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Challenges and opportunities in monitoring the impacts of tidal-stream energy devices on marine vertebrates

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ABSTRACT

Marine tidal-stream renewable energy devices (MREDs) are beginning to move from demonstration to early commercial deployment. However, the ecological impacts which may result when large arrays of these devices are deployed are unknown. This uncertainty is placing a considerable burden on developers who must collect biological data through baseline and post-deployment monitoring programs under the Environmental Impact Assessment process. Regulators and other stakeholders are often particularly concerned about impacts on marine vertebrates (fish, seabirds and mammals) because many of these receptors are of high conservation and public concern. Unfortunately monitoring for most marine vertebrates is challenging and expensive, especially in the energetic waters where tidal-stream MREDs will be deployed. Surveys for marine vertebrates often have low statistical power and so are likely to fail to detect all but substantial changes in abundance. Furthermore, many marine vertebrate species have large geographical ranges so that even if local changes in abundance are detected, they cannot usually be related to the wider populations. Much of the monitoring currently being undertaken at tidal-stream MRED development sites is thus leading to a 'data-rich but information-poor' (DRIP) situation. Such an approach adds to development costs whilst contributing little to wider ecosystem-based understanding. In the present article we discuss the issues surrounding the impacts of tidal-stream MREDs on marine vertebrates and address the questions regulators, developers and other stakeholders need to consider when agreeing monitoring programs for these receptors.

1. Introduction

1.1. The present state of marine tidal-stream energy extraction

Marine renewable energy (MRE) has the potential to provide up to 7% of global electricity demand [1–3]. Whilst most of this potential comes from offshore wind, tidal-stream energy could yield around 0.75% of global demand [4]. Extracting energy from tidal-streams is attractive because the energy source is more predictable compared with offshore wind and wave [4–6] but, on the other hand, there are fewer sites which are suitable for tidal-stream MRE [4,5].

A large number of tidal-stream device designs are presently in development although they cluster into three main categories (i) horizontal axis turbines (ii) vertical axis turbines and (iii) reciprocating devices (Fig. 1). To date axis-mounted systems have dominated the industry including designs where the rotational motion is provided by novel approaches such as kites. In contrast, oscillating devices extract energy using a reciprocal vertical motion but, according to Rourke et al. [7], these are not as efficient as rotational devices. Most tidal-stream MREDs are mounted on frames placed on the seabed but suspending devices from floating structures is also being trialled. The main environmental concerns are likely to be broadly similar across devices and include physical disturbance, collision risk, hydrographic modification and the production of noise and electromagnetic fields. It has generally been concluded that pollution risks should be low since these devices only contain small quantities of chemicals, such as lubricants and coolants. However, the impact of biofouling has probably been underestimated and there is little information on the degree to which

Abbreviations: AA, appropriate assessment;CBD, (United Nations) Convention on Biodiversity; CI, cumulative impacts; DRIP, data-rich, information-poor; EIA, Environmental Impact Assessment; EMF, electromagnetic field; EMMP, Environmental Monitoring and Management Plan; ES, Environmental Statement; EU, European Union; HRA, Habitats Regulations Appraisal;MRE, marine renewable energy; MRED, marine renewable energy device; NGO, non-governmental organisation; PCoD, Population Consequences of Disturbance; SDM, survey, deploy and monitor; SEA, Strategic Environmental Assessment

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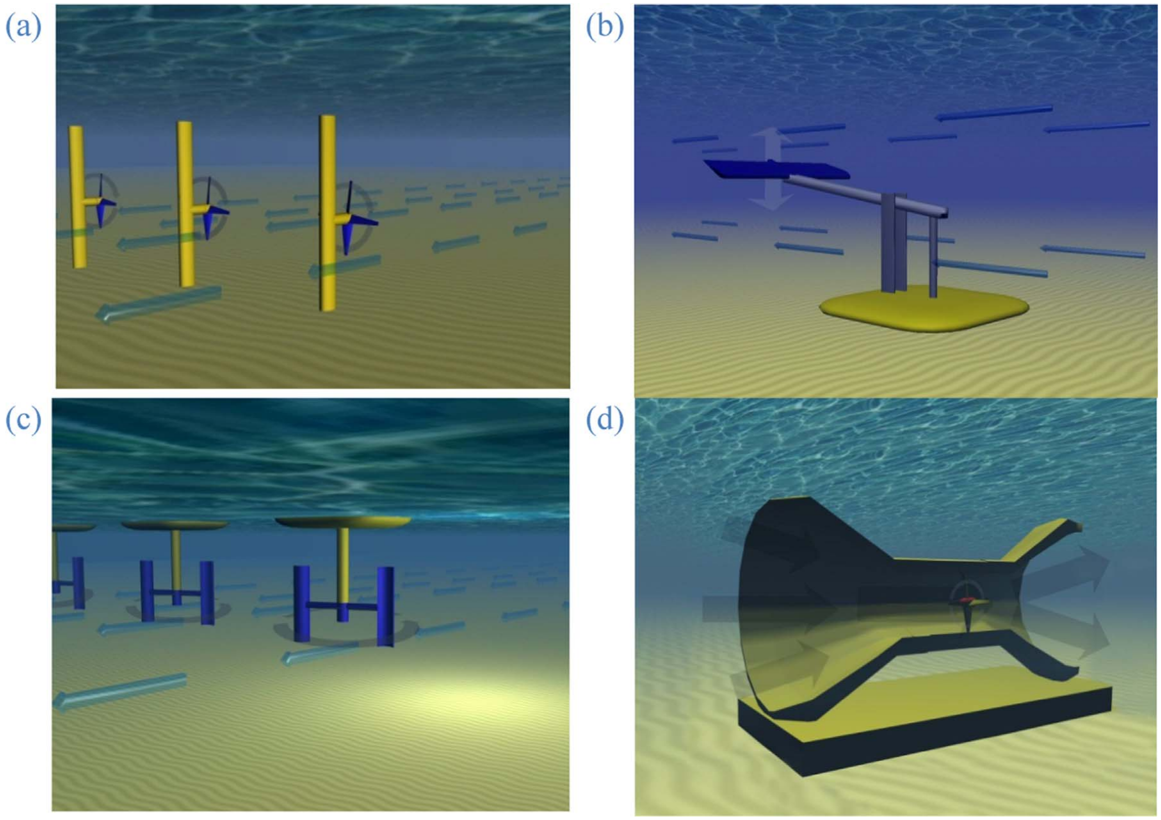

Fig. 1. Generalised examples of tidal-stream MRE technologies currently in development: (a) Horizontal axis turbines; (b) Reciprocating hydrofoil; (c) Vertical axis turbines; (d) Venturi-effect device. Images re-used with kind permission of the Aquatic Renewable Energy Technologies project (Aqua-RET co-ordinated by AquaTT, www.aquaret.com).

anti-fouling coatings will have to be used to protect turbines, transformers and switch gear.

To date, test deployments of tidal-stream MREDs have taken place at a number of sites including the Pentland Firth, Strangford Lough and Ramsay Sound (UK), the Bay of Fundy (Canada), Cobscook Bay, Maine (USA) and Raz Blanchard (France). Several companies are currently developing commercial-scale projects but before consents are granted they will have to satisfy regulators with regard to the likely environmental impacts. National environmental legislation is driven by high-level agreements, such as the 1992 UN Convention on Biodiversity (CBD), which calls for sustainable development and provides a framework for halting and reversing losses in biodiversity [8]. However, this raises the question of how negative environmental impacts should be balanced against wider positive outcomes. For example, the renewables industry and some researchers have argued that the local disruption associated with renewables projects needs to be offset against the wider global benefits of reducing anthropogenic greenhouse gas emissions [9,10]. On the other hand regulators usually take a 'precautionary approach' and focus almost exclusively on the potential negative impacts [11]. Some stakeholders have therefore argued for a risk-based approach as exemplified by the Scottish Government's 'Survey, Deploy and Monitor' (SDM) strategy [12]. However, the SDM guidance was designed for initial, prototype-scale projects and may be less applicable as developments scale-up [13]. Another alternative could be to adopt an adaptive strategy, taking advantage of lessons learned from a gradual increase in deployment [12,14]. Whichever approach is chosen the debates around balancing 'local impacts' against 'global benefits' are heavily culturally contextualised and, despite international conventions such as the CBD, specific outcomes tend to depend on the relative values that societies place on 'ecosystem' versus 'economic' services at the local level [12,15–17]. The role of science is to provide the data on, and analysis of, the potential impacts so that decisions are well-informed. Acceptable levels of impact therefore need to be defined by regulators (with scientific input and wider stakeholder consent) before new technologies, such as tidal-stream energy, enter the commercial "valley of death" which is the critical period between technology demonstration and market pull to full commercialisation [18]. Where such agreement is lacking, the large financial investments needed to move from 'demonstration' to 'commercial' scale may be adversely affected [11,19–21]. In a review of UK investors in renewables, Leete at al. [22] identified the predictability of regulations as being critical. Although the investors quoted in Leete at al. [22] were referring mainly to uncertainty around guaranteed pricing, further uncertainty and unpredictability in environmental consenting is also likely to lead to reduced investor confidence as tidal-stream MRE moves beyond the testing phase [14].

1.2. Requirements for environmental impact assessments

As in most other countries, developers in Europe are required to produce an Environmental Statement (ES) based on an Environmental Impact Assessment (EIA) before any project which might have significant impacts on the environment can commence [23]. The production of the ES/EIA typically involves collecting physical, biolo-