

8 ELECTROMAGNETIC FIELDS (EM-FIELDS)

8.1 INTRODUCTION

Many fish species are able to sense electromagnetic fields, such as the one originating from submarine power cables, and both attraction and avoidance reactions to the electromagnetic fields have been observed in laboratory experiments. There has therefore been a concern that the power cables connecting offshore wind farms to the land could influence the movements of fish in the wind farm area, and in the worst case act as a barrier to, for instance, seasonal migrations.

COWRIE EM-Fields studies have previously been undertaken by CMACS Ltd to investigate the modelling and measurement of the E (electric) and B (magnetic) emission from a typical offshore subsea cable. A desk and laboratory study was completed in 2003 and a review of existing information on the impacts of EM-Fields took place in 2005, including proposals for strategies on future research and monitoring. The key findings of the COWRIE 1 and COWRIE 1.5 reports were originally outlined in the FEPA Report for the period 2003/4 (June 2005).

The COWRIE 1 report concluded that the current state of knowledge regarding the EM-Fields emitted by undersea power cables is too variable and inconclusive. This makes an informed assessment of any possible environmental impact of EM-Fields in the range of values likely to be detected by organisms sensitive to electric and magnetic fields difficult.

As stated in the 2003/4 FEPA Report, the COWRIE report attempted to define the likely range of sensitivity of elasmobranchs to E-fields. The following summarises the present state of knowledge;

Elasmobranch sensitivity:	0.5 – 1000 $\mu\text{V}/\text{m}$
Potential range of attraction:	0.5 – 100 $\mu\text{V}/\text{m}$
Potential range of repulsion:	> 100 $\mu\text{V}/\text{m}$

However, it must be stressed that there is very little rigorous experimentally based evidence to support such generalisations at present.

In relation to North Hoyle, the modelling undertaken for the COWRIE EM-Fields report is relevant. This predicted that the E-field on the seabed adjacent to a 1m buried industry standard three-core power cable would be 91 $\mu\text{V}/\text{m}$. This value therefore lies on the boundary of emissions that are expected to attract and those that repel elasmobranchs.

In 2006 COWRIE produced a consultation document named “COWRIE 2: Electromagnetic Fields (EMF) Phase 2. Stage 1 Project Plan.” This report details the proposed research programme to meet the objectives of the first stage of COWRIE Phase 2.0.

The Environmental Technical Working Group (ETWG) of COWRIE identified as priority research an experimental mesocosm study. The study required investigation of the response

of electromagnetic sensitive organisms to controlled electromagnetic fields (EMF) with the characteristics and magnitude of EMF associated with offshore wind farm power cables.

The research is to be addressed through COWRIE Phase 2.0 which has the specific aim to definitively determine whether electro-receptive elasmobranchs respond to anthropogenic EMFs of the type emitted by offshore wind farm sub-sea cables.

Four main components of the research project were considered:

- Simulation of wind farm type EM-Fields
- Design, construction and siting of mesocosms
- Study species considerations
- Home Office licensing

Simulations based on up to date research has been carried out previously (COWRIE 1 and 1.5). A number of options for a mesocosm experiment are outlined in the 2006 consultation document with respective risks and costs outlined.

A suitable mesocosm experiment and site location are currently being conducted .The mesocosms will be constructed on site and assessed over a period of two to three weeks for potential problems such as movement, gaps, effects of tidal regime and fouling. In addition, daily baseline measurements of tidal range, tidal direction, background E field and background B field will be taken.

The EM-Fields production equipment will also be introduced and tested. The equipment will be placed down the middle of the mesocosm. This will ensure that there is a sector of the mesocosm that fish can move to if they need to avoid the area of the cable when energised. This aspect will be included in the application to the Home Office.

An EM-Fields sensor and data logger will then be used to characterise the EM-Fields at different states of the tide and with different voltages and currents.

The project specification names two species, *Raja clavata* (thornback ray) and *Scyliorhinus canicula* (lesser spotted dogfish/small spotted catshark), to be studied within the mesocosm experiment, although the final choice of species to be tested will be subject to agreement with COWRIE.

Based on previous experiments in laboratory conditions it is anticipated that some 75% of dogfish would respond to E fields over the course of the study. From the limited studies on ray behaviour to E fields this figure is likely to be greater owing to their greater sensitivity to E fields. The mesocosm study will also record movements of the fish during the night, which is the most active time for elasmobranchs.

Statistical power analysis to estimate sample size for a study of behavioural response to E fields in the laboratory gives a value of between 46 and 58 individuals with 80% power. The number of fish of each species proposed is 60.

Home Office Inspectors have determined that a licence would be required for the study under the Animals Scientific Procedures Act 1984 and is related to specific focus on the tagging of fish. The exposure to the EM-Fields is not deemed to be harmful or detrimental to the elasmobranchs, however as the tagging is a necessary part of the wider study the whole project will require a full application to be written and submitted.

8.2 STUDIES AT NYSTED

Survey work and key research findings undertaken for the Horns Rev and Nysted Offshore Wind Farms have been reported in the publication Danish Offshore Wind Key Environmental Issues (Nov 2006) published by DONG Energy, Vattenfall, The Danish Energy Authority and The Danish Forest and Nature Agency. Investigations into the effects on fish and their behaviour from electromagnetic fields were made at Nysted Offshore Wind Farm off the coast at Rødsand, Denmark and the key findings are summarised below.

Nysted Offshore Wind Farm is a 72 turbine site located 10km south of Nysted on Lolland, Denmark on gently sloping seabed (6.5-9m depth) consisting of glacial deposits covered by thin layers of sand. The turbines at Nysted are interconnected by 33kV cables buried to a depth of 1 metre. These cables connect to an offshore transformer station where the electricity is transformed to 132kV and exported to shore via a 132kV AC cable buried to 1 metre depth. Along the cable trace the water depth decreases from 6m to 3.5m for the first 4km of the cable, and then becomes extremely variable from there to shore.

8.2.1 Methods

The assessment of electromagnetic field effects was surveyed using specially designed fishing gear developed and applied to the area along the cable route connecting the wind farm with the shore between 2001 and 2004. The final design of fishing gear included two types of pound nets, bi-directional and quadri-directional. One bi-directional and two quadri-directional pound nets were placed on each side of the cable. This arrangement made it possible to detect the migration direction of the fish and estimate the number of fish crossing the cable. The nets were configured to ensure measurement of east-west movement (i.e. across the power cable), but also north-south movement (DONG et al, 2006).

The statistical test was primarily divided into two parts where one part of the analysis was performed with time series or cross-correlations to distinguish if the catch on each side of the cable occurred at approximately the same time. The cross correlation test compared the variations in time of the catch data from each side of the cable. If the catch on each side of the cable occurred at the same time, then they were compared using the Chi-square test.

The second part used the Chi-square test to analyse if the distribution of each species east and west of the cable changed significantly before and after the cable had become operational. The Chi-square test was based on the overall distribution from the entire sampling period and it did not distinguish if the fish on each side were caught during the same periods. An overall comparison of the distribution of all species combined on each side of the cable in 2003 was done using a Multi Dimensional Scaling test (Bio/Consult A/S, 2004).

As part of the survey programme at Nysted, the migration direction for common eel (*Anguilla anguilla*) was investigated through a mark and recapture programme carried out in 2004. Eels were caught and tagged. Tagged eels were then released on the same side of the power cable as they were caught at a distance of at least 400 m from the power cable. Fishermen then recaptured the tagged fish and reported the catches to the survey programme.

Two potential effects were assessed from the results:

- a measure of possible asymmetries in catches across the cable route indicating an east-west/west-east migration, depicting a hindrance or blocking effect from the cable route, and
- a measure of the possible import or export of fish along either side of the cable route and also an indication of effects on fish behaviour.

8.2.3 Survey Results

In 2001 and 2002, 56 % of the fish representing 54 % of the weight of the total catch was caught in the pound net west of the cable trace. In 2003, 53 % of the fish representing 55 % of the weight of the catch was caught from that side. The preliminary comparison indicated that the cable trace did not cause a major change in the overall distribution of number and weight of the total catch before and after the cable became operational in 2003 (Bio/Consult A/S, 2004).

In the final survey year a total of 6,988 fish representing 27 species were caught. A total of 42 species were caught across all survey years and no differences detected in species composition were detected following commissioning and operation of the wind farm (EnergiE2, 2005).

On the basis of the combined data from 2003 and 2004, barrier effect impacts were identified in relation to four species: baltic herring, common eel, Atlantic cod and flounder. The results suggest that migration of some species across the cable route may be impaired but not necessarily blocked.

In relation to the second effect, some of the common eels reacted by leaving the area along the cable route when analysing the combined data. In the second case, the 2003 data indicated that Atlantic cod accumulated close to the cable route.

The study did not conduct electromagnetic field surveys during the monitoring campaign. However, survey findings were correlated against wind farm power production. Only flounder showed a positive correlation between the impacts observed and the assumed strength of the electromagnetic fields. Flounder primarily crossed the cable when the strength of the electromagnetic fields was estimated to be low, i.e. during calm periods. Eels in particular displayed significant behavioural responses to the cable route but the data failed to link these responses to the electromagnetic fields. The analyses of data have, only to a very limited extent, proven a correlation between these impacts and the strength of the electromagnetic fields.

In the mark-recapture study, 231 common eels were marked and 18 were recaptured. Of the recaptured eels, 72% migrated in a westerly direction and the remaining 28% migrated eastward. The results showed that 39% of the recaptured eels potentially have passed the power cable during their migration. Furthermore, more than 50% of the eels probably changed direction after being recaptured. However, the prevailing migration route for eels in proximity to Nysted is westwards, hence no direct effect on migration direction from the cables could be attributed (DONG et.al, 2006).

Eel movement patterns and behaviour were found to be dominated by influence from the moon phase, meteorological and hydrological conditions, with no statistical evidence of a prevailing migration direction for eels or any other species. Despite some evidence of hindrance, the mark and recapture programme indicated that a relatively high proportion of tagged eels crossed the power cable and in conclusion no statistical evidence was found for the hindrance effects from the power cable on electromagnetically sensitive fish (Energi E2, 2005).

While these studies suggest in a few cases that the movement patterns may be influenced by the electromagnetic field from the cable, alternative explanations to these patterns exist and the studies cannot be viewed as conclusive. One problem has been that the directional nets had to be deployed at a rather large distance from the cable, and there is no firm evidence that the fish caught in the net facing the cable has actually crossed the cable. Similarly, the migration routes of recaptured eels may not have led them across the cable route (DONG et.al, 2006).

8.3 SUMMARY

A further COWRIE study (Stage 2) has been commissioned with Cranfield University that will investigate the specific biological significance for electro-sensitive fish species of EM-Fields. This study will focus on all effects of EM-Fields on elasmobranchs (adverse, neutral or positive) objectively and shall comprise experimental behavioural investigations of fish response to underwater power cables.

At Nysted Offshore Wind Farm the results indicated that some effects from the cable route on fish behaviour indicating both avoidance of the cable as well as attraction, depending on the species. However, only flounder showed correlation between the phenomena observed and the assumed strength of the electromagnetic fields.

Following the assessment of the significance of any impacts, the priorities for further research will be laid out if deemed appropriate. The benefit to the wind farm industry of such research will also be considered. The aim would be to provide COWRIE and the wider marine renewables industry with a specific set of research priorities and a statement of their benefits and limitations.

Given that NHOWF is not considered a prime location for elasmobranch species. The COWRIE work satisfies the EMF consent condition. The results will be scrutinised by Government and their scientific advisors. The conclusions will be taken into account for future development proposals.