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ANALYSIS OF EXPERIENCE FROM ENVIRONMENTAL IMPACT ASSESSMENTS OF WAVE ENERGY TEST CENTRES

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ABSTRACT

The potential environmental impacts of wave energy, and the obligation on developers and regulators to document and assess these, continues to represent a significant barrier to the wave energy industry. As part of the EU IEE-funded SOWFIA project, on streamlining of impact assessment for wave energy farms, an evaluation of experience related to the detection of environmental impacts at wave energy test centres across Europe, coupled with information gained from Environmental Impact Assessments produced for other similar renewable energy developments, has been undertaken. This experience has been examined to understand key receptors of concern and methods used for detecting impacts with the over-arching aim of producing effective methods for communicating the information gathered and to identify, where possible, the type and magnitude of impacts which may be expected in future, larger scale developments. This paper focuses on a selection of these receptors, focusing on the variations found and the implications these variations could have for future assessments.

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INTRODUCTION

The overarching goal of the present paper is to summarise experience related to the detection of environmental impacts at wave energy test centres located across the EU along with information gained from Environmental Impact Assessments (EIAs), in order to provide European wide recommendations for streamlining of approval and EIA processes. Compliance with EU and national legislation often requires the collection and collation of significant amounts of environmental data in order to enable regulatory authorities to make an informed decision on the proposed project and its potential environmental impacts at an early stage.

Whilst not explicitly listed as mandatory in the EIA Directive, wave and tidal projects have often been subject to EIA because of the uncertainty surrounding their environmental impact on the receiving environment. The EIA process requires developers to supply comprehensive environmental data relating to both baseline conditions and possible environmental impacts of device installation. Given the novelty of wave and tidal energy device deployments, many effects and impacts are unknown and have not yet been quantified. This has resulted in a recognised number of information, data and knowledge gaps with which regulatory authorities and developers must contend. Accordingly the procedures and process to be followed is not always clear to either party often leading to increased costs, delay and frustration. This paper therefore examines experience in key areas of wave energy, reviews monitoring requirements and methodologies and summarising principle findings in order to help reduce uncertainties and refine the EIA process for wave energy.

METHODOLOGY

The SOWFIA project worked closely with six test centres in the EU: AMETS in Ireland, *bimep* in Spain, Lysekil in Sweden, Ocean Plug in Portugal, SEM-REV in France, and Wave Hub in England. EMEC, in Scotland, also contributed to the project. Data gathered from monitoring were uploaded to a customised Data Management Platform (DMP), an interactive tool designed and developed to compare, bench-mark and analyse data collected at the various test centres to date. A review of the EIAs performed at each test centre associated with the SOWFIA project was carried out, with the parameters included therein presented in Table 1.

Table 1. Monitoring activities (physical, biological and socio-economic) at six wave energy test sites.

Parameter	AMETS	*bimep*	Lysekil	Ocean Plug	SEM REV	Wave Hub
Bathymetry	X				X	X
Geomorph.	X			X	X	X
Hydrodym.	X	X		X	X	X
Noise		X	X			X
Benthos	X	X	X	X	X	X
Fish/s'fish		X	X			X
Plankton						X
Marine mammals	X	X	X	X		X
Birds	X			X		X
Vis.impacts	X					X
Archaeol.						X
Navigation/Shipping	X					X
Fisheries	X			X		X
Economics						X
Tourism						X

The review was complemented by a comprehensive literature review of guidance and methodologies for monitoring of specific environmental parameters [1]. Survey methodologies employed were found to be dependent on the type of the expected impact and on the monitoring phase, which in turn affects the resolution of the survey, its size, temporal scale and frequency. It is therefore important to understand how these factors could affect the monitoring programme for a given environmental descriptor.

The need to provide comparative information affects the design of the survey and has to be considered form the start of the monitoring programme. Two designs are common: 1. Before and After Control Impact (BACI) and 2. Before and After Gradient (BAG). BAG designs tend to be preferred for surveying of birds and marine mammals as they require less monitoring effort in terms of spatial coverage. BACI designs are well established for biological impact assessment but found limited use in marine renewable energy development, since they can be employed only when the conditions for a control site to be comparable to, but independent from the study site, are met.

OBSERVATIONS

The guidance documents produced by CEFAS in the UK [2] and SNH [3] indicate that there is a general lack of knowledge in procedures for monitoring impacts of offshore renewable structures on the marine environment. From the review work conducted, guidance currently focuses on marine mammals, seabirds and benthic ecology. CEFAS guidelines also advise that fish studies, underwater noise, intertidal studies, and physical and sedimentary process studies are included in EIAs.

As expected, there is clear evidence that the receptors of primary interest are dependent on factors such as the local environmental characteristics, the presence/absence of protected species and the regulatory authority under which the EIA is performed. The potential for devices to remove energy from the physical environment, the introduction of additional noise into the marine environment and the likelihood of impacts on marine mammals were the most commonly considered factors in the EIAs analysed. Accordingly these are the focus of this paper, coupled with lessons learned from their monitoring to date. Further detailed information on all aspects can be found in [1].

Physical environment: monitoring of wave and current conditions is essential. For wave measurements, moored directional wave buoys should be used if possible as they are the most robust and advanced commercial product in the field [e.g. 4]. Alternatively bottom-mounted Acoustic Doppler Current Profilers (ADCPs) in moderate depths (<40m) or high-frequency (HF) radar may be used. The wave measurement campaign should span 1 or 2 years with minimum temporal resolution of 3 hours and as few interruptions due to technical failures (e.g. sensor displacement or loss) as possible. For current measurements bottom-mounted Acoustic Doppler Current Profilers (ADCPs) are preferred [e.g. 5] as long as the water depth is not too great (<100-150m). A measurement campaign generally consists of one to two months of continuous recording (depending on the device settings) and requires collection of the device from the sea once the batteries or memory are exhausted.

Lessons learned: Wave measurements tend to be taken close to a test berth and less commonly (Wave Hub and SEM-REV only) upstream and downstream of the test site so as to measure resource variation (natural and device-related) across the site. To date, there is no certainty that wave and tidal energy farms will impact the wave and current fields significantly.

A regular comment stemming from the literature review is that the methods used to answer the question still need major improvements, in particular the modelling of energy absorption of farms. Preliminary studies generally conclude that the change in significant wave height alongshore due to the presence of an array of wave energy devices should not exceed a few percent (e.g. [6]).

Noise: Different marine species detect and emit sound over a broad range of different frequencies and amplitudes. Marine renewable devices will introduce new sources of noise which could have an effect on species such as whales, dolphins, seals, fish and diving seabirds. Measuring underwater noise is a well-developed science, however, measuring noise in high-energy locations where marine renewable energy devices are to be deployed presents difficulties. There is no established instrumentation or methodology for measuring noise from WECs and their effects on marine animals [7]. Baseline noise measurements incorporating natural noise (e.g. waves, wind, sediment) and anthropogenic noise (e.g. shipping, piling) need to be recorded and understood before measuring [operational] noise from wave energy devices. Recommendations are given in Austin *et al.* [8] on the type of recording equipment which should be used in a noise monitoring programme. At present there is little data of any sort available on the noise output from any type of wave energy device. It has been speculated [8] that the noise emitted by WECs will be in the region of a few kHz and so a sample rate of 16kHz would be adequate to measure this. Sounds up to 180kHz are audible to marine mammals and so it may be necessary to measure noise at higher bandwidths until the noise outputs of devices are better known and understood. Cabled systems or radio telemetry systems are better suited for long-term measurements or real-time data.

Lessons learned: bimep, Lysekil and Wave Hub were required to monitor noise as part of their EIA [1]. There are a number of potential and probable impacts from noise on marine life. Potential impacts may include hearing loss, behavioural disturbance, discomfort, injury and in extreme cases death. Probable impacts can occur during construction, operation or decommissioning phase and will vary with device type. Increased vessel noise may result from installation. Construction may also necessitate drilling or piling. There is little available information on the impacts associated with noise from operational WECs. Noise studies, to date, have focussed on attempts to measure the acoustic signature of different WECs. At Lysekil, in Sweden, analysis of the noise measurements from a WEC was only possible for significant wave heights of less than 0.5m because above this, the recordings were corrupted due to overload distortion. It was concluded that noise levels would be unlikely to induce behavioural reactions in the least sensitive fish and that the intensity of noise is most probably below the threshold of causing physical injury to fish. The low frequencies measured mean that the most of the WEC noise is below the hearing threshold of all marine mammals at the site, apart from harbour seals. It is likely that the noise energy emitted by WECs will have frequencies of up to a few kHz and the nature and intensity may be comparable to that emitted by machinery on-board typical similar sized vessels. It is unlikely that single WECs will cause significant noise impact at longer ranges, however, further studies are required to determine the output of wave energy devices with more certainty (see also [9] in relation to noise from vessels).

Marine mammals: Since MRE devices are likely to be in on-shelf shallow waters (< 200 m depth), the main species that they are likely to affect are seals and coastal on-shelf species of cetaceans (whales, dolphins and porpoises). Monitoring of marine mammal populations before, during and after deployment of devices is often required as part of the EIA process as a result of the high conservation status of these species. The level of monitoring required is highly dependent on the location of the deployment site, the type of devices to be installed, the national and EU legal requirements that may apply if developments are likely to have an impact on sites of importance (e.g. SACs). Due to the low numbers of devices in the water, there have been few impact studies on marine mammals conducted. The most common method used for monitoring marine mammals for baseline data is Static Acoustic Monitoring (SAM), which has been utilised in AMETS, *bimep*, Lysekil, Pico, Reunion, Sotenas Wave Dragon, and Wave Hub. This usually enables noise levels to be evaluated simultaneously if broadband recorders are used. Aerial surveys for marine mammals have only been conducted at Ocean Plug. Elsewhere boat-based line transect surveys (AMETS, Wave Hub, Pilot Zone) or land-based visual observations if the sites are within view from vantage points on land (AMETS, Billia Croo at EMEC) have been employed. Some sites have thus far only undertaken desk studies and reviews (Galway Bay, Pelamis Farr Point and Pentland Firth). A few sites appear to have no known marine mammal monitoring (Peniche, Runde, SEM-REV).

Lessons learned: Whilst many test centres seem to have a baseline understanding of marine mammal populations coinciding with their test site, many sites lack alternative additional locations within their survey programmes (away from the development sites) that could be considered as statistically relevant control locations. As such, data collected cannot be contextualised with what is happening in the broader marine region (geographically), which limits the findings of any studies. The need for good survey design is already recognised [10]. Data should be collected over an extended time period – at least two years - so that an albeit short baseline can be constructed for each season before any devices are installed, otherwise it may not be possible to determine whether changes are due to the device placement or seasonal variation in abundance and behaviour. Data also needs to be collected in several locations, both within and outside appropriate control sites well away from the device location, for similar reasons. Preliminary results from C-POD monitoring at a quarter scale device deployment in Ireland (with two control sites) show no significant difference in detections of vocalising cetaceans at the device and at the control sites [11]. In addition to noise, collision/entanglement; displacement, EMF and cumulative effects are the main risks posed to marine mammals. They may avoid devices but further studies are also needed. Experience with nets and static (but slack) fishing gear indicate that entanglement is a potential issue although the risk associated with wave energy devices is likely to be much lower than other ocean energy technologies. This risk is potentially aggravated by the increased food arising from the FAD potential of wave energy devices. Cumulative effects are also of particular concern given the highly mobile nature of marine mammals.

CONCLUSIONS

In the analysis of all the receptors considered in the SOWFIA project [1], a number of common themes have emerged. The first of these is the appropriate length of baseline studies: two years of monitoring is required to provide a baseline sufficient to detect changes attributable to the presence of wave energy devices. It was repeatedly suggested that for wave energy EIA a Before-and-After-Gradient (BAG) design was preferred over a Before-After-Control-Impact (BACI) design. The latter requires an appropriate independent control site and a higher number of replicates to achieve the desired level of impact detection sensitivity. Finally, concerns relating to cumulative impacts, both from marine renewable energy and a growth in maritime activities generally, was a recurrent theme. These are difficult for individual developers to address adequately and independently with suggestions that this must be comprehensively addressed at a national/regional level as part of the Strategic Environmental Assessment (SEA) process.

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