What are the problems?

There are a number of potential problems and benefits associated with the location, construction, operation and removal phases of OWF. OSPAR derived knowledge on the design and construction of offshore wind-farms and the identification of potential environmental impacts from a number of Environmental Statements for offshore wind-farm developments (primarily from Denmark and the United Kingdom) (OSPAR, 2006). Included within all Environmental Statements for offshore wind-farms is site specific data on the biological environment (biological communities, population dynamics, distribution, abundance etc); habitat types and characteristics and physical and chemical features (morphology, waves, currents, temperature, salinity etc). This data provides the context against which the pressures and impacts associated with the construction and operation of the offshore wind-farm can be assessed. This analysis of the essential characteristics and current environmental status is consistent with the requirements under Article 8 of the EC Marine Strategy Framework Directive (2008/56/EC).

OSPAR (2004) provided an initial overview of the key issues and potential impacts, gaps in scientific knowledge and potential benefits of offshore wind-farms. Table 3 lists the key issues and source of potential impacts identified by OSPAR. The third column provides examples of potential impacts that might arise based on our current knowledge and understanding, it is not exhaustive. Impacts (when they occur) will vary in significance from location to location. Further work is needed to determine the generic significance and/or acceptability of some of these impacts. As our knowledge and understanding progresses the contents and prominence of any list of potential impacts will change with items added or removed as the evidence dictates.

The issues and potential impacts from Table 3 were critically reviewed in the OSPAR (2006) paper in order to rationalise the potential areas for concern and allow a more targeted approach to the assessment, monitoring and management of environmental impacts. The key source of information for the OSPAR 2006 review were the results of monitoring studies and research at offshore wind-farms in Denmark and the United Kingdom and from the research platforms in Germany. The other main source of information came from peer-reviewed reports of studies undertaken on analogous works on the construction and placement of large structures.

The potential problems are identified in the OSPAR (2006) review along with the measures taken to predict, measure, assess and mitigate the associated effects. Attempts have also been made to demonstrate which issues are of local importance and those that have wider implications. It is those activities that affect considerable spatial and temporal scales that have the greatest potential to affect the overall quality status, and this review along with its source documents is intended to identify these.

The OSPAR offshore wind-farm database describes the spatial extent of developments in the OSPAR area and the OSPAR 2004 and 2006 papers provide a generic description of the environmental parameters and the assessment of their impacts. The existing OSPAR work streams also provide an initial step in establishing a link between anthropogenic pressures and observed impacts. The OSPAR 2006 paper looked at providing a detailed assessment of the environmental effects of OWF, however, data on OWF have only been available over relatively short time-scales and, as can be seen from Table 2 and Figures 1a-f, only a relatively small number of developments are operational so the determination of definitive trends is not possible from this assessment.

OSPAR has identified the following significant gaps in understanding pertinent to the QSR 2010:

- Impacts of underwater noise from construction activities and operation;
- Bird displacement and collision risk;
- Seabed morphology (gravity base and multi-pile foundations);
- Public perceptions/acceptance;
- Cumulative impacts.

Table 3. Potential impacts associated with the development of offshore wind-farms (not exhaustive). Source: OSPAR, 2004.

Issue	Source of Potential Impacts	Examples of Potential Impacts
Birds	- turbines, mainly rotor blades and wakes - light emission	- bird collision - attraction of birds due to illumination by navigational lights and subsequent increase in the risk of collision
	- wind-farm as a whole	- temporary or permanent habitat loss or change, including exclusion of habitat, *e.g.* sandbanks, water surface/water body due to disturbance - fragmentation of feeding, breeding and roosting areas, as well as migratory routes due to barrier effect - change of food species availability
	- boat traffic during construction and maintenance	- stress and reduction of biological fitness - temporary or permanent exclusion from habitat
	- electric cable to shore – increase of temperature in sediments during operation	- increased risk of botulism in coastal areas (eulittoral) resulting in an increased death rate for wading birds and water birds
Bats	- turbines mainly rotor blades and wakes	- collision and barrier effects
Marine Mammals	- shadow from rotor blades - emission of sound and vibration into the water body - construction noise (including pile driving)	- habitat loss due to avoidance - fragmentation of migratory routes and of sites for foraging and reproduction - induced permanent or temporary threshold shift in hearing (PTS/TTS), reduced perception of biologically significant sounds (masking)
	- boat traffic during construction and maintenance	- changed behaviour, stress
	- electric cables (see below)	- disturbance of small- and large-scale orientation
Fish	- electric cable within the wind-farm and to shore – artificial electromagnetic fields emitted during operation, in particular from monopolar direct current cables	- disturbance of small- and large-scale orientation (especially migratory species) - impediment of foraging activity - physical barrier
	- emission of sound and vibration into the water body	- habitat loss as fish may leave area - disturbance of behaviour and stress
	- clouding and sedimentation during construction	- damage to fish eggs - damage and or disturbance to spawning grounds
	- introduction of hard substrate - construction noise (including pile driving)	- alteration of food species availability and abundance, which in turn may alter community composition and abundance of fish - induced permanent or temporary threshold shift in hearing (PTS/TTS), reduced perception of biologically significant sounds (masking)
Zoobenthos	- cable laying	- disturbance of intertidal habitats
	- local destruction and sediment plumes during the construction/removal of foundations - permanent covering of the sea floor	- temporary and permanent habitat loss
	- introduction of artificial hard substrate	- alteration in the benthic community composition
	- changes in hydrodynamics	- indirect habitat loss through small-scale changes in sediment structure around the turbine and changes of large-scale sediment dynamics
	- electric cable within the wind-farm and to shore – increase of temperature in sediments during operation	- alteration in the endobenthic community including colonisation by alien species - increased degradation of the organic content resulting in a release of heavy metals (depending on the total organic matter content and metal content of the sediment)

Issue	Source of Potential Impacts	Examples of Potential Impacts
Macrophytes	- local destruction and sediment plumes during the construction of foundations - permanent covering of the seafloor	- temporary and permanent habitat loss
	- change of current dynamics and sediment conditions - introduction of artificial hard substrate	- habitat loss - alteration in the plant community composition
Hydrodynamics and MorphodynamicsHydrodynamics and Morphodynamics	- construction and presence of foundations and cables	- change of sediment dynamics, for example slowing down of natural erosion and sedimentation processes (at the site and adjacent coastlines) - reduction in wave energy (shadow effects) from different sized arrays and how/if this influences sediment inputs and exchanges - beach faces and flood defences
Landscape	- tall structures visible from afar - lighting	- intrusion on the typically flat and featureless sea and "industrialisation" of this natural landscape - alteration of the scenic landscape – especially at night
Navigation	- danger of collisions between vessels and wind turbines (including restriction/constriction of shipping routes)	- pollution through oil spills or chemical spills - impact on socio-economic operations
Emergency Operations	- obstacles due to the presence of static structures	- impact on emergency operations
Other Users	- exclusion of other users from the area - disturbance of the natural landscape	- socio-economic losses, *e.g.* for fisheries and tourism

Gaps in understanding are discussed in more detail in the section of this report titled "Data gaps and sharing information".

However, there were also a number of issues where understanding is sufficient for impacts to be confidently predicted, assessed and managed at the scale of development predicted up to 2010, *e.g.* disturbance/loss of seabed habitat from monopile foundations, which species colonise foundations and monopiles, pollution incidents, agreed construction vessel routes (OSPAR, 2006). Given the qualitative nature of some of the data for OWF and the relatively small data sets currently available where gaps exist, this report suggests options for the type of data and assessments necessary to prepare a trend analysis.

The three OSPAR reports (2004, 2006 and 2007) provide the basis for this JAMP assessment for a concise summary of contemporary knowledge, management techniques and identifying significant gaps in knowledge, the resolution of which will become increasingly important as the scale of OWF development increases beyond 2010 levels.

The next section draws heavily on the OSPAR 2004 and 2006 reports to elaborate on what has been done to date to improve our understanding of the main impacts identified within Environmental Statements under the headings: Sea bed habitat loss / disturbance; Fish; Marine mammals; Birds; Seascape public perception and Cumulative Impacts pertinent to the level of OWF development in the OSPAR maritime area up to 2010.

➥*Go to full QSR assessment report on the environmental impact of offshore wind farms (publication number 385/2008)*