Spotlight on EMF Research

Spotlight on “Do electromagnetic fields from subsea power cables effect benthic elasmobranch behaviour? A risk-based approach for the Dutch Continental Shelf” by Hermans et al. in Environmental Pollution (2024)

Category [low frequency, review]

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Competence Centre Electromagnetic Fields (KEMF)

1 Putting the paper into context by the BfS

Offshore renewable energy installations have expanded rapidly in recent years as a means of mitigating climate change. As a consequence, more submarine transmission cables carrying more electrical power are deployed in coastal waters worldwide. This results in increased exposure of marine life to anthropogenic magnetic and induced electric fields. Elasmobranchs (e.g, sharks, skates and rays) which are endangered in the North Sea possess extraordinary sensitive receptors to perceive magnetic fields (e.g. the geomagnetic field) or bioelectric fields (e.g. from prey or conspecifics). This leads to the question whether they are negatively influenced by anthropogenic electromagnetic fields (EMF).

2 Results and conclusions from the authors‘ perspective

The present study [1] aims to assess the potential risk associated with exposure to anthropogenic EMF emitted by subsea power cables (SPC) in the southern North Sea for benthic elasmobranch (skates, rays, and sharks). A science-based Ecological Risk Assessment (ERA) was carried out through the following four steps:

Hazard identification: The nature of EMF from SPC and their potential impact on benthic elasmobranchs were identified based on observational and experimental studies. Direct current (DC) and alternating current (AC) power cables are surrounded by static and time-varying magnetic fields. Induced electric fields result from seawater movement through a magnetic field and are expected to be in the range of 10^{-5} to 10^{-4} V/m. The latitudinal geomagnetic gradient in the southern North Sea is 0.002 – 0.005 µT/km, therefore, 0.005 µT is assumed to be the minimum level relevant for elasmobranch navigation. Three potential effects of EMF on elasmobranchs were identified:

a) Disturbance during embryonic development: If elasmobranchs deposit their eggs within the EMFs of an SPC, embryos will be exposed to the varying EMF levels during development. This may have an effect on embryonic development, and the behaviour and orientation of hatchlings, as some such effects have been described in scientific literature.
b) Behavioural changes during local dwelling induced by EMF from SPC could alter foraging behaviour, attraction, avoidance, disrupt conspecifics relationships or modify habitat use [2, 3].
c) Interaction with migratory behaviour, if orientation according to the geomagnetic field is locally disrupted by magnetic fields from SPC.

Exposure quantification: The expected exposure was estimated based on results of measurements and numerical modelling found in scientific literature. The reported magnetic field levels measured above SPC ranged from 0.004 µT to 6.540 µT for AC cables and from 0.46 µT to 20.7 µT for DC cables. The magnetic field levels depend on burial depth (mainly 1-2 m) and transmitted power. The maximum modelled magnetic field strength, adjusted to the maximum possible capacity of the cables, reached 13.9 µT for AC and 61.3 µT for DC cables.

Based on the lowest expected perception level of elasmobranchs of 0.005 µT, the area affected by magnetic fields from export and intercontinental cables will cover about 550 km^2, i.e., 1 % of the Dutch Continental Shelf. Considering the EMF from the inter array cables within offshore wind farms, 5.5% of the Dutch Continental Shelf will be exposed to EMF from SPC detectable by elasmobranchs by 2030. The overlap between spatial occurrence of benthic elasmobranch species and areas exposed to EMFs from SPC, and the behaviour, ecology, and habitat use of single species will determine encounter rates.

Hazard quantification: No-observed or lowest observed effects levels (NOEL or LOEL) of EMF inducing behavioural changes in benthic elasmobranchs were established based on available literature. In total, nine suitable studies were found, which is, according to the authors, very limited for a good hazard quantification. Seven studies were laboratory-based and two experimental field studies. For the disturbance of embryogenic development, NOEL of 0.4 µT was adopted for both AC and DC cables as a rough estimate. For behavioural changes during local-dwelling, the LOEL was set to 0.03 µT for DC cables and the NOEL to 0.8 µT for AC cables. For interaction with migratory behaviour, experimental studies on elasmobranch are missing. Based on their ability to navigate using differences in the geomagnetic field as low as 0.002–0.005 µT, NOEL was set to 0.05 µT for DC cables. Time varying magnetic fields from AC cables are not expected to disrupt navigation.

Risk assessment was based on the likelihood of encountering EMF and NOEL.
a) For disturbance during embryogenic development, the likelihood of encounter was considered as likely due to the overlap of cable routes and areas suitable as egg laying sites, which will mean continuous exposure of eggs laid in the vicinity of SPC. The NOEL is two and three orders of magnitude lower than AC and DC exposure levels, respectively, which is a reason for concern.

b) For behavioural changes during local-dwelling, the chances of encountering an SPC are largest within offshore wind farms. The NOEL is an order of magnitude lower than the expected exposure levels. The main risk might be a long-term attraction, which could result in wasted energy expenditure or changes in foraging and habitat use at 5.5% of the Dutch continental shelf.

c) For interaction with migratory behaviour, the maximum expected exposure level for migrating individuals is four orders of magnitude higher than the LOEL, while the probability of encounter was classified as high as cable routes run perpendicular to the coast, suggesting multiple encounters when migrating over larger distances from the North to the South along the Dutch coast. At the Dutch coast, elasmobranchs may encounter up to 34 cables in 2030 and even more in Germany, the United Kingdom, Belgium and France. The authors remark that bipolar DC cables are the norm at the Dutch Continental Shelf. This might be different in other countries, where the positive and negative cores are laid separately with a distance of up to 250 m. This could increase the magnetic fields up to 300 µT (more than three times the values from the presented situation at the Dutch Continental Shelf).

Species-specific risk assessment was performed for six species, three rays and three sharks. The potential risk differs for different species, depending on their biology and ecology. According to the authors, egg laying species will be at higher risk during embryonic development due to the probability of laying eggs close to SPC. Risks during foraging and migration will depend on local habitat preferences and migrating routes. Knowledge gaps concerning embryology, foraging behaviour, habitat use and behaviour within offshore wind parks, habituation to EMF, migratory routs and migratory behaviour close to cables were identified. Filling the knowledge gaps will either retire the risk or support policy decisions to prevent significant ecological impact through mitigation measures.

3 Comments by the BfS

The study applies a well-defined quantitative approach to assess possible risks from EMF of SPCs for elasmobranchs. Based on published data, the expected magnetic fields strengths and possible effects on elasmobranchs are quantified and conclusions drawn.

Whilst this study has focused on the Dutch Continental Shelf, it might be applicable in all seas with offshore wind farms and SPC expansion. In particular the waters of the Belgium, United Kingdom, German and Danish North Sea are habitats of the species that were discussed in the present paper and the species migrate ignoring borders of states. The concept of the approach can also be applied for further species with similar ecological traits and might be even of value when considering other anthropogenic influences in the environment, other habitats and other groups of organisms.

The main weakness of this risk assessment is the restricted knowledge base. For instance, magnetic fields could not be measured during strong wind; thus, the maximum expected values of magnetic fields strengths had to be modelled, and it was not possible to validate the models by measurements. Furthermore, the hazard assessment is based on only nine experimental studies on elasmobranchs, which is a considerably low number. It remains unclear whether all relevant research was included because there is insufficient information on the search strategy and inclusion and exclusion criteria. A reliable hazard and risk assessment further requires that the quality of the included studies is taken into account. However, there is no indication that study quality was indeed considered in the assessment.

In spite of the mentioned shortcomings, the study is an important first step in assessing possible risks from anthropogenic EMF of SPCs on elasmobranchs. This work also identifies knowledge gaps and research needs.

References

[1] Hermans A, Winter HV, Gill AB, Murk AJ. Do electromagnetic fields from subsea power cables effect benthic elasmobranch behaviour? A risk-based approach for the Dutch Continental Shelf. *Environ Pollut*. 2024; 346:123570. doi:10.1016/j.envpol.2024.123570

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