Inventory of Environmental Impact Monitoring Activities at Wave & Tidal Energy Sites in Europe

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SOWFIA project synopsis

The Streamlining of Ocean Wave Farms Impact Assessment (SOWFIA) Project (IEE/09/809/ SI2.558291) is an EU Intelligent Energy Europe (IEE) funded project that draws together ten partners, across eight European countries, who are actively involved with existing or planned wave farm test centres. The SOWFIA project aims to achieve the sharing and consolidation of pan-European experience of consenting processes and environmental and socio-economic impact assessment (IA) best practices for offshore wave energy conversion developments.

Studies of wave farm demonstration projects in each of the collaborating EU nations are contributing to the findings. The study sites comprise a wide range of device technologies, environmental settings and stakeholder interests. Through project workshops, meetings, ongoing communication and networking amongst project partners, ideas and experiences relating to IA and policy are being shared, and co-ordinated studies addressing key questions for wave energy development are being carried out.

The overall goal of the SOWFIA project is to provide recommendations for European-wide streamlining of IA processes which will facilitate simpler and more effective approval processes, thereby helping to remove unnecessary legal, environmental and socio-economic barriers to the development of offshore power generation from waves. By utilising the findings from a range of monitoring experiences at multiple sites, SOWFIA will seek to accelerate knowledge transfer and promote European-wide expertise on environmental and socio-economic impact assessments of wave energy projects. In this way, the development of the future, commercial phase of offshore wave energy installations will benefit from the lessons learned from existing smaller-scale developments.

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1. DEFINITIONS

In this document a number of specific terms are used which have a distinct meaning within the SOWFIA project. These terms are defined below.

Appropriate Assessment (AA) – this is the requirement to consider the possible nature conservation implications of any plan or project on the Natura 2000 site network before any decision is made to allow that plan or project to proceed. Not only is every new plan or project captured by this requirement but each plan or project, when being considered for approval at any stage, must take into consideration the possible effects it may have in combination with other plans and projects, when going through this appropriate assessment process. AA is not a prohibition on new development or activities but involves a case-by-case examination of the implications for the Natura 2000 site and its associated conservation objectives.

Environmental assessment – this is a procedure that ensures the environmental implications of decisions are taken into account before the decisions are made. These can be undertaken for individual projects, under the European Union's Environmental Impact Assessment (EIA) Directive (Directive 85/337/EEC, as amended) or for public plans or programmes under the Strategic Environmental Assessment (SEA) Directive (Directive 2001/42/EC).

Environmental Impact Assessment (EIA) – Under EU law, this is required to identify the direct and indirect effects of a project on human beings; fauna and flora; soil; water; air; climate and landscape; the interactions between these factors; material assets and the cultural heritage. The Directive applies to the assessment of the environmental effects of those public and private projects which are likely to have significant effects on the environment.

Impact Assessment (IA) – an impact assessment generally assesses the potential economic, social and environmental consequences a new initiative (plan, programme, development, decision etc.) may have. It is carried out by way of a set of logical steps which helps the decision-maker come to a decision on the proposed new initiative. It can also be described as a process that prepares evidence for decision-makers on the advantages and disadvantages of possible options by assessing their potential impact.

Natura 2000 – This is an EU-wide network of nature protection areas established under the EC's Habitats Directive. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats. It is made up of Special Areas of Conservation (SAC) designated by Member States under the Habitats Directive and Special Protection Areas (SPAs) designated under the Birds Directive. The establishment of this network of protected areas fulfils a Community obligation under the UN Convention on Biological Diversity. The network is comprised of both terrestrial and marine sites.

Project – within the context of the EIA Directive, project is taken to mean:

- the execution of construction works or of other installations or schemes,
- other interventions in the natural surroundings and landscape including those involving the extraction of mineral resources

(Article 1(2), EIA Directive).

Strategic Environmental Assessment (SEA) – this can be defined as an environmental impact assessment process as applied to policies, plans and programmes, acknowledging the fact that the process of evaluating environmental impacts at a strategic level is not necessarily the same as evaluating them at a project level. SEA is meant to be a continuous source of environmental information throughout all the stages of decision-making Under the EU's SEA Directive an SEA is required for those plans and programmes that meet a complicated set of screening requirements. [Screening is the term given to the process of deciding whether an SEA is needed or not]. The SEA Directive applies to a wide range of public plans and programmes (e.g. on land use, transport, energy, agriculture, etc). The SEA Directive does not refer to policies. Plans and programmes in the context of the SEA Directive must be prepared or adopted by an authority (at national, regional or local level) and be required by legislative, regulatory or administrative provisions.

Streamline – To make a system more efficient and effective by employing faster or simpler working methods. The SOWFIA Project aims to 'provide recommendations for European-wide streamlining of Impact Assessment processes'; however it is evident that the project cannot change the provisions of the governing legislation. The SOWFIA Project will therefore focus on the variation in types of data collected across a range of sites, methods utilised to collect these data and how both the structure of IA activities specific to wave energy sites and the methods employed can be standardised and made as effective as possible.

2. 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 and tidal energy conversion devices have been in development for many years and numerous pilot projects for these devices are now underway in many countries across Europe, as well as areas such as Canada and the United States. In Europe, most developments of marine renewable energy installations (MREIs) require an Environmental Impact Assessment, the purpose of which is to ascertain the effects of the development on the natural environment, species, biological and physical processes. The permitting process can then weigh the scale of such impacts 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. Effects will vary with the stage (construction, operation and decommissioning) and scale of the project, and will depend on location and the ecosystem in that area.

2.1 Impacts of WECs

2.1.1 Physical Environment and Ecosystems

Wave energy holds enormous 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. Dal Ferro 2006; Cada *et al.*2007; Boehlert *et al.*2008; Nelson *et al.*2008). The technology is behind that of offshore wind power but it could, potentially, provide a significant contribution to renewable energy production in areas with suitable wave conditions (Carbon Trust 2006; Kerr 2007). However the effects that Wave Energy Converters (WECs) and other Marine Renewable Energy Installations (MREIs) will have on physical and biological processes and their impact on specific species in the marine environment are yet to be fully determined.

Wave energy converter devices, or WECs, are largely floating structures with minimal structural components across the water column. For this reason, collision risk is largely limited to species which regularly cross the air-water interface or spend a significant proportion of their time on the surface. Pinnipeds (seals and sea lions) may be likely to use floating devices as haul-out sites and birds may use them as landing or roosting areas; thus there may be risks to these animals associated with getting onto or off the structures and any contact with exposed moving or articulated parts (Wilson *et al.*2007). Cetaceans are regularly at the water surface to breathe, while basking sharks and sunfish can, in certain seasons, spend extended periods at or very close to the water surface. Risk for collision is enhanced for WECs because they are not stationary and active components of pitch and surge may increase the chance for injury (Wilson *et al.*2007). It is currently unknown how aware cetaceans and large fish will be of the presence of such structures and thus how capable they will be of avoiding them. The acoustic signal generated by these active devices on the surface also represent a source of potential disturbance for marine mammals and pelagic species.

It is also thought that WECs may act as fish aggregating devices (FADs), a technique used in fisheries where floating material is placed in the water and attracts fish. In a study of offshore wind farms in Swedish waters, Wilhelmsson *et al.* (2006) suggested that these structures were functioning as combined artificial reefs and FADs for small demersal fish. Fayram & de Risi (2007) suggest that floating offshore wind turbines (and thus other structures such as WECs) could positively affect multiple stakeholder groups and potentially support higher recreational fish catch. However, any FAD effect will then likely also attract predators (such as marine mammals and birds) to these areas, which in turn may increase collision risk to these species. Bio-fouling of devices fixed on the seabed may have an artificial reef effect which could change the benthic fauna in the area and thus on the entire ecosystem.

In addition to effects on species, there may also be consequences linked with removing energy from ocean waves. Coasts are shaped by waves and currents, and a reduction in wave strength reaching the shore, over long periods of time, could have effects on patterns of sediment transport and coastal erosion. 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.

2.1.2 Social and Economic Environment

In certain European jurisdictions, socio-economic aspects are a distinct requirement of the EIA process but this is not true for every area. Generally, socio-economic impacts of a wave energy project relate to the effects that the construction, operation and decommissioning of the existing or future wave farm will have on the society and the economy at a local, regional or upper level. Socio-economic impacts for offshore renewable projects typically address elements like demography, employment and regional income; sea and land use; aesthetics; infrastructure; socio-cultural systems and other maritime activities such as fisheries; tourism and recreation (WAVEPLAM, 2010). For example, concerns may be voiced by surfing groups and surf tourism industries about a reduction in wave strength or quality, 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. Bailey *et al*. (2011), in a study of public opinion relating to the WaveHub development in the UK, documented general public support for wave energy as an economically beneficial method of power generation with few adverse side-effects. To-date, however, limited research has been conducted on public attitudes to MREIs, particularly wave and tidal developments, and not all communities may be supportive of such developments.

Work carried out for the WAVEPLAM project (2010) states that while a socio-economic impact assessment may not be strictly required by regulatory authorities when a wave energy project is being developed, it is strongly recommended that the most critical socio-economic aspects are assessed. There are two key reasons for this. Firstly it can help to obtain a wider perspective on the effects of the project on the regional community and economy and, secondly, it may help foster a positive opinion from the consenting authorities and general public. The latter is important as it may alleviate the perceived ‘barriers’ in the associated project development process. For the purposes of this report, we focus on the traditional interpretation of ‘environmental’ data to mean the physical and biological environment. However, the SOWFIA Project recognises the importance of the socio-economic element of wave energy development impact assessment and will specifically target those issues in later tasks and deliverables. This will be accomplished by accumulating the limited number of existing studies related to wave energy development as well as implementing studies on developer perceptions of stakeholder concerns along with stakeholder opinions of wave energy and local wave energy sites.

The table in Annex 1 of this document presents the impacts, social and environmental, that are anticipated or postulated for wave energy developments once they are installed. This table does not include potential impacts during construction and installation. These activities, such as additional vessel traffic at the site resulting in acoustic disturbance and blasting or drilling of the seafloor, are similar regardless of the type of installation involved, and thus lessons can be learned from the offshore wind industry and other construction activities at sea. Also not included are the impacts which may arise during decommissioning, which are likewise important to consider as part of any EIA.

2.2 Legislation for Environmental Assessment

Environmental Assessment is the generic term given to a procedure that ensures the environmental implications of decisions are taken into account before the decisions are made. In the European Union, environmental assessment can take two forms. At the project level, specified individual projects require an Environmental Impact Assessment (EIA) arising from the provisions of the EIA Directive (Directive 85/337/EEC, as amended). Similarly at a more strategic level, public plans or programmes require an environmental assessment under the provisions of the Strategic Environmental Assessment (SEA) Directive (Directive 2001/42/EC).

Table 1: Differences between EIA and SEA.

Some differences between EIA and SEA	
EIA of Projects	**SEA of Policies, Plans and Programmes**
Takes place near the end of decision-making cycle: aims to minimise impacts	Takes place at earlier stages of decision-making cycle: aims to prevent impacts
Reactive approach to development proposal	Pro-active approach to development proposals
Considers limited number of feasible alternatives	Considers broad range of potential alternatives
Limited review of cumulative effects	Cumulative effects assessment is key to SEA
Emphasis on mitigating and minimising impacts	Emphasis on meeting environmental objectives, maintaining natural systems
Narrow perspective, high level of detail	Broad perspective, lower level of detail to provide a vision and overall framework
Well-defined process, clear beginning and end	Multi-stage process, overlapping components, policy level is continuing, iterative
Focuses on standard agenda, treats systems of environmental deterioration	Focuses on sustainability agenda, gets at sources of environmental deterioration

Source: UNEP (2002)

EIA and SEA are often confused. While the procedures for both are very similar, there are some important differences as presented in Table 1. It is probably easiest to think of SEA as taking a broad perspective with a low level of detail whereas an EIA will take a much narrower perspective with a high level of detail. An SEA focuses on identifying the 'likely' significance of 'potential' effects, whereas an EIA deals with precise effects and evaluated actual significance. Usually, an SEA collates existing environmental information whereas, for the purposes of an EIA, new, specific environmental information must be collected. Considering the scale of proposed wave energy projects and the associated Impact Assessment work that is required, documentation associated with the SEA process can act as an important first resource when planning a marine renewable energy development, by collating all existing sources of data on the site in question and providing as comprehensive a baseline as possible from which to begin designing an EIA.

2.3 Strategic Environmental Assessment (SEA)

Generally the findings of an SEA will assist in guiding development to areas where environmental effects are minimal or can be avoided. A key output of the SEA process is to identify areas off the coast where there are potential significant environmental constraints on commercial scale development of marine renewable energy. The SEA therefore examines how these constraints could influence the potential capacity for development in the areas of greatest resource. The Environmental Report associated with the SEA process will also look at the technical constraints within the area concerned. These could include, for example, aquaculture sites; shipping lanes; oil and gas lease areas; etc. An SEA can also look at environmental constraints. Under the SEA Directive these relate to water and soil (sediment); biodiversity, flora and fauna, cultural heritage including archaeological heritage, ports, shipping and navigation, commercial fisheries, recreation and tourism and seascape.

The catalogue of wave energy test centres and review of national targets produced as part of the SOWFIA project (Deliverable 2.1) identified the locations across Europe where SEAs for marine renewable energy have been undertaken or are currently underway (Table 2). These will become the first source of environmental information for developers when thinking about site selection and project development, pointing developers to sources of further and more detailed information. SEAs are not considered in detail in this catalogue, however, for reference purposes information on SEAs carried out, key findings and where they are available from, are presented in the Table below, reproduced from the earlier report.

Table 2: SOWFIA partner countries and details of SEAs completed or underway

SOWFIA partner country	SEA Details
France	None available
Ireland	• SEA on the Draft Offshore Renewable Energy Development Plan currently in the final stages (public consultation phase). • <u>Coverage:</u> all Irish waters from the Mean High Water Mark out to the 200m water depth contour off the west and south west coast of Ireland and the Irish Exclusive Economic Zone off the north, east and south east coast of Ireland. • <u>Finding:</u> Overall, the SEA found that, based on the extent of the available offshore renewable energy resource within Irish waters, and the geographical scale of the overall study area, that it would be possible to achieve a high scenario of 4,500MW from offshore wind and 1,500MW from wave and tidal energy without likely significant adverse effects on the environment. This is subject to a number of caveats contained in the

	final SEA documents. • SEA Documentation available from: http://www.seai.ie/Renewables/Ocean_Energy/Offshore_Renewable_SEA/
Spain	SEA of the Spanish NREAP is currently underway. An SEA for offshore wind energy was completed in 2009.
Sweden	None available
Portugal	• SEA for the National Maritime Spatial Planning is underway and should be completed by the end of 2011. It covers Portuguese territorial waters and all maritime uses including offshore energy (wind and wave). • SEA for the development of the National Electrical Grid Distribution completed in 2008. It considers the development of the Portuguese Pilot Zone within the list of critical decision factors and establishes a number of collaborative actions within public and private institutions regarding the incorporation and compatibility of the implementation of new projects including renewables.
United Kingdom	*See individual jurisdictions detailed below.*
England and Wales	• SEA for Offshore Energy completed in 2011 on a draft plan/programme to enable future renewable leasing for offshore wind, wave and tidal devices and licensing/leasing for seaward oil and gas rounds, hydrocarbon and carbon dioxide gas storage. • Coverage: It covers parts of the UK Renewable Energy Zone and the territorial waters of England and Wales; for hydrocarbon gas and carbon dioxide storage it applies to UK waters (territorial waters and the UK Gas Importation and Storage Zone); and for hydrocarbon exploration and production it applies to all UK waters. • Finding: The conclusion of the SEA is that the areas offered for licensing and leasing should be restricted spatially through the exclusion of certain areas together with a number of mitigation measures to prevent, reduce and offset significant adverse impacts on the environment and other users of the sea. • SEA Documentation available from: http://www.offshore-sea.org.uk/consultations/Offshore_Energy_SEA_2/index.php
Scotland	• SEA completed in 2007 on Freds MEG Roadmap. • Coverage: The study area covers the entire west and north coast of Scotland from Shetland to the Solway Firth to a distance of 12 nautical miles offshore. • Finding: between 1,000MW (wave & tidal, low scenario) and 2,600MW (high scenario) generating capacity could potentially be achieved within the SEA study area taking into account environmental effects and depending on the types of technology (including array density) deployed. However, it should be noted that a large proportion of this capacity is located in the Outer Isles, which are remote from the mainland and would require longer cable routes to shore.

	• SEA Documentation available from: http://www.seaenergyscotland.net/SEA_Public_Environmental_Report.htm
Northern Ireland	• SEA completed in 2010 on Offshore Renewable Energy Strategic Action Plan • Coverage: the full seaward extent of Northern Ireland territorial waters from the mean high water mark to the 12 nautical mile limit. The study area extends from Lough Foyle in the North to Carlingford Lough in the South, the border bays with the Republic of Ireland (not formally delineated). • Finding: the SEA concluded that between 900MW and 1200MW of electricity could be generated by 2020 from offshore wind and tidal arrays in Northern Ireland waters, without significant adverse effects on the environment. As there is limited potential for wave energy, this technology was excluded from the target setting in the related SAP. • SEA Documentation available from: http://www.offshorenergyni.co.uk/EnvironmentalReport.html

Source: SOWFIA Deliverable 2.1 (2011)

2.4 Environmental Impact Assessment (EIA)

The first EIA Directive was adopted in 1985 and applies to a wide range of defined public and private projects, which are defined in Annexes I and II of the Directive. For those projects listed in Annex I, an EIA is mandatory as these projects are considered to have significant effects on the environment. Projects in this category include, for example, dams; pipelines with a diameter of more than 800 mm and a length of more than 40 km; construction of overhead electrical power lines with a voltage of 220 kV or more and a length of more than 15 km etc. For projects listed in Annex II of the Directive, the national authorities have to decide whether an EIA is needed. This is done through a procedure known as 'screening', which determines the effects of projects on the basis of thresholds/criteria or a case by case examination. To do this, the national authorities must take into account the criteria laid down in Annex III of the Directive. The projects listed in Annex II are in general those not included in Annex I and include, for example, industrial installations for the production of electricity; construction of roads, harbours and port installations, including fishing harbours; marinas; etc.

Whilst the EIA Directive was not designed specifically with ocean energy in mind, in practice compliance necessitates developers to supply consenting authorities with comprehensive environmental data relating to both baseline conditions and possible environmental impacts of device installation. For this reason, the requirement to conduct an EIA is the key stimulus for collection of environmental data and to a large extent dictates the environmental information that is currently available in relation to renewable energy developments in the marine environment. According to the EIA Directive (85/337/EEC as amended), an EIA must include 'a description of the aspects of the environment likely to be significantly affected by the proposed development, including:

- human beings, fauna and flora;
- soil, water, air, climate and the landscape;
- material assets and the cultural heritage;
- the interaction between the factors mentioned in the first, second and third indents.

In the context of wave and tidal energy development, at the EU level, no over-arching specific guidance has been formulated for developers or regulators. Some jurisdictions have produced specific guidance, e.g. Spain (Bald *et al.*, 2010) or Scotland (SNH, 2009) and likewise some test centres have also issued EIA guidance, for example, EMEC in Scotland (2008). Other European projects, such as EquiMar, have also been instructive in elucidating the EIA process (EquiMar, 2009). Despite these efforts, however, regulators continue to often place significant information demands on developers in order to address the substantial unknowns that relate to the marine environment generally and the impact of ocean energy devices more specifically.

The EIA procedure can be summarised as follows (adapted from EquiMar, 2009):

1. Screening: to identify under which Annex the project falls – Annex I (mandatory EIA) or Annex II (at Member States discretion);
2. Scoping stage: the developer may request the competent authority to say precisely what environmental information should be provided by the developer in the EIA;
3. Baseline survey: describes the environmental conditions at the deployment site prior to any development activity.
4. Impact report: the developer must provide information on the environmental impact (EIA report – Annex IV) to the environmental authorities, other relevant authorities, the public and affected Member States;
5. Decision: the competent authority decides on whether the development should proceed, taking the results of consultations into consideration;
6. The public is informed of the decision afterwards and can challenge the decision before the courts;
7. Monitoring: the competent authority will require a developer to draw up an environmental monitoring plan to be applied throughout all phases of the development (deployment, construction, operation, decommissioning and post-decommissioning). Mitigation measures can be incorporated into the monitoring plan to reduce or eradicate adverse impacts.

Usually the BACI approach (Before-After-Control-Impact) is employed within the EIA process. This is a classic method for measuring the potential impact of a disturbance or event on the biological components of an ecosystem. Such affects can be analysed by measuring conditions *before* a planned activity and then comparing the findings to those conditions measured *after* - an approach that is applicable for comparing the affects of anticipated future activities. An appropriately-designed study also incorporates at least one site outside the location to be developed. This is known as a *control* site and data generated from this site can be used for comparisons to an affected or *impacted* site. More scientifically robust studies use the 'beyond BACI' approach (Underwood 1994) which incorporates multiple control sites.

2.4.1 Baseline characterisation

Before a project can be licensed, the project developer must collect baseline data on the site and its environs. In this step, data are collected to define the current state of a biological population or community. Usually baseline studies are a '*one-off*' as, by definition, they are not replicated in time. Results from baseline studies can be used to produce a record of a baseline condition prior to a given disturbance. Baseline studies, as the name suggests, establish a baseline for the system against which any future impact can be tested. In some cases baseline studies can comprise of existing data only, particularly in cases where adequate information exists from previous monitoring or research work in the area. More commonly, however, in the marine environment there is a need to determine the existing baseline conditions. Existing datasets may not always be sufficient to provide a good overview of the species and habitats which may be impacted by any development, or other issues which may arise. The creation of a baseline may therefore, require some new and/or supplementary monitoring activities. The survey duration will depend on a range of factors including, for example, the sensitivity of a site, the species being studied (species associated with the benthos, marine mammals, birds, fish, etc); and/or the time of year.

2.4.2 Impact analysis

This step in the EIA process is composed of three main levels of detail: identification (scoping step), valuation and significance (EquiMar, 2010). This step is possibly the most difficult step in an EIA given the uncertainties involved. Direct impacts are usually easy to identify but indirect and cumulative impacts are, often, much more difficult. It is also important to clearly state the degree of uncertainty in any documentation associated with the EIA process. The EquiMar project has found that due to the fact that marine renewable energy developments are only beginning to appear in the water, and that not every environmental parameter can be monitored all of the time, there is a genuine need to determine what environmental monitoring should be prioritised. The information presented in this report highlights those parameters that are most frequently monitored and likewise those that are not with a view to determining where gaps still exist and/or making recommendations on where there is potential to reduce the monitoring burden placed on developers with respect to certain environmental parameters.

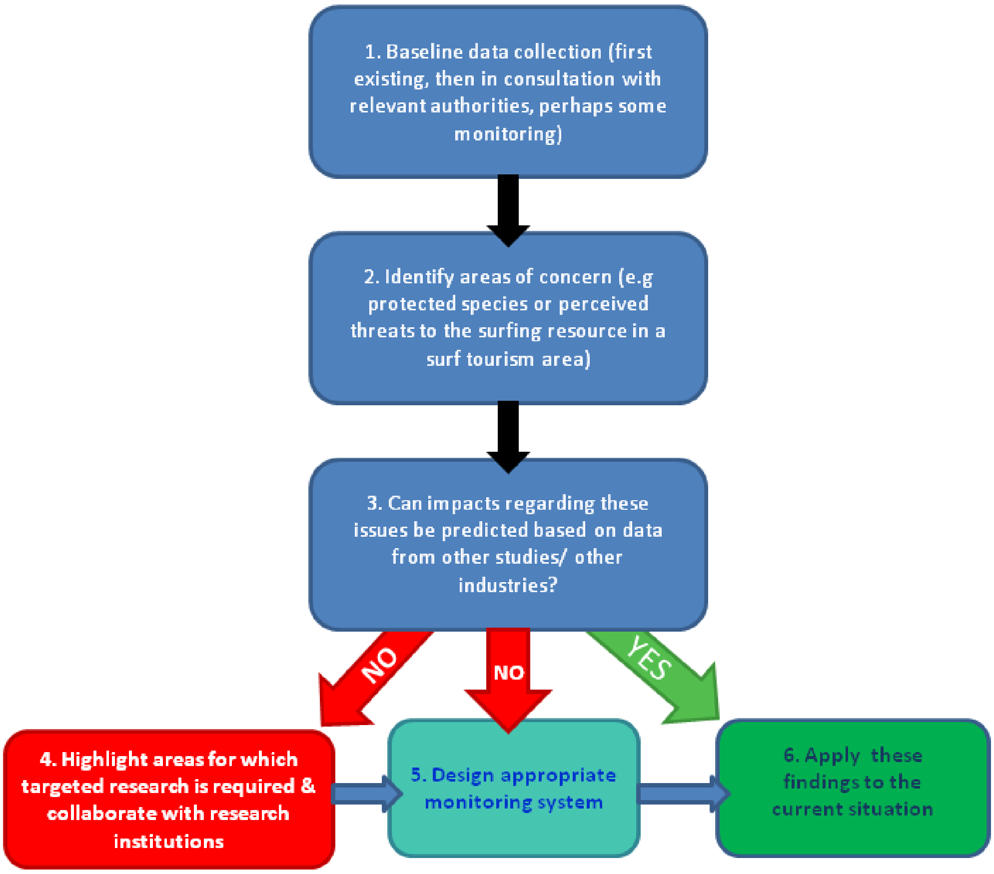

Figure 1: Flow chart showing steps in the design of an Environmental Impact Assessment monitoring programme.

2.4.3 Monitoring activities

During construction and operation of the development, an EIA comprising of specific monitoring activities is required. In designing Environmental Impact Assessment (EIA) surveys for sites of proposed MREIs, no single standard will be universally applicable. The survey techniques, size of the study area, design and duration of the survey will all depend upon the area itself, the species and habitats found there and their conservation status, the nature and scale of the planned MREI and the duration of the construction period. The nature and number of devices to be installed will also be important. As highlighted in Inger *et al.* (2009), a systematic review of previous experience and studies in the field of impact assessments for MREIs, combined with solid study design, are key to appropriately assessing the impacts of MREIs. Figure 1 shows the general process by which EIAs (and complimentary research activities) are, or should, be designed and implemented.

2.4.4 Implications for development

The diversity and novelty both of sites being considered for wave energy developments, and of different technologies of devices being developed and trialled, may potentially lead to regulatory enthusiasm for comprehensive monitoring programmes. This tendency will be intensified as wave energy development is likely to encompass a wide range of environmental, physical and technological factors. A realistic and environmentally acceptable approach to impact assessment is a common goal of all actors in the wave energy sector. Nonetheless, the danger exists that the desire to cover all possibilities, regardless of how likely or significant potential impacts may be, would represent an impediment for pioneering developers of wave energy projects. At this initial development phase of the industry, completed EIAs for wave energy sites are rare. It will thus be important to learn from the experiences of other industries, but also to identify knowledge gaps specific to WECs, which can lead to the development of targeted research programmes to answer specific questions. The findings can then be fed back to the industry and can inform more efficient, strategic impact assessment activities.

2.5 Horns Rev case study [2]

Horns Rev is the world's largest offshore wind farm, constructed off the Danish west coast in 2002. An extremely comprehensive EIA has been carried at this site and provides an opportunity to examine both the topics addressed by the monitoring activities and the lessons learned. Table 3 summarises the fields for which monitoring was carried out, the main questions addressed, the findings and the general methods used. This information has been adapted from the report produced by ENERGI E2 (2005).

All of the general study topics covered in the Horns Rev EIA (hydrography/ geomorphology, birds, cetaceans, seals, benthic fauna, fish and socio-economic elements) are relevant elements to consider for any marine impact assessment. More specific questions within each of these topics will differ considerably, depending on the MREI technology type. Considerable effort was invested into studies of avian fauna in and around the Horns Rev site, as the effects of both terrestrial and marine wind farms on birds has been an issue of particular concern. Less effort on surveys for birds flying through the area would likely be required for a WEC site. However, since WECs involve moving parts at the sea surface or below it (depending on the device type), EIA studies at wave energy sites may have to focus more attention on species

[2] Except where individual references to published papers occur, all information on Horns Rev Impact Assessment work has been sourced from reports available on the Dong Energy website at: http://www.hornsrev.dk/Engelsk/default_ie.htm

inhabiting the water column and the air-water interface (cetaceans, pinnipeds, sharks and other fish species, as well as diving birds), including research on patterns of habitat use at the site before and during WEC installation, and behavioural studies to assess collision risk. Likewise, the effect of new hard substrate and bio-fouling communities on the existing fish and benthic communities was investigated at Horns Rev, whereas, at least for offshore wave energy sites, little hard substrate will be introduced to the environment. Instead, there may be mooring lines or tethers to secure the device, which may present an entanglement risk to some larger marine species, and thus this aspect will also require behavioural studies. For MREIs such as tidal and wave energy converters, where devices actively extracting energy from the ocean may affect the overall energy transmitted to the coast, the effects on coastal structure and coastal processes should also be monitored. It should be noted that many of the studies required at wave energy sites at present will address knowledge gaps and therefore, for every comprehensive research programme which finds no significant impact of a specific element, future monitoring would not need to include that element.

Many of the relevant lessons for wave energy EIA which can be ascertained from the offshore wind experience have been colleted in the WAVEPLAM (2010) and EquiMar (2010) projects. However, in order to assist the development of the wave energy industry, the SOWFIA Project will seek to incorporate the EIA experiences of projects such as Horns Rev and other offshore wind developments, as well as equivalent information from the tidal energy industry , when doing so will provide added value.

2.6 Streamlining Impact Assessment – The way forward

The Environmental Impact Assessment process is clearly a complex one and where wave energy is concerned, raises more questions than it does provide satisfactory data. Many national government and EU institutional activities related to wave energy have been motivated by the recognition of the potentially detrimental effects of excessive IA requirements and seek to overcome these effects by supporting comprehensive environmental assessment programmes with public funds. Often this support comes about through sponsored research activities typically funded by bodies such as the UK DECC, TSB, Marine Scotland etc. and more recently by joint initiatives such as the Marine Scotland/Scottish National Heritage "Marine Environment Spatial Planning Group (MESPG) Environment Research Programme" or the UK NERC/DEFRA Marine Renewable Energy Sandpit[3]. The SOWFIA partners intend to engage with these activities where they overlap and incorporate the publicly funded knowledge gained from these programmes into the outputs of SOWFIA. It should also be noted that some countries are already in the process of licensing wave power developments (that is, at a commercial scale or at least, developments other than test centres), and that this licensing will be completed within the duration of SOWFIA. These countries are therefore already in the process of determining what they consider appropriate to be included in formal EIAs and in associated Appropriate Assessments (HRAs) in relation to Natura 2000 sites. For example, in Scotland, comprehensive documents have already been produced on the EIA process and what it should involve, both in general (SNH 2009) and specifically with marine renewable energy developments in mind (EMEC & Xodus AURORA 2010). Such documents will be integrated into the work of the SOWFIA Project and will provide a useful starting place for developing a streamlined EIA process for marine renewable energy developments.

[3] Marine Renewable Energy Sandpit:
http://www.nerc.ac.uk/research/programmes/mre/events/documents/mre-ao-sandpit.pdf

There is a considerable difference between targeted research and monitoring activities, both of which are currently being carried out at MREI sites. Research activities are key for addressing the knowledge gaps once they have been identified, something that monitoring activities cannot and should not do. Information on both types of activities has been incorporated into this report for completeness. At present, however, there is a strong link between research and monitoring, since the former will direct the latter as our understanding moves forward. Because of this, it is essential that the marine renewable industry supports research activities and works closely with the research community. It follows that the focused research and, potentially, some of the monitoring carried out at this early stage in the development of the wave energy industry, in test centres or elsewhere, will not necessarily be required at larger demonstration and commercial sites, in the longer-term. As the industry moves forward and learns from early research and monitoring findings, the necessary and unnecessary elements of an EIA for wave energy can be identified. By generating a better understanding of the site-specific and technology-specific factors underpinning IA design, the IA process can be streamlined, making it easier and less costly to effect new wave energy developments whilst still ensuring appropriate consideration and protection of marine ecosystems. The SOWFIA Project is ideally placed to set the industry on course to develop this refined, wave energy-specific EIA strategy, by bringing together all sources of information, gathered by monitoring and research activities, and identifying remaining knowledge gaps within the IA process.

Table 3: Summary of monitoring activities at Horns Rev (summary only – may not be exhaustive).

General topic	Specific investigation	Result/finding	Methods*
Hydrography/ geomorphology	Changes in sediment and currents with turbines? Impact on water exchange and water quality?	No No	Baseline data collected Sand eel study (as indicators of sediment composition)
Birds	Avoidance of wind farm during construction? Avoidance during operation? Collision risk with turbine blades?	Yes Yes (some species) Unknown	Baseline Visual surveys & counts Radar
Harbour porpoises	Assessment of auditory impact from wind farm construction (in-situ measurements)? Avoidance during operation? Impacts of construction and/or operation on echolocation behaviour?	Yes (during pile driving) No Immediate-term only	Baseline T-PODs (acoustic monitoring) Boat-based visual surveys
Seals	Assessment of auditory impact from wind farm construction (in-situ measurements)? Avoidance during operation?	Yes (during pile driving) No	Baseline Boat-based visual surveys (for at-sea seals) Satellite tracking individuals
Benthic fauna	Loss of habitat due to foundations? Loss of benthic fauna/ change in structure? Cable placement affecting bottom fauna? Likely extent and effect of bio-fouling? Foundations forming new hard substrate and thus new habitat?	Not significant No/ Yes (greater abundance of some spp) Extensive epi-fouling communities - increased general biodiversity Yes	Baseline collected on area Sediment particle size sampling BACI study design
Fish	Increase in food availability leading to increase in fish biomass? Change in sediment composition leading to change in sand eel abundance?	Likely No negative impact on sand eels Wind farm attracts fish beyond 500m of boundary	Baseline Monitoring of sand eels (dredge samples) Hydro-acoustic fish monitoring programme
Socio-economic studies	Public perceptions of the wind farm Assessment of visual impact Effects on tourism, recreation?	Public want to be informed of plans Better at sea – less visual impact, but some opposition Unclear	Questionnaire survey Interviews Assessment of media coverage

*Where 'baseline' is referred to, the methods have not been stated in the report and thus it is assumed that existing data only were collated & used.

3. CONTEXT OF D3.1

3.1 Work Package 3

The objective of work package 3 (WP3, SOWFIA Annex I) is to interact with ongoing activities related to the assessment of environmental impacts at wave energy test sites and to use the experience gained from this interaction to inform the development of refined European-wide EIA protocol. Some level of environmental monitoring is currently underway at most existing wave energy test sites but the focus of the monitoring and the methodologies applied are varied and partially depend upon factors such as: potential environmental impacts which are considered to be most threatening, the level of involvement of particular stakeholder groups and the resources available. With this in mind, it is intended that the experience gained within WP3 will be derived from a wide distribution of wave energy test sites so that the findings encompass a geographically, technologically and politically diverse range of projects and future EIA requirements can be of a more objective fashion. Given the emerging state of wave energy developments and the low number of operating wave energy sites, all EIA-related experience is of tremendous value in mapping a route forward for the refinement of EIA procedures for the wave energy industry.

By drawing together as much information and experience as possible on current research and monitoring activities we intend to be able to:

- Examine how wave energy EIA requirements have been influenced by earlier marine energy activities and the appropriateness of that influence.
- Investigate pan-European EIA requirements for wave energy developments in order to understand similarities and differences and to be able to place environmental monitoring activities within context of local requirements.
- Examine the range of activities performed for baseline studies and investigate the information provided by such studies.
- Compare study parameters such as, measurement methods, sampling intensity and spatial design and investigate the adequacy of activities as a function of this parameter space.
- Identify metrics selected for detecting effects and investigate what levels of change might be detectable using those metrics.
- Determine what novel issues these studies reveal, why certain parameters are monitored as part of baseline studies and whether they reflect likely effects/impacts.
- Examine how impact detection outputs are communicated to various stakeholder groups and identify which detection methods and means of communication are most effective.
- Identify possibilities for meta-analytical studies from conglomerated data sets. Where possible, use power of data from multiple sites to investigate common lessons about baseline.
- Examine value of baseline studies relative to archival record.
- Where possible, determine likelihood of various impacts and site characteristics which might influence that likelihood.

The ultimate goal of these activities is to facilitate faster, more effective, development of wave energy sites in the future by ensuring that data collected as part of EIA activities address the appropriate questions in the most efficient fashion possible.

The goal of task 3.2 (SOWFIA Annex I) within SOWFIA WP3 is to determine whether the members of the SOWFIA project will have access to sufficient resources to perform the activities outlined in the previous section and thereby contribute to the achievement of goals of WP3. This report, deliverable 3.1, seeks to answer that question in two steps. In the first step, the wave energy-related EIA activities which have occurred in the past, are ongoing or are planned to occur within the lifetime of SOWFIA have been catalogued. In the second step, the sources of monitoring data/experience from those activities which will be available to SOWFIA for use in its activities within WP3 and WP4 (SOWFIA Annex I) have been identified. This report brings together the results of these two actions and outlines the next steps in using the data collected towards the larger goals of SOWFIA: to generate a better understanding of the links between site, technology and required EIA activities, and to use this understanding to streamline Impact Assessment requirements and methodologies.

4. DATA COLLECTION

The SOWFIA Project deliverable D2.1 (SOWFIA Annex I) identified the wave energy test centres across Europe. In task T3.2 (SOWFIA Annex I), all the sites identified in D2.1 were investigated in order to inventory the range of Impact Assessment (IA) activities at each of these sites. In addition, an attempt was made to supplement that catalogue with information from other relevant sites wherever possible. A questionnaire (Annex 2 of this document) was designed to collect this information from any organisation collecting data at a wave and even tidal energy development. These questionnaires were distributed to all SOWFIA partners, who were requested to complete the questionnaires themselves as well as to distribute it to any other organisations or sites in their Member State, of which they were aware. Annex 3 lists the recipients of the questionnaire. The questionnaire was distributed to 74 different organisations with approximately 20% of recipients responding.

The questionnaire aimed to assess:

- Basic information on the site (name, location, operation status, type of device, etc.)
- The organisation carrying out the monitoring
- What was being monitored
- How was it being monitored
- The underlying reasons why each monitoring activity was being carried out
- Whether the collected data would be available to the SOWFIA project, and if so, in what format and under what conditions

In the course of collecting information from partners, it became clear that the term ‘monitoring’ needed clarification. As discussed earlier, there are numerous research activities being carried out at MREIs, which may not have long term time horizons or which are designed to answer very specific questions and therefore not be classified as monitoring. It was decided that such activities, aiming as they do to provide further insight into specific issues such as background noise, should also be included in the inventory. The remainder of this report summarises the information collected as part of this task – essentially qualitative information describing the data being collected at a range of sites, and the availability of those data to the SOWFIA Project for further analysis.

5. RESULTS

5.1 Data Inventory

Fifteen wave energy test centres were identified in D2.1. Questionnaires were received from 18 institutions, providing information on Impact Assessment activities at 16 specific test centres for wave energy and several wave or tidal research sites, where no device deployments are currently planned (Table 4). These data were supplemented with information on five other sites, from Environmental Scoping reports, EIA reports and correspondence.

Table 4: List of test centres and organisations from which information on Impact Assessment activities have been collected. 'Q' indicates information provided via questionnaire; 'R' indicates datasourced from publicly-available reports.

Site name	Location	Organisation Facilitating Measurements
Atlantic Marine Energy Test Site (AMETS) (Q)	Belmullet, Co. Mayo, Ireland	Sustainable Energy Authority of Ireland / Irish Marine Institute
BIMEP (Q)	Spain	Ente Vasco de la Energía (EVE) – AZTI Tecnalia
Coaña & Cudillero, Asturias (Q)	Spain	Fundación Asturiana de la Energía (FAEN)
EMEC Test Site – Billia Croo (Q)	Scotland, UK	European Marine Energy Centre (EMEC)
		Scottish Power Renewables
		Aquamarine Power Ltd.
European OWC Wave Power Plant (Pico) (Q)	Azores, Portugal	WavEC
Farr Point (R)	Scotland, UK	Pelamis Wave Power
Galway Bay (Q)	Spiddal, Co. Galway, Ireland)	Sustainable Energy Authority of Ireland / Irish Marine Institute
Islay (Q)	Scotland	Scottish Association of Marine Science (SAMS)
Khyle Rhea (Q)	Scotland	Scottish Association of Marine Science (SAMS)
Isle of Lewis (R)	Scotland, UK	Aquamarine Power Ltd.
Lysekil (Q)	Sweden	Uppsala University
Pentland Firth & Orkney (scoping only) (R)	Scotland, UK	Scottish Natural Heritage/ Marine Scotland
Pilot Zone (Q)	Portugal	Wave Energy Centre (WavEC)
Reunion (Q)	Réunion Island, West Indian Ocean	SAS SEAWATT
Runde (Q)	Norway	Runde Environmental Centre (REC)
SEM-REV (Q)	France	Ecole Centrale de Nantes
Sotenas (Q)	Sweden	Seabased Industry AB
Various (3 in consideration) (Q)	Ireland	ESB International
Various (for short-term monitoring/ research) (Q)	Scotland	Scottish Association of Marine Science (SAMS)
Wave Dragon	Wales, UK	PMSS (consultants)/Wave Dragon UK
Wave Hub (Q)	England, UK	University of Exeter
		University of Plymouth
		WaveHub

WaveRoller (Q)	Peniche, Portugal	Wave Energy Centre (WavEC)

5.2 Data available to SOWFIA

Of the information provided on monitoring and research activities at various wave and tidal energy sites across Europe, nine organisations have agreed to provide SOWFIA with data in a form which is more organic than printed reports. Access to data in such form will facilitate many of the activities planned in WP3 (Table 5). Some of these datasets will be made available at a cost but the great majority will be available for use freely under an appropriate data sharing agreement (Table 6). For most of the remaining projects for which a questionnaire was received, reports will be available publicly.

Table 5: Catalogue of main data types available to the SOWFIA project.

Environmental data stream	SITE (Organisation)
Point measurements of waves and currents surrounding wave energy test sites	AMETS, EMEC, Galway Bay, Pilot Zone, Reunion, SEM-REV, Wave Hub (UoE), Wave Hub (UoP)
Video monitoring of beach morphology in the shadow of wave energy test sites	Wave Hub (UoP)
Acoustic monitoring of ambient, biological and anthropogenic sound characteristics near test sites and at control locations	AMETS, EMEC, Pilot Zone, Wave Hub (UoE)
Water column properties at wave energy test sites	Wave Hub (UoE), Wave Hub (UoP)
Surveys of marine invertebrates around test sites	AMETS, Lysekil (UU), Reunion, Pilot Zone, SEM-REV, Wave Hub (UoE), Wave Hub (UoP)
Benthic sediment studies at test sites	AMETS, Pilot Zone, SEM-REV
Studies related to the utility of wave power devices as artificial reefs	Lysekil (UU)
Studies on fouling and colonisation of wave energy devices	Lysekil (UU)
Monitoring sites of national heritage	Sem-Rev
Seabird and marine mammal monitoring (both visual and passive acoustic)	AMETS, EMEC, Lewis, Pilot Zone, Reunion, Wave Hub (UoE), Lysekil (UU) (pilot studies only)
Tidal flow data	EMEC

Significantly more detailed information than is available in Tables 4-6 was collected as part of Task 3.2. In order to facilitate flexible access to that information as well as to demonstrate how such information as well as the environmental monitoring data referred to in this report can be arranged on the SOWFIA data management platform (DMP), the information from the returned questionnaires and from reports has been input to the preliminary project-centred DMP[4]. Using the facilities of the platform, acquiring the information contained in the above tables is almost instantaneous. More complex enquiries such as identifying what offshore sites which collected acoustic data but are not supplying it to SOWFIA are also quite simple

[4] Data management Platform: http://sowfia.hidromod.com/

(answer is none). This DMP is under development and more data and data-manipulation tools will be added as the project progresses.

Table 6: Cost basis of the data available to the SOWFIA project.

Site (organisation)	Types of data available	Cost?
AMETS (SEAI/ Marine Institute)	Some biological; wave	No
Galway Bay (SEAI/ Marine Institute)	Wave data	No
EMEC (EMEC)	Wave, tidal; biological, acoustic	Yes[5]
Pilot Zone (WavEC)	Hydrodynamic; some biological	No
Réunion Island (SAS SEAWATT)	Wave; biological data	No
SEM-REV (ECNantes)	Hydrodynamic; meteorological, biological, sediment	No
Wave Hub (UoE)	Biological, acoustic, wave data	No
Wave Hub (UoP)	Radar, hydrodynamic (wave, current); biological, morphological data	No
Lysekil (UU)	Wave, biological, acoustic data	No

5.3 Additional data sources

While developing a cooperative relationship with device and project developers is seen as the optimal model for producing an understanding the wave energy EIA experience, the level of response to the questionnaire in Annex 2 suggests that device developers and project managers presumably have a large quantity of competing demands on their time and contributing to communal efforts may be low on their priority list. For this reason, it appears that it would be prudent to develop additional avenues for information gathering. As part of the license application process for wave energy projects, applicants will typically submit a scoping report to the relevant regulatory agency as an outline of what issues are considered relevant for study under the project EIA. For projects which are further down the road to realization, an Environmental Statement (ES) summarizing the results of the EIA study will also be submitted to the licensing agencies. In most cases all such documents become part of the public record and they represent a potentially valuable resource for examining both perceived threats as well as wave energy EIA study techniques. As an example of the level of information which could be used to inform the activities in WP3, Marine Scotland has provided or agreed to provide the following documents to the SOWFIA project:

- Scoping reports for projects utilising Pelamis devices at Farr Point and west of Orkney in Scotland.
- Scoping report for the Oyster 3 project west of Lewis in Scotland.
- The ES for the Siadar wave project on the west coast of Lewis
- The ES for Oyster 2 devices project at EMEC.

As part of its continuing activities under WP3, the SOWFIA project has or will obtain these studies from Marine Scotland and will seek to obtain equivalent documents for ongoing or approved wave energy project applications from other regulatory agencies around Europe. These documents will be added to the DMP and their contents will be used to inform the analysis performed in the remaining activities of WP3.

[5] If you wish to access data sets gathered at EMEC please contact info@emec.org.uk.

6. DISCUSSION

The monitoring activities performed at wave energy test sites (and other MREIs) are ultimately intended to provide information with which to address stakeholder concerns relating to potential detrimental impacts of such installations on the physical and biological processes at these sites. Impact Assessment data collected for such purposes can, however, often remain in the form of scientific reports and papers, and are thus not readily accessible (in terms of the language used and physical access to hard/electronic copies) to all stakeholder groups. A later goal of WP3 (Task 3.4, SOWFIA Annex I) is to present the data gathered by SOWFIA in the form of novel 'data products' which are more appropriate for the communication of findings to various stakeholder groups. An illustrative example of the type of activity which would be possible utilizing the DMP populated with the kinds of data strings referred to in Table 3.3 relates to wave scatter plots. The recently completed EquiMar project specified a standard format for the production of such figures and this will no doubt serve as the default for scatter plots which will be presented for all site wave data contained in the DMP. However it is highly likely that different stakeholder groups may desire different formats. The production of customised scatter plots for separate user groups would be relatively straightforward from a DMP which is populated by the original data strings, as will be available to the SOWFIA project.

Task 3.5 (T3.5 SOWFIA Annex I) involves a review of the potential environmental impacts for which detection activities have been pursued, and of methodologies used to detect those impacts. The metadata contributed so far to Task 3.2 have formed a foundation for this review by providing details of the methodologies employed at various sites, to achieve specific monitoring goals. This will enable a summary and comparison of the different methods currently being used, their efficiency, costs, reliability and their likelihood of detecting impacts. Information on the underlying reasons for monitoring of each element has also been collected and will be used to assess which impacts are in fact considered likely or of potential fundamental importance. A comparison of IA topics being pursued at wave energy sites with those that have been part of monitoring regimes at offshore wind farms, as well as with a comprehensive list of the potential impacts of WECs as developed by researchers, will facilitate an assessment of whether any areas of monitoring have been neglected thus far at wave energy sites and whether there are any knowledge gaps which prevent a full understanding of which EIA activities are necessary and which are not.

As previously discussed, the data collected are being used to populate the DMP (SOWFIA Annex I, Task 4.1), which will adhere to the European Inspire Directive (2007/2/EC), combining spatial data from diverse sources and sharing them among numerous users and applications. Data collation activities are also going to be co-ordinated with those of the IEA OES-IA Annex IV (http://www.iea-oceans.org/tasks.asp?id=4) which is collecting similar data for MREI sites worldwide. The findings of the SOWFIA Project will thus have an even greater significance and impact.

Annex 3 lists the recipients of the questionnaire. The list demonstrates that the distribution effort for the questionnaire was indeed extensive. It is however evident that of this list, only a small proportion provided responses to SOWFIA for this report. One of the ongoing activities in WP3 will be continuing dialogue with project developers for access to their EIA-related information. As an example, negotiations are currently under way with a wave energy developer who has completed an EIA study and received a positive response to the project licensing application. Despite this result and the public review of the submitted Environmental

Statement, the developer is still concerned about releasing details of their study in the context of loss of competitive advantage. While it is expected that the individual benefits of the general development of the industry will eventually convince this developer and others to share their experiences, this case illustrates the importance of collating EIA experience wherever possible and making these data available to all. Further data gathering activities will be performed throughout the lifetime of WP3 using such opportunities as project workshops and via the SOWFIA Network. These efforts will be effective means of accessing data sets which are not yet publicly available from consultants and developers.

7. CONCLUSIONS

The currently limited number of operational wave energy sites and the early stage of many planned sites means that wave energy impact assessment monitoring activities are relatively rare. However, of the experiences which exist, SOWFIA has been able to obtain access to a relatively high number of the active projects which provide both a broad spectrum of individual activities and multiple instances of common activities (Table 3). Most of these activities involve ongoing efforts with which the SOWFIA partners will interact so that the EIA experience and environmental monitoring data set will continue to grow during the life of the project. In addition, SOWFIA will have access to and be able to collate an even wider collection of technical documentation (see DMP) which will provide additional meta-data covering aspects such as study techniques, sampling plan and temporal resolution and duration. As a result, SOWFIA will be able benefit from a pool of data that extends across Europe and beyond and represents a large proportion of the existing or soon-to-be-collected global wave energy EIA data and experience. This resource will be sufficient to permit the SOWFIA partners to perform the proposed activities, in order to achieve the goals of work package three as enumerated in this document and SOWFIA Annex I.

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Annex 1: Possible environmental & social impacts of WECs

Stressor category	Affected environmental receptor category	Effects
Physical presence of devices	Physical environment	Alteration in water circulation patterns
		Modification of wave climate
		Increased mixing of the water column
		Alteration in sediment dynamics (erosion and accretion pattern change - implication to coastal defence and management)
	Benthos	Habitat change: artificial reef effect, fouling, changes in species composition and species interaction; predation by abundant fish species attracted to artificial structures
		Habitat disruption during operation of the project due to movements of mooring or electrical transmission cables along the bottom
		Motile organisms displacement
		Sessile organisms destruction
		Species smothering due to suspended sediments and sedimentation on organisms (e.g. Seagrass beds)
	Fish	Habitat change: artificial reef effect , fish aggregation effect, change in food source
		Entanglement with mooring lines/slack seabed cables
		Interference with migration routes
	Marine mammals	Collision with devices
		Entanglement in tethers or cables
		Habitat change: haul-out and feeding sites
		Interference with migration routes
	Marine birds	Collision with devices
		Entanglement in tethers or cables
		Interference with migration routes
		Disturbance/disorientation of birds due to lighting at night
		Disturbance during operations
		Habitat change: roost, nest and feeding sites
	Sea turtles	Habitat change: change in food sources
		Collision with devices
		Entanglement in tethers or cables
	Ecosystem and food chain	Habitat change and predator-prey interaction change due to water energy removal
		Impact on phyto/zooplankton larvae dispersion through mixing
	Humans	Closed area around WECs - fisheries restriction
		Impacts on visual seascape and landscape
		Alteration of surfing wave resource – effects on recreational surfers and tourism

		Closed area around WECs – restrictions to recreational sea users (e.g. boaters, sea anglers, scuba divers)
		Impacts on navigation (collision risks)
		Archaeology and other seabed uses
		Land-based infrastructure requirements
Chemical	Benthos	Species disturbance /mortality due to water quality degradation (e.g. decline in dissolved oxygen content due to anoxic sediment excavation)
		Species disturbance / mortality due to oil spills
	Fish	Species disturbance /mortality due to water quality degradation (e.g. decline in dissolved oxygen content due to anoxic sediment excavation)
		Species disturbance / mortality due to oil spills
		Bio-toxicity of species due to introduced contaminants (e.g. chemicals from paints, heavy metals adsorbed to excavated sediments)
	Marine mammals	Species disturbance / mortality due to oil spills
		Bio-toxicity of species due to introduced contaminants (e.g. chemicals from paints, heavy metals adsorbed to excavated sediments)
	Marine birds	Species disturbance / mortality due to oil spills
	Ecosystem and food chain	Water contamination from oil leaks or spills
		Water contamination from antifouling chemicals used in paints
		Bioaccumulation and /or bio-magnification of contaminants in successive trophic levels due to introduced dissolved chemicals (e.g. Paints, heavy metals adsorbed to sediments that are released during installation, operation and decommissioning activities)
Acoustic	Marine mammals	Physical – Auditory (permanent or temporal damages on hearing) or non-auditory (other tissues)
		Behavioural (e.g. interference with mother-calf interaction, avoidance of the area)
		Perceptual (communication, vocalization adaptation, prey/predator detection, exploration of environment)
		Chronic/Stress (sensitivity, disease vulnerability)
	Fish	Avoidance, displacement, mortality or behavioural changes
	Sea turtles	Avoidance, displacement or behavioural changes
	Crustaceans	Avoidance, displacement
	Humans	Aerial noise disturbance of onshore devices (e.g. OWC devices)
Electromagnetic fields	Benthos	Effects of electrical fields on benthic species
	Fish	Electrical fields: interference with prey location, orientation and reproduction
		Magnetic fields: interference with migrations
	Marine mammals	Interference with orientation and migration
	Sea turtles	Interference with orientation and migration

This list may not be exhaustive but is designed to provide an overview of the main effects considered at present in designing an Environmental Impact Assessment monitoring plan for a given site. Based on Environmental effects matrix, OES-IA Annex IV (Copping & O'Toole, 2010).

Inventory of environmental monitoring data being collected at marine renewable energy sites

sowfia Streamlining of Ocean Wave Farms Impact Assessment

Name of organisation/ institution:

Contact person name:

Contact person email:

Name of site:

Location of site (area, country):

Project resource type (wave, tidal, offshore wind):

Technology type:

Project developer:

Project scale (test site, prototype, array, commercial):

Current status of project implementation:

Expected operation date (for projects in development):

Installed capacity:

Project website:

Today's date:

We would like to know about the environmental monitoring activities, past, present and future, at your site	
Is there, has there been or will there be environmental monitoring activities at your site?	

If yes, please list each activity separately and provide any associated information for each activity (the first entry in the table is provided as an example). Please complete this table for all biological, acoustic, coastal processes, hydrographic and socio-economic monitoring, and any other relevant activities.

Monitoring activity	Time period	Methods	Will it be available to SOWFIA & in what form?*	Expected size of dataset to be provided	Why is it being monitored?
e.g. Surveys for marine mammals	*Jan 2008 - present OR scheduled to begin in Jun2011*	*Boat-based transect surveys*	*Yes – raw data (effort & sightings data).*	*20 MB per year OR 150 MB total*	

*Forms in which data can be provided include: metadata only; raw data; refined data products (modified data); reports/papers. If these data will be provided only at a cost, please indicate.

PLEASE COPY THIS TABLE AND CONTINUE ON ADDITIONAL PAGES IF NECESSARY.

Annex 3: Recipients of the D3.1 questionnaire.

Institution	Response received?
Aalborg University	N
Alstom Hydro	N
APPA- Spanish Renewable Energy Association	N
Aquamarine Power Ltd	**Y & via reports**
BG Consulting	N
Bletchley Consulting	N
Bluewater Energy Services BV	N
Bosch Rexroth	N
Center of Innovative Energy Systems	N
CRES	N
DCNS	N
DONG Energy Power A/S	N
Ecole Centrale de Nantes	**Y**
EDF	N
EDP	N
Electrabel	N
EMEC	**Y**
ESB International	**Y**
European Copper Institute	N
Ente Vasco de la Energía (EVE) – AZTI Tecnalia	**Y**
Fundación Asturiana de la Energía	**Y**
Garrad-Hassan	N
Hydraulics and Maritime Research Centre (UCC) for Sustainable Energy Authority Ireland & Marine Institute	**Y**
Iberdrola Renovables	N
IFREMER	N
Inabensa	**Y**
Institute of Marine Research	N
International Power Marine Developments Limited	N
IT Power	N
Marine Renewables Industry Association	N
Narec	N
Norvento Enerxia	N
Norwegian University of Science and Technology	N
Ocean Energy Ltd.	N
OffTek AS	N
OWEMES	N
Pelamis Wave Power	**Via reports**

PLOCAN	N
Principle Power	N
Proyectos Especiales	N
Ramboll	N
Renewable UK Association	N
Runde Environmental Centre	**Y**
Scottish and Southern Energy	N
Scottish Association of Marine Science	**Y**
Scottish Development International	N
Scottish European Green Energy Centre	N
Scottish Natural Heritage/ Marine Scotland	**Via reports**
Scottish Power	**Y**
Seabased Industry AB	**Y**
Seaproof Solutions	N
Sea Mammal Research Unit Ltd	N
Single Buoy Moorings	N
SKF	N
Société de Recherche du Pacifique	**Y**
SOGREAH	N
Tecnalia	N
Tidal Energy Ltd	N
Trinity College Dublin	N
University of Athens	N
University of Edinburgh	N
University of Exeter	**Y**
University of Lancaster	N
University of Oslo - Norway	N
University of Plymouth	**Y**
University of Southampton	N
University of Stellenbosch (South Africa)	N
University of Strathclyde	N
Uppsala University	**Y**
Voith Hydro	N
Wave Dragon	Via reports
Wave Energy Centre	**Y**
Wave Hub	**Via reports**
Wave Star Energy	N
Waveplane	N