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Enabling Wave Power: Streamlining processes for progress

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Streamlining of Ocean Wave Farms Impact Assessment (SOWFIA) Project

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Streamlining of Ocean Wave Farms Impact Assessment

Enabling Wave Power:

Streamlining processes for progress

Co-funded by the Intelligent Energy Europe Programme of the European Union

Enabling Wave Power:

Streamlining processes for progress

September 2013

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Executive Summary

The Streamlining of Ocean Wave Farms Impact Assessment (SOWFIA) project (IEE/09/809/SI2.558291), funded by EU Intelligent Energy Europe (IEE), draws together ten partners, across seven European countries, all of whom are actively involved with monitoring at wave device 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 nearshore wave energy conversion developments.

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

The overall goal of the SOWFIA project is to provide recommendations for European-wide streamlining of IA and approval processes, thereby helping to remove legal, environmental and socio-economic barriers to the development of offshore power generation from waves.

SOWFIA has gathered information on consenting processes, environmental monitoring and stakeholder interests at European wave energy test centres and has analysed this information to identify commonalities and differences between Member States. Test Centres have to go through the same processes that wave farms will and so are a good template for studying Impact Assessment. They also provide important baseline environmental data that can be checked over the pursuing years for WEC effects. The EIAs for each of the test centres have been synthesised and compared and through this analysis, the following recurrent themes in EIAs have emerged:

- **Length of Baseline Studies.** For most receptors, 2 years is identified as the minimum time to provide a baseline sufficient to detect changes attributable to the presence of WECs in the future.
- **Electromagnetic Fields.** There is a lack of any documented evidence of significant behavioural effect at a species level from EMF emissions by any existing undersea power cables. More work is needed to clarify this situation.
- **EIA Monitoring Methodology.** A BAG (Before-After-Gradient) design may be preferred by developers over a BACI (Before-After-Control-Impact) design (see Section 3.3).

To assist in future wave energy planning and decision-making the SOWFIA Data Management Platform (DMP) was developed. This is an interactive web-based tool designed to present Impact Assessment (IA) information in a format suitable for a non-technical audience and to assist the decision-making process for wave energy consenting. The core of the DMP is composed of environmental and socio-economic datasets collected at EU wave energy test centres. Available from sowfia.hidromod.com or the SOWFIA Project website, www.sowfia.eu, access to the DMP is free to any registered users, allowing visualization and downloading of the datasets for each monitored location.

SOWFIA recommendations for wave energy IA streamlining are derived from consultation, workshops and dissemination activities involving a wide range of representatives from the wave energy community, including device developers, utilities, regulatory authorities, financiers and other stakeholders. Three critical themes have emerged, in which the recommendations are presented:

- Integrated Planning and Administrative Procedures;
- Environmental Impact Assessment;

- Human Dimensions and Consultation.

The synthesis of barriers, accelerators, lessons learned and recommendations are presented in Sections 2, 3 and 4 for each of these critical themes. Overall 'Strategic' and detailed 'Operational' recommendations are given for each of the themes, resulting from the European consultation and analysis. These are supplemented by Member State specific recommendations derived from consultation with national regulatory authorities and policy makers with the intention of making the recommendations more relevant to individual countries.

'Strategic' recommendations are viewed as being longer term actions perhaps requiring more significant changes and resources. ***'Operational'*** recommendations refer to shorter term actions which could be implemented with minimal changes yet have the potential to make significant improvements to the consenting process. It should be noted that the level of resources (time/cost/re-structuring) will vary according to geographic location.

Glossary of terms

Acronym	Meaning
AA	Appropriate Assessment [Habitats Directive]
AMETS	Atlantic Marine Energy Test Site
BACI	Before-After-Control-Impact
BAG	Before-After-Gradient
BIMEP	Biscay International Marine Energy Plant
CZM	Coastal Zone Management
DanWEC	Danish Wave Energy Center
DEA	Danish Energy Association
DG MARE	Directorate-General for Maritime Affairs and Fisheries
DMP	Data Management Platform
DSF	Documents Stratégiques de Façade (strategic documents on the shoreline)
EBM	Ecosystem Based Management [Approach]
EC	European Commission
EIA	Environmental Impact Assessment
EMEC	European Marine Energy Centre
EMF	Electromagnetic Fields
ES	Environmental Statement
EU	European Union
FAD	Fish Aggregating Devices
IA	Impact Assessment
MRE	Marine Renewable Energy
MS	Member State
MSP	Maritime Spatial Planning
MW	Megawatt(s)
NREAP	National Renewable Energy Action Plan(s)
OREDP	Offshore Renewable Energy Development Plan [Ireland]
RDP	Refined Data Products
SEA	Strategic Environmental Assessment
SEMREV	Site D'Experimentation En Mer (Marine Test Site)
SNML	Stratégie Nationale pour la Mer et le Littoral (National strategy for the sea and the coastlines)
WECs	Wave Energy Converters

1 Introduction

The SOWFIA project, Streamlining of Ocean Wave Farms Impact Assessment (IEE/09/809/SI2.558291), funded by EU Intelligent Energy Europe (IEE), aims to achieve the sharing and consolidation of pan-European experience and to provide recommendations for streamlining of consenting processes and environmental and socio-economic impact assessment (IA). In this way, the goal of the project is to help remove legal, environmental and socio-economic barriers to the development of offshore power generation from waves.

Wave energy test centres in each of the collaborating EU nations have been studied. At present, most wave energy activity is in solo sea trials by device developers, for whom these non-technical requirements are difficult to address, especially in view of their budget constraints. Once project developers become involved the requirements should be part of the project planning process and accommodated more easily. By utilising the findings from technology-specific monitoring at multiple sites, SOWFIA hopes 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.

Through project workshops, meetings, on-going communication and networking amongst project partners, ideas and experiences relating to IA and policy have been shared, and co-ordinated studies addressing key questions for wave energy development have been carried out. In this Final Report for the SOWFIA Project, an overview of the project and its key findings is presented along with reference to the other detailed SOWFIA Reports that are available on the SOWFIA Website, www.sowfia.eu.

1.1 Motivation

It is widely accepted that wave energy is an innovative and developing industry with the potential to contribute to meeting EU renewable energy targets (EU OEA, 2010; Jeffrey & Sedgwick, 2011). However, when tackling the phase of deployment of a device in the marine environment, a wave energy developer must comply with a range of

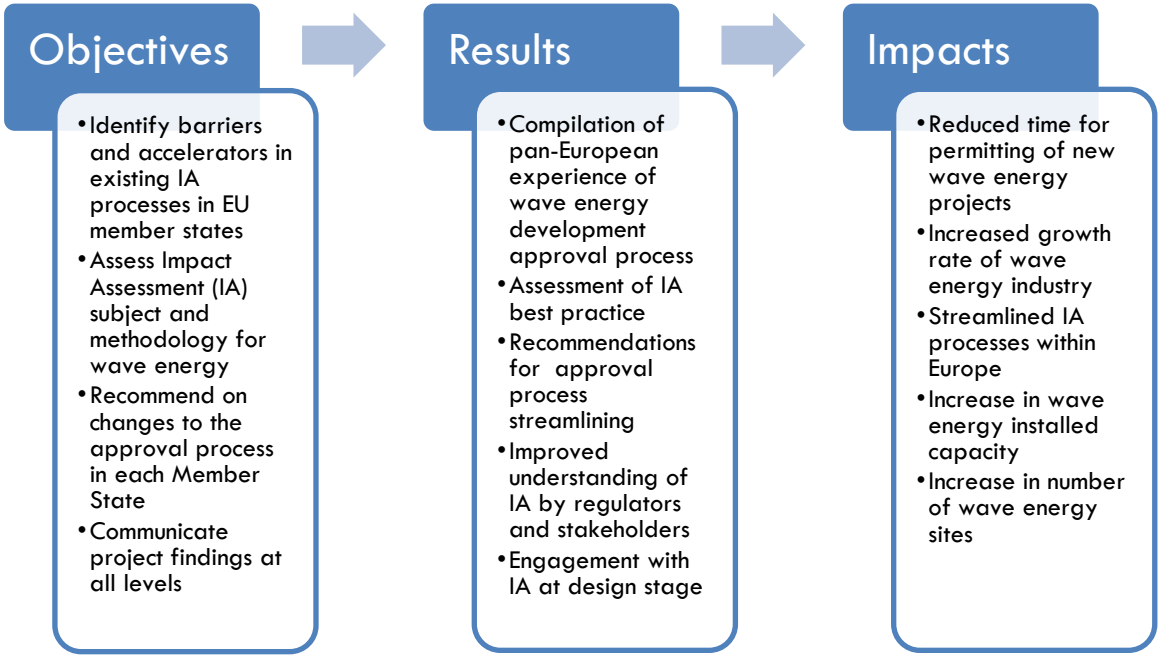


Figure 1: Objectives, results and expected impacts of the SOWFIA project.

consenting processes and administrative procedures, some of which were not designed with wave energy development in mind. Consenting processes and EIA legislation across the EU have been identified previously as barriers to the development of the industry (Waveplam, 2010). These EIA requirements vary throughout the EU, where in some countries an EIA is categorically necessary for all ocean energy projects and in others it is dependent on the nature, size and location of the proposed development (O'Hagan, 2012).

Figure 2: The seven European wave energy test centres that have been involved in SOWFIA

Despite the fact that potential environmental impacts of ocean energy have already been identified (Frid *et al.*, 2012; Inger *et al.*, 2009; Kadiri *et al.*, 2012; Langhamer, Haikonen & Sundberg, 2010), it is widely recognised that there remains a high level of uncertainty regarding real effects of technology on the marine environment. Monitoring results are scarce due to the early stage of the industry and the limited number of projects actually installed at sea; hence it is often difficult to assess full scale and array effects from sub-prototype scale models. These factors often lead to wave energy developers being required to carry out intensive monitoring programmes for the collection of significant amounts of environmental data. This is deemed necessary in order to enable regulatory authorities to make informed decisions on the proposed project and its potential environmental impacts.

Specific consenting regimes are in place, or are expected to be put in place, for designated wave energy test centres where ocean energy projects have been, or will be, installed for demonstration purposes. In general, many of these European test centres are pre-consented. This means developers do not have to go through a full consenting process providing a limited number of permit requirements are fulfilled. These include an environmental appraisal which is usually less onerous than a full EIA. Furthermore, identification of the environmental sensitivities at the site, and or the possible environmental impacts of the test centre development, are usually included in its Environmental Characterisation or in EIA reports, which are normally made to developers.

Test centres can thus be considered as "environmental research centres" for studying the effects of wave energy on key environmental descriptors, the application of monitoring methodologies, the analysis of monitoring results and effectiveness of environmental mitigation measures. The SOWFIA Project is designed to accelerate and maximise learning from these early wave energy test centres in order to help inform and streamline IA for the wave energy industry. The project is built around consultation and

gathering and analysis of experience gained by, and from, wave energy test centres in Europe.

1.2 Objectives and Methodology

The aim of the SOWFIA project is to facilitate the development of European wide coordinated, unified and streamlined environmental and socio-economic Impact Assessment (IA) tools for offshore wave energy conversion developments. Specific project objectives, anticipated results and impacts are summarised in Figure 1.

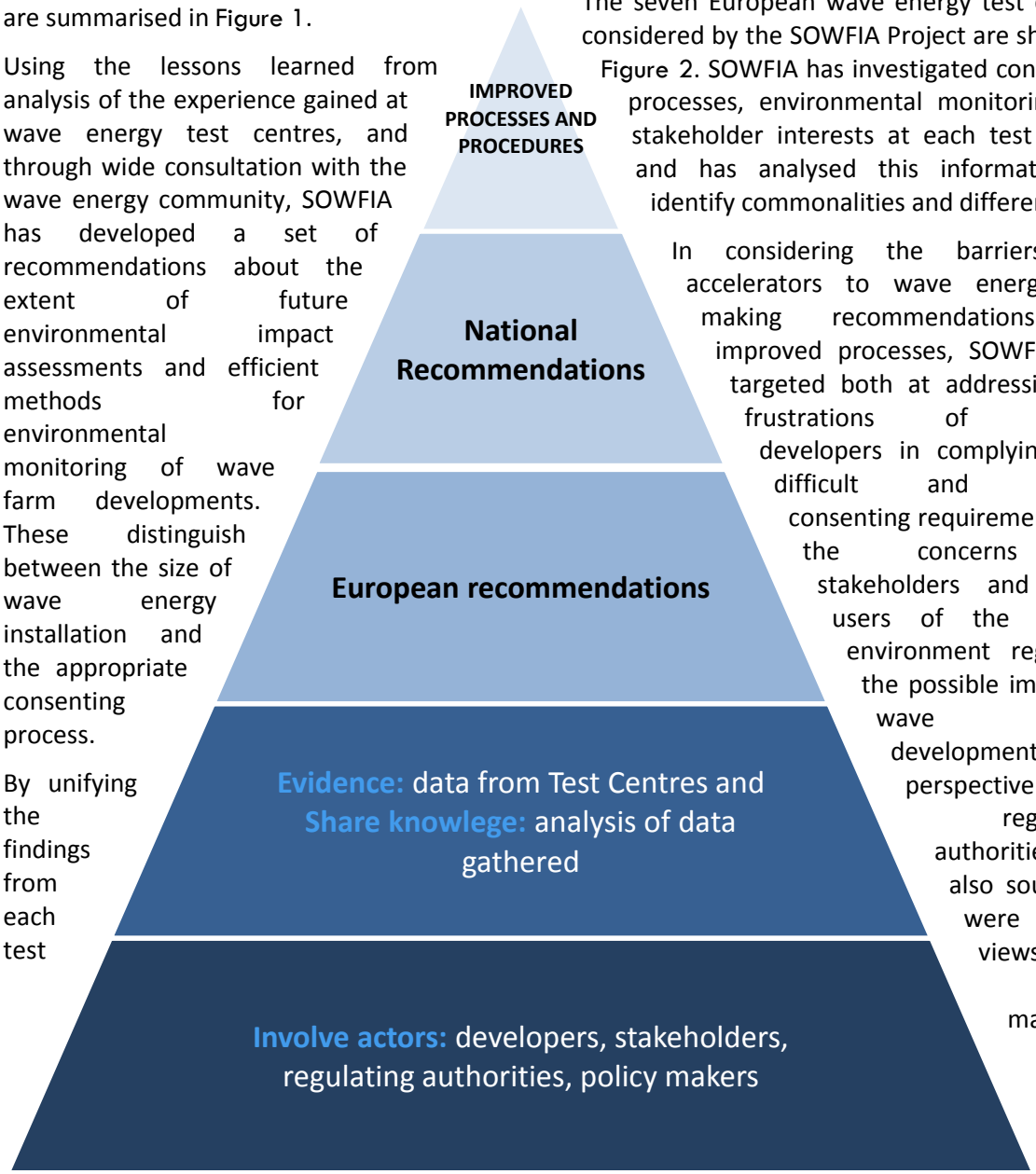
Using the lessons learned from analysis of the experience gained at wave energy test centres, and through wide consultation with the wave energy community, SOWFIA has developed a set of recommendations about the extent of future environmental impact assessments and efficient methods for environmental monitoring of wave farm developments. These distinguish between the size of wave energy installation and the appropriate consenting process.

By unifying the findings from each test centre and by consulting with the wave energy and wider community through workshops and surveys, SOWFIA has produced recommendations for European IA suitable for future large scale wave energy projects. Such recommendations on the nature and detail required for IA of European wave farm developments will accelerate the development of future projects and reduce their costs.

The streamlining process

The seven European wave energy test centres considered by the SOWFIA Project are shown in Figure 2. SOWFIA has investigated consenting processes, environmental monitoring and stakeholder interests at each test centre and has analysed this information to identify commonalities and differences.

In considering the barriers and accelerators to wave energy and making recommendations for improved processes, SOWFIA was targeted both at addressing the frustrations of project developers in complying with difficult and diverse consenting requirements and the concerns of stakeholders and other users of the marine environment regarding the possible impact of wave energy developments. The perspective of regulatory authorities was also sought as were the views of policy makers at both



Streamlining

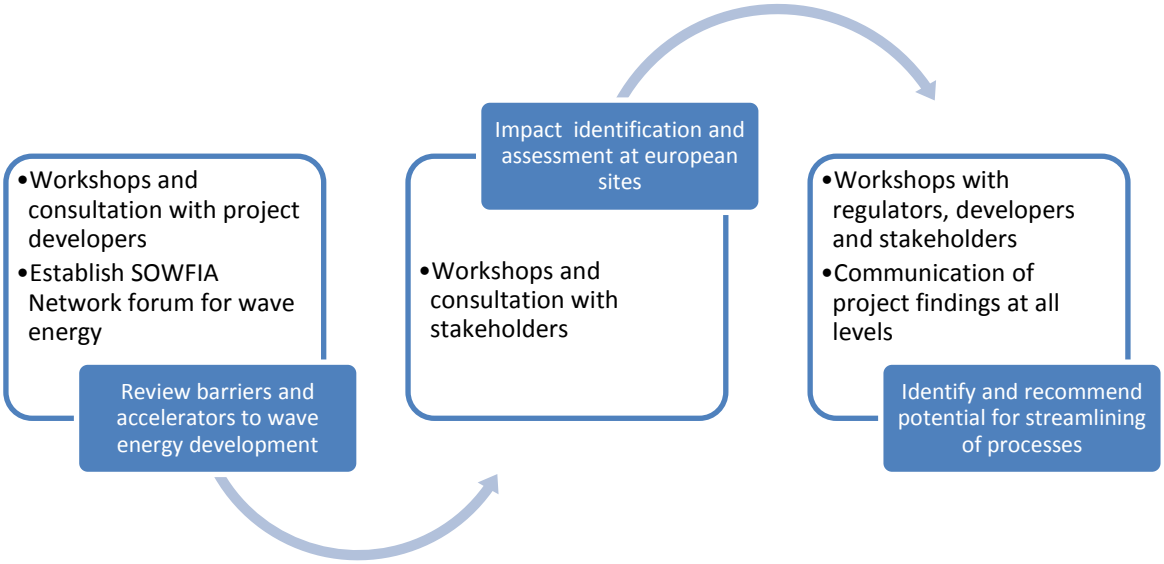


Figure 3: Flow chart of the methodology followed by SOWFIA.

European and national levels. This was necessary not only to identify an 'Idealised' process, but also so that the recommendations could be put into the national context for each member State considered, taking account of local governance structures. During the project, the aim has been to communicate and share experience as well as the concerns and perceptions of each group. This has been achieved by ensuring representation from all groups at the SOWFIA Network, the SOWFIA Workshops and dissemination events.

The SOWFIA project structure follows a three steps approach, as illustrated in Figure 3.

The first step is a review of the barriers and accelerators to wave energy development. The second step concerns impact identification and assessment at European sites. Finally, the last step involves identifying and recommending options for streamlining the applicable processes.

The three critical themes emerging from the SOWFIA Project, in which the recommendations for streamlining of IA for wave energy are organised are:

- Integrated Planning and Administrative Procedures;
- Environmental Impact Assessment;
- Human Dimensions and Consultation.

The synthesis of barriers, accelerators, lessons learned and recommendations are presented for each of these critical themes in the remaining sections of this report. Overall Strategic and Operational recommendations are given for each of the themes, resulting from the European consultation and analysis, and these are followed by nationally specific recommendations derived through consultation with national regulatory authorities and policy makers with the intention of making the recommendations more nationally relevant. 'Strategic' recommendations are viewed as being longer term actions perhaps requiring more significant changes and resources. 'Operational' recommendations refer to shorter term actions which could be implemented with minimal changes yet have the potential to make significant improvements to the consenting process. It should be noted that the level of resources (time/cost/re-structuring) will vary according to geographic location.

2 Integrated Planning and Administrative Procedures

2.1 Context

There is an increasing amount of practical experience being gained about wave energy consenting processes as wave energy projects are being deployed across Europe. To date, this growing experience and knowledge has not been compiled in a structured way and made widely accessible to regulators, project developers, policy makers or stakeholders.

Ocean Energy Targets in EU Member States

Several coastal EU Member States have set targets and scenarios for development of ocean energy (wave and tidal) to 2020. These are outlined in Member State NREAPS and/or various roadmaps and action plans, presented in Table 1. Also included in Table 1 is the estimated spatial extent of wave farms required to meet these targets and scenarios.

Published targets for ocean energy show that some coastal EU Member States are keen to support ocean energy development. This has been backed up with incentives, both financial and legislative, by some national governments. The ocean energy targets extracted provide a scenario of the number of ocean energy developments regulators will potentially be faced with up to 2020. This information is included in the SOWFIA Catalogue of Wave Energy Test Centres, (Osta Mora-Figueroa *et al.*, 2011).

Table 1: Summary table of 2020 targets for Ocean Energy (**Osta Mora-Figueroa *et al.*, 2011**).

Country	NREAP Target for ocean energy (MW)	Targets/ Scenarios presented in Roadmaps/ Action Plans (MW)	Estimated spatial extent to meet targets (km²) (based on extraction of 5MW/km²) NREAP Targets/ (Roadmap and Action Plan Targets)
Denmark	**0**	400[1] (Target for 2030)	**0**/(80)
France	**380**	N/A	**76**/(N/A)
Ireland	**75 (base case) 500 (fast growth case)**	*75-500*[2]	**15-100**/(15-100)
Portugal	**250**	300[3]	**50**/(60)
Spain	**100**	1000[4]	**20**/(200)
Sweden	**0**	N/A	N/A
UK - all	**1300**	2000[5]	**260**/(400)
Scotland	**N/A**	1300[6]	**N/A**/(260)
N. Ireland	**N/A**	N/A	N/A

[1] Mathiesen, B. V., Lund, H. & Karlsson, K. (2009) *IDA's climate Plan Report. Background Report*. Copenhagen, Denmark: The Danish Society of Engineers - IDA. 191 pp. Available at: http://energy.plan.aau.dk

[2] DCENR (2010) *DRAFT Offshore Renewable Energy Development Plan (OREDP)*. Dublin, Ireland: Department of Communications, Energy and Natural Resources - DCENR.

[3] APREN (2010) *Roteiro Nacional das Energias Renovaveis Aplicacao da Directiva 2009/28/CE (Versao Final)*. Lisboa, Portugal: Associação Portugesa de Energias Renováveis - APREN. 87 pp. Available at: http://www.repap2020.eu

[4] APPA (2010) *Hoja de ruta del sector de energías renovables en España*. Madrid, Spain: Asociación de Productores de Energías Renovables - APPA. Available at: http://www.repap2020.eu

[5] UKERC (2008) *UKERC Marine (Wave and Tidal Current) Renewable Energy Technology Roadmap – Summary Report*. Edinburg, Scotland: UK Energy Research Centre, University of Edinburg. 34 pp. Available at: http://ukerc.rl.ac.uk

[6] Scottish Executive (2004) *Harnessing Scotland"s Marine Energy Potential*. Forum for Renewable Energy Development in Scotland/ Marine Energy Group (MEG). 36 pp. Available at: http://www.scotland.gov.uk

Table 2: Cumulative and present wave energy deployments (**Osta Mora-Figueroa *et al.*, 2011**).

	Estimated cumulative no. of wave energy deployments to February 2013 (since 1996)*	Estimated no. of wave energy deployments at February 2013	Estimated capacity of wave energy deployments at February 2013 (MW)
Denmark	7	3	0.3
France	0	0	0
Ireland	4	0	0
Portugal	5	1	0.4
Spain	3	1	0.3
Sweden	2	1	0.1
UK	10	5	2.8
Norway	3	1	0.02

*Note: This compilation may have missed out on some very short term deployments and consequently underestimate the cumulative number of wave energy deployments.

Catalogue of Wave Energy Test Centres

The SOWFIA Catalogue (Osta Mora-Figueroa *et al.*, 2011) shows the status of the industry in Europe at the date of publication (February 2013) and highlights the progress required to meet 2020 ocean energy aspirations. Table 2 shows the estimated number, MW capacity and cumulative total of wave energy deployments that have taken place in Europe. It should be noted that the data in the table are based on deployments for which information is widely available.

Wave energy developments thus far have been medium to full scale deployments of single devices with the aim of testing or demonstrating different technology types. Most of these deployments have taken place at established wave energy test centres (e.g. EMEC in Scotland, DanWEC in Denmark).

The range, size and number of deployments listed in the catalogue highlight the nascent state of the industry. There are many different generic types of device being deployed (onshore, nearshore, offshore, floating, bottom mounted, etc.). No single device or generic type has been proven superior to others and it is likely that different types will suit the various deployment zones that can be exploited.

The progress required by the industry to meet ocean energy targets can be seen by comparing Table 1 and Table 2. Through this comparison it can also be seen that the experience obtained by regulators to date is very small in

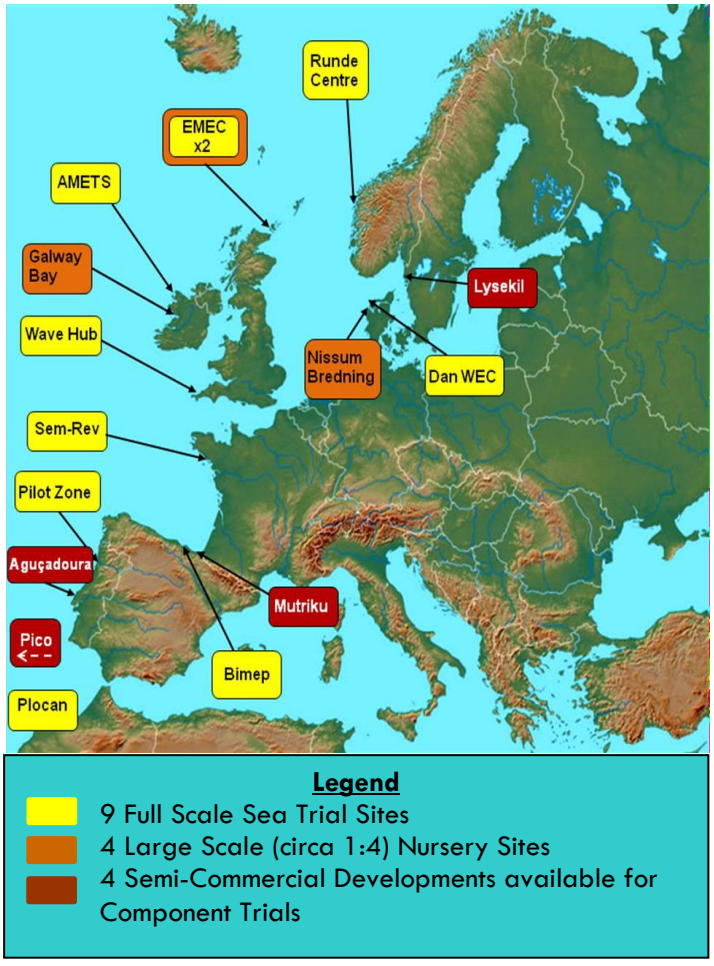


Figure 4: Wave energy test centres in Europe

comparison with what will be required if the plans for ocean energy development by 2020 are to be realised.

2.2 Barriers

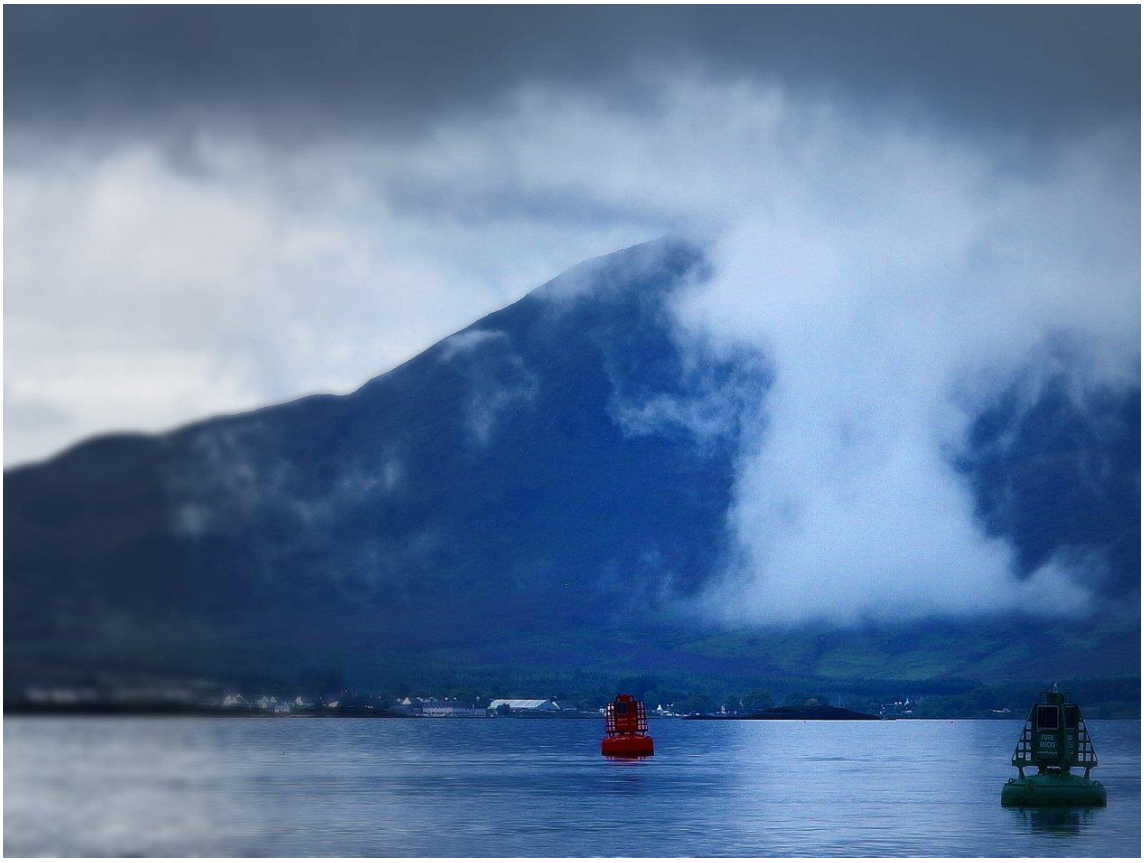
Administrative procedures relating to the granting of consents for wave energy developments have been identified as a barrier to the development of the industry. Many different regulatory bodies have responsibilities in the marine environment due to the variety of activities that take place there. Different permits are required from different authorities to undertake a given development. The permits required vary between EU Member States. This is inevitable, to an extent, for development consent but should be less common for EIA where there is a common legal framework across the EU.

2.3 Accelerators

Throughout SOWFIA, developers and regulators were of the opinion that Marine Scotland's administrative system for dealing with marine consenting is working well. This system is lauded as a 'one-stop shop' approach that aims to reduce the burden on applicants by bringing the required (environmental) permits for wave energy development into a single consent. This approach, along with strong government financial incentives, was cited in workshops as one of the reasons why the Scottish wave energy sector appears to be ahead of other Member States.

2.4 Recommendations

This section presents the proposed strategic and operational recommendations for integrated planning and administrative



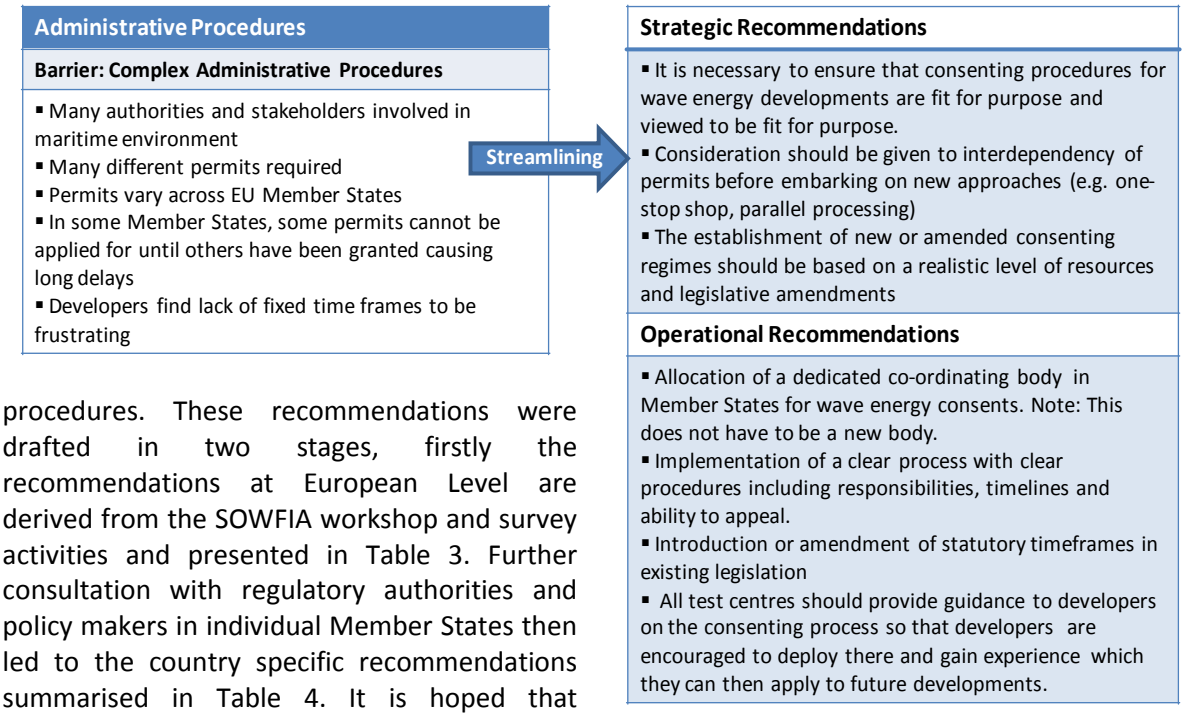


Figure 5: Barriers relating to administrative procedures and recommendations to ameliorate these barriers (O'Callaghan *et al.*, 2013b).

procedures. These recommendations were drafted in two stages, firstly the recommendations at European Level are derived from the SOWFIA workshop and survey activities and presented in Table 3. Further consultation with regulatory authorities and policy makers in individual Member States then led to the country specific recommendations summarised in Table 4. It is hoped that refinement of the over-arching SOWFIA recommendations will make them more applicable to the individual Member States.

SOWFIA recommendations

In order to encourage the development of the wave energy industry in a sustainable manner it is necessary to ensure that consenting processes and administrative procedures for wave energy developments are fit for purpose and are viewed to be fit for purpose. This is important in order to maintain and increase investor confidence while at the same time ensure that stakeholders remain engaged in the consenting process.

It could be argued that in some Member States the poor economic climate, the uncertain future development path for ocean energy and broader governance and legal issues may necessitate current approaches to consenting. On the other hand, the prospect of creating a new, knowledge-based economy sector and regional economic development may prove attractive to other Member States, particularly if they see countries that have developed, for example, the one-stop shop approach gaining a competitive edge in the marine energy sector. The operational recommendations presented should be easier to achieve for Member States that are interested in the development of the wave energy industry but for whom the implementation of new consenting regimes would be unrealistic.

More detailed discussion of these barriers and accelerators and the recommendations derived from SOWFIA consultations is given in by O'Callaghan *et al.* (2013a).

Integrated planning

The publication of a new Maritime Spatial Planning (MSP) and integrated Coastal Management (ICM) Directive by the European Commission in March 2013, if adopted, will require Member States to carry out MSP and ICM which should, over time, provide greater clarity, certainty and identification of compatible uses within the same area of development. Furthermore the adaptive nature of the MSP process can react to changing circumstances which is important for developing industrial sectors such as marine renewable energy. The completion of SEAs for the marine renewable energy sector has helped to inform developers and other stakeholders on the siting of ocean energy developments as well as to raise awareness of potential environmental impacts before development

consent is granted. These factors are potential accelerators for the implementation of the planning process which, in turn, will contribute to more timely consenting of wave energy developments.

Adaptive Management

Several stakeholders (mainly developers and test centre managers) consulted during the course of the SOWFIA project are of the opinion that the EIA screening process can be made more effective by allowing projects to be screened as to the risk of an effect. It is perceived that many small-scale projects are unlikely to cause adverse effects and thus should not be subjected to a full EIA process. The implementation of an adaptive management approach to environmental monitoring can contribute to understanding real project impacts and adjustment of mitigation measures, where deemed necessary. However, this approach may be a 'double edged sword' because it can be uncertain as to what monitoring is going to be required and for how long, and thus there may be no clear picture of the costs of such a programme. In Marine Scotland's 'Survey, deploy, monitor' approach, project risk is ranked based on three criteria: project location, device and project size, and the level of monitoring required is based on the project risk. The aim is that developers will understand the range of monitoring that is required before the project commences.

More in detail considerations and information about adaptive management are given by O'Callaghan *et al.* (2013a).

Parallel Processing

The implementation of a parallel processing approach needs careful consideration to ensure that decision-making is integrated and coordinated, as advocated by the EU and national governments. Whilst applications for development consents may be processed simultaneously to expedite total review and processing time for a project, there will always be interdependence between the required consents. The idea of having one central authority to consider all the submissions and concerns of other regulatory authorities appears sensible, providing they have the expertise to act as a judge on the comments returned. There obviously needs to be an initial agreement between all authorities that the development is appropriate before spending further time on it. This could take the form of an initial administrative sanction to facilitate

the application to go forward for the next stage of the parallel process.

Further information about this topic is given by O'Callaghan *et al.* (2013a).

MS recommendations

Specific national recommendations have been derived by addressing the particularities of each one of the six European countries developing wave energy test centres that are studied in the SOWFIA project: France, Ireland, Portugal, Spain, Sweden and the United Kingdom. These country-specific recommendations are divided into two groups: those relating to integrated planning, which can be seen in Table 3; and those relating to administrative procedures, given in

Table 4. More detailed discussion of the SOWFIA Member State recommendations are given by Simas *et al.* (2013).

Table 3: SOWFIA strategic and operational national recommendations on integrated planning

Country	Strategic recommendations	Operational recommendations
France	• Ensure effective public participation in MRE planning and development • grid connection should be incorporated into MRE project planning • Implement a well-communicated and coherent MRE policy • Consult specialised marine ecology services	• Plan the terms according to the objectives in the SNML • Specify in the Environmental Code the quantitative and qualitative objectives of DSF for MRE
Ireland	• Clear development policy for the marine area • A clear responsibility should be assigned for the MSP • Publication of the OREDP • More staff and resources are needed in SEAI for ocean energy	• More resources for foreshore licensing section • Quicker development of MSP • Concerted effort of regulators and developers to improve the process
Portugal	• Implementation of long term strategic public policies on the promotion of marine renewable energy to ensure attractive conditions for developers to install their projects in Portugal	• The construction and effective operation of the Ocean Plug facility including publication of facility access rules
Spain	• MSP should be undertaken • Construction and promotion of wave energy test centres and pre-commercial demonstration projects • Establish financial incentives and funding for test centres	• MSP should promote development of maritime sectors • R&D grant programmes for demonstration projects should be created in test centres • A feed-in tariff system and an advantageous access to the electricity market should be implemented
Sweden	• MSP implementation; a comprehensive view of current and future needs and marine space sharing cannot be underestimated	• "Blue growth agenda" should be promoted at local and national levels
UK	• Continuous review and encouragement of current initiatives and ongoing plans towards MSP and data management	• To maintain and continue implementation of the initiatives throughout the UK, and to roll-out good practice implemented in Scotland to England, Wales and Northern Ireland • To increase collaboration and standardise planning between the different UK jurisdictions

Table 4: SOWFIA strategic and operational national recommendations on administrative procedures

Country	Strategic recommendations	Operational recommendations
France	• Simplify the consenting process • Create a procedure dedicated to MRE in the Energy Code • Anticipate and facilitate MRE connections to the grid • Facilitate the deployment demands for MRE • Allow administrative simplification • Create a one stop shop administrative body • Implement financial incentives • Create a specific EIA procedure for MREs cable connection	• Adapt land-based archaeology decree to marine archaeology • Adapt the law to allow private offshore cable routes for MRE projects • Demonstrate decrease of greenhouse gases emission • Plan the decommissioning • Establishment of statutory timelines to limit the period for consenting response • Standardise national procedures to allow coherence between regions • Inspectors of classified installations to examine cases for construction and exploitation of MRE • Notify the planned purchase tariff with the European Commission
Ireland	• Coordination between authorities is needed	• Creation of a one-stop-shop, or coordinating body • A separation of the role of landlord and the consenter should exist • Institutions must focus on the interdependency of permits • Guidance for energy developments included in the new consenting Bill • Establishment of statutory timelines to limit the period for consenting response • Consenting of small scale developments should rest with local authorities
Portugal	• Review of the consenting system in order to implement better coordination among licensing authorities	• To make available a clear explanation on the whole wave energy licensing process in Portugal, e.g. through institutional websites or documents
Spain	• Establishment of negotiations between ministries involved in the ocean energy consenting to improve the process	• Implement a well-coordinated parallel processing approach • Establishment of statutory timelines to limit the period for consenting response
Sweden	• The simplification of the consenting process would be for the benefit of authorities and developers • Minimise the requirement of new documentation for each authority needed to be approached	• Better coordination between different relevant authorities • Reduce administrative work and costs • Increase of human resources in regulatory bodies
UK	• To continue the development of the Red Tape Challenge initiative designed to assist departments to ensure regulations are fit-for-purpose	• To encourage and increase collaboration and standardisation among the different jurisdictions of the UK

3 Environmental Impact Assessment

It could be argued that understanding the environmental impacts of wave energy can only be achieved through experience from real deployments. In line with the precautionary principle, deployments should not be permitted if there is any risk of environmental impact. Regulatory authorities are obliged to take cognisance of the precautionary principle when making decisions and this may pose problems for wave energy developments where the environmental impacts may not be fully known or understood.

This section describes SOWFIA project work and recommendations concerning environmental impacts, and specifically the EIA process and environmental monitoring requirements. One aim of the SOWFIA work in this area is to gain experience in activities related to the detection of environmental impacts at wave energy test centres and to use that experience along with information obtained from EIA activities in analogous activities in order to make recommendations for IA streamlining. An important component of this work is the development of the SOWFIA Data Management Platform (DMP). More information can be found in the SOWFIA Work Package 3 Final Report "Report on the analysis of environmental Impact Assessment experience for Wave Energy" (Conley *et al.*, 2013).

3.1 Context

EU Directives

A particular issue experienced across Europe by different device and site developers is the necessity for this new industry to deal with European and national regulatory frameworks. In particular, wave energy developers have to comply with the EU EIA Directive and associated national legislation, which necessitates 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.

In Europe, the EIA process is regulated by the EIA Directive 85/337/EEC (as amended by Directives 97/11/EEC, 2003/35EC and 2009/31/EC), which defines the framework for the EIA process. Uncertainties are experienced throughout the EIA process from the scoping exercise, to the evaluation of the possible impacts, and finally to the design of the monitoring programme. According to Dominguez Quiroga *et al.* (2011), one of the main problems constraining the development of the sector is the scoping of the EIA, i.e., what kinds of data are collected, the resolution required for each type of data and the timeframe for any associated monitoring programme. These uncertainties can have a significant impact on the cost of a project, and also result in delays to the development of the project.

The EIA process is just one element of the broader consenting process applicable to a specific project. The EU has policy and

legislation on a number of issues of global concern including climate change, renewable energy and biodiversity. The EU's biodiversity policy, for example, aims at halting the decline in biodiversity and protecting Europe's endangered species and habitats. This in turn requires protection of habitats and species through site designation and also provides safeguards against potentially damaging developments. Directives implementing these requirements at Member State level may affect the location of proposed wave energy farms, and influence the type of monitoring to be carried out at or near the site.

Of particular relevance to the consenting of wave energy developments are the following Directives:

- Strategic Environmental Assessment Directive (2001/42/EC);
- Birds Directive (2009/147/EC);
- Habitats Directive (92/43/EEC);
- Renewable Energy Directive (2009/28/EC);
- Marine Strategy Framework Directive (MSFD,2008/56/EC);
- Water Framework Directive (2000/60/EC).

Monitoring, data and potential impacts

Environmental monitoring data will, through time, enable scientifically valid decisions to be made in a more effective and efficient manner (Conley *et al.,* 2013). It should be noted that many of the uncertainties relating to the potential environmental effects of wave energy device deployment result from the limited amount of data and information available for this technology. Legislation, and agencies tasked with its application, recommend that site specific assessments are carried out, as highlighted for example in the Offshore Energy SEA (OESEA2, DECC 2011) prepared by the UK Department of Energy and Climate Change (DECC). However, in preparing the SEA, DECC forecast scenarios of wave and tidal energy installation based on limited experience obtained from demonstration sites and test centres.

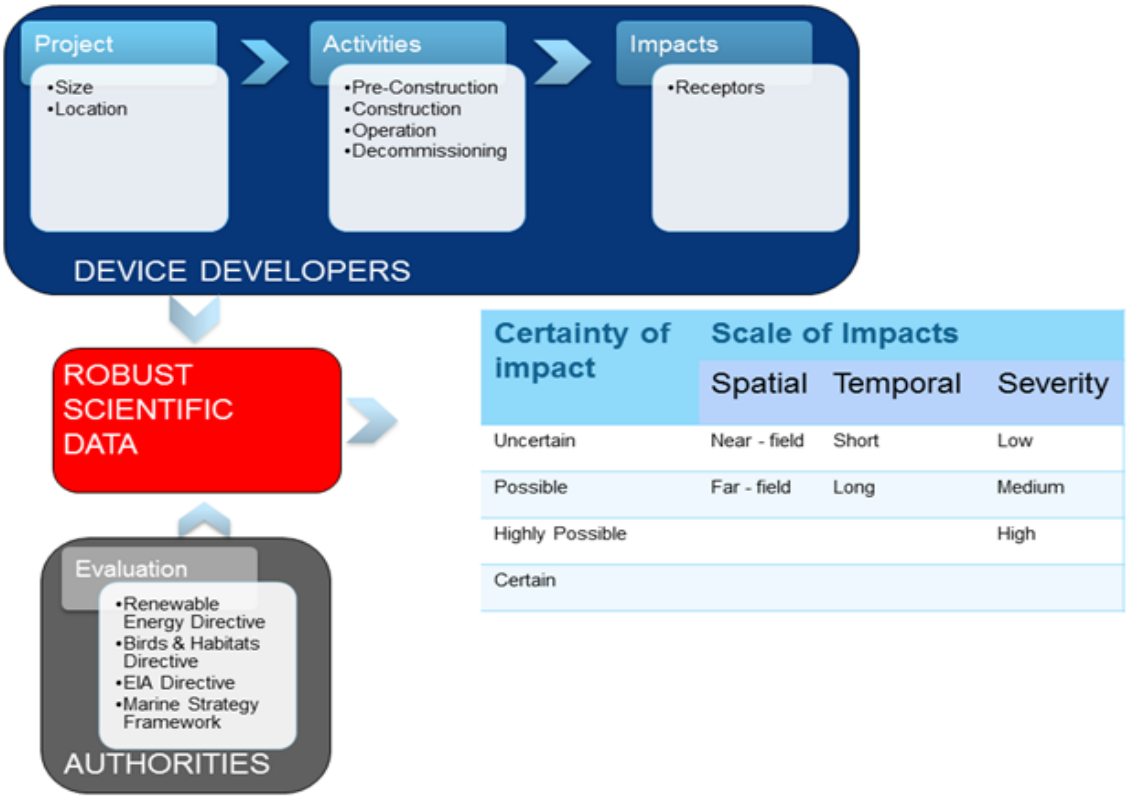


Figure 6: The role of scientific data in the decision making.

3.2 Barriers

EIA process

European Union law and associated national legislation requires that the environmental implications of decisions are taken into account before the decisions are made. In practice this results in the requirement for an EIA to be conducted for certain individual projects on the basis of the EIA Directive or for public plans or programmes on the basis of the Strategic Environmental Assessment Directive. The EIA Directive lists categories of projects for which EIA is mandatory in Annex I and in Annex II lists projects for which national authorities have to decide whether an EIA is needed. Ocean energy is not explicitly listed in either Annex though such developments may require an EIA as they could qualify as "industrial installations for the production of electricity", included as a category in Annex II. Certain EU Member States take a very literal interpretation of this, subjecting almost all wave energy developments to EIA. Throughout the SOWFIA workshops and the questionnaire surveys, the uncertainties and complexity of the EIA process were highlighted as a barrier to wave energy development.

Environmental monitoring requirements

Environmental monitoring can be imposed on a developer as a condition of consent for a development. Environmental monitoring requirements are informed by the Environmental Impact Assessment (EIA) process and, due to the costs and uncertainty involved, have been identified as a potential barrier to the development of the wave energy industry. There are many different important environmental receptors in the marine environment where wave energy devices will be deployed.

Lack of design flexibility in the consenting process

The inability to substitute one device with, for example, an amended device design or more efficient version, has also been identified as a potential barrier to wave energy development. This lack of design flexibility ties a developer to a fixed consent for a specific project. If changes to the design are required, subsequent to carrying out requested environmental characterisation and monitoring, it may become necessary for the developer to undertake further monitoring studies. This is partly linked to the administrative procedures associated with consenting of wave energy device deployments, described previously, as there may be limited opportunities for a developer to liaise with a regulatory authority subsequent to the initial pre-application meeting.

3.3 Accelerators

EIA process

In some Member States a threshold is set for particular types of projects. In Ireland, for example, a wind energy development with more than five turbines or a total output greater than 5 MW must have an EIA. It was suggested during SOWFIA workshops that similar thresholds for EIA be set for wave energy. However, as the wave energy industry is still at the pre-commercial stage, and not yet at the stage of multiple commercial deployments, it is not advisable to set such thresholds at this time. Regulatory authorities could, however, adopt a more streamlined approach to screening whereby only those

developments likely to have significant environmental effects are subject to a full EIA. This would have to be applied with care, and in some situations, for example, where developments could have an impact on an SAC, SPA or other designated site, an EIA and/or Appropriate Assessment (AA) will be required in accordance with existing law. It is suggested that if this is the case, the potential for a combined EIA/AA should be explored by regulatory authorities.

Environmental monitoring requirements

The lack of scientific data on environmental effects from wave energy deployments has been identified as the main cause of this barrier. As more wave energy developments go through the consenting process and environmental monitoring is undertaken, more data and information will be generated. There is a need to turn this information into knowledge on the environmental impacts of wave energy developments, which can then be used to inform the design and operation of future consenting procedures. In the short term, it was suggested in the SOWFIA workshops that incentives should be provided for environmental monitoring information to be shared between developers. It was also suggested that a facility should be set up whereby regulators can share their experiences of the EIA process. The SOWFIA DMP can be used for this purpose.

Lack of design flexibility in the consenting process

As for the previous barrier, the effects of specific devices and components (moorings, foundations, etc.) will become better understood as the industry develops.

3.4 Lessons learned

Monitoring activities

When designing environmental surveys it is necessary to ensure that the data collected are fit for purpose, robust and scientifically defensible.

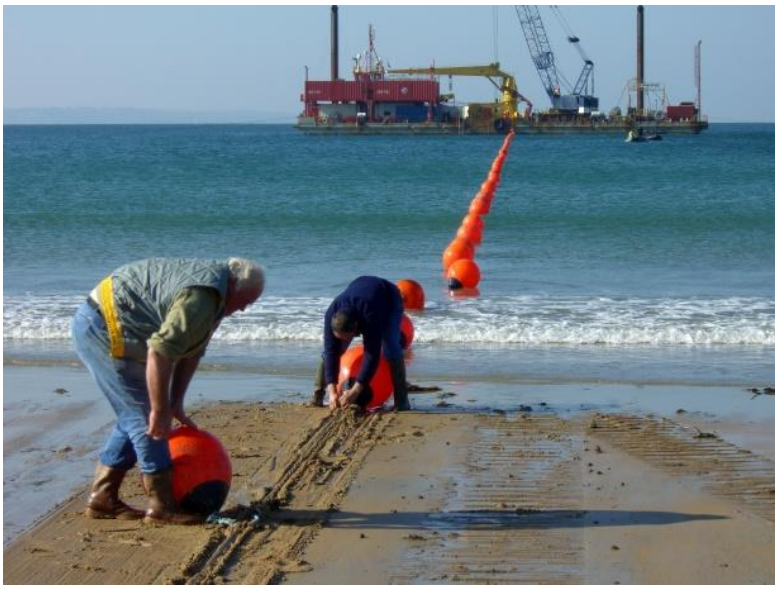
Survey methodologies employed at a particular wave energy deployment site will be dependent on the type of expected impact and on the phase of the environmental monitoring, as this will affect the resolution of the survey, its size and temporal scale and frequency. It is therefore important to understand how these parameters could affect the monitoring strategy for a given environmental descriptor.

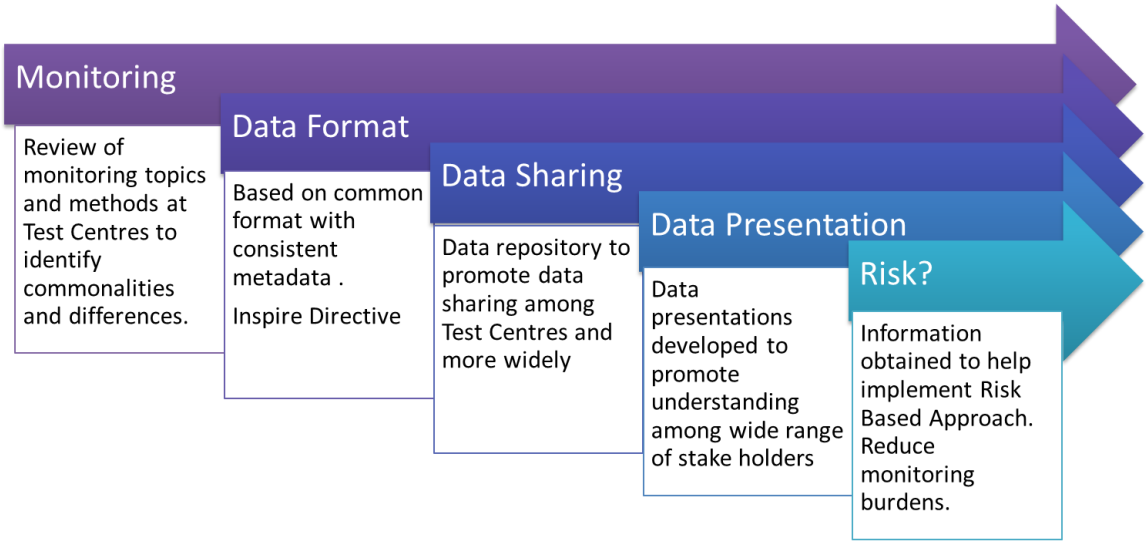
The two phases of environmental monitoring for WEC technology are: (i) pre-consent baseline monitoring as part of the EIA; or (ii) post-consent impact monitoring to check the assumptions of the EIA and the effectiveness of any mitigation measures.

Post-consenting monitoring to evaluate the impact of WEC installation and operation on the environment can be carried out using either:

- **BACI (Before-After-Control-Impact)** which requires careful selection on appropriate 'control' or 'reference' site; or
- **BAG (Before-After-Gradient)** where monitoring is carried out at increasing distances from the impact site.

Both methods require a baseline dataset of at least one year and preferably two to three years over all seasons to allow impacts to be detected against background temporal variation. After the first year of data collection, the methodology should be reviewed to ensure





that it is sufficient to detect impacts.

More detailed information about the design of monitoring activities is given by Conley *et al.* (2013).

The environmental descriptors can be divided into two main categories:

1. Physical environment.
2. Flora and fauna.

Physical environment

Wave and current measurements are required for EIA studies concerning: extreme wave and current conditions; turbulence, turbidity in the water column; sediment transport; changes in wave field and flow; and possible long term changes to beach morphology.

Wave measurement

- **Moored wave buoys:** the most established and robust in situ technique for wave measurements.
- **Acoustic Doppler Current Profilers (ADCPs):** derive wave characteristics by measuring the orbital velocities of water particles as well as the water level.
- **High Frequency (HF) radar:** can measure waves remotely from the coast and cover large spatial areas.

Current measurement

- **ADCPs:** estimate current profiles in the water column.
- **High Frequency (HF) radar:** measure the speed and direction of ocean surface currents over a large region of coastal waters.

Underwater noise

The introduction of noise into the underwater environment from the deployment of marine renewable energy devices is of growing concern because of the potential for disturbance to marine species which use sound for communication, navigation, finding prey and evading predators. Key aspects of assessing the impacts from introduced noise include identifying the baseline noise signal at the site of interest, the noise signature of the planned devices and the auditory sensitivity of species present.

Flora and fauna

Marine mammals

As marine mammals are protected by national, European and/or international legislation, the impacts of wave energy on marine mammals is of significant concern at all the test centres in the SOWFIA project. Monitoring of marine mammal populations before, during and after deployment of marine renewable devices is often required as part of the wave energy EIA process. There are a wide range of methods for monitoring marine mammals and the methods utilised will be determined by the questions to be addressed.

Seabirds

Many species of seabirds are also protected under national, European and international legislation and baseline data and/or monitoring of seabird distribution and behaviour is a widespread component of wave energy EIA. There are, however, significant resources and information available on the abundance, distribution and behaviour of many seabird species within Europe. Survey methods include point counts from land or sea, boat and aerial-based transect counts, aerial-based photogrammetric approaches and radar assessment of birds in flight.

Benthos

Assessment of impacts on benthos are a standard component of all marine developments but expected impacts from wave energy developments are largely limited to the construction phase of development and relate to habitat disturbance, increased suspended sediment, sediment deposition, scour and abrasion and release of contaminants. Potential operational impacts include changes in hydrodynamics and the introduction of new habitat types from foundation structures and/or other submerged equipment. The experiences provided from test centres EIA suggest that the effects of the deployment of wave energy converters on coastal processes and geology would be largely insignificant in comparison with the natural processes occurring at the sites.

Fish and shellfish

It is likely that the potential impacts on fish and shellfish from wave energy developments are limited and of a short duration. The greatest potential for displacement effects is limited to the construction phase and can be mitigated by keeping this phase as brief as possible.

Fish and shellfish represent the receptor for which some of the "positive" or benign effects of wave energy are most apparent. While not designed to enhance marine life and ecosystems, wave energy developments have credible potential to exhibit the same advantages as fish attraction devices and artificial reefs. At the Lysekil test centre, in Sweden, WECs were seen to exhibit clear features of artificial reef, with expected positive effects. The ability to design the WECs to enhance this effect was successfully demonstrated (Conley *et al.*, 2013).

Test centre EIA experience

A review of the EIAs performed at all of the test centres considered by the SOWFIA project is summarised in Table 5. While the selection of receptors discussed in this report follows from this experience, there is clear evidence that the receptors of primary interest are dependent on factors such as the local environment, the presence or absence of protected species and the regulatory authority under which the EIA is performed.

Although the EIA of each project is based on site and project specificities, the comparison of EIA conclusions for the wave energy test centres reveals some commonalities on the environmental descriptors and impact evaluation.

The most significant impacts are those which are associated with the installation phase for both the subsea cable and WECs, including foundations and moorings. The impacts

associated with the operational phase of WECs are generally considered to be insignificant even though it is recognised that potential impacts are largely unknown. Some differences in impacts evaluation between the different test centres occur sometimes as a result of this uncertainty and at other times due to the sensitivity of the site. Across all test centres, the impacts which were perceived to be of lowest significance were air quality and climate, water quality and ground water, with physical processes regarded as the next least significant. In the analysis of all the receptors considered here, there are a few common themes which are evident and deserve separate attention.

Length of Baseline Studies

While there is considerable variation in the frequency and density of sampling, wherever recommendations are provided on the amount of time required to provide a baseline sufficient to detect changes attributable to the presence of WECs, a minimum period of 2 years is proposed.

Electromagnetic fields

The biological significance of electromagnetic fields (EMF) and EMF radiation from undersea cables and generation systems continues to be a concern which requires further study. To date, there has been no documented evidence of significant behavioural effects on a species level from existing installations and one national regulator has declared that EMF radiation from properly buried cables would not qualify as justification for the refusal of consent for any ocean energy development.

EIA Monitoring Methodology

It has been suggested (Conley *et al.*, 2013) that for wave energy EIA monitoring purposes, a BAG design may be preferred by developers over a BACI design, though this is dependent on the scale of development and the question being asked. The reasons for this are both: the BACI requirement for a similar but independent control site, as well as the additional resources necessary to acquire a sufficient number of replicate surveys to achieve the desired level of impact detection sensitivity.

Further details of the Lysekil wave energy test centre experience of EIA are given on Page 22.

Table 5: Summary of the perceived magnitude of different environmental receptors as derived from the EIAs of each European test centre. The simplistic classifications represent a single word summary of the full text in each report.

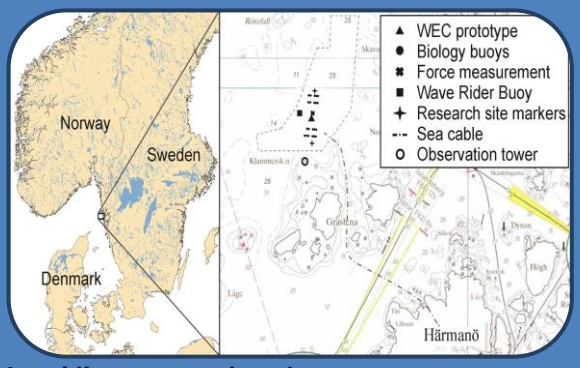
Receptors		AMETS	BIMEP	LYSEKIL	OCEAN PLUG	SEM REV	WAVE HUB
Physical Environment	Water quality and ground water	MODERATE	COMPATIBLE	COMPATIBLE	N/A	MODERATE	COMPATIBLE
	Physical processes	MODERATE	SEVERE	COMPATIBLE	N/A	COMPATIBLE	COMPATIBLE
	Air quality and climate	COMPATIBLE	N/A	N/A	N/A	N/A	N/A
Flora and Fauna	Marine mammals	MODERATE	SEVERE	COMPATIBLE	SEVERE	COMPATIBLE	COMPATIBLE
	Sea birds	MODERATE	MODERATE	COMPATIBLE	SEVERE	COMPATIBLE	COMPATIBLE
	Fish and shellfish	N/A	Noise → MODERATE EMF → SEVERE	COMPATIBLE	N/A	COMPATIBLE	COMPATIBLE
	Benthos	MODERATE	Increased Turbidity → MODERATE Anchors and moorings dragging → SEVERE	N/A	N/A	COMPATIBLE	COMPATIBLE

Improving understanding of environmental impacts of wave energy using test centres:

The Lysekil Test Centre Experience

The Lysekil test centre

The Lysekil test centre was developed to test the WEC developed at Uppsala University, in real sea conditions. In addition to a strong technical focus, extensive efforts have been placed on assessing the effects of the WEC on the marine environment. Water depth at the site is 25 metres and the seabed consists of sandy clay. The fauna in the area is typical of a soft bottom community, common to the Swedish west coast. No threats to fauna were foreseen.



Lysekil test centre location map

The Lysekil test site has been in operation since 2004 and is operated by the Division of Electricity at the Department of Engineering Sciences, Uppsala University. The site is located ca 100 km north of Gothenburg.

Technique

The WEC developed in Uppsala is based on a linear generator, and can be classified as a "point absorber". The motion of a surface buoy relative to a fixed base is converted to electricity by a generator placed on the seabed. Single units are relatively small (7 m height) but the WEC can be deployed in small or large arrays to form wave energy farms.

Experience to date

The test centre is used for technical testing and evaluations of the WEC concept. To date (2013) more than 10 generators have been tested. Also, other necessary operations, such as deployment and servicing trials, are continuously evaluated. Continuous improvements to the design of WECs and buoys have resulted in better energy absorption and higher energy production. Experience has also resulted in less use of materials and improved logistics and deployment economics, helping to make the WEC more economically and environmentally sustainable.

Environmental impacts

Extensive studies show that, to date, environmental impacts are low with only small although detectable changes such as the invasion of the test centre by species preferring hard substrates for settling. This has resulted in an increase in a number of certain fish and crustacean species (e.g. lobsters and crabs). During consultations it has become evident that particular environmental study results are of importance to a range of stakeholders, including local residents, summer visitors and local businesses including fishermen.

Environmental study results

- Increase of biomass and species numbers, especially fish and invertebrates such as crustaceans. This is likely to be partly due to artificial reef and Fish Aggregation Device (FAD) effects which occur due to the presence of new hard substrates in a previous soft bottom community and positive modifications of foundations. Many species also establish communities on generators and foundations resulting in small changes in species composition near foundations.
- Acceptable noise emissions.
- Creation of resting places and feeding points for seabirds.

Environmental study results

Up to the end of 2013, the project operated on a number of temporary permits and consents. To enable longer term use of the site, an application for a permanent consent was made in 2013. Increased internal research and testing demands requires a larger test area.

3.5 The Data Management Platform (DMP)

To assist the decision-making process, the interactive DMP has been designed and developed within the SOWFIA Project. The core of the DMP is composed of environmental and socio-economic datasets collected at six EU test centres: AMETS in Ireland, BIMEP in Spain, Lysekil in Sweden, Ocean Plug in Portugal, SEMREV in France and the Wave Hub in the United Kingdom.

The DMP is a tool designed to present Impact Assessment (IA) information in a format suitable for a non-technical audience. It integrates datasets from the six different sites, providing scientifically robust data on the potential environmental effects of wave energy devices to support consenting and licensing processes.

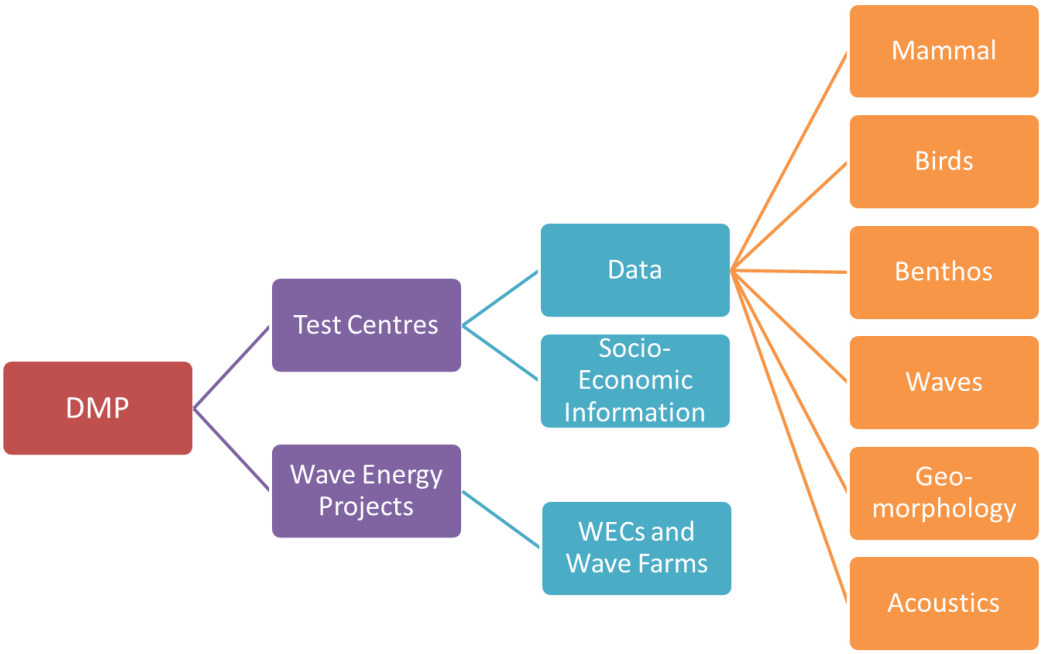
Data availability and types of data

The DMP provides monitoring information on two main categories of receptors: physical environment and flora and fauna. Datasets, including time series data, shapefiles, text files and relevant reports, are continuously being uploaded to the DMP. Specifically users can find:

- Time series of wave data, enabling sea-state conditions at each centre to be determined;
- Shapefiles of marine mammals and sea birds, in particular protected species;
- Shapefiles of benthic organisms to evaluate changes on benthic ecosystems; and
- Documents generated from the EIA process and other relevant reports e.g., fish monitoring, reef effects etc.

Refined Data Products

In order to support decision making, data should be easy to understand and scientifically robust. Refined Data Products (RDP) have been developed through the SOWFIA project, taking into account existing legal requirements and in consultation with stakeholder groups and regulatory authorities. These products can be used in the public consultation phase of the development planning process. They will also be of value to developers, regulatory authorities, maritime planners and others interested in wave energy. An example of an RDP available for wave data is given on Page 24. Wave and wind reanalysis datasets for 33 years can also be found in the DMP.



Accessing the datasets

The DMP is accessible at sowfia.hidromod.com or from the SOWFIA web site (www.sowfia.eu). Access is free to any registered users, allowing visualization of the datasets for each location

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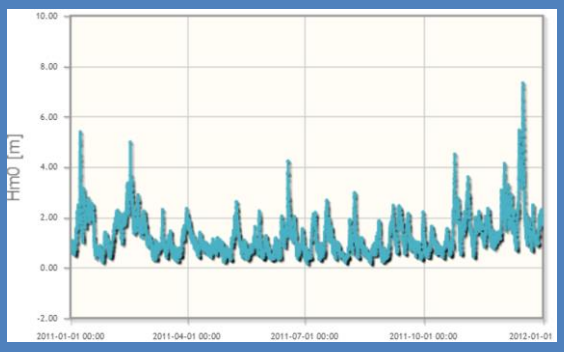
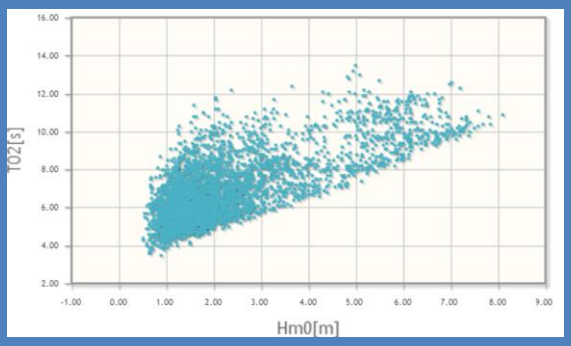
Refined Data Products (RDP)

Using the DMP, wave and current data from European test centres can be displayed as time-series plots or scatter diagrams. For wave measurements time series plots of important parameters over a given time period, such as significant wave height, which is the average of the 1/3 highest waves in a record, or maximum wave height, can be displayed. Scatter diagrams show the number of occurrences of certain sea states over a given duration. Different sea states are represented by different cells in a matrix and defined by wave height and period.

For current data, time series can be created of important parameters such as current speed and direction.





TIME SERIES

SCATTER PLOTS

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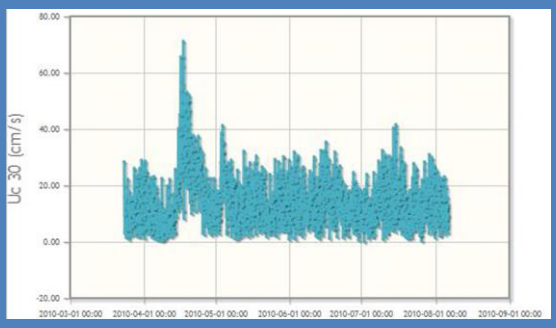
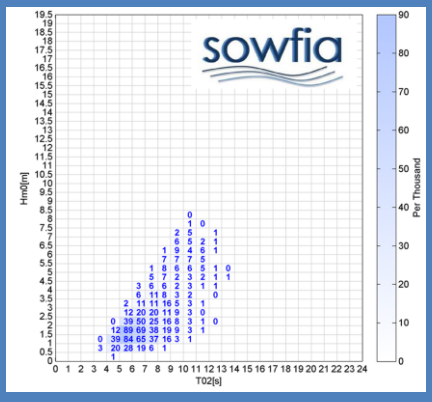




3.6 Recommendations

It is necessary to ensure that the EIA process and environmental monitoring requirements are sufficient to ensure protection of the marine environment and stakeholder interests while at the same time, do not prevent the development of the wave energy industry. A summary of barriers related to the EIA process and environmental monitoring, together with strategic and operational recommendations that are proposed to help to ameliorate these barriers are shown in Figure 7.

SOWFIA recommendations

Suggestions to improve the EIA Directive and its application are presented in the SOWFIA Report on the analysis of the Work Package 2 findings regarding barriers and accelerators of wave energy (O'Callaghan *et al.*, 2013b). Potential results of these suggestions which could affect wave energy development include the requirement for an EIA of projects with significant effects only, mandatory scoping, EIA 'one-stop-shop' and the provision that new aspects, such as climate change, can be taken into account in the EIA process. Separately the European Commission have published a proposal to amend the EIA Directive. It will be 2014 before this new Directive is adopted meaning that, if it is adopted, it will be 2016 before it has to be transposed into national legislation. Given the current state of the wave energy industry, this may come in time for many wave energy developments.

MS recommendations

A summary of the specific national strategic and operational recommendations on Environmental Impact Assessment that have been identified within the SOWFIA Project are described in detail by Simas *et al.* (2013) and can be seen in Table 6.

Barriers Relating to Environmental Impacts		Strategic Recommendations
Barrier: Environmental Impact Assessment process ▪ Inconsistency in the manner in which the EIA Directive is applied to developments across different EU Member States in terms of information required and monitoring requirements ▪ There is a feeling within the industry that the EIA process is overly burdensome on small scale developers		▪ Accelerate the rate at which understanding of the impacts of wave energy developments is being obtained. This can be done through: (i) facilitation of an adaptive management approach (ii) EU funding for research programmes on environmental impacts, especially in wave energy test centres. (iii) Require EIA data to be made publicly available (This is already the case in Denmark) ▪ It is suggested that competent authorities adopt a stricter approach to EIA screening whereby only those developments likely to have significant environmental effects are subject to a full EIA.
Environmental Monitoring Requirements ▪ Unknown effects of wave energy devices on the marine environment ▪ Developers feel that monitoring requirements are too onerous for the current state of the industry ▪ Not enough guidance from regulators on the scope of EIAs ▪ Monitoring requirements subsequent to EIA can be too vague ▪ Long term monitoring results in additional costs for developers which may put off investors ▪ Environmental data availability is often compromised by developers desire for confidentiality.	Streamlining	**Operational Recommendations** ▪ Baseline and impacts data should be made available at least for test centres and this could be made a condition of funding ▪ Site specific impacts should be the priority for small scale projects ▪ Results from monitoring programmes should be analysed and synthesized so as to better inform management decisions. ▪The environmental assessment should be based on site sensitivity (i.e. It should focus on things that are important in that particular location not things that should be included just for comprehensiveness). It should also be based on the size of the project and the type of device being installed. ▪ Clear environmental assessment requirements should be provided by consenting authorities to developers.
Lack of design development in the consenting process ▪ This ties developers to a fixed consent for a specific project which is a big difficulty for burgeoning industry which is rapidly changing.		

Figure 7: Barriers relating to Environmental Impact Assessment (EIA process and monitoring requirements) and recommendations to ameliorate these barriers (O'Callaghan et al., 2013b).

Table 6: SOWFIA strategic and operational national recommendations on EIA

Country	Strategic recommendations	Operational recommendations
France	• Ensure efficient impacts management during the project • Improve the use of the impacts assessment • Improve the knowledge of MRE potential and the maritime constraints associated with their development	• Implement effective mitigation measures • Implement new integrated management for MRE farms • Conduct an analysis of the interactions between MRE and fisheries • Improve knowledge on the potential impacts of MRE • Build open source environmental databases • Provide guidance on how to address uncertainties in MRE
Ireland	• More independent research to reduce uncertainty • Developers should be required to make all the data associated with their EIA available as a condition of the consent	• Creation of a central repository of EIAs; clear environmental assessment requirements should be available to all
Portugal	• Organisation of events like workshops, seminars, short courses, etc. to train regulators and decision-makers on the state-of-the-art of ocean energy impacts • Creation of a comprehensive baseline database on the Portuguese marine environment to provide a context for accurate impacts evaluation	• Develop EIA guidance for developers and test centres • Creation of an EIA repository (including monitoring reports)
Spain	• To set up national standards for environmental assessment	• To establish mechanisms that allow project developers to exchange knowledge and experiences • To facilitate transfer of experiences from other offshore sectors
Sweden	• More governmental support is required for studies on environmental issues as they are seldom local issues but rather more of strategic, regional or national concern	• A national Swedish "red book" on where to, and not to, locate marine renewable projects should be developed • Produce guidelines on environmental assessment and how to find support to finance them
UK	• Promote specific research projects on wave energy impact assessment to produce guidelines for future deployments • Encourage the continuity of existing initiatives to enhance data exchange and to make data publicly available	• Monitor EIA guidance to check their effectiveness and establish a continuous improvement process • Baseline and impact data should be made publicly available for the EMEC and Wave Hub test centres • Establish specific EIA requirements according to the site

4 Human Dimensions and Consultation

4.1 Context

Environmental and social impact assessment provide important tools for evaluating the environmental sustainability of projects, promoting public awareness and participation, and making wave energy more attractive to investors and governments that may view environmental and social concerns as a barrier.

Consultation is critical for promoting public understanding, scrutiny and acceptance of wave energy. A key condition for developing offshore renewable energy is that relevant stakeholders are informed about proposals and are enabled to participate in decision-making on the siting and scale of projects.

Lists of key stakeholder groups have been compiled by SOWFIA for seven European wave energy test centres. Questionnaires and workshops were used to determine stakeholders' understandings and concerns about wave energy and suggestions for improving the consultation processes. This information was analysed to draw out similarities and differences across the wave energy test centres considered in Europe and to identify recommendations for improved practice and streamlining.

4.2 Barriers

Stakeholder consultation

Many different stakeholder groups have an interest in the maritime environment. As part of the consenting process for wave energy development, public consultation with stakeholders is a requirement. This enables stakeholders to give their input and opinion into the development planning process, to express their concerns or to safeguard their interests. This consenting process can be both time and resource consuming and is seen by some as potentially posing a barrier to wave energy development.

Conflicts of use

As part of the consenting process for wave energy development, consultation events allow stakeholders to raise any concerns they have relating to the proposed development. Such concerns can relate to the marine environment and how it will be affected but can also relate to potential conflicts with other, more established uses such as fishing, recreation and shipping.

4.3 Accelerators

Stakeholder consultation

In general, the point of view of wave energy developers was that the formal stakeholder consultation procedures in place are sufficient to address stakeholder concerns. Examples of this include the developers of the AMETS test centre in Ireland, the Lysekil test centre in Sweden and BIMEP in Spain who all felt that formal procedures provided enough guarantees for stakeholders.

Developers have found that approaching stakeholders from an early stage of development and establishing open

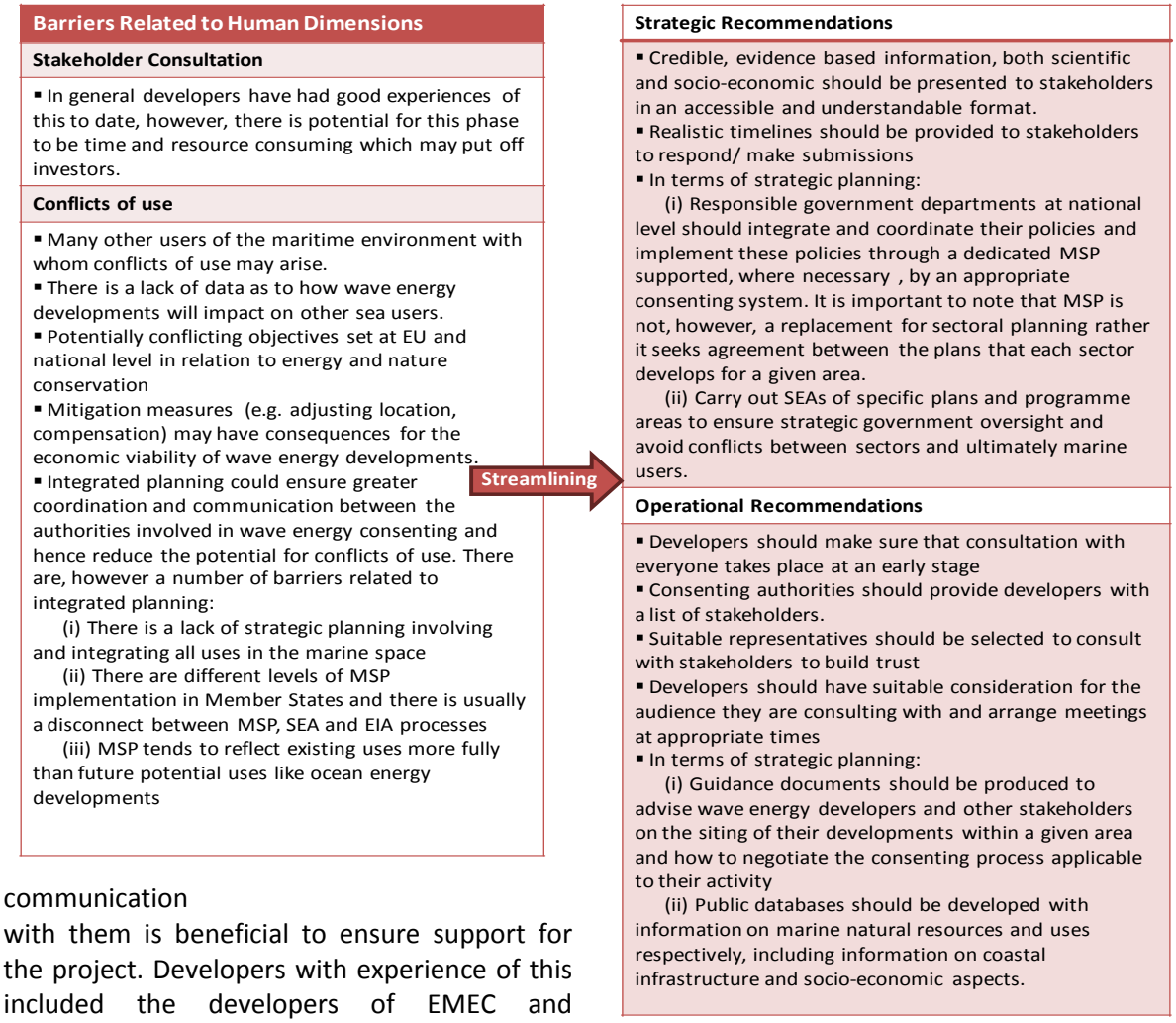


Figure 8: Barriers relating to human dimensions and recommendations to ameliorate these barriers (O'Callaghan *et al.*, 2013b).

communication
with them is beneficial to ensure support for the project. Developers with experience of this included the developers of EMEC and Aquamarine Power in Scotland. Wave energy developers have also found that, for the most part, stakeholders and the public have a positive attitude towards wave energy.

Conflicts of use

Many wave energy test centres have presented examples where conflicts of use were resolved, at an early stage of a development, to the satisfaction of both the test centre developer and the stakeholder in question. Examples include consultation with fishermen affected by the AMETS development to agree on an amended location for the test centre, the creation of a monetary fund by WaveHub for the development of fishing activities in the Cornish North Coast and the movement of the traffic separation zone near WaveHub to avoid navigational risks.

4.4 Lessons learned

Perceptions of MRE

The overall opinion of stakeholders on implementation and deployment of MRE test sites appears to be positive, mainly due to the idea that it can boost local development and the economy, particularly as it brings employment benefits. Nevertheless, some respondents have highlighted that most of the required skills are highly specialised, which will probably lead to the recruitment of people from outside the local community. Other frequent supportive arguments are the increase of cleaner/ greener energy production; the reduction of energy dependence on fossil fuels;

decrease in energy prices and mitigation of climate change. Reducing dependence on energy imports was most keenly expressed by respondents from the southern European test centres.

The main concerns identified for all test centres were conflicts relating to the shared-use of sea areas (e.g., impediments to navigation and loss of fishing grounds), visual impacts, potential adverse environmental effects and the high costs of wave energy projects. The potential visual and environmental impacts of wave energy, in contrast, were recognised but were generally judged to be less serious than those from offshore wind farms.

Key messages from stakeholders on consultation

Purpose and audience

- Consultation should be used to increase public awareness about marine renewable energy in general alongside providing project-specific information;
- Additional efforts are required to encourage participation by local businesses and communities in consultation processes; and
- Levels and types of consultation need to reflect the specific concerns and needs of individual stakeholder groups.

Techniques

- Engage actively with local media to maintain contact and provide regular updates;
- Choose time, location and format of consultations carefully to meet needs of different groups;
- Define boundaries clearly through honest acknowledgement of what can and cannot be achieved in consultations;
- Avoid consultation fatigue to maximise participants' input; and
- Explain clearly how input will be used.

Information

- Information provided must be clear, transparent and honest with a level of technical content appropriate for target audiences;
- Realistic benefits of wave energy projects should be emphasised but potential adverse effects must also be acknowledged to help build trust with local stakeholder groups;
- Encourage stakeholder groups to provide lists of concerns before discussions to maximise the benefits of consultation events;

- Information relevant to consultation processes is often technical and lengthy. Be prepared to extend consultation periods to allow full discussion of salient issues; and
- Particular emphasis should be placed on evaluation of the socio-economic impacts of proposed developments for key stakeholder groups.

4.5 Recommendations

SOWFIA recommendations

Successful consultation and interaction with other users of, and stakeholders in, the maritime environment is crucial for the development of the wave energy industry. Developers have expressed satisfaction with stakeholder consultation for wave energy projects to date and it is important that lessons learned from these projects are transferred to future developments. Integrated planning can play a role in reducing the potential for conflicts of use; however, there are a number of barriers related to this. A summary of barriers related to human dimensions and consultation, including strategic planning, together with strategic and operational recommendations which can help to ameliorate these barriers are shown in Figure 8.

MS recommendations

The specific national strategic and operational recommendations on stakeholder consultation that SOWFIA has identified and are reported by Simas *et al.* (2013) are summarised in Table 7.

Table 7: SOWFIA strategic and operational national recommendations on human dimensions and consultation

Country	Strategic recommendations	Operational recommendations
France	• Specify the definition, the impact, the field and the application terms of the public participation • Ensure effective public participation in MRE mapping and development • Use a coherent approach to gathering stakeholders' opinions	• Plan the CODERST (local committee of health and technological risks) consultation before conducting the public inquiry • Adopt public consultation at an early stage
Ireland	• Authorities and developers should comply with the provisions of the Aarhus Convention (Simas *et al.*, 2013)	• More time for consultation should be given to the public
Portugal	• More information needs to be available on ocean energy, particularly for the public in general, especially in locations where wave energy projects are starting to be developed • Information on marine renewables should be introduced early in scholarly programmes as well as didactic activities on the subject.	• Developers and/or test centre managers should put more efforts on consultation with local stakeholder groups and general public
Spain	• To provide stakeholders with realistic timelines to allow them to respond to the consultation	• To hold informative meetings with interested parties as soon as the project is defined
Sweden	• Early stage and well prepared consultation, adapted to the level of interest and understanding of the audiences	• Ensure that both competent and a satisfactory number of officials are able to handle and evaluate applications
UK	• Rigorous application of EIA and SEA preceded by active consultation to ensure the decisions from the Major Infrastructure Unit are informed by stakeholder input	• Ensure early consultation with local stakeholders • Provide appropriate and timely information giving careful consideration to effective communication channels

5 Conclusions

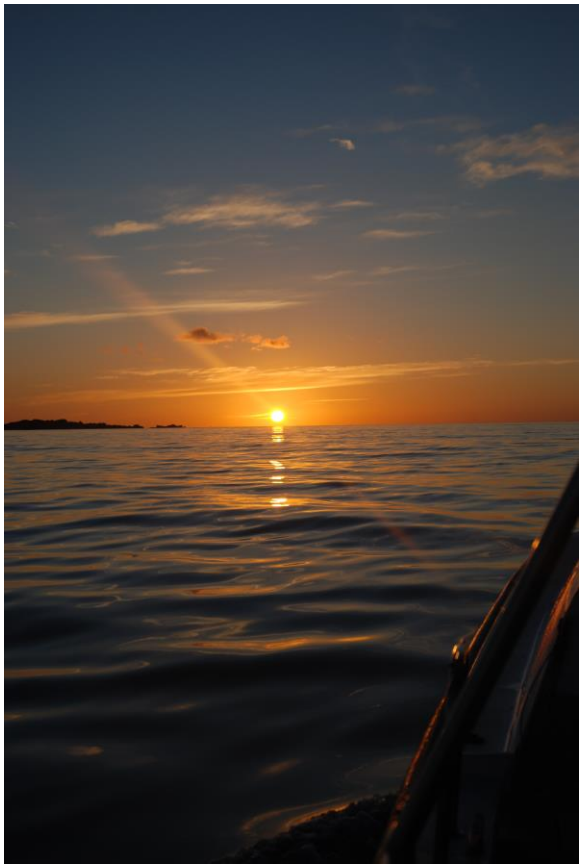
The SOWFIA Project was conceived to help streamline Impact Assessment for Wave Energy. As the project draws to a close in 2013, the anticipated arrays of wave energy devices to be deployed at the test centres planned for construction at the start of the SOWFIA project in 2010, have not yet materialised. This is partly due to the economic downturn in Europe, partly due to the high cost and remaining technical challenges in wave energy, and partly due to lack of strong political support for wave energy in many countries. However, in 2013, leases have been granted for wave energy projects in Scottish waters, the first commercial arrays in the UK are undergoing consenting applications and many countries are actively adapting their consenting processes so as to be more appropriate for wave energy.

The SOWFIA project is built around consultation and participation with the ocean energy and wider community and analysis of experience gained from wave energy test centres in Europe. It is focussed on non-technical barriers to wave energy and aims to accelerate and maximise learning from these early wave energy test centres in order to help inform and streamline IA for the wave energy industry.

Using the lessons learned from the experience gained in wave energy so far, the SOWFIA project has developed a set of recommendations on three critical themes: Integrated Planning and Administrative Procedures; Environmental Impact Assessment; and Human Dimensions and Consultation. The recommendations are organised according to both strategic and operational levels and are presented as over-arching SOWFIA Recommendations and nationally specific MS Recommendations.

Recognising the need for compilation of wave energy monitoring data, SOWFIA developed the DMP. It provides an effective new web tool giving an up-to-date overview of wave energy projects in Europe, a GIS compatible database for environmental monitoring data at wave energy test centres in Europe and an interactive tool for generating refined data products.

The SOWFIA DMP provides a practical facility for consolidating and analysing wave energy impact assessment data which, together with the SOWFIA and Member State Recommendations, for improved procedures and processes, has the potential to make a significant contribution to the development of the wave energy industry. Coupled with ongoing advances and cost reductions in wave-energy technologies, the work of the SOWFIA project reported in the detailed reports available from the SOWFIA website (www.sowfia.eu) and in this report, provides important information and guidance to assist the wave energy industry to realise its potential energy contribution while safeguarding ecosystems and communities.



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