MASTS Coastal Forum Small Grant
Report for CSG6 – Effects of electromagnetic fields from renewable energy subsea power cables on post disturbance recovery of coastal invertebrates

Erica Chapman (erica.chapman@marinestation.co.uk), Althea Piper, Corentine Rochas
St Abbs Marine Station, The Harbour, St Abbs, Berwickshire, TD14 5 PW

Dr Johanne Vad and Dr Georgios Kazanidis
School of Geosciences, The University of Edinburgh, Grant Institute, James Hutton Rd, Edinburgh, EH9 3FE

Funding summary

We are grateful for the £500 small grant from the MASTS coastal forum that has been used to buy two custom tanks for the following research. Due to various manufacturing delays, the tanks were only delivered on 22/12/2020; therefore, this experiment is not due to start until 2021. The below report gives a brief introduction into the importance of this research and planned methods.

Further funding of £1,000 has also been received from the School of Geosciences at the University of Edinburgh for aquarium and research supplies and the purchase of animals from local fishermen.

Introduction

The effects of anthropogenic Electromagnetic Fields (EMFs) on marine species is an emerging field of research, due to the rapidly increasing number of subsea electrical cables from offshore Marine Renewable Energy Devices (MREDs), which are known to generate EMFs (Taormina et al., 2018). This increase in subsea cables is taking place globally; yet, significant gaps exist in the current knowledge of the effects on marine and freshwater organisms (Cada et al., 2011; Dannheim et al., 2019; Scott et al., 2018). For example, Scottish Marine Energy Research (ScotMER), part of the Scottish Government, identifies EMF impacts as a high priority area of research that needs addressing (Marine Scotland Directorate, 2020).

The Neart na Gaoithe offshore wind farm (https://nngoffshorewind.com/) is planning to have its marine cable route landing site at Thorntonloch Beach in East Lothian, Scotland, which will introduce coastal species to EMFs (Sinclair Knight Marz, 2013). There are planned to be two export cables, each travelling a route of 33 km, which are due to be placed between 70 and 300 m apart and buried 1-3 m. Modelling of the planned Neart na Gaoithe offshore wind farm using 220 kV [Um 245 kV] 3-phase Alternating Current (AC) Cross-Linked Polyethylene (XLPE) insulated export cables with a maximum loading of 657 A_{rms} has calculated the maximum EMF density of the intertidal/sea defence section of the cables to be 8.55 µT, and the offshore section to be 7.99 µT (Sinclair Knight Marz, 2013).

Field studies at Nysted offshore wind farm (Denmark) provided the first evidence that B-fields (magnetic fields) emitted from export cables alter migration and behaviour of marine fish

(Klaustrup, 2006). Research on the effects of anthropogenic EMFs on invertebrate behaviour, physiology, development, early life stages, and fisheries, has been limited and mixed, and requires further investigation (Scott et al., 2020), especially when considering realistic EMFs produced from subsea power cables (WaterProof Marine Consultancy & Research BV and Bureau Waardenburgh BV, 2016). Furthermore, post-disturbance recovery times have not been studied with regards to EMF exposure and coastal species, anywhere in the world. A common recovery measure after a disturbance is an animal's righting reflex. Righting reflex is a measure of how long it takes an upturned individual to turn over (i.e. to correct or "right" their position). It is an important measure of anti-predation, as animals are often moving from a vulnerable position (with the weaker underside exposed) to a position allowing for anti-predator behaviours to take place (Day et al., 2019; Wale et al., 2013). It is also indicative of whether the sensory systems involved in this reflex are damaged (Payne et al., 2007).

The main objective of this research is to investigate the adaptation and resilience of coastal species by testing whether simulated EMFs from MRED subsea power cables affect the post-disturbance recovery times, as an indicator of stress, of coastal invertebrates. Species which form important parts of the coastal ecosystem and provide recreational and commercial benefits will be investigated.

Improving our understanding about the impacts of the Renewables industry/EMFs on ecosystem components is vital for the development of Marine Spatial Planning and sustainable exploitation of resources. In addition, the produced knowledge facilitates the implementation of the ambitious Marine Strategy Framework Directive (MSFD) which specifically addresses the introduction of energy in the marine environment, and ultimately serves the achievement of Good Environmental Status.

Proposed methods

Experiments are to be held at the St Abbs Marine Station, Berwickshire, Scotland in 2021. Fifty animals of each invertebrate species listed below will be collected by hand or by local fishermen within the Berwickshire Marine Reserve. Similar-sized animals within each species will be used in experiments. Only animals in good condition, with no signs of shell or carapace damage or missing limbs, will be used. Where identification is feasible, only males will be used, to remove any possible confounding effects due to sex. Possible species include:

- Echinoderms
    - Common starfish (*Asterias rubens*)
    - European edible sea urchin (*Echinus esculentus*)
- Crustaceans
    - Edible crab (*Cancer pagurus*)
    - Green shore crab (*Carcinus maenas*)
    - European lobster (*Homarus gammarus*)
    - Velvet swimming crab (*Necora puber*)
    - Common hermit crab (*Pagurus bernhardus*)

- Molluscs
    - Common whelk (*Buccinum undatum*)
    - Dog whelk (*Nucella lapillus*)
    - Periwinkles (*Littorina spp.*)

Animals will be held in flow through tanks for at least one week before experimentation, then placed in individual glass tanks (Figure 1) for 24 hours in either the control set-up or the active Helmholtz-coil used to generate an EMF of at least 8.55 µT that will simulate the EMF around a marine cable landing site (Sinclair Knight Marz, 2013).

After a minimum of 24 hours, individual animals will be placed within a 75 W x 75 D x 45 H cm glass tank on their dorsal side, with a CCTV system used to record their behaviour, as they right themselves. These tanks have been custom made with this grant to allow a variety of species to have enough space on all sides to right themselves and allow for filming. These tanks will have a rough bottom made from a fine layer of siliconed sand, to create a more realistic 'seabed' and give the animals more grip than a bare bottom tank.

R studio and R will be used for data exploration and analysis.

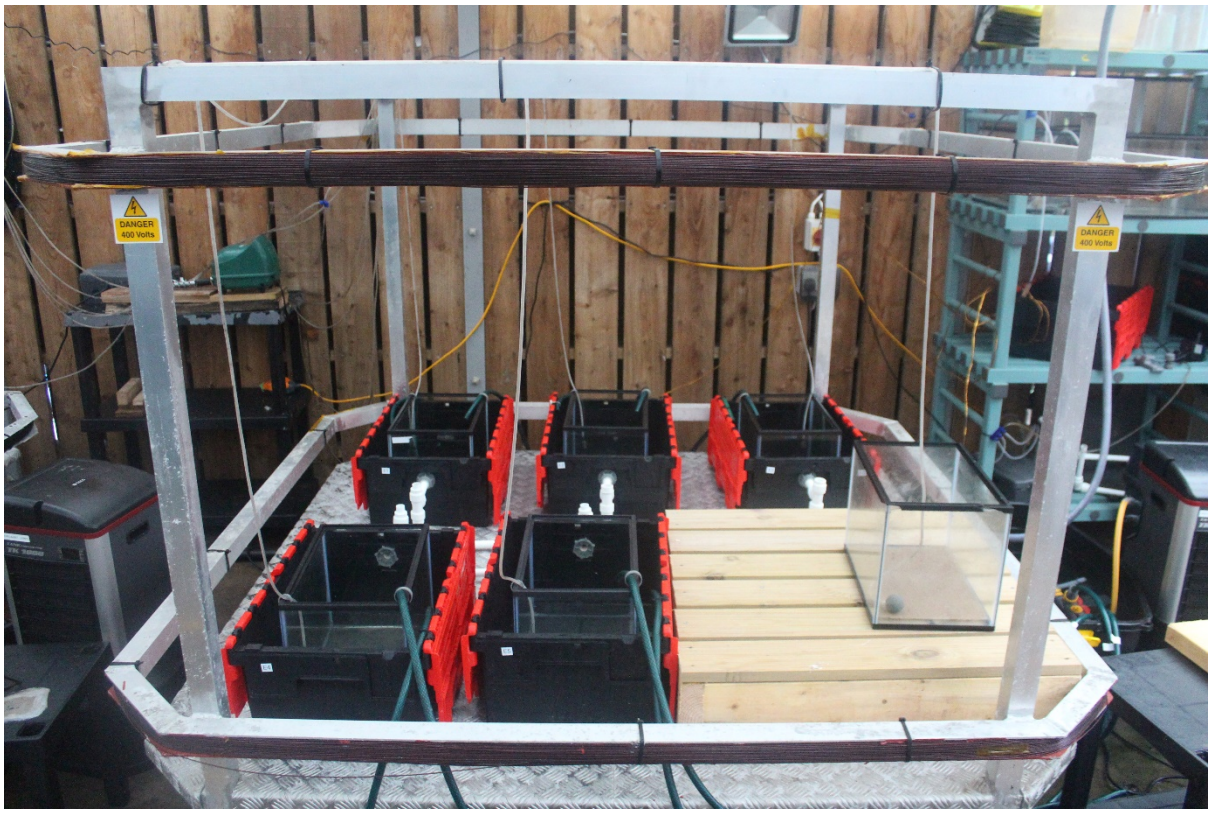

Figure 1. Proposed experimental set-up to investigate effect of short-term Electromagnetic Field (EMF) exposure on coastal invertebrate righting reflex. Custom tanks built under this grant will be placed on the wooden platform shown in the bottom right of the image, in place of the small tank shown currently, in both the active Helmholtz-coil and control set-up.

References

Cada, G.F., Bevelhimer, M.S., Riemer, K.P., Turner, J.W., 2011. Effects on freshwater organisms of magnetic fields associated with hydrokinetic turbines, ORNL/TM-2011/244. Oak Ridge, Tennessee.

Dannheim, J., Bergström, L., Birchenough, S.N.R., Brzana, R., Boon, A.R., Coolen, J.W.P., Dauvin, J.-C., De Mesel, I., Derweduwen, J., Gill, A.B., Hutchison, Z.L., Jackson, A.C., Janas, U., Martin, G., Raoux, A., Reubens, J., Rostin, L., Vanaverbeke, J., Wilding, T.A., Wilhelmsson, D., Degraer, S., 2019. Benthic effects of offshore renewables: identification of knowledge gaps and urgently needed research. ICES J. Mar. Sci. 1–17. https://doi.org/10.1093/icesjms/fsz018

Day, R.D., McCauley, R.D., Fitzgibbon, Q.P., Hartmann, K., Semmens, J.M., 2019. Seismic air guns damage rock lobster mechanosensory organs and impair righting reflex. Proc. R. Soc. B Biol. Sci. 286. https://doi.org/10.1098/rspb.2019.1424

Klaustrup, M., 2006. Few effects pf the fish communities so far, in: Dong Energy, Vattenfall, Danish Energy Authority, Danish Forest and Nature Agency (Eds.), Danish Offshore Wind: Key Environmental Issues. pp. 64–79.

Marine Scotland Directorate, 2020. Streamlined ScotMER evidence map [WWW Document]. URL https://www.gov.scot/publications/streamlined-scotmer-evidence-map/ (accessed 12.3.20).

Payne, J.F., Andrews, C.A., Cook, A.L., Christian, J.R., Branch, S., Canada, O., 2007. Pilot study on the effects of seismic air gun noise on lobster (Homarus americanus). Canadian Technical Report of Fisheries and Aquatic Sciences No. 2712.

Scott, K., Harsanyi, P., Lyndon, A.R., 2018. Understanding the effects of electromagnetic field emissions from Marine Renewable Energy Devices (MREDs) on the commercially important edible crab, *Cancer pagurus* (L.). Mar. Pollut. Bull. 131, 580–588. https://doi.org/10.1016/j.marpolbul.2018.04.062

Scott, K., Piper, A.J., Chapman, E.C., Rochas, C.M., 2020. Review of the effects of underwater sound, vibration and electromagnetic fields on crustaceans.

Sinclair Knight Marz, 2013. Neart na Gaoithe Offshore Wind Development HVAC EMF Studies. Newcastle upon Tyne, UK.

Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N., Carlier, A., 2018. A review of potential impacts of submarine power cables on the marine environment: knowledge gaps, recommendations and future directions. Renew. Sustain. Energy Rev. 96, 380–391.

Wale, M.A., Simpson, S.D., Radford, A.N., 2013. Noise negatively affects foraging and antipredator behaviour in shore crabs. Anim. Behav. 86, 111–118. https://doi.org/10.1016/j.anbehav.2013.05.001

WaterProof Marine Consultancy & Research BV, Bureau Waardenburgh BV, 2016. Potential effects of electromagnetic fields in the Dutch North Sea. Phase 1 – Desk Study for Rijkswaterstaat Water, Verkeer en Leefomgeving.