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Benthic Interactions with Renewable Energy Installations in a Temperate Ecosystem

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ABSTRACT
Wave Hub is a Marine Renewable Energy Installation (MREI) off the southwest peninsular of the UK. Wave Hub's seabed infrastructure, including the main connection unit and 18 km of seabed cable were deployed in 2010. To enhance knowledge on the potential future impacts of MREI, this study assesses the effect of the power cable, with its associated 80,000 tonnes of rock armoring. Species assemblages were compared between rock armored and control sites two years after installation.

INTRODUCTION
While Marine Renewable Energy Installations (MREI) could help meet the demands of a growing global need for 'clean' energy (1); it is essential that their local impacts are quantified to ensure that future installations do not negatively affect benthic habitats and their associated species (1-4). Species and habitats provide numerous beneficial ecosystem functions and services. Some species have a direct commercial value as food, others provide ecosystem services such as primary and secondary production, which is vital for ecosystem resilience (5,6). Gaining detailed knowledge of the habitats and species present at a potential MREI site is therefore vital to aid understanding of the likely potential effects of development on the supply of ecosystem goods and services.

Wave Hub is an 8 km^2 MREI located off the north coast of Cornwall, south west UK. Seabed cable connecting Wave Hub to an electricity sub-station south of the site in Hayle, north Cornwall, was deployed in summer 2010. At the time of deployment, only a small area surrounding the hub (the cable plug) benefited from a safety exclusion zone, prohibiting other sea users from entering the region. To avoid fishing gear damaging the subsea cable, it was buried when passing through near shore sandy habitat and was laid on the seabed for the remaining distance to the offshore hub, upon which boulders and concrete mattressing were deployed. The cable armoring was completed at the end of summer 2010, and there is little chance that epifauna beneath the cable and armoring survived this installation process. The armoring should, however, in principle provide replacement relief habitat for subsequent colonization.

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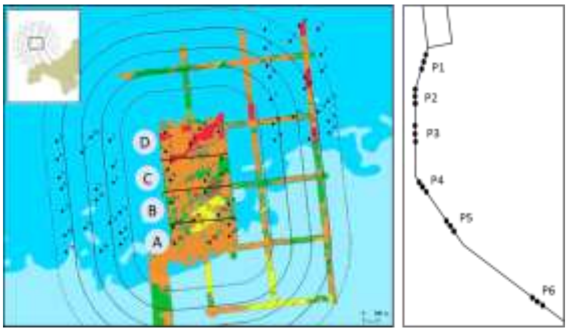

Fig. 1 Wave Hub development zone showing sampling Areas (A-D) and sampling Plot locations along the cable route (not to scale).

This study quantifies the effect of the cable laying and rock armoring on the benthic epifauna community 2 years after deployment.

METHODOLOGY
In order to determine the effect of the cable route upon the local ecosystem it is important to quantify both the habitat that was buried and how long it takes that habitat to recover. By comparing the species that have colonized the cable route since installation with those found in control areas it is possible to investigate whether the cable rock armoring is still affecting the epifaunal assemblage 2 years after deployment. It was hypothesized that the assemblages would be different on the cable bouldering compared to controls, and so the null hypothesis of no difference between treatments was examined for the response variables: species richness (number of taxa), overall abundance (number of organisms) and assemblage composition.

The Cable route survey was carried out in June 2012 to quantify the effect of the cable armoring on the seabed fauna. Sites of data collection were located in water depths between 24 – 60 m.

Benthic sampling along the Cable route rock armoring

Six Plots were identified along the Wave Hub subsea cable to investigate faunal assemblages that had colonized the cable armoring 2 years after installation (Fig.1).

Within each Plot, 3 sites were positioned 200 m apart running perpendicular to the cable armoring. At each site, 200 m of remote high definition video were recorded, the start point of which was undisturbed seabed, then cable armoring and then returning to seabed on the opposite side of the armoring. Undisturbed seabed sites adjacent to the rock armoring were considered to be controls and representative of the seabed type likely to have been affected by the installation of the cable and associated armoring.

The towed flying array

Fig. 2 The towed flying array mounted with high definition video

The survey employed a method of filming the seabed using High Definition (HD) video mounted on a towed 'flying array' described in Sheehan et al. (7) (Fig. 2). The flying array is an aluminum sled that floats above the seabed, which makes it suitable for sampling epibenthos over variable seabed relief. Chain is used to control height above the seabed and a drop-weight is attached to a tow rope to provide extra stability and minimize the effect of the pitch and roll of the survey boat. This design was selected as it has been shown to be time and cost effective and relatively non-destructive (7,8), which is essential if this survey was to be replicated over time to investigate the potential for positive or negative effects of MREI.

Video analysis

To analyze the video, frame grabs were extracted at 5 s intervals for the Cable route control sites. Frame grabs of the Cable route were extracted at 1 s intervals to maximize analyzable footage. Frame grabs were overlaid with a digital quadrat (3Dive Frame Extractor Software) (see Fig. 3d). Unsuitable frames were rejected in accordance to Sheehan et al. 2010. 10 frame grabs were randomly selected from video footage from each site for the Cable route (five on the cable and five at the control zones occurring either side of the cable armoring). All taxa within each frame grab were identified to the highest taxonomic level possible and counted. The area sampled was corrected for every frame based on the position of the laser dots, giving density units of individuals m^{-2}.

Statistical Analyses

Permutational multivariate analysis of variance (PERMANOVA+ in the PRIMER v6 software package (9,10) was used to determine whether assemblages of organisms were different between Treatments (Cable route vs Controls) and Plots (1-6) for the Cable route.

RESULTS

For each treatment in each Plot, the mean species richness was 9.73 m^{-2} ± 0.6 SE on the Cable route, and 11.44 m^{-2} ± 1.2 SE in the Controls. For each treatment in each Plot, the mean abundance of organisms was 207.61 ind. m^{-2} ± 26.2 SE on the Cable route, and 141 ind. m^{-2} ± 37.5 SE in the Controls. Neither of the univariate response variables, species richness or overall abundance, were significantly different between the Cable route and the Controls $P > 0.05$, while the assemblage composition was different between treatments $P = 0.017$.

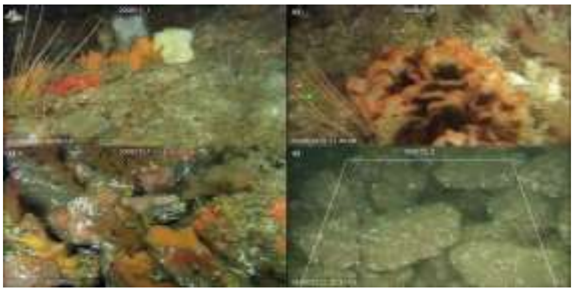

Fig. 3 Image plate showing a) Hydroids (*Nemertesia antennina* and grouped hydroids), sponges (*Amphilectus fucorum*), bryozoans (*Cellepora pumicosa*, *Alcyonidium diaphanum*), dead man's fingers, b) Hydroids (*Nemertesia antennina* and other hydroids), Bryozoans (*Pentapora fascialis*, *Alcyonidium diaphanum*), c) Sponges (including *Amphilectus fucorum*), bryozoans (*Alcyonidium diaphanum*), d) Digital quadrat overlay showing cable boulders with keel worm, hydroids, bryozoan turf and encrusting sponge.

CONCLUSIONS

The armoring of the cable route provided the first evidence of what effect adding structure to the seabed would have over a two year period at the Wave Hub site. After two years there were similar numbers of taxa and overall abundance of organisms. Nevertheless, the species assemblage composition was very different. The cable route had far less variation among samples. These findings were in keeping with researchers (11) who studied the colonization of wind turbine monopiles.

More opportunistic, fast growing species that are typical of early colonization, on new habitat, such as hydroids (12) were found in greater abundances on the cable route than in the controls. Similarly, the encrusting bryozoan *Cellepora pumicosa* was also more abundant on the cable route. It may be that this species facilitates the growth of more upright structure forming bryozoans such as the structurally complex bryozoan Ross coral (Fig. 3), which was not yet observed on the cable route, yet was large and abundant in controls. Other structure forming sessile species were also either absent or had low abundance on the cable route such as sponges and soft corals. These are typical of species that are slow growing and long lived, making them most susceptible to disturbance and the slowest to recover (12). In order to assess impact to ecosystem function we can link species traits such as susceptibility to disturbance and recoverability with the ecosystem processes and services that organisms are responsible for.

Whilst some recovery was seen for fast growing species within two years, appropriate monitoring is needed over longer timescales to assess recovery of slower growing, long lived species such as habitat building Ross coral, sponges and corals (13,14). This is vital to determine the positive and negative impacts of MREI post deployment, its potential impacts on ecosystem goods and services, and hence, whether the benefits outweigh the costs.

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