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Environmental Impact Assessments for wave energy developments – Learning from existing activities and informing future research priorities

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ABSTRACT

Plans for Marine Renewable Energy Installations (MREI) are developing worldwide, yet many questions still remain about the impacts such developments may have on marine ecosystems and on coastal and oceanographic processes. This uncertainty, combined with a lengthy and complex Environmental Impact Assessment (EIA) phase prior to consent, has slowed the growth of the marine renewables sector. Information on completed and ongoing EIAs at MREI sites across Europe was summarised and compared amongst sites and with completed, comprehensive EIAs for Horns Rev offshore wind farm and the SeaGen tidal turbine site at Strangford Lough. This allowed for the identification of commonalities and differences in monitoring activities, and of data gaps in the wave energy EIA process. Studies on the socio-economic impacts of MREIs were lacking, as were monitoring of fish, fish habitats, electromagnetic fields and their impacts on marine wildlife. Even amongst sites monitoring similar topics, methodologies varied greatly. Science cannot inform the management of marine renewables whilst there are inconsistencies in baseline and impact monitoring, as this study has documented. A streamlined EIA process and collaborations between researchers and developers are required to move the industry forward.

1. Introduction

Whilst wind power is currently the main form of renewable energy generation in the marine environment, developments in the fields of wave and tidal power in recent years have brought these technologies to the forefront of renewable energy generation. Wave energy holds enormous global potential for meeting future renewable energy goals and this has encouraged the development of wave energy pilot projects, test sites and pre-commercial sites across the world (e.g. Boehlert et al., 2008; Cada et al., 2007; Dal Ferro, 2006; Nelson et al., 2008). The technology could, potentially, provide a significant contribution to renewable energy production in the future, in areas with suitable wave conditions (Carbon Trust, 2006; Kerr, 2007). Renewable UK (2010) estimated that marine renewable energy could provide 15–20% of electricity generation in the longer term, based on current demand levels. However, the effects that Wave Energy Converters (WECs) and other Marine Renewable Energy Devices (MREDs) will have on physical and biological processes and their impact on various species and habitats in the marine environment are yet to be fully determined.

In Europe, the majority of marine renewable energy installation (MREI; used here to describe devices for harnessing wave and tidal energy) developments require some level of Environmental Impact Assessment (EIA), the purpose of which is to ascertain the effects of the development on the natural environment, species, biological and physical processes (although test sites and small-scale demonstration projects may not be required to carry out a full-scale EIA). The permitting process can then weigh the scale of such effects on the environment against the value of the installation, in order to determine whether consent to proceed with the development will be granted or not. While some of the effects of introducing MREIs to the marine environment will be the same regardless of the installation involved, other effects will be device-specific (Margheritini et al., 2012). Effects will vary with the stage (construction, operation and decommissioning) and scale of the

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project and will depend on the location and ecosystem in that area. In particular, removal of energy directly from the water column distinguishes wave and tidal energy generation from the offshore wind experience and presents a suite of new potential issues which have not been confronted in offshore wind EIA. One obvious example of this is the introduction of moving components to the underwater environment. The question of scale is important, as experience to date indicates that some small-scale demonstration projects have not had to go through a full EIA process. EIAs for marine renewables installations have thus far evolved, in most instances, without any specific guidance and have thus been largely based on the design and principle of EIAs for offshore wind farms. The wind energy industry is several decades ahead of wave energy and consequently of all the categories of MREIs, the greatest knowledge base regarding effects on the marine environment comes from offshore wind turbine developments (e.g. Evans, 2008; COWRIE[1]).

The potential effects of WECs on marine organisms have been comprehensively investigated by Inger et al. (2009), Nelson et al. (2008) and Witt et al. (2012), and include effects on nearshore intertidal and benthic habitats, fish, fish habitats, large marine vertebrates (sea birds, marine mammals and large fish), oceanographic and coastal processes. Marine mammals or diving birds, for example, may be at risk of collision or entanglement with underwater elements of WECs (Wilson et al., 2007). Decreases in wave energy and the resulting changes in wave-driven processes are the basis for the majority of anticipated impacts of wave energy conversion technology on the coastal environment and morphological processes. Numerical modelling has predicted that WECs will extract between 3 and 15% of incident wave energy, (Largier et al., 2008) and this energy reduction is likely to affect wave shoaling, sediment transport, beach building and mixing. Coastal erosion patterns may be altered, and the seabed and mid-water habitats could be affected by changes in currents, mixing of the water column and sedimentation patterns. This, in turn, may affect benthic vegetation and fauna and have knock-on effects through the ecosystem.

Whilst many of the impacts considered may be negative, there are also potential positive impacts of marine renewable energy (MRE) developments. The closing of an offshore area to vessel transit and, in particular, to fishing activities, may cause the MREI to act as a *de facto* Marine Protected Area (MPA), by removing fishing pressure and potentially allowing fish to breed and grow (Witt et al., 2012). This in turn could have spillover effects to other areas (e.g. Gell and Roberts, 2003). Likewise, the provision of additional hard substrate and seabed structure, which may be a component of the foundations or anchoring of some (though not all) MREIs, may have artificial reef effects, as the structures are colonized by benthic organisms and then attract other marine life (Linley et al., 2007). The structures themselves may also act as fish aggregating devices (FAD) (Fayram and de Risi, 2007; Wilhelmsson et al., 2006). In this way, MREI may help restore areas of seabed that have been lost through destructive methods of commercial fishing (Thurstan and Roberts, 2010). Most pertinently, it is unknown at this stage in the industry's development whether many of the postulated effects will actually occur. For some impacts, such as the long-term effects of changes to sediment deposition patterns or coastal processes and possible FAD effects, it is also unclear whether such a change would be of overall benefit or not.

The socio-economic impacts of MREIs are less frequently addressed and there is even less structure in place in terms of the guidance on requisite elements to address, or appropriate methods with which to address them. Socio-economic impacts for offshore renewable projects typically include elements like demography, employment and regional income; sea and land use; aesthetics; infrastructure; socio-cultural systems and implications for other maritime activities such as fisheries, tourism and recreation (e.g. Bailey et al., 2011; Haggett, 2008; Lilley et al., 2010; WAVEPLAM, 2010). Concerns may be voiced by, for example, surfing groups and surf tourism industries about a reduction in wave strength or quality (e.g. McLachlan, 2009; Bailey et al., 2011); by other recreational sea user groups and local fishing industries regarding closed areas to prevent collisions between vessels and WEC devices; or local residents regarding the visual impact of WECs and the onshore stations to which they are linked (e.g. West et al., 2010). However, diminished erosional potential from reduced wave fields may be perceived by landowners or coastal managers as a beneficial outcome of such a development, as would opportunities associated with construction, deployment, and operations and maintenance, which usually contribute jobs and income to local communities.

Many of these potential environmental impacts of MREIs, at least in terms of the biological and oceanographic elements, have yet to be confirmed or refuted. In order for the marine renewables industry to move forward, it is now necessary to identify the knowledge gaps in the Environmental Impact Assessment process, determine how best to address those gaps and then create partnerships between industry, researchers and government that will facilitate the investigative process. This study collected data on the monitoring activities that were underway or complete at wave energy sites throughout Europe in 2011. Differences and commonalities between these monitoring programmes and EIAs completed for the now well-developed offshore wind industry were identified, and gaps in the wave energy EIA process have been highlighted. Recommendations are made for the efficient use of research activities to address potential concerns, inform a calculated risk-based approach and encourage the growth of the wave energy industry. The findings are relevant to MRE developments worldwide.

2. Methods

2.1. Gathering data on existing wave energy EIAs in Europe

In order to identify both the necessary elements of EIAs for wave energy and the data gaps or areas where more understanding is required, data were collected on ongoing and planned EIA activities at wave energy sites in Europe. This work was carried out as part of the SOWFIA Project (Streamlining of Offshore Wave Farm Impact Assessment; www.sowfia.eu). The SOWFIA Project drew together ten partners, across eight European countries, who were actively involved with existing or planned wave farm test centres. Anticipated tidal stream test sites were also included, as not only are they required to address many of the same monitoring issues as wave energy sites, but consideration of them significantly increased the sample size. A questionnaire (Appendix I) was developed and emailed to wave energy project developers, device developers, renewable energy consortia and researchers, to collect information on the completed, ongoing and planned monitoring activities at wave and tidal energy developments and test sites. In addition, publicly-available EIA documents were scrutinised in order to gather more information on the baseline data collection and baseline or impact monitoring that had been carried out at various sites. Data were collected between April and August 2011.

[1] Collaborative Offshore Wind Research into the Environment; associated reports available at: http://www.thecrownestate.co.uk/energy-infrastructure/downloads/cowrie/.