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Report of the Study Group on Environmental Impacts of Wave and Tidal Energy (SGWTE)

4-6 May 2012

Stromness, Orkney, UK



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International Council for
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Executive Summary

The Study Group on the Environmental Impacts of Wave and Tidal Energy (Chair: Michael Bell, UK) held its second meeting in Stromness, Orkney, UK, 4-6 May 2012. The meeting was attended by nine participants from Ireland, Spain, Sweden and the UK (England, Scotland and Wales) and contributions by correspondence were made by four participants, from France, Norway, Portugal and the UK (Wales).

The wave and tidal energy sector is a newcomer to the marine environment, but is developing rapidly. There is an urgent need for new science to understand the potential environmental and socio-economic interactions of wave and tidal energy developments and for this science be applied in policy, planning, consenting and regulatory processes. SGWTE 2012 continued the work of the previous meeting, collating information on the current state of development of the wave and tidal energy industry, in both testing and commercial deployment phases, on progress with leasing and consenting processes, and on research relating to environmental and socio-economic interactions. Status reports were made for individual countries and summary tables were prepared for 53 wave and tidal energy developments or test deployments and 74 research projects. The aim is to compile a searchable database as a resource for scientists and regulators. SGWTE also reported on progress addressing research gaps identified in the previous meeting, and compiled a list of priority research areas under topics such as marine mammals, oceanography and fisheries interactions.

SGWTE is set to finish with a third meeting in 2013, but it is clear that there is an ongoing and increasing need for ICES to develop science in relation to marine renewable energy. SGWTE noted the existence of at least 17 other ICES expert groups with interests in marine energy. A new Working Group on Marine Energy is proposed for the purpose of coordinating the flow of science between topic-based science Working Groups (e.g. on seabirds, benthic ecology, fish ecology) and its application in planning, consenting and regulatory processes in relation to tidal (both in-stream and barrage), wave and offshore wind energy.

1 Opening of the meeting

The second meeting of the Study Group on Environmental Impacts of Wave and Tidal Energy (SGWTE) was held at the International Centre for Island Technology, Heriot-Watt University, Stromness, Orkney, UK, 4–6 May 2012. A complete list of participants is given at Annex 1. Terms of Reference for the meeting are given in Section 2.

The agenda given at Annex 2 was adopted by the meeting.

2 Terms of Reference

2011/2/SSGHIE14 The Study Group on Environmental Impacts of Wave and Tidal Energy (SGWTE), chaired by Michael Bell, UK, will meet in Orkney, Scotland, UK, 4–6 May 2012 to:

- a) Update, augment (include environmental monitoring at commercial lease sites) and extend national coverage of directories for existing wave and tidal energy activities and research activities relating to environmental and socio-economic interactions, and report on progress with commercial leases and consenting processes;
- b) Collate bibliography of outputs from current and recent research activities relating to wave and tidal energy;
- c) Review crucial information gaps hindering the capacity to plan and manage wave and tidal energy activities, identifying progress in addressing re-search requirements noted by SGWTE2011 and identifying further requirements;
- d) Report on the current state of development of decision-making tools and the extent to which they are supported by systemic understanding, understanding system components and the monitoring and measurement tools used to generate such understanding;
- e) Compile spatial data on areas used for wave and tidal energy and make these available through the ICES spatial facility;
- f) Report on experience and lessons learned from other industries relating to social acceptability issues and stakeholder engagement in wave and tidal energy planning and consenting processes;
- g) Review Theme Session S from ASC 2011;
- h) Report on interactions with SIASM and other Expert Groups.

SGWTE will report by 15 June 2011 (via SSGHIE) for the attention of SCICOM.

3 Country reports (ToR a, b,d,e)

Terms of Reference a), b), d) and e) were addressed by compiling reports on wave and tidal energy developments and associated environmental research activities in each country. Summary information on developments, regulatory frameworks and research activities is given on a country-by-country basis below. Summary tables giving information on individual developments and research projects is given in Annexes 5 and 6 respectively. Note that coverage of ICES member nations is currently incomplete and it is planned to update and extend these summaries on an ongoing basis.

3.1 Report for UK-Scotland

National roadmaps for wave and tidal energy development

The Scottish Government is committed to the development of a successful and sustainable offshore renewables industry in Scotland. The Scottish Government has a target of 100% of Scotland's domestic electricity needs to be met by renewable sources by 2020. The Sectoral Marine Plan for Wave and Tidal Energy is being developed to ensure that offshore wave and tidal energy sources will make a substantial contribution to meeting the Scottish Governments ambitious targets. These sectoral plans will be adopted into statutory national and regional marine plans with Scotland.

Scotland is well placed to take a global lead in the exploitation of wave and tidal energy sources, with an estimated 25% of Europe's tidal resource and 10% of its wave potential. *The Scottish Government recognizes that offshore renewable energy represents a huge opportunity for Scotland to create new industries and to make great progress towards achieving our ambitious renewable energy targets.*

The UK and Scottish Marine legislation has been used to deliver a Marine Planning System and introduce best practice through efficiencies in licensing and consenting processes. An example of this is the establishment of the partnership initiative between MS and Scottish Natural Heritage (SNH), the MS/SNH Marine Renewables Research Group (formally the Marine Energy Spatial Planning Group).

Scottish Ministers have started the process of implementing the streamlining of marine licensing and are taking forward secondary legislation within the Scottish Parliament. This efficient licensing has been delivered through four main initiatives: (i) the establishment of a one stop shop covering marine licensing (MS Licensing and Operations), (ii) the production of a marine renewables licensing manual, (iii) development of licensing policy guidelines, and (iv) the SNH monitoring protocol. The Licensing policy guidelines include (i) Survey, Deploy and Monitor Policy, (ii) Demonstration Strategy, Deemed Planning, and (iv) Rochdale Envelope.

Current development activities

Current commercial deployments

There are no fully commercial arrays of wave or tidal stream energy devices yet deployed in Scotland. However, most of the devices being tested at the EMEC cabled berths (Billia Croo and Falls of Warness) are generating power into the National Grid and are therefore selling power into the commercial market.

Test sites and how they are being / have been used

The European Marine Energy Centre (EMEC) in Orkney is an essential element of the Scottish effort on marine renewables. EMEC has test sites at Billia Croo and the Falls of Warness for testing full-scale wave and tidal stream devices respectively, with connections to the National grid. The main services EMEC offers to the Marine renewable industry are:

- Provision of Wave and Tidal testing capabilities: (i) Independent assessment of devices' energy conversion capabilities, structural performance and survivability; (ii) Assistance with Grid connection and ROCs (Renewable Obligations Certificate) accreditation; (iii) Real-time monitoring of meteorological and marine resource conditions; (iv) Extensive assistance with consent and regulatory issues; (v) Opportunity to join EMEC's Monitoring Strategy; (vi) Extensive local research and engineering support; (vii) Nearby access to sheltered water and harbours; and (viii) Office and data centre support.
- Consultancy and Service provision: (i) Provision of off-site testing validation; (ii) Provision of consultancy on all aspects of design and operation of marine test centres; and (iii) Provision of data and marine services.
- Projects and Research: (i) Provision of specialist resources for all projects related to Marine Renewable research specifically related to a Marine Test site.

EMEC operates within a UKAS accredited integrated management system, which incorporates Quality Health & Safety and Environmental standards. EMEC can offer independent, internationally recognized verification of the performance of devices which come to test in Orkney. EMEC has recently established "nursery" sites in Shapinsay Sound and Scapa Flow which do not have grid connection but which are suitable for testing devices under less demanding resource conditions than are experienced at the full-scale cabled sites.

Commercial developments at planning and construction stages

The total projected capacity for wave and tidal stream energy in Scotland covered by existing agreements for lease, many of which are progressing through the licensing process, now exceeds 2000 MW. It is anticipated that further agreements for lease will emerge through biannual invitations for bids for leasing.

Range of technologies considered

The most prominent technologies being considered for commercial scale projects are:

Tidal stream: Horizontal axis turbines

Wave: Overtopping device (offshore)

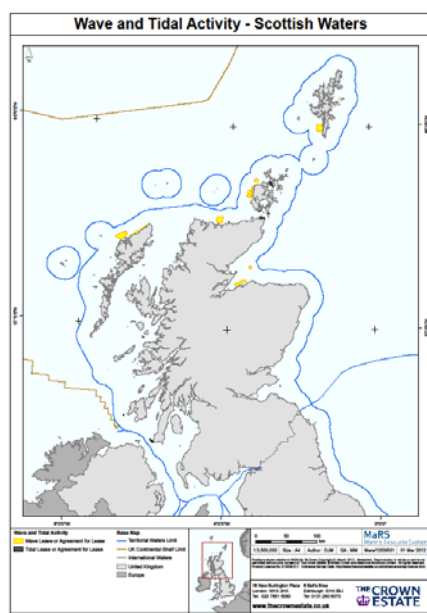
 Attenuator

 Point absorber

 Oscillating wave surge converter

Seabed leases or permissions for commercial developments

The areas currently under agreement for lease for wave and tidal stream energy are shown in the map below.



Locations of leased areas, and projected scales of development

Planning and consenting processes

Strategic Environmental Assessment (SEA)

In 2007, the Scottish Government published a Strategic Environmental Assessment (SEA) for Marine Renewables covering Scottish Territorial Waters for our West and North Coasts. The report concluded that there is significant resource within Scottish territorial waters for wave and tidal energy development.

<http://www.scotland.gov.uk/Publications/2007/03/seawave>

Work is progressing on the Marine Renewables Sectoral Plan which requires Sustainability Appraisal in line with the requirements of Environmental and Marine legislation. This work will refresh the 2007 SEA and increase the geographic scope to include Scotland's renewable energy zone (out to 200 miles). Sustainability Appraisal includes SEA, strategic HRA, Socio-economic Impact Assessment and consultation.

An Initial Plan Framework will be produced which will draw upon the original SEA, Scoping and Regional Locational Guidance for The Saltire Prize and Regional Locational Guidance for the Pentland Firth Strategic Area. Additional scoping work will be undertaken using the MaRS model to map resource and constraint areas covering the Scottish renewable energy zone to develop further Plan options. Regional Locational Guidance review and application will be applied to the areas identified to produce refined Plan options and these will be reported within an Initial Plan Framework. Sustainability Appraisal will be applied to produce a Draft Plan and will be subject to statutory public consultation.

The Plan will provide clear guidance to Industry on where to focus investment and pursue development opportunities.

Development of Marine Spatial Planning frameworks and tools

The Scoping Studies to identify Plan Option areas described above have been undertaken in collaboration with The Crown Estate, using their MaRS spatial planning tool. The MaRS system is a powerful tool for the handling and integration of a wide range of spatial data referring to environmental and technical factors that can influence the

development of offshore energy, including tidal stream and wave energy (and other activities). The integrated data are presented as spatial models which map the opportunities and constraints applying in potential development areas. From these outputs, broad areas of technical opportunity and relatively low constraint on development can be identified and explored in more detail through Regional Locational Guidance.

In order to apply the MaRS tool, it is necessary for the user to make a number of decisions regarding the data to be included in the models and the way in which the data are to be handled. These decisions include factors such as:

- The factors that require consideration when locating tidal stream energy developments and the availability of spatial data that can be included in the models.
- Whether particular activities or uses should be considered as incompatible with tidal stream energy development, or whether activities or uses should be considered as presenting gradations of limitation to development potential.
- The relative importance (weighting and scoring) that should be applied to the different layers of data in the final integrated model.
- The relative quality and reliability of data layers.

Building on experience of the Scoping Studies for the Saltire Prize, the data layers were grouped into themes (e.g. technical, industrial, environmental, socio-cultural). This procedure minimizes the conceptual problems associated with defining appropriate relative weightings for very diverse types of data (e.g. the relative weightings of seabird colonies, fisheries landings, and basking shark sightings). The thematic grouping allows assessment of the sensitivity of the outputs to variation in the overall weighting between themes. This approach had previously been used successfully in the Scoping Study for the Saltire Prize, and also in the Scoping Study for Offshore Wind in Scottish waters (Davies and Watret, 2011). A similar approach has therefore been adopted in the current study, grouping constraints layers into themes representing constraints arising from industrial activity, environmental factors and socio-cultural interests.

Application of national and international legal instruments (e.g. Marine Strategy Framework Directive) applied in planning and consenting processes

This section contains information on the key legislation that forms the basis of consenting/licensing requirements for offshore renewable energy developments in Scottish waters. Legislation is subject to amendments and the applicants should liaise with MS-LOT to ensure they are using the most up-to-date information. The licences for which Marine Scotland is the regulator are:

- Marine Licence (Marine (Scotland) Act (2010) and Marine and Coastal Access Act (2009));
- Section 36 Consent (Electricity Act 1989);
- Habitats Regulations Consent (The Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2007 and associated amendments);
- European Protected Species Licence (The Conservation (Natural Habitats, &c.) Amendment (Scotland) Regulations 2007 and associated amendments); and
- Wildlife and Natural Environment (Scotland) Act 2011 (WANE Act).

However, other marine and terrestrial licences may also be required in support of a development.

Marine Scotland as Regulator and the Marine Licence

The Marine (Scotland) Act 2010 received Royal Assent on 10 March 2010 and along with the UK Marine and Coastal Access Act (2009) provides a framework for marine management. The UK Act provides executive devolution to Scottish Ministers for marine planning and licence and conservation powers in the offshore region (12-200 nautical miles). The Marine (Scotland) Act (2010) legislates for marine planning and licensing and conservation activities in the inshore region. An agreement between UK and Scottish Ministers defining the responsibilities was established through a Joint Ministerial Committee. Through the agreement Scotland received executive responsibility for planning and nature conservation out to 200 nautical miles. In addition to the UK Act, international responsibilities for the implementation of the Marine Strategy Framework Directive (MSFD) in the Scottish inshore and offshore region, will fall to Scottish Ministers who are the competent authority.

The Acts meet demands from a wide diversity of marine users for better stewardship and management of Scotland's seas and introduce a framework for sustainable management. The framework includes:

- The introduction of a statutory marine planning system;
- Improved marine nature conservation and conservation of the marine historic environment with new powers to protect and manage areas of importance for marine wildlife, habitats and historic monuments; and
- Improved protection for seals.

The Acts also introduce a streamlined marine licensing system with accompanying enforcement powers. The new marine licence combines the former Food and Environmental Protection Act (FEPA) licence and Coast Protection Act (CPA) consents, making Scottish Ministers responsible for issuing new marine licenses in the Scottish offshore region.

Under the Acts a marine licence from Scottish Ministers is required if any person intends to do any of the following from a vehicle, vessel and other structure in Scottish Waters (from Mean High Water Springs out to 12 nautical miles (nm) under the Marine (Scotland) Act and 12-200nm through devolved powers from the Marine and Coastal Access Act (2009)):

- Deposit any substance or object in the sea or on or under the seabed;
- Construct, alter or improve works on or over the sea or on or under the seabed;
- Remove substances or objects from the seabed;
- Dredging (including plough, agitation, side-casting and water injection dredging);
- Deposit and/or use explosives; and
- Incinerate substances or objects.

This is the legislation under which MS-LOT operates. Part 7 of the Marine (Scotland) Act (2010) also makes specific provision for Marine Enforcement Officers. These officers have specific powers to enforce the marine licensing regime, and all issues relat-

ing to marine protection and nature conservation legislation. For the majority of off-shore renewables developments EIA will be required to support the application for a Marine Licence. MS-LOT makes sure applications meet the requirements of the EIA Directive prior to formally accepting the application.

Overview of national consenting processes for WTE developments

On the 1st of April 2010, Marine Scotland assumed administrative responsibility for a range of statutory controls in waters adjacent to Scotland for which responsibility lies with Scottish Ministers. A single point of access was subsequently created, bringing together some of the Scottish Government's delivery functions in relation to a range of activities in UK waters adjacent to Scotland. On the 6th April 2011 the Marine Licence was implemented in Scotland. This completed the introduction of the 'one stop shop' arrangements for marine licensing in Scotland. This means that Marine Scotland Licensing Operations Team (MS-LOT) has operational responsibility for a number of statutory responsibilities therefore streamlining licensing processes and reducing the administrative burden on applicants.

One Stop Shop for offshore windfarms, wave and tidal power development applications

A developer must obtain a site lease from The Crown Estate prior to installing a renewable energy device in the marine environment. Since 6th April 2011 in Scotland, through the one stop shop arrangements (see flow chart on reverse page), the legislative and regulatory requirements include a licence under the Marine (Scotland) Act 2010 and where appropriate the Marine Coastal Access Act 2009. Additionally, if the offshore generating station is proposed to have over 1MW capacity, consent from the Scottish Ministers is required under section 36 of the Electricity Act 1989 (s.36). Developers also require a European Protected Species licence under the Habitats Regulations 1994 (as amended; EPS) and a decommissioning plan approved by the Department for Energy and Climate Change.

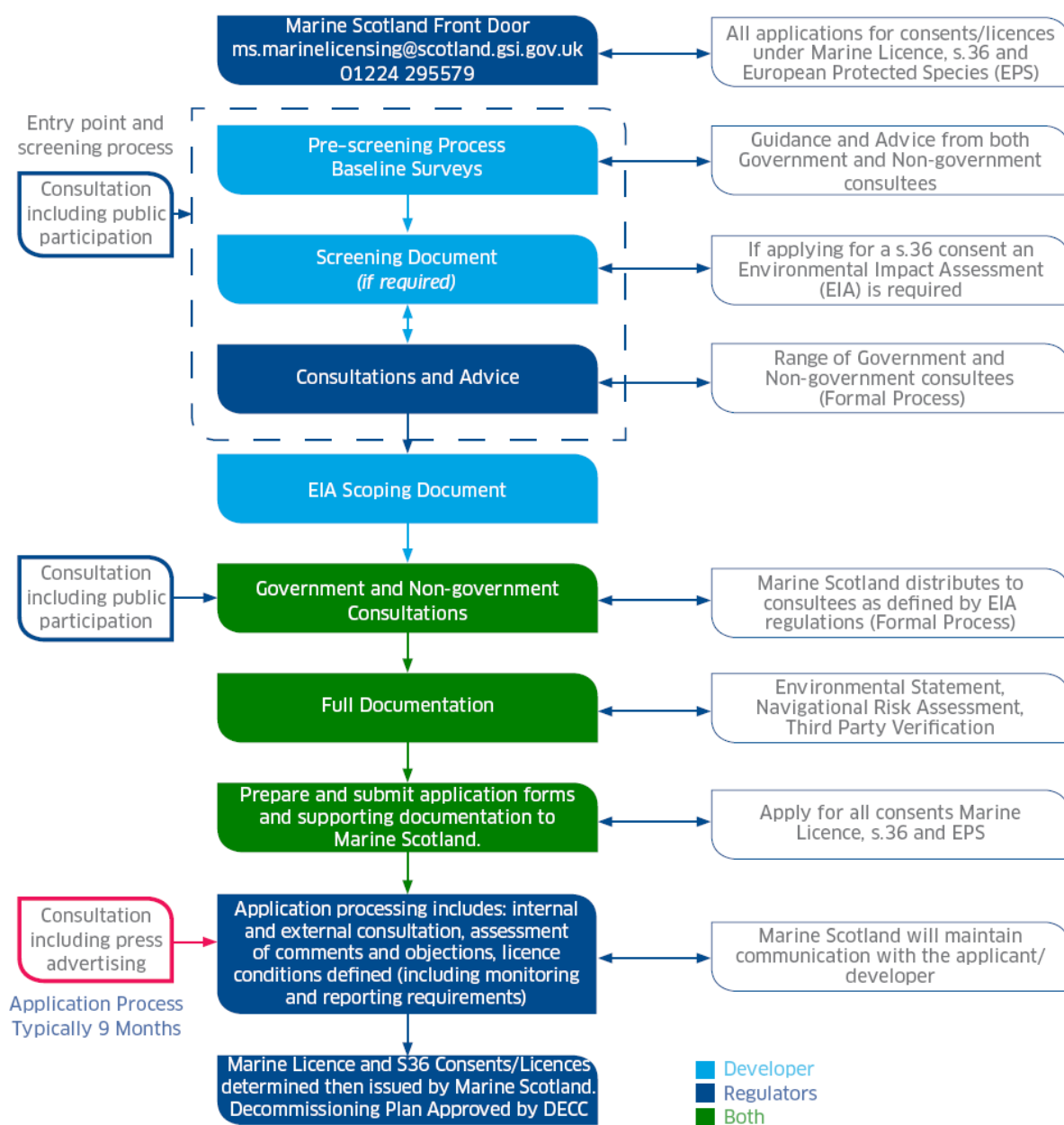
The one stop shop approach reduces the burden on applicants by providing a single contact for advice, enquiries and applications. This approach also allows coordinated consultation with the relevant nature conservation bodies and other stakeholders and interested parties, as well as a more holistic assessment of proposed projects.

The Scottish Government produced in partnership with consultants Xodus Aurora and EMEC Ltd a consenting manual for wave and tidal projects, and guidance on the associated EIA and HRA processes. The document is available on Marine Scotland's website. The consenting manual will assist developers, stakeholders and regulators to achieve sustainable development in our waters. This has been updated and amended to include a wind annex.

Pre-contact preparation

Before contacting MS-LOT, developers should, where possible, ensure that they have an awareness of the proposed site. Such awareness would include an understanding of the sensitivities of the local environment and of the potential risks arising from their proposed development. Early consultation with the Maritime and Coastguard Agency, Civil Aviation Authority, Northern Lighthouse Board and Ministry of Defence is encouraged, particularly where there might be issues involving aviation and navigational safety.

Renewable Consenting Guidance – April 2011



Requirements for / examples of participation with other marine stakeholders in decision-making and revenue sharing

Developers are encouraged by Marine Scotland to take advantage of the single point of entry (one stop shop) facility now available for renewables licensing. The Marine Scotland Licensing Operations Team will provide advice to developers in designing schemes for engagement with statutory and non-statutory consultees to resolve issues as may arise during the pre-application process and in stakeholder responses to advertised applications.

Community benefit (revenue sharing) is a well established element in the planning process for terrestrial developments. So called planning gain is used to mitigate the negative impacts that some forms of development can have on the host communities.

There is potential for parallel processes in marine developments, but may be more difficult to achieve. First, the planning and consenting authorities are national rather than local, and therefore do not have direct links with community-based democratic processes and accountability. Second, the appropriate community considered to be suffering negative impacts may not be simple to identify. Even limitations to fishing opportunity may not affect solely local fishers, but can have effects of fishers from more distant ports. The clearest opportunities for community benefit /planning gain currently appear to arise in relation to the onshore components of developments, where facilities for connection to the National Grid, building of new substations, or housing of generating plant may be required.

Requirements for / application of Environmental Impact Assessments

As indicated in the flow diagram above, the need for Environmental Impact Assessment is a central element of the workflow leading to the submission of an application for a wave or tidal power development.

Decision-support tools

MaRS spatial modelling tool

Marine Scotland has used The Crown Estate Marine Resource System (MaRS) spatial modelling tool to configure large amounts of information in a form suitable for assisting in the selection of potential development areas for wave and tidal energy projects. These are subsequently taken forward to more detailed analysis in Regional Locational Guidance. MaRS is used to map zones of broad environmental sensitivity and technical opportunities and constraints.

The MaRS system is a powerful tool for the handling and integration of a wide range of spatial data referring to environmental and technical factors that can influence the development of offshore wave or tidal energy (and other activities). The integrated data are presented as spatial models which map the constraints applying in potential development areas. In order to apply the MaRS tool, it is necessary for the user to make a number of decisions regarding the data to be included in the models and the way in which the data are to be handled. A system of scoring and weighting of information held in MaRS is used to produce graduated maps of the least to greatest technical, and subsequently environmental, and socio-cultural sensitivity. From these outputs, broad areas of technical opportunity and relatively low constraint on development can be identified and explored in more detail through Regional Locational Guidance.

In order to apply the MaRS tool, it is necessary for the user to make a number of decisions regarding the data to be included in the models and the way in which the data are to be handled. These decisions include factors such as:

- The factors that require consideration when locating wave energy developments and the availability of spatial data that can be included in the models.
- Whether particular activities or uses should be considered as incompatible with wave energy development, or whether activities or uses should be considered as presenting gradations of limitation to development potential.
- The relative importance (weighting and scoring) that should be applied to the different layers of data in the final integrated model.
- The relative quality and reliability of data layers.

Building on experience of the Scoping Studies for the Saltire Prize, the available data layers were grouped into themes (e.g. technical, industrial, environmental, socio-cultural). This procedure minimizes the conceptual problems associated with defining appropriate relative weightings for very diverse types of data (e.g. the relative weightings of seabird colonies, fisheries landings, and basking shark sightings). The thematic grouping allows assessment of the sensitivity of the outputs to variation in the overall weighting between themes. This approach had previously been used successfully in the Scoping Study for the Saltire Prize, and also in the Scoping Study for Offshore Wind in Scottish waters (Davies and Watret, 2011).

It is normal in the use of MaRS to classify data layers as either exclusion layers (i.e. indicating areas where development was not appropriate), or constraint layers (i.e. indicating the distribution of factors that acted as partial constraints on development). The constraint layers were each allocated a weighting. Within each constraint layer, the data had been assessed through a scoring scheme. The constraint layers were allocated either to technical resource assessment or to a non-Technical Model. The non-Technical Constraints Model was comprised of the outputs from three thematic Restriction models, covering constraints arising from industrial activity, environmental factors, and socio-cultural interests. The socio-cultural layer is broad in its scope, covering visual and recreational factors as well as historical heritage and archaeological potential. The outputs of these models had been normalized against the Exclusion Model.

Typical data layers which have been included in various models for marine renewable energy include:

Socio-cultural Restriction Model

Data layer	Weight	Maximum score	Potential relative influence
Landscape	1000	182	182000
Royal Yachting Association cruising routes	500	50	25000
Royal Yachting Association racing areas	500	50	25000
Royal Yachting Association sailing areas	500	50	25000
Scheduled Ancient Monuments	800	80	64000
Surfing beaches	700	100	70000
World Heritage sites	1000	100	100000
Wrecks	700	70	49000
Protected wrecks	700	70	49000
Potential for marine archaeological remains	700	70	49000

Environmental Restriction Model

Data layer	Weight	Maximum score	Potential relative influence
Bird reserves	800	80	64000
Important Bird Areas	500	50	25000
Local nature reserves	800	80	64000
Special Areas of Conservation	1000	100	100000
Special Protection Areas	1000	100	100000
Sites of Special Scientific Interest	900	100	90000
Offshore candidate SACs and SPAs	1000	100	100000
Offshore draft SACs and SPAs	1000	100	100000
Offshore possible SACs and SPAs	1000	100	100000
RAMSAR sites	1000	100	100000
Possible sea haul out sites	600	60	36000
Areas of importance to basking sharks	400	73	29200
Nursery areas for commercial fish species	300	55	16500
Spawning areas for commercial fish species	300	55	16500
Areas of search for potential Marine Protected areas	600	60	36000
Areas of search for seabird aggregations	400	40	16000
Areas of importance to breeding seabirds	400	73	29200
Areas of importance to seabirds in winter	400	73	29200
Areas of importance to marine mammals	800	145	116000

Industry Restriction Model

Data layer	Weight	Maximum score	Potential relative influence
Offshore cables in UK waters (not active)	500	100	50000
Pipelines in UK waters (not active)	500	100	50000
Potential gas and CO2 storage sites	800	80	64000
Carbon capture and gas storage infrastructure	800	80	64000
Current Licensed Areas for Hydrocarbons	700	70	49000
Closed waste disposal sites	700	70	49000

Military Practice and Exercise Areas	1000	180	180000
Shipping density	800	145	116000
Ferry routes	1000	100	100000
Commercial fisheries – combined layer covering inshore and offshore, mobile and static gear landings from mobile gear in inshore waters	1000	182	182000
Dredging	1000	100	100000

Non- technical Exclusion Model

The following features have been treated as incompatible with offshore wave energy projects, i.e. areas from which wave farms should be excluded at this time.

All Offshore Cable inside UK Waters

All Pipeline in UK Waters (active)

Anchorage Areas

Aquaculture Leases – Current

Aquaculture Leases - Pending

Waste disposal sites (open)

IMO Routeing - excluding ABTAs

Munitions Dumps

Navigation aids

Offshore Shipping Zones

Offshore Wind Farm Demonstration Sites

Operational Anemometers in UK Waters

Protected Wreck Exclusion Buffers

UK offshore wind activity

Shipping Density - Exclusion Areas

Tidal Leases – Live

UK Deal oil and gas Safety Zones

UK Deal oil and gas Surface features

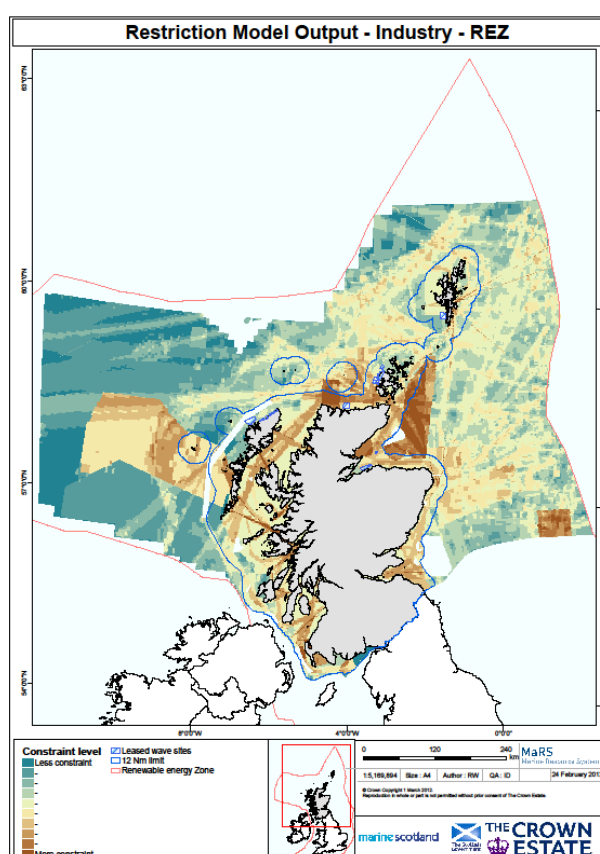
UK Deal oil and gas Subsurface features

UKCS Exclusion Buffer - 500 m

Wave Leases – Live

UK Detailed Coastline - not including Isle of Man (Polygon)

The outputs from the three restriction models express the relative level of constraint to wave, tidal or wind development in Scottish waters. The Industry restriction model below clearly shows the influences of various ferry and shipping routes, MOD practice areas, etc.



Combined Models

An expression of the overall level of constraint on wave, tidal or wind energy developments in Scottish waters needs to take account of environmental, industry and socio-cultural restrictions. The presentation of the information by theme has been shown to reduce the difficulties inherent in developing relative weightings for very diverse types of data (e.g. the relative weighting of seabird colonies, wrecks, fish landings, and basking shark sightings). Having grouped the data and developed thematic restriction models, it is now possible to combine the models within MaRS and assess the sensitivity of the outputs to variation in the overall weighting between themes. This approach had previously been used successfully in the Scoping Study for the Saltire Prize

Combined models can be created, in which the relative weightings of the themes were changed. In an Equal Weighting model, the three themes would be weighted equally. Other Combined models can also be developed, in which the themes can be assigned different weightings. The scheme below, for example illustrates a scheme in which each theme in turn was assigned a weighting equal to the sum of the weightings for the other two themes.

	Environment theme	Industry theme	Socio-cultural theme
Equal weighting constraints model	100	100	100
Environmental focused constraints model	200	100	100
Industry focused constraints model	100	200	100
Socio-cultural focused constraints model	100	100	200

The scorings and weightings of the layers within the themes were designed with the minimization of consenting risk in mind. A Combined model integrates this wide range of data into a single map. These maps have been used to help identify priority areas for development, for example in the context of the Saltire prize.

Research in support of sustainable wave and tidal energy development

There is currently a substantial amount of marine renewable energy related research ongoing across Scotland. This research is being performed by a number of different bodies and organizations including universities, government and government agencies, and industry and developers. Research areas include hydrodynamic modelling initiatives to better understand the nature of the wave and tidal energy resource, but there are many more projects investigating the environmental consequences of wave and tidal energy extraction, and the presents of marine renewable energy devices (see list of tables). There are also a number of projects looking into marine stakeholder interactions. There has been some focus on the development of monitoring and decision-making tools (see table under ToR d). These aim to further streamline the licensing procedure. There is also a great deal of ongoing baseline collection of physical and ecological related data, and monitoring. This is to help identify strategic areas but also to help inform the licensing and consenting process. The Scottish Government (SG) is making distinctions between strategic level monitoring in support of the SG responsibility for marine planning, and investigations and monitoring that are project specific. Project developers typically undertake bird, mammal and seabed survey work in and around their development sites. At the same time, the SG has undertaken detailed seabed bathymetric and habitat surveys in potential wave and tidal development areas to aid the site identification and assessment work by developers. This strategic level work coordinated by the SG also includes broad scale seabird distribution surveys, and will soon include marine mammals. Much of this strategic work is relevant to the planning and site characterization stage of development. In addition, the SG is developing a Demonstration Strategy, by which the SG would fund targeted research activities, mainly related to impact monitoring, at wave and tidal sites once they have been established. The aim would be to improve understanding of the scope and intensity of specific environmental interactions of wave and tidal devices.

3.2 Report for UK-England

National roadmaps for wave and tidal energy development

The Government has established a new UK Marine Energy Programme that is focusing on enhancing the UK marine energy sector's ability to develop and deploy wave and tidal energy devices at a commercial scale. The Programme will allow DECC to put in place a coherent programme of policies across Government, led by DECC, to

allow the UK Marine Energy sector to move from prototype testing to commercial deployment over the coming 5 years and provide a direct link between DECC Ministers and sector stakeholders. The Marine Energy Programme Board, which draws together key stakeholders from across the marine energy sector, will play a central role in advising Ministers what actions the Programme should address to advance the industry.

The Marine Policy Statement (MPS) is the framework for preparing Marine Plans and taking decisions affecting the marine environment including the licensing of wave and tidal devices under the Marine and Coastal Access Act. The marine environment will make an increasingly major contribution to the provision of the UK's energy supply and distribution and this includes a growing contribution from marine renewable energy with wave and tidal stream technologies having significant potential in the medium to long term. Marine Plans should take account of and identify areas of potential for the deployment of different renewable energy technologies. Measures should be taken to prevent, mitigate, and where that is not possible compensate, for any potential negative impacts in line with legislative requirements. Marine Plans and the marine planning process will need to be flexible in responding to emerging evidence about the impacts of new technologies; in particular the monitoring and review arrangements for plans will be important in this. It is important for marine planning to take account of appropriate locations for such developments alongside more established uses of marine space and to recognize the time-scales and stages against which the sector is likely to progress, including the lead time for grid and infrastructure development. For example, pre-commercial demonstration deployments will need to manage the potential environmental impacts in relation to the scale of risks and legislative requirements while recognizing that not all uncertainties can be addressed in the early life of this technology.

The DECC Roadmap sets out the approach for unlocking the UK's renewable energy potential. The key action for marine energy (excluding offshore wind) is to provide up to £20m over the next 4 years to support innovation in wave and tidal devices and commission marine energy testing facilities at the National Renewable Energy Centre (NaREC) early in 2012. Work with The Crown Estate to introduce a knowledge sharing network to accelerate the level of marine energy deployment. Provide guidance to the sector by March 2012 to help develop Marine Energy Parks in order to stimulate the supply chain. Manage potential conflicts with other users of the sea by working with marine regulators and publishing later this year the response to the wave and tidal elements of the Offshore Energy Strategic Environmental Assessment

Current development activities

Wave Hub is a grid-connected offshore facility in South West England for the large-scale testing of technologies that generate electricity from the power of the waves. It holds a 25 year lease of 8 sq km of seabed connected to the grid by a 11/33kv subsea cable. Plans for deployment of both Ocean Energy Ltd OE buoy and Ocean Power Technologies' Power Buoy later this year are underway at Wave Hub.

Neptune Tidal Stream Generator comprises of a floating tidal stream generator located in the Humber Estuary linked by several power and control cables leading from the generator to a switch room inside The Deep Business Centre. Also in the Humber Pulse tidal has been testing the 100kW "Pulse-Stream 100" into the mouth of the River. Plans to scale up at a site in Scotland Kyle Rhea are now underway.

The FaB (Falmouth Bay) Test site is a pre-consented two square kilometre area situated within Falmouth harbour between three and five kilometres offshore in Falmouth Bay. The site offers water depths of 20m-50m and seabed types; rock, gravel and sand. The FaB Test nursery facility will enable wave energy device developers to test components, concepts or full-scale devices in a moderate wave climate with excellent access to nearby port infrastructure. FaB Test's pre-consented status which allows for up to three devices to be deployed concurrently aims to provide a fast, flexible low cost solution for the testing of wave energy technologies, components, moorings and deployment procedures. The first device to be tested at the FaB site is the Fred Olsen's BOLT "Lifesaver" wave energy converter deployed during April 2012 and now undergoing testing.

No other areas currently leased by Crown Estate in English waters.

Data on leasing areas possibly available from Crown Estate and Marine License areas from MMO.

Planning and consenting processes

The draft plan/programme to be covered by the current SEA will help to contribute to the latest Government targets by allowing future rounds of renewable leasing for offshore wind, wave and tidal devices and licensing/leasing for seaward oil and gas rounds and gas storage (including carbon dioxide storage). In terms of wave and tidal energy the elements of the draft plan/programme are;

- Wave – to enable future leasing in the UK Renewable Energy Zone and the territorial waters of England and Wales. The Scottish Renewable Energy Zone and Northern Irish waters within the 12 nautical mile territorial sea limit are not included in this part of the plan/programme. In view of the relatively early stage of technological development, a target generation capacity is not set in the draft plan/programme.
- Tidal stream – to enable future leasing in the UK Renewable Energy Zone and the territorial waters of England and Wales. The Scottish Renewable Energy Zone and Northern Irish waters within the 12 nautical mile territorial sea limit are not included in this part of the plan/programme. In view of the relatively early stage of technological development, a target generation capacity is not set in the draft plan/programme. Similarly, a minimum average tidal current velocity threshold is not proposed.
- Tidal range – to enable future leasing in the territorial waters of England and Wales. The Severn tidal power schemes are not included as they are part of a separate DECC SEA initiative. It is considered unlikely that there will be tidal range developments outside territorial waters.

MMO have gathered together all the information available to build a picture of the current status of the East marine plan areas and the east coast and estuary communities, as well as the current activities in the areas, with the help of stakeholders during 2011 and earlier in 2012. The information was used to identify the issues that are key in managing the East marine areas in a sustainable way. The next step in producing marine plans for the East marine plan areas has been to draft a 20-year vision, looking forward to how the marine areas could look in 2033 and also to draft a set of objectives covering both plan areas that will lead us towards this vision which is available on the MMO website. The MMO are engaging with the future plan areas across the rest of England while the planning process for the first plans for the East Inshore and East Offshore areas takes place over the next two years.

Seabed leases are granted by Crown Estate. MMO are responsible for licensing offshore generating stations including wind farms, wave and tidal devices with a capacity between 1 and 100 megawatts in England. In addition to a Marine Licence, these applications may also require consent under the Electricity Act 1989. Applications for a Marine Licence will be subject to assessment under the Habitats Regulations and Water Framework Directive and may be subject to an environmental impact assessment if they fall under Annex I or Annex II of the Marine Works Regulations 2007. In considering Marine Licence applications the MMO will consult any person or body that they consider fit, these could include local authorities, nature conservation bodies, Environment Agency, English Heritage, Maritime and Coastguard Agency, Corporation of Trinity House, The Crown Estate, inshore fisheries and conservation authorities and local harbour authorities. In most cases the MMO will consult also with their local office and their scientific and technical advisors (Cefas). As part of the application process the MMO will either publish notification of the application or require the applicant to do so, so that other parties can make representations to the MMO.

Outside the application process the Fishing Liaison with Offshore Wind and Wet Renewables Group (FLOWW) was set up in 2002 to foster good relations between fishing and the offshore renewable energy sectors. In 2008 the group produced a document entitled 'Recommendations for Fisheries Liaison: Best practice guidance for renewables developers'.

The Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC) was formally adopted by the European Union in July 2008 and was transposed into UK law by the Marine Strategy Regulations in 2010. The responsibility for implementing the MSFD lies with Defra, although delivery of the measures to achieve Good Environmental Status (GES) will rely on regulatory and delivery bodies such as MMO. Existing measures implemented under UK legislation (Marine and Coastal Access Act 2009) and European legislation (e.g. Water Framework Directive (

EN 12.1), EIA D
EN 4.1) and the B

at improving the state of the UK's marine and coastal environments and will support the proposed targets and the achievement of GES. Additional management measures will undoubtedly be necessary; however at this stage it is not possible to identify them until further work to develop UK proposals is carried out between now and 2016.

Examples of data that could be made available through the ICES spatial facility are details of current marine plan areas, conservation designations, fish spawning areas and shellfish production areas.

Decision-support tools

Cefas has developed a tool to assist the Marine Management Organization (MMO) determine licensing decisions (Stelzenmüller *et al.*, 2010). The tool is based on a geo-spatial modelling framework that combines standardized data describing footprints and/or intensities of human activities with a measure of the sensitivity of marine landscapes to the pressures of these activities and allows the quantification of the risk of cumulative impacts on the UK continental shelf.

With the help of GIS - Multi-Criteria Analysis, Cefas developed an algorithm that produced four different scenarios to quantify risk of cumulative impacts. Modelled scenarios have been used to reflect additive interactions of pressures and account for linear and logistic decrease of importance of ranked pressures.

The risk assessment framework has been tested by examining the outputs from both a wide range of possible modelled scenarios and uncertainties, but all scenarios revealed similar locations with an increased risk of cumulative impacts.

The standardized framework and GIS decision-making support tool can be applied to identify suitable areas for the development of marine resources and therefore provides a practical tool that can be used to support the development of sustainable marine plans.

The MMO also undertake priority assessments based on the level of risk to determine what level of advisory and scientific input is required to underpin licensing decisions.

Reference

Stelzenmüller, V., Lee, J., South, A., and Rogers, S.I. 2010. Quantifying cumulative impacts of human pressures on the marine environment: A geospatial modelling framework. *Mar Ecol Prog Ser*, 398: 19–32.

Tool	Principles of operation	Geographical application
	MMO undertake priority assessments based on risk (list of questions)	Generic
	Cefas Planning tool (available to MMO planners) - this is a geospatial modelling framework plus a GIS tool for quantifying cumulative impacts of human pressures on the marine environment	Based on GIS
	Cefas Regulatory assessment team have developed a Risk Assessment Tool (Determines level of advisory input)	Generic
SAFESIMM	Behavioural responses of marine mammals to sonar - development underway to adapt for underwater noise and to link to sound propagation models	Generic
	Collision risk models – to predict the outcome of marine mammal interactions with wave and tidal devices	
MaRS	MaRS – Marine spatial planning tool (developed by Crown estate)	GIS based

Research in support of sustainable wave and tidal energy development

See summaries of research projects at Annex 6.

3.3 Report for UK-Wales

Current development activities

Tidal Energy Ltd (TEL), based in Cardiff will be deploying a 1.2MW tidal energy device in the north of Ramsey Sound, Pembrokeshire, in 2013. This will be the first deployment of a wave or tidal device in Welsh waters. There are currently no plans for other developers to deploy at this site.

Consent has been given for this device (by the MMO), baseline monitoring and construction has begun.

Planning and consenting processes

Planning and consent in Wales is identical with the process in England with responsibilities for leasing and licensing being covered by Crown Estate and the MMO (for capacities between 1 and 100 MW) respectively. The Welsh Government can grant licenses for deployments up to 1MW.

Research in support of sustainable wave and tidal energy development

Research in Wales has been focused on two main geographical areas, Ramsey Sound, Pembrokeshire in southwest Wales and to a lesser extent the Skerries, Anglesey, in North West Wales. Some smaller studies have also been conducted in the Bristol Channel.

Studies are underway to model wave resources and potential impacts of wave devices on beach geomorphology, but most effort has concentrated on modelling and characterizing tidal stream sites. Modelling studies include resource assessment, influence of turbulence and wave surge on tidal devices and interactions with marine life.

Environmental studies include development of assessing fish communities at fast current sites and baseline monitoring of fish, assessment of natural underwater noise, porpoise behaviour, seal population studies, boat mounted ADCP surveys and water quality monitoring.

Additional studies have been conducted looking at marine and coastal archaeology and heritage as well as perceptions of marine renewable by tourists in the coastal zone.

3.4 Report for UK - Northern Ireland

National roadmaps for wave and tidal energy development

The Department of Enterprise, Trade and Investment (DETI) published an overarching Strategic Energy Framework 2010 in September for Northern Ireland. It sets out a vision for a much more sustainable system where energy is used as efficiently as possible; more of Northern Ireland's energy is from renewable sources; and where Northern Ireland ensures that all generation is as competitively priced as possible. A draft Offshore Renewable Energy Strategic Action Plan 2009–2020 (ORESAP) was the subject of a Strategic Environmental Assessment (SEA) during 2009, the purpose of which is to integrate environmental considerations into the preparation and adoption of plans with a view to promoting sustainable development. A final version of the ORESAP was published by DETI in 2012. This takes account of the findings of the SEA and associated Habitats Regulations Assessment (HRA) and Appropriate Assessment exercises. The overall aim of the ORESAP is "to optimize the amount of renewable electricity sustainably generated from offshore wind and marine renewable resources in Northern Ireland's waters in order to enhance diversity and security of supply, reduce carbon emissions, contribute to the 40% renewable electricity target by 2020 and beyond and develop business and employment opportunities for NI companies. The associated development opportunity is for up to 900 MW of offshore wind and 300 MW from tidal resources in Northern Ireland waters by 2020" (DETI, 2012).

The Crown Estate, as manager of the seabed around Northern Ireland, launched the process for the first Northern Ireland Offshore Renewable Energy Leasing Round in March 2011. This was followed by an industry-focused Design Discussion stage in

April/ May 2011. During this discussion those involved in the sector were able to offer their views on how the opportunities could be presented to maximize market interest and commitment to development as well as the benefits to Northern Ireland. Regional Locational Guidance, developed in association with numerous marine stakeholders, was developed and published in advance of the Leasing Round so as to facilitate consideration by developers and other stakeholders of the opportunities and constraints for developing offshore renewables in the waters around Northern Ireland. This provides greater detail on the different interests and possible interactions at each of the Resource Zones, previously identified in the SEA, possible landfalls, advice and guidance on the statutory marine licence and consenting procedures.

In December 2011, the Crown Estate launched two parallel leasing rounds in December 2011 for offshore wind and tidal developments covering two geographic locations:

- The offshore wind area, off the southeast coast of County Down, will be leased to a single development company to deliver up to 600MW of generating capacity, and,
- Given the current development status of the tidal sector, there is a demand for both commercial scale and demonstration schemes such as small-scale arrays and, with this in mind, the Rathlin Island and Torr Head Strategic Area with up to 200MW generating capacity will be leased to developers for the delivery of multiple projects. Applications have been invited for projects for commercial demonstration leases (up to and including 10 MW) and full commercial leases (over 10MW and up to 100MW).

Independently of the above leasing round, the Crown Estate also operates a separate competition for demonstration projects up to 10MW across all UK waters including Northern Ireland waters outside the Rathlin Island and Torr Head Strategic Area.

Current development activities

The MCT Sea Gen 1.2 MW tidal stream demonstration project is currently operating in Strangford Lough. It is hoped that a small-scale tidal device array will become operational in the near future but as yet this has not happened.

With respect to the leasing round outlined above, development rights are expected to be offered by the Crown Estate to successful companies in September 2012. At that stage DETI and the Northern Ireland Environment Agency will engage with those companies to ensure they understand the statutory marine licence, electricity consenting and stakeholder engagement requirements. Consenting and licensing activities including those associated with EIA and AA are anticipated to occur during late 2012 to 2015, after which full Crown Estate leases will be issued. Deployments are expected from 2015-16 onwards. These time frames are suggested only and not definitive (DETI, 2012).

In addition to the leasing round outlined above, the availability of wave and tidal test facilities operated by Queen's University Belfast at Strangford Lough and its Marine laboratory at Portaferry offer the opportunity for early stage testing of prototype devices.

Planning and consenting processes

An SEA has already been carried out and DETI has indicated that the ORESAP is being implemented in such a way so as to ensure that it does not cause any significant adverse effects on the environment and other users. A key recommendation of

the SEA was the establishment of an Offshore Renewable Energy Forum (OREF). This was established by DETI in January 2011 and will advise DETI on the implementation of the ORESAP. It builds on the existing cross Departmental Project Steering Group membership and includes representatives from key stakeholder groups such as the fishing sector, the ports and harbours sector, the renewable industry, Invest NI, environmental groups and local authorities.

Northern Ireland is part of wider UK initiatives on integrated marine management through the implementation of the Marine and Coastal Access Act 2009 and accordingly the Department of the Environment (DOE) in Northern Ireland are in the process of putting in place a new marine licensing system which replace the previous Food and Environment Protection Act 1985 (FEPA) regime. This new system also covers appeals, fees, exemptions, civil sanctions and the registration of marine activities. In parallel with this, DOE is also leading on the development of a Northern Ireland Marine Bill which will address a number of areas which fall within Northern Ireland's devolved settlement arrangements. The Marine Plans developed under this will set the long-term direction of the management of the marine environment; provide increased certainty for business and other users; promote the sustainable use of marine resources and help users of the sea and coastal communities understand what is happening in the marine environment. The Bill was introduced to the Northern Ireland Assembly in February 2012 and it is anticipated that the legislation will be enacted early in 2013.

In advance of the enactment of the Northern Ireland Marine Bill it has been recognized that there is scope to consider more immediate actions to set out clearly roles, responsibilities and time frames for the licensing and consenting of offshore renewable energy projects for both developers and regulators. The current offshore electricity licensing and consenting regime involves a lease from the Crown Estate, as managers of the seabed; a Marine Licence from NIEA, required for placing anything on or removing material from the seabed, and electricity generation consents from DETI and UREGNI under the Electricity Order 1992. Within their respective legislative frameworks, NIEA, DETI and DOE Planning Service (in respect of any land-based development arising from the project) require three separate Environmental Impact Assessment (EIA) regulations to be met. Streamlining such requirements would help create a smooth development pathway for future developers. In light of this DOE and DETI are finalizing a Memorandum of Understanding (MOU). In light of the outcomes from the extensive environmental monitoring work that has gone on as part of the SeaGen deployment, DETI in conjunction with NIEA are also developing a "Survey, deploy and monitor" policy for Northern Ireland waters which is expected for publication by December 2012. This will therefore be an important future consideration in the policy context.

It is not yet clear what format Maritime Spatial Planning will take at the local level in Northern Ireland. There is also cross-border and transnational aspects to be considered here. There has never been a formal, legal delimitation of the marine border between Northern Ireland and the Republic of Ireland. In recognition of this, the Irish and UK governments have adopted a Memorandum of Understanding (MOU) which states that the Governments of Ireland and the UK may each arrange for the lease of the seabed to facilitate the development of offshore renewable energy installations, and for the licensing of construction and operation of such installations, up to their respective sides of the two lines constituted by the lists of coordinates and depicted on illustrative maps. The MOU represents a political commitment between the two Governments but its legal status is debatable.

Reference: Department of Enterprise, Trade and Investment (DETI). 2012. Offshore Renewable Energy Strategic Action Plan 2012-2020. DETI, Belfast, Northern Ireland. March 2012. Available from:

http://www.detini.gov.uk/ni_offshore_renewable_energy_strategic_action_plan_2012-2020_march_2012_.pdf

3.5 Report for Ireland

National roadmaps for wave and tidal energy development

Ireland's Ocean Energy Strategy was published in 2006 and aimed to assist with the development of the wave and tidal sector (SEAI and MI, 2006). This brought with it dedicated funding and created the Ocean Energy Development Unit (OEDU) in the Sustainable Energy Authority of Ireland (SEAI) in 2008. Since then, there has been ongoing work in relation to R&D facilities, a supportive policy framework and test site infrastructure. In 2010 the Department of Communications, Energy & Natural Resources (DCENR) published a draft Offshore Renewable Energy Development Plan (OREDPP) for public consultation (DCENR, 2010a). This outlines the current state of offshore wind, wave and tidal energy in Ireland and explains how policy for this sector is developing and some of the factors that are likely to affect development. The content of the draft OREDPP reflects the findings of the recent Strategic Environmental Assessment on marine renewables in Ireland and therefore considers low, medium and high scenarios for the development of offshore wind, wave and tidal energy up to 2030. A final version of the OREDPP is expected to be published in 2012.

Coupled with the SEA and draft OREDPP, Ireland also has a binding renewable energy target under Directive 2009/28/EC and, in compliance with this Directive, has published a National Renewable Energy Action Plan (NREAP) setting out how the target for 2020 is to be achieved (DCENR, 2010b). The NREAP states that Ireland expects 555MW of offshore wind to be contributing to its 2020 target as well as 75MW of wave and tidal generated power. In recognition of the fact that the Directive provides for cooperation mechanisms for Member States to trade renewable energy in the period to 2020, if they are able to exceed their national target, a study on the cost benefits of Ireland engaging in the cooperation mechanisms under the Directive was commissioned in 2011 and is due for publication in the coming months.

The Sustainable Energy Authority of Ireland (SEAI) published a dedicated Ocean Energy Roadmap in 2010 (SEAI, 2010). This was designed to take a longer term view, to 2050, and help initiate a debate on the pathway for ocean energy development. The analysis presented in the Roadmap is based on programme experience, analysis and modelling, as well as a number of specially commissioned studies. The pathways presented were also analysed in terms of economic competitiveness, employment opportunities and energy security. In addition to this Roadmap, SEAI have also commissioned and published several reports including a report on the industrial development potential of offshore wind in Ireland (March 2011); an assessment of ports and shipping requirements for the marine renewable industry sector (August 2011), which is important because of its relevance to the supply chain, and a study of the supply chain requirements and Irish company capability in the offshore wind, wave and tidal energy sector (April 2012).

Current development activities

The Galway Bay Test site, which is a quarter scale test site, remains operational but works have commenced to augment the facility by providing power and bandwidth

to the test site, in conjunction with the SmartBay initiative (see below). This is due for completion in late 2012. Work on the full-scale, grid-connected test site, the Atlantic Marine Energy Test Site (AMETS) is continuing in Belmullet, Co. Mayo on Ireland's west coast. The Environmental Impact Assessment of this development has been completed and was open for public consultation until the end of May 2012. Data and information from this will be made available through the SEAI website in due course. An Appropriate Assessment has also been carried out and published. A foreshore lease application has been submitted to the Department of Environment, Community & Local Government with a decision expected in September 2012. The Test Site will be connected to the national electricity grid and will be able to accommodate up to 3 devices at any one time.

Ocean Energy Ltd. deployed their ¼ scale 'OE Buoy' device from March to May 2011 at the Galway Bay Test Site, as part of the EU-funded CORES project. The project, which was coordinated by the Hydraulics & Maritime Research Centre (HMRC) in University College Cork, involved 13 European project partners and sought to address particular issues that arose from the development of Oscillating Water Column Wave Energy Converters (OWC WECs). The successful testing period in Galway Bay allowed the integration of the resulting real, validated and verified results into a holistic system model, a "Toolbox" for wave-to-wire simulations of complete WEC systems.

Separately, the WestWave project aims to develop the first wave energy project in Ireland by 2015 by generating 5 MW of electricity from the wave energy resource off the west coast of Ireland. WestWave is a collaborative project being led by ESB International (ESBI) in conjunction with a number of wave energy technology partners including Wavebob, Ocean Energy Ltd., Aquamarine Power and Pelamis Wave Power. Potential financial support was sought from the EU's NER300 scheme in the Wave Energy category, though this has been unsuccessful. The project will represent Phase 3 of the aforementioned Ocean Energy Strategy. The project leader, EBSI, has carried out a site selection study and identified eleven potential candidate areas. The criteria used to assess the sites included seabed conditions, wave power, marine traffic, local area considerations, required infrastructure, network conditions, environmental constraints, onshore works, port facilities and other marine users and activities. Following this process, three preferred sites were selected and currently more detailed information at three locations is being collected in order to make a final selection. These are:

- 1) Atlantic Marine Energy Test Site, Belmullet, Co. Mayo: this site is suited to offshore technology, namely deep-water converters with mooring depths of 50 to 100m.
- 2) Site south of Achill Island, Co. Mayo: this site is suitable for nearshore wave energy converter technology. Seabed surveying and wave measurements have been ongoing at this location since 2011.
- 3) Site close to Killard Point, Co. Clare: this site is also suitable for nearshore technology and seabed surveying and wave measurements have been ongoing at this location since 2011.

Environmental Scoping documents were published by ESBI for both the Achill and Killard sites in January 2012. A supply chain study, specific to WestWave is outlined below.

Planning and consenting processes

A Strategic Environmental Assessment (SEA) of the Offshore Renewable Energy Development Plan (OREDPA) in Ireland was published in October 2010. The associated Offshore Renewable Energy Development Plan (OREDPA) is still in draft format and expected to be completed by the Department of Communications, Energy & Natural Resources in 2012.

In relation to the planning and consenting process, there is no dedicated legislation dealing with offshore renewables (wind, wave or tidal) as yet and consequently there is a reliance on existing foreshore, environmental and maritime jurisdiction legislation. For a complete discussion of the current regime, see O'Hagan and Lewis (2011). In summary developers require a foreshore licence (for EIA / survey activities); a foreshore lease (for sole occupation); an EIA (required as a matter of policy when making an application for a foreshore lease; planning permission (for onshore works); Appropriate Assessment (site dependent); a Licence to Generate and a Licence to Construct, both under the Electricity Regulation Act, 1999. In addition developers will also require a Grid Connection Offer and a Power Purchase Agreement which operate outside the legal system.

In recognition of the fact that the current regime is in need of review and updating, the Government have started to work on a new consenting regime. This will require enactment of new legislation, which is expected in 2012. Briefly, this will see the inclusion of marine renewable energy developments in the operation of the Strategic Infrastructure Development (SID) regime, whereby a development application will be made to a centralized authority (An Bord Pleanála – the Irish Planning Board). The statutory provisions contained in the current SID regime provide for up to three stages: mandatory pre-application consultation, scoping of the Environmental Impact Statement (EIS) and the application for permission. An application made under the SID regime must be accompanied by an Environmental Impact Statement (EIS), the term given in Irish law to an EIA.

In terms of public participation in the SID process, notice of the proposed development must be published in a local newspaper and also displayed at the site. Information on the development, including the EIS, must also be available for public inspection for a minimum period of six weeks. The application fee for the SID process is €100,000 and is payable when the application is lodged. One possible criticism of the SID regime is the fact that the local planning authority is treated as a *de facto* consultee and required to submit a report to the Board within 10 weeks of the receipt of the application by the Board. Submissions can also be made by any member of the general public subject to payment of €50. When making a final decision, the Board must consider all of the submissions received; the EIS and any other relevant information. The Board must make its decisions within 18 weeks. A decision of the Board must contain the main reasons and considerations on which the decision is based, the main reasons for the imposition of the conditions and detail costs to be paid to the Board and/or the planning authority for determining the application. The permission does not become operative until these costs have been paid. There is no right of appeal against the decision of the Board on a SID application. It can only be challenged by way of judicial review in the High Court within 8 weeks of the decision being made.

Ireland has transposed the provisions of the Marine Strategy Framework Directive into national law through the enactment of the European Communities (Marine Strategy Framework) Regulations 2011. These Regulations require an initial assess-

ment of the status of Ireland's marine waters, a determination of good environmental status and the establishment of a series of environmental targets and associated indicators in 2012. The Department of the Environment, Community & Local Government have ultimate responsibility for the implementation of the Directive and associated Regulations.

Independently, as an initiative of the high-level, inter-departmental Marine Coordination Group (MCG), *Harnessing Our Ocean Wealth*, a Roadmap for an integrated marine plan for Ireland was published in July 2012. This sets out the Government's vision, high-level goals and integrated actions across policy, governance and business to enable the country's marine potential to be realized. Implementation of *Harnessing Our Ocean Wealth* lies with the numerous Government departments that have a marine remit with over-arching responsibility resting with the MCG and the Minister for Agriculture, Food and the Marine who will supervise cross-government delivery and implementation. In addition it is proposed that the MCG will establish independently chaired Task Force(s), that are 'enabler' or 'development' focused, for a set time period and with defined Terms of References involving government and non-government participants. The goals and key actions set out in *Harnessing Our Ocean Wealth* are in line with the EU's Integrated Maritime Policy. One stated key action is the "development of an appropriate Maritime Spatial Planning Framework for Ireland within which the scope and objectives of an overarching national Marine Spatial Plan will be defined" which will happen in the short-medium term through the Enablers Task Force (Government of Ireland/MCG, 2012). The document concludes with a section on summary feedback from the public consultation where it is recognized that the need to link MSP with ICZM as a continuously evolving overarching framework focusing on long-term sustainable development is vital, however, no mention of this is made in the body text of the document.

Research in support of sustainable wave and tidal energy development

Assessment and modelling of the energy resource

Galway Bay:

- Directional Waverider buoy deployed on site since 2006.
- Wave data are updated every three minutes.

AMETS:

- Since February 2010, wave energy buoys have measured the shape and height of every wave crossing a specified point and this information has been transmitted via satellite link to the OEDU at the civic offices in Belmullet.
- In addition, an Acoustic Doppler Current Profiler (ADCP) is located on the seabed adjacent to one of the weather buoys.
- A hydrographic and geophysical survey (multibeam sidescan sonar and sub-bottom profiling) was conducted in August 2008 and in the nearshore zone in autumn 2009.
- Data are also used for benthic information.
- Modelling of the impact of wave energy converters on the wave resource, sediment transport and coastal landform was carried out by the Hydraulics & Maritime Research Centre in UCC. The modelling indicated that the impact of the wave energy converters when deployed at the test area would be insignificant in comparison to the natural processes occurring in

the bay. There will be no significant impacts on sediment transport, coastal landform or surfing waves.

Achill Island:

- In November 2011 a Waverider wave monitoring buoy was deployed at the 41m water depth contour adjacent to the likely locations of the West-Wave site. In addition an Acoustic Doppler Current Profiler (ADCP) was deployed simultaneously to collect wave and current data at the shallower 21m water depth location. The Waverider buoy will be deployed for a period of one year initially. The ADCP was deployed for a period of two months to collect near shore wave data.
- Between 12th July and 28th July 2011, a set of nearshore seabed surveys were carried out on behalf of SEAI. The Survey area extends approximately 5km SW offshore from Achill and covers depths ranging from 0-55 metres LAT (Lowest Astronomical Tide).

Killard Point:

- In November 2011 a Waverider wave monitoring buoy was deployed at the 50m water depth contour adjacent to the likely locations of the West-Wave site. The Waverider buoy will be deployed for a period of one year initially.
- In addition an Acoustic Doppler Current Profiler (ADCP) was deployed simultaneously to collect wave and current data at the shallower 21m water depth location. The ADCP was deployed for a period of two months to collect near shore wave data.
- Between 12th July and 28th July 2011, a set of nearshore seabed surveys were carried out on behalf of SEAI. Survey work was carried along the coast of Killard, Co Clare, located a few kilometres north of Kilkee and a few kilometres south of Liscannor Bay on the Irish west coast. The Survey area extends approximately 5km NW with survey-lines running parallel with the area's depth contours. Depths in the survey area range from 6-58 metres Lowest Astronomical Tide (LAT).

Direct impacts, e.g. on marine mammals, birds, benthic biotopes

The objective of the IEE-funded SOWFIA (Streamlining of Ocean Wave Farms Impact Assessment) project is to develop and improve tools and methods for environmental and social impact assessment of wave farms. As part of this the Hydraulics and Maritime Research Centre at University College Cork is working with the Irish Whale and Dolphin Group on a comparison of what monitoring of whales, dolphins and other megafauna is being done across Europe in order to compare programmes and methodologies. This information will feed into the Data Management Platform being developed under the project. Initially the information gathered will be from Test Centres involved in the project but it is hoped that other data and information can be incorporated at a later stage.

Interactions with other stakeholders

Galway Bay: Nothing to date.

AMETS:

- A preliminary navigation risk assessment using AIS data (radar) provided by the Coastguard for ship traffic in the area of the site for 2009; also VMS

data from larger vessels was produced in 2010. Meetings with relevant authorities with different competencies around the site have also taken place (2010 and 2011).

- In 2010, a detailed study of applicable development plans was carried out to ascertain specific landscape, visual and scenic amenity policies and landscape character assessments relating to the area. Photomontages of the landscape and seascape with WECs deployed and of the substation in the seascape and landscape setting were prepared and used to visualize the substation in the context of the surrounding landscape/seascape. This culminated in the preparation of a Zone of Theoretical Visibility (ZTV) map to check visibility of any WECs from the vantage points in the area.

Other:

As part of the SOWFIA project, a questionnaire on stakeholder perceptions of marine renewable energy generally, the AMETS development in particular and public consultation in the decision-making process was circulated to stakeholders in the Belmullet area, surrounding the AMETS site. This information has been written up and will be included in the associated project report.

Development of monitoring tools

National: The Marine Institute's SmartBay Project in Galway Bay is designed to be a research, test and demonstration platform and innovation test bed for new ocean technologies developed by research institutes and companies, e.g. communications, informatics, instrumentation and sensors. The core infrastructure comprises a suite of commercially available technology. This includes a network of buoys, sensor hardware and communications systems against which prototype products or services can be validated. SmartBay augments the Galway Bay test site by creating a facility for the coordinated development of ocean energy technology and associated information and communication technology (ICT) capabilities. In 2010, for example, Intel installed and tested the performance of a WiMAX base station in Spiddal to provide high speed wireless communications at the wave energy test site located offshore.

Collection of baseline data

Galway Bay: Grab sampling at 6 sites in 2009 and repeated in 2010. Dive survey in 2009 to collect sediment profile imagery. Desktop review and collation of existing information on marine reptiles, mammals and birds that occur in the area carried out in April 2010. Weather buoys deployed since 2009 automatically collect data on atmospheric pressure, windspeed, wind direction, air temperature, relative humidity, significant wave height and period, max. wave height and period, mean direction, sea temperature and salinity. This is helpful for validating operational models.

AMETS:

- Sublittoral dive and camera survey; subtidal soft sediment grab survey along cable route and at proposed berths and intertidal sediment survey along landfall cable route.
- Preliminary assessment of terrestrial (non-intertidal) habitats carried out in 2009 and followed the method for phase 1 habitat surveys (JNCC, 1990) with adaptations to allow the mapping of habitats in accordance with the Guide to the Habitats of Ireland (Fossitt, 2000).
- A preliminary intertidal assessment report was written in 2009. The surveys carried out for this were conducted in accordance with the methods

outlined in the Marine Monitoring handbook (JNCC, 2003). Following examination of the ortho-imagery for the site a walkover was conducted and habitats mapped according to a Guide to the Habitats of Ireland (Fossitt, 2000) and biotopes recorded according to the Marine Classification of Britain and Ireland (Connor *et al.*, 2004).

- Desktop research; a limited magnetometry survey and some dives were conducted during 2010 as part of the archaeological assessment report.
- Visual and towed hydrophone survey, static acoustic survey and land-based observations were carried out in October 2009 and again in December 2009 and continued to September 2010 to provide a preliminary assessment of marine mammal activity in the area.
- Surveys of onshore, offshore and flighted birds were conducted in September and October 2009. Four seabird at sea surveys were conducted, with one every three months to cover seasonality. The first of these surveys covering the autumn season was completed in September 2009. Monthly surveys of seabirds in nearshore waters (land-based viewing) and monthly boat based surveys of seabirds at sea are continuing.
- Walkover surveys and vantage point watches were used to survey the use of the sea area, the intertidal habitats and the terrestrial habitats by wintering and summer breeding birds. Standard European Seabirds at Sea (ESAS) survey methods were used to survey the sea area.
- With respect to noise, desk-based research of published information and monitoring of background noise levels of nearest sensitive receptors was collated. Noise propagation calculations were carried out, where required, using accepted acoustic calculation methodologies.

Achill Island:

- Preliminary ecological site assessment for the proposed WestWave Project published in January 2012.
- Preliminary cultural heritage impact assessment of proposed WestWave Project published in January 2012.
- AIS data has been provided by the Irish Coast Guard giving information from October 2009 to September 2010 for the general area.
- Preliminary VMS data has been provided by the Marine Institute.
- Consultation with the West Mayo Fishermens Development Co-op identified that the rocky seabed areas along the coast of Achill Island at the proposed project location is used for lobster potting by local fishers.

Killard Point:

- Preliminary ecological site assessment for the proposed WestWave Project published in January 2012.
- Preliminary cultural heritage impact assessment of proposed WestWave Project published in January 2012.
- AIS data has been provided by the Irish Coast Guard giving information from October 2009 to September 2010 for the general area.
- The Marine Institute analysed data relating to international fishing effort from 31 August 2007 – 31 August 2010. The principal VMS fishing activity identified around Killard is midwater otter trawl.

- Consultation with the West Clare Lobstermen's Association identified that the rocky seabed areas along the coast at Killard at the proposed project locations is used for lobster potting by local fishers.
- Vessel activity data are limited as the smaller vessels used in the area are not required to carry VMF.

Other:

The SOWFIA project is developing a Data Management Platform (DMP) that collates environmental and socio-economic data from seven wave energy test centres across Europe in Ireland, France, Portugal, Spain, Sweden and the UK (England and Scotland). The DMP is designed to provide regulators, device developers and stakeholders with a repository of data and best practice to enable cross-comparison of impacts and facilitate informed decision-making. Much of this information is derived from studies associated with the EIA process and includes access to both raw data and composite environmental data in the form of Refined Data Products.

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3.6 Report for France

National roadmaps for wave and tidal energy development

A new institute called “France Energies Marines” has been officially launched by the French government in March 2012. This 10 year national project aims to promote an efficient development of marine renewable energy in France.

Current development activities

Current commercial deployments

For tidal energy, France has a 3.5 GW resource potential. Currently one tidal project has been completed and six are in progress:

- one pilot device (1:3 scaled) has been tested in the Odet Estuary in 2008: SABELLA-D03 project (completed);
- one pilot device should be tested in 2012 in the Fromveur channel, close to Ouessant island (Finistère, Brittany): SABELLA-D10 project;
- one pilot device (OpenHydro) has been tested by EDF during winter 2011-2012 close to Bréhat island; cable should be installed next May;;
- one pilot device (Beluga) is under construction by Alstom and should be tested in the Bay of Fundy in 2012;
- one pilot device (ORCA) is under development by Alstom and should be tested in 2013 in the Paimpol-Bréhat tidal test site.

In addition to in-stream tidal energy, France has a tidal barrage site at La Rance (EDF, 240 MW), deployed in 1986.

For wave energy, France has a 10-15 GW resource potential (40 TWh / year). Two pilot devices (SEA-REV and S3) are under construction and will be tested at the SEM-REV test site.

Test sites and how they are being / have been used

An estuary tidal test site (SEENEOH) is under development, in the Gironde estuary. An open ocean tidal test site (Paimpol-Bréhat) is under development in the same area as the EDF site. A wave test site (SEM-REV, at Le Croisic) could be operational in October 2012. The installation of its 8MW submarine cable is currently in progress.

Commercial developments at planning and construction stages

Four commercial tidal devices (OpenHydro; 0.5 MW each) should be installed by EDF in 2012 in the Paimpol-Bréhat EDF site. A commercial tidal project is planned by Eole Generation and GDF-Suez at the Raz Blanchard (Basse-Normandie) and could start in 2015 with the deployment of 2-12 turbines (1 MW each).

There are two commercial wave projects, “CETO” (EDF-EN and DCNS) and “Pelamis” (SeaWatt) at a final planning phase, representing about 30 wave devices that will be installed in the coastal area of La Réunion island, close to Saint-Pierre.

Range of technologies considered

All available technologies are considered in the research and development activities of France Energies Marines.

Seabed leases or permissions for commercial developments

A seabed lease for the pre-commercial tidal site at Paimpol-Bréhat (EDF) was acquired in 2009.

Research in support of sustainable wave and tidal energy development

Imagery data (HD-video) of the benthic compartment (nature and morphology of substrate; structure of benthic communities) have been acquired in March 2012 by the Ifremer and France Energies Marine institutes at the Paimpol-Bréhat tidal test site. These data are just starting to be exploited with the objective to get a reference state of the benthic ecosystem.

3.7 Report for Portugal

National roadmaps for wave and tidal energy development

The National Ocean Strategy (NOS) delineated in 2005 (and further established in the national law (Resolution of Ministers Council no. 163/2006 from 12th December¹) has been the first attempt to debate how the ocean could become one of the main factors for country development. The support for new forms of technology applied to maritime activities, such as ocean energy, was defined as a strategic action. Since then, a number of direct and indirect governmental initiatives have been developed to promote the marine energy sector. These can be summarized in the following topics:

- 1) Portuguese Pilot Zone (recently renamed to Ocean Plug): designated in 2008 (Decree-law nº 5 /2008, 8th January) to attract demonstration and industrial development to the country, to create an industrial cluster associated with wave power, to increase renewable energy production (from 39% to 45% of green electricity consumption; a 2010 target) and to promote innovation supported by R&D. The Ocean Plug has an area of about 320 km² and should allow a given technology to evolve from the demonstration to the commercial scale. Thus, the area will be equipped with a test site zone for demonstration projects along with infrastructures for the installation of pre-commercial and commercial projects. The exploitation potential of the Ocean Plug is of 250 MW.
- 2) Feed-in-tariffs: the Decree-law 225/2007 introduced new tariffs for emerging technologies, such as wave energy providing the legal basis for government use of public maritime areas for producing electricity from sea-wave power.
- 3) Maritime Spatial Planning: the public discussion of the national maritime spatial plan ended in February 2011; the final redaction of the plan has been prepared and is expected very soon; the plan includes not only the current sites and areas for wave energy development (Aguçadoura park, Peniche site and Ocean Plug) but also potential sites for wave energy and

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https://webgate.ec.europa.eu/maritimeforum/system/files/National_Ocean_Strategy_Portugal_en.pdf

offshore wind harnessing, which were selected based on resource assessment studies.

- 4) Simplex program: the program aims to expedite and simplify the licensing procedures' activities for the maritime sector; the public discussion of the program of measures has been under public discussion and its results were made available in August 2011; the implementation of the simplex program is carried out by the Central Administration Agency.
- 5) National Renewable Energy Action Plan (NREAP): a review of the NREAP has been proposed and is currently available for public discussion; new renewable energy targets and technology road map have been proposed.

Current development activities

To date four wave energy projects have been deployed in Portugal: AWS (2004) in Aguçadoura, Pico Oscillating Water Column the installation ended in 1999 but deployment started in 2005, Pelamis (2008) in Aguçadoura and the first prototype of the WaveRoller technology (2007) that was tested in the Peniche coast. Current development activities include the installation of the new WaveRoller device which is predicted to June (2012) in Peniche, the offshore wind platform WindFloat which is now being tested in Aguçadoura and the operation of the Pico OWC plant which is connected and producing to the grid (although not regularly since the equipment is still under test procedures).

The Ocean Plug area is at the moment under geophysical characterization which would be finished by the end of August 2012. Collected data would be available through the Ocean Plug website (GIS platform) also by August 2012. The access regulation to the area is under development, and will be available soon allowing, in a first stage, the installation of demonstration projects without needing grid connection. The grid connection infrastructure (subsea hubs, cables and substation) is planned to be available in the demonstration test site area by 2013. The extension of licensing to offshore wind projects has been under study and a change of the current legal context has been planned to be available soon.

Planning and consenting processes

Strategic Environmental Assessment (SEA)

The SEA for the National Maritime Spatial Planning is underway and should be completed soon. It covers Portuguese territorial waters and all maritime uses including offshore energy (wind and wave). The SEA for the development of the National Electrical Grid Distribution was completed in 2008 and considers the development of the Portuguese Pilot Zone within the list of critical decision factors. It establishes a number of collaborative actions within public and private institutions regarding the incorporation and compatibility of the implementation of new projects including renewables.

Maritime Spatial Planning

As referred above the public discussion of the national maritime spatial plan ended in February 2011; the final redaction of the plan has been prepared and is expected very soon; the plan includes not only the current sites and areas for wave energy development (Aguçadoura park, Peniche site and Ocean Plug) but also potential sites for wave energy and offshore wind harnessing, which were selected based on resource assessment studies.

Application of national and international legal instruments applied in planning and consenting processes

The Marine Strategy Framework Directive has been transposed to the National law and is being implemented.

Examples of participation with other marine stakeholders in decision-making and revenue sharing

The present Portuguese feed-in law describes a specific procedure that aims at minimizing local opposition towards new wind projects. Under this procedure, municipalities in which a wind farm is located will automatically benefit from the remuneration the operator of the wind project receives. Altogether, the municipality receives a share of 2.5 percent of the monthly remuneration paid to the wind project operator. As expected, municipalities have responded with support for wind power projects in their territory. Local resistance against new installations has consequently remained negligible. A comparable procedure for other renewable technologies does not exist under the Portuguese regulation but is likely to be implemented.

Requirements for / application of Environmental Impact Assessments

According to the Portuguese EIA law (DL no. 69/2000 amended by DL 197/2005) and concerning marine renewable energy projects, wind energy is the only one covered. The decision on whether an EIA is needed is based on the number of project turbines. The Portuguese legal regime for the environmental licensing of a renewable energy project which is not covered by the EIA national law, such as wave energy, is established in DL no. 225/2007. According to this instrument an Environmental Impact Assessment process should only be carried out for projects located within Natura 2000 sites, National Ecological Reserve sites or National Grid of Protected Areas. In this case the factors to be evaluated under the EIA process are: gas emissions that are going to be avoided, seascape (visual impact of the project), geology and geomorphology, natural values (flora, fauna and habitats) under the Birds and habitats Directives, local heritage, airborne noise, only if the project is located within 100 m from residential / urban areas, soils occupation, other maritime uses and socio-economy. However, in any case the decision on whether the EIA process is required has to be confirmed by the competent authority.

Research in support of sustainable wave and tidal energy development

EQUIMAR: development of a protocol on environmental impact assessment for wave and tidal energy projects.

WEAM: development of a hydrophone for acoustic monitoring, noise data collection.

SOWFIA: interactions with other stakeholders, collection of baseline data, and development and load of a data management platform for environmental data for wave energy test sites in Europe.

FAME: collection of baseline data on birds' migratory distribution, abundance and migratory routes; impacts evaluation of marine energy developments on birds.

SURGE: collection of baseline data.

3.8 Report for Sweden

National roadmaps for wave and tidal energy development

There is no existing national Swedish policy/goal on progressing the wave and tidal energy industry. National goals for renewable energy development until 2030 do exist (focusing on wind power) but do not distinguish between land-based and marine developments (offshore wind is expected to contribute ca 30% of the wind development). The calculated annual potential for wave power, in Swedish waters, are in the range 10–15 TWh. The potential for in-stream power, not tidal but from e.g. sounds etc, are only a few TWh annually.

Current development activities

There are no existing commercial project in Sweden (spring 2012). One commercial site has consent, since 2010, a 10 MW installation on the Swedish west coast, build up to be started late 2012/early 2013. The developer is Seabased AB (Ltd), a spin-off company of Uppsala University. The utility and operating company is Fortum AB/Ltd.

There is one existing test site, “the Lysekil project/test site”, with permits since 2004 and where the deployment of the first wave energy converter (WEC) took place in 2006. Since then, at least seven more WECs have been tested in the area. The Lysekil site also includes “dummy buoys” especially for marine environmental/ecological studies. The site is operated by Uppsala University, and funded, over the years, by a large number of smaller fundings, but foremost by a number of larger funders including the Swedish Energy Agency, several larger utility companies and some large national research foundations. The test site is mainly for the “Uppsala University point absorber concept”, but also for general research on e.g. logistics, deployment, decommissioning processes, material tests, environmental impact etc. Seabased leases do not exist (yet) in Sweden (but is suggested as a possible future “tool”). Consent and permits are mainly through regional authorities and Environmental Court decisions, but also including other permits, including Electricity Act etc.

Planning and consenting processes

There is no existing or planned Strategic Environmental Assessment on renewable energy in Sweden. Forthcoming Marine Spatial Plan (MSP) is, however, intended to include “planning” of future offshore wind and ocean energy development, in respect of other offshore activities and activities. This is not likely to be finished until 2016/17.

The MSP is in its starting phase (see above) and to be conducted by the newly started “Marine and Water Management Agency” (MWMA). Consenting processes for marine renewable energy lie partly within the MSP and other initiatives by MWMA. The goal is to simplify consent processes. Overall, the process is quite lengthy and “complicated” (as in most other EU-countries).

Participation with/by stakeholders is mandatory within Swedish Environmental Law for all offshore projects where EIA is required, especially within referral processes. Stakeholder consultations were important for the approval and consent of the first Swedish wave park on the Swedish west coast.

Research in support of sustainable wave and tidal energy development

There are no direct national (Swedish) initiatives for research support on wave and tidal projects (although the commercial “Sotenas project” has received substantial national support through the Swedish Energy Agency (SEA) but only marginally including environmental matters. Some national research fundings have contributed substantially, but more on theoretical issues.

Otherwise, there is some national/governmental support (by SEA), but more depending on private/company funds or research funding:

- general research/developmental activities on wave and tidal energy;
- initiatives wholly dependent on research group initiatives (mainly within universities etc), including resource assessments (but which may be “included” within future MSP);
- little or no research on impacts;
- little or no research on interactions;
- little or no research on monitoring/monitoring tools;
- no baseline data collection.

3.9 Report for Norway

National roadmaps for wave and tidal energy development

Source: OEC website (Ocean Energy Systems Implementing Agreement) at <http://www.ocean-energy-systems.org/country-info/norway/>

Strategy and National Targets

An updated governmental strategy for energy is expected in 2012. Norway has no special policy for ocean energy but ocean energy is included in more general renewable energy policies and programmes. An updated governmental strategy for ocean energy is expected in 2012.

Support Initiatives and Market Stimulation Incentives

In 2011 Norway and Sweden signed an agreement for a joint green certificate market. From 2012 on, one certificate per MWh will be given to all new renewable energy generation for 15 years, independent of the technology. The price per certificate is driven by the market with a common electricity production target of 26.4 TWh by the end of 2020. No extra certificates will be given for ocean energy generation and a likely certificate and a power price in the joint market are approximately €25/MWh and €50/MWh, respectively.

A total income of €75/MWh is almost certainly not enough for wave and tidal projects in the next decade, but governmental support programmes for research and development are intended to drive the development.

Main Public Funding Mechanisms

The Norwegian Energy Agency, ENOVA, offers capital grants for full-scale demonstration projects of marine renewables. While up to 50% of eligible costs can be covered, ENOVA’s funding - measured in absolute figures - is limited. In addition, ENOVA has a programme that supports demonstrations of new energy technology. In 2010, Innovation Norway launched a programme supporting prototypes within “Environmental friendly technology”. Ocean energy is included in this definition. Projects are supported with up to 45% of eligible costs.

The Research Council of Norway has an energy research programme called RENER-GI. This programme supports R&D within all renewable energy technologies. In 2011, these three institutions had a combined budget of approximately €110 million.

Current development activities

To date, there are few commercial developments in Norway. Whereas there are a few examples of tidal power plants at full-scale testing sites, wave power developments have lagged behind. In general, the industry is still working with technology and device type testing – largely in wave tanks, and with few examples of field deployments. Some Norwegian owned and founded companies have moved their activities outside the country.

So far, little attention has been devoted to considerations of environmental impact.

Current commercial deployments

There are currently two tidal power deployments in Northern Norway:

- The ANDRITZ HYDRO Hammerfest (previously Hammerfest Strøm) tidal turbine HS300 at Kvalsund and the Hydra Tidal Morild at Gisøystraumen in the Lofoten Islands. The former site has been producing power for the grid for some years now, and the developers have expanded the concept to an advanced type (HS1000), which is now being tested at EMEC in Scotland.
- Hydra Tidal Morild was first deployed in 2010, then faced major problems in 2011 and is intended to be re-deployed in 2012.

Test sites and how they are being / have been used

Apparently, there is only one municipality in Norway (Eigersund) which has designated a certain coastal area to renewable ocean energy development. This a-priori designation of the area includes concessions from the regulating local and national authorities (municipalities and Norwegian Coastal Administration), as well as from NVE (the Norwegian Water Resources and Energy Directorate - the authority which needs to consent if the installation is intended to be connected to the public power grid).

In addition, there is a wave energy test centre at the island of Runde, where a 3.25 km² area has received consent on principle for wave energy test installations by the municipality and the Norwegian Coastal Administration. If any of the deployments to be intended to be connected to the public grid, the operators will have to apply for consent to the NVE.

Responsibility and administration of the test site at Runde lies with Runde Environmental Centre.

Commercial developments at planning and construction stages

Several companies claim that they are in a construction stage. The most relevant and furthest advanced is Langlee with an oscillating wave surge converter. They intend to use the Eigersund area and have already come to an agreement with the local stakeholders.

Range of technologies considered

Whereas both relevant tidal turbines are horizontal axis turbines, are the wave power devices that have been tested or are currently under development part of a wide

range of different technologies. It appears that one of the major challenges is the large variety and irregularity of wave climates on the west coast of Norway.

Seabed leases or permissions for commercial developments

See above: Eigersund kommune

Planning and consenting processes

Relevant Legislation and Regulation

The Ocean Energy Bill, which regulates renewable offshore energy production entered into force on 1 July 2010. According to this new legislation, licences to build offshore wind, wave and tidal farms in certain farshore geographical areas cannot be given without a prior governmental process, where suitable areas are identified, made subject to consequence assessments and made available for leasing. This legal framework is very much inspired by similar legislation in the Norwegian Petroleum Sector. As a follow up on the Ocean Energy Bill, a group of relevant governmental bodies has identified 15 areas that could be suitable for large-scale offshore wind power. More detailed “strategic consequence assessments” will be finalized in 2012. Meanwhile, the licensing body NVE has continued to prioritize small-scale demonstration projects located nearshore according to the existing Energy Bill. The licensing process is efficient and pragmatic. (OEC website (**Ocean Energy Systems Implementing Agreement**) at <http://www.ocean-energy-systems.org/country-info/norway/>). In practice this means that most current (including planned) deployments have had almost no EIA requirements.

Research in support of sustainable wave and tidal energy development

Little detailed and specific information is available here. The following text is changed slightly from the OEC website (**Ocean Energy Systems Implementing Agreement**) at <http://www.ocean-energy-systems.org/country-info/norway/> and gives some kind of an overview, but does not reveal ongoing research projects.

“In Norway, ocean energy is included in more general renewable energy support programmes. The overall funding for renewable energy R&D made available through the Norwegian Research Council, Innovation Norway and ENOVA has increased significantly over the last years. This has also resulted in increased funding for ocean energy projects as well, from research to prototypes and demonstration.

“The research cluster in Trondheim, comprising of NTNU and SINTEF/MARINTEK, is active in ocean energy research. Some of the activities are technology screening and verification, control systems, mooring, marine structures, safety, optimal design of devices and load modelling. MARINTEK’s model tank is also used to test ocean energy devices.

“The Stadt Towing Tank (STT) was founded in 2007 to deliver test and research services to the marine industry. The main market for STT has been ship designers in the maritime cluster of northwestern Norway, but projects related to renewable energy were the main market in 2011, as new concepts are being developed and in need of testing and verification.”

3.10 Report for Spain

National roadmaps for wave and tidal energy development

Strategy and National Targets

The Spanish Government officially approved the “Renewable Energy Plan 2011-2020” in November 2011. This plan includes targets for ocean energy for the first time:

- The first 10 MW of installed ocean power are expected by 2016.
- An annual growth rate of 20 - 25 MW between 2016 and 2020 is expected to accumulate to 100 MW by 2020.
- The average electricity production in the period 2011 - 2020 will be approximately 50GWh/annum with a peak in 2020 of 220 GWh/annum.

The plan foresees an important growth of ocean energy after 2020 with the following phases:

- Reliability confirmation (2010 - 2015): simulation, modelling and prototypes will be key aspects. Cost of the electricity is not a major issue during this phase.
- Technology development (2016 - 2020): demonstration of full-scale prototypes with generation costs between €21 and €33 per MWh.
- Technology consolidation (2021-2030): commercial deployment of ocean power plants with a cost reduction of the electricity down to €7- €15 per MWh.

Support Initiatives and Market Stimulation Incentives

The Spanish Renewable Energy Plan 2011–2020² includes some strategic actions to facilitate the achievement of its targets. Regarding ocean energy the following actions are proposed:

Technology strategy actions:

- An intensive R&D programme focused on new designs and components clearly aimed at reducing costs and improving the survivability of the devices.
- A demonstration programme aimed at developing and testing small-scale prototypes; Support of experimental testing infrastructures to validate the performance of the devices during the full life cycle. This includes a specific and simplified consenting process for experimental platforms.
- Collaboration with other European countries by means of an initiative of the European Union focused on improving the reliability and new installation techniques.

Non-technology strategy actions:

- Definition of a specific regulatory framework for ocean energy projects, with simplified licensing processes.
- Modification of the feed-in tariff system to create a different group for ocean energy more appropriate to its stage of development.
- Planning of grid infrastructures to facilitate ocean energy integration.

² <http://www.idae.es/index.php/id.670/reلمenu.303/mod.pags/mem.detalle>

- General dissemination and promotion campaigns amongst different stakeholders to improve social acceptance and to facilitate a new market.
- There is a feed-in tariff system for the support of renewable energy sources in Spain but this system is not very attractive for ocean energy. It is possible to negotiate a specific tariff for every individual project, depending on the investment cost. However, a comprehensive description of the project is required and no references are available so far.

Relevant Legislation and Regulation

There are no additional changes in the current Spanish legislation regarding ocean energy, which is defined by means of two Royal Decrees from 2007. The first establishes the administrative procedure to apply for an authorization for electricity generation installations at sea. The second sets the feed-in tariff mechanisms. As mentioned before, the legal situation of ocean energy in Spain needs important improvements, which should cover the following aspects, according to the Renewable Energy Plan 2011-2020:

- Simplification of administrative procedures.
- R&D subsidies for technology development, including prototypes, resource assessment and experimental platforms.
- Investment grants for demonstration and pre-commercial projects.
- Specific and more attractive feed-in tariff system for ocean energy projects.

Relevant documents released

The Renewable Energy Plan 2011-2020 is available in Spanish at www.idae.es. It includes some technical support documents, such as a detailed evaluation of the Spanish wave energy resource³.

Current development activities

Current commercial deployments

Mutriku OWC Plant. The main milestone of ocean energy in Spain in 2011 was the final deployment of the first grid connected wave power plant, promoted by EVE - Ente Vasco de la Energia (the Basque energy agency). Voith Hydro Wavegen handed over the Mutriku OWC plant to EVE in November 2011, resulting in the first wave power plant to be sold on a commercial basis, with standard guarantees for performance and availability. The 300kW wave power plant, consisting of 16 turbines, is housed within a breakwater at the port of Mutriku. It has been designed for a 25 year operational life and will provide electricity for 250 homes. During commissioning and acceptance testing the plant has produced 100MWh.

Test sites

The Biscay Marine Energy Platform (BIMEP) provides wave energy device manufacturers with facilities to validate their designs and to test their technical and economic feasibility. The Basque coast, and specifically the location of BIMEP off the coast of Arminza (Bizkaia), offers suitable wave conditions for device testing and a relatively low exposure to extreme waves that could damage the prototypes. BIMEP occupies a

3

http://www.idae.es/index.php/mod.documentos/mem.descarga?file=/documentos_11227_e13olas_b31fcafb.pdf

5.3 km marked area excluded for navigation and maritime traffic, and located at a minimum distance of 1,700 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 at 50-90 m water depths. Once authorization has been granted for the installation of facilities and contracts awarded for the supply and installation of submarine power lines and ground cables, which will transfer power from the offshore sites to land, BIMEP is expected to commence operations in the last quarter of 2012.

The Oceanic Platform of the Canary Islands (PLOCAN) is a public consortium aimed to build and operate an offshore infrastructure to facilitate and accelerate the development of new oceanic technologies. The Spanish Government (50%) and the Regional Government of the Canary Islands (50%) govern PLOCAN. This Consortium is located on the island of Gran Canaria. PLOCAN offers a marine test site for ocean energy converters prototypes. The submarine electrical infrastructure is being designed (expected by the end 2013) offering the required grid connection. The initial capacity is set in 10 MW with a future extension planned up to 50 MW by 2020. Main technologies on testing will be related with waves and offshore wind conversion.

Santoña Test Centre: The regional Government of Cantabria has the objective of developing a test site for prototypes of Wave Energy Converters. The Testing Field Area would accommodate up to 10 WEC devices with a maximum combined power of 1.5MW

Ubiarco Test Centre: The objective of this project is to develop a testing site for prototypes of WECs and Floating Wind Turbines (FWT). The Testing Field Area will allocate up to four Floating Substations, up to 4MW each, which will provide connection to a maximum of four devices. These two test facilities will be supported by “The Great Maritime Engineering Tank” that is being built in the Scientific and Technological Industrial Park of Cantabria which will integrate experimental management, a system of physical modelling and a system of numerical modelling.

Developments

WELCOME project and PIPO Systems: The WELCOME Project was funded by the Spanish Ministry of Science and Innovation and led by the Spanish company PIPO Systems. The project aimed to design, build and deploy a 1:5 scale wave energy converter prototype (called APC-PISYS and patented by PIPO Systems). The deployment of the small-scale prototype was completed in March 2011 and the company is now working on a new project funded again by the Spanish Ministry of Science and Innovation with the objective of extending the concept of APC-PISYS technology looking for new applications. The deployment is expected by the end of 2012.

UNDIGEN project and Wedge: Wedge is currently leading an Ocean Demonstration Project based on its innovative electrical power take-off (PTO) to be deployed offshore at the Canary Islands’ hub by 2012. This project has been awarded as unique & sole marine project within the 2011 INNPACTO Programme granted by the Spanish Ministry of Science and Innovation. The UNDIGEN Project is formed by FCC (Final User), CIEMAT (R&D Institute), PLOCAN (Site) and WEDGE (Tech Company), and is aimed to test the cutting edge electrical solution (switched reluctance) into a standard floating body (WEC) with no grid connection in 2012.

Abencis Seapower installed its prototype of a “marine pump” at ¼-scale during 2011. The ultimate goal is the design and construction of a plant to convert wave energy into electricity, in a sustainable and efficient way. The prototype consists of a float-arm structure with a hydraulic system that allows the simulation of any kind of load.

Tests are taking place in the Mediterranean Sea and the data collected are being used to optimize the control strategies. The results from the 1/4-scale prototype will be used to design a demonstration power plant in the Atlantic Ocean during 2012.

WavePort is an EU funded project lead by Ocean Power Technologies (OPT) who are collaborating in a consortium with Degima SA, University of Exeter, the UK Intelligent Systems Research Institute, Fugro Oceanor, and the Wave Energy Centre (WavEC). WAVEPORT project aims to expedite the development of alternative devices by installing in Santoña site in Spain a ten port “open platform” 1.5 MW-rated underwater substation pod for the validation of future wave energy converters. To address the need for improved efficiency, a novel Real-Time Wave-by-Wave tuning system is being developed.

Within the OceanLider project, Norvento Enerxía (www.norvento.com) is developing its own concept of a wave energy converter. The system is between a point absorber and an outline tracker. The prototype is made up of collecting converter floating units which capture the power in all directions. Nowadays, the design and manufacture of a scale prototype is being carried out to test in real conditions on the Atlantic coast. Such trials will allow validation and optimization of the designs and systems for the subsequent full-scale application. Norvento is also developing other projects in the ocean renewable energy field in order to promote the sector, for example, Operation and Maintenance in Ocean Renewable Energy Installations, Swell Resource Assessment on the Atlantic Coast, and Environmental Studies in Ocean Renewable Energy Installations.

Planning and consenting processes

Strategic Environmental Assessment (SEA)

An SEA for the offshore wind energy plan was completed in 2009⁴. An SEA of the Spanish Renewable Energy Plan 2011-2020 is currently underway⁵.

Marine Strategy Framework Directive

The Law 41/2010 for the Protection of the Sea transposed to the Spanish legal framework the Directive 2008/56/CE. The article 3 of the Law 41/2010 establish that any activity that intend to install facilities in the sea or in the seabed need the favourable statement of the Ministry of Rural, Marine and Natural Environment in relation with the compatibility of this activity with the requirements of the Law 41/2010.

National consenting process

At a national level, there are few regulations referring to marine energy, the most recent are found in Royal Decree 661/2007, regulating the production of electricity under a special regime. In its second article the possibility for wind power installations located in the territorial sea to make use of the special regime of electricity is foreseen.

Apart from this accessible and generic reference, little more can be found in the Spanish Law concerning this form of generating electric power until Royal Decree

⁴ <http://www.minetur.gob.es/es-es/gabineteprensa/notasprensa/Paginas/Mapaeolicomarino200409.aspx>

⁵ http://www.magrama.gob.es/es/calidad-y-evaluacion-ambiental/participacion-publica/32010_p_006_documento_inicio_tcm7-111310.pdf

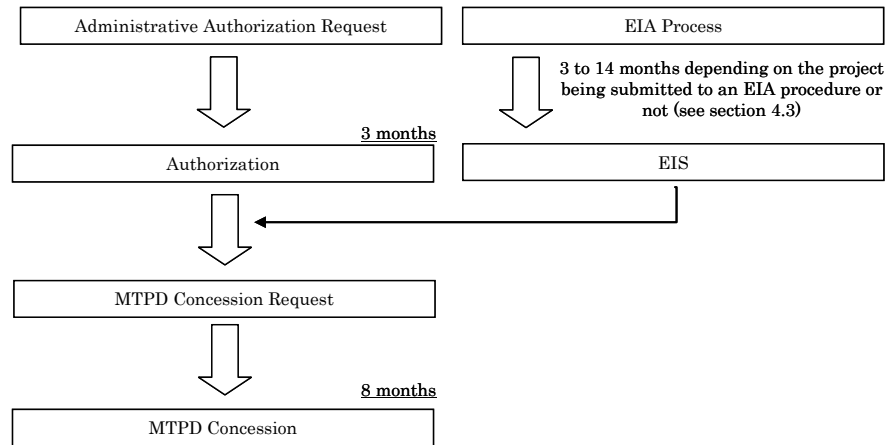
1028/2007, 20 July 2007, establishing the administrative procedure for processing applications for the authorization of electricity generating facilities in territorial waters.

In spite that RD 1028/2007 focuses on marine wind energy, it also contemplates in article 32 authorizing other electricity generation technologies of a renewable marine nature located in the territorial sea, but it only foresees a simplified procedure which is regulated by a subsidiary character in accordance with Royal Decree 1955/2000, 1 December 2000, regulating the activities of transport, distribution, commercialization, supply and authorization procedures for electrical power plants, without establishing a minimum power limitation.

RD 1955/2000 establishes that construction, extension, modification and exploitation of all electric installations mentioned in article 111 require the following administrative procedures:

- a) Request of Administrative Authorization: refers to the project's draft of the installation as a technical document. Such request must be addressed to the Directorate General for Energy Policy and Mining (DGEPM), and might also be forwarded to the Department or Division of Industry and Energy of the Government Delegations or Sub-Delegations of the province where the installation requesting this administrative authorization is located for the construction, extension, modification and exploitation of electric installations to be produced, transported and distributed. Likewise, these requests may be addressed to the entities mentioned in article 38.4 of Law 30/1992, 26 November, on Rules governing general government institutions and Common Administrative Procedure. The authorization procedure is determined by the DGEPM. According to RD 1955/2000, the resolution and notification shall occur "within three months from receipt of the request for administrative authorization" (art. 128.1).

The administrative authorization request can be submitted together with the application of an Environmental Impact Assessment (EIA) process according to the Legislative Royal Decree 1/2008, of 11 January, approving a compiling text of the Law on Environmental Impact Assessment Projects. For the approval of the administrative authorization, the Environmental Impact Statement (EIS) of the General Council on Environmental Quality Assessment of the Ministry of Rural, Marine and Natural Environment is needed. With these two elements, the process for the occupation of the Maritime-Terrestrial Public Domain (MTPD) according to the Coast Law, 28 July 1988 will be initiated. The Directorate General for Coasts will determine the occupation of the MTPD considering the EIS and conditions stated in the authorization of the procedure by the DGEPM. Thus, the administrative procedure for projects on wave energy harnessing can be summarized as shown in the following figure:



- b) Approval of the Execution Project: refers to the specific project of commissioning and allows the applicant to start building up. The applicant of the authorization will submit to the division or, if applicable, the Department of Industry and Energy (DIE) in the Government Delegations or Sub-delegations of the province where the installation will be developed, a request addressed to the DGEMP, as required in article 70 of Law 30/1992, of 26 November 1992, on Rules governing general government institutions and Common Administrative Procedure (see previous section), together with the execution project based on the relevant specific Technical Regulations. Divisions, or if applicable, DIE in the Government Delegations or Sub-delegations of the provinces where the installation will be located and developed, will be responsible for processing the request for approval of the execution project and shall resolve and grant the consent within three months. The competent administration may consult other affected institutions, entities or companies devoted to public service or general interest services in charge of goods and rights in the area so that they can set relevant technical conditions within twenty days.
- c) Exploitation Authorization: allows, once the project is executed, to power up the installations and proceed to their commercial exploitation. Once the project is executed, the relevant request for certificate to come into service will be submitted to the Divisions or Departments of Industry and Energy in the Government Delegations or Sub-delegations of the province where the file has been processed. This request will be submitted together with a certificate of end of works signed by a qualified technical engineer, mentioning the installation developed according to the specifications described in the approved execution project, and also the requirements set in the relevant specific Technical Regulations.

The EIA procedure is described in chapter II of the Legislative Royal Decree 1/2008, and is divided in two sections. A first section covers the environmental impact assessment for projects in Annex I (those projects that must compulsorily submit an impact assessment).

A second section regulates the environmental impact assessment for projects in Annex II and those projects, even if they are not included in Annex I, that may affect directly or indirectly protected areas under the Natura 2000 Network.

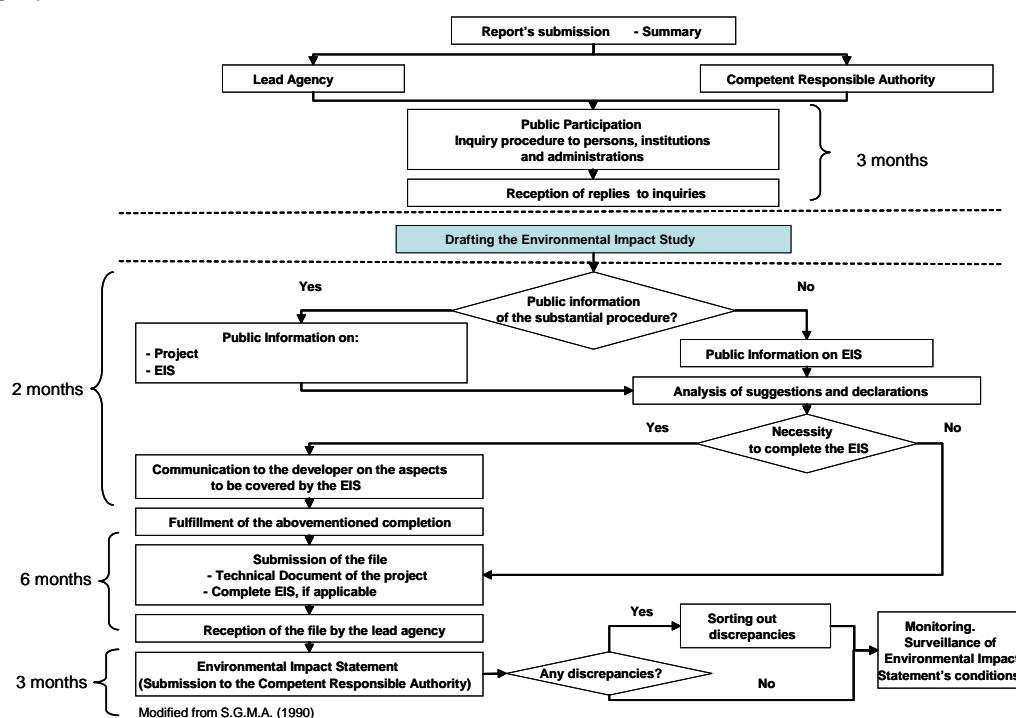
When specifically referring to projects on wave energy, competences belong to the State's General Administration as they are located in the Maritime-Terrestrial Public Domain (MTPD). In this case, the lead agency is the General Council on Energy Pol-

icity and Mines (GCEPM) of the Ministry of Industry, Tourism and Trade, and the responsible authority is the General Council on Environmental Quality Assessment (GCEQA) of the Ministry of Rural, Marine and Natural Environment.

The procedure for EIA for projects observed in Annex I will include the following actions:

- a) Request of submission of the project to EIA.
- b) Determination of Environmental Impact Study (EIS) scope.
- c) Development of EIS.
- d) Public information and inquiries.
- e) Environmental Impact Statement (EIS).

The following figure shows the approximate order and deadlines of the procedure for projects included in Annex I:



The procedure for those projects observed in Annex II and projects not included in Annex I which may affect directly or indirectly areas belonging to the Natura 2000 Network will cover the following actions:

- a) Application for determination of submission or not to an EIA. For projects that shall be authorized or approved by the State's General Administration, the application and documentation mentioned in the previous point shall be submitted to the lead agency, and once conformity is granted, all documentation shall be forwarded to the responsible authority to determine if the project must be submitted to an EIA or not.
- b) Determination of submission or not to an EIA. The responsible authority shall reply within three months from the following day upon reception of the application and environmental document, after having inquired administrations, persons and institutions that might be affected by the project's development and making available for them the environmental document of the project.

The Coast Law, 28 July 1988, offers a legal framework on territorial sea occupation, together with issues affecting the fishing sector and safety conditions for maritime navigation. Management and surveillance competences on MTPD, which the territorial sea belongs to, lie upon the General Council on Coast and Ocean Sustainability (GCCOS) which forms part of the Ministry of Rural, Marine and Natural Environment. Coast Demarcation Departments are their representative in each coastal province and Autonomous Community.

Therefore, the development of projects on electric power in the territorial sea must comply with the legal requirements regulating the conditions to process administrative titles granting a certain territory's occupation (both previous and during the project's development) and the dispositions in terms of deadlines, transference and extinction.

The administrative title varies depending on time permanence, work requirements and/or fixed or removable installations: (i) authorizations and (ii) concessions.

- Authorizations: an authorization procedure starts when the application, together with credentials identifying the applicant and representative person, as well as previously related documentation, is presented in the Coast Service Peripheral. Once the project is examined, after paying the applicable fees, field confrontation will follow, aimed at determining its suitability and feasibility. A project's report will be submitted to Guildhalls, where the object of authorization may be developed, and to the Autonomous Community, the competent entity in navigation issues in case the works or installation may imply a risk on maritime safety, and any other entities that may be involved. Authorizations with analogous criteria are granted by the Coast Service Peripheral.
- Concessions: regarding concessions (which is the case of WTE projects), the Project must be submitted for public information for a time period of twenty days, simultaneously to the report to official entities. In case consent is granted, the applicant will comply with the conditions set thereby. In case of agreement, the Ministry of Rural, Marine and Natural Environment will discretionally determine if the concession is finally granted.

Application deadlines of the files are set to be four months for authorizations and eight months for concessions.

Marine Spatial Planning (MSP)

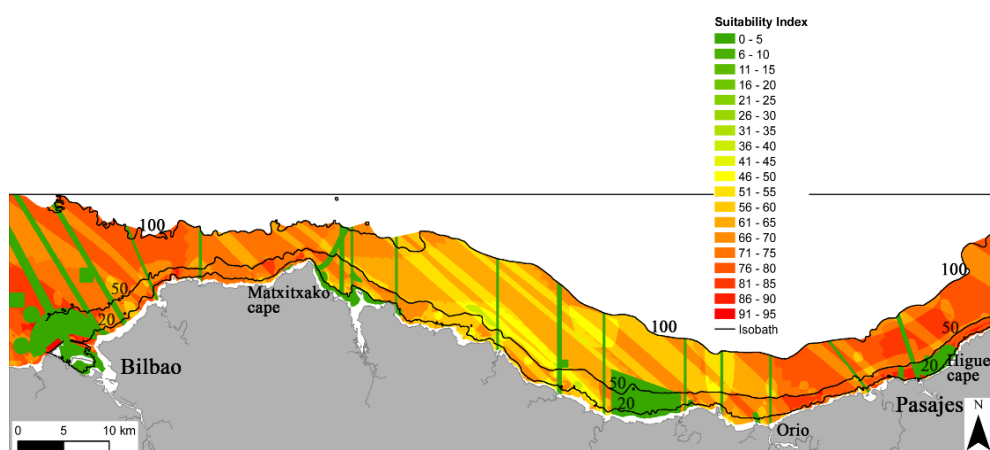
Supported by the Basque Energy Agency (EVE) and the European MESMA project (Monitoring and Evaluation of Spatially Managed Areas: 7th Framework Programme, Grant Agreement no: 226661), as far as we know, the unique place in Spain where a MSP approach for the installation of wave energy converters has been done, is the Basque Country in the Northern part of Spain:

Galparsoro, I., Liria, P., Legorburu, I., Bald, J., Chust, G., Ruiz-Minguela, P., Pérez, G., Marqués, J., Torre-Enciso, Y., González, M., and Borja, A. 2012. A Marine Spatial Planning approach to select suitable areas for installing wave energy converters on the Basque continental shelf (Bay of Biscay). *Coastal Management Journal*, 40, 1–19.

In this contribution: (a) a methodology for the establishment of a Suitability Index (SI) for wave energy converter installation location selection is proposed; (b) the spatial distribution of the SI is mapped; and finally, (c) the accessible wave energy potential has been calculated for the entire Basque continental shelf. As the SI represents the appropriateness of several locations for WECs installation, while minimizing the

conflict with other marine uses, the first step in the development of the analysis involved gathering all such information that may be likely to determine, or influence, the decision-making process. Seventeen information layers (among them ten technical, four environmental, and three socio-economic layers), corresponding to the identified key factors, including the theoretical wave energy in the study area, were generated to define their spatial distribution. Geographical Information System algorithms were used then in the assessment of the total theoretical energy potential and the accessible theoretical energy potential; these were calculated excluding areas where conflicts with other uses occur, such as navigation regulations or designated Marine Protected Areas.

The resulting map indicates that, taking into account the zones not affected by use conflicts, together with the estimated energy performance of the most advanced WECs technology, the potential energy produced in the study area could supply between 37% and 50% of the electrical consumption of households in the Basque Country. This contribution could avoid the annual emission of 0.96 to 1.54 million tonnes of CO₂ into the atmosphere.



The Case of the BIMEP project

According to the Basque Country's Energy Strategy, wave energy is the only form of marine energy for which a significant production is expected in the midterm. The technological development and the particular geographical characteristics of the Basque Country provide suitable preconditions for the production of such energy. Furthermore, the presence and current level of development of the naval industry in the Basque Country are determinants for the wave energy sector to be considered as a strategic and promising sector in the Basque Country.

In this context, the Basque Energy Board (Ente Vasco de la Energía-EVE) launched in 2008 the initiative to build the BIMEP (Biscay Marine Energy Project).

The BIMEP platform is to be established encompassing part of the inner waters of the Basque Country's continental shelf and the Spanish territorial waters, two miles offshore the shoreline of Armintza (Bizkaia, Basque Country), which is under the jurisdiction of the municipality of Lemoiz (Bizkaia). The establishment of this platform entails the installation of wave energy converters. The installation of such devices requires the closure of a sea area of 5 km² to activities like artisanal fishing, navigation, aquaculture and recreational activities.

Besides the technical difficulties of installing the BIMEP platform infrastructure in the chosen location, the installation of BIMEP is also administratively complex; it involves the participation of both national and local administrations. Furthermore, several ministries and departments participate in different sections/steps of the administrative process. Such administrative process generally shares the following common structure:

- ask/consult with the Spanish Ministry for Environment, Rural and Marine Affairs (the Spanish environmental agency) the need for conducting an Environmental Impact Assessment (hereinafter, the environmental procedure);
- request the Spanish Ministry of Industry, Tourism and Trade to provide the administrative authorization for conducting the works and the Provincial Industry and Energy Dependency of the Spanish Government Delegation in Bizkaia to declare its Public Use;
- apply for the concession of marine-terrestrial public domain, which is a two-step process and involves the Spanish Ministry of Public Works and that for Environment, Rural and Marine Affairs.

In this sense, and in accordance with Article 16 of *Royal Decree 1/2008*, the Promoter (EVE) initiated the environmental procedure in 2008. In the particular case of the BIMEP project, the activity was classified under Section 4.c of Annex II of the aforementioned Royal Decree, and consequently the environmental procedure aimed at determined the need for a full Environmental Impact Assessment. In order to make an informed decision on whether or not an Environmental Impact Assessment was needed, three documents/steps are required:

- Project submission, including the objective, description and location of the project
- Submission of an additional Environmental analysis document undertaken by AZTI-Tecnalia. This document should cover the following aspects: a) actions that may cause environmental impacts throughout the different stages of the project (i.e. planning, construction, operation and abandonment), b) potential environmental impacts of the project, c) mitigation and corrective measures/strategies to offset the potential negative environmental impacts, and d) an Environmental Monitoring Plan of the project.
- Consultation with stakeholders, which is to be carried out by General Directorate for Environmental Quality and Evaluation (Spanish Ministry for Environment, Rural and Marine Affairs). In this case, the consultation process included key stakeholders, such as fishermen guilds (*cofradías*⁶) and environmental NGOs, among others.

⁶ Spanish *cofradías* (fishing guilds) are institutions with an old tradition that in some cases dates back many centuries. Their aim is to assure collective economic exploitation of fishing resources in coastal area. The *cofradías* are the institutional system for more than 80% of the employment in fisheries in Spain. In addition, more than 50% of landings are under the control of *cofradías*. It is a clear distinction between *cofradías* and other organizations such as boat owners associations or producer organizations. The *cofradías* are related exclusively to coastal fisheries while the other organizations deal with industrial fisheries. The *cofradías* are organized democratically and both the crew and the boat owner have representatives in the executive bodies. These institutions are well recognized by the Spanish and regional law and can propose management rules in their area of influence such as fishing time, allowed fishing gear and area

Based on a detailed analysis of these three documents/steps, the Spanish Ministry for Environment, Rural and Marine Affairs adopted in 2009 the decision for the BIMEP not to be subject to the full Environmental Impact Assessment process. The analysis of the Environmental document had concluded that no significant environmental impacts would be found as a result of the implementation of the BIMEP project. Furthermore, most stakeholders consulted about the potential affection of the BIMEP did not envisage significant impacts on habitats, protected species or environment as a result of the implementation of the BIMEP.

Taking into account the aforementioned decision and continuing with the administrative process, in 2009, the Promoter (EVE) requested the administrative authorization for the BIMEP installation and its public use declaration.

For the purpose of obtaining the administrative authorization and public use declaration of the installation of the BIMEP infrastructure, the Promoter (EVE) submitted to Spanish Ministry of Industry, Tourism and Trade and the Provincial Industry and Energy Dependency of the Spanish Government Delegation in Bizkaia several documents, which included, a) the preliminary draft of the project, b) an environmental analysis document, and c) an economic evaluation analysis document.

In accordance with the provisions of Articles 125 and 144 of *Royal Decree 1955/2000* and *Article 27 of Royal Decree 1028/2007*, the preliminary draft was submitted for public consultation and reprints were sent to key administrations and stakeholders. The City Council of Lemoiz, the General Directorate for Planning, the General Directorate of Ports and Maritime Affairs, and the General Directorate for Fisheries and Agriculture of the Basque Government, as well as the Basque Water Agency did not provide any feedback. On the other hand, the Department of Public Works of the Provincial Council of Bizkaia, the Bilbao Bizkaia Water Consortium, the General Directorate for Fisheries and Aquaculture of the Spanish Ministry for Environment, Rural and Marine Affairs and Iberdrola (Spanish energy company) did not present any opposition to the project and, where appropriate, they indicated technical aspects to be considered in drafting the execution project of the BIMEP.

Based on several documents and outcomes of the consultation process, the Spanish Ministry for Industry, Tourism and Trade (of the General Directorate for Energy Policy and Mining) authorized, in 2011, the installation of the BIMEP, and stated in particular the declaration for its public use.

In 2011, the Promoter (EVE) proceeded to tackle the final step and obtain the concession of marine-terrestrial public domain. To obtain such concession, the Promoter (EVE) had to request the following two licenses:

- the beacon permission, which was requested to the Spanish Ministry for Public Works (General Directorate of the Merchant Marine); and
- the concession of maritime-terrestrial public domain, for which the Coastal Delegation of the Spanish Ministry for Environment, Rural and Marine Affairs is responsible.

To date, the beacon permission and the concession of maritime-terrestrial public domain are both pending. Once the beacon permission is approved, the concession of maritime-terrestrial public domain permission will be granted. Therefore, and despite

and time closures. The rights of *cofradías* can be considered a form of territorial use rights in fisheries (TURFs).

the fact that the start of the construction of the BIMEP was foreseen for summer 2012, the delay in obtaining these final licenses will delay the construction of the BIMEP one year, that is 2013.

The role of the stakeholders

From the point of view of governance, the installation of BIMEP is also highly complex. To minimize potential conflicts and impacts of the BIMEP on particular interests, it has to be considered the many and diverse interests of the different stakeholders. Parallel with the consultation processes carried out by the General Directorate for Environmental Quality and Evaluation and the Provincial Industry and Energy Dependency of the Spanish Government Delegation in Bizkaia during the environmental and authorization procedures respectively, other social groups/stakeholders were directly consulted by the Promoter (EVE) and expressed their concerns. These concerns related to the specific location of the BIMEP platform infrastructure, which could limit the access to the harbour of Armintza. The answer of the Promoter (EVE) to these concerns was that moving the infrastructure further away from the entry towards the harbour would not be economically or technically viable. Technical solutions have been proposed to improve the access to the harbour without the need for changing the location of the BIMEP.

Other highlighted concerns referred to competition for space, already identified by the Department of Agriculture, Fisheries and Food as a source for potential conflict in an earlier stage of the administrative process. Indeed, fishers considered the platform as an impediment to their artisanal fishing activities in the area and consequently, as a limitation to their economy and livelihoods. These concerns were also reflected in the results of a preliminary economic evaluation (subcontracted by the Promoter (EVE) to a private contractor), which stated a loss of 16.400 tons in the artisanal fishing catch, which is valued on approximately 86,400 Euros. This economic loss may affect around 12 vessels that use the BIMEP area as their usual fishing spot. Diverse pecuniary and non-pecuniary alternatives have been proposed to compensate fishers for the potential economic loss associated with the platform construction and operation. To date, negotiations to achieve a non-pecuniary solution between the Promoter (EVE) and fishers are still in progress and the compensation mechanism is yet to be defined.

The outcomes of the different consultation process have proven to be useful in identifying problems and looking for/suggesting solutions to minimize the conflicts between the diverse uses in the maritime area of concern. However, a gap in participation has also been detected during such consultation processes at two different levels. First, the “key stakeholder” list used by the different “consultancy bodies” was limited, and it excluded some relevant stakeholders. Second, not all consulted stakeholders participated in the consultation process led by e.g. the Spanish Ministry for Environment, Rural and Marine Affairs (the General Directorate for Environmental Quality and Evaluation). These are issues to be further explored since they may respectively indicate limited/biased stakeholder representation in the outcomes, and insufficient organizational, technical and/or economic capacity of some of the stakeholders to respond to a consultation process, lack of commitment or even a lack of an adequate forum for participation.

A more extensive list of stakeholders can be consulted in the Deliverable D. 4.2. Stakeholders Listing of European Wave Energy Test Sites of the SOFWFIA project: http://www.sowfia.eu/fileadmin/sowfia_docs/member_section/D4%20%20StakeholdersListing_final.pdf.

Research in support of sustainable wave and tidal energy development

Government and Industry Funded R&D

OCEANLIDER

The most important R&D project has been running since 2009 partially funded by the Ministry of Science and Innovation within its CENIT programme. OceanLider, led by “Iberdrola Ingeniería y Construcción”, includes several R&D activities with a holistic perspective, covering the following research lines:

- identification and characterization of suitable sites and optimum resource assessment;
- technology development of wave and tidal devices, including hybrid systems with offshore wind;
- distribution, transportation, transformation and quality of electricity;
- management, maintenance and intelligent communication systems;
- technologies and systems for the operation and safety;
- preservation of resources, environmental management and climate change.

The project has a budget of €30 million (€15 million public funding) a duration of 40 months and the participation of 20 industrial partners and 24 research centres.

ENOLA

IH-Cantabria Institute of the Cantabria University, funded by Ministry of Industry, Tourism and Commerce of the Spanish Government, developed the Atlas of Wave Energy Resource of the Spanish Coast (<http://www.ihcantabria.com/enola/>). This atlas provide data on wave energy at different depths and seasons of the year.

Participation in Collaborative International Projects

Coordination of European Ocean Energy Research

Within the context of the European Strategic Energy Technology Plan (SET-plan), fifteen leading European Research Institutes have taken up the challenge to found a European Energy Research Alliance (EERA). The key objective of the EERA is to accelerate the development of new energy technologies by conceiving and implementing Joint Research Programmes in support of the SET-plan pool and integrate activities and resources, combining national and Community sources of funding and maximizing complementarities and synergies. In 2011, a Joint Research Programme (JP) on ocean energy was launched with the active participation of Spain through the involvement of TECNALIA and AZTI. The EERA Ocean Energy JP is based around six key research themes. These themes have been developed, based on existing research roadmaps, which identify the critical areas of research required for the successful growth of the industry. The 6 research themes are Resource, Devices and Technology, Deployment and Operations, Environmental Impact (with the participation of AZTI-Tecnalia), Socio-economic Impact and Research Infrastructure, Education and Training. Spain is participating in all of the research themes and TECNALIA is leading the “Deployment and Operation” theme together with the German centre Fraunhofer IWES.

MaRINET - Marine Renewables Infrastructure Network

The Spanish marine renewable energy sector is set to benefit from a new €9 million EU-funded initiative to provide access to test facilities in specialist marine renewable energy centres across Europe. ‘MaRINET’ (Marine Renewables Infrastructure Net-

work) offers periods of marine renewable energy testing at these centres at no cost to participants through funding from the European Commission. The initiative, with at least four calls for applications, runs until 2015 and the first call for applications started in December 2011. In Spain, EVE and TECNALIA are key partners in this initiative: TECNALIA is offering its Electrical PTO lab testing facilities, and EVE is offering its Mutriku OWC plant and BIMEP testing facilities. A significant number of European companies and research groups are expected to apply to use these facilities. Further information can be found at www.fp7-marinet.eu

Spanish leadership in offshore multi-purpose platforms (MARINA)

With the leadership of the Spanish company Acciona Energia, the European MARINA-Platform project will establish a set of equitable and transparent criteria for the evaluation of multi-purpose platforms for marine renewable energy. Using these criteria, the project will produce a novel, whole-system set of design and optimization tools addressing, inter alia, new platform design, component engineering, risk assessment, spatial planning, platform-related grid connection concepts, all focused on system integration and reducing costs. These tools will be used, incorporating into the evaluation all currently known proposed designs including (but not limited to) concepts originated by the project partners, to produce two or three realizations of multi-purpose renewable energy platforms. The MARINA-Platform project started in January 2010 with the support of the European Commission through the seventh framework programme and will run during 54 months. More information at www.marina-platform.info.

TROPOS

The Oceanic Platform of the Canary Islands (PLOCAN), is leading another European Project (TROPOS) recently funded under the call “the Ocean of Tomorrow”. The objective of this project is to design multiuse offshore platforms where ocean energy plays a key role.

WAVETRAIN2

The WAVETRAIN2 project is a multinational Initial Training Network (ITN) funded under the FP7-People program, in order to face the wide range of challenges that industrial-scale wave energy implementation faces in the near future, focusing on technical issues, from hydrodynamic and PTO (Power Take-Off) design, to instrumentation issues and energy storage and cost reduction show to be critical for successful deployment. On the other hand, also non-technical “barriers”, typically less tangible difficulties related to legal issues (licensing, conflicts of use, EIA procedures, grid connection, regional differences) and the non-sufficient representation of socio-economic benefits of the sector, will be dealt with, as they are seen as a major obstacle for fast implementation on a European scale. The network consists of 13 European partner institutions and 17 associated entities, from research units and device developers to project developers and consultants. TECNALIA and EVE participate on the “WP devoted to grid and control issues, electrical components”.

Streamlining of Ocean Wave Farms Impact Assessment (SOWFIA)

The SOWFIA project (<http://www.sowfia.eu/>) 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. 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. The Spanish participant is the Basque Energy Agency (EVE).

OES-IA Annex IV

The purpose of Annex IV is to provide a collaborative project under the International Energy Agency's (IEA) Ocean Energy Systems Implementing Agreement (OES-IA) that will identify ongoing research and bring together data on the environmental effects of marine and hydrokinetic (MHK) energy development, analyse those data to understand effects, identify potential monitoring and mitigation strategies to address those effects, and share those results and data broadly. The US has the lead for Annex IV; and the US Department of Energy (DOE) is the overall Operating Agent, also partnering with the Federal Energy Regulatory Commission (FERC) and the Bureau of Ocean Energy Management (BOEM). The DOE Water Power Program has also tasked one of the US national research laboratories, Pacific Northwest National Lab (PNNL), to carry out a significant amount of the Annex IV work. The database created to support Annex IV data will be built as an adjunct to the Knowledge Management System (Téthys) created for a similar PNNL project on environmental effects of MHK development. One of the first steps in implementing the Annex was to convene an experts' workshop in Dublin Ireland September 27th – 28th 2010. PNNL was responsible for organizing the content of the workshop, overseeing the contractors (Irish Marine Institute) hosting the event, presenting material on Annex IV and materials applicable to the workshop intent. PNNL is also overseeing a contractor (Wave Energy Center/University of Plymouth – WEC/UP) in the collection and analysis of the Annex IV data. The work is supported by 8 pay members, among them AZTI-Tecnalia.

Decision-support tools

In Spain there are no specific decision-making tools. As far as we know the only tentative approach to a tool for future decision on wave energy disposal is the work undertaken by AZTI-Tecnalia within the MESMA European project (Galparsoro *et al.*, 2012).

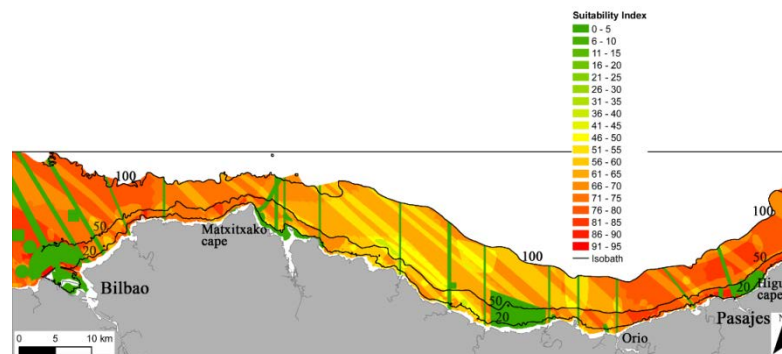
Reference

Galparsoro, I., Liria, P., Legorburu, I., Bald, J., Chust, G., Ruiz-Minguela, P., Pérez, G., Marqués, J., Torre-Enciso, Y., González, M., and Borja, A. 2012. A Marine Spatial Planning approach to select suitable areas for installing wave energy converters on the Basque continental shelf (Bay of Biscay). *Coastal Management Journal*, 40: 1–19.

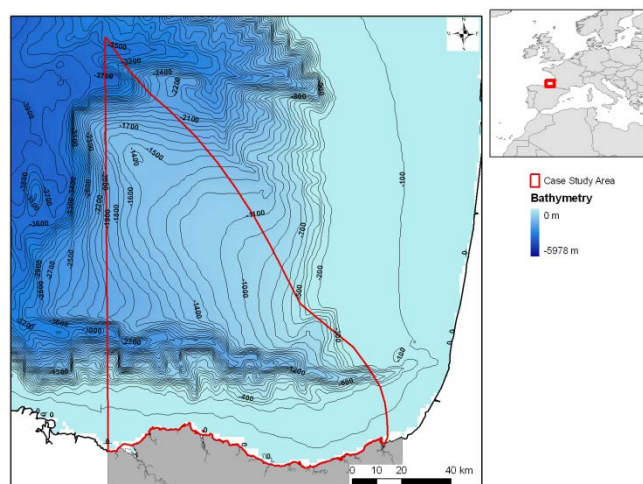
In Marine Spatial Planning seventeen information layers (among them 10 technical, 4 environmental, and 3 socio-economical layers), corresponding to the identified key factors, including the theoretical wave energy in the study area, were generated to define their spatial distribution. Geographical Information System algorithms were

used then in the assessment of the total theoretical energy potential and the accessible theoretical energy potential; these were calculated excluding areas where conflicts with other uses occur.

The final output is a Suitability Index map:



This is applied to the Basque continental shelf: located in the southeastern part of the Bay of Biscay, in the border between France and Spain.



Data comes from projects funded by the Basque Government to AZTI-Tecnalia.

4 Information gaps (ToR c)

A list of information gaps hindering the capacity to plan and manage wave and tidal energy activities was compiled by SGWTE 2011. Progress against these research gaps, grouped under thematic headings, is summarized in Annex 7. Annex 8 gives a list of knowledge gaps compiled by the UK NERC Marine Renewable Energy Knowledge Exchange Programme (MREKE).

These gaps were discussed during the SG2012 meeting, and the following list of main priorities was agreed:

Marine mammals

- Use of marine space
- Behaviour around turbines
- Problems with monitoring methods

Seabirds

- Displacement
- Collision Risk
- Consequences of development for feeding and energetic

Fish

- Interference with migration routes
- Behaviour around turbines
- Basking sharks in relation to oceanographic fronts
- Electromagnetic Fields
- Lack of information on pelagic fish
- General interactions of fish with marine renewable energy devices
- Problems with monitoring methods

Benthos

- Change in seabed habitats around devices
- Systemic changes owing to energy extraction
- Intertidal communities in relation to wave energy

Oceanography

- Development of numerical models in areas of interest
- Representing energy extraction in models in areas of interest
- Collection of validation data
- Measuring and modelling fronts and other oceanographic features of importance

Interactions with fisheries and other sea users

- Displacement of fishing effort
- Knowledge of fishing by small vessels in inshore areas
- Lack of information on other sea users (for use at planning and consenting stages)

Marine Protected Areas / reef effects

- Changes in seabed habitats around devices
- Value of development areas as a conservation tool

Cross-cutting themes

- Upscaling
- Cumulative impacts
- Data and information
- Synergistic impacts

5 Lessons Learned from other industries (ToR f)

There was little time for discussion of ToR f) during the meeting, but the following table contains contributed by SGWTE members from England, Spain and Sweden regarding experience and lessons learned from other industries relating to social acceptability issues and stakeholder engagement in wave and tidal energy planning and consenting processes:

Other industries	Stakeholder engagement	Planning and consenting processes	Lessons for WTE industry
Aquaculture	In some regions of Spain a Marine Spatial Planning for the development of the Aquaculture was done due to the continuous conflicts of aquaculture promoters with other users (beaches, marine protected areas, military zones, sand extraction areas, shipping lines, etc).	The outcomes of stakeholders have been taken into account within the EIA and Marine Public Terrestrial Domain (MPTD) concession process.	The WTE industry needs a Marine Spatial Planning approach in order to avoid problems with other sea users and social acceptability. This is the main objective of MESMA project.
Offshore wind	FLOWW – fisheries liaison for offshore wind and wet renewables	Meet periodically to discuss issues of conflict	Yes
Aggregates	South and east coast liaison groups	Talk about sensitive issues to resolve consenting / licensing	Yes
Nature Conservation	MCZ stakeholder groups e.g.. Finding sanctuary / Netgain etc	Discussion and mapping of activities leading to recommendations for potential MCZs	Yes
Seabed users development group	Workshops and discussion fora to explore key issues	Flagging up issues to regulators to promote streamlining and level playing field in consenting	Yes
Dorset Coastal Forum	Regular meetings and annual conference broad spectrum of stakeholders	Promoting use of research to underpin management of coastal zone	Yes

Other industries	Stakeholder engagement	Planning and consenting processes	Lessons for WTE industry
Some (marginal) info from the national offshore wind industry, but more from the Danish and UK experiences rather than from national experiences as they seldom gets published or are difficult to obtain.	Little done on societal studies regarding wind developments in Sweden, unfortunately. However, the fact that the national wind development did perform badly has inspired the Swedish WTE to (successfully) be considerably more extensively-	Mandatory, and extensively, within the Swedish EIA/consent process.	Nothing in particular adopted from e.g. wind developments.
No offshore oil/gas extraction in Swedish waters.	No connection to WTE	No connection to WTE	No connection to WTE
Newly finished gas line between Russia and Germany (within Swedish waters) and a gas line between Norway and Denmark (incl. parts of Swed. west coast	No connection to WTE	No connection to WTE	No connection to WTE

6 Report on Theme Session S from ICES ASC 2011 (ToR g)

Theme Session S at the ICES Annual Science Conference 2011 (Gdańsk, 19–23 September 2011) was convened by Jonathan Side (UK) and Michael Bell (UK): “Extracting energy from waves and tides – what are the consequences for ecosystems, physical processes and other sea users?”

The development of a new industry extracting hydrokinetic energy from waves and tides is seen as an important mitigating action for climate change, helping to meet global energy demands while reducing greenhouse gas emissions. Wave and tidal energy developments currently exist more in potential than in actuality, but there is huge impetus from political, environmental and commercial interest groups for rapid growth of the sector over the immediate future. The emergence of a major new industry in the marine environment has unknown consequences for ecosystems, the physical processes upon which they depend and the many other sea users for which the marine environment is also a resource.

Theme Session S addressed the question of the extent to which marine renewable energy extraction can coexist with healthy ecosystems, and with the human activities that depend on the services provided by these ecosystems. Given the rapid emergence of a wave and tidal energy industry and ambitious national targets for expanding its contribution to renewable energy generation, this question is an urgent one. Nineteen papers and six posters were presented during the session addressing topics including marine planning, interactions with other sea users, the potential for direct and indirect impacts on physical and ecological processes, and methods to predict and mitigate such impacts.

Uncertainty about the performance of marine energy technologies and their potential environmental interactions has prompted the establishment of wave and tidal energy test centres at which technology and associated infrastructure and working methods can be tested before proceeding to commercial scale developments, with the opportunity also to undertake research into potential impacts and interactions. Test centres are being developed worldwide and several papers highlighted the utility of these sites in Scotland and across Europe (S:08, S:12, S:18). Commercial leases and development consents are now being granted and this presents new challenges for the rapid development of marine planning systems and consenting processes (S:01, S:10, S:18). At this stage of development, inferences about potential environmental interactions and impacts comes largely from modelling studies and experience from other industries. These lines of evidence are being used to investigate near- and far-field effects of energy extraction on sediment transport processes (S:08, S:17), circulation patterns (S:19) and other aspects of the physical environment (S:04).

Mediated by changes in physical processes, energy extraction potentially may influence ecological processes and the distribution of marine organisms at scales ranging from devices (e.g. fish around tidal turbines, S:13) to systemic levels (S:14). In assessing such impacts it is important to establish baselines (S:06, S:16) and to identify sentinel species and other indicators that may highlight wider ecological responses to development activities (S:15, S:16). Collection of good spatial information on benthic communities and environmental factors in potential development areas is key to predicting impacts and informing spatial planning decisions (S:02, S:03). Development of sensing and measurement technologies is also important in this context (S:22, S:23). As long-standing users of the marine environment, fisheries are of particular interest with regards to potential interactions with wave and tidal energy developments. Both synergies and potential conflicts can be identified (S:24, S:26). Data on the distribution of fishing effort by larger fishing vessels may be informative about potential interactions (S:26), but information is often lacking for smaller vessels that may be important in inshore areas. Direct impacts on marine mammals and birds are of particular concern to regulators, owing to legislative requirements and to the high profile and levels of concern about these organisms among the general public. Direct impacts could include disturbance by noise from marine energy developments (S:09) and collisions particularly with tidal devices (S:11). Several presentations considered surveys and survey methodology for birds and mammals (S:05, S:07, S:25) and predicting the likely impacts of developments (S:21).

The diversity of papers and posters presented during Theme Session S demonstrates the wide range of issues that are being considered in relation to the consequences of wave and tidal energy developments. As developments proceed rapidly from testing of scaled prototype devices to full-scale commercial realization of arrays of multiple devices, it is very important that the results of this research are applied to minimize and mitigate impacts and to make maximum use of opportunities for synergies. Co-ordination of existing and future research in this field and identification of research gaps are important activities for ICES at this time.

Many thanks are due to the authors of papers and posters presented during this Theme Session and to all who attended the session and contributed to fruitful and stimulating discussions.

7 Interaction with other ICES Expert Groups (ToR h)

Concerns with wave and tidal energy overlap many ICES Expert Groups, particularly those focusing on receptors of potential impacts. Contact was established during the meeting with WGMME (marine mammal ecology) and BEWG (benthic ecology) with regard to opening lines of communication for future interaction. Based on examination of recent Terms of Reference for Expert Groups, there is potential for interaction with many other groups within ICES.

ICES Expert Groups with interests in wave and tidal energy

The following ICES groups specifically mention renewable energy and/or wave and tidal energy in their terms of reference or scientific justification statements:

Working Group on Marine Mammal Ecology (WGMME). ToR (c) “This is completion of the review of the effects of renewable energy on marine mammals within the ICES Area. It addresses the research topic “Influence of development of renewable energy resources (e.g. wind, hydropower, tidal and waves) on marine habitat and biota” within the ICES Science Plan”

Working Group on Seabird Ecology (WGSE). ToR (b) “Review data studies on effects of wet renewable energy developments on seabirds”

Working Group for Marine Planning and Coastal Zone Management (WGMPCZM). “High Priority Research Topics in the ICES Science Plan that are relevant to the WG are: ... Influence of development of renewable ocean energy resources (e.g. wind, hydropower, tidal and waves) on marine habitat and biota; “

Working Group on Marine Shellfish Culture (WGMASC). ToR (b) “.....In addition, it is intended to investigate the sustainable use of oceans by integrating aquaculture and fisheries and assess the potential for combining shellfish culture with other off-shore constructions such as renewable energy facilities or any other.”

Working Group on Integrative, Physical-biological, and Ecosystem Modelling (WGIPEM). “ToRs a-e contribute to coded topic areas including: Climate Change (112, 114, 115), Biodiversity and Health of Ecosystems (123), Life History (144, 145, 147), Role of Top Predators (173), Impacts of Fishing (211), Renewable Energy issues ().”

The following ICES groups don't specifically mention renewable energy but cover areas that might be relevant to SGWTE:

Benthos Ecology Working Group (BEWG). Areas covered include: influence of climate change; species distribution modelling; keystone species.

Working Group on Fisheries Acoustics, Science and Technology (WGFAST). Areas covered include: use of acoustic techniques in ecosystem studies; design of observing systems; using acoustic techniques to study animal behaviour; characterizing natural and anthropogenic acoustic footprints.

Working Group on Marine Habitat Mapping (WGMHM). Areas covered include: habitat modelling; use of habitat maps in management and marine spatial planning.

Working Group on Operational Oceanographic Products for Fisheries and the Environment (WGOOFE). Areas covered include: making available oceanographic data-sets.

Study Group on VMS data, its storage, access and tools for analysis (SGVMS). Areas covered include: provision and use of VMS data.

Workshop to Define the Ocean Observing Needs for ICES (WKOOL). ToR a): “Review ICES Observation products and systems, in relation to present and potential future scientific and advisory needs of ICES and ICES member nations”.

Working Group on Oceanic Hydrography (WGOH). ToR c): “Provide support to other Expert Groups requiring information on oceanic hydrography”.

Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEA-WESS). ToR a): “Carry out data review and metadata compilation about relevant ecosystem components and process at the regional scale and carry out preliminary evaluation of data and trends”.

Working Group on the Science Requirements to Support Conservation, Restoration and Management of Diadromous Species (WGRECORDS). ToR a): “Stimulate international scientific cooperation in the study of diadromous fish species and provide a mechanism through which issues relating to these species, including in estuarine and freshwaters, can be addressed and coordinated within the ICES science plan”.

Workshop on Effects of Offshore Windfarms on Marine Benthos - Facilitating a closer international collaboration throughout the North Atlantic Region (WKEOMB). ToRs: “a) Review the science of offshore wind farms effects on the benthic system in the North Atlantic; b) Exchange and consolidate state-of-the-art knowledge among experts; c) Evaluate future scientific perspectives, i.e. to identify potential gaps in knowledge; d) Assess the scientific efficiency of ongoing monitoring programs, based on e.g. (major) knowledge gaps and overlap in research focus; e) Scope for international collaboration, i.e. to reduce redundancy in ongoing research.”

Working Group on Fish Ecology (WGFE). ToR c): “Review existing fish-based indicators (e.g. of biodiversity) suggested for the descriptors of the Marine Strategy Framework Directive, assessing their basis in theory (e.g. linkage to changes in ecosystem function), feasibility and performance; suggest new and alternative indicators where appropriate”.

Working Group on Integrative, Physical-biological, and Ecosystem Modelling (WGIPEM). ToRa): “Report on the state-of-the-art within the ICES community and worldwide in coupled physical-biological and ecosystem modelling and simulation results (e.g. population connectivity, life cycle dynamics, foodweb interactions and/or ecosystem responses to human activities) including: i) Components of coupled biophysical integrated models (single species to foodwebs; ii) Coupled, integrative ecosystem (end-to-end) models including all core components; iii) Calibration, corroboration and confidence in model estimates and management application”.

Proposed new Working Group on Marine Energy (WGME)

Given the diversity of interest within the ICES in wave and tidal energy and in marine renewable energy more generally (i.e. including tidal barrages and offshore wind energy), SGWTE recommends the setting up of a new Working Group on Marine Energy (WGME) to coordinate the flow of science from the topic-based science Working Groups to its application in a management context. SGWTE is due to have its final meeting in 2013 and a suggested Term of Reference for SGWTE 2013 (Annex 3) is fully to develop a proposal for this new WG. The remit of this WG would be likely to include planning, consenting and regulatory processes and to cover tidal barrages and offshore wind in addition to wave and in-stream tidal energy. It is envisaged that

WGME would interact with science WGs including on marine mammals (WGMME), seabirds (WGSE), benthos (BEWG), fish as receptors (WGFE), ecosystem role of fish (WGRECORDS), fisheries interactions and other sea users (WGMPCZM) and oceanography (WGOH). Interaction with 'service' WGs over data and information might include WGFASST, WGOOFE and WGVMS.

Terms of Reference for WGME would address:

- a) State of development of the marine energy sector;
- b) Consenting procedures and seabed leasing;
- c) Decision-support and management tools;
- d) Cross-cutting themes;
- e) Outputs on state of development;
- f) Identifying needs for thematic ICES Workshops based on regulatory and planning needs.

This last ToR is envisaged as an important function of WGME, ideally generating ICES Cooperative Research Reports for wider dissemination. Generic ToRs for these Workshops in relation to any given topic area would be:

- a) Summarize state of knowledge of interactions;
- b) Formulate advice on monitoring and assessment methods;
- c) Identify priority research gaps;
- d) Set out mitigation and management options;
- e) Format outputs as a Cooperative Research Report.

Workshop membership would be likely to cut across WGME and the thematic WGs.

A venue for the first meeting of WGME in 2014 has tentatively been agreed as Pasa-
jes, Spain.

Annex 1: List of participants

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Annex 2: Agenda

Agenda for SGWTE 2012, Stromness, Orkney, UK

Friday 4 May	
10:00	Arrival and coffee
10:20	Introductions and Terms of Reference
10:40	Reports back from EIMR and WKWTETS
11:00	Term of Reference (g) – ASC 2011 Review of Theme Session S from ICES Annual Science Conference in 2011 Discussion of need for future conference sessions to disseminate results of research relating to environmental and socio-economic interactions of wave and tidal energy
11:30	Term of Reference (h) – Interactions with other ICES groups Involvement of SGWTE members with other ICES Expert Groups, including the Strategic Initiative on Area-Based Science and Management (SIASM) Discussion of need for SGWTE to interact with other groups
12:00	Overview of Country Reports England – Annie Linley Ireland – Anne-Marie O'Hagan Spain – Juan Bald Sweden – Jan Sundberg Scotland – Ian Davies Wales – Ian Horsfall Material provided by correspondence for Canada, France, Norway, Northern Ireland and Portugal
13:00	Lunch
14:00	Continue Country Reports ... Discussion of need for additional international representation
15:30	Break & Coffee
16:00	Continue and complete Country Reports
17:00	Agree agenda for Saturday and Sunday
Saturday 5 May	
9:30	Plan for the day, assignment of report writing tasks and leaders for Terms of Reference
9:45	Overview of Term of Reference (a), (b) & (e) – Directories of development and research activities, progress with consenting processes, bibliography of research outputs, spatial data What information do we have from the Country Reports How is this information best organized and disseminated?
10:15	Overview of Term of Reference (d) – Decision-making tools What information have we already collated? Identify commonalities and differences
10:45	Break & Coffee
11:15	Individual work time Collating information across countries Compiling additional information Report writing tasks
13:00	Lunch
14:00	Discussion of Term of Reference (f) – Lessons from other industries Review information contributed so far Collate overview

14:45	Individual work time
15:30	Break & Coffee
16:00	Individual work time
17:00	Round-up of progress and plans for Sunday
Sunday 6 May	
9:30	Plan for the day, identifying outstanding tasks
9:45	Overview of Term of Reference (c) – Research gaps Plenary discussion of research gap table, agreeing priorities and identifying ways forward How should this information be disseminated more widely?
10:45	Break and coffee
11:15	Continue overview of Term of Reference (c) Individual work time
11:50	Round up of progress, identify outstanding items for the final report
12:00	Future meetings Need for continued work by SGWTE? Do we need an ICES Working Group on the topic, or should the work be subsumed into existing Expert Groups? Terms of Reference for future meetings Chairing future meetings
13:00	Meeting close Lunch and Departure
14:00 -	Opportunity for additional work time for any SGWTE member who has not already departed

Annex 3: SGWTE terms of reference for the next meeting

The **Study Group on Environmental Impacts of Wave and Tidal Energy** (SGWTE), chaired by Michael Bell, UK, will meet in Cork, Ireland, 19-21 March 2013 to:

- a) Update and extend coverage of country reports on the state of development of wave and tidal energy and associated environmental research in ICES nations, including databases of development activities and research activities and bibliographies of current and research outputs;
- b) Develop a proposal for a new ICES Working Group on Marine Energy to coordinate the flow of science between topic based Working Groups (e.g. marine mammals, seabirds, benthic ecology) and planning, consenting and regulatory processes in relation to marine renewable energy, to consider tidal barrages and offshore wind as well as in-stream tidal and wave energy;
- c) Discuss the application of Integrated Ecosystem Approaches to management of renewable energy activities in the marine environment;
- d) Review the potential of and mechanisms for interaction of ICES science on marine renewable energy with OSPAR, HELCOM and other commissions.

SGWTE will report by DATE (via SSGHIE) for the attention of SCICOM.

Supporting Information

Priority	The activities of this Group are leading ICES into issues related to the ecosystem impacts of ocean renewable energies especially with regard to the application of Marine Spatial Planning (MSP) and ICZM. Consequently, these activities are considered to have a very high priority.
Scientific justification	<p>Term of Reference a)</p> <p>The pace of development by the wave and tidal energy industry is rapidly accelerating in a number of ICES nations. In order to appreciate the scale of potential impacts there is an urgent need to keep track of these developments and to integrate the body of research that is growing alongside them. It is currently difficult to keep pace with outputs from the diverse range of research relating to wave and tidal energy. A searchable bibliography of current outputs will be a valuable resource for scientists and regulators. Current research activities are doing much to address important issues relating to the environmental and socio-economic consequences of wave and tidal energy developments, but in order to best direct future research resources and avoid duplication and overemphasis on certain topics it is crucial to keep track of issues that remain unaddressed and to identify those issues that relate to the most immediate needs.</p> <p>Term of Reference b)</p> <p>SGWTE completes its term of three meetings in 2013. It is apparent that there is a growing need for advice on potential impacts in the marine environment of the rapidly developing marine renewable energy sector, and to keep track of the state of development and related marine environmental research. A number of ICES EGs are focusing on science relevant to marine renewable energy (e.g. WGMME) and a new Working Group on Marine Energy would greatly facilitate the flow of science from topic-based WGs to its application in planning, consenting and regulation of marine energy.</p> <p>Term of Reference c)</p> <p>New risk-based and integrated ecosystem approaches to management of human activities in the marine environment are emerging in countries such as Canada. It is timely for SGWTE to consider how these could best be applied in the context of wave and tidal energy, particularly in relation to the requirements of</p>

	<p>the Marine Strategy Framework Directive.</p> <p>Term of Reference d)</p> <p>In order to maximize the utility of ICES science on environmental impacts of marine renewable energy it is essential for information to flow from EGs to OSPAR, HELCOM and other relevant bodies. It is timely for SGWTE to consider how best to interact with and deliver advice to these bodies.</p>
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group consists of experts in ocean energy resources, environmental and socio economic aspects of marine planning and regulation.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	There are obvious direct linkages with the advisory committees (see last years OSPAR request).
Linkages to other committees or groups	There should be close links with SSGHIE, STIG-MSP, WGMPCZM and several other WGs.
Linkages to other organizations	Need to be established, OSPAR is interested in this issue.

Annex 4: Recommendations

Recommendation	Adressed to
1. SGWTE recommends to continue the work of collating information on wave and tidal energy activities and related research by ICES nations (ToR a)	SCICOM, SGWTE
2. SGWTE recommends to compile a publicly searchable bibliography of outputs from state-of-the-art research relating to the environmental and socio-economic impacts of wave and tidal energy developments.	SCICOM, SGWTE
3. SGWTE recommends a new ICES Working Group on Marine Energy to coordinate the flow of science between topic-based Working Groups and planning, consenting and regulatory processes in relation to marine renewable energy, to consider tidal barrages and offshore wind as well as in-stream tidal and wave energy. A proposal for this new Working Group and its ToRs should be worked up by SGWTE in 2011.	SCICOM, SGWTE

Annex 5: Summary information on wave and tidal energy developments

Country:	UK (Scotland)				
Development:	Npower Siadar - Lewis				
Web-link:					
Location name:	NW Lewis	Latitude (decimal):	58.42	Longitude (decimal):	-6.48
Deployment start:			Deployment end date:		
Device type:	Oscillating wave surge converter	Anchor type:	Mooring strings:		
Number of devices:			Total installed capacity (MW):	4MW	
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Consented to be built					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Aquamarine Power Ltd - Oyster 2 B & C				
Web-link:					
Location name:		Latitude (decimal):		Longitude (decimal):	
Deployment start:			Deployment end date:		
Device type:		Anchor type:		Mooring strings:	
Number of devices:			Total installed capacity (MW):	1.6MW	
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Consented to be built					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)		
Development:	AlbaTern - EMEC		
Web-link:			
Location name:	EMEC	Latitude (decimal):	Longitude (decimal):
Deployment start:	Deployment end date:		
Device type:	Anchor type:	Mooring strings:	
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:			
Consenting process:			
Consented to be built			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)		
Development:	Seatricity - EMEC		
Web-link:			
Location name:	EMEC	Latitude (decimal):	Longitude (decimal):
Deployment start:	Deployment end date:		
Device type:	Anchor type:	Mooring strings:	
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:			
Consenting process:			
Consented to be built			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)		
Development:	Scapa Flow - EMEC		
Web-link:			
Location name:	EMEC	Latitude (decimal):	Longitude (decimal):
Deployment start:	Deployment end date:		
Device type:	Anchor type:	Mooring strings:	
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:			
Consenting process:			
Consented to be built			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)		
Development:	ScottishPower Renewables - Sound of Islay		
Web-link:			
Location name:	Sound of Islay	Latitude (decimal):	55.84
		Longitude (decimal):	-6.1
Deployment start:	Deployment end date:		
Device type:	Horizontal axis turbine	Anchor type:	Mooring strings:
Number of devices:	Total installed capacity (MW): 10MW		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:			
Consenting process:			
Consented to be built			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)				
Development:	Nova Innovations -Bluemull Sound Shetland				
Web-link:					
Location name:	Shetland	Latitude (decimal):	60.7	Longitude (decimal):	-0.98
Deployment start:	Deployment end date:				
Device type:	Horizontal axis turbine	Anchor type:	Mooring strings:		
Number of devices:			Total installed capacity (MW):	30KW	
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Consented to be built					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Aquamarine Power Ltd - Lewis				
Web-link:					
Location name:	NW Lewis	Latitude (decimal):		Longitude (decimal):	
Deployment start:			Deployment end date:		
Device type:		Anchor type:	Mooring strings:		
Number of devices:			Total installed capacity (MW):	40MW	
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Consent period					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Ocean Flow Energy - Sanda Sound				
Web-link:					
Location name:	Sanda Sound, South of Mull of Kintyre	Latitude (decimal):	55.3	Longitude (decimal):	-5.6
Deployment start:	Deployment end date:				
Device type:	Horizontal axis turbine	Anchor type:	Mooring strings:		
Number of devices:	Total installed capacity (MW):			35KW	
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
Consent period					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Swan Turbines - Montrose				
Web-link:					
Location name:	Montrose	Latitude (decimal):		Longitude (decimal):	
Deployment start:	Deployment end date:				
Device type:	Horizontal axis turbine	Anchor type:	Mooring strings:		
Number of devices:	Total installed capacity (MW):			500KW	
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
Consent period					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)	
Development:	Aquamarine Power Ltd - Oyster 1	
Web-link:		
Location name:	Latitude (decimal):	Longitude (decimal):
Deployment start:	Deployment end date:	
Device type:	Anchor type:	Mooring strings:
Number of devices:	Total installed capacity (MW):	850KW
Test scale of devices:	Deployment area (km2):	
Environmental data collected:		
Consenting process:		
Constructed / Monitoring		
Monitoring activities:		
Research activities:		
Spatial data available:		
Additional information:		

Country:	UK (Scotland)	
Development:	Aquamarine Power Ltd - Oyster 2 A	
Web-link:		
Location name:	Latitude (decimal):	Longitude (decimal):
Deployment start:	Deployment end date:	
Device type:	Anchor type:	Mooring strings:
Number of devices:	Total installed capacity (MW):	800KW
Test scale of devices:	Deployment area (km2):	
Environmental data collected:		
Consenting process:		
Constructed / Monitoring		
Monitoring activities:		
Research activities:		
Spatial data available:		
Additional information:		

Country:	UK (Scotland)		
Development:	Wello Oy - EMEC		
Web-link:			
Location name:	EMEC	Latitude (decimal):	Longitude (decimal):
Deployment start:	Deployment end date:		
Device type:	Anchor type:	Mooring strings:	
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:			
Consenting process:			
Constructed / Monitoring			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)		
Development:	E.ON - Pelamis - Billia Croo		
Web-link:			
Location name:	Billia Croo, EMEC	Latitude (decimal):	58.97 Longitude (decimal): -3.38
Deployment start:	Deployment end date:		
Device type:	Anchor type:	Mooring strings:	
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:			
Consenting process:			
Constructed / Monitoring			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)				
Development:	Atlantis - EMEC				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:	Deployment end date:				
Device type:	Horizontal axis turbine	Anchor type:	Mooring strings:		
Number of devices:	Total installed capacity (MW):		1MW		
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Voith - EMEC				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:	Deployment end date:				
Device type:	Horizontal axis turbine	Anchor type:	Mooring strings:		
Number of devices:	Total installed capacity (MW):		1MW		
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Tidal Generation Limited - EMEC				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:			Deployment end date:		
Device type:	Anchor type:		Mooring strings:		
Number of devices:			Total installed capacity (MW): 500KW		
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	ScottishPower Renewables - Falls of Warness - EMEC				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:			Deployment end date:		
Device type:	Anchor type:		Mooring strings:		
Number of devices:			Total installed capacity (MW): 1MW		
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Kawasaki - EMEC				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:			Deployment end date:		
Device type:	Anchor type:		Mooring strings:		
Number of devices:			Total installed capacity (MW):	1MW	
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Flumill - EMEC				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:			Deployment end date:		
Device type:	Anchor type:		Mooring strings:		
Number of devices:			Total installed capacity (MW):	1MW	
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Shapinsay Sound - EMEC				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:			Deployment end date:		
Device type:	Anchor type:		Mooring strings:		
Number of devices:			Total installed capacity (MW):		
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Scotrenewables Tidal Power Ltd - EMEC UA				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:			Deployment end date:		
Device type:	Anchor type:		Mooring strings:		
Number of devices:			Total installed capacity (MW):		
Test scale of devices:			Deployment area (km2):		
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Scotrenewables Tidal Power Ltd - EMEC M				
Web-link:					
Location name:	EMEC	Latitude (decimal):	59.14	Longitude (decimal):	-2.82
Deployment start:	Deployment end date:				
Device type:	Anchor type:		Mooring strings:		
Number of devices:	Total installed capacity (MW):				
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	ScottishPower Renewables - Billia Croo - EMEC				
Web-link:					
Location name:	Billia Croo, EMEC	Latitude (decimal):	58.97	Longitude (decimal):	-3.38
Deployment start:	Deployment end date:				
Device type:	Anchor type:		Mooring strings:		
Number of devices:	Total installed capacity (MW): 3.2 MW				
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
In construction					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Wales)				
Development:	DeltaStream device, Tidal Energy Ltd. To be deployed in Ramsey Sound, Pembrokeshire for a trial period of 12 months after which, it will be removed from the water.				
Web-link:	http://www.tidalenergyltd.com/?page_id=650				
Location name:	Ramsey Sound Pembrokeshire	Latitude (decimal):	51.8775	Longitude (decimal):	-5.326
Deployment start:		Spring / summer 2013	Deployment end date:		Spring / summer 2014
Device type:	Triangular gravity base foundation 3 fixed pitch blades per nacelle, 3 nacelles per device (i.e. one at each corner of base)	Anchor type:	Up to 8	Mooring strings:	2 sinkers
Number of devices:		1 (3 nacelles)	Total installed capacity (MW):		1.2
Test scale of devices:		36m triangular base, 15m diameter blades.	Deployment area (km2):		Approx 0.5 , plus sinkers and anchors
Environmental data collected:					
Baseline info on bathymetry, seabed composition, suspended sediment, tidal flows, baseline seabed surveys (intertidal and subtidal), 2 years pre-deployment survey of marine mammals (inc harbour porpoise and grey seal) and seabirds					
Consenting process:					
Marine consents: DECC issued Section 36 Electricity Act licence in October 2009. Welsh Government simultaneously issued Marine Act licence. A Habitats Regulation Assessment was required since the deployment is within a European Marine Special Area of Conservation (various seabed habitat features and grey seal as a species feature). Various European Special Protection Areas with diving bird features are in the vicinity of the deployment. In addition, there is a significant presence of harbour porpoise, a European Protected Species, in Ramsey Sound. The HRA process was led by DECC. Collision risk for marine mammals was the single biggest issue. Other potentially significant effects were ruled out in the assessment by micro-siting (e.g. to avoid effects on protected seabed habitats) and given short term, temporary nature of trial (e.g. to avoid long-term effects on seabird populations). Consent was issued on the basis that thresholds were set for collisions between the device and harbour porpoise / grey seal. These thresholds were provided by Countryside Council for Wales, using Potential Biological Removal as a tool for calculating limits of acceptable mortality to populations of marine mammals (widely used in US to manage bycatch), on the basis that if thresholds are not exceeded, the long-term viability of the population will not be affected. Thresholds also took into account other significant sources of non-natural mortality acting upon the same mammal populations.					
Terrestrial aspects: Planning permission for the temporary onshore works granted by the Pembrokeshire Coast National Park Authority October 2009.					
Monitoring activities:					

In addition to a monitoring programme to validate the predictions of the EIA process, detailed collision risk monitoring is required as strict condition of consent for the project. The monitoring programme must be capable of a) detecting a collision with the device and b) determining (i.e. to species level) what that collision was with, so that thresholds can be monitored. A feasibility study has been undertaken by SMRU Ltd on behalf of the developer, to determine the most appropriate suite of technologies to achieve these objectives. The final collision risk monitoring programme will comprise a combination of technologies, including passive and active sonar, which, in combination, will provide the information required.

An Environmental Management Committee has formed to oversee the deployment, including the finalizing of the collision risk monitoring programme. The group comprises of representatives from the developers, DECC, Welsh Government (Marine Section), Welsh Government (Marine Consents Unit), Countryside Council for Wales, Cefas and the Sea Mammal Research Unit Ltd (appointed by the developer).

Research activities:

To be fully determined - CCW have been pushing for additional research to be associated with the deployment. The consent requires that monitoring ensures that thresholds for collisions are not breached, but the whole for taking a thresholds based approach is that it allows the device to operate when mammals are in close proximity, so we can increase our understanding for avoidance / evasion behaviour around operating devices. However, there is no statutory requirement to undertake research to quantify any evasion and avoidance behaviour in marine mammals or to ensure that data are gathered in such a way and in a format that can be incorporated into refining collision / encounter risk models, etc.

Spatial data available:

Additional information:

By consenting the deployment without the need to shut down when mammals are in the vicinity, the project should provide much needed information and data on close scale interactions between an operating device and marine mammals. Ramsey Sound and the deployment areas are frequented (on a daily basis) by grey seal and harbour porpoise, so the trial is going ahead in an area where close-scale interactions are highly likely. Although other projects have been consented (e.g. deployments at EMEC and SeaGen in Strangford Lough), none of these are providing information in close scale interactions between devices and mammals either because (in the case of projects at EMEC), interaction are not being monitored, or in the case of SeaGen, the device is shut down when mammals come within a 50m radius of the device.

Country:	Portugal				
Development:	Pico OWC				
Web-link:	http://www.pico-owc.net/				
Location name:	Pico Island, Azores	Latitude (decimal):	38.5571	Longitude (decimal):	-28.4459
Deployment start:		End of construction 1999; first test ran in 2005	Deployment end date:		In operation
Device type:	Oscillating water column (shoreline)	Anchor type:	Shoreline structure	Mooring strings:	Shoreline structure
Number of devices:	1		Total installed capacity (MW):	0,4	
Test scale of devices:	Full-scale		Deployment area (km2):	150 (m2)	
Environmental data collected: airborne and underwater noise measurements.					

Consenting process: at that time, the licensing of the device and its evaluation with respect to environmental issues was new to the authorities. As EDA (Electricidade dos Açores) was a project partner, some facility in obtaining the required permission can be assumed. However, the regional authorities showed their serious concern regarding the environmental acceptability of the plant, which proved very difficult to overcome.

Monitoring activities: to date, and mainly due to the short operational periods of the plant, there are no systematic monitoring regarding environmental issues however an acoustic monitoring survey has been carried out to characterize both airborne and underwater noise levels.

Research activities: The underwater noise characterization and the sound propagation of the wave energy device have been analysed under the national funded WEAM project (<http://www.siplab.fct.ualg.pt/proj/weam.shtml>). The interrelation between the airborne and underwater device noise is currently under analysis.

Spatial data available:

Additional information:

Country:	Portugal				
Development:	WaveRoller				
Web-link:	http://www.aw-energy.com/blog.html				
Location name:	Praia da Almagreira, Peniche	Latitude (decimal):	39.389075	Longitude (decimal):	-9.308125
Deployment start:	June 2012		Deployment end date:	May 2013	
Device type:	Oscillating wave surge converter	Anchor type:	Deadweight anchor	Mooring strings:	Fixed to seabed
Number of devices:	1		Total installed capacity (MW):	3 x 100 kW	
Test scale of devices:			Deployment area (km2):	410 m2	
Environmental data collected: environmental data have been collected for baseline studies on benthic community composition and abundance, acoustic background characterization and near shore morphology, geology, characterization of sedimentary cover, oceanographic regime, beach/inner shelf morphology and impacts of extreme events on bottom morphology and sediment dynamics.					
Consenting process:					
Monitoring activities: monitoring activities are predicted after the equipment installation for noise characterization and benthic communities' evaluation. The colonization of the equipment with aquatic fauna will also be under analysis. Monitoring of physical parameters will also be accompanied (near shore morphology, geology, characterization of sedimentary cover, oceanographic regime, beach/inner shelf morphology and impacts on sediment dynamics).					
Research activities: SURGE project (http://fp7-surge.com/)					
Spatial data available:					
Additional information:					

Country:	Norway		
Development:	Wave Energy AS, Wave Energy Converter		
Web-link:	http://www.waveenergy.no/WorkingPrinciple.htm		
Location name:	Kvitsøya	Latitude (decimal):	Longitude (decimal):
Deployment start:	2005	Deployment end date:	2007?
Device type:	Overtopping device (shoreline)	Anchor type:	Mooring strings:
Number of devices:	1	Total installed capacity (MW):	?
Test scale of devices:	?	Deployment area (km2):	?
Environmental data collected:	?		
Consenting process:	?		
Monitoring activities:	?		
Research activities:	?		
Spatial data available:	?		
Additional information:	Project initiated in 2005, seems to have been terminated / abandoned after 2007		

Country:	Norway				
Development:	MAREN, Seabased, Wave Energy Converter (Vattenfall AB)				
Web-link:	http://www.vattenfall.com/en/file/R_D_Magazine - Ocean energy 8918811.pdf http://www.swedishtrade.se/PageFiles/165419/Norsk%20Handelskammer%20FINAL%20(091119%20LU).pdf?epslanguage=sv				
Location name:	Runde	Latitude (decimal):	62.391	Longitude (decimal):	5.603
Deployment start:	2009		Deployment end date:	2014	
Device type:	Point absorber	Anchor type:	Deadweight anchor	Mooring strings:	
Number of devices:	2, plus transformer		Total installed capacity (MW):	0.04	
Test scale of devices:	1:1		Deployment area (km2):	<1km2	
Environmental data collected:					
Environmental Monitoring program, planned for fish, benthos and birds; realized fish and benthos over a two-yr period					
Consenting process:					
Local authorities, Norwegian Coastal Administration; permission required from the Norwegian Resources and Energy Directorate. Permission was given for the project period (2009 – 2014)					
Monitoring activities:					
Production and Performance, Wave data, Environmental monitoring programme (see above)					

Research activities:
Environmental monitoring
Spatial data available:
Yes, Runde Env. Centre
Additional information:
MAREN pilot plant was never connected to the grid. The generators and transformer were installed in 2009, but the floating device was lost (drifted ashore) only few months afterwards. In 2010, transformer and one of the generators were recovered. The project has not officially been terminated.
Publ.: Andersen, K., Chapman, A. S., Hareide, N. R., Folkestad, A. O., Sparrevik, E. & Langhammer, O. (2009) Environmental Monitoring at the Maren Wave Power Test Site off the Island of Runde, Western Norway: Planning and Design. Proceedings of the 8th European Wave and Tidal Energy Conference, Uppsala, Sweden, 2009.
CHAPMAN, A. S.; Hareide, N. R.; Kvalsund, R. (2010): The MAREN wave power test site off the island of Runde, Norway. Environmental Monitoring Programme Annual Report. May 7, 2010.

Country:	Norway				
Development:	Fred Olsen Ltd Buldra / BOLT, Wave Energy Converter				
Web-link:	http://www.fredolsen-renewables.com/				
Location name:	Risør	Latitude (decimal):	58.685	Longitude (decimal):	9.323
Deployment start:		2009	Deployment end date:		2010
Device type:	Point absorber	Anchor type:		Mooring strings:	
Number of devices:		1	Total installed capacity (MW):		0.045
Test scale of devices:		1:3	Deployment area (km2):		
Environmental data collected: ?					
Consenting process: ?					
Monitoring activities: ?					
Research activities: ?					
Spatial data available: ?					
Additional information:	<p>Fred Olsen Ltd has developed the 'Buldra' system further into the 'BOLT', which has recently been deployed as the 'Life Saver Donut' in Falmouth Harbour, UK.</p> <p>In 2009 Fred Olsen Ltd. deployed the wave energy buoy, called "BOLT", their first full-scale prototype wave energy buoy with electricity production. The point absorber unit, which has a 45 kW installed capacity, is located on the southeast coast of Norway, close to the town of Risør. The system is not grid connected. As of mid-December 2010, BOLT has endured 18 months of sea operations with electricity production. The buoy will now be moved to a harsher environment further offshore in order to test max operating capabilities and production performance. The successful development of BOLT has also resulted in Fred Olsen Ltd being awarded a significant grant from the Technology Strategy Board in the UK and a precommercial full-scale BOLT unit was developed and deployed in the UK during 2011.</p> <p>(http://www.ocean-energy-systems.org/country-info/norway/)</p>				

Country:	Norway				
Development:	E-Co Seahorse, Wave Energy Converter				
Web-link:	http://www.e-co.no/English/E-CO_Energi/About_E-CO/ http://www.ocean-energy-systems.org/country-info/norway/				
Location name:	Runde	Latitude (decimal):	62.3984	Longitude (decimal):	5.6855
Deployment start:	2011		Deployment end date:	2012,	
Device type:	Point absorber	Anchor type:	Deadweight anchor	Mooring strings:	Fixed to seabed
Number of devices:	1		Total installed capacity (MW):	0.003	
Test scale of devices:	prototype		Deployment area (km2):	0.3	
Environmental data collected:					
Wave height, frequency					
Consenting process:					
Local authorities, Norwegian Coastal Administration; no permission required from the Norwegian Resources and Energy Directorate (this is only the case if device is connected to the public grid).					
Monitoring activities:					
no					
Research activities:					
no					
Spatial data available:					
Yes (Runde Env. Centre)					
Additional information:					
The floating device of the system was damaged after a few days at sea. The trial has been terminated and the system is being recovered.					
Seahorse is a single point absorber concept developed by the utility E-CO Energi. A main buoy on the surface and a submerged torpedo buoy are connected to the submerged generator unit by separate cords. The wave motion will move the surface buoy up and down, while the torpedo buoy will move in the opposite direction. This rotates the permanent magnet generator and produces electricity. The cords and the generator can be described as a two-drum/two-cord system. In this way, two drums have different sizes for the two cords to get correct speeds and force. A 3 kW prototype of the Seahorse concept has been tested at the Runde Environmental Centre (REC) in 2011.(http://www.ocean-energy-systems.org/country-info/norway/)					

Country:	Norway				
Development:	Langlee, Wave Energy Converter				
Web-link:	http://www.langleewavepower.com/global-projects.html				
Location name:	Svåhei, Egersund	Latitude (decimal):	58.371	Longitude (decimal):	5.969
Deployment start:	2013		Deployment end date:		?
Device type:	Oscillating wave surge converter	Anchor type: Using fish farm anchoring and mooring systems :	Other fixing type	Mooring strings:	
Number of devices:	1		Total installed capacity (MW):	0.05 MW	
Test scale of devices:	Full-scale E1 device		Deployment area (km2):	<1km2	
Environmental data collected:					
Not yet					
Consenting process:					
The municipality of Eigersund is unique in Norway (and perhaps in the world??) as it has included a priori designation of a certain coastal area for testing / development of renewable energies. This means that consent is 'awaiting' the companies that want to use the area.					
Monitoring activities:					
Required by funders and operators: production and performance monitoring, no other type of monitoring planned as of yet					
Research activities:					
Not determined yet					
Spatial data available:					
See Eigersund kommuneplan					
Additional information:					
<p>The Norwegian company Langlee Wave Power has developed an offshore floating wave energy converter with the innovative flap/wing system designed for the horizontal movements of the wave. The semisubmersible design for 50-150 m water depths is based on Norwegian offshore engineering and in 2010 Aker Solutions executed analysis and structural engineering for Langlee. The second round of extensive testing at Aalborg University, Denmark, was successful. Recently, Langlee has announced the development of a new mooring system based on proven fish-farm technology to drive down supply chain costs. In summer 2012, Langlee will deploy its own demo unit outside Egersund, Norway, for testing and verification. The Turkish company Ünmaxsan has also a cooperation agreement with Langlee for a customer pilot in 2013. Projects for Island States, South America and Spain/Gran Canaria are in progress. Langlee has signed a Letter of Intent with Tangaroa Energy in New Zealand to launch a demonstration project off Steward Island, South Island, New Zealand. The project has just secured NZ\$ 312,000 of funding from the New Zealand Government. Deployment is planned in 2012.</p> <p>http://www.ocean-energy-systems.org/country-info/norway/</p> <p>Telephone conversation with Cathrine Bryøen, Business development manager (Cathrine@langlee.no); Tel: +47 92630726</p>					

Country:	Norway		
Development:	Intentium, IOWEP (Intentium Offshore Wave Energy Project)		
Web-link:	http://www.proexca.es/Informacion/Ponencias/2011.11.14-seminario-hispanonoruego/Intentium.pdf		
Location name:	n/a	Latitude (decimal):	Longitude (decimal):
Deployment start:	n/a	Deployment end date:	n/a
Device type:	Point absorber	Anchor type:	Mooring strings:
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:	?		
Consenting process:	?		
Monitoring activities:	?		
Research activities:	Patented, wave tank testing		
Spatial data available:	n/a		
Additional information:	<p>Intentium AS is a Norwegian-based wave power developing company. Founded in 2007, the company's main goal has been to contribute to a sustainable energy production, through developing a wave energy system, called Intentium Offshore Wave Energy Project - iowep. Since start-up, the company has conducted internal model tank testing, carried out some external feasibility studies and gained patent NO329737B1 (international patent pending). The major news in the innovation is a focus on the dominant wave direction and wave crest length, the use of a double-acting pump, a buoyancy-controlled water anchor and a power take-off (PTO) consisting of an accumulator, water turbine and generator. (http://www.ocean-energy-systems.org/country-info/norway/)</p>		

Country:	Norway		
Development:	OWC Power AS, Wave Energy Converter		
Web-link:	http://www.owcpower.com/index.php?parent=193&groupid=195		
Location name:	n/a	Latitude (decimal):	Longitude (decimal):
Deployment start:	2012?	Deployment end date:	
Device type:	Oscillating water column (offshore)	Anchor type:	Mooring strings:
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:	?		
Consenting process:	?		
Monitoring activities:	?		
Research activities:	Wave tank testing		
Spatial data available:	n/a		
Additional information:	<p>The Norwegian company OWC Power AS develops a wave power device based on the Oscillating Water Column (OWC) principle. Both the offshore engineering and fabrication specialist NLI and hydropower turbine supplier, Rainpower, are involved in the development project. This project is partly funded by the Norwegian Research Council. In the second half of 2011 tests of a small-scale OWC device in wave tank and small-scale air turbine in a turbine lab were carried out. The technology is expected to be applicable both in shoreline based and offshore based installations. The first prototype is expected to be a shoreline based installation. For further information about OWC Power AS, please visit their web pages at: www.owcpower.com (http://www.ocean-energy-systems.org/country-info/norway/)</p>		

Country:	Norway		
Development:	Havkraft, Wave Energy Converter		
Web-link:	http://www.havkraft.no/		
Location name:	n/a	Latitude (decimal):	Longitude (decimal):
Deployment start:	n/a	Deployment end date:	
Device type:	Oscillating water column (offshore)	Anchor type:	Mooring strings:
Number of devices:	Total installed capacity (MW):		
Test scale of devices:	Deployment area (km2):		
Environmental data collected:	n/a		
Consenting process:	n/a		
Monitoring activities:	n/a		
Research activities:	Patented, wave tank testing		
Spatial data available:	n/a		
Additional information:	<p>Havkraft AS</p> <p>Havkraft is a Norwegian 'green technology' company specializing in offshore installations for the utilization of wave energy for power production. The company's shareholders are founder Geir Arne Solheim and Fjord Invest. Tests conducted in 2011 show promising results. H-WEC (Havkraft Wave Energy Converter) combines high efficiency and simple construction - with no movable parts in contact with sea - in an improved and patented OWC device (PCT pending). A large-scale test programme will be started in 2012 with support from Innovation Norway and co-investors. (http://www.ocean-energy-systems.org/country-info/norway/)</p>		

Country:	Norway				
Development:	ANDRITZ HYDRO Hammerfest (previously Hammerfest Strøm), Tidal Energy System, HS300				
Web-link:	http://www.hammerfeststrom.com/ http://www.hammerfeststrom.com/products/tidal-turbines/hs300/ http://www.hammerfeststrom.com/research-and-development/site-evaluation/				
Location name:	Kvalsund	Latitude (decimal):	70.760	Longitude (decimal):	24.065
Deployment start:	2004?		Deployment end date:		2010
Device type:	Horizontal axis turbine	Anchor type:		Mooring strings:	
Number of devices:	1		Total installed capacity (MW):		0.3
Test scale of devices:	Full-scale		Deployment area (km2):		
Environmental data collected:					
?					
Consenting process:					
?					
Monitoring activities:					
?					
Research activities:					
One full testing cycle completed. Now updating to a new HS 1000 model (tidal turbine array) to be deployed at Sound of Islay, Scotland					
Spatial data available:					
?					
Additional information:					
Hammerfest Strøm is among the leading technology developers in the world and is now taking the step into commercial delivery. The company has unrivalled commercial operation experience, by having developed and installed the world's first grid connected tidal turbine – the HS300. The technology has been tested and operated for more than 6 years, and has a track record over 17500 hours production time.					
Based on this technology and experience, the company has developed a 1 MW tidal turbine, named HS1000™, and the company has received Carbon Trust funding for the HS1000 turbine development. The installation of the pre-commercial unit HS1000 was completed in the first part of December this year at the European Marine Energy Centre (EMEC) and commissioning will be in January 2012, after a test period.					
Hammerfest Strøm is working closely together with its industrial shareholders, Andritz Hydro, Statoil and Iberdrola, and in cooperation with R&D institutions and sub-suppliers.					
(http://www.ocean-energy-systems.org/country-info/norway/)					
http://www.hammerfeststrom.com/research-and-development/site-evaluation/					

Country:	Norway				
Development:	Hydra Tidal Morild, Tidal turbine				
Web-link:	http://www.hydratidal.no/#!/technology				
Location name:	Grimsøystraumen, Lofoten Islands	Latitude (decimal):	68.236	Longitude (decimal):	14.148
Deployment start:	2010		Deployment end date:		?
Device type:	Horizontal axis turbine	Anchor type:		Mooring strings:	
Number of devices:	1		Total installed capacity (MW):		1.5
Test scale of devices:	Full-scale		Deployment area (km2):		
Environmental data collected:					
?					
Consenting process:					
?					
Monitoring activities:					
?					
Research activities:					
?					
Spatial data available:					
?					
Additional information:					
Damaged in 2011, under repair – planned for re-deployment in autumn 2012					
Hydra Tidal’s floating concept idea for Morild I was registered in 2001 - and subsequently developed and laboratory tested through to 2008. The focus has since been directed towards designing, building and commissioning the full-scale 1.5 MW prototype Morild II in Lofoten, Norway. Since the official opening in November 2010, the plant has been grid-connected and pretested for performance, and has made several successful trial-feeds to thegrid. Following a current modification and upgrade of the tidal power device, it will be re-connected to the grid, and tested further for performance, leading towards a complete verification and evaluation of the technology.In June 2010, Hydra Tidal was awarded the Schweighofer Prize for using turbine blades machined from pine timber. In 2011, the company became part of major Norwegian industrial group, and is currently seeking collaboration for tidal lease opportunities in strategic territories in the UK, North-America, the Far East, as well as in the Norwegian waters.Hydra Tidal is part of Straum, a Norwegian based technology developer and turn-key provider of marine renewable power plants (see www.straumgroup.com and www.hydratidal.com for more information). (http://www.ocean-energy-systems.org/country-info/norway/)					

Country:	SPAIN				
Development:	Biscay Marine Energy Platform				
Web-link:	http://www.eve.es/web/Energias-Renovables/Energia-marina.aspx				
Location name:	Arminza (Basque Country, Northern Spain)	Latitude (decimal):	43°27.835N	Longitude (decimal):	2°52.905W
Deployment start:	2013	Deployment end date:			
Device type:	Anchor type:		Mooring strings:		
Number of devices:	7	Total installed capacity (MW):		20MW	
Test scale of devices:	1:1	Deployment area (km2):		5.3	
Environmental data collected:					
<p>A baseline characterization of the environment was done in order to analyse the potential impacts of the BIMEP project. This study can be consulted in the Environmental Impact Study of the BIMEP project. This is a brief summary:</p> <p>Physical Environment:</p> <p>Wave measurements and numerical modelling to predict the potential impacts of WEC devices on the wave regime. Data coming from a measurement platform installed in bimep (Wavescan buoy of Fugro Oceanor) in March 2009, current meters and other buoys were employed. Shoreline wave attenuations of 0-10% might be expected.</p> <p>Sediment characterization (29 sampling stations): granulometry and organic content</p> <p>Hidrography characterization: Water quality data analysis coming from the Littoral Water Quality Monitoring and Control Network of the Basque Country that AZTI-Tecnalia undertake since 1995 for the Department of Land Action and Environment of the Basque Government.</p> <p>Bathymetry: Seabed characterization with a multibeam echosounder. This information involves a high resolution Digital Elevation Model (DEM) and topographic products derived, such as slopes' map, shady digital elevation model, rugosity, topographic index, etc.</p> <p>Landscape characterization: Characterization based on the catalogue of Basque Landscapes. There exist some significant landscape places near bimep.</p> <p>Biotic Environment:</p> <p>Benthic communities (soft and hard bottom): Benthic communities sampling with grab in soft sediments and analysis with AZTI Marine Biotic Index was done. For hard bottom communities, sampling was done in several intertidal sampling stations. Benthic communities are in slight disequilibrium due to the high hydrodynamics of the area.</p> <p>Fish: No specific data available. Thus, an extensive bibliographic and web source information search was done.</p> <p>Marine mammals: Some data coming from sightings of AZTI-Tecnalia personnel in different sampling campaigns. Common dolphin (<i>Delphinus delphis</i>), Bottlenose Dolphin (<i>Tursiops truncatus</i>), Fin whale (<i>Balaenoptera physalus</i>) and long-finned pilot whale (<i>Globicephala melas</i>) are common species in the bimep area.</p> <p>Marine Birds communities characterization: No specific data available. Thus, an extensive bibliographic and web source information search was done.</p> <p>Socio-economic environment:</p> <p>Fisheries: a characterization of the commercial fisheries was done based on fish landing statistics, fisheries surveillance data, academic studies, previous fisheries reports and consultation with local fisherss.</p> <p>Archaeological resources: Consult on the Subaquatic Archaeological Catalogue of the Basque Government. A sunken vessel was identified near the bimep area.</p>					
Consenting process:					

Environmental authorization

In July 2008 a preliminary Environmental Impact Study (EIS) of the bimep project was undertaken by AZTI-Tecnalia.

In November 2008, the General Directory of Energy Policy and Mines of the Spanish Ministry of Industry, Tourism and Trade (which is the competent authority to concede the technical permission for the bimep project) sent all the documents of the project to the General Directory of Quality and Environmental Evaluation of the Spanish Ministry of Environment, Rural and Marine Environment (which is the competent authority to concede the environmental permission of the bimep project).

In April 2009, the General Directory of Quality and Environmental Evaluation of the Spanish Ministry of Environment, Rural and Marine Environment request for some additional information about the project and their impacts. In order to respond to this request, in April 2009 a complete Environmental Impact Study (EIS)(undertaken in December 2008) was sent to the above mentioned General Directory and in parallel a personal meeting was held with their representatives.

According to the Royal Decree 1/2008 of Environmental Impact Assessment (EIA), the bimep project fall in those projects grouped in the Annex II of the RD 1/2008 and then, the competent authority in environmental issues, that is, the General Directory of Quality and Environmental Evaluation of the Spanish Ministry of Environment, Rural and Marine Environment had to decide whether to submit or not the project to the whole process of EIA.

In January 2009, the General Directory of Quality and Environmental Evaluation undertake an extensive period of public consultation to more than 30 different stakeholders.

Following the result of the public consultation, the analysis of the project and the EIS, in June 2009 the General Directory of Quality and Environmental Evaluation decide not to submit the bimep project to the whole EIA process. They concluded that no significant environmental impacts would be found as a result of the implementation of the BIMEP project. In any case, taking in to account the uncertainties of the impacts due to the early development stage of wave energy harnessing devices and the lack of referenced data accounting for environmental surveillance of specific projects, the Environmental Statement recommend the implementation of the environmental monitoring program suggested in the Environmental Impact Study of bimep project.

This environmental monitoring program started in August 2012 in their preoperational phase and will be undertaken by AZTI-Tecnalia.

Administrative authorizations

Taking into account the aforementioned decision and continuing with the administrative process, in 2009, the Promoter (EVE) requested the administrative authorization for the BIMEP installation and its public use declaration.

For the purpose of obtaining the administrative authorization and public use declaration of the installation of the BIMEP infrastructure, the Promoter (EVE) submitted to Spanish Ministry of Industry, Tourism and Trade and the Provincial Industry and Energy Dependency of the Spanish Government Delegation in Bizkaia several documents, which included, a. the preliminary draft of the project, b. an environmental analysis document undertaken by AZTI-Tecnalia and c. an economic evaluation analysis document.

In accordance with the provisions of Articles 125 and 144 of Royal Decree 1955/2000 and Article 27 of Royal Decree 1028/2007, the preliminary draft was submitted for public consultation and reprints were sent to key administrations and stakeholders. The City Council of Lemoiz, the General Directorate for Planning, the General Directorate of Ports and Maritime Affairs, and the General Directorate for Fisheries and Agriculture of the Basque Government, as well as the Basque Water Agency did not provide any feedback. On the other hand, the Department of Public Works of the Provincial Council of Bizkaia, the Bilbao Bizkaia Water Consortium, the General Directorate for Fisheries and Aquaculture of the Spanish Ministry for Environment, Rural and Marine Affairs and Iberdrola (Spanish energy company) did not present any opposition to the project and, where appropriate, they indicated technical aspects to be considered in drafting the execution project of the BIMEP.

Based on several documents and outcomes of the consultation process, the Spanish Ministry for Industry, Tourism and Trade (of the General Directorate for Energy Policy and Mining) authorized, in 2011, the installation of the BIMEP, and stated in particular the declaration for its public use.

In 2011, the Promoter (EVE) proceeded to tackle the final step and obtain the concession of marine-terrestrial public domain. To obtain such concession, the Promoter (EVE) had to request the following two licenses:

The beacon permission, which was requested to the Spanish Ministry for Public Works (General Directorate of the Merchant Marine) and,

The concession of maritime-terrestrial public domain, for which the Coastal Delegation of the Spanish Ministry for Environment, Rural and Marine Affairs is responsible.

To date, the beacon permission and the concession of maritime-terrestrial public domain are both pending. Once the beacon permission is approved, the concession of maritime-terrestrial public domain permission will be granted.

Monitoring activities:

The Preoperational monitoring phase started in August 2011:

Physical Environment:

Hydrodynamic characterization: Two Nortek profilers will be installed, one in the shadow area of Bimep and other one in a place far beyond from Bimep in order to act as control area. Additionally, ADCP transects along all the bimep area will be undertaken.

Underwater Noise: For this purpose, a design and installation of one buoy equipped with high and low frequency hydrophones will be carried out, apart from amplifiers and digital recording sound systems. This buoy will determine the origin of sound generated by devices, marine mammals, support vessels, etc). This buoy will be anchored and will continuously register the sound environment in different periods, during day and night, rendering the previous reference noise level to the installation.

Landscape: a characterization of landscape was carried out in 4 stages : (i) defining Landscape unit's area; (ii) defining landscape unit's characteristics; (iii) defining activities, visibility and views and; (iv) presentation of landscape characterization and base visual analysis

Biotic environment:

Benthic communities: Benthic communities sampling with grab and visual inspection with ROVs in soft sediments and analysis with AZTI Marine Biotic Index. For hard bottom communities, sampling will be undertake in several intertidal sampling stations.

Ichthiofauna: Five active acoustic sensors will be placed in the bimep area. These sensors will record biomass estimates of fish shoals. Additionally, visual inspections by divers will be undertaken.

Marine mammals: same methodology than those proposed for underwater noise.

Socio-economic environment:

Fisheries: commercial fisheries study (based on fish landing statistics, fisheries surveillance data, academic studies, previous fisheries reports) and consultation with local fishers.

Archaeological resources: Visual inspection by divers and ROVs

Research activities:

Associated with the monitoring activities. Once the operational phase of the BIMEP project begins we will be able to apply a "Before-After-Control-Impact" methodology in order to ascertain the main impacts of the project.

Spatial data available:

Additional information:

Environmental Impact Study available through request (in Spanish).

Detailed explanation of the methodology can be consulted in the following paper:

Bald, J., A. Del Campo, J. Franco, I. Galparsoro, M. González, P. Liria, I. Muxika, A. Rubio, O. Solaun, A. Uriarte, M. Comesaña, A. Cacabelos, R. Fernández, G. Méndez, D. Prada y L. Zubiate, 2010.

Protocol to develop an environmental impact study of wave energy converters. Revista de Investigación Marina, 17 (5):79. <http://www.azti.es/rim/component/content/article/28.html>

Country:	SPAIN				
Development:	PLOCAN				
Web-link:	http://www.plocan.eu/en/index.php				
Location name:	Canary Islands	Latitude (decimal):	43°18.527N	Longitude (decimal):	2°22.651W
Deployment start:	Deployment end date:				
Device type:	Anchor type:		Mooring strings:		
Number of devices:	Total installed capacity (MW):				
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
Environmental Impact Assessment underway					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	SPAIN				
Development:	Santoña Test Centre				
Web-link:					
Location name:	Santoña (Northern part of Spain)	Latitude (decimal):		Longitude (decimal):	
Deployment start:	July 2011	Deployment end date:	2036		
Device type:	Point absorber	Anchor type:	Mooring strings:		
Number of devices:	10	Total installed capacity (MW):	1.5		
Test scale of devices:	Deployment area (km2):				
Environmental data collected:					
Consenting process:					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	SPAIN		
Development:	Ubiarco Test Centre		
Web-link:			
Location name:	Santoña (Northern part of Spain)	Latitude (decimal):	Longitude (decimal):
Deployment start:	Deployment end date:		
Device type:	Anchor type:	Mooring strings:	
Number of devices:	10	Total installed capacity (MW):	1.5
Test scale of devices:	Deployment area (km2):		
Environmental data collected:			
Consenting process:			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	SPAIN		
Development:	WELCOME project and PIPO Systems		
Web-link:	www.piposystems.com/EN/welcome.php		
Location name:	Canary Islands	Latitude (decimal):	Longitude (decimal):
Deployment start:	2008	Deployment end date:	2011
Device type:	Anchor type:	Mooring strings:	Fixed to seabed
Number of devices:	1	Total installed capacity (kW):	100-150
Test scale of devices:	1:5	Deployment area (km2):	
Environmental data collected:			
Consenting process:			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	SPAIN			
Development:	UNDIGEN project and Wedge			
Web-link:	http://plocan.es/en/images/stories/project/UNDIGEN_English.pdf			
Location name:	PLOCAN	Latitude (decimal):	Longitude (decimal):	
Deployment start:			Deployment end date:	
Device type:	Other wave device	Anchor type:	Mooring strings:	Fixed to seabed
Number of devices:			Total installed capacity (MW):	
Test scale of devices:			Deployment area (km2):	
Environmental data collected:				
Consenting process:				
Monitoring activities:				
Research activities:				
Spatial data available:				
Additional information:				

Country:	SPAIN			
Development:	Abencis Seapower			
Web-link:	www.abencis.com/energia-marina.php			
Location name:	Mediterranean sea	Latitude (decimal):	Longitude (decimal):	
Deployment start:			Deployment end date:	
Device type:		Anchor type:	Mooring strings:	
Number of devices:			Total installed capacity (MW):	
Test scale of devices:	1/4	Deployment area (km2):		
Environmental data collected:				
Consenting process:				
Monitoring activities:				
Research activities:				
Spatial data available:				

Additional information:

Country: **SPAIN**

Development: Norvento Enerxía

Web-link: www.norvento.com

Location name:	Latitude (decimal):	Longitude (decimal):
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Deployment start:	Deployment end date:
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Device type:	Point absorber	Anchor type:	Mooring strings:
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Number of devices:	Total installed capacity (MW):
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Test scale of devices:	1	Deployment area (km2):
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Environmental data collected:

Consenting process:

Monitoring activities:

Research activities:

Spatial data available:

Additional information:

Country: **Portugal, Spain, UK, Norway, USA**

Development: Waveport

Web-link: www.wavec.org/index.php/81/waveport

Location name:	Santoña	Latitude (decimal):	Longitude (decimal):
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Deployment start:	Deployment end date:
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Device type:	Point absorber	Anchor type:	Mooring strings:
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Number of devices:	1	Total installed capacity (kW):	150kW
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Test scale of devices:	Deployment area (km2):
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Environmental data collected:

Consenting process:

Monitoring activities:

Research activities:

Spatial data available:

Additional information:					
Country: Sweden					
Development: The Sotenas project – Commercial					
Web-link: www.seabased.com / www.fortum.com					
Location name:	Sotenas	Latitude (decimal):	Longitude (decimal):		
Deployment start:	2012/13	Deployment end date:	20 year(~2035)		
Device type:	Point absorber Seabased	Anchor type:	Gravity concrete foundation	Mooring strings:	None – but wires bw buoys and generators placed on seabed
Number of devices:	420	Total installed capacity (MW):	10 MW		
Test scale of devices:	1:1	Deployment area (km2):	~ 0.8		
Environmental data collected:					
Most prominently:					
Baseline benthic fauna / seabed changes					
Modelling of changes in sedimentation and effects on currents					
Historic / recent fishing data					
Wave energy data/physical resources					
Consenting process:					
Full-scale EIA also including court application, application according to “Electrical law”, building permits etc.					
Monitoring activities:					
Especially on (according to Enviro. Court decision):					
effects (population) on Norwegian lobster - starting spring 2012					
effects on benthic fauna – starting autumn 2013					
noise/sound emission – starting 12/13					
“effects on fish” – starting 2013					
wave data – starting 2012					
Research activities:					
See above under Monitoring					
Spatial data available:					
Yes					
Additional information:					

Country:	Sweden				
Development:	Lysekil Test Site, Uppsala University				
Web-link:	www.el.angstrom.uu.se				
Location name:	Lysekil test site	Latitude (decimal):	Longitude (decimal):		
Deployment start:	2004(equipm) /06 (generators)		Deployment end date:	Ongoing and to be continued	
Device type:	Point absorbers	Anchor type:	Gravitation foundations	Mooring strings:	None – but wires bw buoys and generators on seabed
Number of devices:	Max. 10 (may be expanded)		Total installed capacity (MW):	~ 0,05 to ~0,20 pending on tests	
Test scale of devices:	1:1		Deployment area (km2):	~0.01	
Environmental data collected:					
Benthic fauna, fish presence/abundance, artificial reef/FAD effects, UW noise/sound, wave data (hs/ts), (only notes on “observations” of birds and mammals)					
Consenting process:					
“Short/simple” - due to non-commercial/Univ. research site and the small-scale/area use. Application was sent out for referral but without complaints. Short EIA was produced, incl. baseline studies on seabed fauna and geophysics.					
Monitoring activities:					
See above - under Environmental data collected					
Research activities:					
Apart from technical - Environmental studies and data collected (see above). Also stakeholder investigations underway.					
Spatial data available:					
All data spatially referable, including control sites/points just outside park area.					
Additional information:					
see: www.el.angstrom.uu.se/Lysekilsprojektet E.html					
Publications (100+, both technical and environmental) – see homepage above					

Country:	UK (England)				
Development:	Wave Hub				
Web-link:	www.wavehub.co.uk				
Location name:	Cornish Coast	Latitude (decimal):	50 20.700 N	Longitude (decimal):	05 37.230 W
			50 22.830 N		05 37.760 W
			50 20.860 N		05 35.560 W
			50 22.980 N		05 36.100 W
Deployment start:		2007	Deployment end date:		2036
Device type:	Other wave device	Anchor type:	Percussion / driven pile	Mooring strings:	Other mooring
Number of devices:		One	Total installed capacity (MW):		None
Test scale of devices:			Deployment area (km2):		8
Environmental data collected:					
Baseline surveys and construction monitoring of noise, marine ecology, fisheries and coastal processes.					
Consenting process:					
FEPA and Section 36					
Monitoring activities:					
Pre construction baseline followed by construction monitoring and post construction monitoring					
Research activities:					
See website					
Spatial data available:					
See website					
Additional information:					
See website					

Country:	UK (England)				
Development:	Neptune Tidal Device				
Web-link:	www.neptunerenewableenergy.com				
Location name:	Humber Estuary	Latitude	53 37.500 N	Longitude	00 08.760 E
		(decimal):	53 37.490 N	(decimal):	00 08.750 E
			53 37.480 N		00 08.760 E
			53 37.490 N		00 08.770 E
			53 37.120 N		00 09.460 E
Deployment start:		2011	Deployment end date:		2014
Device type:	Horizontal axis turbine	Anchor type:	Percussion / driven pile	Mooring strings:	Other mooring
Number of devices:		Two	Total installed capacity (MW):		0.5
Test scale of devices:		Full-scale	Deployment area (km2):		<1
Environmental data collected:					
Baseline data for EIA purposes					
Consenting process:					
FEPA and Section 36					
Monitoring activities:					
Scour monitoring required					
Research activities:					
See website					
Spatial data available:					
See website					
Additional information:					
See website					
Country:	Ireland				
Development:	OE Buoy at Galway Bay Test Site				
Web-link:	http://www.marine.ie/home/aboutus/organizationstaff/researchfacilities/Ocean+Energy+Test+Site.htm				
Location name:	Spiddal, Co. Galway	Latitude (decimal):		Longitude (decimal):	
Deployment start:		March 2011	Deployment end date:		May 2011
Device type:	Oscillating water column (offshore)	Anchor type:		Mooring strings:	Catenary mooring
Number of devices: 1			Total installed capacity (MW):		n/a
Test scale of devices:		Quarter	Deployment area (km2):		0.37 km2
Environmental data collected:					
Environmental appraisal 2009 and surveys repeated in 2010.					
Consenting process:					
Demonstration – no EIA carried out.					
Monitoring activities:					
No formal monitoring programme.					
Research activities:					

SMARTBAY – see accompanying text.			
Spatial data available:			
None			
Additional information:			
To be grid connected in 2012.			
Country: Ireland			
Development:	Atlantic Marine Energy Test Site		
Web-link:	http://www.seai.ie/Renewables/Ocean_Energy/AMETS/		
Location name:	Annagh Head, Belmullet, Co. Mayo	Latitude (decimal):	Longitude (decimal):
Deployment start:	2010	Deployment end date:	Unknown
Device type:	Anchor type:	Mooring strings:	
Number of devices:	4 berths	Total installed capacity (MW):	5 MW
Test scale of devices:	Full	Deployment area (km2):	21km2
Environmental data collected:			
See text in Country Report for Ireland			
Consenting process:			
Full EIA carried out. Appropriate Assessment carried out. Foreshore Lease application made. Grid connection offer secured.			
Monitoring activities:			
Yes			
Research activities:			
Yes			
Spatial data available:			
Need to check			
Additional information:			

Annex 6: Summaries of research relating to environmental interactions of wave and tidal energy developments

Countries:	UK (Scotland)					
Project title:	Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables					
Research providers:	Marine Scotland					
Framework:	N/A					
Funding sources:	Scottish Government					
Web-link:						
Start date:	2010		End date:	2011		
Geographical relevance:	Scottish waters		Topical relevance:	Migratory fish		
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	
	N/A	High		Medium	High	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Medium	High	Low	Low	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	Low	Low	High	Low	Medium
Project description: ..						
To establish potential for interactions between turbine arrays and salmon entering FW SACs. Covers review of behaviour, depth preference etc						
Project deliverables:						
Report						
Spatial data generated: Some						
Bibliography of outputs:						
Countries:	UK (Scotland)					
Project title:	Strategic seabed surveys					
Research providers:	Marine Scotland					
Framework:						
Funding sources:	Scottish Government					
Web-link:						
Start date:	2009		End date:	Ongoing		
Geographical relevance:	Scottish waters		Topical relevance:	Bathymetry, sea bed habitats, conservation value		

This project will identify what is known about the impacts of wave and tidal energy devices in the marine environment, and gather additional knowledge to provide information to (i) develop guidance and requirements for monitoring (ii) aid in the delivery of a marine renewables research strategy that is complimentary to other national and international research programmes.

Project deliverables:

A report

Spatial data generated:

Nil

Bibliography of outputs:

To be published shortly

Countries:	UK(Scotland)					
Project title:	Guidance on Survey and Monitoring in relation to marine (wave and tide) renewable deployments in Scotland					
Research providers:	Royal Haskoning					
Framework:						
Funding sources:	Scottish Government					
Web-link:						
Start date:	2010		End date:	2011		
Geographical relevance:	Wide		Topical relevance:	Monitoring, birds, mammals, seabed		
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	
	Low	High		High	Low	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Medium	High	Medium	Low	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	Low	High	High	Medium	Low

Project description:

The aim of this contract is to develop baseline survey and monitoring protocols and guidance (for marine mammals, seabirds and benthic habitats) that can be adapted or applied directly by developers deploying wave or tidal turbines in Scottish waters to a) inform the EIA and AA processes, and b) detect and describe the principal natural heritage impacts that such devices might have

Project deliverables:

Report

Spatial data generated:

Nil

Bibliography of outputs:

To be published shortly

Countries:		UK (Scotland)				
Project title:		Wave test site acoustic monitoring programme				
Research providers:		EMEC				
Framework:						
Funding sources:		Scottish Government				
Web-link:						
Start date:		2010		End date:		2012
Geographical relevance:		Wide		Topical relevance:		Acoustic, noise, wave
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	N/A	High		High		Low
Development life cycle stage:	Planning and pre-development survey:	Installation:		Operation:		Decommissioning:
	High	Low		High		Low
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	High	Medium	Low	High	Low	Low
Project description:						
To provide a repeatable and robust methodology to allow developers at EMEC's wave test site to ascertain whether or not there is any detectable acoustic output from wave energy devices operating in a high energy wave climate under varying conditions.						
Project deliverables:						
A monitoring protocol, and field data from wave and tidal test sites						
Spatial data generated:						
Nil						
Bibliography of outputs:						

Countries:		UK (Scotland)				
Project title:		Pentland Firth Bird Monitoring Project				
Research providers:		APEM				
Framework:						
Funding sources:		Scottish Government				
Web-link:						
Start date:		2010		End date:		2012
Geographical relevance:		Pentland and Orkney area		Topical relevance:		Birds
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	N/A	High		High		Low

Development life cycle stage:	Planning and pre-development survey:		Installation:	Operation:	Maintenance:	Decommissioning:
	High		Medium	Medium	Low	Low
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	Low	Low	High	Low	Low
Project description:						
Aerial surveys of seabird distribution in the Pentland Firth and Orkney waters strategic area						
Project deliverables:						
Strategic information on the use of this area by seabirds						
Spatial data generated:						
Maps of seabird distribution						
Bibliography of outputs:						
Marine Scotland website						
Countries:		UK (Scotland)				
Project title:		West of Lewis bird and mammals surveys				
Research providers:		HiDef				
Framework:						
Funding sources:		Scottish Government				
Web-link:						
Start date:		2012		End date:		2013/14
Geographical relevance:		West of Lewis		Topical relevance:		Birds, mammals
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	N/A	High		High		Low
Development life cycle stage:	Planning and pre-development survey:		Installation:	Operation:	Maintenance:	Decommissioning:
	High		Medium	Medium	Low	Low
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	Low	Low	High	Low	Low
Project description:						
Aerial surveys of seabird distribution in the potential development area west of Lewis						
Project deliverables:						
Strategic information on the use of this area by seabirds and mammals						
Spatial data generated:						
Maps of seabird and mammal distribution						
Bibliography of outputs:						
Marine Scotland website						

Countries:	UK (Scotland)					
Project title:	Estimates of collision risk of harbour porpoises and marine renewable energy devices at sites of high tidal stream					
Research providers:	Scottish Association for Marine Science (SAMS)					
Framework:						
Funding sources:	Scottish Government					
Web-link:						
Start date:	2009		End date:	2012		
Geographical relevance:	Wide		Topical relevance:	mammals		
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	
	N/A	High		High	Low	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Medium	Low	Low	Medium	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	Low	Low	High	Low	Low
Project description:						
The current project seeks to provide data in relation to the possible presence of harbour porpoise in those areas most likely to be suitable for tidal energy, and to use such information in a collision model. The results of this research will inform the future development and siting of tidal energy projects.						
Project deliverables:						
Report						
Spatial data generated:						
Few						
Bibliography of outputs:						
Marine Scotland website						

Countries:	UK (Scotland)					
Project title:	The use of acoustic devices to warn marine mammals of tidal-stream energy renewable devices					
Research providers:	Scottish Association for Marine Science (SAMS)					
Framework:						
Funding sources:	Scottish Government					
Web-link:						
Start date:	2009		End date:	2012		
Geographical relevance:	Wide		Topical relevance:	mammals		
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	

	N/A	High	High	Low		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Medium	Low	Low	Medium	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	Low	Low	High	Low	Low
Project description:						
This project will investigate whether existing marine mammal acoustic deterrent devices (ADDs) could be used to mitigate collision risks in Scottish waters. To do this first measurements of ambient sound in Scottish seas will be undertaken. They will then be used as an input together with source level of existing acoustic deterrent devices (pingers, ADDs etc) to the acoustic warning model developed by SAMS to assess their effectiveness.						
Project deliverables:						
Report						
Spatial data generated:						
No						
Bibliography of outputs:						
Marine Scotland website						
Countries:	UK (Scotland)					
Project title:	Underwater acoustic interactions between emerging tidal-energy technologies and vulnerable vertebrates					
Research providers:	Scottish Association for Marine Science (SAMS)					
Framework:						
Funding sources:	Scottish Government					
Web-link:						
Start date:	2009		End date:		2012	
Geographical relevance:	Wide		Topical relevance:		mammals	
Project type:	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
	N/A	High	High	Low		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Medium	Low	Low	Medium	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	Low	Low	High	Low	Low
Project description:						

(1) Select example Scottish sites where tidal energy extraction and marine vertebrates (particularly marine mammals) overlap and where collision concerns are likely. (2) Map the levels of ambient underwater sound in an illustrative selection of these sites. (3) Compile emerging data on underwater sound output from tidal-energy extraction devices. (4) Combine ambient with device sound levels in a propagation model to determine over what spatial range marine mammals can detect such devices. (5) Evaluate the magnitude of the problem and consider options for mitigation.

Project deliverables:

Report

Spatial data generated:

Some

Bibliography of outputs:

Marine Scotland website

Countries:		UK (Scotland)				
Project title:		Monitoring of the fishery in a no-take zone established at the Billia Croo wave test sites at EMEC				
Research providers:		EMEC				
Framework:						
Funding sources:		Scottish Government				
Web-link:						
Start date:		2010	End date:		2012	
Geographical relevance:		Orkney	Topical relevance:		Fisheries, lobster	
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	N/A	Low		Medium		High
Development life cycle stage:	Planning and pre-development survey:	Installation:		Operation:		Decommissioning:
	Low	Low		High		Low
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	N/A	Medium	Low	Medium	Low	High

Project description:

The project addresses the possible effects of marine energy deployments on fish and fisheries, and investigates the effects of a no-take zone established around wave energy devices. Particular emphasis on lobsters

Project deliverables:

Report

Spatial data generated:

No

Bibliography of outputs:

Countries:	UK (Scotland)					
Project title:	An Assessment of the sensitivity of Scottish seabirds to interactions with wave and tidal developments					
Research providers:	McArthur Green Ltd					
Framework:						
Funding sources:	Scottish Natural Heritage					
Web-link:						
Start date:	2011		End date:	2012		
Geographical relevance:	Scotland		Topical relevance:	Seabirds		
Project type:	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project will investigate Scottish seabird populations interactions with offshore renewable (wave and tidal) developments, in particular recording particularly sensitive species and devices						
Project deliverables:						
Sensitivity tables for seabirds to wave and tidal projects						
Spatial data generated:						
No						
Bibliography of outputs:						
SNH website						

Countries:	UK (Scotland)					
Project title:	SCOTMAP					
Research providers:	Marine Scotland					
Framework:						
Funding sources:	Scottish Government					
Web-link:						
Start date:	2011		End date:	2012		
Geographical relevance:	Pentland and Orkney		Topical relevance:	fisheries		
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:	N/A	High	High	High		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Low	Medium	Low	Medium	

Bibliography of outputs:

<http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Action/leading/iles/presentations>

Countries:		UK (Scotland)				
Project title:		Sub-Mesoscale Flow Regime Modelling and the Influence of Energy Extraction at a Tidal Energy Site				
Research providers:		PhD student at Heriot-Watt University (ICIT), Orkney				
Framework:		Scottish Energy Research Academy (SERA)				
Funding sources:		Energy Technology Partnership (ETP), Marine Scotland, Heriot-Watt University				
Web-link:						
Start date:		2012		End date:		2015
Geographical relevance:		Pentland Firth and Orkney Waters		Topical relevance:		
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	High	Low		High		n/a
Development life cycle stage:	Planning and pre-development survey:	Installation:		Operation:	Maintenance:	Decommissioning:
	High	n/a		High	n/a	n/a
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	High	Low	Low	n/a	n/a	n/a
Project description:						
Fast-flowing tidal energy sites are unsteady at a variety of spatial and temporal scales, and traditional tidal prediction methods are unable to fully represent the flow. One of the first objectives of the PhD is a 3D model of a typical tidal stream energy site at a scale capable of resolving such unsteady flow. This is essential for (i) detailed resource characterization; (ii) exploitability assessment; and (iii) Environmental Impact Assessments of tidal stream marine energy extraction such as changes to tidal velocities, tidal elevations, sediment transport and ultimately benthic habitat. In order to perform more detailed performance evaluation and exploitability assessment, at the device scale, the flow must be modelled at higher resolutions. Such high resolution modelling is important in order to accurately represent each device within an array of devices, and to predict the combined energy yield and environmental impact.						
Project deliverables:						
(i) Development of a SUNTANS model to simulate the flow on a ‘sub-mesoscale’ at typical marine energy sites. (ii) Marine Energy Model allowing the extraction of tidal energy at a site to be incorporated into models. This should be able to represent a typical marine turbine. (iii) Validation against field data. (iv) Insight into the environmental impacts of tidal energy extraction. (v) Performance evaluation at the device scale						
Spatial data generated:						
Bibliography of outputs:						
Countries:		UK (Scotland)				
Project title:		CFD Modelling of Fish (and Birds) Passing Through Tidal Turbines				
Research providers:		Capita Symonds				
Framework:						

Funding sources:	The Scottish Government (Marine Scotland)					
Web-link:						
Start date:	2012		End date:	2013		
Geographical relevance:	Topical relevance:					
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	
	n/a	n/a		High	n/a	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	n/a	n/a	n/a	n/a	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	High					
Project description:						
Construction of a CFD modelling tool that can be used to estimate collision rates of migratory fish (and diving birds) with marine current turbines, and to better understand the fatal and non fatal collision risks. Such a tool will be able to help Marine Scotland Science to offer better advise as part of the regulatory and licensing procedure of the Scottish Government.						
Project deliverables:						
A CFD model that accurately predicts the flowfield through a tidal turbine; A Trajectory model to simulate organisms interacting with the turbine and resultant flowfield; Estimating the organism encounter rate with the marine current turbines under different operating conditions; and Investigating the impact of organism modes of encounter; origin and orientation, relative velocity and size/mass on the encounter rate.						
Spatial data generated:						
Bibliography of outputs:						

Countries:	UK (Scotland)				
Project title:	Marine Energy Spatial Planning Group research activities on the direct impact on fish				
Research providers:	SNH				
Framework:	Marine Energy Spatial Planning Group (MESPG)				
Funding sources:	The Scottish Government (Marine Scotland)				
Web-link:	http://www.snh.org.uk				
Start date:			End date:		
Geographical relevance:			Topical relevance:		
	Resource assessment:	Baselines:	Impacts:	Socio-economics:	
Project type:	n/a	High	High	n/a	
	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:
Development life cycle stage:	High	n/a		n/a	n/a

Nature of impact / study:	Physical processes: n/a	Ecological processes: Low	Direct seabed impacts Low	Direct wildlife impacts High	New ecological space Low	Interactions with other sea-users: n/a
Project description:						
Project deliverables:						
Literature review of the effects of electro-magnetic fields and noise arising from Marine Renewable Energy infrastructure on Atlantic Salmon, sea trout and European eel.						
Spatial data generated:						
Bibliography of outputs:						
Countries:	UK (Scotland)					
Project title:	Marine Energy Spatial Planning Group research activities on the direct impact on marine mammals					
Research providers:	SNH					
Framework:	Marine Energy Spatial Planning Group (MESPG)					
Funding sources:	The Scottish Government (Marine Scotland)					
Web-link:	http://www.snh.org.uk					
Start date:			End date:			
Geographical relevance:			Topical relevance:			
	Resource assessment:	Baselines:	Impacts:		Socio-economics:	
Project type:	n/a	High	High		n/a	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	n/a	n/a	n/a	n/a	
Nature of impact / study:	Physical processes: n/a	Ecological processes: Low	Direct seabed impacts Low	Direct wildlife impacts High	New ecological space Low	Interactions with other sea-users: n/a
Project description:						
Project deliverables:						
Utilization of space by grey and harbour seals in the Pentland Firth and Orkney waters						
Abundance and distribution of basking sharks and cetaceans in the Pentland Firth and Orkney Waters						
Scoping study to investigate the development and establishment of a marine mammal stranding scheme in Orkney and Pentland Firth.						
Spatial data generated:						
Bibliography of outputs:						

Countries:	UK (Scotland)					
Project title:	Guidance on Survey and Monitoring in relation to marine (wave and tide) renewable deployments in Scotland					
Research providers:	SNH, Marine Scotland					
Framework:	Marine Energy Spatial Planning Group (MESPG)					
Funding sources:	The Scottish Government (Marine Scotland)					
Web-link:	http://www.snh.org.uk					
Start date:				End date:		
Geographical relevance:				Topical relevance:		
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:						
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:	UK (England), France					
Project title:	Marine Energy in Far Peripheral and Island Communities (MERiFIC)					
Research providers:	University of Plymouth, University of Exeter, Cornwall Council, Cornwall Marine Network (UK), Ifremer (France), Bretagne Développement Innovation, Conseil General du Finistère, Partners, Parc Naturel Marin d'Iroise, Pôle Mer, Technopole Brest Iroise (France)					
Framework:	INTERREG					
Funding sources:	EU					
Web-link:	http://www.merific.eu/					
Start date:	2011		End date:		2014	
Geographical relevance:	Regional		Topical relevance:		Marine renewable energy for remote and island communities	
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:	Medium/High	Medium	Medium	High		

The Marine Renewable Energy Strategic Framework (MRESF) project investigated the potential marine renewable energy resource of Welsh Territorial Waters (TWs) and considered potential scenarios for the sustainable development of that resource primarily as an aid to policy development and also an indicator of resource for potential developers.

The project took place in 3 stages:

Stage 1 identified the available energy resource and information and knowledge gaps on possible constraints to development in these areas; Stage 2 undertook additional reviews and research to fill some of the identified knowledge gaps. This included specific studies on mammals, birds, fish, MOD interests and positive effects of marine renewables; Stage 3 produced outputs identifying the wave and tidal stream energy resource around Wales, and the various constraints associated with each of these resource areas.

Project deliverables:

Final report and technical addendum. Various Phase 2 reports also available. Final output maps are GIS based and available through web portal.

Spatial data generated:

Final output maps showing resource areas and 'constraints' are GIS based and available through web portal.

Bibliography of outputs:

ABPmer 2010. Collision Risk of Fish with Wave and Tidal Devices. Commissioned by RPS Group Plc on behalf of the Welsh Assembly Government. Project Ref. R/3836/01. Report No. R.1516.

Gordon, J, Thompson, D, Leaper, R, Gillespie, D, Pierpoint, C, Calderan, S, Macauley, J and Gordon, T. 2011. Assessment of Risk to Marine Mammals from Underwater Marine Renewable Devices in Welsh Waters. Phase 2 – Studies of Marine Mammals in Welsh High Tidal Waters. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R100707JG Version 5.

RPS 2008. Marine Renewable Energy Strategic Framework for Wales. Stage 1 Report FINAL. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R081124 Version 4.

RPS 2010. The Potential for Interaction between Wave and Tidal Stream Devices with Military Interests in Welsh Waters. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R100113SF Version 8.

RPS 2010. Marine Renewable Energy Strategic Framework for Wales – Stage 3. Stakeholder Participation Process. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R100428SK Version 6.

RPS 2010 (UNPUBLISHED). Positive Effects of Wave and Tidal Energy Devices. Literature Review and Desk Study. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R090910TM Version 5.

RPS 2011. Assessment of Risk to Diving Birds from Underwater Marine Renewable Devices in Welsh Waters. Phase 1 – Desktop Review of Birds in Welsh Waters and Preliminary Risk Assessment. On Behalf of the Welsh Assembly Government. Doc Ref. JER3688R100929MT Version 7.

RPS 2011. Assessment of Risk to Diving Birds from Underwater Marine Renewable Devices in Welsh Waters. Phase 2 – Field Methodologies and Site Assessments. On Behalf of the Welsh Assembly Government. Doc Ref. JER3688R100920CR Version 4.

RPS 2010. Marine Renewable Energy Strategic Framework for Wales – Stage 3. Stakeholder Participation Feedback. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R100819AB Version 6.

RPS 2011. Marine Renewable Energy Strategic Framework for Wales – Stage 3. Technical Addendum. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R101118SK Version 7.

RPS 2011. Marine Renewable Energy Strategic Framework for Wales – Stage 3. Review of the Policy Context for Sustainable Development in Welsh Waters. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R100831TM Version 4.

RPS 2011. Marine Renewable Energy Strategic Framework for Wales – Stage 3. Approach to Sustainable Development. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R100813SK Version 7.

Wilson, B and Gordon, J. 2011. Assessment of Risk to Marine Mammals from Underwater Marine Renewable Devices in Welsh Waters. Phase 1 – Desktop Review of Marine Mammals and risks from Underwater Marine Renewable Devices in Welsh Waters. On Behalf of the Welsh Assembly Government. Doc. Ref. JER3688R101122BW Version 4.

Countries:	Portugal					
Project title:	Wave Energy Acoustic Monitoring					
Research providers:	Wave Energy Centre and CINTAL – University of Algarve					
Framework:	PTDC programme of FCT					
Funding sources:	Fundação para a Ciência e Tecnologia (FCT)					
Web-link:	http://www.siplab.fct.ualg.pt/proj/weam.shtml					
Start date:	November 2007		End date:	April 2011		
Geographical relevance:	All regions		Topical relevance:			
Project type:	Resource assessment:		Baselines:		Impacts:	
					Socio-economics:	
Development life cycle stage:	Planning and pre-development survey:		Installation:		Decommissioning:	
			Operation:		Maintenance:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description: the project aims at developing, testing and validating a monitoring system for determining underwater acoustic noise generated by wave energy-based generators and its impact in the sea fauna. This study will be able to extend noise predictions to farms of wave generators with predetermined configurations.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						

Countries:	UK, Ireland, France, Spain and Portugal				
Project title:	Future of the Atlantic Marine Environment				
Research providers:	Royal Society for the Protection of Birds (RSPB), BirdWatch Ireland (BWI), Ligue pour la Protection des Oiseaux (LPO), Sociedade Portuguesa para o Estudo das Aves (SPEA), SEO/BirdLife, Universidade do Minho (UMinho), Wave Energy Centre (WavEC)				
Framework:	Atlantic Area Program – European territorial cooperation (INTERREG)				
Funding sources:	EU				
Web-link:	http://www.fameproject.eu/en/				
Start date:	November 2007		End date:	April 2011	
Geographical relevance:	All regions		Topical relevance:		
Project type:	Resource assessment:		Baselines:		Impacts:
					Socio-economics:
Development life cycle stage:	Planning and pre-development survey:				
	Installation:		Operation:		Maintenance:
					Decommissioning:

In 2009, MAREN (MARine ENergy) wave power testing plant was deployed near Runde, Norway. In connection to the MAREN testing, an extensive environmental monitoring programme, testing effects of the installations, was initiated. Environmental impact investigations have been focused on fish and benthic communities to date, but will include seabirds as well. In addition, the potential effects of noise on marine species will also be included in the environmental monitoring programme.

Assessments of whether MAREN installations affect the environment are based on modified BACI-designs (Before-After-Control-Impact), i.e. investigations are, on principle, carried out before and after MAREN installations, as well as at impact and control sites. The suggested project duration is 3 to 5 years.

Benthic investigations in June (pre-installation) were based on ROV-mounted video filming of transects surrounding the future wave energy converter locations, as well as control sites in the vicinity. Benthic communities were generally species-poor and dominated by encrusting red algae and calcareous polychaetes. No differences in benthic community characteristics were detected between impact and control areas. In October, qualitative video analysis of MAREN wave energy converters indicated minimal colonization of structures after app. 6 weeks of deployment.

Two sets of fish investigations, both pre-installation, confirmed that there was no difference in fish biomass between the preliminarily assigned impact and control areas. It became apparent that data processing and analysis techniques associated with echo integrations have to be adapted to seasonally variable fish communities throughout the year.

Further progress plans with regard to current and future environmental monitoring programme components will have to be reviewed.

Project deliverables:

Field investigations, frequent field reports, biannual informal reports, final annual report

Spatial data generated:

Fish abundance (echosounding), size & sex distribution of fish, benthic fauna abundance

Bibliography of outputs:

Andersen, K., Chapman, A. S., Hareide, N. R., Folkestad, A. O., Sparrevik, E. & Langhammer, O. (2009) Environmental Monitoring at the Maren Wave Power Test Site off the Island of Runde, Western Norway: Planning and Design. Proceedings of the 8th European Wave and Tidal Energy Conference, Uppsala, Sweden, 2009.

Chapman, A. S.; Hareide, N. R.; Kvalsund, R. (2010): The MAREN wave power test site off the island of Runde, Norway. Environmental Monitoring Programme Annual Report. May 7, 2010.

Countries:	SPAIN, Portugal, France Sweden UK, Ireland, etc.					
Project title:	European Energy Research Alliance (EERA)					
Research providers:						
Framework:						
Funding sources:						
Web-link:	www.eera-set.eu					
Start date:	2011			End date:		
Geographical relevance:	All regions			Topical relevance: Implementing Joint Research Programmes		
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	High	High		n/a		n/a
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
<p>Within the context of the European Strategic Energy Technology Plan (SET-plan), fifteen leading European Research Institutes have taken up the challenge to found a European Energy Research Alliance (EERA). The key objective of the EERA is to accelerate the development of new energy technologies by conceiving and implementing Joint Research Programmes in support of the SET-plan pool and integrate activities and resources, combining national and Community sources of funding and maximizing complementarities and synergies. In 2011, a Joint Research Programme (JP) on ocean energy was launched with the active participation of Spain through the involvement of TECNALIA and AZTI. The EERA Ocean Energy JP is based around six key research themes. These themes have been developed, based on existing research roadmaps, which identify the critical areas of research required for the successful growth of the industry. The 6 research themes are Resource, Devices and Technology, Deployment and Operations, Environmental Impact (with the participation of AZTI-Tecnalia), Socio-economic Impact and Research Infrastructure, Education and Training. Spain is participating in all of the research themes and TECNALIA is leading the "Deployment and Operation" theme together with the German centre Fraunhofer IWES</p>						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						

Countries:	SPAIN, Portugal, France, UK, Norway, Denmark, Germany, Greece.					
Project title:	TROPOS					
Research providers:	See partners in Web Page					
Framework:						
Funding sources:						
Web-link:	http://tropos.plocan.eu/index.php					
Start date:				End date:		
Geographical relevance:	All regions		Topical relevance:	The objective of this project is to design multiuse offshore platforms where ocean energy plays a key role		
Project type:	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
The Oceanic Platform of the Canary Islands (PLOCAN), is leading another European Project (TROPOS) recently funded under the call "the Ocean of Tomorrow". The objective of this project is to design multiuse offshore platforms where ocean energy plays a key role.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						

Countries:	See web page					
Project title:	WAVETRAIN2					
Research providers:	See partners in Web Page					
Framework:	FP7					
Funding sources:	FP7					
Web-link:	www.wavetrain2.eu					
Start date:				End date:		
Geographical relevance:	All regions		Topical relevance:	to face the wide range of challenges that industrial-scale wave energy implementation faces in the near future, focusing on technical issues, from hydrodynamic and PTO (Power Take-Off) design, to instrumentation issues and energy storage and cost reduction show to be critical for successful deployment		
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	High		High	High	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
<p>The wavetrain2 project is a multinational Initial Training Network (ITN) funded under the FP7-People program, in order to face the wide range of challenges that industrial-scale wave energy implementation faces in the near future, focusing on technical issues, from hydrodynamic and PTO (Power Take-Off) design, to instrumentation issues and energy storage and cost reduction show to be critical for successful deployment. On the other hand, also non-technical “barriers”, typically less tangible difficulties related to legal issues (licensing, conflicts of use, EIA procedures, grid connection, regional differences) and the non-sufficient representation of socio-economic benefits of the sector, will be dealt with, as they are seen as a major obstacle for fast implementation on a European scale.</p>						
Project deliverables:						
www.wavetrain2.eu						
Spatial data generated:						
Bibliography of outputs:						

Countries:	Spain, Sweden, Portugal, New Zealand, UK, Ireland, Canada, Norway, Korea					
Project title:	OES-IA Annex IV- Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems					
Research providers:						
Framework:	OES-IA (Implementing Agreement on Ocean Energy Systems of the International Energy Agency)					
Funding sources:	Through pay members of the Annex IV					
Web-link:	http://www.ocean-energy-systems.org/					
Start date:	2009		End date:	2012		
Geographical relevance:	All regions		Topical relevance:	Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems		
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:	<p>The purpose of Annex IV is to provide a collaborative project under the International Energy Agency's (IEA) Ocean Energy Systems Implementing Agreement (OES-IA) that will identify ongoing research and bring together data on the environmental effects of marine and hydrokinetic (MHK) energy development, analyse those data to understand effects, identify potential monitoring and mitigation strategies to address those effects, and share those results and data broadly. The US has the lead for Annex IV; and the US Department of Energy (DOE) is the overall Operating Agent, also partnering with the Federal Energy Regulatory Commission (FERC) and the Bureau of Ocean Energy Management (BOEM). The DOE Water Power Program has also tasked one of the US national research laboratories, Pacific Northwest National Lab (PNNL), to carry out a significant amount of the Annex IV work. The database created to support Annex IV data will be built as an adjunct to the Knowledge Management System (Téthys) created for a similar PNNL project on environmental effects of MHK development. One of the first steps in implementing the Annex was to convene an experts' workshop in Dublin Ireland September 27th – 28th 2010. PNNL was responsible for organizing the content of the workshop, overseeing the contractors (Irish Marine Institute) hosting the event, presenting material on Annex IV and materials applicable to the workshop intent. PNNL is also overseeing a contractor (Wave Energy Center/University of Plymouth – WEC/UP) in the collection and analysis of the Annex IV data.</p>					
Project deliverables:						
Téthys database:	http://mhk.pnnl.gov/wiki/index.php/Tethys_Home					
Spatial data generated:						
Téthys database:	http://mhk.pnnl.gov/wiki/index.php/Tethys_Home					
Bibliography of outputs:						

Countries:	UK (Scotland)					
Project title:	Advancing Marine Renewable Energy Capabilities in Scotland					
Research providers:	Heriot-Watt University (ICIT), University of the Highlands and Islands (ERI), UK					
Framework:	Marine Renewable Energy Development in Scotland (MREDS) Work Package 5					
Funding sources:	Scottish Funding Council (Strategic Research Development Grant)					
Web-link:	http://www.mreds.co.uk/					
Start date:	2008		2008		2008	
Geographical relevance:	All regions		Topical relevance:		Hydrodynamics, fisheries, ecology, impacts	
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	High	Medium		High		Medium
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	Medium	Medium	High	Low	Low	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	High	High	Medium	Low	Low	High
Project description:						
Development of research capacity relating to the development of wave and tidal energy in Scotland						
Project deliverables:						
Spatial data generated:						
Outputs from SUNTANS model of tidal flow in the Pentland Firth						
Bibliography of outputs:						

Countries:	UK (Scotland, Northern Ireland)				
Project title:	Ecological Consequences of Tidal and Wave Energy Conversion				
Research providers:	Heriot-Watt University (ICIT), Queen’s University Belfast, UK				
Framework:	SuperGen Marine 2 Work Stream 10				
Funding sources:	UK Engineering and Physical Sciences Research Council				
Web-link:	http://www.supergen-marine.org.uk/drupal/content/work-stream-10				
Start date:	2008	End date:	2011		
Geographical relevance:	All regions	Topical relevance:	Development of generic ecological modelling tools		
Project type:	Resource assessment:	Baselines:	Impacts:	Socio-economics:	
	n/a	High	High	n/a	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:

Research providers:	IMARES (NL), University College London (UK), Senckenberg (DE), Ughent (BE), HCMR (GR), IO-BAS (BG), IMR (NO), University College Cork (IE), CNR-IAMC (IT), Tecnalia AZTI (ES), MRAE-MCFS (MT), DTU AQUA (DK), Cefas (UK), Heriot-Watt University (UK), ILVO (BE), Deltares (NL), NIVA (NO), TNO BenO (NL)					
Framework:	FP7					
Funding sources:	EU					
Web-link:	http://www.mesma.org/					
Start date:	2009		End date:	2013		
Geographical relevance:	All regions		Topical relevance:	Marine Spatial Planning		
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	Low	Low		Low		High
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	n/a	n/a	n/a	n/a	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	n/a	n/a	n/a	n/a	n/a	High
Project description:						
Development of generic tools for Marine Spatial Planning. Aims to produce integrated management tools for monitoring, evaluation and implementation of Spatially Managed Areas						
Project deliverables:						
Spatial data generated:						
Collation of data for nine case studies. Portal for spatial data at http://mesma.ucc.ie/geonetwork/srv/en/main.home						
Bibliography of outputs:						
Countries:	UK (Scotland)					
Project title:	The determination of possible ecological disturbance to the littoral zone due to prospective wave energy converter arrays: an investigation of potential metrics to economically quantify littoral wave energy					
Research providers:	Heriot-Watt University (ICIT), UK					
Framework:	SuperGen Marine 2, PhD Studentship					
Funding sources:	UK Engineering and Physical Sciences Research Council					
Web-link:						
Start date:	2008		End date:	2011		
Geographical relevance:	All regions		Topical relevance:	Wave energy measurement		
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:

Countries:		Portugal				
Project title:		Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact (Equimar)				
Research providers:		WaveEC (WP6 lead), Portugal				
Framework:		FP7				
Funding sources:		EU				
Web-link:						
Start date:		2008		End date:		2011
Geographical relevance:		National		Topical relevance:		
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Development of generic protocols for main areas of activity in pre-commercial development of wave and tidal devices; WP 6 dedicated to environmental impacts assessment (desk work, collation of existing data and information and extrapolation from related areas).						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:		UK (Scotland)				
Project title:		Unsteady flow				
Research providers:		Heriot-Watt University (ICIT), University of Glasgow, Strathclyde University, UK				
Framework:		Marine Renewable Energy Development in Scotland (MREDS) Work Package 4				
Funding sources:		UK Engineering and Physical Sciences Research Council				
Web-link:						
Start date:		2008		End date:		2009
Geographical relevance:		All regions		Topical relevance:		Tidal turbine rotors
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	Low	n/a		Low		n/a

Countries:		UK (Scotland)				
Project title:		Hebridean Marine Energy Futures				
Research providers:		University of the Highlands and Islands (LCC, ERI, SAMS), Heriot-Watt University (ICIT), Strathclyde University, University of Edinburgh, UK				
Framework:						
Funding sources:		Scottish Funding Council, Pelamis Wave Power, Aquamarine, Scottish Power Renewables, E.on UK, Voith Hydro Wavegen, RWE npower renewables, Comhairle nan Eilean Siar				
Web-link:		http://www.hebmarine.com/				
Start date:		2011	End date:		2014	
Geographical relevance:		Regional	Topical relevance:			
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	High	Medium		High		Low
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Medium	High	Low	Low	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	High	High	High	High	Low	Low
Project description:						
A project to accelerate marine energy developments, primarily in the Scottish Hebrides, through a programme of industry-academic knowledge exchange activities that will build a significant skills base in resource characterization and mapping, site surveying, grid integration design and pre-development consent planning. Work packages focus on: resource modelling and assessment; site surveying; marine energy effects on power system operation; pre-development consenting activities; knowledge exchange, dissemination and project management.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:		UK (Scotland)				
Project title:		Marine Renewable Energy and the Environment (MaREE)				
Research providers:		University				
Framework:						
Funding sources:		EU European Regional Development Fund, Scottish Funding Council and Highlands and Islands Enterprise				
Web-link:		http://www.eri.ac.uk/MaREEP2722.asp				
Start date:		2010	End date:		2013	
Geographical relevance:		All regions	Topical relevance:		Resource and risk, environmental impacts, management for sustainability	

Baseline habitat mapping in advance of deployment of WECs at Wave Hub site.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries: UK (England)						
Project title:		WaveHub vertebrates				
Research providers:		University of Exeter, UK				
Framework:						
Funding sources:		South West Regional Development Agency				
Web-link:						
Start date:		2009		End date:		2011
Geographical relevance:		Regional		Topical relevance:		Assessing impacts on cetaceans and birds
Project type:	Resource assessment:		Baselines:		Impacts:	
	Socio-economics:					
	n/a	High		High		n/a
Development life cycle stage:	Planning and pre-development survey:		Installation:		Operation:	
	Decommissioning:					
	High	Medium		Medium		n/a
Nature of impact / study:	Physical processes:		Ecological processes:		Direct seabed impacts	
	Direct wildlife impacts		New ecological space		Interactions with other sea-users:	
	n/a	High		n/a		High
Project description:						
Baseline habitat mapping in advance of deployment of WECs at Wave Hub site.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries: UK (England)						
Project title:		WaveHub hydrodynamics				
Research providers:		University of Plymouth, UK				
Framework:						
Funding sources:		UK Natural Environment Research Council				
Web-link:						
Start date:		2011		End date:		2014
Geographical relevance:		Local		Topical relevance:		Understanding impact on tidal mixing, frontal behaviour, etc.

Bibliography of outputs:						
Countries:	UK (England)					
Project title:	Fish movements and site fidelity at WaveHub site					
Research providers:	Marine Biological Association					
Framework:						
Funding sources:	UK Natural Environment Research Council					
Web-link:						
Start date:	2009		End date:	2011		
Geographical relevance:	Site		Topical relevance:	Understanding fish movements in no take zone		
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	
	n/a	High		High	n/a	
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	High	High	Low	Low	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	n/a	n/a	n/a	Medium	High	High
Project description:						
Landers to be deployed, plus tagging of commercially significant species.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:	UK (England, Scotland)					
Project title:	Reliable Data Acquisition Platform for Tidal (ReDAPT)					
Research providers:	Rolls-Royce, Plymouth Marine Laboratory, Tidal Generation Limited, Garrad Hassan, University of Edinburgh, EDF Energy, E.ON, EMEC, UK					
Framework:	ETI					
Funding sources:	Energy Technology Institute, BP, Caterpillar, EDF Energy, E.ON, Rolls-Royce, Shell					
Web-link:	http://www.pml.ac.uk/media/news_archive/redapt_project.aspx					
Start date:	2010		End date:	2014		
Geographical relevance:	Local		Topical relevance:	Biofouling		
Project type:	Resource assessment:	Baselines:		Impacts:	Socio-economics:	
	n/a	n/a		Low	n/a	

Countries:		UK (England)				
Project title:		Noise standards				
Research providers:		Southampton University, UK				
Framework:		Institute of Sound and Vibration				
Funding sources:		DSTL / MoD				
Web-link:						
Start date:				End date:		
Geographical relevance:		All regions		Topical relevance:		Device noise
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	n/a	n/a		High		n/a
Development life cycle stage:	Planning and pre-development survey:	Installation:		Operation:		Decommissioning:
	n/a	n/a		High		n/a
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	n/a	n/a	n/a	High	n/a	n/a
Project description:						
Developing standards for device noise.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:		Guernsey				
Project title:		Guernsey renewable energy assessment				
Research providers:		University of Plymouth, UK				
Framework:						
Funding sources:		Guernsey Government				
Web-link:						
Start date:		2010		End date:		2011
Geographical relevance:		Local		Topical relevance:		Methods
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
Development life cycle stage:	Planning and pre-development survey:	Installation:		Operation:		Decommissioning:

Countries:		UK (England, Scotland, Northern Ireland)				
Project title:		Flow, Water Column & Benthic Ecology 4D (FLOWBEC)				
Research providers:		National Oceanography Centre Liverpool, University of Aberdeen, University of Bath, University of Plymouth, University of Exeter, Plymouth Marine Laboratory, University of Edinburgh, Queen's University Belfast, UK				
Framework:		NERC Marine Renewables Sandpit				
Funding sources:		UK Natural Environment Research Council				
Web-link:		http://www.nerc.ac.uk/research/programmes/mre/facts.asp				
Start date:		2011	End date:		2014	
Geographical relevance:		All regions	Topical relevance:		Sensing techniques, flow, ecology	
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	High	High		High		Low
Development life cycle stage:	Planning and pre-development survey:	Installation:		Operation:	Maintenance:	Decommissioning:
	High	High		High	n/a	n/a
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	High	High	High	High	n/a	n/a
Project description:						
FLOWBEC aims at measuring flow, water column and benthic ecology in four dimensions, to assess the potential effects of Marine Renewable Energy Devices (MREDs) on the environment. It will use a wealth of observation techniques above and underwater, ranging from radar to sonar and in situ measurements, to be deployed over two years at three key sites around the UK. These measurements will feed into models of ecological interactions and habitat preferences, allowing predictions of the multiple effects of large MRED arrays.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:		UK (Scotland, England)				
Project title:		Optimizing Array Form for Energy Extraction & Environmental Benefit (EBAO)				
Research providers:		University of Edinburgh, Cefas, Sea Mammal Research Unit, Loughborough University, University of Exeter, University of the Highlands and Islands (SAMS), UK				
Framework:		NERC Marine Renewables Sandpit				
Funding sources:		UK Natural Environment Research Council				
Web-link:		http://www.nerc.ac.uk/research/programmes/mre/facts.asp				
Start date:		2011	End date:		2014	

Geographical relevance:	All regions		Topical relevance:		Array configuration, migration routes, shipping, fishing, habitats	
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:	n/a	n/a	High	High		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	n/a	n/a	n/a	n/a	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	n/a	High	High	High	n/a	High
Project description:						
This project will establish and evaluate a design feedback process which can protect and perhaps enhance the natural environment, while allowing energy extraction to be maximized. Engineers will work with project and device developers to establish appropriate development scenarios which will then be considered using state-of-the-art modelling techniques to assess the levels of ecological impact across a range of key ecological parameters.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:		UK (England, Scotland)				
Project title:	Quantifying benefits and impacts of fishing exclusion zones on bioresources around Marine Renewable Energy Installations (QBEX)					
Research providers:	MBA, University of Exeter, Cefas, University of Plymouth, Heriot-Watt University, Plymouth Marine Laboratory, UK					
Framework:	NERC Marine Renewables Sandpit					
Funding sources:	UK Natural Environment Research Council					
Web-link:						
Start date:	2012		End date:		2015	
Geographical relevance:	All regions		Topical relevance:		Fish and shellfish movements, fishing, modelling	
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:	n/a	High	High	High		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	High	Low	Low	n/a	n/a	

Yes						
Bibliography of outputs:						
Reports to regional government (most in Swedish only), if possible environmental data/findings also in peer-reviewed journals if part of impact studies are to be done by Uppsala University (in English).						
Countries:	Sweden					
Project title:	Lysekil project – test site for prototypes, equipment and marine ecological environmental studies					
Research providers:	Uppsala University					
Framework:	Swedish Centre for Renewable Energy Conversion (Div. of Electricity, Uppsala Univ)					
Funding sources:	National/regional research foundations, Swedish Energy Agency, Utilities etc (30+ sources, altogether, including smaller sources of funding)					
Web-link:	www.el.angstrom.uu.se					
Start date:	2004		End date:	Ongoing		
Geographical relevance:	Local to regional		Topical relevance:	General to specific marine ecology and impact		
Project type:	Resource assessment:	Baselines:		Impacts:		Socio-economics:
	Medium	Medium		High		Low
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
	n/a	Low	High	Low	n/a	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
	Low	High	High	Medium	High	Low
Project description:						
University test site, located ca 100 km N Gothenburg, Swedish west coast.						
Goal is to test and demonstrate techniques and investigate environmental impact on marine fauna and flora from wave energy conversion programmes, and also physical resource data.						
Present permits run to end 2013 – prolongation under process.						
Project deliverables:						
Test and study results – technical as well as environmental. All (most) findings are published in international peer-reviewed journals or conferences papers.						
Spatial data generated:						
Yes						
Bibliography of outputs:						
See above - Proj. Deliv. !						
www.el.angstrom.uu.se/Lysekilsprojektet - Publications						

Countries:	UK (England)
Project title:	Fishermen's information mapping (UKFIM)
Research providers:	Cefas
Framework:	
Funding sources:	Crown estate and Scottish Fishermen's federation
Web-link:	

Start date:	2010		End date:	2012 (?)		
Geographical relevance:	UK		Topical relevance:	Baseline info for future assessment of impacts on fisheries		
Project type:	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Producing VMS datalayers and producing them by métier and by year to compare with existing / new TCE datalayers .						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries: UK (England)						
Project title:	Monitoring ambient noise for the Marine Strategy Framework Directive					
Research providers:	Cefas					
Framework:						
Funding sources:	DEFRA					
Web-link:						
Start date:	2010		End date:	2012 ?/ 13		
Geographical relevance:	UK		Topical relevance:	Baseline noise levels		
Project type:	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						

Methods development for monitoring ambient noise, field measurements and recommendations for implementation of MSFD

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (England)					
Project title:	The impact of anthropogenic noise on fish and invertebrates at the individual, population and community level					
Research providers:	University of Bristol					
Framework:						
Funding sources:	DEFRA					
Web-link:						
Start date:				End date:		
Geographical relevance:				Topical relevance:		
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:						
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						

Countries:	UK (England)					
Project title:	The impact of anthropogenic noise on fish and invertebrates at the individual, population and community level					
Research providers:	University of Newcastle					
Framework:						
Funding sources:	DEFRA					
Web-link:						
Start date:				End date:		
Geographical relevance:				Topical relevance:		

	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:						
Development life cycle stage:	Planning and pre- development survey:	Installation:	Operation:	Maintenance:	Decommiss- ioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:	UK (England)					
Project title:	Spawning and nursery areas of fish of commercial and conservation importance					
Research providers:	Cefas					
Framework:						
Funding sources:	DEFRA / MMO					
Web-link:						
Start date:			End date:			
Geographical relevance:			Topical relevance:			
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:						
Development life cycle stage:	Planning and pre- development survey:	Installation:	Operation:	Maintenance:	Decommiss- ioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						

Countries:	UK (England)					
Project title:	Low-cost VMS data analysis: Assessment and applications					
Research providers:	SEAFISH					
Framework:						
Funding sources:	DEFRA					
Web-link:						
Start date:	2010		End date:	2012 ?		
Geographical relevance:				Topical relevance:		
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:						
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
Countries:	UK (England and N. Ireland)					
Project title:	Large-scale interactive coupled modelling of environmental impacts of marine renewable energy farms					
Research providers:	QUB, Imperial College, Cefas					
Framework:						
Funding sources:	EPSRC					
Web-link:						
Start date:	2012		End date:	2015		
Geographical relevance:				Topical relevance:		Hydrodynamics fisheries and impacts
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:						
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	

Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						
<hr/>						
Countries:		UK (England)				
Project title:	Guidelines for data acquisition to support marine environmental assessments for offshore renewable energy projects					
Research providers:	Cefas					
Framework:						
Funding sources:	DEFRA / MMO					
Web-link:						
Start date:	2010		End date:	2012		
Geographical relevance:			Topical relevance:			
	Resource assessment:	Baselines:	Impacts:	Socio-economics:		
Project type:						
Development life cycle stage:	Planning and pre-development survey:	Installation:	Operation:	Maintenance:	Decommissioning:	
Nature of impact / study:	Physical processes:	Ecological processes:	Direct seabed impacts	Direct wildlife impacts	New ecological space	Interactions with other sea-users:
Project description:						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						

Annex 7: Review of progress against research gaps identified by SGWTE 2011

(1) FUNCTION: WHAT DO WE KNOW ABOUT THE FUNCTIONING OF EXISTING PHYSICAL AND ECOLOGICAL PROCESSES IN AREAS SUITABLE FOR WTE DEVELOPMENTS?		
Key research issues	Existing research progress	Further research requirements
Shelf and regional scale hydrographic and sediment transport modelling	ABPMer – Marine Atlas (Waves and Tides) ALSF REC's Southern North Sea Sediment Transport Study	
Hydrographic and sediment transport models for sites nested within regional scale models	Alex Sousa (PML)?	
Integration of wave-current interactions and boundary layer processes in hydrographic models		
Understanding the role of hydrodynamic variables in determining the distribution of species and biotopes at a systemic scale	Borja, A., P. Liria, I. Muxika y J. Bald, 2006. Relationships between wave exposure and biomass of the goose barnacle (<i>Pollicipes pollicipes</i> , Gmelin, 1790) in the Gaztelugatxe Marine Reserve (Basque Country, northern Spain). ICES Journal of Marine Science, 63 (4):626-636. TeraWatt project (UK EPSRC funded) examining relationships between wave and tidal energy and distribution of marine organisms (conference papers by Bell <i>et al.</i> on bryozoans and fish).	Extend to other species.
Understanding the role of physical processes in determining connectivities for populations and ecosystems	EPSRC Grant to QUB Imperial and Cefas 'Large-scale interactive coupled modelling of environmental impacts of marine renewable energy farms' (Commencing Oct 2012)	Use of genomic techniques.
Understanding the role of physical processes in determining trophic linkages and predator-prey relationships in vertebrate populations	Cefas project 'Ecosystem connections: Essential indicators of healthy, productive and biologically diverse European Shelf Seas'	

(2) BASELINE: WHAT DO WE KNOW ABOUT THE CHARACTERISTICS OF POTENTIAL WTE DEVELOPMENT AREAS AND THEIR EXISTING IMPORTANCE FOR SPECIES, BIOTOPES AND HABITATS?		
Key research issues	Existing research progress	Further research requirements
Collection of baseline data on waves, currents, bathymetry and substrates	High in Spain EA Wave, Current & Tidal Data for UK Coast (Humber – Thames) Tidal Elevation Data (BODC – UK Wide) Channel Coastal Observatory WaveNet (See http://www.cefas.defra.gov.uk/our-science/observing-and-modelling/monitoring-programmes/wavenet.aspx) Bathymetry – SeaZone (Atlas) Medin – various data archive centres (BODC, PML, BGS)	
Collection of baseline data on the distribution of marine and littoral biotopes	High in the Basque Country. See Galparsoro <i>et al.</i> (2012) and results from MESMA project. Defra/JNCC/NE/Cefas/EA – MCZ data collection programme	To coordinate the nomenclature of the biotopes. EUNIS habitats system of classification
Collection of baseline data on the distribution of marine fish, birds and mammals	Cefas: Spawning and nursery areas of fish of commercial and conservation importance (Cefas Technical Report 147). http://www.cefas.defra.gov.uk/our-science/fisheries-information/ecologically-important-fish-habitats/distribution-of-spawning-and-nursery-grounds.aspx Seawatch foundation (maps of cetacean distribution)	Significant data gaps currently limit greater understanding of potential impacts of marine renewable energy devices on marine mammals, fish and birds. These include basic knowledge of how they behave around devices. We need long-term monitoring techniques and technologies in order to detect changes in the behaviour of these species different from natural variation.
Description of natural variability of baselines	Cefas project: Natural variability of REA regions, their ecological significance & sensitivity http://cefas.defra.gov.uk/alsf/projects/natural-seabed-resources/09p114.aspx	
Knowledge of essential habitats for fish, bird and mammal populations	Cefas projects	
Description of migratory patterns for marine vertebrates	Cefas projects	
Movement patterns of commercial fish and crustaceans in relation to devices and development areas	Defra/NERC study : QBEX (MBA, Cefas, PML, Exeter)	

(3) PREDICTION: CAN WE FORECAST THE CHANGES IN PHYSICAL PROCESSES CONSEQUENT ON EXTRACTION OF HYDROKINETIC ENERGY, AND THE IMPLICATIONS OF THIS FOR ECOLOGICAL PROCESSES?		
Key research issues	Existing research progress	Further research requirements
Development of predictive modelling capacity for ecological consequences of future energy extraction and climate change scenarios	<p>Some exercises have been done in the Environmental Impact Study of the BIMEP project, e.g. the annual decrease of wave energy in the shadow area of BIMEP can cause a reduction of gooseneck barnacle biomass of about 0.47 y 0.66 kg·m⁻² in the shadow area according to the calculations undertaken by Borja <i>et al.</i> (2006).</p> <p>Defra/NERC study: EBAO (Edinburgh, Exeter, Cefas, Loughborough, SAMS, SMRU).</p> <p>EPSRC Grant to QUB Imperial and Cefas 'Large-scale interactive coupled modelling of environmental impacts of marine renewable energy farms' (Commencing Oct 2012)</p>	Extend these analyses to other species.
Modelling the interaction of wave and tidal energy extraction with physical processes at small and large-scales	<p>EPSRC Supergen II Current Call</p> <p>PerAWat: Numerical models of devices, interactions between devices in arrays and interactions between arrays at the coastal scale are being developed during the project. These models are being validated using extensive scale model tank testing and full-scale data from in-service devices where appropriate.</p>	

(4) MONITORING: HOW DO WE DETECT AND MEASURE ENVIRONMENTAL IMPACTS AGAINST A BACKGROUND OF NATURAL VARIATION?		
Key research issues	Existing research progress	Further research requirements
Development of cost-effective tools and protocols for environmental / ecological baseline measurements and impact monitoring, including use of remote sensing technologies	Medium in Spain. The European Marine Ecosystem Observatory (EMECO) is a consortium of European Marine Institutes that aim to integrate marine environmental monitoring, ecosystem modelling and coastal and ocean research. (see http://www.emecogroup.org/)	We need long-term monitoring techniques and technologies in order to detect changes in the behaviour of these species different from natural variation.
Adding value to environmental surveys and impact assessments by sharing data, protocols and experience	EERA Network, Annex IV and ICES groups WaveNet (See http://www.cefas.defra.gov.uk/our-science/observing-and-modelling/monitoring-programmes/wavenet.aspx) Cefas Project 'Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects' in press (will be published as a ORELG report)	
Physical measurements as proxies for biological features of sites	JNCC UK SeaMap 2011	
Measuring connectivities in animal populations without large-scale tagging projects	QBEX (UK, NERC-funded)	Genomic techniques
Measuring ecological responses against a background of natural variation, including climate change		
Methods to detect interactions between devices and marine wildlife	RESPONSE Low in Spain – some baseline studies	BACI techniques

(5) SOCIO-ECONOMICS: WHAT DO WE KNOW ABOUT HOW AREAS OF POTENTIAL IMPORTANCE FOR WTE DEVELOPMENTS ARE USED BY OTHER MARINE STAKEHOLDERS?		
Key research issues	Existing research progress	Further research requirements
Collection of data on shipping lanes	BIMEP Preoperational Monitoring Plan. Annatec – shipping intensity and collision risk around windfarms	Continues with the monitoring of fishing activity during operational and decommissioning phases.
Distribution of fishing effort and catches at spatial scales relevant to lease and development areas	BIMEP Preoperational Monitoring Plan. MEPF ALSF Project (Cefas, Sussex SFC, BGS) Assessment of the distribution and intensity of fishing activities in the vicinity of aggregate extraction sites. http://cefas.defra.gov.uk/alsf/projects/socio-economic-issues/08p73.aspx TCE and SFF funded Study: Fishermen's Information Mapping (UKFIM) project	
Measuring trade-offs between outcomes for different sea users		
Local community benefits from WTE developments		
Consequences of displaced fishing effort for sustainable fisheries management	BIMEP Preoperational Monitoring Plan. EPSRC Grant to QUB Imperial and Cefas 'Large-scale interactive coupled modelling of environmental impacts of marine renewable energy farms' (Commencing Oct 2012) EU KNOWSEAS Project	Continues with the monitoring of fishing activity during operational and decommissioning phases.
Significance in planning and consenting processes of cultural and aesthetic responses to changes in landscapes and seascapes	BIMEP Preoperational Monitoring Plan. A landscape characterization has been done. Once we will know the type of device to be placed, we will undertake visual simulations.	Characterization of seascapes and landscapes in order to be able to do visual simulations prior to the installation of any device.

(6) SYNERGY: WHAT ARE THE POTENTIAL OPPORTUNITIES ARISING FROM WTE DEVELOPMENTS?		
Key research issues	Existing research progress	Further research requirements
Potential for WTE developments to enhance ecosystems and biodiversity	QBEX (UK, NERC-funded)	Long-term monitoring of fishing activity
Opportunities for commercial fishery enhancement	BIMEP Monitoring plan. We know the use of the BIMEP area by the most common fishing vessels in the occupation area of BIMEP.	
Potential contribution of WTE development areas to spatio-temporal controls in fishery management		
(7) CONSEQUENCES: WHAT IS THE NATURE AND SCALE OF IMPACTS EXPECTED FROM WTE DEVELOPMENTS?		
KEY RESEARCH ISSUES	EXISTING RESEARCH PROGRESS	FURTHER RESEARCH REQUIREMENTS
Approaches to determining individual, population and ecosystem level consequences from device and site level impacts (mortality, displacement, disturbance)	EPSRC Grant to QUB Imperial and Cefas ‘Large-scale interactive coupled modelling of environmental impacts of marine renewable energy farms’ (Commencing Oct 2012)	
Acoustic outputs from WTE developments, considering propagation models and thresholds for noise impacts on marine wildlife	Cefas Ambient Noise Project	
Developing improved models of collision risks for marine vertebrates, determining critical behavioural parameters		
Describing local wake structures around devices, considering consequences for impacts on benthic habitats and effects on marine vertebrate behaviour		

(8) MITIGATION: HOW CAN IMPACTS BE AVOIDED, MINIMIZED OR COMPENSATED?		
KEY RESEARCH ISSUES	EXISTING RESEARCH PROGRESS	FURTHER RESEARCH REQUIREMENTS
Quantifying trade-offs between energy extraction and reductions in current velocity	Project ReDAPT: will install an innovative 1MW tidal generator at the European Marine Energy Centre in Orkney. The project will test the performance of the tidal generator in different operational conditions. Its aim is to increase public and industry confidence in tidal turbine technologies by providing a wide range of environmental impact and performance information, as well as demonstrating a new, reliable turbine design.	
(9) CONSTRAINTS: WHAT ARE THE CONSTRAINTS TO DEVELOPMENT OF WTE IN DIFFERENT REGIONS?		
KEY RESEARCH ISSUES	EXISTING RESEARCH PROGRESS	FURTHER RESEARCH REQUIREMENTS
Improved information on grid availability and capacity		

Annex 8: Summary of knowledge gaps relating to marine renewable energy collated by the UK NERC Marine Renewable Energy Knowledge Exchange Programme (MREKE)

<i>END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)</i>	<i>DRIVERS (e.g. Risk reduction, relevant stage of application, reduced cost /improved efficiency)</i>	<i>RECENTLY COMPLETED / ONGOING PRO- JECTS</i>	<i>PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc,)</i>	<i>FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS</i>
COORDINATION and COMMUNICATION				
Facilitate alignment of UK roadmapping and identify research / data / evidence needs and issues	Promote collective responsibility, cost efficiencies and clarity of purpose	MSCC through ORRSG with support from NERC MREKE programme	MSCC to seek representation from marine renewable sector on Marine Industry Liaison Group (MILG)	
Set up communications portal for dissemination research products and services and as conduit for end-user input	Streamlining access to data and up to date research outputs	CROWN ESTATE / DECC and NERC MRE KE	Discussion underway regarding AMEC advice to DECC / TCE	
Facilitate development of central data repositories for baseline, monitoring information and data products	Promotes cost-effective use and sharing of data	MSCC with DECC DEFRA and Crown estate		
Facilitate access to research data and services at testing sites	Promotes and facilitates industry / science collaboration	Testing sites and NERC MREKE portal	Discussion ongoing with testing centres regarding needs	
Facilitate access to EU projects, conference proceedings and outcomes of ICES working group, OES Annex IV advice and services	Cost efficiencies, promotion of best practice based on up to date knowledge and information	NERC MREKE and project websites	MREKE portal and dedicated project websites e.g. EQUIMAR, SOWFIA	
Facilitate development of consortia / funding calls which cross organizational and topic boundaries through workshoping and joined up communications	Cost efficiencies better collective outcome	EPSRC - call for proposals - workshop run by EPSRC with NERC input to scope the call to encourage cross disciplinary research	TSB - NERC call in development	
(1) SUSTAINABLE DEVELOPMENT OF MARINE RENEWABLE ENERGY				

END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)	DRIVERS (e.g. Risk reduction, relevant stage of application, reduced cost /improved efficiency)	RECENTLY COMPLETED / ONGOING PROJECTS	PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc,)	FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS
Technology choice to optimize energy extraction with minimal negative and maximum positive environmental impact	Sustainable design for whole life cycle of project from concept / design through construction and operational life to decommissioning taking engineering environmental and socio-economic aspects into consideration; needed pre application	NERC - DEFRA : EBAO - optimizing energy arrays for environmental benefits and energy extraction (Commissioned Sept 2011)LCRI - Method for design optimization and performance prediction of tidal stream turbines (2011 - 2013)	ETI call just closed for Deep-water floaters - discussion re integrated environmental research programme	Discussion re integrating environmental research programme into demonstration project
Technology choice for supporting infrastructure (e.g.. cabling) to minimize environmental impacts			TSB - NERC joint call in development	
Construction methods which minimize environmental impacts (including DP vessels etc)			as above	
Integrated decision tools / methods for whole life cycle economic appraisal to allow selection of appropriate technologies for a given site		LCRI - site appraisal and economic assessment based on case study of TEL deployment at Ramsay Sound (TBC 2013)		
Integration of ecosystem services valuation into tools for technology evaluation		UKERC : Research methods in development phase 2 Energy and environment theme (TBC 2013)		
(2) CHARACTERIZATION OF ENVIRONMENTAL SETTING AND SITES FOR DEVELOPMENT				
Up to date recommendations for technology, methods and survey design for characterizing renewable energy sites		MESPG : Guidance on survey and monitoring in relation to marine renewable deployments in Scotland (completed March 2011) see also monitoring section below		
Guidance for optimizing use of data and information collected at different spatio-temporal scales			MREKEP proposal received from CREEM	MREKE proposal in development with MAREMAP
(i) Resource assessment				
Accurate resource estimates	Development planning and	Supergen wind wave and tidal - PRIMaRE PER-		

END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)	DRIVERS (e.g. Risk reduc- tion, relevant stage of appli- cation, reduced cost /improved efficiency)	RECENTLY COMPLETED / ONGOING PRO- JECTS	PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc,)	FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS
	licensing	AWATT / ReDAPT / LCRI and Univ of Bangor, NOCS wave resource modelling etc . EMEc - comparison / validation of different technologies (ADCPs complete)		
Comparison of technologies and methods for quantifying resource in space and time	as above also improves cost efficiencies in project devel- opment phases			
Models and methods to reduce uncertainty in resource assessment.	Improves investor / devel- oper confidence			
(ii) Physical - geology, water column				
Seabed characteristics - geomorphology, sedi- ment etc.	Legislation, better quality information needed for pre application, cost efficiencies also needed	DEFRA : Developing a database to promote the exchange of marine survey data focusing on multi beam data since 2003 (completed 2009)		
Hydrodynamic characteristics - currents, tides, temporal / spatial		NERC : National capability (NOC) data freely available		
Improved methods for determining physical characteristics of sites (integrated methods multi beam, habitat mapping)				MAREMAP - possible backscat- ter workshop
(iii) Physical - noise				
Technology development for measuring ambi- ent noise at development sites and impact of device / array noise	Legislation - better quality information needed for pre application and cost efficien- cies also needed	EPSRC (outcome of recent call not known) MESPG : Acoustic monitoring at wave / tidal test sites plus nursery sites at EMEC (TBC Aug 2011 / March 2012 resp)		
Understanding of variations in ambient noise, and other anthropogenic noise sources		Monitoring ambient noise for the Marine Strat- egy Framework Directive (TBC March 2013)		
Determining the thresholds and consequences of noise - injury / disturbance / avoidance from geotech / geophysical surveys through to con- struction and operation (ie whole life cycle)		MESPG : Lit review of the effects of noise and EMFs arising from energy devices on trout salmon and eels (completed sept 2010) NERc - DEFRA RESPONSE (Started Sept 2011)	TSB - NERC call in devel- opment	

<i>END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)</i>	<i>DRIVERS (e.g. Risk reduction, relevant stage of application, reduced cost /improved efficiency)</i>	<i>RECENTLY COMPLETED / ONGOING PRO- JECTS</i>	<i>PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc.)</i>	<i>FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS</i>
Review of technologies / methods to measure noise - parallel testing different technologies to provide recommendations and guidance		TCE workshops focused on measurement / mitigation of piling noise - next event Jan 14th	SOFI workshop Feb 6-8th; industry input being developed	
Understanding how operational noise changes at array scale and can it be modelled		NERC - DEFRA EBAO project just started (Oct 2011) LCRI - modelling of environmental effects of ambient noise (2011 - 2013)		
Determining the implications of injury / disturbance / displacement effects from noise for protected species		DEFRA : The impact of anthropogenic noise on fish and invertebrates at the individual, population and community level (TBC Mar 2013)		High priority for marine mammals
Determining effects of noise on non-protected species of benthic fish and crustaceans		DEFRA : The impact of anthropogenic noise on fish and invertebrates at the individual, population and community level (Q to DEFRA - 2 projects ?)		
<i>(iv) Benthos / fish</i>				
Characterization of marine habitats in energy development areas	Needed pre application - cost reduction consistency better quality data	MESPG : Analysis and assessment of marine habitats and species surveyed by Marine Scotland in Pentland Firth, Orkney, and additional surveys of Islay and west of Hebrides (Dec 2009) SWRDA : Baseline characterization of marine habitats at the Wave Hub site (completed 2010)		
Best practice for surveying / sampling in extreme wave / tidal environs		MESPG : Survey work to provide general description of tidal resource areas to create a better benchmark against which specific sites can be compared in future.	TSB - NERC call in prep	
Transfer of knowledge and development of expertise to facilitate safe working in extreme environments			as above	
Broad scale benthic community technologies and mapping techniques - need greater cost		MAREE project (ERI) / Univ of Plymouth (PRI-MaRE)		

<i>END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)</i>	<i>DRIVERS (e.g. Risk reduc- tion, relevant stage of appli- cation, reduced cost /improved efficiency)</i>	<i>RECENTLY COMPLETED / ONGOING PRO- JECTS</i>	<i>PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc.)</i>	<i>FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS</i>
efficiencies and savings				
Fish behavioural responses to wave and tidal devices		DECC : Fish behaviour in vicinity of renewable energy devices (poss extension of NERC DEFRA project QBEX)		
Distribution and abundance of basking sharks in Uk waters and improved information on their ecology				
Migratory patterns, distribution and abundance of salmon trout and eel in Uk coastal waters		MESPG : Review of migratory routes and behav- iour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implica- tions for devt of marine renewables (completed Jan 2011) LCRI - Field studies of fisheries and migratory fish (2011 - 2013)		
Distribution of fish eggs and larvae, and vari- ability of space and time		DEFRA (cefas - underway details requested from DEFRA)		
Proxy methods (such as remotely sensed fronts) for biodiversity hot spots		NERC PhD		
<i>(v) Birds</i>				

<i>END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)</i>	<i>DRIVERS (e.g. Risk reduction, relevant stage of application, reduced cost /improved efficiency)</i>	<i>RECENTLY COMPLETED / ONGOING PRO- JECTS</i>	<i>PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc,)</i>	<i>FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS</i>
Baseline observational data for seabirds to allow characterization of regional seas areas affected by development as well as offshore renewable energy sites, as well as migration routes and sites used for breeding birds / foraging in adjacent SPAs etc		MESPG : Collation of bird data for Pentland Firth and Orkney waters (part 1, 2, and 3; completed Oct 2009) MESPG : Surveys of marine birds in and around marine areas proposed for wave and tidal energy developments off the west coast of Scotland (completed May 2010) MESPG : Investigation of the utilization of sea space by seabirds in the Orkney/ Pentland area, emphasizing those areas indicated as having potential for tidal turbine installation (Nov 2015) DECC : Comparison of results of data collected in 3 representative areas of the N. Sea with older data (Completion ???); SOSS-05 Review of bird migration routes in relation to offshore wind farm development zones (finalized guidance by Nov 2011)		Baseline data are key requirement for EIA - but not a knowledge gap priority ; poss PhD on foraging preferences (currently utilize foraging range data to inform likely connectivity between breeding birds and foraging sites)
Improved understanding of ecological and behavioural characteristics of diving seabirds relevant to development of marine renewable energy		MESPG : The determination of foraging range and diving depths by diving seabirds, especially in the Orkney and Pentland Firth wave and tidal resource areas (completed Aug 2010)		High priority for wave and tidal
Improved technology for surveying esp over large areas ie. Novel combinations of technology appropriate to R3 offshore wind areas		Problem definition completed with BTO - technology developers now engaged		
Review of existing technology for registering collisions with turbine blades and development of novel technology where this is not fit for purpose		MESPG : Review of techniques to detect seabird presence and movement below the sea surface and determine potential application in the vicinity of tidal turbines (completed August 2010) this work is underway for wind by SOSS 3.		
How do abiotic and biotic factors control distribution / abundance ?			MREKE project in development with CREEM and BTO	Poss PhD project ? - understanding population level impacts

<i>END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)</i>	<i>DRIVERS (e.g. Risk reduction, relevant stage of application, reduced cost /improved efficiency)</i>	<i>RECENTLY COMPLETED / ONGOING PRO- JECTS</i>	<i>PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc,)</i>	<i>FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS</i>
How do birds interact with surface and submerged wave and tidal devices ?		MESPG see also section (1) NERC PhD		High priority
Population Viability Analysis for sensitive species - research to improve the accuracy of inputs to the models				High priority
Tagging studies for key species to understand foraging, migration, ranges etc.		DECC: Tagging of gannets at Bempton Cliffs by RSPB; DECC: Tagging of lesser black backed gulls and great skua at various UK sites by BTO; DECC: Tagging of whooper swans, light-bellied Brent, Svalbard barnacle and Greenland white-fronted geese at various breeding and wintering sites by WWT.	DECC interested in funding (possibly)	
Standardization of methods and establishment of best practice and /or consensus on guidance				
Integration of existing datasets to support interpretation (long-term / inter annual) to inform a more spatially complete distribution mapping exercise (cf JCP for cetaceans)				
Population modelling - requires up to date demographic parameters and an understanding of the appropriate population scale to assess. This would inform the need for threshold levels to trigger adaptive management				

<i>END-USER KNOWLEDGE NEEDS (i.e. Technology, methods, research, data, evidence)</i>	<i>DRIVERS (e.g. Risk reduction, relevant stage of application, reduced cost /improved efficiency)</i>	<i>RECENTLY COMPLETED / ONGOING PRO- JECTS</i>	<i>PLANNED ACTIVITIES (Calls, Workshops / RfPs / EoIs etc.)</i>	<i>FUTURE ACTIVITIES - PRIORITY KNOWLEDGE GAPS</i>
Update the JNCC Oilspill Vulnerability Index (OVI) to surface pollutants in the light of results from aerial and boat-based bird survey data - it would be useful to combine forces to develop an updated distribution map of bird species, using spatial modelling, and combining all available data (similar to JCP). This would inform future marine spatial planning.				
<i>(vi) Mammals</i>				
Need clearer definition on data requirements for consenting	Legislation - better quality more robust information to support site development / decision-making by regulator	MESPG : Analysis of wildlife observation data (completed March 2011) DECC: Tagging, observation and acoustic study of the effects of piling noise on marine mammals in the outer Moray Firth by University of Aberdeen (SMRU)		High priority (developers)
Updated info on the ecology of most marine mammal species and in particular important areas for breeding, foraging and resting		MESPG : Abundance and distribution of cetaceans in the Pentland firth and Orkney waters (completed Feb 2011) Cetacean monitoring in the Pentland Firth tidal energy waters (completed July 2011) MESPG : Seal population viability study (completed April 2010) MESPG : To develop a PBR for seals across Scotland (completed August 2010) MESPG : Utilization of space by grey and harbour seals in the Pentland Firth and Orkney waters (completed Jan 2011) DECC: Seal distribution and ecology - Further analysis of existing seal tag data for both species, UK wide and drawing in relevant European tagging data. Two year post-doctoral project at SMRU, with coordinated links to a SG funded project and an SNH/NERC CASE studentship.		

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The effects of behavioural disturbance and injury/death at a population level, taking into account the effects of single developments and also the cumulative effects of several developments within the natural range of populations		MESPG : Scoping study to investigate the development and establishment of a marine mammal stranding scheme in Orkney and Pentland Firth (Completed April 2011) CROWN ESTATE : Research into the interaction of seals with offshore wind farms	JNCC : (about to commission) : 'Assessing the risk of population level effects on marine mammals in UK waters from the installation and operation of renewable energy devices'.	High priority (ALL)
Lack of knowledge of the physiological, behavioural, spatial and temporal characteristics of marine mammal and prey responses to construction and operational noise, and the influence of the local environment (some cross over between offshore wind and tidal - (construction) and some between wave and tidal (operation))		DECC: Tagging of harbour seals to investigate behaviour in vicinity of operating tidal turbines (Strangford Lough). Continuation of existing SMRU project; DECC : Tagging and acoustic study of the effects of wind farm construction and operation on harbour seals in the southeastern North Sea 2102-2013 (SMRU); DECC: Tagging, observation and acoustic study of the effects of piling noise on marine mammals in the outer Moray Firth by University of Aberdeen (SMRU)	JNCC : (about to commission) : 'Behavioural responses of marine mammals to noise resulting from the installation of renewable energy devices'.	High priority (ALL)
Technology and methods to detect and observe mammal behaviour directly esp as scaling up from single device to arrays		MESPG : Peer review of land-based visual monitoring methods and protocols for wave and tidal test sites (completed March 2011)		technology innovation would assist with monitoring at arrays
How can existing broad scale studies inform understanding of finer scale variability ?			CREEM proposal in development	
Acoustic interactions between marine mammals and devices		SNH : PhD studentship at SAMS		
Understand predator - prey behaviour at tidally active sites		RESPONSE - FLOWBEC NERC - DEFRA projects just starting		Suitable for PhD - contributes to understanding behavioural ecology at energy farms

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Analysis methods for integrating survey data from different sources /time periods into population level assessments			MREKE - CREEM proposal	Check with JNCC who is doing JCP work - value of CREEM proposal ?
<i>(vii) Characterizing / interactions with other marine sectors</i>				
Precision on the offshore distribution of navigation to allow the identification and maintenance of priority navigation routes (good quality AIS data coverage typically only extends 50km from shore);			TSB - NERC call in prep	
Characterizing activities of fishers to better understand marine space use in areas where energy development planned		DEFRA : Development and piloting of low-cost Vessel Monitoring Technology on English In-shore Vessels (Completed Oct 2011) DEFRA : Low-cost VMS data analysis: Assessment and applications (March 2012)		
Understanding the impact of energy development on aquaculture and fisheries		Impact of MRE development on aquaculture and fisheries focusing on impact on larval dispersal		
<i>(viii) Stakeholder engagement</i>				
Development of methods / approaches for stakeholder dialogue	Accelerating deployment with more sustainable outcomes			
Public understanding of marine renewable energy technology - costs and benefits		LCRI - Communications programme cutting across all LCRI programme WPs to reach general public and promote general understanding		

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(3) IMPACT PREDICTION AND ASSESS- MENT				
Improve quality of predictive tools for all critical project components (ie for EIA) , plus regional and shelf scale decision-making - also understanding of how to use them	Long-term sustainability for development of the sector integrated with other activities in coastal and shelf waters	EPSRC current call outcome not known		MREKEP workshop series in development
(i) Whole system & far-field impacts				
What is the sustainable capacity of the marine system as a whole for low carbon energy technologies ? Ie. UK waters	Inform public debate about the choices and trade-offs to be made in decarbonising the energy sector; plug specific evidence gaps about impacts to help speed up consenting and deployment of new infrastructure; to meet international and national legal requirements; minimize negative impacts and maximize co-benefits ; reduce the risk of lock into unsustainable technologies or sudden future changes of policy in the face of unforeseen impacts; facilitate investment decisions through greater clarity about the future energy mix	UKERC - research methods in development in relation to offshore wind - linking physical modelling and socio-economic valuation - case study to be completed in phase 2 UKERC (by 2013)	DEFRA : Sustainable pathways to a low carbon future (early 2012)	HIGH PRIORITY FOR DEFRA - sustainable pathways to a low carbon economy Some of these issues discussed at LWEC scoping workshop - Belmont group to investigate possibility of global suite of case studies bringing energy technology and climate change issues together in discrete geographical areas
What is the sustainable carrying capacity for each specific technology given practical resource limitations and interactions between different technologies ?				
What are the cumulative effects / long term and far-field effects of each specific technology given the moving baseline of climate change				
Which development pathways or energy technology mixes optimise the benefits and minimize the costs for the marine system and communities dependent upon it				
What development processes / methods should be adopted for quantifying the international / transboundary consequences of extraction of energy		EPSRC current call outcome not known		

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What is the impact of resource extraction by multiple arrays at bay / regional scale and interaction with sea level rise / coastal defence		LCRI - Hydro environmenatal modelling to predict impacts of energy extractioun at key sites around the welsh coast (2011 to 2013): EPSRC current call outcome not known		
What is the impact of multiple arrays on physical processes (esp sediment dynamics) and ecosystem functions		LCRI - Quantification of the marine energy resource and env impact of its use focusing on sediment dynamics (2011 2013); LCRI - Impacts of MRE development on coastal processes thro beach monitoring (2011-2013) EPSRC current call outcome not known.		
What is the evidence of environmental impacts of renewable energy development at the farm scale ?		MESPG : Review of potential impacts of renewable energy development on Scotland's marine environment (completed June 2011)		
What are the ecological and socio-economic costs and benefits of closing marine space for energy farms ?		DEFRA : Lyme Bay: A case study. Assessing recovery of benthic species; spillover effects and socio-economic impacts (TBC March 2012)		
Integration of socio-economic consequences of energy development into decision tools		UKERC Phase 2 - systematic review based on ecosystem valuation methods (TBC 2012)		
<i>(ii) Collisions (mammals birds fish)</i>				
Technology to detect / monitor collisions, observe behavioural responses and for tracking - this is both aerial and sub sea collisions	Pre application info, legislation and long-term sustainability of individual sites, leading to sustainable outcomes for industry as a whole as it goes global	ETI - ReDAPT ; SOSS-03 work on developing methods for monitoring bird collisions (interim report by Sept 2011)		High priority for birds and mammals
Determination of incidence of collisions and consequences for different species		RESPONSE - NERC - DEFRA project just started; DEFRA : CSIP Cetacean Strandings around UK coast (TBC 2014)		High priority for birds and mammals
Improved methods / support for collating input parameters (ie avoidance rates) into behavioural models of collision (birds, mammals and fish)		RESPONSE - NERC - DEFRA project just started ; SOSS02 A review of methods to estimate the risk of bird collisions with offshore wind farms		

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Consequences of collisions for protected species requires population level assessment - for both birds and mammals population modelling required		RESPONSE - NERC - DEFRA project just started ; SOSS-04: Gannet population viability analysis to assess the cumulative effect on the population from collisions with existing and planned off-shore wind farms.		JNCC / CCW workshop March 2012
Consequences of collisions for different sized animals of same and different species		Crown estate - Modelling collision risk for marine mammals (Swansea Univ) Oct 2010 to ?		
Collision risk models for different at risk species in relation to different infrastructure components (devices, moorings etc.)		MESPG : Estimate of collision risk of harbour porpoises and marine energy devices at high tidal stream sites (Completed Jun 2011) MESPG : Assessment methodology for determining collision risk of marine renewable energy devices (excluding offshore wind farms) on marine birds (completed Sept 2010) Crown estate : the interaction of marine wildlife with tidal stream turbines at Ramsay Sound, Pembrokeshire (see also Risk assessment section below)		High priority - CHECK what further work needs to be done on collision risk model - is this Bob Batty's work ?
How to reduce collision risk - considering location, device type, species		DEFRA / AEA projects by BTO ; SOSS-05: A review of bird migration routes in relation to offshore wind farm development zones.		
Need to collate existing data on interactions with devices and obtain new empirical / field data on impacts		SOSS-02: A review of methods to estimate the risk of bird collisions with offshore wind farms. plus Aquatera report about to be released (SG)		High priority

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<i>(iii) Displacement / disturbance</i>				
Impacts on individuals and knock on impacts for MAMMAL BIRD AND FISH populations (behaviour / reproduction / energetics / survival)	Pre application, legislation and long-term sustainability of individual sites, leading to sustainable outcomes for industry as a whole as it goes global	MESPG : Utilization of space by grey and harbour seals in the Pentland Firth and Orkney waters (completed Jan 2011) Review of migratory routes and behaviour of salmon trout and eels in Scotland (completed Jan 2011) Land-based observations of vertebrate behaviour at EMEC Scapa Flow and Shapinsay nursery sites to establish whether changes as result of presence of wave and tidal devices (TBC March 2012) LCRI - Behaviour of marine mammals at Ramsay Sound development site (2011 - 2013)		High priority for both birds and mammals
Tools / methods to measure displacement - both temporal and spatial (vertebrates)		SOSS-01A: Collation and review of bird survey data from existing offshore wind farm sites to assess data suitability for estimating bird displacement rates.		High priority for both birds and mammals
What are the factors driving displacement / habituation (dose response + thresholds) and development of predictive models		RESPONSE - NERC - DEFRA just started ; HRWallingford predictive model development for noise (recently announced)	CREEM proposal to develop SAFE SIMM	
The ecological significance of field responses of fish and seals to electromagnetic fields associated with cables;			TSB - NERC call in development - needs field testing programme	
<i>(iv) Socio-economic impacts</i>				
Methods to quantify socio-economic impacts of temporarily disrupted or permanently displaced fishing activity with knock on effects	Pre application, legislation and long-term sustainability of individual sites, leading to sustainable outcomes for industry as a whole as it	DECC / TCE : Fine scale distribution of fishing effort gears and catches for smaller vessels in R3 wind farm zones (Completion date unknown) DEFRA : Low-cost VMS data analysis: Assessment and applications (TBC March 2012)	MREKE - WG proposal following MarCoPol conference June 2011	

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Quantitative information on effects (both short and longer term) of fishing activity in and immediately adjacent to constructed wind farms	goes global	Cost impact review of fishing effects and recovery times for different gears (Completed 2010) NERc - PhD case study area North Hoyle (TBC March 2012) Crown Estate study of potential impact of fishing no-take zones on seabed habitats. (completed 2010 ?)		
<i>(v) Risk assessment</i>				
Adaptation of generic risk assessment methods for :	Better quality and more robust decision-making which integrates considerations of different aspects of project development in a transparent but systematic and rational framework		MREKEP - proposal received	
- integration risk approaches into whole project life cycle				
- risks to specific legally protected species (population level assessments)				High priority for protected species
- risks of collision with devices / arrays				
- risk based approaches to post implementation monitoring				
<i>(vi) Cumulative impact assessment</i>				
Development of framework for Cumulative Impact Assessment (CIA) at a development site	Sustainability carrying capacity and marine system limits	CROWN ESTATE : discussion paper - responses being collated (Nov 2011) MMO review Tender out : 'Evaluation of the current state of knowledge of potential cumulative effects from offshore windfarms to inform marine planning and licensing' (TBC Feb 2012) MESPG: Assessment methodology for determining cumulative impacts of marine renewable energy devices (excluding offshore wind farms) on marine birds (completed august 2010)	Support for invited round table / workshop to discuss needs and issues (could be TCE / MMO / MREKE with JNCC / developers etc.)	High priority
Framework / approach to assessing cumulative impact of multiple activities				
Implications of array size(s) / location (s) for collision risk / displacement				
Implications of clusters of schemes for determining impacts of individual schemes				

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Implications of arrays and multiple arrays on birds and mammals with UK wide / European distributions (carrying capacity ?)				High priority
(4) MITIGATION and MONITORING				
Facilitate development of central data repositories for baseline, monitoring and other data products	Promotes cost-effective use and sharing of data	Crown estate, DECC NaREC Capital		
Facilitate access to field research data and monitoring at testing and device deployment sites	Promotes and facilitates industry / science collaboration	Potential ecological impacts of a small-scale tidal device at the Isle of May SAC (PhD student 2013 end date)		
Facilitate learning from other sectors to support monitoring - e.g. Ports and harbours, aggregates, cabling, onshore wind - much of data are under analysed	Optimizes use of historical and indigenous sector knowledge of environmental; impacts of technology to support licensing decisions		MREKEP - review - proposal received	
Review design principles for monitoring programmes and mechanisms for feedback to 'deploy and monitor'	Cost efficiencies combined with improved information to support decision-making	MESPG : Guidance on survey and monitoring in relation to marine renewable energy development in Scotland (Completed March 2011) Peer review of land-based observations and their capacity to detect impacts (Mar 2011 - delayed)		High priority
Review consenting processes and identify where barriers to streamlining	Cost efficiencies combined with improved information to support decision-making			
Review new, currently used or potential monitoring technologies - develop strategy for field testing and validation e.g. HF radar	Cost efficiencies combined with improved information to support decision-making		TSB-NERC call in development	

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Mitigation of collision risk - considering location, device type, species (once we know the mechanisms of interaction)	Legislation and long-term sustainability of development sites	MESPG : Use of acoustic devices to warn marine mammals of tidal energy devices (Completed June 2011) DEFRA : Identifying a range of options to prevent avian collision with wind turbines, using a UK-based case study (completed Oct 2010)		Need to be thinking more proactively about mitigation now - economic and geological feasibility of alternatives ?
Mitigation of displacement risk for legally protected species		MESPG : Production of guidance wrt to EPS (ongoing)		
Mitigation of displacement risks for migrating species birds, or those foraging / breeding in SPAs adjacent to development sites				
Mitigation of conflict with marine conservation zones development		MMO : (about to be commissioned) 'Evaluation of the potential for co-location of activities and interests in Marine Plan areas'. (completion due feb 2012)		
Quantifying spillover effects at energy development sites (wind wave and tidal)	Cost efficiencies combined with improved information to support decision-making	MESPG : Monitoring of the fishery in a no-take zone established at the Billia Croo wave test sites at EMEC (August 2011) NERC - DEFRA : QBEX - quantifying the benefits of no take as result of development of a marine renewable energy site (Commissioning still underway) CROWN ES-TATE : an examination of the potential impact of fishing no-take zones on seabed habitats.		
Case studies to demonstrate effective economic mitigation of fisheries displacement		DEFRA: Lyme Bay: A case study. Assessing recovery of benthic species; spillover effects and socio-economic impacts (2008 to 2012) NERC - DEFRA QBEX project just starting NERC PhD student ship (2012 finish)		
Longer term studies to assess ecosystem and socio-economic impact of windfarms				

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Ecological consequences of introducing novel structures for enhanced productivity and / or biodiversity protection				