Development of a Data Management Platform for the integration of European Wave Energy Impact Assessment datasets

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Abstract
An absence of coordinated policies across Europe for the environmental and socio-economic impact assessment (IA) of wave energy projects is seen by many as an obstacle to the development of the wave energy sector. The generation of IA tools that facilitate the decision-making process by providing easy to access and understand data is encouraged. The SOWFIA project aims to capitalize upon the experiences of IA from EU wave energy test sites by developing a GIS-based Data Management Platform (DMP).

Keywords: ocean energy, environmental impact assessment, data management, environmental monitoring.

1. Introduction
Wave energy is an emerging industry and in many regards it can be considered as a new user of coastal seas. The potential of wave energy to contribute towards EU green energy goals and climate change mitigation have been long discussed [1]. However, technological and administrative hurdles still need to be overcome in order to establish wave energy as viable and reliable energy source. A particular issue experienced across Europe by different device and site developers is the necessity of this new industry to deal with European and National regulatory frameworks. Through a series of surveys and interviews it has emerged that device developers, local stakeholders as well as authorities would like to be updated on the environmental monitoring at test centres to allow for more open and transparent talks on mitigation activities or alternative installations. In particular, wave energy developers have to comply with Environmental Impact Assessment (EIA) legislation, requiring them to supply large amounts of environmental data to allow for informed decision on potential impacts of the proposed project.

To support the critical process of decision making, interactive tools based on GIS (Geographic Information System) software technology have been developed. GIS maps have been widely used for the evaluation of human impacts on the environment, from the analysis
of water pollution [2] to assessing the benefits of wind energy farms [3].

GIS tools are now being applied to Wave Energy projects, such as the Oregon MarineMap, developed by the Oregon Wave Energy Trust (OWET), allowing users to explore and analyze relevant marine geospatial data in order to identify suitable areas for ocean energy development whilst simultaneously considering existing marine uses, users and the conservation of marine resources and ecological functions.

The Intelligent Energy Europe (IEE) funded SOWFIA project is developing a Data Management Platform (DMP) that collates environmental and socio-economic data from seven wave energy test centres across Europe in Ireland, France, Portugal, Spain, Sweden and the United Kingdom.

The DMP is designed to provide regulators, device developers and stakeholders a repository of data and best practice to enable cross-comparison of impacts and facilitate informed decision-making. This paper presents insights from the development of the DMP, including the initial integration of data from the EU wave energy test centres.

2. Data Management Platform

The Data Management Platform is a tool designed for the presentation of IA information in a format suitable for a non-technical audience. It has been developed as a GIS-based platform that integrates environmental data with other marine users and stakeholder concerns. The core of the DMP is composed of environmental and socio-economic datasets collected and analysed at the seven different wave energy test centres in Europe: AMETS in Ireland, Bimep in Spain, Lysekil in Sweden, Ocean Plug in Portugal, SEM-REV in France, EMEC and the Wave Hub in the United Kingdom (Figure 1).

These centres were set up to allow for installation and testing of Wave Energy Converters (WECs) but given the unknowns surrounding potential environmental effects of WECs it has become necessary from a regulatory point of view to monitor the environmental, physical and socio-economic receptors so as to increase knowledge of the impacts of ocean renewable installations on the environment. The results of such monitoring can then be analysed and interpreted by scientists and regulatory authorities tasked with managing the marine environment and ultimately enable them to make more informed and scientifically robust decisions on consents for similar developments in the future.

The integration of datasets from the seven test centres contributing to the DMP will create a data repository of the environmental information for different factors and to increase the ability to undertake more powerful statistical analysis of impacts across sites. The innovation of the DMP lies in the fact that it brings together, for the first time, data gathered as part of the EIA and regular monitoring from wave energy sites across Europe. The DMP also contains information on what is being monitored, in what way, by whom and with what frequency. This is useful to developers as it alerts them to the type of information they may need to collect at a site to fulfill regulatory requirements, but it is useful to decision-makers as they can see what has happened elsewhere with the same or similar technologies. The latter is of particular importance given the limited experience to date in device deployment. Data on the DMP is displayed in a consistent format which enables scientists, engineers and regulators to share, compare and contrast data from different countries and allows for the benchmarking of the impacts across sites.

3. Accessing the DMP and its content

The Data Management Platform is publically available on the SOWFIA website and can be accessed at sowfia.hidromod.com/pivotmapviewer2 from any computer with an internet connection. The DMP is structured into three main components:

- A Project tab, highlighting the different WECs developed and tested in EU waters
- A Sites tab, providing information on the environmental monitoring carried out at each test site. This allows for comparison of monitoring techniques and information among the test centre participating in the SOWFIA project
- A Map tab, based on Google® Maps technology, which provides a user interface for visualizing and downloading data. Each test centre is indicated with a place-mark, and from here the user can access the different type of data available for that site, view time series data, visualise shape files and become familiar with the monitoring requirements for each activity undertaken at specific locations.

4. Test Centres and data availability

Data from seven European tests centre are collated into the DMP. A list of the monitoring activities carried out at each of the different test centres is presented in Table 1.

Monitoring activities are divided into three main categories:

1. Studies on physical factors such as bathymetry and water quality.
2. Studies on biological factors such as benthos and marine mammals.
3. Socio-economic studies evaluating the impacts of the proposed installation on local communities.

Each test centre has encountered different monitoring requirements; often due to different legal requirements or as a result of consultation with local authorities, developers and stakeholder groups. For example, monitoring of wave condition is carried out to provide device developers with information on the sea-conditions for optimization of their devices; or, as in
the case of the Wave Hub, requested as part of the consultation with local stakeholders [4].

Figure 1: Location of the wave energy test centres

Biological monitoring such as boat surveys for marine mammals and migratory birds are carried out as required by the EU EIA Directive (85/337/EEC, as amended) and by the Birds and Habitats Directives (79/409/EEC as amended and 92/43/EEC as amended, respectively). Socio-economic studies on the impacts of marine renewable installations are carried out to document the consequences of a development on a local community, businesses and infrastructure and to assist in the preparation of mitigation measures or alternatives, where deemed appropriate.

Whilst there are differences in the methods used to collect and analyse data it can be seen that there is a strong correlation in what is monitored at the different sites. The integration of environmental data from the different sites could provide the foundation for understanding the environmental impact of marine renewable energy installations [5][6].

5. Populating the DMP

One of the strengths of the DMP is that it is able to present data, collected using different monitoring techniques and sampling equipment at differing sites, in a consistent and standardised manner, providing easy to interpret, non-technical, outputs. All the data presented in the DMP has been edited in accordance with the INSPIRE Directive (2007/2/EC) which ensures that spatial data-sets are compatible and useable in a trans-boundary context, assuring that the data can be shared across different applications and users, and their suitability to for purposes. In order to allow for a broader understanding of the data, the production of refined data to be presented on the DMP is being evaluated and discussed with stakeholders and authorities.

<table>
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<tr>
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</table>

Table 1: Monitoring activities at 7 test sites, (WH) Wave Hub, (E) EMEC, (LS) Lyseki, (OP) Ocean Plug, (AM) AMETS, (SR) SEM-REV and (BI) BIMEP.

These data will provide additional added-value, hopefully allowing for a smoother consultation process with a broader understanding of baseline environmental and socio-economic impact data. Examples of the data availability and homogenization process are presented in the following sections.

5.1 Wave Data

A main source of data collected at wave energy test sites is that of wave and sea state condition.

Wave data are normally acquired through the use of wave buoys, which provide a single point measurement. Wave state mapping instrumentation, such as the HF Radar, has been recently developed and is increasingly being used. The volume of data collected by this type of equipment is considerable and needs translating from its mathematical engineering format to be usable by non-specialists. Up to 50 different wave parameters are provided as output from the wave buoys (for example): including spectral moments and directionality. Many of these parameters are highly specific and not suited to the needs of the wider public and decision-making authorities. For this reason, a simple set of wave parameters have been selected for use on the DMP (Table 2). Time series of wave data are available for direct visualization on the DMP website (Figure 2).
Marine mammals (whales, dolphins, porpoises and seals) are protected under EU Habitats Directive as well as national legislation, and consequently monitoring of marine mammal populations is usually required as part of the EIA process. The level of monitoring is often site-specific and is determined by the legal requirements in a particular country. Some marine mammal species, such as the bottlenose dolphin, grey and harbour seals are listed in Annex II of the Habitats Directive, meaning their conservation requires the designation of Special Areas of Conservation (SAC). As a result of such a designation it is imperative that no significant environmental effects impact on that species and therefore careful monitoring of MRE installations must be undertaken if these are located in close proximity to such sites.

A variety of methods have been used for monitoring of marine mammals at the different WEC test sites (Table 3). However, if the impacts of WECs are to be assessed sufficiently, monitoring should address both spatial and temporal variation in the ecosystem with baseline data collected over a long enough period to be able to identify seasonal patterns in the population [7].

From monitoring and surveillance datasets two main categories of data on marine mammals can be generated:

- Composition – providing information on the different species at a given location
- Abundance – providing information of the number of animals for each species at a given location

**Table 3: Marine mammals survey activities at 7 test centres, where WH is Wave Hub, (E) EMEC, (LS) Lysekil, (OP) Ocean Plug, (AM) AMETS, (SR) SEM-REV and (BI) BIMEP**

<table>
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<th>Survey Methodology</th>
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<td>Land-based/ fixed point survey</td>
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Collecting these data over the long-term can provide insight into the potential impact of WECs on marine mammals in the vicinity of the site.

**5.3 Seabirds**

Seabirds constitute a major component of the marine environment and surveys of the spatial and temporal distribution of the different species are often required for baseline studies and impact assessment during the EIA process. In Europe wild birds are protected by the Birds Directive (2009/147/EC) and associated designation of Special Protection Areas (SPAs) to protect threatened species. Habitats of these species may also be protected under the Habitats Directive outlined above. Under the provisions of both legal instruments, activities that could be damaging to nesting birds and their breeding habitats can be prohibited.

**Figure 3: Example of seabird survey data from Wave Hub.**

Monitoring of seabirds is usually carried out using aerial and/or boat-based surveys, or land-based monitoring if the WEC site is situated within visual...
sighting distance of land. This provides data on the species composition and abundance at a particular site and in the local proximity to development sites.

5.4 Benthos

Organisms associated with the seabed (the benthos) are a major component of the marine ecosystem. Benthic communities can be divided into three functional groups: infauna, epibenthos and hyperbenthos. Describing benthic communities at wave energy test centres is usually required within the EIA processes. The installation of wave energy device may alter the local benthic ecosystem through the introduction of moorings lines and favouring the formation of hard-bottom benthos, as witnessed during the installation of wind energy turbines [8]. Sampling methods for benthos communities normally aim to estimate the species richness and diversity of the species, as well determining the composition of the sample in terms of particle size and category (e.g. sand gravels, clay silts etc).

Benthic monitoring procedures are already standardised assuring a quick comparison among the different test centres, as highlighted in the earlier work by Pohle and Thomas [9](Table 4). Remote methods for monitoring benthic communities have been developed, providing a first non-destructive and quantitative way to determine benthic populations [10].

<table>
<thead>
<tr>
<th>Soft-bottom</th>
<th>Hard-bottom</th>
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<tbody>
<tr>
<td><strong>Intertidal areas</strong></td>
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<tr>
<td>Manual sample collection, during low tide, with quadrats into the sediment. Five to ten replicates are normally taken.</td>
<td>Samples should be collected at a series of standard tidal levels. With the use of quadrats the rock surface can be scraped.</td>
</tr>
<tr>
<td><strong>Subtidal areas</strong></td>
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<tr>
<td>Integrity of samples should be guaranteed ensuring the vertical set down and lift up of the grab at right angles to the bottom.</td>
<td>Almost all hard-bottom benthic sampling relies heavily on the use of underwater cameras.</td>
</tr>
</tbody>
</table>

Table 4: Sampling Methods for benthos assessment in wave energy test centres [9].

6. Conclusion and Further work

Understanding the potential environmental impacts of WECs is a critical step in granting consent for wave energy installations. To allow for the data to be easily understood and exchanged by the different parties data should be presented in a standardised and easy to interpret way.

Further developments of the DMP include generating data outputs defined in collaboration with relevant stakeholders, designed to facilitate understanding of the data.

Socio-Economic information gathered at each site, through stakeholder questionnaires and interview, will also be included in the DMP to provide insight on the experiences gathered.

Through the DMP the SOWFIA project provides a platform aimed at speeding up informing decision-makers and assisting them in the consenting process for wave energy installation through the reduction of the increased availability of relevant information on uncertainties associated in monitoring and determines documented environmental impacts.

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References


