Project report for SG450

Understanding the effects of electromagnetic field emissions from Marine Renewable Energy Devices (MREDs) on the commercially important edible crab, *Cancer pagurus* (L.)

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Following the publication of the paper "Understanding the Effects of Electromagnetic Field Emissions from Marine Renewable Energy Devices (MREDs) on the commercially important edible crab, *Cancer pagurus* (L.)" in Marine Pollution Bulletin, two of the authors were asked to attend and present at the International Meeting on Marine Research (IMMR) 2018 in Peniche, Portugal on the 5th July. The MASTS small grant of £500 contributed towards the travel expenditure to attend the conference.

Conference Abstract

The predicted decline in non-renewable energy sources in future decades indicates the need for alternative renewable energy sources. Due to reduced planning constraints, lack of inexpensive land near major population centres, and perceived aesthetic problems with many renewable energy structures, there is increasing pressure to move potential locations offshore. With the rapid increase in Marine Renewable Energy Devices (MREDs) worldwide, there is a clear need for the implications to be properly assessed with regards to current ecological status and potential future consequences. Proposed sites and developments are based on current knowledge and assessments of the local environment, despite relatively little being known about the ecological effects of such developments on marine benthic organisms.

Electromagnetic fields (EMF) originate from both anthropogenic (telecommunication cables, power cables, MREDs) and natural (Earth's natural geomagnetic field) sources. It has been shown that industry-standard Alternating Current (AC) cables can be effectively insulated to prevent electric field (E-field) emissions but not magnetic field (B-field) emissions[1]. Standard cable configurations combined with the existing B-field creates induce electromagnetic fields (iEM fields). Many marine animals can detect electric and magnetic fields and utilize them in important life processes such as movement, orientation and foraging[2]. Several decapod crustaceans are known to be magneto-sensitive, yet information available on the effects of EMFs emitted from MREDs is scarce[3,4].

The European edible crab, *Cancer pagurus* (L.) (fig.2), is found throughout Western Europe from Norway to northern France. They are commonly found from the shoreline to offshore depths of around 90m. They are a heavily exploited commercial species, with the present annual catch for the UK and Ireland totalling around 34,600 tonnes (Bannister 2009). There is a high probability that this species will encounter sub-sea power cables resulting in increased EMF exposures, potentially leading to stress responses.

In this study, the effects of simulated EMFs emitted from sub-sea power cables (Fig.1) on the commercially-important *C. pagurus*, were assessed. Crabs were obtained from the St Abbs and Eyemouth Voluntary Marine Reserve (North Sea) and transported to St Abbs Marine Station. Crabs were kept in 1000L flow through tanks supplied with raw seawater of ambient sea temperature and natural photoperiod for a minimum acclimation of one week.

Crabs were exposed for 24-hours to static EMFs at strengths of 2.8mT and 40mT to correspond with the expected, and highly variable, levels on the surface of a sub-sea power cable as shown in previous studies[5]. The EMF was produced by electric solenoid magnets (24V) placed underneath the experimental tanks or by Helmholtz coil generating a uniform electromagnetic field area around the experimental tanks.

Stress-related physiological parameters were measured (L-Lactate, D-Glucose, Haemocyanin and respiration rate), along with behavioural and response parameters (antennular flicking, activity level, attraction/avoidance, shelter preference and time spent resting/roaming).

Exposure to EMFs of the strength predicted around sub-sea cables had significant physiological effects on *C. pagurus* and changed their behaviour.
Crabs showed a clear attraction to EMF-exposed shelter (69%) compared to control shelter (9%) and significantly reduced their time spent roaming by 21% (Fig.5). This suggests that the natural roaming behaviour, where individuals will actively seek food and/or mates, has been overridden by an attraction to the source of the EMF. When given the choice between a shelter exposed to EMF and one without this exposure, the crabs were always drawn to the EMF. These results predict that an increase in the abundance of *C. pagurus* will be seen in benthic areas surrounding MREDs, where there are increased EMFs.

EMF disrupted the circadian rhythm of haemolymph L-Lactate and D-Glucose levels (Fig.3,4). Melatonin levels in several species have been found to be affected by EMF exposure[6,7]. This suggests that EMF exposure could affect crustaceans on a hormonal level.

This potential aggregation of crabs around benthic cables and the subsequent physiological changes brought about by EMF exposure strongly suggest there is a cause for concern. Berried female Edible crabs move offshore and spend 6-9 months buried with minimal movement and lower feeding rates[8]. Given this species' proven attraction to EMF sources, incubation of the eggs may take place around areas with increased EMF emissions. Long-term studies are needed to investigate the effects of chronic EMF exposure along with the effects of EMF on egg development, hatching success, and larval fitness.

This study shows that the impact of EMF on crustaceans must be considered when planning the construction of MREDs. With the recent large-scale renewable energy developments, it is clear more research is needed to reduce uncertainty of the environmental effects of these activities on benthic marine species, particularly on other commercially and ecologically important decapod crustaceans. These knowledge gaps need to be addressed before the implementation of the many approved wind farm sites around the UK to help mitigate an ever-growing problem.

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Fig.1 *Cancer pagurus* next to sub-sea power cable.

Fig.2 The edible crab, *Cancer pagurus*.

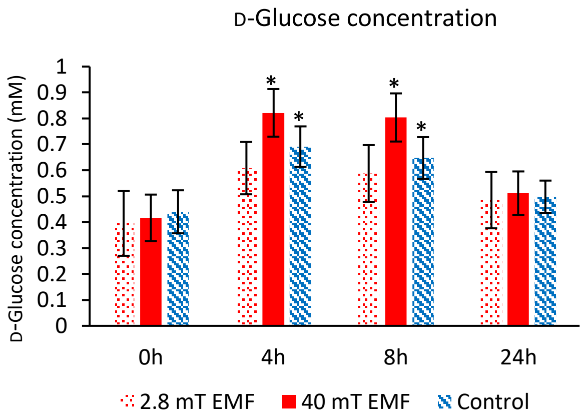

Fig.3 D-Glucose concentration over a 24-hour period during control conditions and exposure to low strength (2.8mT) and high strength (40mT) EMF.

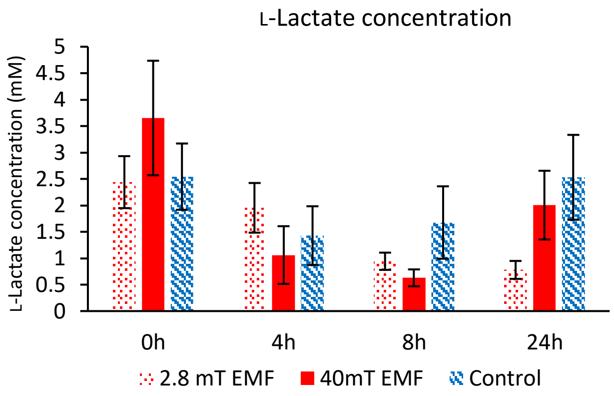

Fig.4 L-Lactate concentration over a 24-hour period during control conditions and exposure to low strength (2.8mT) and high strength (40mT) EMF.

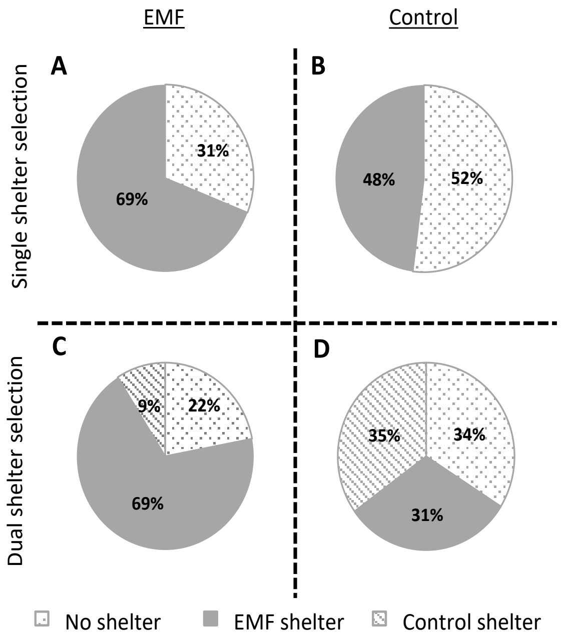

Fig.5 The effects of EMF exposure (2.8mT) on shelter selection.

References

1. Bochert, R. and Zettler, M.L., 2006. Effect of electromagnetic fields on marine organisms. In Offshore Wind Energy (pp. 223-234). Springer, Berlin, Heidelberg.
2. Boles, L.C. and Lohmann, K.J., 2003. True navigation and magnetic maps in spiny lobsters. Nature, 421(6918), p.60.
3. Fernie, K.J. and Bird, D.M., 2001. Evidence of oxidative stress in American kestrels exposed to electromagnetic fields. Environmental research, 86(2), pp.198-207.
4. Gill, A. B. 2005. Offshore renewable energy: ecological implications of generating electricity in the coastal zone. Journal of Applied Ecology, 42(4), 605-615.
5. Hutchison, Z.L., Sigray, P., He, H., Gill, A.B., King, J. and Gibson, C., 2018. Electromagnetic Field (EMF) Impacts on Elasmobranch (shark, rays, and skates) and American Lobster Movement and Migration from Direct Current Cables. Sterling (VA): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM, 3.
6. Naylor, J.K., Taylor, E.W. and Bennett, D.B., 1997. The oxygen uptake of ovigerous edible crabs (Cancer pagurus)(L.) and their eggs. Marine & Freshwater Behaviour & Phy, 30(1), pp.29-44.
7. Shields, M.A. and Payne, A.I. eds., 2014. Marine renewable energy technology and environmental interactions. Springer.
8. Woodruff, D.L., Ward, J.A., Schultz, I.R., Cullinan, V.I. and Marshall, K.E., 2012. Effects of electromagnetic fields on fish and invertebrates. US Department of Energy.