Visual intrusion and decrease of recreational qualities.
    - Visibility depends on the bend of the earth, perspective, haziness, meteorological sight, seasonal effects, height of the observer, and clarity. The aspect of visual intrusion is mainly significant for nearshore sites. Though visibility is restricted in many cases, in the public opinion exists a tendency to overestimate possible negative effects. To gain acceptance for offshore wind farms, participation of inhabitants can play an important role.
    - The turbines of the Near Shore Wind (NSW) farm studied in the Netherlands will be visible less than 15% of the time. 94% of the interviewed persons is positive about the NSW.
    - Seven British EIAs of different locations predict that there will be no significant impact on the quality of life of the local population. The development may become a tourist attraction both during construction and once in operation. In one location a significant cumulative landscape and visual effects arising from two different locations is expected: the Lynn and Inner Dowsing projects.

  - It should be noted that significant effects are not necessarily unacceptable.
  - Some experience has been collected on the visual intrusion at night by the lights on turbines

- Noise during construction
  - Reportedly, the noise during construction has an impact on mankind.

4.6 Mitigation measures

Several studies give suggestions for mitigation measures to reduce or eliminate the expected impacts on the environment.

- Reduction of visibility. Three rotor blades are least visible for humans. Absorbing paint and compact and systematic placement of the poles also reduce visibility. In the singular case it has to be decided, if low visibility (in the interest of lowering visual intrusion for men) or high visibility (in the interest of avoiding collision; see below) is required.
- Reduction of collision risks by boats. Reducing collision risks for boats requires high visibility of the poles during day and night. Light coloration of the poles, lights on top the turbines and closure of the area 500m around the park support minimizing risks. It is recommended that navigational aids are as far as possible fitted on the turbines pre-installation.
- Reduction of collision risks by birds. 1000 to 2000m distance between turbines; stop turbine operation during periods of high collision risks. The park should be carefully planned taking the bird migration routes into account.
- Reduction of noise and vibration. Minimise vibration by detachment of rotor, gondola and pole. Construction must be scheduled to avoid spawning periods, particularly mid-January to May. To ensure minimal impact on both fish and mammals pile driving should start gently to allow individuals to move away from the noise source. The time periods, in which construction work should be avoided, depend on the affected species' main periods of foraging, resting and breeding.
- Scour and magnetic field protection. There is likely to be an engineering requirement to protect each structure against scour through the use of suitable sized materials. The cable has to be isolated to prevent electromagnetic fields and heating of the surrounding seabed. To significantly minimise any adverse effects in the estuary, cables should be buried during the winter period when the numbers of species such as salmon and sea trout are expected to be at their lowest.

5 Preliminary Conclusions

The analysis presented above is limited by the number of Offshore Wind Energy Parks in place, the amount of reports, and concrete data in the reports. The preliminary conclusions need to be viewed in that light, and should be reconsidered in the future based on discussions in the COD expert group and any new data.

This overview considers 173 publications on environmental issues related to offshore wind energy.

From this first assessment of the publications the following preliminary conclusions are drawn:

1. More input from planned and ongoing research projects is needed, specifically on the actual effects of offshore wind farms. At this stage it is not possible to univocally answer any of the key questions (see 1.2).
2. The systematic collection and comparison of the reports as done in this database, leads to a larger understanding of the anticipated environmental effects of offshore wind parks. It is now clear who did what study, which effects were analysed how, and what (minimal) knowledge exists on the effects birds, fish, mammals, benthos, and other subjects.
3. The first monitoring results show that only little effect on marine mammals and birds is caused by the construction activities.
4. There is total absence of quantitative data on the cumulative effects of offshore wind farms on migrating birds, marine mammals, or migratory fish.
5. Only a few computer-modelling studies exist for environmental impacts of offshore wind parks.

6 Draft Recommendations

The analysis presented above is limited by the number of Offshore Wind Energy Parks in place, the amount of reports, and concrete data in the reports. The draft recommendations need to be viewed in that light. They should be reconsidered in the future based on discussions in the COD expert group and new monitoring results.

1. Based on the conclusion on lack of data in the database but the outlook on additional existing and/or future data, it is recommended to
    a. enlarge the basis of the overview by collecting additional information on structures and framework of environmental research in each country (as background information) concerning Offshore Wind Energy in each country,
    b. complete the database with Belgian and Polish studies.
    c. keep the database alive with regular updates. A unified proceeding has to be ensured when the database is updated and completed,
    d. collect reports on environmental issues from the oil, fishery, and defence industry, and
    e. insert the costs and duration of environmental studies into the database.
2. It is recommended to distribute the database and the overview report, and to invite comments and extra inputs with the aim to
    a. solicit additional data,
    b. generate more and possibly different analyses, and
    c. achieve consensus between different stakeholders.
3. Based on the absence of data on universal applicable baseline studies, effect studies and EIA's, it is recommended to
    a. design and start a 3-5 year European environmental monitoring programme (following the Danish example) for all European offshore wind parks to monitor local and cumulative effects of offshore wind farms.
4. Based on the small amount of computer modelling reports on environmental impacts of offshore wind parks, it is recommended to
    a. start a comprehensive network for the computer modelling study of offshore wind parks on a European scale.

Annex 1 Publication references and titles

Reference	Title
COD-D-001	Standard Programme for Environmental Examination (First Update 25th February 2003)
COD-D-002	Accompanying Ecological Research to the Offshore Wind Energy Deployment. Workshop 28./29. May 2002 Bremerhaven, Proceedings
COD-D-003	MINOS - Marine warm-blooded animals in the North and Baltic Seas: Foundations for assessment of offshore wind farms
COD-D-004	BEOFINO - Accompanying Ecological Research on Offshore Research Platforms in the North and Baltic Seas
COD-D-005	Standard procedures for the determination and assessment of noise emissions by offshore wind farms
COD-D-006	Accompanying Ecological Research to the Offshore Wind Energy Deployment - Instruments of Environment Protection and Nature Conservation: Strategic Environmental Assessment, Environmental Impact Assessment and Habitats Assessment
COD-D-007	Environmentally sound grid connections for offshore wind parks
COD-D-008	Studies on avoidance and mitigation of marine environment stress due to offshore wind turbines in areas off the coast of the North and Baltic Sea areas off the coast of the North Sea and Baltic Sea
COD-D-009	Evaluation of foundations for offshore wind farms with a view to potential shipping collisions
COD-D-010	FINO - Research Platforms in the North and Baltic Seas
COD-D-011	Development of environmental criteria for the identification of especially suitable areas for offshore wind farms in the German EEZ
COD-D-012	Technical intrusions upon the marine habitats
COD-D-013	Survey of marine mammals in the German EEZ of the North Sea
COD-D-014	Survey of marine mammals in the German EEZ of the Baltic Sea
COD-D-015	Survey of resting birds in the German EEZ of the North and Baltic Seas
COD-D-016	Benthic surveys in the potential suitable areas for offshore wind farms "Kriegers Flak" and "Westlicher Adlergrund" in the Baltic Sea
COD-D-017	Maps representing proposals for NATURA 2000 sites in the German EEZ of the North and Baltic Seas
COD-D-018	Standards for site investigation - Minimum requirements for the foundation of offshore wind energy plants
COD-D-019	Survey of harbour porpoises in the German EEZ of the Baltic Sea by means of porpoise detectors
COD-D-020	Survey of Annex II fish species in the German EEZ of the North and Baltic Seas
COD-D-021	Spatial analysis of the anadromous migrating fish species twaite shad 'Alosa fallax' in the North Sea
COD-D-022	Delimitation of sandbanks as propasals for areas of conservation according to the Habitats Directive

Reference	Title
COD-D-023	Derivation of scientific criteria for identification and delimitation of marine Special Protection Areas (SPA) according to Art. 4, Para. 1 and 2 of the Wild Birds Directive, respectively proposed Sites of Community Interest under the Habitats Directive in the German Exclusive Economic Zone (EEZ)
COD-D-024	GIGAWIND - Structure, Design and Environmental Aspects of Offshore-Windenergy-Converters
COD-D-025	Strategy of the German Government on the use of off-shore wind energy - in the context of its national sustainability strategy
COD-D-026	Continental Shelf Information System (CONTIS)
COD-D-027	Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index
COD-D-028	Consideration of effects on the marine environment within the licensing procedure of wind parks in the German EEZ: Discussion of methods and practical advise for the drafting and the quality assurance of EIA studies and of Habitat Assessment studies
COD-D-029	Development of an environmental strategy for the use of wind energy onshore and offshore
COD-D-030	MINOS plus: Ongoing research on seabirds and marine mammals for the evaluation of offshore wind turbines
COD-D-031	Strategic Environmental Assessment and strategical monitoring for offshore wind farms
COD-D-032	Computational simulation of the risk of avalanche of the wind turbine housing in case of ship collision
COD-D-033	Standardised methods for measurement and assessment of impact of sound on the marine environment by offshore-wind turbines
COD-D-034	Specious related levels of impact to migrating birds for the aerea of the south west Baltic Sea and hazard to bird migration caused by offshore wind turbines
COD-D-035	Development of a technical conception for an information centre for the technology and consequences of offshore wind energy deployment
COD-D-036	Changes in cultural landscape of coastal areas - Methodology of landscape analysis for the planning of offshore wind farms
COD-DK-001	Environmental Impact Assessment of hydrography
COD-DK-002	Investigation of marine mammals in relation to the establishment of a marine wind farm on Horns Reef
COD-DK-003	Effects on birds of an offshore wind park at Horns Reef: Environmental impact assessment
COD-DK-004	Environmental Impact Assessment of Sea Bottom and Marine Biology
COD-DK-005	Effects of marine windfarms on the distribution of fish, shellfish and marine mammals in the Horns Reef area
COD-DK-006	Offshore Wind Power Farm - Environmental Impact Assessment on Water Quality
COD-DK-007	Investigations on the artificial reef effect on fish from marine wind turbine park at Horns Reef
COD-DK-008	Elsam. Offshore Wind Farm. Horns Reef - Annual Status Report for the Environmental Monitoring Programme

Reference	Title
COD-DK-009	Base-line investigations of birds in relation to an offshore wind farm at Horns Reef: results and conclusions 2000/2001marine windmill parks at Horns Reef.
COD-DK-010	Base-line investigations of birds in relation to an offshore wind farm at Horns Reef, and results from the year of construction
COD-DK-011	Horns Rev havmøllepark Fremdriftsrapport for miljøundersøgelser 1. januar - 30. juni 2002
COD-DK-012	Horns Rev. Kontrol- og overvågningsprogram. Kunstigt rev
COD-DK-013	Horns Rev. Overvågningsprogram. Introduktion af hårdbundssubstrat
COD-DK-014	Fremdriftsrapport Effektstudie på marsvin 1. halvår 2002
COD-DK-015	Harbour seal satellite monitoring program, Horns Reef, North Sea
COD-DK-016	Short-term effects of the construction of wind turbines on harbour porpoises at Horns Reef
COD-DK-017	Satellite tracking of Harbour Seals on Horns Reef
COD-DK-018	Horns Reef Offshore Wind Farm - Introducing Hard Bottom Substrate Sea Bottom An Marine Biology
COD-DK-019	Horns Reef Offshore Wind Farm - Introducing Hard Bottom Substrate Sea Bottom An Marine Biology
COD-DK-020	Investigations on the artificial reef effect on fish from a marine wind turbine park at Horns Reef.
COD-DK-021	Investigations of harbour porpoises at the planned site for wind turbines at Horns Reef
COD-DK-022	Marinarkæologisk Survey i de lavvandede områder i kabeltracéet fra vindmølleparken ved Horns rev
COD-DK-023	Porpoise project
COD-DK-024	Horns Reef. Introducing hard substrate habitats
COD-DK-025	Monitoring effects of offshore windfarms on harbour porpoises using PODs (porpoise detectors)
COD-DK-026	Horns Reef wind farm: Progress report: 1. January - 30. June 2002
COD-DK-027	Investigations on the artificial reef effect on fish from marine windmill parks at Horns Reef.
COD-DK-028	Monitoring programme. Hard Bottom Substrate. Progress memorandum 3
COD-DK-029	Control and monitoring programme. Artificial reef. Progress memorandum 2
COD-DK-030	Seals using the Area of Horns Reef
COD-DK-031	Basic Study/Surveillance of Porpoises at Horns Reef
COD-DK-032	Status report of seabird surveys at Horns Reef, 2000-2001
COD-DK-033	Elsam. Offshore Wind Farm. Horns Reef Annual Status Report for the Environmental Monitoring Programme 1st January 2001 - 31st December 2001

Reference	Title
COD-DK-034	Status for fugleundersogelser samt forslag til opfolgende fugleundersogelser 2002 og 2003 for Horns Rev vindmollepark
COD-DK-035	Sandeels and clams (Spisula sp.) in the wind turbine park at Horns Reef
COD-DK-036	Windfarm at Rødsand VVM-review Backgroundreport no 1
COD-DK-037	Windfarm at Rødsand VVM-review Backgroundreport no 2
COD-DK-038	Windfarm at Rødsand VVM-review Backgroundreport no 3
COD-DK-039	Windfarm at Rødsand VVM-review Backgroundreport no 4
COD-DK-040	Windfarm at Rødsand VVM-review Backgroundreport no 5
COD-DK-041	Windfarm at Rødsand VVM-review Backgroundreport no 6
COD-DK-042	Windfarm at Rødsand VVM-review Backgroundreport no 7
COD-DK-043	Windfarm at Rødsand VVM-review Backgroundreport no 8
COD-DK-044	Windfarm at Rødsand VVM-review Backgroundreport no 9
COD-DK-045	Windfarm at Rødsand VVM-review Backgroundreport no 10
COD-DK-046	Windfarm at Rødsand VVM-review Backgroundreport no 11
COD-DK-047	Windfarm at Rødsand VVM-review Backgroundreport no 12
COD-DK-048	Windfarm at Rødsand VVM-review Backgroundreport no 13
COD-DK-049	Windfarm at Rødsand VVM-review Background report no 13a
COD-DK-050	Windfarm at Rødsand VVM-review Background report no 14
COD-DK-051	Environmental Impact Assessment (EIA) of offshore windfarms at Rødsand and Omø Stålgrunde, Denmark
COD-DK-052	Rødsand Offshore Wind Farm EIA Technical Background Report Birds nr 16
COD-DK-053	Windfarm at Rødsand VVM-review Backgroundreport no 17
COD-DK-054	Windfarm at Rødsand VVM-review Backgroundreport no 18
COD-DK-055	Windfarm at Rødsand VVM-review Backgroundreport no 19
COD-DK-056	Windfarm at Rødsand VVM-review Backgroundreport no 19a
COD-DK-057	Windfarm at Rødsand VVM-review Backgroundreport no 20
COD-DK-058	Windfarm at Rødsand VVM-review Backgroundreport no 21
COD-DK-059	Windfarm at Rødsand VVM-review Backgroundreport no 22

Reference	Title
COD-DK-060	Windfarm at Rødsand VVM-review Backgroundreport no 23
COD-DK-061	Windfarm at Rødsand VVM-review Backgroundreport no 24
COD-DK-062	Windfarm at Rødsand VVM-review Backgroundreport no 25
COD-DK-063	Windfarm at Rødsand VVM-review Backgroundreport no 26
COD-DK-064	Evaluation of the Effect of Noise from Offshore Pile-Driving on Marine Fish
COD-DK-065	Evaluation of the Effect of Sediment Spill from Offshore Wind Farm Construction on Marine Fish
COD-DK-066	Distribution of benthic communities at the proposed wind farm at Rødsand and along the cable connection between the wind farm and Lolland in May 2001
COD-DK-067	Sampling stations and results of photosampling along the cable connection in May 2001
COD-DK-068	Marine Biological Surveys Along the Cable Connection in the Lagoon of Rødsand in 2001
COD-DK-069	Base-line investigations of birds in relation to an offshore wind farm at Rødsand: results and conclusions, 2000
COD-DK-070	Satellite tracking as a tool to study potential effects of offshore wind farm on seals at Rødsand
COD-DK-071	Porpoise detectors (PODs) as a tool to study potential effects of offshore wind farm on harbour porpoises at Rødsand
COD-DK-072	Base-line investigations of birds in relation to an offshore wind farm at Rødsand: Results and conclusions, 2001
COD-DK-073	Monitoring effects of offshore windfarms on harbour porpoises using PODs (porpoise detectors)
COD-DK-074	EIA study of the proposed offshore wind farm at Rødsand Technical background report concerning fishery
COD-DK-076	EIA for An Offshore Wind Farm at Rødsand Technical report concerning Marine Biological Conditions (bottom vegetation and bottom fauna) in the park area
COD-DK-079	Development of the Fouling Community on Turbine Foundations and Scour Protections in Nysted Offshore Wind Farm, 2003
COD-DK-080	Offshore Wind-Turbine Construction, Offshore Pile-driving Underwater and Above-water Noise measurement and Analysis
COD-DK-082	Baseline study Fish, fry and commercial fishery Nysted offshore Wind Farm at Rødsand Status report
COD-DK-083	Morphological Survey Campaign
COD-DK-084	Aerial surveys of seals at Rødsand seal sanctuary and adjacent haul-out sites
COD-DK-086	Movements of seals from Rødsand seal sanctuary monitored by satellite telemetry
COD-DK-087	Remote video registration of seals at Rødsand seal sanctuary - Technical improvements and feasibility for detecting effects of the construction of Nysted Offshore Wind Farm
COD-DK-088	Base-line investigation of birds in relation to an offshore wind farm at Rødsand - Results and conclusion 2002

Reference	Title
COD-DK-090	Possible Effects of the offshore wind farm at Vindeby on the outcome of fishing
COD-IRL-002	Cost Benefit Analysis of Government Support Options for Offshore Wind Energy
COD-IRL-003	Assessment of the Impacts of offshore wind Energy Structures on the Marine Environment
COD-IRL-004	Assessment of Offshore Wind Energy Resources in the Republic of Ireland & Northern Ireland
COD-IRL-005	Environmental Impact Statement, Arklow Bank Wind Park, Non Technical Summary
COD-NL-001	Nocturnal flight activity of sea ducks near the windfarm Tunø Knob in the Kattegat
COD-NL-002	Monitoring of birds in the Near Shore Windfarm
COD-NL-003	Terms of reference, procurement base line studies North Sea Wind
COD-NL-004	Environmental Impact Assessment Off Shore Windfarm Q7-WP
COD-NL-005	Strategy of approach, Lot 1 Benthic
COD-NL-006	Strategy of approach, Lot 2 Demersal Fish Fauna
COD-NL-007	Base line studies North Sea wind farms: strategy of approach for pelagic fish (lot 3)
COD-NL-008	Detailed strategy of approach, lot 4 Assessment of the reference situation of the near Shore Windpark (NSW) for Harbour Porpoises
COD-NL-009	Detailed strategy of approach, lot 5 Marine Birds
COD-NL-010	Strategy of approach Non marine birds (Lot 6)
COD-NL-011	Environmental Impact Assessment Near Shore Windfarm
COD-NL-012	Strategic Environmental Assessment Near Shore Windfarm
COD-NL-013	North Sea Wind Farms: NSW Lot 1 Benthic Fauna. Final Report (ZBB607.2-F-2004)
COD-NL-014	Preliminary Study into Bird Research Methods for the MEP-NSW (RIKZ/2003.045)
COD-SE-001	Studies of birds near an off shore windpower unit
COD-SE-002	Investigation of fish at the wind power unit "Svatne 1" during 1990-1993
COD-UK-001	Offshore Wind Energy. Building a New Industry for Britain.
COD-UK-002	Assessment of the Effects of Offshore Wind Farms on Birds (DTI/Pub URN 01/1434, ETSU W/13/00565/REP)
COD-UK-003	Assessment of the Effects of Noise and Vibration from Offshore Wind Farms on Marine Wildlife (DTI/Pub URN 01/1341, ETSU W/13/00566/REP)
COD-UK-004	An Assessment of the Environmental Effects of Offshore Wind Farms (ETSU W/35/00543/REP)

Reference	Title
COD-UK-005	Continuation of bird studies at Blyth Harbour Wind Farm and the Implications for offshore Wind Farms (ETSU W/13/00495/REP)
COD-UK-006	Guide to Best Practice in Seascape Assessment (Report No.5)
COD-UK-007	Assessing the Navigational Impact of Offshore Wind Farms Proposed for UK Sites - Draft Report (Project MSA/10/6/200)
COD-UK-008	Wind Turbines and Aviation Interests. European Experience and Practice (ETSU W/14/00624/REP)
COD-UK-009	Potential Effects of Offshore Wind Developments on Coastal Processes (ETSU W/35/00596/00/REP)
COD-UK-010	The effect of wind turbines on the bird population at Blyth Harbour (ETSU W/13/00394/REP)
COD-UK-019	High Level Environmental Screening Study for Offshore Wind Farm Developments - Marine Habitats and Species Project (ETSUW/35/00632/00/00)
COD-UK-022	Development of a methodology for the assessment of cumulative effects of marine activities using Liverpool Bay as a case study - CCW Contract Science Report 522
COD-UK-023	Safeguarding Our Seas: A Strategy for the Conservation and Sustainable Development of our Marine Environment
COD-UK-024	Windfarms and Birds : An analysis of the effects of windfarms on birds, and guidance on environmental assessment criteria and site selection issues
COD-UK-027	The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon elasmobranch fishes
COD-UK-030	Barrow Offshore Wind Farm Environmental Impact Assessment
COD-UK-034	Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report
COD-UK-037	Offshore Wind Farms - Guidance note for Environmental Impact Assessment in respect of FEPA and CPA Requirements in respect of FEPA and CPA requirements
COD-UK-038	UK Offshore Wind 2003
COD-UK-039	Burbo Offshore Wind Farm Environmental Statement
COD-UK-040	Norfolk Offshore Wind Farm Project - Environmental Statement
COD-UK-041	UK Offshore Wind Farm at Gunfleet Sands - Environmental Impact Assessment
COD-UK-042	Inner Dowsing Offshore Wind Farm - Environmental Impact Statement (EIS)
COD-UK-043	Kentish Flats Offshore Windfarm - Environmental Statement
COD-UK-044	Lynn Offshore Wind Farm - Environmental Statement
COD-UK-045	North Hoyle Offshore Wind Farm - Environmental Statement
COD-UK-046	Rhyl Flats - Environmental Statement

Reference	Title
COD-UK-047	Scroby Sands - Environmental Statement
COD-UK-048	Robin Rigg - Environmental Statement
COD-UK-049	Scarweather Sands Offshore Windfarm - Environmental Statement
COD-UK-050	Aerial Surveys of Birds in Proposed Strategic Areas for Offshore Wind Farm Development, Round 2: Preliminary Report, Winter 2002/2003
COD-UK-051	Wind Energy and Aviation Interests: Interim Guidelines
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COD-UK-053	A Baseline Assessment of Electromagnetic Fields Generated by Offshore WindFarm Cables. COWRIE-EMF-01-2002
COD-UK-054	Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the UK