OSPAR
COMMISSION

Assessment of the environmental impacts of cables

Biodiversity Series

2009

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the “OSPAR Convention”) was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Community and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998.
La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l’Irlande, l’Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d’Irlande du Nord, la Suède et la Suisse et approuvée par la Communauté européenne et l’Espagne.

Acknowledgement

This report has been prepared by:

Thomas Merck
Bundesamt für Naturschutz
Aussenstelle Insel Vilm
D-18581 Lauterbach
Germany

assisted by:

Ralf Wasserthal
Bundesamt für Seeschiffahrt und Hydrographie
Bernhard-Nocht-Strasse 78
D-20359 Hamburg
Germany

Photo credit
Cover page: Laying cables at sea@transpower stromuebertragungs gmbh

Contents

Executive summary

Submarine cables have a long history within the OSPAR Maritime Area and new cable connections are to be expected

Sub-sea cables are found throughout the five OSPAR regions. Most of the more than 300 cables laid since the middle of the 19th century are cables intended to provide fast telecommunication links. Most long-distance telecommunication cables are found in the southern parts of both the Greater North Sea (Region II) and the Celtic Seas (Region III) and in a corridor crossing the Wider Atlantic (Region V) to North America. Longer-distance power cables to date are confined to the Greater North Sea (Region II) and the Irish Sea (in Region III). These cables supply islands or offshore installations with electrical power or serve as transfer cables between the terrestrial grids of different countries. Transmission cables from offshore wind farms in coastal areas of the North Sea and the Celtic Seas (Region II and III) have been installed over the last decade. It is expected that the number of submarine telecommunication and in particular power cables will increase in the coming years. In particular, the number of offshore wind farm transmission cables is predicted to grow rapidly. This could intensify potential environmental impacts resulting from submarine cables. Developments in the European energy market may also result in an increase in submarine electricity transfer cables.

Cable-laying temporarily disturbs seabed habitats

As far as the construction phase (*i.e*. the placement) of both power and telecommunication cables is concerned, the associated impacts (disturbance, habitat damage) are generally not likely to be detrimental to the overall quality status of the OSPAR region because they are mostly local and temporary. The main long-term impact of submarine cables is the presence of the cable itself and any accompanying protective structures. These can provide artificial hard substrate habitats that attract flora and fauna that may not be typical of the area. Again, since it is confined to the cable route itself, such change is not likely to be significant.

Operational power cables may disturb electromagnetically sensitive or temperature-adapted species

Submarine cables, particularly power transmission lines, may have operational impacts in the form of electromagnetic fields and thermal radiation. Although only few long-distance power cables are in use in the OSPAR maritime area, a final assessment of their effects on the overall environmental state is difficult. For example, the effects of the electromagnetic fields on migrating species (fish, marine mammals) are not sufficiently understood and significant impacts cannot be excluded. Field studies into changes in benthic communities and microbial sediment processes due to increased temperatures in the immediate vicinity of sub-sea cables have not been conducted to date.

Appropriate mitigation measures are available and should be applied

Since there is sufficient evidence that the placement and operation of submarine cables may affect the marine environment, the precautionary principle should be applied and appropriate mitigation measures should be taken. Available measures to minimise or even avoid most of the anticipated environmental impacts include careful routeing and scheduling of installation activities, suitable choice of cable types, appropriate burial of the cable and use of inert material if protective cover is necessary. In addition, further scientific investigations into the environmental impacts of the placement and operation of cables should be conducted in order to close existing gaps in knowledge.

Common guidelines for the placement of submarine cables should be developed

Common guidance on environmental considerations for the placement and operation of submarine cables should be developed by OSPAR. This should include issues to be covered in an environmental impact assessment as well as a description of appropriate mitigation measures related to the choice of cable types, routeing (location), timing of installation, bundling, placement (including burial) and operation of cables. The purpose of the guidance will be to assist OSPAR Contracting Parties, developers, consultants, regulators or any other party interested in the identification and consideration of the environmental impacts of the placement and operation of submarine cables.

Récapitulatif

La question des câbles sous-marins dans la zone maritime OSPAR est de longue date et on peut s'attendre à de nouveaux raccordements de câbles

Des câbles sous-marins sont présents dans les cinq Régions OSPAR. Plus de 300 câbles ont été posés depuis le milieu du XIXème siècle et la plupart sont prévus afin de permettre des liens télécommunications rapides. La plupart des câbles pour télécommunication à longue distance se trouvent dans les parties méridionales de la mer du Nord au sens large (Région II) et des mers celtiques (Région III) et dans un couloir qui traverse l'Atlantique au large (Région V), en direction de l'Amérique du Nord. Les câbles électriques à plus longue distance se limitent à la mer du Nord au sens large (Région II) et à la mer d'Irlande (dans la Région III). Ces câbles amènent le courant aux îles ou aux installations offshore ou assurent le transfert entre les réseaux électriques terrestres des divers pays. Des câbles de transmission pour les parcs d'éoliennes offshore dans les zones côtières de la mer du Nord et des mers celtiques (Régions II & III) ont été installés au cours des dix dernières années. On s'attend à une augmentation du nombre de câbles sous-marins pour télécommunication et en particulier de câbles électriques au cours des prochaines années. On prévoit en particulier que le nombre de câbles de transmission pour les parcs d'éoliennes offshore augmentera rapidement. Ceci pourrait intensifier les impacts potentiels des câbles sous-marins sur l'environnement. Les avancées du marché de l'énergie européen ont également entraîné une augmentation des câbles sous-marins de transfert électrique.

La pose de câbles perturbe temporairement les habitats du fond marin

En ce qui concerne la phase de construction (c'est-à-dire la pose) des câbles électriques et des câbles pour télécommunication, les impacts correspondants (perturbations, dégradation des habitats) ne sont pas dans l'ensemble susceptibles de nuire à l'état de santé général de la région OSPAR car ils sont surtout locaux et temporaires. Le principal impact à long terme des câbles sous-marins est la présence du câble proprement dit et des structures de protection correspondantes. Ceux-ci peuvent constituer des habitats de substrat dur artificiels qui attirent une flore et une faune qui risquent de ne pas être propres à la zone en question. Puisque ces impacts sont limités à la route des câbles, ces modifications ne risquent donc pas d'être significatives.

Les câbles électriques opérationnels risquent de perturber les espèces sensibles à l'électromagnétisme ou adaptées à la température

Les câbles sous-marins, en particulier les câbles électriques, risquent d'avoir des impacts opérationnels sous forme de champs magnétiques et de radiations thermiques. Il est difficile d'effectuer une évaluation définitive des effets, sur l'état général de l'environnement, des câbles électriques à longue distance, bien que peu d'entre eux soient utilisés dans la zone maritime OSPAR. Par exemple on ne comprend pas suffisamment les effets des champs électromagnétiques sur les espèces migratoires (poisson, mammifères marins) et il n'est pas possible d'exclure des impacts significatifs. On n'a pas encore entrepris, à ce jour, des études sur le terrain des modifications subies par les communautés benthiques et les processus microbiens dans les sédiments causés par l'augmentation de la température à proximité immédiate des câbles sous-marins.

Des mesures d'atténuation adéquates sont disponibles et devraient être appliquées

On devrait appliquer le principe de précaution et prendre des mesures d'atténuation adéquates puisque l'on dispose de preuves suffisantes que la pose et l'exploitation de câbles sous-marins risquent d'affecter le milieu marin. Des mesures disponibles permettant de minimiser ou même d'éviter la plupart des impacts environnementaux anticipés sont notamment le soin apporté au choix d'un itinéraire, du calendrier des activités d'installation et du type de câble pertinent, à l'enfouissement adéquat des câbles et à l'emploi de matériau inerte lorsque une couverture de protection est nécessaire. Il faudrait de plus réaliser des enquêtes scientifiques supplémentaires sur les impacts environnementaux de la pose et de l'exploitation de câbles afin de combler les lacunes actuelles des connaissances.

Il faudrait élaborer des lignes directrices communes pour la pose de câbles sous-marins

OSPAR devrait élaborer des orientations sur les considérations environnementales de la pose et de l'exploitation des câbles sous-marins. Il s'agira notamment des questions qu'une évaluation de l'impact environnemental devra couvrir ainsi que d'une description des mesures de mitigation adéquates correspondant à la sélection du type de câble, à l'itinéraire (emplacement), au calendrier de l'installation, au groupement, pose (notamment l'enfouissement) et exploitation des câbles. Ces orientations auront pour objectif d'aider les Parties contractantes OSPAR, les exploitants, les consultants, les régulateurs ou autre partie intéressée à déterminer et à étudier les impacts environnementaux de la pose et de l'exploitation des câbles sous-marins.

1. Introduction

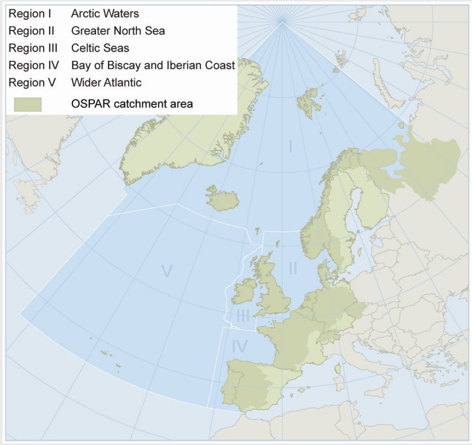
Submarine cables have a long history in the OSPAR maritime area. Telecommunication services started in the middle of the 19th century with the deployment of the first commercially successful telecommunication cable, the England to France link across the English Channel. In 1858 the first trans-ocean telecommunication cable, the Atlantic Cable connecting Ireland and the USA, commenced operation. Since then numerous cables have been put into operation world wide (www.atlantic-cable.com). Nevertheless, the demand for fast communication links is still growing rapidly and results in cable-laying activities around the globe.

A second aspect of submarine cables gaining more and more importance is the transmission of electric power. Power cables are used to supply islands and offshore facilities or to transport electricity from one country to another. In May 2008, the world's longest sub-sea power cable (NorNed) crossing the North Sea between Norway and the Netherlands was commissioned. A growing number of cables will be needed in the future to transmit electric power supplied from offshore renewable energy sources such as wind farms, tidal power plants and wave power devices into the various terrestrial grids.

In 2008, OSPAR published the 'Background document on potential problems associated with power cables other than those for oil and gas activities' (OSPAR Commission 2008a). The following assessment of the environmental impact of power cables is based on this background document, which contains more details on the scientific background to these issues. It has been prepared as part of the series of assessments of the environmental impact of human activities on the marine environment of the OSPAR maritime area and its Regions (see box). The series of assessments contributes to the Quality Status Report 2010. The assessment of the environmental impact of cables complements the assessment of other activities (see box).

Electronic navigator to complementary QSR assessments

- Offshore wind-farms (OSPAR, 2009a)
- Construction or placement of structures (OSPAR, 2008b)
- Underwater noise (OSPAR, 2009b)



Map: OSPAR maritime area and its five Regions

2. What are the problems? Are they the same in all OSPAR regions?

2.1 Generic Impacts

Modern submarine telecommunication systems are fibre optic cables using pulses of light to transport information. Coaxial cables, as the former standard, use electric current to carry information and are sporadically still in service. However, long-distance optical cables require repeaters and thus also need a constant power supply. Whereas coaxial cables have a diameter of up to 10 cm, fibre optic cables are only 2 – 5 cm thick.

Power cables are deployed to transport electrical energy. As with terrestrial cables, marine power cables use either Alternating Current (AC) or High Voltage Direct Current (HVDC) transmission. Cables may be monopolar (using the sea water as return conductor), bipolar or three-phase systems. Depending on their design the diameter of power cables may be up to 15 cm. Power cables may have a capacity of several hundred megawatts (MW), for example, 700 MW in the case of the NorNed cable between Norway and the Netherlands (www.statnett.no).

Submarine cables are usually buried to minimise the risk of damage by, for example, anchors and fishing gears. Drew & Hopper (1996) and Emu Ltd (2004) reported cables to be buried in areas with water depth of up to 1000 m and 1200 m, respectively. According to Deutsche Telekom AG (pers. comm.), telecommunication cables installed over the last decade have been buried as far as technically feasible, but not in areas with a water depth of more than 3000 m. Where cables cannot be buried, for example, in areas of exposed bedrock, they are laid directly on the seabed and may be (partially) covered with mechanical protection (for example, rock armour).

Submarine cables have a wide range of potential impacts on the marine environment due to their placement (i.e. cable-laying) as well as due to their operation. The various potential impacts of submarine cables differ considerably in terms of their spatial extent, duration, frequency and reversibility. A general overview is given in Table 1.

The various impacts act on different components of the ecosystem in different ways. Seabed disturbance and thermal radiation may impact benthic organisms, underwater noise is most relevant for marine mammals, electromagnetic fields may have effects on sensitive fish and marine mammals and visual disturbance (including visual and aerial noise) has the potential to displace sensitive sea birds and seals. The extent of such impacts is determined by the technical design of the cables, the laying equipment, and in the case of power cables, the amount of electrical power transmitted. Some environmental impacts are mainly linked to the installation phase and/or maintenance, repair activities and removal. Others are only relevant during operation.

Table 1: ***Main environmental impacts associated with submarine cables***

	Installation, Maintenance and Repair work, Removal	**Operational phase**
Telecommunication cable	Seabed disturbance Damage/disturbance of organisms Re-suspension of contaminants Visual disturbance Noise (vessels, laying machinery) Emissions and wastes from vessels	Introduction of artificial hard substrate
Power cable	Seabed disturbance Damage/disturbance of organisms Re-suspension of contaminants Visual disturbance Noise (vessels, laying machinery) Emissions and wastes from vessels	Introduction of artificial hard substrate Electromagnetic fields Thermal radiation

2.2 Seabed Disturbance

The laying of cables leads to seabed disturbance and associated impacts of damage, displacement or disturbance of flora and fauna, increased turbidity, release of contaminants and alteration of sediments. Along with noise and visual disturbance, these effects are mainly restricted to the installation, repair works and/or removal phase and are generally temporary. In addition, their spatial extent is limited to the cable corridor (in the order of 10 m width if the cable has been ploughed into the seabed). Such impacts relate to both submarine telecommunications and power cables. Some mobile benthos (for example, crabs) are able to avoid disturbance (Emu Ltd, 2004) and though sessile species (bivalves, tubeworms etc.) will be impacted, the principal risk is in sensitive habitats which include, for example, slower growing vulnerable or fragile species. Avoidance of such areas for cable placement would be an appropriate mitigation measure.

The application of protection along the cable route in areas characterized by soft sediments will lead to artificial introduction of hard substrates. The submarine cables themselves, if not buried, will also provide a solid substrate for a variety of species (Figure 1). This ‘reef effect’ has been extensively discussed in literature (see for example, Wenner *et al.,* 1983; Reimers & Branden, 1994; Birklund & Petersen, 2004) and essentially leads to the introduction of non-local fauna and thus to an alteration of the natural benthic community. In most cases effects will be localized although long-term. In general, if armouring is required, inert natural stone material should be used to minimise the degree of impact.

Figure 1:*Sub-sea cable, in place for approximately 50 years, covered with sessile encrusting organisms at Vancouver Island (BCTC, 2006).*

Though modern equipment and installation techniques can reduce the re-suspension of sediment during cable burial or removal, remaining turbidity may nonetheless obstruct the filtration mechanisms of some benthic and pelagic organisms at least temporarily (Söker *et al.*, 2000). It can also affect the growth of the macrobenthos and may have a lethal effect on some species.

Contamination arising from seabed disturbance is only a risk in heavily contaminated locations. Again, avoidance of such areas would be an appropriate mitigation measure. Release of contaminants into the environment from the cable itself can only occur if cables are not removed after decommissioning or if operational cables are damaged, in particular if fluid-filled cables are damaged.

2.3 Noise

There are no clear indications that underwater noise caused by the installation of sub-sea cables poses a high risk of harming marine fauna. Richardson *et al*. (1995) provide an overview of investigations into behavioural responses of cetaceans to dredging, an activity emitting comparatively higher underwater noise levels. However, it is not clear if behavioural responses were due to sound or the increased presence of ships. Appropriate scheduling of cable-laying activities will minimise the potential for such impacts on sensitive species (for example, marine mammals or turtles). In addition, performing aerial or other surveys, with suspension of activities if sensitive species are found, are possible mitigation measures.

2.4 Visual disturbance

Some sea bird species, for example, divers, are very sensitive to visual disturbance and are displaced by ship traffic (Mendel *et al*., 2008). It can be expected that the working vessel during the installation process will have the same effect and that these birds will avoid these areas during the cable-laying. Scheduling these activities and/or avoiding of wintering, resting and foraging areas of such sensitive species are possible mitigation measures.

2.5 Electromagnetic fields

Electromagnetic fields are generated by operational transmission cables. Electric fields increase in strength as voltage increases and may be as strong as 1000 µV per m (Gill & Taylor, 2001). In addition, induced electric fields are generated by the interaction between the magnetic field around a submarine cable and the ambient saltwater. Magnetic fields are generated by the flow of current and increase in strength as current increases. The strength may reach the multiple of the natural terrestrial magnetic field. In general, HVDC cables produce stronger electromagnetic fields than AC cables. Magnetic fields are best limited by appropriate technical design of the cable (for example, three-phase AC, bipolar HVDC transmission system). Directly generated electric fields are controllable by adequate shielding, however, induced electric fields generated by the magnetic field will occur. Because the strength of both magnetic and electric fields rapidly declines as a function of the distance from the cable, an additional reduction of the exposure of marine species to electromagnetic fields can be achieved by cable burial.

Magnetic fields generated by cables may impair the orientation of fish and marine mammals and affect migratory behaviour. Field studies on fish provided first evidence that operating cables change migration and behaviour of marine animals (Klaustrup, 2006). Marine fish use the earth's magnetic field and field anomalies for orientation especially when migrating (Fricke, 2000). Elasmobranch fish can detect magnetic fields which are weak compared to the earth's magnetic field (Poléo *et al.*, 2001; Gill *et al.*, 2005).

Marine teleost (bony) fish show physiological reactions to electric fields at minimum field strengths of 7 mV*m-1 and behavioural responses at 0.5-7.5 V*m-1 (Poléo *et al.*, 2001). Elasmobranchs (sharks and rays) are more than ten-thousand fold as electrosensitive as the most sensitive teleosts. Gill & Taylor (2001) showed that the dogfish *Scyliorhinus canicula* avoided electric fields at 10 µV cm-1 which were the maximum expected to be emitted from 3-core undersea 150kV, 600A AC cables.

2.6 Thermal radiation

Thermal radiation from submarine cables has become an issue of increasing concern over the past few years. When electric energy is transported, a certain amount gets lost as heat, leading to an increased temperature of the cable surface and subsequent warming of the surrounding environment. Important factors determining the degree of temperature rise are cable characteristics (type of cable), transmission rate and characteristics of the surrounding environment (thermal conductivity, thermal resistance of the sediment etc.). In general, heat dissipation due to transmission losses can be expected to be more significant for AC cables than for HVDC cables at equal transmission rates.

Published theoretical calculations of the temperature effects of operational buried cables are consistent in their predictions of significant temperature rise of the surrounding sediment. The one field study carried out so far, at the Nysted wind farm, did not provide conclusive results (Meißner *et al.*, 2007). The rise in temperature did not exceed 1.4°C in 20 cm depth above the cable, but the capacity of the cable was only 166 MW. In addition, it was not possible to establish a correlation between temperature increase and power transmitted due to lack of data. Furthermore, the coarse sediment of the study location allowed for increased heat loss through the interstitial water than would be the case in common fine sands or mud.

There is evidence that various marine organisms react sensitively to an even minor increase in the ambient temperature. For example, the recruitment of eastern populations of Atlantic cod (*Gadus morhua*) decreases with increasing water temperature (Drinkwater, 2004) and the mortality rates of some intertidal gastropods increases due to rising temperatures (Newell, 1979). Nevertheless, field studies on operational submarine cables are almost completely lacking. Preliminary laboratory experiments revealed that the polychaete worm *Marenzellaria viridis* shows the tendency to avoid areas of the sediment with increased temperature whereas the mud shrimp *Corophium volutator* does not (Borrmann, 2006). Knowledge of warming effects on bacterial and other microbial activity and, thus on biogeochemical processes is currently insufficient.

Due to the lack of field data, the effects of artificially increased temperature on benthos are difficult to assess. It has to be assumed that a permanent increase of the seabed temperature will lead to changes in physiology, reproduction or mortality of certain benthic species and possibly to subsequent alteration of benthic communities due to emigration or immigration. The temperature increase of the upper layer of the seabed inhabited by the majority of benthos depends, amongst other factors, on the burial depth of the cable. To reduce temperature rise an appropriate burial depth should be applied.

Other than direct effects on the marine biota, temperature rise of the sediment due to heat emission from the cable may also alter the physico-chemical conditions in the sediment and increase bacterial activity (Meißner & Sordyl, 2006). Processes set off in deeper sediment layers are likely to finally affect the entire seabed above the cable due to contact with pore water. Alteration of sediment chemistry might possibly exert secondary impacts on benthic fauna and flora. It should be noted that the content of organic matter in the sediments determines these processes.

2.7 Status of submarine cables within the OSPAR region

A comprehensive catalogue of cables in service or planned within the OSPAR maritime area does not exist. Since the middle of the 19th century more than 300 long-distance cables have been laid within the OSPAR maritime area including about 40 trans-ocean connections (http://www.atlantic-cable.com). Figure 2 gives an (incomplete) overview of existing submarine cables in the OSPAR maritime area:

Most long-distance (especially transatlantic) submarine cables in the OSPAR maritime area serve telecommunication purposes. About half of these cross the Greater North Sea (Region II), mainly in the southern part (Figure 2). Since the 1950s about 20 000 km of telecommunication cables have been laid here. Cables crossing the Wider Atlantic (Region V) towards Canada and the USA are concentrated in the Channel and the southern part of the Celtic Seas (Region III). Only few further cables are in use in the Arctic Waters (Region I) and the Bay of Biscay and Iberian Coast (Region IV).

Since 1998, more than 44 new telecommunication cables, several thousands of kilometres long, have been laid within the OSPAR maritime area (http://www.atlantic-cable.com). This represents an increase of more than 15% over the total number laid prior to 1998. Approximately half of the newly-laid cables are in Region II including connections to offshore installations. Eight of the nine new trans-oceanic cables laid since 1998 are to North America and cross Region III and V. This increased the number of intercontinental connections by about 30%. It is likely that future demand for increased communication capacity will lead to further cables being installed.

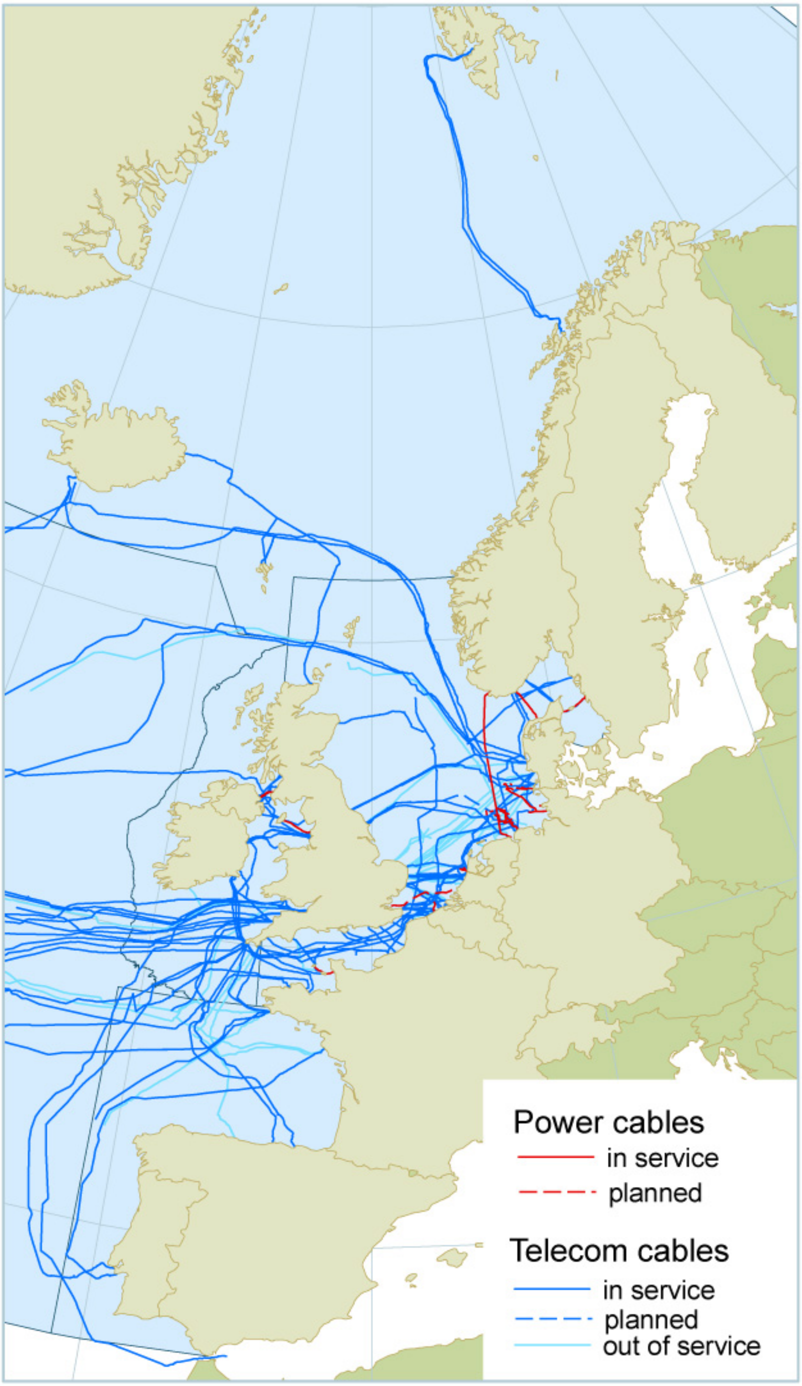


Figure 2:*Submarine cables in the OSPAR Maritime area (incomplete). Compiled from different sources by the German Federal Agency for Nature Conservation.*

A number of short power cables are in use to supply islands with electricity from the mainland (see for example OSPAR Commission, 2008b) or to transmit electric energy produced by offshore wind farms to the terrestrial grids (see below). Longer-distance power cables in service in the OSPAR Maritime Area connecting countries are the Konti-Skan cable in the Kattegat linking the grids of Denmark and Sweden, the cross-Skagerrak cable between Norway and Denmark, the cross-Channel cable between France and England and the NorNed cable between Norway and the Netherlands. The BritNed connection between England and the Netherlands is currently under construction. All these cables are

HVDC cables and are situated in the Greater North Sea (Region II). In Region III, a HVDC cable connects Scotland and Northern Ireland and the world's longest submarine AC cable links the Isle of Man with England.

The two longest power cables in use to date, the Isle of Man connection and the NorNed cable both have been built in the last decade leading to a 200% increase of the length of operational submarine power cables. It is reasonable to assume that in the future more power cables will be required to allow exchange of electricity within the European grid. Nevertheless, no further information is available on other planned sub-sea power cables in the OSPAR maritime area.

There will be an increasing number of cables entering service as the number of offshore wind farms increases in various OSPAR member states. Beside the cables transporting electricity to the grids, wind farms also have cables connecting the turbines with each other and with transformer stations. To date there are 17 offshore wind farms in operation or under construction in the OSPAR maritime area and more than 100 additional wind farms have been authorised or have been applied for. In the medium-term, development of marine renewable energy projects (wave and tidal energy) will create a similar requirement for new cables.

For technical and economic reasons, in the near future offshore wind farms and the respective cables will be mainly restricted to coastal waters and the adjacent EEZs. Offshore power generation is likely to move further out to sea thus leading to an increasing number and length of cables perpendicular to the coast. Within the OSPAR regions this development is expected to take place mainly in the Greater North Sea (Region II), the Celtic Seas (Region III) and may be followed by the Bay of Biscay and the Iberian Coast (Region IV). Reference is made to OSPAR Assessment of the environmental impact of offshore wind-farms (OSPAR 2008 and OSPAR's database on wind farms and the associated maps indicating the location, status (application, authorisation, operation) and size of wind farms in the OSPAR Maritime area (www.ospar.org).

3. What has been done? Did it work?

So far, no common programmes or measures have been developed by OSPAR with respect to the placement of sub-sea cables.

The EIA Directive 85/337/EEC (as amended by Directive 97/11/EC) does not require an environmental impact assessment for the placement of submarine cables, though this may be required by the permitting system of individual Contracting Parties. For example, in Germany an environmental impact assessment has to be provided in the framework of the application procedure (www.bsh.de). The respective permission will include specifications concerning cable routeing, placement time, burial, design of the cable (for example, no monopolar systems) etc.

To increase knowledge on potential effects of the operation of cables, the UK is funding an ongoing investigation into the effects of electromagnetic fields (EMF). This project includes an experimental mesocosm study of the response of sensitive organisms to controlled EMF with the characteristics and magnitude associated with offshore wind farm power cables (Gill *et al.* 2009).

Also in the context of offshore wind farms, Germany facilitated field measurements of seabed temperature changes in the vicinity of the 33 kV and 132 kV AC power cables at the Danish Nysted wind farm. The results (Meißner *et al.*, 2007) underlined in principle the correlation between temperature rise and power transmission. However, so far only qualitative information could be provided since quantitative data on power transmission were not available.

In Germany the nature conservation authorities agreed on a threshold of a maximum tolerable temperature increase of 2 K in 20 cm depth in the sediment in the German offshore areas (which requires burial of cables in depths of about one meter and more). This 2 K value was considered appropriate for applying the precautionary approach to protect benthic organisms and communities from cable-induced temperature rises. The effectiveness of this measure has not been monitored to date.

4. How does this affect the overall quality status?

From the ecological perspective, the most significant environmental impacts of the installation of submarine cables are disturbance effects, especially if the cables are buried. It is difficult to assess how far the status of the marine environment has been affected due to the laying of new-cables since the publication of the QSR 2000. However, it can be assumed that in the Greater North Sea (Region II) and in the Celtic Seas (Region III) cables have often been buried whereas within large parts of the Arctic Waters (Region I) and the Wider Atlantic (Region V) cables have not been buried because of the great water depth.

Impacts of placement are limited to narrow but long stripes along the cable routes and are in most cases temporary. In case of habitat changes due to the introduction of artificial hard substrate, longer-term effects such as the introduction of non-local fauna may occur. Another longer-term impact may arise where unburied cables are moved by tides and currents causing repeated physical disturbance to the seabed in the cable corridor. Provided that no valuable or sensitive habitats have been disturbed and heavily contaminated areas have been avoided, the wider impacts of the placement of cables are of low intensity in OSPAR Regions II and III and probably negligible in Regions I, IV and V.

With respect to the operational phase, the main impacts on the marine environment are expected from the generation of electromagnetic fields and heat. Both these effects are much more relevant to power transmission cables than to telecommunications cables, even though modern fibre-optic cables are equipped with electrical power supplies. While most power cables are found in the coastal waters of all OSPAR regions except the Wider Atlantic, the few longer distance power cables to date are restricted to the Greater North Sea (Region II) and the Celtic Seas (Region III). Most of these HVDC connections use separate monopolar cables for much of their length[1] thus emitting much stronger magnetic fields than do bipolar cables or bundled systems of comparable capacities.

The operation of power cables generates electromagnetic fields that are probably detectable to sensitive species. This may result, for example, in behavioural changes or barrier effects hampering the migration of fish or marine mammals. Because power cables in use outside the North Sea and the Irish Sea are to date only found in coastal areas, most of the OSPAR maritime area may not be affected. The expected future increase in submarine power cables will intensify the effects of electromagnetic fields and the heat unless appropriate mitigation measures are applied. There is concern that cables associated with the large number of planned offshore wind farms may, for example, disrupt the migration of sensitive anadromous fish species on their route into the rivers where they reproduce. The significance of such changes and related impacts especially on migrating species are unknown but potentially high.

The significance of impacts on the overall quality status of the OSPAR region from operational power cables is difficult to assess as field studies are few. Bearing in mind the low number and the relatively small spatial extent of cables, the impact on the overall quality status of the OSPAR region is expected to be low. However, if migration of electromagnetic-sensitive species is affected, the environmental impact will not be restricted to the close vicinity of the cables. The same would be the case if

---

1 For example, the NorNed cable consists of 270 km two-core cable (bundled) and 2 x 310 km stretches of single-core cable. (www.statnett.no)

increased sediment temperature results in major changes of benthic communities. Additional extensive field research is needed to understand the significance of such effects.

5. What do we do next?

Even though cables are not covered by the EIA Directive, it is recommended that the Contracting Party responsible should assess the environmental impacts of newly planned submarine cables, especially power cables within the OSPAR maritime area through the EIA process. This assessment should take into consideration the site specific biotic and abiotic features of the cable route. Based on the results of the EIA appropriate mitigation measures should be identified and applied. In general, as a basic prerequisite, a route survey should be carried out to circumvent habitats of conservation interest (for example, boulder fields, seagrass meadows) and in order to provide an adequate description of impacts on the seabed and benthos, including forecasts of possible future impacts (for example, BSH, 2008).

OSPAR Guidance on environmental considerations for the placement and operation of submarine cables should be developed. This should include guidance on appropriate mitigation techniques including routeing (location), bundling and placement of the cables. The purpose of the guidance will be to assist OSPAR Contracting Parties, developers, consultants, regulators or any other party interested in the identification and consideration of the environmental effects of the placement and operation of sub-sea cables. Relevant recommendations of the International Committee for Cable Protection (ICPC) should be taken into account when developing the OSPAR Guidance.

A sound assessment of the environmental impact of cables has to be based on a comprehensive overview of cables in the OSPAR maritime area. In particular, information on existing or planned power cables should be gathered from OSPAR Contracting Parties. Such information should include specification with respect to cable design and capacity, location etc. In addition, new scientific findings on the environmental effects of submarine power cables should be made available.

Gaps in knowledge concerning the operational effects of submarine cables have to be addressed. *In-situ* measurements of the electromagnetic fields (including induced fields) emitted by operating cables should be carried out, taking into account various operational and environmental variables, including burial depth. In order to better understand the effects of electromagnetic fields on fish and marine mammals, information on their specific sensitivities is required. This requirement includes necessary field studies on behavioural changes and on potential disturbance of migration routes of marine species. With respect to heat dissipation in various sediments, monitoring is required to verify the predicted temperature increases. Potential changes in species composition of the benthic fauna due to a temperature rise should also be analysed by respective investigations along the cable routes.

6. Conclusion

Even though sub-sea cables have been in use since the middle of the 19th century, environmental concerns associated with their placement and operation are only recent. One main reason for the increased awareness is the rapid development of offshore wind farms in the last decade and the related increase of the use of submarine power cables.

The approval of new sub-sea cables should follow a licensing procedure and include the preparation of an EIA. The EIA should describe the environmental impacts of installing, operating and removing the cable and develop or propose adequate technical or organisational mitigation measures to manage these impacts.

The placement of both power and telecommunication cables may temporarily lead to impacts such as increased turbidity, noise, disturbance, habitat loss, habitat damage and in certain cases to long-term habitat change due to introduction of artificial substrate. The environmental impacts are generally limited to the near proximity of the cable routes and only in the case of alteration of the habitat are they long-term. However, appropriate mitigation measures are available and should be applied:

- avoiding sensitive habitats/areas;
- scheduling laying activities to certain times of the year to avoid disturbance of sensitive species, for example, marine mammals or resting/feeding (sea) birds;
- avoidance of heavily contaminated areas in order to prevent the re-mobilisation of contaminants from sediments.

Depending on their technical design, the transmission of electric power through these cables may generate electromagnetic fields strong enough to disturb the behaviour and migration of species sensitive to electromagnetic fields, for example, fish and marine mammals. In addition, loss of energy in the form of heat will occur, raising the temperature of the inhabited sea bottom and potentially affecting benthic species and processes.

The environmental impact of electromagnetic fields and thermal radiation on the population or ecosystem level is uncertain. Nevertheless, there is sufficient evidence that significant effects cannot be excluded. Suitable mitigation measures are available and should be applied following the precautionary principle when commissioning new cables. These include:

- application of cable types suitable to reduce the emission of magnetic fields, such as three-phase AC-cables, bipolar HVDC transmission systems;
- use of adequate shielding to minimise the emission of directly generated electric fields;
- burial of the cables to reduce exposure of sensitive species to electromagnetic fields by increasing the physical distance of the animals to the cable;
- an appropriate trenching depth to limit the rise in sediment temperature to prevent macrozoobenthic fauna from harm and benthic communities and processes from changes.

A coherent marine transmission grid should be promoted to reduce the number of anticipated power cables, amongst others linking various individual offshore wind farms together by using sub-sea cables with a high transmission capacity.

Both power and telecommunication cables should be removed once they are out of operation to allow for a recovery of the sea bottom.

7. References

BCTC - British Columbia Transmission Corporation (2006). Application for an Environmental Assessment Certificate for the Vancouver Island Transmission Reinforcement Project. Mai 2006. http://www.eao.gov.bc.ca/epic/output/html/deploy/epic_ document_250_21816.html

Birklund, J. & Petersen, A.H. (2004). Development of the fouling community on turbine foundations and scour protections in Nysted Offshore wind farm, 2003. Report by Energi E2 A/S, 42 pp.

Borrmann, C.B. (2006). Wärmeemission von Stromkabeln in Windparks – Laboruntersuchungen zum Einfluss auf die benthische Fauna. Thesis for a diploma, Rostock University and Institute of Applied Ecology Ltd., 82 pp.

BSH (2008). Standard Ground Investigations for Offshore Wind Farms. - Edt.: Federal Maritime and Hydrographic Agency (BSH) Hamburg and Rostock 2008. http://www.bsh.de/en/Products/Books/Standard/index.jsp

Drew, S.C. & Hopper, A.G. (1996). Fishing and submarine cables working together. Report commissioned by the International Cable Protection Committee (ICPC). http://www.iscpc.org/publications/18.3Fishing_Booklet.pdf

Drinkwater, K. (2004). Response of Atlantic Cod (Gadus morhua) to Future Climate Change.- Vortrag ICES Symposium: „THE INFLUENCE OF CLIMATE CHANGE ON NORTH ATLANTIC FISH STOCKS“, Bergen, Norway. - www.imr.no/2004symposium/web/We_1015_Drinkwater.ppt

Emu Ltd. (2004). Subsea Cable Decommissioning – A Limited Environmental Appraisal. Report commissioned by British Telecommunications plc, Cable & Wireless and AT&T, Report no. 04/J/01/06/0648/0415, available from UKCPC

Fricke, R. (2000). Auswirkungen elektrischer und magnetischer Felder auf Meeresfische in der Nord und Ostsee. . – In: Merck, T. & Nordheim, H. von (eds.): Technische Eingriffe in marine Lebensräume. Workshop des Bundesamtes für Naturschutz- INA Vilm 27.-29. Oktober 1999. – BfN Skripten 29: 41-61.

Gill, A.B. & H. Taylor (2001). The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon Elasmobranch Fishes. CCW Science Report 488. http://www.ccw.gov.uk/Images_Client/Reports/Reportfinal.pdf

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. & Kimber, J.A. (2005). COWRIE 1.5 Electromagnetic fields review - The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically andmagnetically sensitive marine organisms – a review. http://www.offshorewindfarms.co.uk/ Downloads/COWRIE_Final_compiled.pdf

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. & Wearmouth, V. (2009). COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry. http://www.offshorewindfarms.co.uk/Assets/Report%20EMF%20COWRIE2%20EMF%20FINAL_Combined_april%2009.pdf

Klaustrup, M. (2006): Few Effects on the Fish Communities so far. In: Danish Offshore Wind – Key Environmental Issues (eds. DONG Energy Vattenfall, The Danish Energy Authorities & The Danish Forest and Nature Agency), PrinfoHolbæk, Hedehusene, pp. 64-79. http://ens.netboghandel.dk/english/PUBL.asp?page=publ&objno=16288226

Meißner, K. & Sordyl, H. (2006). Literature Review of Offshore Wind Farms with Regard to Benthic Communities and Habitats. - In: Zucco, C., Wende, W., Merck, T., Köchling, I. & Köppel, J. (eds.): Ecological Research on Offshore Wind Farms: International Exchange of Experiences - PART B: Literature Review of the Ecological Impacts of Offshore Wind Farms. BfN-Skripten 186: 1-45. http://habitatmarenatura2000.de/de/downloads/berichte/Ecological_Research_Offshor-Wind_Part_B_Skripten_186.pdf

Meißner, K., Bockhold, J. & Sordyl, H. (2007). Problem Kabelwärme? – Vorstellung der Ergebnisse von Feldmessungen der Meeresbodentemperatur im Bereich der elektrischen Kabel im dänischen Offshore-Windpark Nysted Havmøllepark (Dänemark). In: Meeresumwelt-Symposium 2006. Hrsg. Bundesamt für Seeschiffahrt und Hydrographie, Hamburg : 153-161. http://www.bsh.de/de/Das%20BSH/Veranstaltungen/MUS/2007/Symposium_2006_Internet.pdf

Mendel, B., Sonntag, N., Wahl, J., Schwemmer, P., Dries, H., Guse, N., Müller, S. & Garthe, S. (2008). Profiles of seabirds and waterbirds of the German North and Baltic Seas - Distribution, ecology and sensitivities to human activities within the marine environment. - Naturschutz und Biologische Vielfalt 59.

Newell, R.C. (1979). Biology of intertidal animals. 3rd edition. Marine Ecology Surveys Ltd, Kent.

OSPAR Commission (2008a): Background document on potential problems associated with power cables other than those for oil and gas activities. – Biodiversity Series, Publication Number 370/2008, 50 pp. http://www.ospar.org/documents/dbase/publications/p00370_Cables%20background%20doc.pdf

OSPAR Commission (2008b): Assessment of the Environmental Impact of the Construction or Placement of Structures (other than Oil and Gas and Wind-farms). – Biodiversity Series, Publication Number 367/2008, 40 pp. http://www.ospar.org/documents/dbase/publications/p00367_Placement%20of%20structures.pdf

OSPAR Commission (2009a): Assessment of the Environmental Impact of Offshore Wind-farms – Biodiversity Series, Publication Number 385/2009, 35 pp.

OSPAR Commission (2009b): Assessment of the Environmental Impact of Underwater Noise – Biodiversity Series, Publication Number 436/2009, 43 pp.

Poléo, A.B.S., Johannessen, H.F., Harboe, M. jr. (2001). High voltage direct current (HVDC) sea cables and sea electrodes: Effects on marine life. – 1st revision of the literature study: 50 p.

Reimers, H. & Branden, K. (1994). Algal colonization of a tire reef - influence of placement date. Bulletin of Marine Science 55: 460-469.

Richardson, W.J., Malme, C.I., Green, C.R. jr. & D.H. Thomson (1995). Marine Mammals and Noise. - Academic Press, San Diego, CA 576 pp.

Söker, H. Rehfeldt, K., Santjer, F., Strack, M. & Schreiber, M. (2000). Offshore Wind Energy in the North Sea. Technical Possibilities and Ecological Considerations - A Study for Greenpeace. http://archive.greenpeace.org/climate/climatecountdown/dewifinal10.pdf

Wenner, E.L., Knott, D.M., Dolah, R.F. van & Burrell, Jr., V.G. (1983). Invertebrate communities associated with hard bottom habitats in the South Atlantic Bight. Estuarine Coastal and Shelf Science 17: 143-158.

OSPAR COMMISSION

New Court
48 Carey Street
London WC2A 2JQ
United Kingdom

t: +44 (0)20 7430 5200
f: +44 (0)20 7430 5225
e: secretariat@ospar.org
www.ospar.org

OSPAR's vision is of a clean, healthy and biologically diverse North-East Atlantic used sustainably

ISBN 978-1-906840-77-8
Publication Number: 437/2009