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Deliverable D.4.4

Interim report

T. Simas, D. Magagna, I. Bailey, D. Conley, D. Greaves, J. O'Callagahn, D. Marina, J.B. Saulnier, J. Sundberg, C. Embling

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Streamlining of Ocean Wave Farms Impact Assessment

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Critical environmental impacts for relevant socio-economic activities and mitigation measures including main conclusions and feedback analysis from Workshop B and analysis of the stakeholder survey

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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 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, on-going 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 approval process streamlining and European-wide streamlining of IA processes, thereby helping to remove legal, environmental and socio-economic barriers to the development of offshore power generation from waves. By utilising the findings from technology-specific monitoring at multiple sites, SOWFIA will 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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Interim report - Critical environmental impacts for relevant socio-economic activities and mitigation measures including main conclusions and feedback analysis from Workshop B and analysis of the stakeholder survey

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01	February 2013	Report outline	Simas, T.	All other partners
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Executive Summary

This report aims to compile the information gathered so far regarding environmental and socio-economic key issues for each test centre under analysis and integrate it with stakeholders opinions collected during Workshop B and the stakeholders' survey for each test centre (Deliverable 4.3). For that purpose the environmental key issues for each test centre have been reviewed using the EIA reports available so far.

The comparison of EIA results for the six wave energy test centres reveals some commonalities on the environmental descriptors and impact evaluation. The same environmental descriptors have usually been identified for most but not all test sites (i.e. benthos, marine mammals, avifauna, coastal processes and water quality). Perhaps surprisingly, potential impacts on fish and elasmobranches have only been looked at for a minority of test centres. Even though the classification of impacts in the EIAs for the different test centres is different, the significance of an impact is generally linked to whether and how quickly the original site conditions can be restored and often linked to the magnitude of the habitat or species population potentially affected in comparison to the overall size of the habitat or species population. The significance of a potential impact is also determined by comparing the potential effects from the wave energy test centres with effects caused by naturally occurring phenomenon. The impacts identified are generally not significant, sometimes after mitigation. The most significant impacts are those which are associated with the installation phases 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 not significant even though it is recognised that potential impacts are largely unknown. Some differences in impacts evaluation occur often because of this uncertainty over impacts and sometimes due to site sensitivity. Given the low expected impacts of test centres on most of the environmental descriptors, mitigation measures are not overly onerous and often aim to be preventative. These mostly take the form of good practice during construction, good project management, contingency planning and avoiding certain construction operations at sensitive periods. To deal with the uncertainty of impacts evaluation, monitoring plans have been proposed but the exact nature of these (e.g. objectives, methodologies and duration) are not however specified.

The main socio-economic issues identified in the review were impacts on fishing, navigation and tourism. This is in agreement with the key socio-economic issues identified in the second SOWFIA workshop and the stakeholder survey. Consultation with stakeholders groups prior to the design of test centres layout has been identified in the EIA reports as an effective measure which the test centre developers undertook to mitigate stakeholders' concerns. The potential for positive socio-economic impacts is also highlighted in some of the EIAs. These include the direct and indirect creation of employment, increased tourism and the potential for increased fish stocks due to the creation of no take zones. There was however an important warning that potential benefits from developments should not be oversold in order for stakeholders' trust to be retained.

Guidance can be taken from this work regarding the environmental descriptors and socio-economic issues that may be assessed in commercial scale projects in the future even though these are likely to require assessment on a larger scale. Similarly, guidance can be taken on the types of mitigation measures that may be required from commercial scale projects although it is uncertain how these will scale up. Once more is known about the environmental and socio-economic impacts of wave energy developments, assessment requirements, mitigation measures and stakeholder opinions may change considerably. Indeed, in the stakeholder surveys, concerns were expressed that test centres were relatively small facilities and consulted stakeholders stressed that this should not be automatically taken as acceptance of commercial scale ocean energy sites.

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Glossary of terms

EIA: Environmental Impact Assessment

EMF: Electromagnetic fields

ES: Environmental Statement

FAD: Fish Aggregating Devices

MRE: Marine Renewable Energy

WECs: Wave Energy Converters

Foreword

The current report presents the interim review of WP4 work on "Integration and Streamlining". This work package aims:

- To integrate environmental data from wave energy sites in a data management platform that is intended to help decision making surrounding ocean energy projects;
- To understand project developers' frustrations and stakeholders' concerns during wave energy licensing procedures;
- To provide good practice examples and recommendations for streamlining consenting procedures of wave energy developments across Europe.

Purpose of this document within the SOWFIA Project

This report aims to compile the information gathered so far regarding environmental and socio-economic key issues for each test centre under analysis (Deliverable 4.1) and integrate it with stakeholders opinions collected during Workshop B ("Taking wave energy forward: implementation and community integration") and the stakeholders' survey for each test centre (Deliverable 4.3). Comparing environmental and socio-economic data from different test centres will enable conclusions to be drawn regarding the EIA process and socio-economic sensitivities. These conclusions together with the review of the licensing procedures in each test centre (SOWFIA Deliverable 4.5) will allow final SOWFIA recommendations and strategies to be devised towards streamlining the consenting process for wave energy schemes (SOWFIA Deliverable 4.6).

1 Introduction

Although potential environmental impacts of ocean energy have already been identified (e.g. Inger et al., 2009; Langhamer et al., 2010; Kadiri et al., 2012; Frid et al., 2012) the high level of uncertainty regarding real effects of technology on the marine environment is widely recognised. Monitoring results are scarce due to 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 programs for the collection of significant amounts of environmental data in order to enable regulatory authorities to make informed decisions on the proposed project and its potential environmental impacts.

The EIA requirement for ocean energy projects varies throughout the EU. In some countries is categorically necessary for all ocean energy projects and in others is dependent on the nature, size and location of the proposed development (O'Hagan, 2012). However, 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 / will be installed for demonstration. In general, many of these European test centres are pre-consented, meaning that developers do not have to go through a full consenting process providing a limited number of permit requirements are fulfilled including an environmental appraisal, which is usually less onerous than a full EIA. Furthermore, the designation of each of these test centres normally includes the identification of the environmental sensitivities at the site and or the possible environmental impacts of the test centre development in Environmental Characterisation or in EIA reports which are usually made available to developers.

Test centres can thus be considered as "environmental research centres" for the effects of wave energy on key environmental descriptors, the application of monitoring methodologies, analysis of monitoring results and effectiveness of environmental mitigation measures. Environmental data sets for some of these wave energy test centres exist and have been compiled in a Data Management Platform (DMP), an interactive database developed as part of the SOWFIA project (www.sowfia.eu/) from which users can download several types of environmental data or information for six wave energy test centres in Europe.

1.1 Objectives and report structure

As an interim report of WP4, this deliverable aims to compile the information gathered so far regarding environmental and socio-economic key issues for each SOWFIA test centre (Fig. 1) and integrate it with stakeholders opinions collected during Workshop B ("Taking wave energy forward: implementation and community integration") and the stakeholders' survey for each test centre (Deliverable 4.3). Comparing environmental and socio-economic data from different test centres will enable conclusions to be drawn regarding the EIA process and socio-economic sensitivities. These conclusions together with the review of the licensing procedures in each test centre (SOWFIA Deliverable 4.5) will further allow recommendations and strategies to be devised towards streamlining of consenting processes for wave energy schemes (SOWFIA Deliverable 4.6).

The report presented herein has five main sections which are described as follows:

1) Key environmental issues for each test centre
2) Relevant socio-economic activities in test centres' areas

3) Identification and analysis of proposed mitigation measures
4) Stakeholders feedback on critical impacts and mitigation measures
5) Conclusions

The information presented in the first three sections of the report is based on the review of the EIA reports for each test centre (when available) and /or on other available information such as test centre reports and the Data Management Platform. In Section 4 the information collected during Workshop B is analysed in the light of the environmental and socio-economic key issues compiled in previous sections. A final section on conclusions is presented.

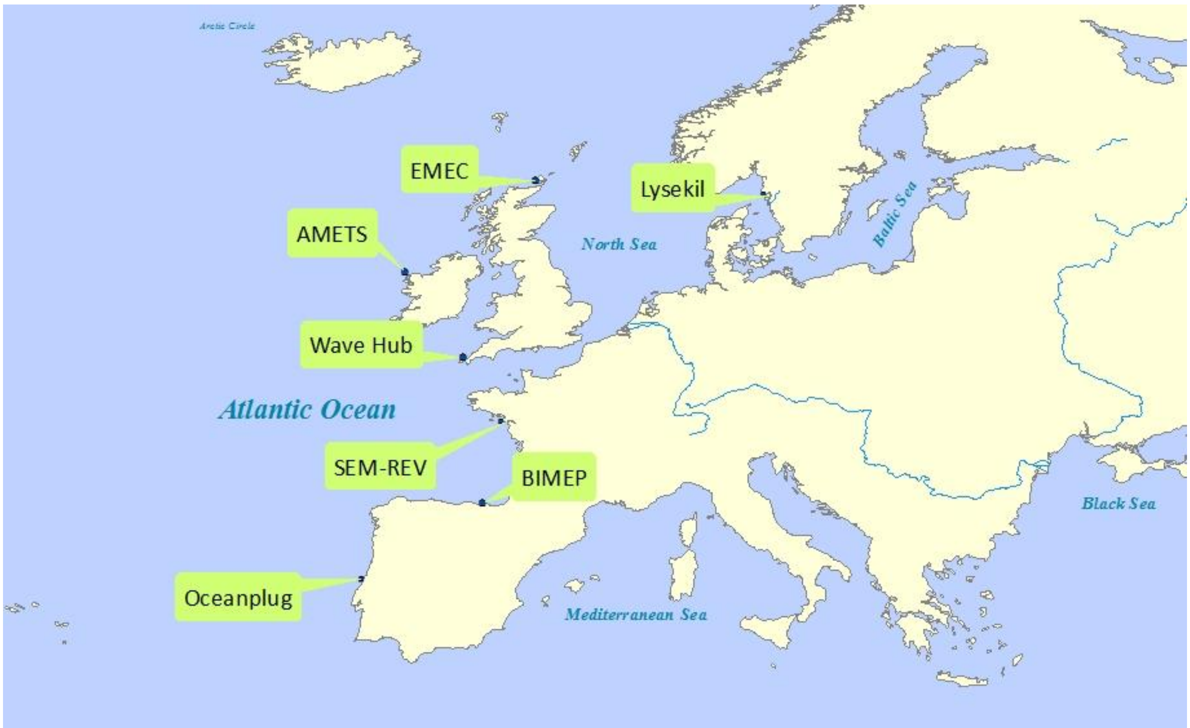

Fig. 1 – Location of the wave energy test centres under analysis.

2 Key environmental issues and mitigation measures

Most part of the information presented below on environmental impacts is based on field work surveys conducted for each test centre under the EIA process or during the environmental characterisation needed for test centre licensing (in the case of Ocean Plug). All the available data have been compiled during the SOWFIA project in a Data Management Platform (DMP) available from the project website[1]. Details on the methodologies used to collect the data and a proposal have been also reviewed and are one of the main outputs of the project WP3 (Deliverable 3.5 available in the project website).

[1]The Data Management Platform (DMP) can be accessed from the project website or directly through the url: http://sowfia.hidromod.com/ManageData/Account/Login.

2.1 AMETS

2.1.1 Brief description of test centre infrastructure

The Atlantic Marine Energy Test Site (AMETS), located off Belmullet in North West of County Mayo on the west coast of Ireland, consists of two offshore test areas for testing wave energy devices. The first, Test Area A, is located in 100 m water depth, 16 km from shore and is 6.9 km^2 in area. The second, Test Area B, is located in 50 m water depth, 6 km from shore and is 1.5 km^2 in area. Two subsea cables from each of the test areas will connect them to shore. The cables will be buried to an average depth of 1m. The cables cross an area of rocky seabed for a distance of 4 km and in this area the cable will be protected by using rock armour or other suitable means of protection. Onshore, the installation of a land-side cable transition joint bay will allow the connection of submarine electricity cables to land-side electricity cables. The land-side underground cables will be connected to the substation, which will be built on a two acre site, and a 10/20kV overhead line will connect the substation to the electricity network. Oceanographic monitoring equipment has been deployed in both test areas, including a Met Ocean buoy and an ADCP on the seabed in Test Area A and a Waverider buoy in Test Area B. Special marker buoys have been deployed to prevent collisions with this equipment. There are plans to deploy a small amount of additional monitoring equipment and marker buoys in the two test areas and at one location at 20m water depth outside of the test areas. Once the test site is operational, wave energy converters (WECs) will be deployed at the test areas. These WECs will either be towed or shipped to site using tug boats or barges; the WECS will then be anchored and connected to the submarine electricity cables. The maximum capability of the test site is for ten WECs to be deployed at Test Area A and for two WECs to be deployed at Test Area B.

2.1.2 Environmental Impacts

The possible environmental impacts of the development were examined in the Environmental Impact Assessment (EIA) for AMETS. Significant impacts were examined by assessing the environment in terms of existing conditions, the impact of the proposed development and the measures taken to mitigate these impacts. The remainder of this section outlines the main potential environmental impacts of the AMETS development.

2.1.2.1 Physical environment

Water quality

The main effects on water quality are expected to be due to suspended sediments during cable burial and anchoring operations. These are expected to settle quickly and there will only be a temporary and insignificant effect on water quality. There is a risk of accidental oil pollution should there be an accident involving vessels being used in the construction or operation phases. There is a risk of silt entering the local drainage system, the risk and impact of which can be minimised. Overall, the effects of deployment and operation of AMETS are not expected to have any significant effect on water quality during construction, operation or decommissioning.

Soils, geology and groundwater

It is not expected that the deployment or operation of AMETS will have any significant impact on soils, geology or groundwater during construction, operation or decommissioning. The construction of the land elements of the project presents limited risk to groundwater quality, the risk and effects of which can be minimised.

Air quality and climate

The impacts on air quality and climate can be considered to be negligible, both in the national context and in the immediate receptor area.

Coastal Processes

It is expected that the impact of wave energy converters when deployed at the test areas would be insignificant in comparison to the natural processes occurring in the bay. No significant impacts on sediment transport, coastal landform or surfing waves are expected.

2.1.2.2 Flora and Fauna

There are no designated areas in the marine environment at the location of the test areas or along the cable route. However, the submarine cable comes ashore at Belderra Strand which is a Special Area of Conservation (SAC) and there is a protected habitat in the marine environment comprising of reefs in Test Area B. Close to the test centre there are a number of designated sites including a number of Special Protected Areas (SPAs) under the EU Birds Directive and SAC areas including one important for its birds and grey seal breeding population. The EIA examined the impacts from the development on flora under five categories: Subtidal, Intertidal, Marine Mammals, Avifauna and Terrestrial. The impacts from the development on each of these categories are outlined below.

Benthos

The general effects of the development on reef habitats are likely to be a temporary increase in sediment displacement during the cable burial process. This is unlikely to have any more effect on the subtidal communities than a natural storm event would have. The greatest potential for impact on subtidal benthos is the creation of artificial reefs. These reefs could fragment benthic communities or provide a habitat for predatory species which could impact benthic communities. The creation of the artificial reefs could also increase biodiversity in the area although the extent of this is expected to be small in the context of the total available habitat.

It is expected that any impacts on the intertidal area will come from the construction phase. Surveys indicated an extremely low diversity of species and biomass in the intertidal area. This is indicative of the harsh environment of the area. The impact of the development on the intertidal zone is expected to be low and over a small area and full recovery is expected within one year of construction.

Marine Mammals

The North West Mayo coast has a long association with marine mammals. During the EIA marine mammal surveys, cetaceans (whales, dolphins and porpoises) were recorded throughout the year with common dolphin and porpoises particularly abundant and bottlenose dolphins abundant in summer and autumn. Some species such as minke whale were only present in the summer.

AMETS is a relatively small area when considering mobile marine species such as marine mammals. It is thought that the construction phase is likely to be the most disruptive to marine mammals due to increased noise and boat traffic. Of the species recorded in the area, porpoise are likely to be the most sensitive to disturbance, and actively avoid vessels because they are sensitive to high frequency sounds. The impact is however not expected to be significant and mammals are expected to return to the area once construction has been completed.

Operational impacts on marine mammals presented in the EIA are speculative but are not expected to be significant. Potential impacts identified include the risk of collision with WECs or their anchoring systems, disturbance from underwater noise and effects associated with EMF.

Sea birds

There are a number of SPA designations protecting birds in the areas surrounding AMETS. Important species and species groups that use shore habitats in the area are wintering waders, common sandpiper and ringed plover. The use of the shore habitats by flocks of roosting gulls and by waders during the summer months is also of note. Near shore regions are used by a range of birds including wintering waterfowl and foraging seabirds. Of note are Birds Directive Annex 1 species, great northern diver and eider duck. Long tailed duck regularly occur in nationally important numbers in the area and large flocks of Manx shearwater were also recorded. Annex 1 species, Arctic tern, little tern and sandwich tern, were recorded during the breeding season. Gulls, shags and auk species also breed locally. Species that breed at nearby colonies were present during the breeding season including auks, terns, gulls and fulmars. Storm petrels were identified on Inishglora, an SPA near AMETS. Passage migrants such as great skua and great and sooty shearwater were present during the autumn.

Again potential impacts on birds from AMETS are speculative but it is expected that these can be minimised. The impacts will vary depending on nature, age and reproductive stage of the species. The main potential for impacts is similar to those for marine mammals and comes from physical disturbance, risk of collision and noise disturbance. There is also the potential for entrapment of diving birds within WEC structures.

Protected areas, habitats and species

There were no rare or protected species recorded during terrestrial surveys of areas affected by the AMETS development. The principal impact will be the loss of semi-improved agricultural grassland but this is not of conservation interest and only two acres will be affected.

2.1.3 Mitigation measures

The environmental mitigation measures are presented for the construction phase followed by those for the operational phase. Most of the mitigation measures for the decommissioning phase are common to those for the construction phase.

2.1.3.1 Construction Phase

Many of the mitigation measures for environmental impacts are common to different receptors. To minimise impacts on flora and fauna, it has been stated that the development footprint should be as small as possible and the development should be carried out as efficiently as possible in the shortest possible timeframe. Materials used should be suitable for use in the local environment. For onshore and offshore works, care must be taken to ensure that no oils or hydraulic fuels are allowed to leak from machinery or vessels. All machinery and vessels are required to have an oil pollution emergency response plan and carry emergency response equipment and be prepared to clean up accidental spillage and dispose of contaminated material in accordance with best legal practice.

A number of mitigation measures are required for the submarine cable laying operation. To minimise impacts on subtidal benthos it has been stated that the cable should be buried deep enough so that it cannot cause any potential warming of the superficial sediments. Ploughing has been stated as the preferred method of cable laying. It is stated that trenching should be avoided in areas favoured by the foraging long tailed duck. Marine mammal observers should be present during the placing of rock armour on the submarine cable to ensure there is a minimum distance between the vessel and marine mammals while the placing of rock armour should avoid areas where winter and spring moulting occurs. An ecologist should be present during the cable laying operations in the intertidal area to avoid disturbance of the beach. To minimise effects on intertidal avifauna, cable laying operations in this area should take place in summer months. To minimise EMF effects, it has been stated that the AMETS cable should be buried to a minimum depth of one metre to reduce magnetic field from the cable while the magnetic fields should be limited by cable technical design. Terrestrial impacts can be minimised by using best construction practices.

2.1.3.2 Operational Phase

During the operational phase, the impacts are less certain. Many mitigation measures again focus on minimising the risk and potential impacts of oil or hydraulic fluid spills from WECs and service vessels. The amount of antifoulants used on board WECs should also be strictly controlled to prevent the accumulation of antifoulant sediments. The design of WECs used at the test site should be such so as to minimise the risk of collision or entrapment of avifauna.

Many of the impacts of wave energy converters are uncertain. To mitigate this uncertainty, a critical remit of the AMETS Management Organisation is environmental monitoring, once the test site has been established. This monitoring will include monitoring the potential effects of antifoulants on adjacent biota, ongoing monitoring of marine mammal activity in the vicinity of AMETS and monitoring of interactions of birds with WECs to determine if unforeseen impacts are occurring.

2.2 BIMEP

2.2.1 Brief description of test centre infrastructure

The Biscay Marine Energy Platform (BIMEP) is an open-sea test facility developed to demonstrate wave energy devices and conduct further research. Located off the coast of Armintza (Bizkay), it occupies a 5.3 km^2 marked area excluded for navigation and maritime traffic, with a depth of 50-90m and placed at a minimum distance of 1700 m from shore, close enough for fast access to deployed devices. The total power of 20 MW is distributed over four offshore connection points of 5 MW each.

2.2.2 Environmental Impacts

To make an environmental inventory of the natural environment potentially most directly affected, and to establish the existing ecological interactions some *in situ* campaigns were carried out to characterise the seabed morphology of the studied area, the sediments, the benthos communities and the hydrodynamics.

Each of the identified potential environmental impacts was classified as follows depending on their expected severity:

- Compatible environmental impact: impact that can be recovered immediately after the activity is ceased and that does not need any protective or preventive measure.
- Moderate environmental impact: impact that can be recovered without any protective or corrective intensive practices, but in which recovering the initial environmental conditions may take some time.
- Severe environmental impact: impact that needs some adequate protective and corrective measures to recover the initial environmental conditions and in which, despite these measures, recovery takes significant time.
- Critical environmental impact: impact of magnitude greater than the acceptable threshold. It produces a permanent loss, which cannot be recovered even after undertaking protective or corrective measures.

2.2.2.1 Physical environment

Hydrodynamic (waves, currents and tides)

No significant impacts are expected from the installation and decommissioning of the submarine cables or the WECs. The possible reduction in energy of the wave climate at the coast due to removal of energy by WECs, was considered a compatible impact. The possible alteration of the ocean currents due to the submarine cable was also classified as a compatible impact.

Water quality

Apart from accidental collisions or device break up, both of which are expected to be rare occurrences, the possible damage caused to the water quality during the installation, functioning and decommissioning of the WECs is considered to be minimum. The impact is considered to be compatible. The installation and decommissioning of the subsea cable will result in a suspension of the seabed's sediments which can have an influence on the waters optical characteristics and on phytoplankton development due to the lack of light but these impacts were considered to be limited and were classified as compatible. The power flow through the umbilical cable of the WECs may result in an increase in temperature of the water but this is also considered to be a compatible impact.

Sediments

Two thirds of the seabed of the area occupied by BIMEP is predominantly sedimentary and the other third is predominantly rocky. The moorings of the devices placed at BIMEP were not supposed to be removed after the testing period. The accumulation of these moorings over a period of 5 years could change the substratum and this is considered to be a severe impact.

2.2.2.2 Flora and fauna

Benthos

The installation of the cables and the moorings will result in suspended sediments in the water, which could damage benthos communities. This has been classified as a moderate impact. Even if the moorings at the seabed may facilitate the recovery of some damaged communities, the dragging of the anchors or of the moorings can harm the fauna and the flora of the area. This impact is considered severe. Another severe impact caused by the functioning of the WECs and by their moorings is the fact that the height of the waves will be reduced and as a consequence the waves arriving at the coast will be smaller affecting the biomass of the coast.

Fish and shellfish

It is considered that the installation and decommissioning of the cables and the WECs and the operation of the WECs will produce vibrations and noise that will have a moderate impact on fish species. The operation of the cables can involve changes in the electromagnetic fields and this has been classified as a severe impact.

Marine mammals

Vibrations and noise produced during the installation and decommissioning of WECs and cables are expected to have an impact on marine mammals. It is expected that vibrations and noise produced by WEC operation will have less of an impact. Protected marine mammal species have been identified in the area and so these impacts are defined as severe. The impacts on marine mammals due to the electromagnetic fields around the subsea cable are also considered to be severe.

Sea birds

Birds can be affected by sounds and vibrations during the installation, operation and decommissioning of both cables and WECs. These impacts together with a possible disturbance when installing cables and WECs during the nesting time are classified as moderate.

Protected areas, habitats and species

While accidents are possible during the installation or decommissioning of WECs and cables, no significant impact is expected to protected environmental areas. The presence of a WEC just above the so-called 'Isla de las lubinas' may result in damage to the flora and fauna of this unique area of the Basque Country and this is considered to be a moderate impact.

2.2.3 Mitigation measures

A very important aspect to consider about mitigation measures is the temporal scale of their application. It is very prudent to carry out them out as soon as possible in order to avoid secondary impacts. It is better to avoid an impact rather than establishing a protective or corrective measure because these measures require additional cost in terms of time and money and sometimes only a part of the alteration is corrected and new impacts can be created.

2.2.3.1 Installation and decommissioning of WECs and submarine cables

The following measures should be taken so as to reduce the acoustic impact the installation of moorings can cause on fish fauna and marine mammals:

- A correct size of the moorings and the machinery required for their installation;
- To carry out a progressive installation;
- Avoid installations during marine mammals' breeding periods;

- During installations an observer should be present to detect the presence of marine mammals in the area;
- Decommissioning of the moorings after the test period;
- Reuse the existing moorings whenever it's possible;
- The cable laying should be done over sedimentary seabed avoiding rocky zones;
- The cable laying should be placed at a minimum distance of 100m from singular elements such as 'la isla de las lubina'.

2.2.3.2 WEC's maintenance

A maintenance plan for each project to be installed should be established. There should be continuous monitoring of the devices and contingency plans should be drawn up to take account of different risks such as loss of data, problems with connectors and cables, etc. Rules regulating the oils of hydraulic motors and antifouling paints should be respected.

2.2.3.3 Contingency plans

To minimise the potential impacts of the project on the water quality in case of accident, for example device break up in rough weather, the development of a contingency plan is recommended summarizing the responsibilities and tasks to be carried out in case of emergency.

2.3 EMEC

2.3.1 Brief Description of the test centre infrastructure

The EMEC concept was developed in 1999, when the UK ministerial task force responded to a growing need for a dedicated test site for Marine Renewable Energy Installations to aid the industry in the development of wave and tidal devices. EMEC now comprises a Wave Test Site (WTS), a Tidal Test Site (TTS) and two Nursery Sites (NS), one for wave and the other for tidal device testing. The EMEC wave test site was built in 2003 and it is placed on the western end of Orkney Mainland at Billia Croo, and it is equipped with 5x11kV subsea cable located approximately 2 km from shore.

2.3.2 Critical environmental issues

Many wave energy devices have been tested at EMEC since 2003, and guidance is offered by EMEC to device developers when applying for a Marine Licence. In 2009 EMEC and Scottish Natural Heritage produced a document highlighting the key environmental issues to be assessed when submitting an EIA. These are also given in the guidance document provided by EMEC to developers[2] (Table 1).

[2] http://www.emec.org.uk/download/Environmental-Documentation-Guidance.pdf

Table 1 – Critical environmental issues at EMEC.

Impact	What should be considered/ Why it is important?
Ecological and tidal energy balances and flows	Consequence of energy extraction and physical presence of devices in the sea should be assessed, e.g. changes in vertical mixing, may lead to changes in currents, offshore and coastal habitats/features, and knock on effects to biological communities present (see 7).
Disturbance to seabed habitats	Anchoring, mooring/foundation installation operation and maintenance equipment and other seabed disturbances can lead to disturbance/destruction of seabed habitats, which may have a knock on effect on wildlife
Disturbance to water masses	The scale and implications of changes to such factors as nutrients, temperature, light levels, turbidity (suspended sediments), surface waves and current patterns should be considered.
Shoreline disturbance	Activities that have the potential to cause change to the coastline either directly or indirectly such as erosion/deposition through changes in tidal energy flows, changes in character, etc, , should be considered.
Disturbance of landward areas	Siting of any onshore activities/works should avoid onshore habitats and species important from a conservation perspective and minimise the loss of natural habitat and protected species
Behavioural changes in wildlife	Test activities have the potential to affect the distribution of wildlife. The potential influence of activities and facilities upon wildlife, in particular those protected by European Directives and national legislation (see also issue 7) should be considered.
Impacts on conservation areas/protected species	Any impacts on designated conservation areas and protected species of international, national and local significance must be fully considered. For example European Protected Species, Natura Sites, other protected species such as seals, etc.
Contamination of water, seabed and wildlife (inc fish stocks)	Contamination may result from effluent discharge, chemical discharge / leaching / leaks, oil discharge / leaks, sewage discharge, dumping of waste etc. All potential sources, planned or accidental should be considered.
Wildlife entanglement, entrapment and collision	The potential for damage and entrapment of wildlife in particular marine invertebrates, fish, mammals and birds, should be addressed in relation to structure, operation, season, and location. Impacts may include entanglement or collision with any blades/rotors, jamming in joints, entrapment etc.
Underwater noise, light and vibration	Test devices and associated activities are likely to give rise to noise, light and other disturbances that may disturb and affect the behaviour or the well-being of marine life. Although the exact cause and effect relationships can be difficult to determine, there is keen interest in this issue with regulators and stakeholders. Any effects should be minimised.
Airborne noise, light and other nuisances	Airborne noise, light and other nuisances can affect wildlife (potentially offshore, coastal and onshore) and impinge upon coastal resident communities and recreational activities. Any effects should therefore be minimised.
Electromagnetic and electrical effects	Some organisms e.g. elasmobranches fish (sharks, rays and skates), are particularly sensitive to electric and electromagnetic fields generated from electric cables. Consideration of this needs to be given.
Greenhouse gas Emissions	Consideration should be given to potential greenhouse gas emissions e.g. from fuel use etc.
Visual and landscape impacts	Devices visible from the coast and at sea may affect the landscape qualities of particular views. Factors (within navigational requirements) that help structures blend in with or enhance the landscape are important. This can include colour, orientation, structural design, materials etc. Consider visibility distance of lights and ensure compliance with Northern Lighthouse Board (NLB) requirements.

2.3.3 Mitigation measures

The guidelines provided by EMEC to device developers indicate that mitigation measures should be presented for each potential impact evaluated, and for each different phase of the project: installation, operation, maintenance and decommissioning. Mitigation activities are device specific and are therefore contained in the EIA report issued as part of the licensing process by each developer (e.g. Aquamarine Power[3]).

2.4 Lysekil

2.4.1 Brief description of test centre infrastructure

The Lysekil project, located within the municipality of Lysekil (ca 100 km N Gothenburg) in the Västra Götaland region, has been an active test centre since 2004. The site was mainly started as a field test centre for the point absorber WEC design first developed at Uppsala University. The Lysekil site is approximately 40,000 m^2 in area, located in 25 m depth on a seabed of mixed silt and sand.

Several smaller harbours exist in the vicinity of the test site. For large scale deployments the harbour in Lysekil, about 4 km north of the test centre, has been used as a base for larger work at the site.

The test centre was only approved of by the regional authorities. No full scale EIA was needed and only a limited number of consultations were required. This is due to a special paragraph in the Environmental Code (Chap. 11 and 12) allowing small projects to start up as no interference with other activities were foreseen and as no party objected. A number of additional permissions were later asked for, including a sea cable, an observation tower with video monitoring, two subsea transformer stations etc. A measuring station was also built on a nearby island, were the cable came onshore and were grid connection is prepared for. In 2004, a Wave Rider buoy was installed, continuously feeding data online. Two separate signal cables are now in place as well as a 240V power feeding line. The main permission allowed 10 generators and 30 dummy buoys for marine ecological studies. The Swedish Maritime Administration is serving two 6m sea markers, denoting the south and north boundaries of the area.

Especially during the first years the project received laboratory and logistic support from the nearby Sven Lovén Centre for Marine Sciences, Kristineberg. In addition, the Geological Survey of Sweden conducted a seabed survey in 2005.

During the almost ten years of operation, eight different generators have been tested, at the most six of these at the same time, and 25 smaller buoys used simultaneously.

By the end of 2013 most permits will have to be extended. Therefore, a large application will be produced and a number of consultations will be performed during the year, including a newly produced EIA and a consultation process. An application will then be sent in to the Environmental Court before the end of December 2013, and hopefully a new and extended consent will be accepted in 2014. This new consent will also include an enlarged area of use and possibilities of extended field tests, including equipment and tests from other ocean energy projects.

[3] http://www.aquamarinepower.com/sites/resources/Reports/2879/Oyster%202%20Array%20Project%20ES%20-%20Non-Technical%20Summary.pdf

2.4.2 Environmental Impacts

The light consenting process for the project was a consequence of little or no impact being foreseen from WEC's and other project equipment. The area has no greater, or special marine values and was irregularly used for commercial fishing (trawling). Also, a coastal shipping lane passes nearby; a lane mainly used in the summer time by leisure boats. Consequently, the area was quite disturbed before the start of the project. However, the project site is just within, or on the southern border of the Gullmarfjorden Natura2000, a reserve mainly set aside for the Gullmaren fjord, the largest in Sweden. The project site may be considered not to affect the fjord area itself. Also, on the nearby island where a measuring station is set up a Natura2000 site is located, but this is set aside mainly for the geomorphology of the area and the scenic quality of west coast islands. The project was not considered to have an influence on the main objectives of the reserve.

2.4.2.1 Physical environment

Water quality, geology and coastal processes

The project area is affected by a northern current, sometimes at a speed of up to 2 m/s. Natural sedimentation often makes the waters very turbid. Neither of these factors was expected to be affected by the project in any significant manner.

Buoys, and other equipment, are affected by bio fouling. Studies have shown that this results in an increase of sedimentation around and nearby WECs (on the seabed). Continuing studies are investigating this development but the effect is considered to be local only and should be compared with other, similar and common natural occurrences in waters, in general.

2.4.2.2 Flora and fauna

Apart from the Natura2000 areas mentioned above, the Lysekil site and its surrounding areas are not known to host species of special interest, or at least not any which are being affected by the project. On land the measuring station is located in an area of considerable human activity with several summer cottages nearby. The fact that part of the Natura2000 site on the island was located in an old built up area further indicates that the site was designated on other grounds rather than species protection. A brief inventory of the flora along the on land cable route only revealed common and typical species for that environment. In addition there were neither any mammal or bird species that required special caution. The island only hosts common species such as hares, rodents and occasionally foxes. The avifauna at the site is composed of common species. An archaeological survey along the 250 m on land cable route was done in 2004, revealing nothing of interest.

Marine Mammals

The Swedish west coast only hosts a small number of marine mammal species, only a few of which can be seen in or around the project area. The most commonly seen mammal is the harbour seal which breeds and hauls out on nearby islands. This species is regularly seen swimming in the project area. Although harbour seals are red listed, as vulnerable, it is common in the area and no special concern in relation to the project site was given. Harbour porpoise is the second species to be mentioned, also listed as vulnerable, but is less seldom observed in the area. One observation of a harbour porpoise swimming through the project area was made during the project. No special concern for these two species was indicated for the project site by any consulting parties.

Sea birds

The area was not and is not known for special bird species or populations but has a typical species composition of both sea and terrestrial birds. A colony of cormorants breeds on a nearby islet but appears not to be affected. Some seabirds, eider and guillemots, are sometimes seen swimming and feeding in the project site but appear not to be disturbed. Eiders have been observed feeding on bio fouling blue mussels growing on buoys and other equipment. Many species of birds, land and seabirds, are commonly seen resting on the buoys in the project area, when deployed.

2.4.3 Mitigation measures

As little or no impact was foreseen to result from the project very few restrictions were set upon the work and activities related to the test site. However, the project has been dependent on several smaller consents, e.g. restricted to specific equipment being deployed. A general condition for deployment has been to avoid major work at the site during biologically sensitive periods (spring and early summer).

As one aim of the project, and the test site, has been to investigate the impact on and from the marine fauna and flora, studies have focused on e.g. biofouling and colonisation patterns, artificial reef effects and noise emissions. Results strongly indicate that many organisms actually are favoured by the test site and its equipment resulting in higher biomass and species occurrences in the project area compared to surrounding areas.

2.5 Ocean Plug

2.5.1 Brief description of the test centre infrastructure

The Portuguese Pilot Zone more recently renamed as Ocean Plug – Portuguese Pilot Zone, has been limited in the national law in 2008. It is located at a distance of about 5 to 8 km off the coast of the Leiria district and has an area of about 320 km^2. It is intended that Ocean-Plug will enable the technology to evolve from demonstration to commercial scale and thus the area will be equipped with a test site zone for demonstration projects along with infrastructure for the installation of commercial projects. The regulations for using the area are under development, and will soon be available, allowing, at the first stage, the installation of demonstration projects without grid connection.

As a designated area, which will be managed through a concession regime, the required environmental assessment of the Ocean Plug is a baseline geophysical and environmental characterisation which has to be carried out prior to the test site infrastructure installation. An EIA will also be required for each project to be installed there. To date, data for hydrodynamics, seabed sediments, seabirds and marine mammals have been collected and a yearly monitoring program is being developed for data collection to complete the information already gathered. The main conclusions taken from the analysis of the information collected are summarised below.

2.5.2 Key environmental aspects

2.5.2.1 Flora and fauna

Marine mammals

Boat-based surveys for the identification of marine mammals in the Ocean Plug area were made using a line-transect method. The results indicated the presence of the common dolphin (*Delphinus delphis*) over the whole area with an abundance that varies from 3 to more than 20 individuals per point. Barrier to movement, disturbance / displacement and noise were the main potential adverse effects reported to affect the population of common dolphins in the Ocean Plug area due to wave energy activities.

Sea birds

Visual observations of seabirds during the summer campaign carried out in 2011, indicate the presence of 15 different species. The most abundant were the balearic shearwater (*Puffinus mauritanicus*), the cory's shearwater (*Calonectris diomedea*), the gannet (*Morus bassana*) and the yellow-legged gull (*Larus michaellis*). According to the IUCN conservation status, the Balearic shearwater is classified as a critically endangered species. This classification corresponds to a drastic reduction of the population numbers during the last years, the cause of which is thought to be mainly related to mortality in the breeding colonies. In the Figueira da Foz IBA, Balearic shearwater mortality is thought to be linked with fisheries by-catch but this still needs to be confirmed. The analysis of the data collected for this species in the Ocean Plug area determined the dominance of non-breeding birds flying above the collision risk height. Wave energy activities in the Ocean Plug area have been reported to potentially affect this species in terms of disturbance / displacement and/or "barrier effects" since this is a migratory species.

Protected areas, habitats and species

There is a partial overlap of the Ocean Plug with an area classified as "Important Bird Area": IBA of Figueira da Foz (PTM01). Important Bird Areas are key sites for conservation, small enough to be conserved in their entirety and often already part of a protected-area network. Although these areas do not have a legal context, they are supposed to be included in the Natura 2000 network of the country. The IBA of Figueira da Foz has significant numbers of the globally threatened species Balearic shearwater (*Puffinus mauritanicus*). This species occurs in coastal shallow waters from 10 to 70 m water depth (25 km from the coast).

2.5.3 Mitigation measures

Since no EIA is going to be carried out for the entire Ocean Plug area, mitigation measures will only be evaluated for environmental and socio-economic impacts within the EIA process for each project to be installed.

2.6 SEM-REV

2.6.1 Brief description of test centre infrastructure

SEM-REV is a fully equipped wave energy test facility intended to test and improve the efficiency of Wave Energy Converters (WECs) and floating wind turbines at an early stage of development. This test facility aims to help the Marine Renewable Energy (MRE) sector to grow in France and Europe. The SEM-REV test site is located off the cost of the Pays de la Loire region less than 100 km from the city of Nantes. The geographical area of the project was selected based on several feasibility studies involving technical and economical constraints and ease of access. The 1 km wide offshore area is located in the north of Le Croisic peninsula and faces the Guérande Bay. The offshore test zone is located at approximately 20 km offshore from Le Croisic in 35 m of water depth. The offshore facility is connected to the French national electrical network EDF through a 24km-long submarine cable with fibre optics to transmit the energy produced by the devices to the substation.

The construction and operation of the test site encompasses several aspects, namely:

- The coastal electrical connection to the substation, which requires directional rock drilling along a few hundreds of meters from the coast to the near shore zone;
- The submarine cable installation, from the near shore zone to the test site (cable laying and seabed burying along about 24 km);
- Operations at sea including the installation of marking buoys, marine monitoring instruments (meteorological and wave buoys, ADCP), mooring anchors, connection hub and any activity related to device testing and maintenance;
- The refurbishment of the onshore facilities such as the technical and scientific station based in the Penn Avel public park in Le Croisic.

2.6.2 Environmental impacts

The critical environmental and socio-economic impacts for the construction and operation of the SEM-REV have been addressed by a comprehensive study that was conducted in 2010 by the company CREOCEAN for the whole project development. The report (in French, 438pp) considers in particular:

- The initial state of the site and its environment in terms of:
  - Physical environment (seabed geology on the testing site and along the cable route)
  - Local water quality
  - Living environment (macrofauna, marine mammals, avifauna)
- The direct, indirect, temporary and permanent effects of the project on the environment induced during the implementation, the exploration, and the dismantling phases, in terms of:
  - Natural environment (benthos, cetaceans, avifauna, noise, electromagnetic field)
  - Physical environment (sediments, water quality),
  - Human environment (fishing activities and leisure),
  - Landscape and heritage,
  - Protected areas (Natura 2000),
  - Public health and safety (navigation, air quality, noise)

For the purpose of extending the concession to the installation of floating wind turbines a complementary study was required. This was finalized in early 2013 by CREOCEAN, which reconsiders the same aspects as presented here above for the case of floating wind turbines (in French, 289pp). It also completes the first document in accordance with the national authorities' comments.

A landscape study – undertaken by ATILE in June 2012 – is included in the document, which contains:

- The description of the very diversified surrounding landscapes namely the Loire estuary from Rhuys peninsula to Noirmoutier island and the islands of Belle-île-en-mer, Houat and Hoëdic,
- The presentation floating wind device, its shape, advantages and disadvantages,
- The description and analysis of the landscape (visual) impacts of the project based on photomontages of sensitive coastal locations surrounding the site.

2.6.2.1 Physical environment

Water and sediments quality

Water quality alteration due to fluid industrial waste (hydraulics, paints) and turbidity is deemed moderate and temporary using conventional mitigation measures (environmental requirements for such products). Modification of sedimentary dynamics is deemed moderate to negligible due to the small extent of the impacted area, small number of anchors and weak sediment transport locally.

Air quality

Air quality is affected in a very temporary way (only during construction phases, device installation/decommissioning). The support to marine renewable energies is considered as a positive impact in regard to CO_2 emissions.

2.6.2.2 Flora and fauna

The analysis of the natural environment covered benthos, marine mammals, birds, fish and the effects of the project on those descriptors (e.g. noise and electromagnetic fields). The report addresses the destruction of benthic species and micro and macroalgae on the submarine cable's route and on the test site itself, which is deemed reversible and negligible (restricted impact area, conventional anchoring, and positive biomass increase by biofouling on hulls and chains). The physical disturbance of cetaceans, fish and birds is also deemed negligible due to the short duration of works and limited number of devices to be tested (wave energy converters and floating wind turbines). The indirect impact on local water quality is considered as very local and negligible (dilution). Noise and electromagnetic effects are moderate to minor/negligible using ad hoc mitigation measures (e.g. cable sheathing for electromagnetic effects). Counterbalancing effects are expected due to the positive biomass increase (biofouling and fish attraction) and repulsive aspects like noise and electromagnetic fields (still to be studied).

Protected areas, habitats and species

The closest Natura 2000 area to SEM-REV is the zone of the Plateau du Four, located north of the cable route. The destruction of benthic species is deemed reversible, very local and minor. The disturbance of migrating species (cetaceans, birds) is also deemed temporary or negligible as no particular nesting species is present in the area. Impacts of devices' noise and electromagnetic fields are moderate to negligible as explained above, as is the impact for water quality.

2.6.3 Mitigation measures for environmental impacts

Some measures to reduce, suppress, mitigate, control and supervise the impacts during the implementation, the exploration, and the dismantling phases and to protect the environment are reported by CREOCEAN as listed below:

- Health and safety (navigation, waste treatment, e.g. pumping muds during rock drilling for cable connection)
- Moorings specifications (scouring effect)
- Environmental constraints for devices (anti-fouling and anti-corrosion paints, regular maintenance, materials recycling, pollution/accident responsibilities)
- Noise monitoring
- Cable survey and impacts on marine mammals

Most of these measures have been taken into account in the specifications required from the device developers. Noise measurement campaigns in SEM-REV are expected in 2013/2014.

2.7 Wave Hub

2.7.1 Brief description of test centre infrastructure

The Wave Hub wave energy test site is situated 18.5 km offshore from Hayle on the north coast of Cornwall, comprising a 33 kV subsea power cable that runs from a land-based substation to the Wave Hub, an electrical junction box from where four tails extend for future connection with Wave Energy Converters (WECs). The development site supports four bays (1 x 2 km) that can be leased to wave energy device developers for the deployment of WECs. The summary of critical environmental impacts at the Wave Hub is based on the Environmental Statement (ES) carried out by Halcrow (2006) detailing the Environmental Impact Assessment (EIA). Focused research upon biodiversity at the Wave Hub site is also being conducted by the Universities of Exeter and Plymouth (Witt et al, 2012).

2.7.2 Environmental impacts

2.7.2.1 Physical environment

Coastal processes

WECs will remove energy that would otherwise be available for ocean mixing with knock-on effects on a range of processes from biological productivity to regional current circulation. The EIA included wave monitoring at the Wave Hub site continuously for over a year and use of hydrodynamic models. Results showed that waves could be impacted up to 13% at the coastline but more typically by up to 5%, and a minimal impact due to changed sediment transport on beaches should be expected along the northern Cornish coast.

Water, sediment & soil quality

Introducing devices and cable to the marine environment, and the increased associated boat traffic during construction, maintenance and decommissioning were identified as having potential impacts on water, sediment and soil quality. The main concern was that pollution or disturbance of the sediment during construction and decommissioning could impact water and sediment quality. Also re-suspension of contaminated sediment could impact water quality by releasing contaminants into the water column. The survey of water and sediment quality carried out to determine the baseline showed that no impact on water, soil or sediment quality will take place during construction, operation or decommissioning. However the Environmental Statement (ES) suggested that there should be a contingency plan for the risk of pollution due to damage, negligence and/or accidents that could release pollutants into the water column.

2.7.2.2 Flora and fauna

Benthos

The intertidal biotope survey carried out as part of the EIA revealed that the intertidal communities within the cable area were of no particular conservation importance. Any disturbance to intertidal seabed communities due to the installation and decommissioning of the cable was considered to have minimal impact due to rapid recolonisation by benthic invertebrate species from the surrounding area. There was therefore considered to be no significant impacts to the intertidal ecology. The subtidal surveys carried out as part of the EIA identified only two biotopes likely to be affected by the cable burial. Although cable burial would disturb seabed communities within the footprint of the trenching, benthic communities were considered likely to recolonise the site quickly. Also, only a relatively limited area of the two biotopes was likely to be affected, thus the impact was considered to be of minor adverse significance.

Fish and shellfish

The most frequently recorded species was the basking shark, with some sightings of blue and thresher sharks. There is also a limited fishery for skates and rays off the north coast of Cornwall. Basking sharks have a protected listing under CITES (Convention on International Trade in Endangered Species).

The main impact considered to be of concern to elasmobranches in the ES were electromagnetic fields (EMF) generated by the cable. Elasmobranches detect their prey by the electric fields that prey species induce in the surrounding seawater, and thus can be attracted by anthropogenic EMF. The EMF generated by the cable was predicted to be within the range detectable by elasmobranches but is only likely to affect benthic species since the EMF decays rapidly with distance. There was therefore considered to be potential for cabling to impact elasmobranches but that this was unlikely to be significant enough to cause damage. Given the limited zone of influence and the localised nature of the cable EMF, the ES considered the impact on elasmobranches to be of minor adverse significance.

Marine mammals

The main species identified in the vicinity of the Wave Hub included bottlenose dolphins, grey seals, common dolphins and harbour porpoises. The TPOD deployed as part of the EIA showed that the Wave Hub area was used regularly at low intensity by both porpoises and dolphins (the PODs are unable to distinguish between dolphin species). Subsequent data collected by the University of Exeter showed seasonal patterns with porpoises present during the winter months, but dolphins during the summer months (DMP refined data product output – report 3.5). Seal count data showed seals distributed around the Cornish coast with clear seasonal patterns at the largest haul-out site on the north coast of Cornwall, Godrevy, which is also the closest haul-out site to the Wave Hub.

The EIA considered construction and operation noise to be the most significant concern for marine mammals in the vicinity of the Wave Hub. Installation of WEC anchors or moorings is likely to involve either pile driving or seabed drilling for some types of WECs. The ES suggested that smaller piles would be required for WECs than for wind turbines, resulting in lower noise levels. It was predicted that marine mammal avoidance behaviour could occur up to 1 km from the pile driving, and the worst-case scenario (given all berths taken by WECs requiring multiple pile driven anchors) was that this would take place over a maximum of 27 days. As a result of these considerations impact of construction noise on marine mammals was considered to be of minor adverse significance.

There is little available data on operational noise of WECs in order to determine possible impacts on marine mammals. However, WECs do not generally contain mechanical components that require power to function and so were not considered to produce significant noise levels during operation. It was therefore considered unlikely that operational noise would have any significant adverse effects on marine mammals and the impact was classed as negligible. However, given the novel nature of WECs the ES did recommend monitoring despite the low risk.

Sea birds

The main impacts considered by the EIA included: (i) disturbance of both offshore and intertidal birds during construction; (ii) effects on the nearby Hayle Estuary which is a Site of Special Scientific Interest (SSSI) for wintering bird populations and; (iii) impacts on offshore birds due to the presence of WECs.

Low numbers of intertidal birds that were concentrated in the estuary during winter months, but since construction (cable-laying) was only likely to take place during summer months, no significant impact on intertidal birds during construction or decommissioning was expected. However, any maintenance work carried out during winter months could have an impact on birds. This impact could be reduced to low risk if any maintenance work avoided the first 2 hours after sunrise.

The offshore surveys identified 13 species of bird of which the key species were fulmar, gannet, auks (guillemots and razorbills), manx shearwaters and storm petrels. Since there was little feeding activity in the area, the construction/decommissioning phase was considered to cause little disruption to feeding birds, similarly the risk of collision was considered low. The highest risk was considered to be from pollution incidents, causing local mortality of surface resting birds such as guillemots and razorbills from surface pollutants such as lubricants and cooling oils, however, the likelihood of such an event was considered low.

There has been the suggestion that WECs could form fish aggregating devices (FADs), increasing food availability to seabirds and so having a potentially positive impact on birds. In this case, there could be a beneficial effect to seabirds, although the FAD effect might lead to entanglement of birds in mooring systems as birds attempt to catch fish that have aggregated near to WECs. Overall the ES considered that there would be no significant residual impacts of the construction, maintenance, operation or decommissioning on either intertidal or offshore birds (given the mitigation against pollution incidents and timing of cable laying).

In terms of vulnerability index, all birds observed at the Wave Hub are considered to have low to very low vulnerability for negative impacts from wave energy devices.

Protected areas, habitats and species

Since the Wave Hub included construction of a sub-station, an EIA was required to ensure minimal impact on the local terrestrial ecology. The new substation site and dunes through which the cable passes lie within an area designated as an Area of Great Scientific value and Cornwall Nature Conservation Site. However, since there were no features of national, regional, county or district value, construction at the site was not considered likely to have a significant impact on these habitats. Some features of local value (such as figwort and reptiles) were considered highly likely to suffer habitat loss so mitigation measures were put in place to protect or translocate these species.

There are no statutory protected areas within the vicinity of the Wave Hub, however, St Ives Bay is designated as a Sensitive Marine Area (SMA) by Natural England with national importance for its marine animal and plant communities.

2.7.3 Mitigation measures for environmental impacts

The mitigation measures discussed here are based on the Environmental Statement (ES) for the Wave Hub. Given the predicted low impact of the Wave Hub on most of the environmental descriptors, mitigation measures are not overly onerous, however due to the high level of uncertainty post-construction monitoring is recommended.

2.7.3.1 Physical environment

Based on wave measurement and the modelling study carried out as part of the EIA, little impact is expected either on sediment transport or waves. However, impacts are still uncertain given the nascent state of WECs, and the lack of WECs so far deployed at the Wave Hub. Given the deemed low level of impact, no mitigation measures were proposed. However, The University of Plymouth have been carrying out baseline monitoring of beach profiles since early 2009 and measurement of wave regime since 2011 (refined data products).

Water, sediment & soil quality

The construction, operation, maintenance and decommissioning of the Wave Hub was considered to have a negligible likelihood of impact on water, sediment and soil quality. Although no pollution impact was predicted under normal conditions, it was recommended that mitigation measures should be put in place in the event of a pollution incident. In addition, although there was considered to be negligible risk of impact due to turbidity from sediment disturbance, two mitigation measures were proposed:

- Sub-sea infrastructure should be founded on bedrock to prevent undermining through scouring and be anchored or weighted down to prevent flow-induced vibration
- Cables should be weighted or anchored to prevent uplift and abrasion against exposed rock outcrops.

2.7.3.2 Flora and fauna

The EIA identified some locally important features of both flora and fauna, which required mitigation measures prior to the sub-station being built and the cable being laid. There was considered to be a minor negative impact on habitats and flora, recommended mitigation measures included: identification and fencing of clear working areas; transplanting of the locally important flora; and a pre-construction survey for invasive plants. To mitigate against minor (birds and reptiles) to negligible (invertebrates) negative impacts on protected and notable fauna species, recommendations included: clearing vegetation during winter months; ceasing works if breeding birds are suspected to be present; and reptile translocation prior to works.

Benthos

Although there was deemed to be some disturbance to benthic ecosystems along the cable route during construction, there were no proposed mitigation measures other than minimising the cable footprint. It was predicted that the cable route would quickly be recolonised by organisms from the surrounding habitats, resulting in negligible long term impact.

Marine mammals

There was considered to be a minor negative impact of disturbance to marine mammals due to the generation of underwater noise during installation. The highest impact was associated with pile driving, if used, thus suggested mitigation measures included: (i) ensuring that the correct specification of pile and pile driver is used to minimise noise emissions; and (ii) using a 'soft' start up procedure so that noise levels are gradually increased allowing animals to respond and move away from the noise source. Given the lack of knowledge associated with impact due to operational noise levels, monitoring of operational noise levels was recommended as a mitigation measure.

Sea birds

None of the inshore or offshore bird populations were found in nationally significant or important numbers, so the impact of the Wave Hub was considered to be of low significance or negligible. However, a few mitigation measures were recommended based on the surveys carried out. To avoid any potential impacts on intertidal birds from the cable-laying construction and maintenance, mitigation recommendations included: measures to avoid any work at times when birds are in highest numbers (winter and around high tide); and minimising duration and extent of any work carried out. Recommended measures to minimise any impact on offshore birds included: producing method statements where there is a risk of pollution; and only allowing lighting at night time where required for safety and navigation purposes to avoid bird attraction.

Monitoring

Higher levels of monitoring are recommended for a novel technology such as WECs due to the high level of uncertainty associated with environmental impacts. Post-construction monitoring allows for verification (or not) of the EIA findings, and informs any future wave developments. The ES recommended post-construction monitoring of offshore birds, and extensive monitoring of noise levels. It was recommended that noise monitoring should assess (i) baseline ambient noise levels with simultaneous cetacean acoustic monitoring prior to WEC deployment; (ii) monitoring of noise levels during deployment and its impact on both fish & marine mammals (especially if pile driving is used); (iii) monitoring of noise levels during WEC operation combined with simultaneous acoustic monitoring of cetacean populations. The University of Exeter have been carrying out this baseline monitoring since early 2012.

3 Relevant socio-economic activities, impacts and mitigation measures

3.1 AMETS

3.1.1 Socio-economic activities and impacts

The main socio-economic activities identified in the vicinity of AMETS are fishing, navigation, tourism and agriculture. This section will give a brief description of these activities in the area and outline potential impacts from the development of AMETS on these activities.

3.1.1.1 Fishing

Inshore fisheries[4] for crab and lobster are of significant value to coastal communities in Ireland and there are 40 boats involved in inshore fishing off Belmullet. The inshore fishing effort in the region is mainly focussed on brown crab (*Cancer pagarus*) and lobster (*Homarus gammarus*), with some gill netting and trawling. Almost all inshore fishermen in the area are members of the Erris Lobster Conservation and Restocking Organisation (ELCRO) or the Erris Inshore Fishermen's Association (EIFA). Crab fishing is the most significant economic activity and total annual landings at Belmullet are around 3000 tonnes. One boat lands up to 100 tonnes per year at a value of around €1.20 per year. A typical lobster boat lands up to 1.5 tonnes per year. The inshore fishing season extends from March to November.

Trawling in the area is carried out by members of Killybegs Fisherman's Organisation (KFO), three of whose trawlers operate in the vicinity of AMETS. The vessels trawl in a sandy seabed area 110km^2 west of Belmullet. This is one of five such sandy seabed areas used for trawling in the extended vicinity. Trawling is carried out occasionally during the year for prime fish species, the main ones being monkfish, megrim, rough skate and haddock.

During construction and decommissioning phases and during WEC deployment and recovery operations, the project's impacts on the fishing industry will be temporary in nature and of low significance overall. During the operational phase of AMETS, the test area locations will be fishing exclusion zones. Designating Test Area B as an exclusion zone will have little impact on fishing activity in the area; however, up to six crab fishing boats operate in the area adjacent to Test Area A. The layout of this area was redesigned following consultations with the local fishery organisations. There is also a 9% reduction in trawling ground area adjacent to Test Area A. This can be considered as a low impact because, as mentioned above, this is one of five such trawling areas fished in the region.

3.1.1.2 Navigation

Deep sea shipping, fishing vessels and pleasure craft routinely operate along the Irish west coast. There are no merchant shipping ports close to AMETS. The closest commercial ports are Galway, over 100km to the south east, and Sligo, over 80km to the north east. There is a large fisheries harbour at Rossaveal, west of Galway and a large deepwater fisheries harbour at Killybegs, north of Sligo. There are also a large number of smaller harbours, piers and slipways dotted along the coast in

[4] Inshore fishing is generally defined as fishing within the region twelve nautical miles from shore.

the area. These are mainly used by smaller fishing vessels, pleasure craft and small ferries serving islands.

The majority of marine traffic close to the test site is fishing traffic. There is some marine traffic in the area due to vessels travelling from Broadhaven and Killybegs to the Corrib Gas field which is located approximately 20 km from AMETS. There are medium sized vessels which trade from port to port in the area as well as some larger ocean going vessels in operation. Marine leisure traffic includes boating and sailing, sea angling and diving and water sports.

An assessment of the traffic near AMETS indicated that the shipping activity close to the site is low in comparison to other offshore areas where similar developments have been constructed. Once established, marine traffic will have to reroute around the test sites. The impact of rerouting vessels is likely to be low because there is substantial sea room to the east and west of Test Area A. The displacement of the routes is likely to be very small relative to typical voyages undertaken.

During the construction phase of AMETS, the additional number of vessel movements and number of construction vessels in the area will pose additional navigational risks. The majority of risks are 'broadly acceptable' provided risk control measures are put in place. A smaller number of risks were deemed to be 'tolerable with monitoring' and mitigation measures have been identified.

3.1.1.3 Tourism

Tourism is vitally important for Ireland's economy and it has been identified as a priority sector for growth by the national government. Maximising the potential of the tourism sector is seen by the government as being critical in helping to maintain the population of rural areas which have suffered from population decline. Tourism is also a key industry sector in the Belmullet area. There are many beaches within a short distance from Belmullet which are frequented by local, national and international visitors. Recreational activities such as fishing, walking and water sports are also important for the area. Following consultations with the local surfing community, it was established that surfers regularly use waters in the area for many types of surfing (local surfing, towed surfing, sail boarding, kite surfing and wind surfing)

The laying of electricity cables on Belderra Strand will cause the temporary loss of use of the beach and may disrupt tourism use of the area. There is also the potential for the submarine cable to impact on a sand bank, which has been identified by the surfing community as being important for the generation of good surfing waves. There is the potential for the increase in traffic in the area during construction to lead to a temporary impairment in the amenity value of the area. This is expected to be of low significance as the predicted traffic is well within the load carrying capacity of local roads. The overall impact of the construction phase on tourism is expected to be temporary, insignificant and of short duration.

The operational phase of AMETS is not expected to have a significant impact on tourism and it is expected that the presence of the test site may lead to increased visitor numbers to the area due to the uniqueness of the development.

3.1.1.4 Agriculture

Apart from the fishing industry, employment in the Belmullet area typically derived from agriculture. Along with fishing, agriculture and forestry accounted for almost 10% of employment in County Mayo in 2006 which was twice the national average. This is likely to be larger for a small coastal community such as Belmullet. The AMETS development will have a not have a significant direct impact on agriculture in the area. The project will only result in the medium term loss of two acres of pasture land at the substation site.

3.1.2 Mitigation measures for socio-economic impacts

4.1.1.1 Fishing

The principle mitigation measure to reduce the impacts on fishing came from consultation with the main fishing organisations in the area, ELCRO, EIFA and KFO. This led to the optimum design, layout and location of the test sites to minimise impacts on crab and lobster fishing. The impact on trawling activities has been deemed to be low and no mitigation measures have been put in place for this.

Advance notice of all marine activities relating to the test site will be given to stakeholders during construction, operation and decommissioning. To the greatest extent possible, all marine activities will be timed to minimise disruption of fishing activity, however, good weather conditions are required for all operations. A specific communication forum will be established to facilitate consultation with and information dissemination to all stakeholders. All operations at the test site will be governed by a strictly binding operational plan setting out rules for the test site users and their interaction with other stakeholders. This includes measures for defining and agreeing a procedure for retrieving any fishing gear lost at the site. It is stated that a specific project to determine the influence of the wave energy test site on crab and lobster numbers and the effectiveness of the test site as a nursery area should be established.

4.1.1.2 Navigation

To reduce the risk to navigation from the AMETS development, a number of mitigation measures have been outlined. Marine notices must be issued in advance of any construction or operation works on the AMETS development and the site location should be communicated to all fishing organisations and marked on navigation charts. It should be ensured that the site layout and changes to it are communicated to the Royal National Lifeboat Institute (RNLI) and other rescue services. The site needs to be adequately marked with navigation buoys equipped with radar reflection panels. Vessels not involved in AMETS operations will not be allowed inside the site. Individual structures need to be marked and lighted adequately. Control measures for frequent users of the area should be put in place.

During construction and decommissioning, suitable contractors using vessels suitable for working in the area should be employed. These works should be planned and managed to ensure the safety of those involved and of other users in the area. Guard vessels should be used to protect working vessels and to alert other vessels in the area to site operations. The submarine cables should be buried sufficiently to avoid damage by fishing vessels or mooring operations. Adverse weather working conditions should be put in place.

During operation of AMETS, navigation buoys should be subject to regular inspection and maintenance. A device specific risk assessment outlining the hazards associated with WECs deployed at the site should be developed by WEC developers. Position monitoring of the WECs at the test site is required. A salvage response plan should be drawn up in the event of an emergency such as a WEC drifting from its position or capsizing. The WECs should be designed to reduce the maintenance and service vessel activity at the site.

4.1.1.3 Tourism

The impact of the development on tourism is not expected to be significant. Construction activities will be timed so that the impact on amenity users will be minimised while the local community will be kept informed of all operations at the test site. The sand bank, identified by surfing groups as being important for surfing waves will be avoided during cable laying.

4.1.1.4 Agriculture

There is not expected to be any significant impact from the development on agriculture. Mitigation will involve restoration of the land used for the substation to its original use, if the substation is decommissioned. This will be subject to agreement between the AMETS developers, the Sustainable Energy Authority of Ireland (SEAI) and Mayo County Council.

3.2 BIMEP

3.2.1 Socio-economic activities and impacts

The main productive sectors identified in the vicinity of BIMEP are industry and services, with services being the larger sector. The impacts of the test centre deployment on these industries together with the impacts on other social related descriptors are described below.

3.2.1.1 Fishing

The size of the Basque fishing sector has decreased in the recent decades as a consequence of the increase in oil prices and a decrease of fishing resources. Within the Basque fishing sector, more vessels are involved in shallow-water fishing than any other activity. The vessels that operate off the coast of Armintza are traditional fishing vessels which are included in the minor fishing equipment census, operating close to the coast. The traditional fleet has the capability of being adapted to capture different species of fish, crustaceans or cephalopods depending on the period of the year.

3.2.1.2 Industry

The most important industrial sectors of the Basque Country in terms of productivity and employment are Metallurgy, Machinery and Material Transport. But the most active ones in terms of increasing of the added value are the oil refining, electrical energy, gas and water, nutrition and metallurgy.

3.2.1.3 Services

At the coast side, fishing activity is now only the second most important sector behind tourism. Activities such as nautical sports, diving, sports fishing, hiking and birds' observations among others are practiced in the area.

3.2.1.4 Submarine archaeological resources

It is not expected that the installation, operation and decommissioning of the WECs and the cables will have significant impacts on the submarine archaeological resources of the area occupied by BIMEP.

3.2.1.5 Landscape

The vessels that will be in the area during the installation and decommissioning will have a compatible impact on landscape. This is also the case for the devices that will be tested in BIMEP during their operation period.

3.2.1.6 Socio-economic impacts

At a regional level the economic impact of BIMEP project in the area can be summarized as:

- Investment of approximately 15M€ for constructing the infrastructure.
- Generation of a direct and indirect activity of about 5M€ per annum.
- Creation of a research centre with several researchers and with capacity for hosting people from the enterprises that will test their devices in the platform.
- Creation of 200 jobs in 4 years.
- Hospitality: opportunity for creating local businesses.

At a local level, the socio-economic impact will be indirect as personnel and vessels will be subcontracted for the installation, maintenance and decommissioning of the devices. Similarly small workshops for vessel repair nautical material, etc. could see an increase in activity as a consequence of the requirements of different projects.

Fishing will be forbidden in the area occupied by BIMEP as it will be an area where navigation will not be permitted. Between 11 and 14 vessels will be affected by this measure and the impact this will involve is considered as severe. No impact on fishing related with the cable is expected as it will be buried under the seabed.

3.2.2 Mitigation measures for socio-economic impacts

3.2.2.1 Compensation to the professional fishing sector

With the aim of minimizing the impact on fishing derived from the use of the same area, economic compensation to the fishermen grid is proposed. With this measure the impact on fishing will become moderate or compatible instead of severe.

3.3 EMEC

3.3.1 Socio-economic activities and impacts

EMEC guidelines to developers provide information on critical socio-economic and managerial issues that should be addressed in the EIA report (Table 2).

Major socio-economic concerns experienced at EMEC involve navigational risk and the potential impact on the local fishing industry[5]. The survey carried out for the SOWFIA project on stakeholder sensitivities[6] highlighted that the fisheries are concerned mostly with commercial scale development beyond testing within the EMEC facilities. Fishing groups however expressed their willingness to

[5] http://www.sowfia.eu/fileadmin/sowfia_docs/documents/D2.3_Final.pdf
[6] http://www.sowfia.eu/fileadmin/sowfia_docs/documents/D4.3_StakeholdersReport.pdf

collaborate with wave energy developers in sharing their valuable experience of the marine environment, in order to increase the engineering life of MRE devices and to reduce potential danger to small fishing boats.

3.3.2 Mitigation measures for socio-economic impacts

On a broader scale, EMEC coordinates consultation and engagement between device developers and stakeholders groups:

- A fisheries liaison office has been appointed. Fishermen groups are routinely invited to take part in consultation on MRE developments at EMEC. Consultations are held at the beginning of the licence phase to favour open discussion on the potential issues. This has resulted in positive feedback from local fishermen on consultation strategy and has proven successful in the development of the test site.
- Local communities are involved in the consultation process and are aware that their opinion is taken into account.

Table 2 – Critical socio-economic and managerial issues identified at EMEC.

Impact	What should be considered/ Why it is important?
	Socio-Economic Issues
Local air quality issues	Any emissions of combusted or vented gases have the potential to reduce air quality. Consideration should be given to minimising any such emissions.
Interference with communication systems	Some device to shore communications could interfere with normal shipping communications. This aspect needs to be addressed.
Waste minimisation and disposal	All efforts should be made to minimise waste. Ensure suitable storage, transport and disposal for all waste streams. Some wastes will be able to follow existing waste disposal routes, others may not.
Navigation/sea user interference	The presence of devices and their mooring systems has the potential to interfere with vessels and other sea users e.g. fisheries. Although test berths will generally be avoided by such activities, they are not "exclusion zones‟ and therefore such impacts need to be considered
	Overall Management Issues
Suitability of the device for local environmental conditions	Ensure full consideration of local environmental conditions during design of devices and mooring systems.
Timing of activities regarding seasonal sensitivities for weather and wildlife	An assessment of seasonal sensitivity is an integral aspect of the environmental appraisal and timing of activities should be considered within overall mitigation and management plan. Specific seasonal sensitivities are summarised in the test site environmental descriptions (provided separately).
Accidental spillages and releases	Spillages of materials to sea have the potential to cause damage to wildlife and livelihoods e.g. fisheries. Appropriate procedures for accidental/emergency situations should be in place to minimise the potential for accidental releases and how to deal with them effectively should an accident occur.

3.4 Lysekil

3.4.1 Socio-economic activities and impacts

The municipality of Lysekil, including some nearby market centres and the surrounding region, is based on small to medium sized businesses. Agriculture and forestry are also major sources of income, but not considered to be affected by the project. Lysekil has a medium sized harbour but activity has been declining there for several decades due to the dismantlement of several industries. Naturally, fishing has historically been important in this area but the number of active commercial fishermen has declined drastically during the last decades and only a few remain active in the area. Several smaller harbours are also available in the vicinity. Household fishing is still common and is an important activity for parts of the year, especially for lobster. Local businesses have gained from the project as much material, equipment and other services have been commissioned from local companies. No special concern has been given to onshore activities such as agriculture and forestry.

3.4.1.1 Fishing

Historically the area around Lysekil was one of the most important areas for commercial fishing in Sweden. However, the number of active boats and number of persons employed by the fishing industry has declined drastically over the last number of decades. Some fishing boats still have their home harbour in nearby villages but their fishing grounds are further out at sea. When the Lysekil project was under planning consultations were held with the major fisherman organisation (SFR) and with the only local fisherman actively using the area. The final project area to be used was adjusted accordingly and therefore accepted. Consequently, the Lysekil test site has had no influence on commercial fishing. Local house hold fishing activities are still ongoing in the area and some have even used the project area for lobster cages (lobsters immigrate to the WEC area as they build nests under the gravity foundations) and lost nets have been found around WEC's, indicating that fishing takes places.

3.4.1.2 Navigation and leisure boats

Shipping and navigational risks are a major issue for wave power. A coastal shipping lane runs between the Lysekil test site and the mainland (2 km away) but is mainly for small to medium sized boats. Larger ships only rarely pass nearby. In the summer time the shipping lane is very busy with leisure boats, and some also pass nearby the test site or even go straight through. This happens more often when no buoys are visible in the area and the surface is free of objects. In general, it is not considered that the test site affects navigation and, over the years, no complaints have been raised. Most of the working activities at the site, deployment and decommissioning etc., have been performed outside the summer months when boat traffic has been low or absent. The test site is marked according to Swedish Maritime Administration regulations. As the project is likely to increase in size when new permits become affective in 2014, new markers and more safety regulations may be required.

3.4.1.3 Tourism and summer inhabitants

Three nearby old fishing villages are today mainly summer vacation sites where the large majority of houses are used for summer vacation only. Most summer visitors also own leisure boats and therefore tourism and summer residents are considered to be important for the area. Tourism cannot be considered to have been affected negatively by the project; rather it may have increased the interest for the area.

3.4.2 Mitigation measures for socio-economic impacts

A general condition for deployment has been to avoid major work during periods with intense boat traffic (i.e. during the summer time). Consequently, no special means of mitigation has been required in relation to either fishing, navigation, tourism or other economic interests. There are no constraints or special regulations for operating the WEC's at the site either, and as no social-economic impact was foreseen, or has later been indicated, no special measures have been taken.

3.5 Ocean Plug

The main socio-economic activities in the Ocean Plug region which will be affected by the project still need to be identified. This topic will possibly be addressed during the geophysical and environmental characterisation which is ongoing.

Since no EIA is going to be carried out for the entire Ocean Plug area, mitigation measures will only be evaluated for environmental and socio-economic impacts within the EIA process for each project to be installed.

3.6 SEM-REV

The socio-economic aspects covered in the EIA study addresses the following key points:

- Human activities and site users including the analysis of the proximity to maritime ports, extraction sites (sand), shipping routes, fishing activities, leisure activities;
- Cultural and historical heritage, in particular restrictions for construction works onshore and land occupation planning;
- Natural heritage inventory and protection measures (critical zones from the testing area to the onshore cable landing);
- Landscape and heritage (submarine archaeology).

Some informal positive socio-economic impacts are expected from the project's financers as:

- Development of the Marine Renewable Energy industry sector in the Region and in France more generally;
- Job creation (in the sectors of engineering, maritime construction, electricity, electronics, telecommunication sectors) and large support to local SMEs/SMIs,
- Positive image and new attractiveness of the region (industries, tourism).

The results of the analysis of some of the topics listed above are briefly addressed below. No specific socio-economic measures have been established for the test centre.

3.6.1 Landscape and heritage

Measurement campaigns (bathymetry by sonar and benthos) have not revealed any particular archaeological item around the zone and the cable's route so the impact of construction and operation is nil. Neither the test site (except floating wind turbines) nor the cable's connection onshore (rock directional drilling and cable buried up to the substation) are visible from the coast.

Decommissioned structures are stored in places with no landscaping interest so that the impact is minor. The visual impact caused by the testing of floating wind turbines is deemed to be low due to the long distance to the shore and the fact no more than two such devices can be tested at the same time in SEM-REV (study by ATILE).

3.6.2 Public health and safety

Risks for navigation near SEM-REV are negligible as the area is duly marked by beacons working day and night, and all devices and floats are equipped with AIS systems for marine localisation and marine users are informed for navigation. Devices' noise is not perceptible from the coast and thus was not considered to have any impact on public health.

3.6.3 Fishing, leisure and tourism activities

Impacts on the human environment are deemed minor to negligible. The zone – wherein fishing is prohibited – was selected based on public consultations with marine users and authorities. Construction works take place in periods where tourism activity is low in the region and fishing activities are not affected along the cable route since the cable is buried in the seabed. Impacts on local leisure activities are negligible due to the distance to the coast (about 20 km) and the small size of the testing area (1 km^2).

3.7 Wave Hub

3.7.1 Socio-economic activities and impacts

Interview data suggest that the Wave Hub has generally been well-received by nearby communities, partly as a result of active community engagement by the Wave Hub Company and other organisations involved in the project and because no devices apart from the Hub and supporting cabling had been installed at the time. Consequently, few tangible negative impacts have yet occurred beyond those identified above for fisheries[7].

3.7.1.1 Economic benefits

The main positive effect of the Wave Hub for local communities is the potential economic benefits of hosting a new and potentially significant industrial sector. Cornwall has experienced a severe decline in many traditional industries (e.g. mining and fishing) and suffers from lower-than-national-average incomes and a predominance of low-wage, low-skilled employment (e.g. the tourism sector), making such benefits of considerable value to the county. The observed economic benefits experienced so far occurred chiefly during the construction/installation phase of the Wave Hub and the FAB wave test site in Falmouth Bay. Other emerging economic benefits include the Cornwall Marine Energy Park. However, doubts remain as to the scale of economic benefits to Cornwall if EIA projections of revenue and employment after the construction phase prove over-optimistic and if existing residents do not possess the skills sought by the marine energy sector. A further adverse effect may be

[7] More detailed summaries of the potential stakeholder sensitivities related to the Wave Hub are provided by McLachlan (2009) and Bailey et al. (2011).

increased local property prices driven by the wave energy sector in an area already experiencing housing shortages and low affordability for first-time homebuyers as a result of high levels of second-home ownership.

3.7.1.2 Fishing

WECs have the potential to both negatively and positively affect fisheries. The Wave Hub will exclude fishing activity from around the site when WECs are in place, potentially negatively impacting the local fisheries. However, excluding fishing vessels from the area will also result in de facto No Take Zones, providing refuges for fish and potentially resulting in spill-over of fish into surrounding areas with knock-on benefits to fisheries. Other potential impacts to fisheries include: potential impact of construction noise on fish; potential impact of construction on food resources; and the impact of EMF on rays. These latter impacts were addressed under marine ecology (section 2.7.3.5 above).

Based on the EIA, the main fisheries in the Wave Hub area included spider crabs, brown crab, lobster, mackerel and sole. The fishery is seasonal, with beam trawlers targeting the sole fishery in February-April, brown crab potting between May-November, and a summer fishery for spider crab and lobster. Two main concerns were raised by local fishermen: (i) the commercial effects of any exclusion zones; (ii) the worry of snagging gear on the cable. Although there is no exclusion zone around the cable, safety zones established around the WECs (when deployed) will act as fishery exclusion zones. The EIA assessed the effect of exclusion on fisheries based on the assumption that the maximum extent of the Wave Hub was populated with WECs. It is unlikely that this will have a significant impact on fisheries landings at the level of the ICES rectangle; however, it could impact on the local fishermen that use the Wave Hub area for a large proportion of their fishing livelihood. Also some parts of the Wave Hub area are used as refuges away from trawling areas where static gear fishermen have a lower likelihood of gear damage by trawlers. Thus, any fishery activities based within the Wave Hub area would be displaced to other areas, potentially conflicting with other vessels, and competing for limited resources & limited refuges away from trawling activity. On this basis, the impact of exclusion zones on fishermen was considered to be of moderate adverse impact (the highest environmental impact within the Wave Hub EIA). There is no mitigation against this prospect; however, reduced fishing pressure within the Wave Hub area could have a benefit on local fish stocks with knock-on benefits to local fishermen by acting as a de facto No Take Zone.

3.7.1.3 Tourism

Another concern for local communities is that the Wave Hub may produce negative impacts on tourism activities. Cornwall is a premier UK holiday destination and has seen impressive growth in surf tourism during recent decades. Direct and indirect employment in tourism accounts for around 22% of employment in Cornwall and well in excess of this in some locations. Initiatives that are perceived to diminish the quality of waves on popular beaches may encounter strong opposition and undermine the area’s attractiveness as a tourism destination. Surfers Against Sewage (SAS) has supported the Wave Hub on the basis of reports that it will not produce a discernible negative effect on wave quality. However, this may change if proposals are made for commercial-scale wave farms near the Cornish coast.

3.7.1.4 Landscape

Concerns about the visual impact of wave farms (a major problem for on- and off-shore wind farms; Devine-Wright, 2009 and Wolsink, 2007) appear negligible according to recent public attitude surveys (Bailey et al., 2011 and Northcott, 2011). Some concern was expressed about light pollution from marker buoys around the exclusion zone but overall support for wave energy remained high.

3.7.2 Mitigation measures for socio-economic impacts

3.7.2.1 Fisheries

The Wave Hub was predicted to have a negative impact on fisheries; however, this is counterbalanced by the potentially positive impact of creating a de facto No Take Zone and the possible resulting benefits to surrounding fisheries. To avoid conflict between commercial fishing activity and the construction works during installation of the cable, two mitigation measures were proposed: (i) notification via a Notice to Mariners; and (ii) the appointment of a fisheries liaison officer. There were a wide range of mitigation measures proposed to minimise the risk of snagging the cable with fishing gear, including: burying the cable where possible; careful alignment of cable on bare rock so that it is in contact with the seabed as much as possible; for any unavoidable spans physical measures or navigation guidance measures should be used.

There was no proposed mitigation measures associated with the impact of the exclusion of fishing activity from the Wave Hub deployment area once WECs are in place.

3.7.2.2 Navigation

Restrictions in access (in particular to navigation routes) and threats to marine safety as a result of increased collision risk have been the main concerns for other commercial vessel operators and recreational boating organisations. However, navigation routes were negotiated between relevant authorities (e.g. Marine Management Organisation, Crown Estates), while exclusion zone markers are used to provide safety warnings to commercial and recreational vessels.

3.7.2.3 Natural and cultural heritage

Statutory consultees for the Wave Hub focus mainly on the conservation of local natural and cultural heritage, e.g. Natural England, English Heritage and the Marine Biological Association. Their main concern was that the Wave Hub did not have serious unfavourable impacts on the environmental quality of nearby marine habitats or features of cultural heritage. Assessments of impacts on local ecosystems conducted as part of the EIA produced for the planning process for the Wave Hub have been supplemented by ongoing environmental and socio-economic research conducted by the Peninsula Research Institute for Marine Renewable Energy (PRIMaRE), SOWFIA and the MERiFIC INTERREG project.

3.7.2.4 Local community concerns

One of the main roles for the Wave Hub Company has been to maintain community support by providing information and advice about the project to local residents. To illustrate, some local residents were worried that the cable connecting the Wave Hub to the local electricity sub-station posed a risk after it was temporarily exposed by strong storm and tidal currents. The cable is heavily insulated and was not transmitting any charge, but the example underscores the benefits of a local presence to provide information and reassurance to residents.

4 Comparing environmental and socio-economic sensitivities

The comparison of the results obtained in the test centres EIAs are summarised in Table 3. Only test centres for which an EIA was conducted are presented in Table 3 although sensitive environmental and socio-economic issues are included, when available, in the discussions below. To allow a better comparison among test centres, the environmental and socio-economic descriptors analysed in the EIA's have been uniformed in Table 3.

4.1 Key environmental issues and mitigation measures

Potential environmental impacts of ocean energy have already been identified in a number of papers and reports (e.g. Inger et al., 2009; Langhamer et al., 2010; Kadiri et al., 2012; Frid et al., 2012). However, the quantification of the real effects of technologies on the marine environment are site specific and still needs to be assessed during devices' operation through the implementation of monitoring plans. Thus, it should be noted, that the impacts evaluation carried out under the EIA processes reviewed herein, is usually based on potential impacts.

The comparison of the environmental descriptors among test centres shows its distribution among two types (described above under section "Environmental impacts": 1) physical environment, which includes the environmental descriptors for the non-living chemical and physical factors affecting the ecosystem; 2) flora and fauna, which includes the living components that shape the ecosystem.

The most common descriptors of the physical environment include the analysis of the impacts on the coastal processes and hydrodynamics, water and sediments quality and air quality and climate (only in two of the five reviewed EIAs).

The most common descriptors of the flora and fauna section include the analysis of the impacts on benthos, fish and shellfish, marine mammals and seabirds. Information regarding the existence of protected areas, habitats or species, as well as their vulnerability to the potential effects of the nearby test centres' is also an issue regularly discussed within the EIA reports.

The analysis of the identified impacts of test centres' deployment are presented below considering the common environmental descriptors referred to above in order to find general commonalities and site specific issues.

Table 3 – Impacts evaluation identified for each test centre. The descriptors names have been changed to allow comparison amongst test centres.

	AMETS	BIMEP	Lysekil	SEM-REV	Wave Hub
Physical environment	**Coastal processes / hydrodynamics** Impact of WECs would be insignificant compared to natural processes; no significant impacts on sediment transport, coastal landform or surfing waves are expected. **Water quality** Any significant impacts are expected during all project phases. **Sediments** Any significant impacts are expected during all project phases. **Air quality and climate** Impacts are considered to be negligible.	**Coastal processes / Hydrodynamics** No significant impacts are expected. **Water quality** The possible damage caused during all project phases is considered to be minor. **Sediments** Since the moorings of the devices are not supposed to be removed from the seabed, the impact of their presence is classified as severe.	**Water quality** The project is not considered to have any significant effect on the natural turbidity of the water, which is due to the northern current that affects the area; **Sediments** The bio-fouling growth is responsible for an increase in sedimentation around and nearby WECs; studies are ongoing although the effect is considered to be local and similar to other natural occurrences in offshore areas.	**Water quality** Impact considered local and thus negligible due to the high dilution rate in the area. **Sediments** Modification of sedimentary dynamics is deemed moderate to negligible due to the small extent of the area, small number of anchors and weak sediment transport. **Air quality and climate** Air quality can be affected in a very temporary way (only during construction and decommissioning phases); The support to marine renewable energies is considered a positive impact as regards CO2 emissions reduction.	**Coastal processes / hydrodynamics** Waves could be impacted by 13% at the coastline but more typically by 5%; minimal impact due to changed sediment transport on beaches is expected. **Water, sediments and soil quality** No impacts will take place during all project phases.

	AMETS	BIMEP	Lysekil	SEM-REV	Wave Hub
Flora and fauna	**Benthos** Temporary sediment displacement during cable burial; Creation of artificial reefs. **Marine mammals** Construction phase is the most disruptive but temporary and harbour porpoise is the most sensitive species; Speculative impacts related with: risk of collision, noise disturbance, EMF effects. **Sea birds** Speculative impacts related with diving birds collision and entrapment and physical and noise disturbance. **Protected areas / habitats / species** No rare or protected terrestrial species; loss of semi-improved agricultural grass land.	**Benthos** Installation of cables considered a moderate impact; Anchors dragging is considered a severe impact; The impact of wave height reduction on coastal biomass is classified as severe. **Fish and shellfish** Vibrations and noise could have a moderate impact on fish species; The impact of the EMF is classified as severe. **Marine mammals** Severe impacts are expected on protected species identified in the area due to noise, vibrations and EMF. **Sea birds** Moderate impacts are expected due to noise and vibrations especially in sensitive seasons (e.g. nesting). **Protected areas / habitats / species** No significant impacts are expected from possible accidents on protected areas existing in the vicinity; Overall impacts on flora and fauna of the protected area “Isla de las lubinas” are considered to be moderate.	**Marine mammals** The harbour seal and harbour porpoise are the most important species presented in the project area but no special concern was given to them by consulting parties. **Seabirds** No protected species or populations are present in the area; Many species have been seen resting on the buoys and other have been observed feeding on bio fouling blue mussels growing on the submerged equipment.	**Benthos** Destruction of benthic species along the cable route and on the test centre seabed due to anchoring, which have been classified as reversible and negligible. **Fish and shellfish, marine mammals and sea birds** Disturbance during installation and operation is classified as negligible due to short duration of the works and limited number of WECs to be tested; The effects of noise and EMF are classified as moderate to minor / negligible; Counter-balancing effects are expected between the artificial reef effect (bio-fouling and fish attraction; biomass increase) and repulsive aspects like noise and EMF. **Protected areas / habitats / species** Impacts on the nearby protected area “Plateau du Four” are considered temporary or negligible.	**Benthos** Intertidal communities within the cable route were of no particular conservation importance; Two biotopes of sub-tidal communities affected by the cable burial; minor impact due to the limited area affected and quick re-colonisation. **Fish and shellfish** Minor EMF effects from the cable. **Marine mammals** Construction and operation noise is the most significant concern; avoidance behaviour during construction has been predicted up to a maximum of 27 days; this impact was considered of minor adverse significance; operation noise considered as negligible. **Sea birds** Overall, no significant impacts on intertidal and offshore birds are expected if mitigation measures are fulfilled. **Protected areas / habitats / species** Habitat loss of local value species (figwort and reptiles); mitigation measures were suggested.

	AMETS	BIMEP	Lysekil	SEM-REV	Wave Hub
Human environment	**Fishing** The project's impacts will be temporary in nature and of low significance overall. **Navigation** Marine traffic will have to be reroute but the impact of this is considered to be low; Risks related with the additional number of construction vessels are "broadly acceptable" provided control measures are applied. **Tourism** Increased traffic in the area during construction can lead to temporary impairment of the area amenity value; Increased visitor numbers are expected during operation. **Agriculture** No direct impacts were identified.	**Fishing** The impact of the fishing exclusion zone is classified as severe. **Landscape** Compatible impacts are expected. **Archaeological resources** No impacts are expected. **Other social impacts** Job creation; Development of a research centre; Opportunity for local businesses diversification.	**Fishing** No impacts have been considered on commercial fishing. **Navigation** The test centre does not affect navigation and, to date, no complaints have been raised. **Tourism** No impacts have been identified and the test centre may have increased the interest for the area **Agriculture** No special concern has been given to such activities. **Other social impacts** Local businesses have gained from the test centre deployment.	**Fishing** Impacts are deemed to be negligible. **Navigation** Risks for navigation are considered negligible providing the area is duly marked as required. **Landscape** Neither the test centre nor the cable connection onshore is visible from the coast and only two devices can be tested simultaneously; no visual impacts are expected. **Archaeological resources** No remains have been found in the test centre area and cable route; no impacts are expected.	**Fishing** The impact of exclusion zones on fishermen was considered to be of moderate adverse impact (the highest environmental impact within the Wave Hub EIA); Reduced fishing pressure within the area could have a benefit on local fish stocks with knock-on benefits to local fishermen by acting as a "No Take Zone" **Tourism** Support has been given by surfing associations on the basis the test centre will not produce a negative effect on wave quality. **Landscape** Concerns about the visual impact of wave farms appear negligible according to the recent public attitude; Some concern was expressed from marker buoys around the exclusion zone but overall support for wave energy remained high. **Other social impacts** Economic benefits: new industry in the region; job creation.

4.1.1 Coastal processes, sediment dynamics and seabed communities (benthos)

Coastal processes involve erosion, transportation and deposition of sediments controlled by the hydrodynamic pattern in a given coastal area. The removal of energy from the marine environment due to the presence of wave energy devices has been identified as a potential negative effect of this group of technologies. Changes in the water flow energy may influence the transport of gases, nutrients and food for some species and interfere with the distribution of others with dispersive juvenile stages reliant on transport by currents (e.g. Nowell and Jumars, 1984; Koehl, 1996; Abelson and Denny, 1997; Gaines et al., 2003; Gaylord, 2008). Furthermore, the long shore transport of material (and thus the sites where sediment accumulates or erodes) is dependent on the size and direction of incoming waves. Thus, by reducing waves in general and particularly those from a specific direction (i.e. downstream of the device), long shore drift of material and ultimately beach morphology, shallow water bathymetry and substrata may be altered (Defeo et al., 2009; Shields et al., 2011). Theoretical models of wave energy parks (consisting of 270 devices; about 200 MW total installed power; moored in 50 to 70 m water depth off the coast of Portugal) indicated that the significant wave height at the 10 m depth contour may be reduced by 5 cm, considering a monthly mean significant wave height range of 1.3 to 2.9 m, and the relative percentage of wave energy removal by the devices will be greatest during the summer (Palha et al., 2010).

The available EIA reports conclude that the effects of the deployment of wave energy converters on coastal processes and geology would be insignificant in comparison to the natural processes occurring in the sites.

Seabed disturbance from construction or wave energy converters installation is generally considered to be local, temporary and similar in magnitude to common natural occurrences in the marine environment (e.g. storms). Due to the dynamic nature of the sites, it is assumed that the local marine environment will fully recover in a short period of time.

The greatest potential for impact on communities associated with the seabed (benthos) is the creation of artificial reefs. These reefs could fragment benthic communities or provide habitats for predatory species which could impact benthic communities. The creation of artificial reefs could also increase biodiversity in the area. In some EIA reports the extent of this effect has been evaluated to be small in the context of the total available habitat. In other reports the accumulation of mooring structures on the seabed is classified as a major change to the local natural substratum and thus represents a severe impact which may change sediment transport in the area, interfere with the height of waves and consequently decrease coastal biomass. The reutilisation of the moorings or their removal from the seabed after testing, are the main proposed mitigation measures to deal with this impact.

4.1.2 Water and sediments quality

In terms of the vessels and equipment used to install and remove wave energy test centres' infrastructure and wave energy converters, the principal types of substances that may pose a risk to water quality are fuels, lubricants and coolants (used in hydraulic fluids and painting of devices). Furthermore the seabed disturbance during test centres' construction and device installation (e.g. cable burial and installation of mooring systems) may increase sediment suspension and water column turbidity decreasing light penetration and interfering with primary production (e.g. phytoplankton, algae, seagrasses, kelp).

In the studied wave energy test centres, there is a consensus on the identification of potential impacts on water quality from test centre construction and device deployment. All reviewed EIA reports refer to the possibility of a decrease in water quality due to seabed sediments' disturbance during installation and decommissioning and potential accidental oil spills involving vessels used in construction and operation phases. However, the reports conclude that the overall construction, deployment and operation of test centres are not expected to have significant effects on water quality related to sediment re-suspension and that the effects are expected to be temporary. In theory, the vessels and equipment used during test centre installation and deployment are designed to minimise the risk of leakage of fuels, lubricants and / or coolants under normal circumstances and thus the risk of these substances coming into contact with the marine environment is low.

In one of the test centres, sedimentation around and nearby WECs due to bio-fouling is referred as a possible cause for organic matter accumulation on the seabed. Although this effect is still under study, it has been considered to be local and similar to other natural events in offshore areas.

4.1.3 Marine mammals

Much concern has been expressed about the potential effects of wave energy developments on marine mammals. Collision, entanglement, entrapment, noise, habitat disturbance and electromagnetic fields are the main potential adverse impacts associated with wave energy deployment on marine mammals (e.g. Cada et al., 2007; Dolman et al., 2007; Ortega-Ortiz and Lagerquist, 2008).

The installation of wave energy developments in the marine environment will bring new sources of noise into the marine environment, which may interfere with several marine mammal species that use sound for communication, navigation, foraging and evading predators (e.g. Richardson et al., 1995; Patrício et al, 2009; Croxall, 1987).

Almost all test centres' locations are associated with marine mammals' distribution and thus surveys are documented in all reviewed EIAs. Table 4 shows the species that occur in each test centre. Dolphins are the dominant group of species amongst test centres.

Table 4 – Marine mammal species occurring in the area of European wave energy test centres under study.

Test centre	Common dolphin	Bottlenose dolphin	Harbour porpoise	Minke whale	Pilot whale	Grey seal	Harbour seal
AMETS	X	X	X	X			
BIMEP	X	X			X		
Lysekil			X				X
Ocean Plug	X	X					
Wave Hub	X	X	X	X		X	

The review of the EIA reports shows that results diverge from reports assuming that wave energy impacts on marine mammals will be severe to reports that consider test centres as relatively small areas, when considering mobile marine species such as marine mammals, and thus that they will have little impact on such species. The classification of the impacts on marine mammals as "severe" in some test centres is associated with the construction / installation phase based on the assumption that acceptable sound exposure levels are going to be exceeded for the protected marine mammal species occurring in the area. In all reviewed reports the construction phase is recognised as likely to be the most disruptive to marine mammals due to increased noise and boat traffic. Of the species recorded, porpoises are identified as likely to be the most sensitive species to disturbance as they have been known to actively avoid vessels due to high frequency sounds. Marine mammals are expected to return to the area once construction has been completed. The impacts of the operational phase have been classified as moderate to minor / negligible. In one of the reviewed EIAs, operational impacts of wave energy converters on marine mammals are considered to be speculative and not expected to be significant.

The risk of collision with devices and anchoring systems, as well as the interference of electromagnetic fields are also mentioned in the EIA reports as potential local adverse effects of wave energy deployment. On the other hand, the possible role of the test centres as marine mammal feeding areas (due to the fishing restriction and the FAD effect) is identified in some reports as a positive effect of the developments on marine mammals' welfare.

4.1.4 Sea birds

Seabird communities represent a major component of marine life within the marine environment. The diversity of seabird species utilising European marine coastal offshore habitats is considerable. It is expressed in many forms, including feeding method (from deep diving species, like gannets, to surface foragers such as petrels), preferred flight heights, migratory period and selected routes, young rearing behaviour, selection of mates and foraging distances from breeding colonies (Croxall, 1987).

Due to the lack of information and data, impacts of wave energy devices on seabirds are mostly extrapolated from those observed in offshore wind farms (McCluskie et al., 2012). They depend on different factors: species behaviour, season and site (Langton et al., 2011; Lindeboom et al., 2011). The most identified effects (which include negative and positive impacts) are disturbance (e.g. noise, interference with foraging – due to water turbidity increase during installation), collision, barrier effects to migrating seabirds, habitat modification (which can include new roosting and foraging sites) or loss and entrapment (Wilson et al., 2007; Witt et al., 2012; Cruz and Simas, 2012).

Table 5 shows the main seabird species occurring in each wave energy test centre under study. The most identified potential impacts in the reviewed EIAs are the risk of collision, noise disturbance and entrapment. The magnitude of such impacts is expected to vary according to the age and reproductive stage of the species. The review of the EIA reports reveals that the impacts of wave energy test centres' deployment on seabirds are mainly associated with the installation phase, thus considered temporary, and classified in some reports as moderate. The seabirds' ability to avoid the area as well as the possibility for minimising the impacts caused by test centre construction (e.g. avoiding sensitive periods) are two factors considered in other reports to attenuate the potential adverse interference of the developments on seabird communities. This has contributed to the classification of the potential impacts on them as non significant.

4.1.5 Mitigation measures

In general, and given the predicted low impact of the test centres on most of the environmental descriptors, mitigation measures are not overly onerous and usually preventive, based on good practices during construction and project management (e.g. presence of marine mammal observers during construction, use of suitable materials, machinery and vessels). Most mitigation measures include burial of cables at least 1 m to avoid electromagnetic emissions or fixing them to the seabed to prevent uplift and abrasion against exposed rocky outcrops, establishing contingency plans for pollution incidents (related with devices' oil and hydraulic fluids spills), and avoiding work during biota sensitive periods (e.g. breeding periods).

Environmental monitoring is mentioned in all EIA reports as critical for reducing uncertainty about impacts and adjusting mitigation measures. The proposed activities usually include monitoring the potential effects of antifoulants on adjacent sediments and biota, monitoring marine mammal and sea birds activity in the vicinity of the test centres and possible interactions of these organisms with the devices and other installed equipment, and noise levels combined with acoustic monitoring of cetacean populations.

Table 5 – Most abundant seabird species occurring in the area of European wave energy test centres under study. When available the IUCN conservation status assigned for a given species is presented; LC: Least Concern; V: Vulnerable; NT: Near Threatened; CE: Critically Endangered.

AMETS	BIMEP	Lysekil	Ocean Plug	Wave hub
Great northern diver (LC) Eider duck Long tailed duck (V) Manx shearwater (LC) Great shearwater (LC) Sooty shearwater (NT) Arctic tern (LC) Sandwich tern (LC) Great skua (LC) Storm petrel Also abundant in the area: gulls, shags, auks and fulmars	Storm petrel Shag Yellow-legged gull (LC) Lesser black-backed gull (LC)	Cormorant Eider Guillemot (LC)	Cory's shearwater (LC) Ballearic shearwater (CE) Northern gannet (LC) Storm petrel Common tern (LC)	Northern gannet (LC) Lesser black-backed gull (LC)

4.2 Socio-economic impacts and mitigation

In general the main socio-economic activities identified in the vicinity of the wave energy test centres under study are fishing, navigation and tourism. Industry is also referred in some reports as an important socio-economic activity but impacts of wave energy deployment on it are all considered positive in terms of sector development in the region and job creation. A summary of the results from the evaluation of the impacts of test centres' installation, operation and decommissioning on the common activities is presented below using the available EIA reports.

4.2.1 Fishing

Most marine traffic in the vicinity of the wave energy test centres is generated by the fishing sector, especially the shallow water fishing sector. The main impact of wave energy deployment on fishing is related to the exclusion zones that are created, for the safe deployment of devices, where activity is not allowed or is restricted.

The impacts on the fishing industry from construction and decommissioning phases and from wave energy device installation are considered in the reviewed EIAs to be temporary in nature and of low significance overall. However, during the operational phase, the impacts on fishing through the existence of exclusion zones are dependent on the fishing grounds and on the fishermen's usage of the site. During the layout of some test centre's deployment areas, consultation with fishery organisations was carried out and some areas were redesigned, being reduced, in some cases, to accommodate fishery activities. In other cases, because the impact on fishing was considered severe, mitigation took the form of financial compensation to fishermen that had used the area previously. Although restricted to fishing, in the Lysekil test centre some lost lobster cages have been found, indicating that fishing is taking place anyway (lobsters migrate to WECs as they build nests under the gravity foundations).

4.2.2 Navigation

Shipping and navigational risks are a major issue for wave energy developments. Deep sea shipping, fishing vessels, ferries servicing the area and pleasure craft routinely operate along all the coasts where wave energy developments are to be installed.

During the construction phase of test centres, the additional number of vessel movements and number of construction vessels in the area are expected to pose additional navigational risks. In general, the majority of risks are 'broadly acceptable' in the reviewed EIA reports providing risk control measures are put in place. These include:

- The issue, in advance, of marine notices for any construction or operation works, which should be communicated to all fishing organisations and marked on navigation charts;
- The communication of the sites layout to rescue services; a salvage response plan should be drawn up in the event of an emergency such as the device drifting from its position or capsizing;
- The need to adequately mark the site with navigation buoys equipped with radar reflection panels; these should be subject to regular inspection and maintenance
- The need to adequately mark devices or other individual structures with light; a device specific risk assessment outlining the hazards associated with its deployment at the site should be developed by the developer;
- The implementation of control measures for frequent users of the area should be put in place.

In addition to these measures, the design of the devices is recommended to take into account a minimum number of maintenance operations. The devices' maintenance plan shall also be delineated to avoid larger work at site during known periods of intense boat traffic (especially during the summer time).

4.2.3 Tourism

Tourism and recreation-related development is one of the major factors shaping development pattern in coastal zones. Beaches and associated old fishing villages are today part of the most selected sites for vacations especially during the summer.

In the majority of the reviewed EIAs, the tourism sector is considered as vital for the regions' economy especially because it is helping to maintain the declining population number in rural and remote areas, where some test centres are located. The operational phase of the test centres is not expected to have a significant negative impact on tourism. It has been stated that it may lead to increased visitor numbers to the areas due to the uniqueness of the development.

On the other hand, during test centres' construction, loss of use of the nearby beaches due to the laying of electricity cables and the construction works of other equipment onshore (e.g. substations) are identified as temporary impacts. The potential increase of the traffic in the sites during construction may also lead to a temporary impairment in the amenity value of the areas. The impact of the submarine cable on the seabed morphology (e.g. sand banks) has been identified, by the surfing community, as a potential impact on the generation of good surfing waves in the case of one test centre. However, the overall impact of the construction phase on tourism is mostly considered to be temporary, insignificant and of short duration.

5 Stakeholders feedback on impacts and mitigation measures

This section of the report corresponds to the information collected in the SOWFIA project activities dedicated to understand the opinion of stakeholders about wave energy in general and more specifically on wave energy projects' consultation activities (D.4.3 on test centres' stakeholders' survey and Workshop B report). An integrated analysis of these opinions has been already provided in D.4.3 (Stakeholder survey) and is summarised below.

5.1 Opinions on MRE

The overall opinion of stakeholders about the 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, especially 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 abroad instead of local work force. Other frequent supportive arguments are the increase of a cleaner/ greener energy production; the reduction of energy dependence on fossil fuels; the 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.

5.2 Key messages from stakeholders on consultation

Based on the opinions gathered from consulted stakeholders, brief recommendations on consultation activities were drawn by the SOWFIA team and these are summarised in Table 6 below.

Table 6 – Recommendations from consulted stakeholders on consultation activities.

Purpose	• Consultation events need to increase public awareness about MRE (including public authorities and regulators) in general as well as include project-specific information; • Project messages should be consistent.
Audience	• Additional effort is required to ensure the participation of local businesses and the public in consultation processes; • Levels of consultation needed may differ accordingly to stakeholder group – those in close proximity to a proposed development will have different concerns to those who live 10 km from a proposed development.
Technique	• Developers, and those responsible for consultation activities, should actively engage with the local media as a means of keeping stakeholders up-to-date with project progress; • There should be a balance between projects updates and requirements to host consultation events so as to minimise consultation 'fatigue' and maximise input from participants; • Particular attention should be paid to the times and locations proposed for consultation activities recognising that marine users are not always on land; • Upfront acknowledgement of what can and cannot be influenced by stakeholders during consultation; • It should be clearly explained to stakeholders how their input will be used.
Information	• Information provided should be clear, transparent and honest with a level of technical content appropriate for the audience; • Project successes should be celebrated but shortcomings should also be acknowledged – this builds trust with the stakeholder community; • To maximise opportunities stakeholder groups should have a tentative list of concerns to raise at consultation events. • As information to be reviewed during the consultation process is often lengthy and response times are limited, it may be necessary to extend consultation periods. • Particular emphasis should be place on socio-economic impacts of proposed developments as this is a key interest to stakeholders.

6 Conclusions

This document presents the key environmental and socio-economic sensitivities identified at the wave energy test centres associated with the SOWFIA project as well as the key findings from surveys of stakeholders of each of the test centres and feedback from a workshop of key stakeholders in marine energy. This section presents the main conclusions from this document and some discussion on applying the findings from wave energy test centres to larger, commercial scale developments.

6.1 Environmental Assessment

Although the Environmental Impact Assessment of each project is based on site and project specificities, the comparison of EIA conclusions for the six wave energy test centres reveals some commonalities on the environmental descriptors and impact evaluation. This is perhaps not surprising since the test centres are mostly of similar size and require similar infrastructure for the testing and demonstration of different types of wave energy converters (WECs). The same environmental descriptors have usually been identified for most but not all test sites (i.e. benthos, marine mammals, avifauna, coastal processes and water quality). Perhaps surprisingly, potential impacts on fish and elasmobranches have only been looked at for a minority of test centres.

Even though the classification of impacts in the EIAs for the different test centres is different, the significance of an impact is generally linked to whether and how quickly the original site conditions can be restored and often linked to the magnitude of the habitat or species population potentially affected in comparison to the overall size of the habitat or species population. The significance of a potential impact is also determined by comparing the potential effects from the wave energy test centres with effects caused by naturally occurring phenomenon.

The impacts identified are generally not significant, sometimes after mitigation. The most significant impacts are those which are associated with the installation phases 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 not significant even though it is recognised that potential impacts are largely unknown. Some differences in impacts evaluation occur often because of this uncertainty over impacts and sometimes due to site sensitivity.

Given the low expected impacts of test centres on most of the environmental descriptors, mitigation measures are not overly onerous and often aim to be preventative. These mostly take the form of good practice during construction, good project management, contingency planning and avoiding certain construction operations at sensitive periods. To deal with the uncertainty of impacts evaluation (which usually lead to the classification of impacts as “potential”), monitoring plans have been proposed for installation and decommissioning and operational phases of test centres. The exact nature of these monitoring plans including the objectives, methodologies and the durations are not however specified.

6.2 Socio-economic assessment and stakeholder concerns

The main socio-economic issues identified in the review of EIA reports and other information from each of the test centres were impacts on fishing, navigation and tourism. This is in agreement with the key socio-economic issues identified in the second SOWFIA workshop (see Workshop B report available in the project website) and the stakeholder survey (Deliverable 4.3 available in the project website).

Consultation with stakeholders groups (e.g. fishermen, surfers and navigation authorities) prior to the design of test centres layout has been identified in the EIA reports as an effective measure which the test centre developers undertook to mitigate stakeholders concerns. This has resulted in an agreeable location and layout for a number of test centres meaning there is no further mitigation measures required to satisfy the stakeholders concerned. Meaningful consultation such as this, whereby stakeholders can have an input into the final project design, was identified in the second SOWFIA workshop as being important for successful stakeholder consultation. Consultations, after design decisions have already been made, are unlikely to gain stakeholder support. Where this has occurred economic compensation may be the only acceptable form of mitigation, which may have implications for the economic viability of projects, especially smaller projects in the near future. Further recommendations for the consultation process are provided in the workshop and stakeholder survey reports (SOWFIA deliverables 4.3 and Workshop B report available in the project website).

The potential for positive socio-economic impacts is also highlighted in some of the EIAs. These include the direct and indirect creation of employment, increased tourism and the potential for increased fish stocks due to the creation of no take zones. It was found in the stakeholder survey and the workshop that stakeholders' opinions of ocean energy were generally positive for some of the above reasons and because they believe that developments will result in cleaner energy production and a reduction in the dependence on fossil fuels. There was however an important warning that potential benefits from developments should not be oversold in order for stakeholders' trust to be retained.

6.3 Final remarks

Although some useful conclusions can be drawn from environmental and socio-economic assessments of wave energy test centres and from stakeholders of these test centres, there are some limitations as to the conclusions that can be drawn for future commercial scale wave energy developments.

The wave energy test centres involved in the study are likely to be far smaller than commercial scale wave energy farms in terms of spatial footprint, required infrastructure and number of devices; consequently, the construction period of these wave farms is likely to be more disruptive than that of test centres. Wave energy test centres are viewed by some stakeholders to have scientific and research value which may not be the case for commercial developments. It is likely that a single device type will be deployed in commercial scale farms whereas test centres have been designed to accommodate multiple device types. Nevertheless, guidance can be taken as to the environmental descriptors and socio-economic issues that may be assessed in commercial scale projects in the future even though these are likely to require assessment on a larger scale. Similarly, guidance can be taken on the types of mitigation measures that may be required from commercial scale projects even though again, it is uncertain how these will scale up.

Apart from Lysekil and EMEC, no WECs have yet been installed at any of the test centres involved in this study for meaningful durations. This means that it is still too early to assess whether impacts have been correctly identified and evaluated and whether proposed mitigation measures are effective. Once more is known about the environmental and socio-economic impacts of wave energy developments, assessment requirements and mitigation measures and stakeholder opinions may change considerably. Indeed, in the stakeholder surveys, stakeholders expressed concern that the test centre projects which they were being consulted about were relatively small facilities and they stressed that this should not be automatically taken as acceptance of commercial scale ocean energy sites.

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