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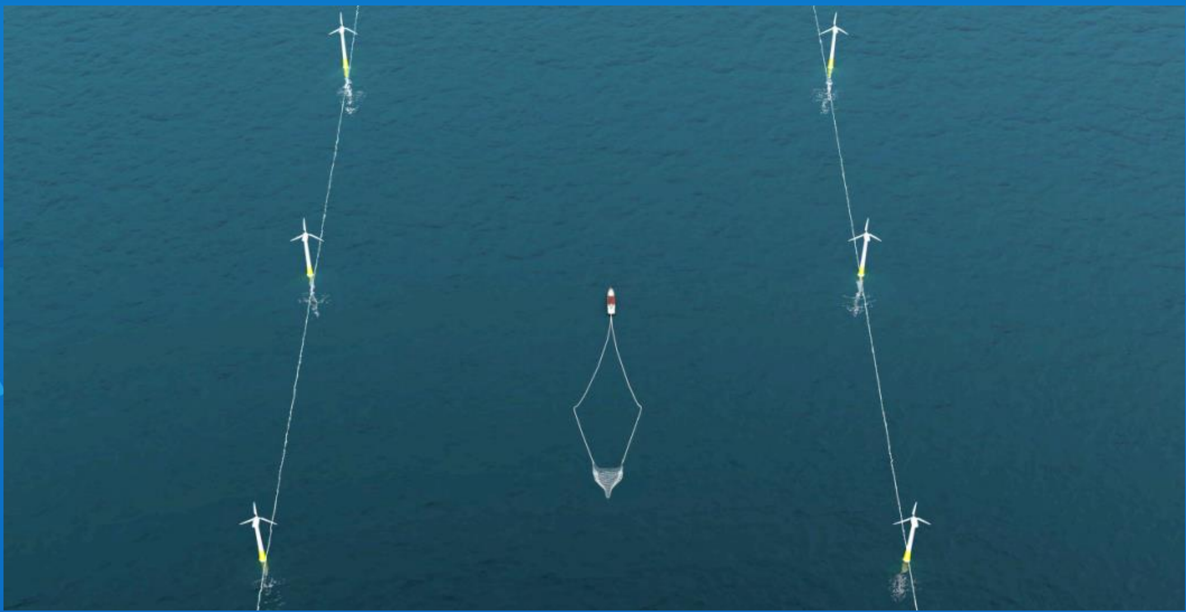
Underwater noise, vibration and electro-magnetic fields from offshore renewable energy developments: Impacts on commercial crustaceans



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This factsheet summarises information on the impacts of underwater noise, vibration, and electro-magnetic fields (EMFs) generated by MREDs in relation to behavioural changes, physical damage, and life cycle effects on UK commercial crustacean species. The information provided is drawn from a literature review commissioned by Seafish and delivered by St Abbs Marine Station. The full literature review is available here.

Summary

Research into the effects of underwater noise, substrate vibration and electro-magnetic fields (EMFs) from offshore renewable energy generation on commercially important species of crustacean is limited, with much more information available for marine mammals and finfish. However in summary we know that:

- Crustaceans are able to detect particle motion in the water, seabed vibrations and EMFs.
- The impacts detected include disruption to normal behaviour patterns including foraging activity and predator avoidance, reduced reproductive success and evidence of increased metabolic stress such as impaired immune responses.

It is possible therefore that underwater noise, vibration and EMFs could potentially have fundamental negative impacts on crustacean fisheries by impacting on survival and the ability to successfully reproduce, and behavioural changes could also affect the catchability of these species.

Introduction

1. Marine Renewable Energy Devices (MREDs)

Offshore marine renewable energy (MRE) generation is seen by many governments as a vital part of meeting their climate change commitments such as the net zero carbon emission targets. There are three prominent types of MRE: wave, tidal, and wind, with wind being the most common (Figure 1).

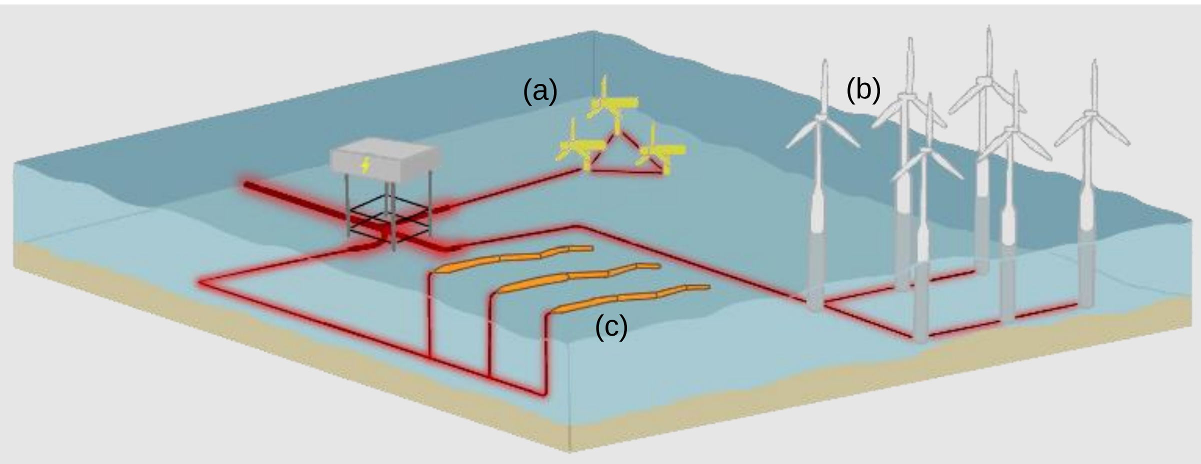

Figure 1. Illustration of subsea cables around Marine Renewable Energy Devices (MREDs): (a) tidal turbines, (b) wind turbines, (c) wave devices. © St Abbs Marine Station.

The focus of research on the impacts of underwater noise, sound transmission and EMFs emitted by MREDs has been on marine mammals (e.g. cetaceans and seals), due to their protected status, and on commercial species of finfish. Historically very few studies have investigated the impacts on seabed-dwelling animals, although there has been research on wider seabed and habitat changes around MREDs focussing on scour and sediment changes. All of the UK's highly valuable commercial crustacean species are seabed-dwelling and live in areas likely to be targeted for MRED development (or where such developments are now in place).

An MRED development consists of a series of different phases, from site identification through construction, operation and final decommissioning. These different phases result in different sources of underwater noise, vibration and EMF emissions (see Table 1). The impact on commercially important crustaceans may therefore vary through time depending on the MRED development stage.

Table 1. Typical MRED 'life-cycle' and sources of underwater noise, vibration and EMFs.

Phase	Crustacean 'Stressor'	Sources
1. Site selection and pre-construction surveys	Short-term exposure to underwater noise and vibration	Geophysical surveys including multibeam echosounder, sidescan sonar, sub-bottom profiler/seismics and vessel noise
2. Construction	Medium-term exposure to underwater noise and vibration	Explosive detonation, pile driving, vessel noise
3. Operation	Long-term exposure to low level underwater noise and vibration	Operational noise, service vessel noise
	Long-term exposure to EMFs	Subsea cables – alternating and direct currents (AC and DC)
4. Decommissioning	Short-medium term exposure to underwater noise and vibration	Potentially pile driving, geophysical surveys, vessel noise

2. UK commercial species of crustaceans

Commercially important crustacean fisheries in the UK include:

- Nephrops (also referred to as langoustine, prawn, Dublin Bay prawn, scampi, Norway lobster) (*Nephrops norvegicus)*
- Brown or edible crab (*Cancer pagurus*)
- European lobster (*Homarus gammarus*)
- Velvet swimming crab (*Necora puber*)
- Crayfish (also referred to as crawfish or European spiny lobster) (*Palinurus elephas*)
- Brown shrimp (or North Sea prawn) (*Crangon crangon*)

In 2018, crab, lobster, and Nephrops landings from UK and foreign vessels into the UK equated to 56,800 tonnes with a value of £192.7 million. The most significant species by value was Nephrops (£79.1 million), followed by crabs (£69.5 million) then lobsters (£44.1 million). Given their commercial significance, an understanding of the impacts of MREDs, through resulting underwater noise, vibration and EMFs, on these species is needed to evaluate potential wider effects on the ecosystem and on fishing opportunities (e.g. catchability and stock sustainability).

Impacts of underwater noise, vibration and EMFs by species

Underwater noise moves from its source through the water column as a pressure change and an associated back and forth movement of molecules known as particle motion. The noise can also move through the seabed as vibrations, which can be detected considerable distances from the noise source (e.g. 400m for a pile driving site).

Crustaceans are thought to be able to detect particle motion and seabed vibrations through receptors such as hairs and balance organs, and may use these for important behavioural cues (e.g. foraging, predator avoidance). Crustaceans also use chemical signals to sense their surroundings and to find key resources such as food, shelter and mates and noise and vibrations in the environment are known to disrupt this ability.

Crustaceans have an ability to detect electric and magnetic fields, with some species utilizing them for orientation and foraging purposes. As a result, human activity-induced underwater noise, vibration and EMFs could interfere with cues usually taken from the natural environment, and negatively affect the ability of crustaceans to find food, shelter and a mate, which in turn could have a fundamental and deleterious impact on survival and reproductive success. Surprisingly, however, there are limited studies on the specific impacts of underwater noise, substrate-borne vibration or EMFs on UK commercial species of crustaceans. What has been documented is summarised for each species. There are no studies investigating impacts on the velvet swimming crab.

Nephrops

Figure 2: *Nephrops norvegicus*. © Hans Hillewaert

There are a number of documented impacts of underwater noise and vibration on Nephrops but no available research on the impacts of EMFs. Nephrops are known to be sensitive to noise generated by vessel noise and offshore construction. Research indicates that noise can negatively affect the lifecycle of Nephrops, reducing their capacity to burrow and their ability to avoid predators. Shipping noise was also found to increase the behaviour of flushing of burrows with overlying water by Nephrops (known as ‘bioirrigation’), which will affect nutrient cycling between the sediment and the water column, and potentially affect feeding activity as some Nephrops have been shown to ‘filter feed’ within their burrows.

Brown crab

There are a number of documented impacts of underwater noise from vessels and EMFs on brown crab but no available research on the impacts of vibrations. Noise negatively impacts the brown crab life cycle through a slowing of larval development leading to smaller juvenile individuals. EMFs act as an attractant (Figure 3) and so disrupt normal behaviour patterns, leading to reduced foraging and reduced growth rates. EMFs have also been linked to negative impacts on metabolic rate and an individual's response to the light/dark cycle, both common indicators of stress. A decrease in successful matings and reduction in egg volumes in females has also been observed. This will ultimately affect recruitment to the adult population and, potentially, the sustainability of the fishery.

Figure 3. Edible crab (*Cancer pagurus*) attracted to a subsea cable. © St Abbs Marine Station.

European Lobster

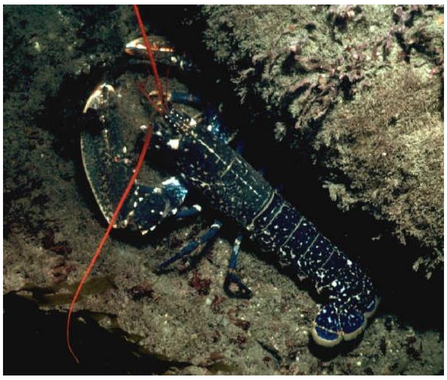

Figure 4: European lobster (*Homarus gammarus*). © Keith Hiscock.

Research has focused on the impacts of underwater noise from vessels and EMFs on European lobsters, with no studies on the impacts of vibration. Shipping noise generates avoidance behaviour in lobsters, i.e. the individual moves away. This is more pronounced in summer than in winter. It is likely that, in winter, the need to forage overrides any noise disturbance. EMFs have been linked to negative impacts on metabolic rate and the immune system, as well as causing stress through disruption of the natural responses to the light/dark cycle. EMFs have also been linked with a decrease in egg volume, reduced larval fitness and survival, increased prevalence of deformities and smaller sized juveniles. Over the longer term, such effects will have a negative effect on recruitment to the fishery.

European spiny lobster/crayfish

Impacts of underwater noise from vessels, pile driving and offshore construction on the European spiny lobster have been investigated. There has been no research on the impact of vibration or EMFs. Underwater noise increases movement in the spiny lobster and evidence of stress has been documented through changes in metabolic rate and the increased production of specific proteins. Although there is no research, it is likely that EMFs will impact behaviour as the species utilises electric and magnetic fields for orientation and foraging purposes.

Figure 5: European spiny lobster (*Palinurus elephas*). © Sue Scott

Brown shrimp

Figure 6: Brown shrimp (*Crangon crangon*). © John Rundle.

There are documented impacts of underwater noise from vessels, seismic survey, pile driving and offshore construction, as well as EMFs on brown shrimp, but no available research on the impacts of vibrations. The effects of noise have been linked to a reduction in growth and reproductive rate, as well effects on metabolism through increased oxygen consumption and ammonia excretion. Noise has also been shown to reduce the efficiency of feeding, i.e. individuals increase their foraging behaviour but not the feeding rate. Brown shrimp were shown to be sensitive to EMFs but no specific impacts have been documented.

Summary of effects of noise, vibration and EMFs on Crustacea

The research undertaken to date indicates that the reactions of Crustacea to noise (both pressure waves and particle motion), substrate-borne vibrations and EMFs is extremely complex. Notably, the understanding of how crustaceans detect and use underwater noise, vibration and EMFs is still in its infancy.

Potential mitigation options

There are mitigation measures already in place which are designed to minimise the possible impacts of underwater noise from MRED developments on marine mammals, some of which may help minimise impacts on crustaceans:

- Reducing unwanted/damaging sound through setting noise criteria (e.g. level, duration, duty cycle, deliberately minimising substrate-borne vibration), changing vessel propeller/ propulsion systems and activity minimisation;
- Using alternative sound sources, e.g. hydraulic pile driving instead of impulsive pile driving, BLUE piling technology.

Other existing mitigation options are unlikely to benefit seabed-dwelling crustaceans (e.g. bubble curtains while pile-driving, soft-start/ramp-ups for geophysical surveys, acoustic deterrent devices).

Research gaps: where next?

The understanding of how crustaceans detect and use underwater noise, vibration and EMFs is still in its infancy and without a good knowledge of this it is impossible to understand the full impacts of MREDs on commercial crustacean species, or the fisheries for these.

Further research is needed to understand how MRED developments could impact commercially important crustacean species and, subsequently, affect these important and valuable fisheries. The lack of evidence regarding the potential impacts of MRED development and operation on commercially important crustaceans, particularly with regard to substrate-borne vibration and particle motion needs to be addressed.

Without a thorough understanding of the impacts of noise, vibration and EMFs on crustaceans throughout their life cycle, it is not possible to develop best practice mitigation options that will reduce any negative effects on some of the most valuable and commercially important UK fisheries. The effect of underwater noise, vibration and EMFs acting together (‘cumulative impact’) has also not been studied. Evidence on how these stressors, individually and in combination, could affect catchability for a fishery requires further investigation.

On a more positive note, MREDs often create local man-made ‘reef’ environments which can attract species such as brown crab and lobster. Because MRED developments are usually closed to fishing activities, there is the potential for spill-over effects as have been observed in some Marine Protected Areas. Research on the potential for these spill-over effects to have positive benefits on nearby commercially accessible fishing grounds is also required.

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