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

19-21 March 2013

Cork, Ireland

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Executive summary

The Study Group on the Environmental Impacts of Wave and Tidal Energy (Chair: Michael Bell, UK) held its third and final meeting in Cork, Ireland, 19–21 March 2013. The meeting was attended by four participants from Ireland, and the UK (England, Scotland) and contributions by correspondence were made by participants, from Spain and the UK (Scotland).

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 2013 continued the work of the previous meetings, 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 updated for five countries and summary tables were updated and extended to 80 wave and tidal energy developments or test deployments and 121 research projects.

SGWTE 2013 also considered the application of Integrated Ecosystem Approaches to management of marine renewable energy activities in the marine environment. Potential interactions of marine renewables with Ecosystem Services were identified, and their relevance to GES descriptors under the MSFD was assessed. Canada's development of risk analysis and the ecosystem approach (as detailed in the recent CRR No. 317) was reviewed and application of risk-based approaches to management were compared between Scotland and Canada.

This was the third and final meeting of SGWTE, but it is clear that there is an ongoing and increasing need for ICES to develop science in relation to marine renewable energy. SGWTE 2013 developed a proposal for a new Working Group on Marine Renewable Energy (WGMRE), to be established with multi-annual Terms of Reference running from 2014. A key role for WGMRE will be to work in close collaboration with topic-based science Working Groups with the purpose of synthesising their outputs in relation to marine renewable energy for application to planning, consenting and regulatory processes for tidal (both in-stream and barrage), wave and offshore wind energy. WGMRE will also continue the work of SGWTE to facilitate access to up-to-date information on the state of development of the marine renewable energy sector and on associated research activities.

1 Opening of the meeting

The third meeting of the Study Group on Environmental Impacts of Wave and Tidal Energy (SGWTE) was held at University College Cork, Cork, Ireland, 19–21March 2013. 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

2012/2/SSGHIE05 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.

3 Country reports (ToR a)

Updated country reports on wave and tidal energy developments and associated environmental research activities were received for Scotland, England, Northern Ireland, Ireland and Spain. Summary information on developments, regulatory frameworks and research activities is given for these countries below. Summary tables giving information on individual developments and research projects are given in Annexes 5 and 6 respectively. Refer to the SGWTE report for 2012 for information on wave and tidal energy developments and research in other ICES nations (ICES, 2012).

Reference

ICES. 2012. Report of the Study Group on Environmental Impacts of Wave and Tidal Energy (SGWTE). ICES CM 2012/SSGHIE:14.

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. Sectoral Marine Plans for Wave and Tidal Energy are being developed to ensure that offshore wave and tidal energy sources will make a substantial contribution to meeting the Scottish Governments ambitious targets. Draft plans are currently available on Scottish Government's website (http://www.scotland.gov.uk/Topics/marineenergy/Planning). These sectoral plans will be adopted into statutory national and regional marine plans for 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 recognises 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 a partnership initiative between Marine Scotland (MS), Scottish Natural Heritage (SNH), Highlands and Islands Enterprise, The Crown Estate, the Joint Nature Conservation Committee and representatives of industry. This is the Scottish Marine Renewables Research Group (formerly the Marine Energy Spatial Planning Group) which has a research programme including five themes: generic research, marine mammals, seabirds, habitats and fish.

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 Team), (ii) the production of a marine renewables licensing manual, (iii) development of licensing policy guidelines, and (iv) SNH monitoring guidance and protocols. The Licensing policy guidelines include (i) Survey, Deploy and Monitor Policy, (ii) Demonstration Strategy, (iii) Deemed Planning for onshore development required to link offshore developments with the grid, and (iv) Rochdale (design) 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 European Marine Energy Centre (EMEC) cabled berths (BilliaCroo 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 BilliaCroo and the Falls of Warness for testing full scale wave and tidal stream devices respectively, with connections to the National grid. EMEC has recently established "nursery" sites in Shapinsay Sound (tide) and Scapa Flow (wave) 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. 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 & 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 recognised verification of the performance of devices which come to test in Orkney.

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:	Oscillating wave surge converter
	Attenuator
	Point absorber

One scheme involving an offshore overtopping device had been considered at Siadar, Lewis, but this project has now been shelved.

Sea-bed 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.

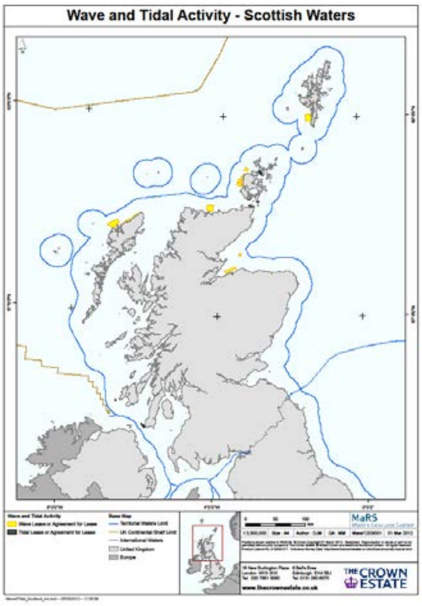


Figure 1. Locations of leased areas, and projected scales of development.

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 Sectoral Plans, and these are currently undergoing Sustainability Appraisal in line with the requirements of Environmental and Marine legislation. This work refreshes 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.

Initial Plan Frameworks have been produced which 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 has been undertaken using the MaRS model to map resource and constraint areas covering the Scottish renewable energy zone to develop further Plan options (Davies *et al.*, 2012a, b). Regional Locational Guidance review and application has been applied to the areas identified enabling refined Plan options to be developed for each sector (http://www.scotland.gov.uk/Topics/marine/marineenergy/Planning).Following Sustainability Appraisal and statutory public consultation it is envisaged that these will be completed and adopted by the end of 2013.

The Plan will provide clear guidance to industry on where to focus investment and seek 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 minimises 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 studies for Offshore Wind, wave and tidal energy in Scottish waters (Davies & Watret, 2011; Davies *et al.*, 2012 a, b). 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 Protect 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 12–200 nm 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 relating to marine protection and nature conservation legislation. For the majority of offshore 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), 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 enables 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.

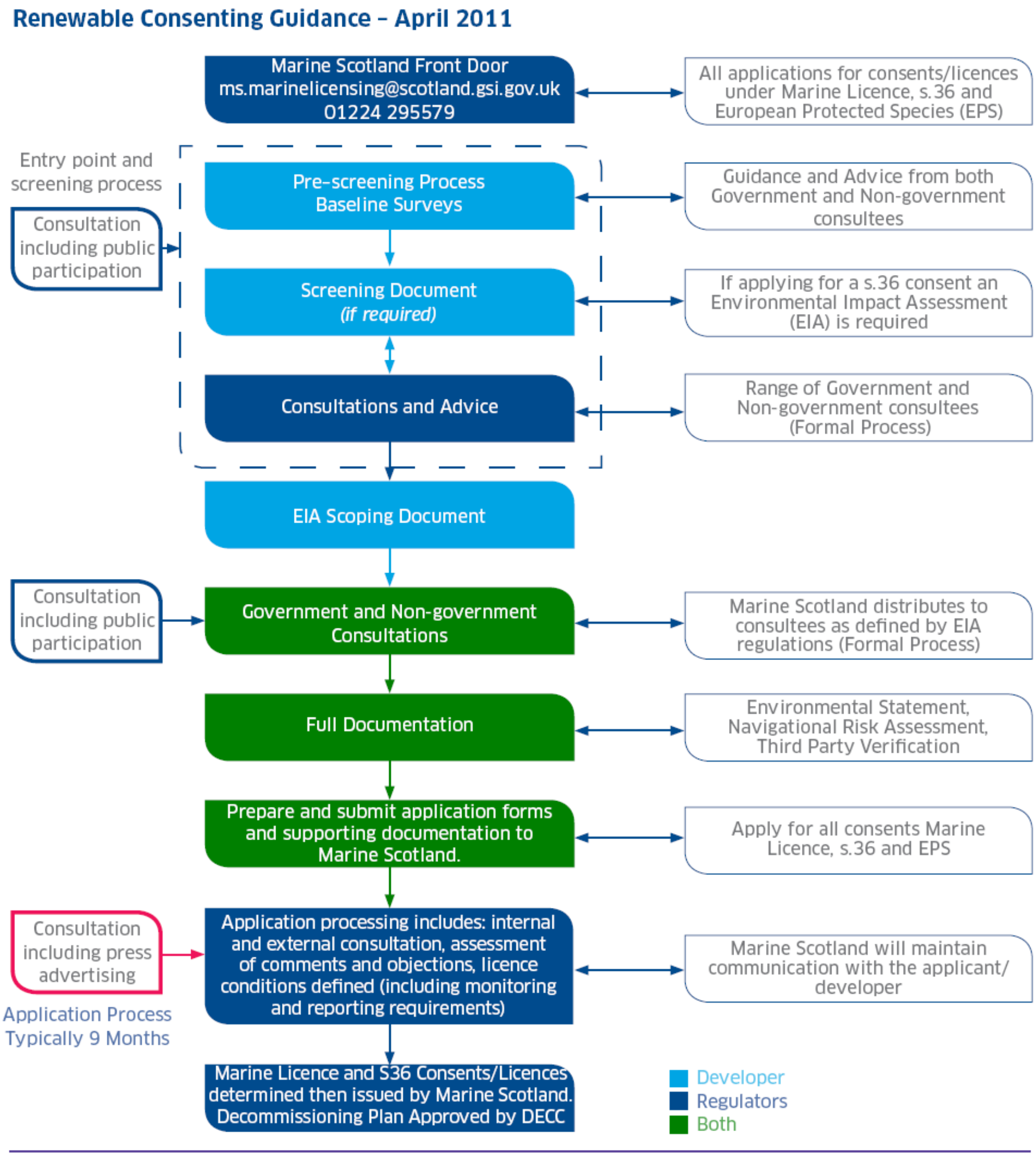


Figure 2. Requirements for / examples of participation with other marine stakeholders in decision making and revenue sharing.

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. Firstly, the planning and consenting authorities are national rather than local, and therefore do not have direct links with community-based democratic processes and accountability. Secondly, 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 on-shore 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 minimises 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 normalised 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 sea birds	400	73	29200
Areas of importance to sea birds in winter	400	73	29200
Areas of importance to marine mammals	800	145	116000

Industry Restriction Model

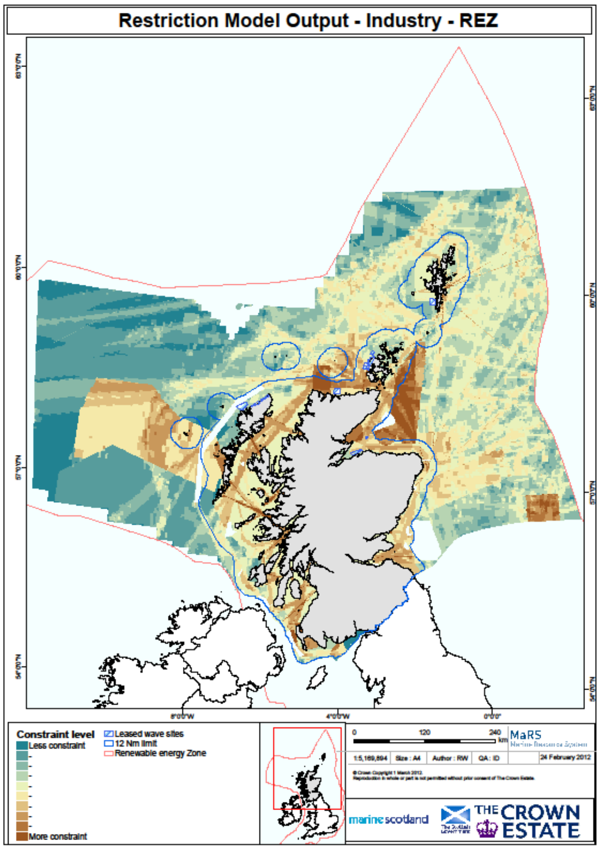
Data layer	Weight	Maximum score	Potential relative influence
Offshore cables in UK waters (not active	500	100	50000
Pipelines in UK waters (not active)	500	100	50000
Potential gas and CO_2 storage sites	800	80	64000
Carbon capture and gas storage infrastructure	800	80	64000
Current Licensed Areas for 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 minimisation 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 organisations 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 Section 4). 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 characterisation 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.

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3.2 Report for UK - England

3.2.1 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 enable DECC to put in place a coherent programme of policies across Government, led by DECC, to enable 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 recognise the timescales 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 recognising 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 km^2 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.

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.

The SOEC (Solent Ocean Energy Centre) is a tidal array testing site currently in development off the south coast of the Isle of Wight, with 5 km^2 of seabed leased from The Crown Estate to allow 20MW tidal array testing and demonstration. Although the tidal stream resource is moderate (~3m/s) this is considered ideal for testing and deployment of multiple scale devices to assess and optimise array design. The site will be grid connected and two different cable routes are currently being considered and the site is also close to port facilities. The EIA scoping report has recently been released for consultation, and there are already technology developers locating to the Isle of Wight to be near the testing centre.

Two other areas are leased by The Crown Estate in English waters. Neptune Renewable Energy trialled a 0.5 MW tidal device in the Humber Estuary in January 2012, but ceased work in early 2013 after concerns about low power output levels. A 1.6 MW tidal project by Pulse Tidal at Lynmouth, Devon, is at the planning stage.

Data on leasing areas are available from The 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 enabling 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 of 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 The 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 of 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 (DN12.1), EIA Directive (DN4.1) and the Birds and Habitats Directives (DN5.1)) are already aimed 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 Organisation (MMO) determine licensing decisions (Stelzenmüller *et al*., 2010). The tool is based on a geospatial modelling framework that combines standardised 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 standardised 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.

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 The Crown Estate)	GIS based

Research in support of sustainable wave and tidal energy development

See summaries of research projects at Annex 6.

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3.3 Report for UK - Northern Ireland

National roadmaps for wave and tidal energy development

There are no national roadmaps *per se* for wave and tidal energy development in Northern Ireland, however, there is an Offshore Renewable Energy Strategic Action Plan 2012–2020. This was published in March 2012. This incorporates the findings of the SEA and associated Habitats Regulations Assessment (HRA) and Appropriate Assessment exercises. The overall aim of the ORESAP is "to optimise 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, manager of the seabed around Northern Ireland, launched two parallel leasing rounds in December 2011 for offshore wind and tidal developments. This has resulted in the first tidal and offshore wind projects beginning to appear. Details of these projects are outlined in the next section.

Current development activities

With respect to the leasing round outlined above, DP Marine Energy (DPME) and DEME Blue Energy (DBE) hold two Agreements for Lease (AfL) from the Crown Estate for two sites. One is located in Islay off the west coast of Scotland and one relates to Fair Head on the north coast of Co. Antrim. The latter relates to a proposed 100MW development with the AfL granted in October 2012. The company take a technology neutral approach though they are currently looking at the Siemens MCT and Alstom TGL devices. DPME carry out the project management and the consenting which is currently underway. A scoping exercise was conducted in March 2013 with a view to an application being submitted in April 2014 (subject to on-going monitoring etc.). DBE will lead the construction but installation is grid-dependent. Project updates will be made available on the website as they occur (http://www.dpenergy.com/tidal/fairhead/index.html).

The second tidal project off Northern Ireland is a joint venture between OpenHydro and BordGáis Energy, established in 2010. It will also be a 100MW project to be located off Torr Head, Co. Antrim. An EIA Scoping study has been completed and published in March 2013. Further environmental baseline studies and characterisation will continue from mid-2013 to 2014 with a view to marine licence and planning permission submission subsequent to that. The project consortium has already commenced stakeholder engagement focusing in particular on fishermen operating around the area.

The offshore wind farm leased as part of the same round will be situated off the coast of Co. Down. It is proposed that the farm will have a capacity of 600MW. The successful consortium, First Flight Wind, is currently conducting studies across the whole leased area to identify a location that will meet the technical requirements and environmental constraints for the wind farm. These studies will be informed by stakeholder consultation and the whole zone characterisation process is anticipated to be complete by spring 2014. Further information can be found at http://www.firstflightwind.com/

The MCT Sea Gen 1.2 MW tidal stream demonstration project continues to operate successfully in Strangford Lough. In addition to this, Queen's University Belfast operate a tidal test centre there which uses specific locations within the Lough to simulate full-scale conditions.

Planning and consenting processes

Northern Ireland is part of wider UK initiatives on integrated marine management through the implementation of the Marine and Coastal Access Act 2009. As part of this the Northern Ireland Marine Bill has been drafted and subjected to the applicable legislative process. The Bill has gone through the First, Second and Committee stages and is currently under consideration with the latest amendments collated and published on 24th April. Progress of the Bill can be followed at http://www.niassembly.gov.uk/Assembly-Business/Legislation/Primary-Legislation-Current-Bills/Marine-Bill/. It is proposed that the new Bill provide for marine plans in relation to the Northern Ireland inshore region; marine conservation zones; and streamline marine licensing for certain electricity works. The Northern Ireland inshore region is defined as the territorial sea and the seabed adjacent to Northern Ireland, out to 12 nautical miles.

The current operational 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. This has been identified for streamlining in the NI Marine Bill and a Memorandum of Understanding between the two relevant government departments (Enterprise, Trade & Investment [responsible for energy] and Environment) was signed in early 2013.

Independently the Department of Enterprise, Trade & Investment (DETINI) published an Offshore Renewable Energy Bill in February 2013. This is to facilitate delivery of some of the objectives contained in the Strategic Energy Framework 2010, which require primary legislation. The corresponding UK legislation does not apply to Northern Ireland hence the need for dedicated NI legislation to cover the following topics:

- Safety zones around offshore renewable energy installations and prohibition of certain activities in those safety zones;
- Navigation and extinguishing of public rights of navigation in the relevant areas;
- Preparation and implementation of decommissioning programmes; and
- Consequential amendments to legislation as a result of the above measures.

The proposals for this legislation are provided in a consultation document (http://www.detini.gov.uk/offshore_bill_consultation_document.pdf). Consultation on this closed in mid-April 2013.

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3.4 Report for Ireland

National roadmaps for wave and tidal energy development

The Ocean Energy Strategy from 2006 is still the main policy covering wave and tidal energy (SEAI and MI, 2006). This was complemented by an Ocean Energy Roadmap 2050 document published in October 2010. The Roadmap takes a longer term view, to 2050, so as to 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. Also in 2010, the Department of Communications, Energy & Natural Resources (DCENR) published a draft Offshore Renewable Energy Development Plan (OREDP) 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 OREDP reflects the findings of an associated Strategic Environmental Assessment of 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. The OREDP was accompanied by a Natura Impact Statement. A final version of the OREDP is still awaiting publication but anticipated in early 2013.

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. The Galway Bay Ocean Energy Test Bedwill provides a test and demonstration platform for marine renewable energy and marine ICT. This platform will emulate a grid connection and supply power to wave energy convertors and will be accompanied by sensor packages so as to contribute to marine scientific knowledge; aquaculture, environmental monitoring, shipping, security and education. This project has been funded by Science Foundation Ireland and represents a partnership between the Marine Institute, Sustainable Energy Authority of Ireland (SEAI), SmartBay Ireland Ltd., and three third level institutions: NUI Galway, Dublin City University and the Hydraulics & Maritime Research Centre in University College Cork. A foreshore licence was applied for in early 2013. Installation is expected to start in early 2014 becoming fully operational by autumn, 2014.

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. An EIA has been completed and a foreshore lease application submitted to the Department of Environment, Community & Local Government with a decision expected later in 2013. Substantial progress has been made on sub-station and grid connection as well as work with developers. A planning application for the substation was made at the end of 2012. The current campaign of marine mammal monitoring at the test site is due to end in April 2013. In light of a recent proposed Special Area of Conservation (SAC) in the area an Appropriate Assessment is now being carried out. Marine Power Technologies Pty Ltd. (MPT) is currently working closely with SEAI in a bid to be the first wave energy developer to deploy in this site at a commercial testing scale.

Progress on the WestWave project is on-going. This project aims to be the first commercial wave energy project in Ireland by 2016 by generating 5 MW of electricity from the wave energy resource off the country's west coast. Up to €19.8m of funding has been awarded under EU NER300 wave energy category. ESBI are at an advanced stage of site selection having already completed seabed surveys, scoping reports and continuing wave measurement data assessment. ESBI continues to assess various technology options and the early steps have been taken in relation to technology procurement. Grid offers are also in place.

Carnegie Wave Energy Ltd. has applied for a foreshore licence for an area of interest between Freagh Point and Spanish Point off Co. Clare with a view to developing a potential 5 MW commercial demonstration project. The conceptual design and site project study was completed in 2011 and 50% funded by SEAI's Ocean Energy Prototype Research and Development Programme and Carnegie's Irish subsidiary CETO Wave Energy Ireland.

Planning and consenting processes

In relation to the planning and consenting process, 2013 saw the publication of a consultation paper on anew planning and consent architecture for development in the marine area (DECLG, 2013). This acknowledges the need for provision of an efficient foreshore licensing and leasing process for marine energy; streamlining of planning and regulatory processes for bringing energy reserves ashore; and the development of an integrated marine and coastal planning process in order to maximise the potential of Ireland's coastline in fishing, aquaculture, ocean energy and tourism; as contained in the current Programme for Government. Key elements of these foregoing commitments would be advanced by the development of legislation in the form of a Foreshore and Marine Area Development Bill. The options relating to the development of that Bill were outlined in a consultation paper and subject to a public consultation process that ended on 1 March. The Department of the Environment, Community and Local Government are currently working through the submissions received. It is expected that the associated legislation will be published later this year.

The Department of the Environment, Community and Local Government have also submitted an initial assessment of Ireland's marine waters to the European Commission in accordance with the provisions of the Marine Strategy Framework Directive.

Independently the Inter-departmental Marine Coordination Group has a technical working group on Maritime Spatial Planning and has commissioned a number of research studies on this topic, including a legal analysis and best practice approaches. These studies are due for completion by the end of August 2013.

In February 2013 the Irish Minister for Communications, Energy and Natural Resources and the British Secretary of State for Energy and Climate Change signed a Memorandum of Understanding on energy cooperation. The EU Directive on Renewable Energy (2009/28/EC) provides a mechanism whereby renewable energy produced in one country can not only be exported to another but can also be counted towards meeting that other country's national target. The electricity so exported is subtracted from the renewable output of the exporting state. Under the Directive, a formal Inter-Governmental Agreement between the two Member States is required, under which the Governments agree that a certain proportion of renewable energy produced in one country is counted in the other. This Memorandum of Understanding acts as a first step towards that required Inter-Governmental Agreement and will enable studies to be carried out on the economic realities of such an export regime.

Research in support of sustainable wave and tidal energy development

Galway Bay:

- The Galway Bay Test Site will be further developed to become a dedicated test and demonstration platform for marine renewable energy and marine ICT;
- The floating platform provides a low voltage grid connection point which can sink power from the wave energy convertors (WECs) or, when needed, supply power to the WECs. The platform will house a micro-grid system (~15 kW) with storage, loads and generation (from a diesel generator-set). In addition there will be a shore connection via a standard telecommunications cable, a 4.5 km fibre optic and an power cable will provide 400 V DC (3.5 kW) to the WECs and subsea sensors;
- Sensor packages will contribute to marine scientific knowledge; aquaculture, environmental monitoring, shipping, security and education;
- This project has been funded by Science Foundation Ireland (SFI) and involves a partnership of the Marine Institute, SEAI, SmartBay Ireland Ltd., and three higher education institutes: NUI Galway, Dublin City University and the Hydraulics & Maritime Research Centre, University College Cork;
- The test bed is expected to be operational by the end of 2014.

AMETS:

- Marine environmental monitoring, of marine mammals in particular, is ongoing at the test site to ensure data is up-to-date.
- A final report on the monitoring to date will be submitted to SEAI by the end of April 2013.

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

Subsequent to the EIA, additional monitoring of birds and mammals took place. Static Acoustic Monitoring was carried out in Belmullet using C-PODs for the past three years. Additionally dedicated line transect surveys and monthly land-based visual watches were conducted. Marine mammal monitoring was due to end in March 2013 with a view to having a final report submitted to SEAI by June 2013. The bird monitoring team conducted monthly boat based and land based surveys from October 2009 to present.

Interactions with other stakeholders

Galway Bay:

- As part of the foreshore licence for development of the test bed infrastructure referred to above, a public consultation exercise was carried out, which involved all stakeholders. More information on this project can be found at:

  http://www.marine.ie/home/services/operational/oceanenergy/National+Test+Facility+for+Marine+Technology+and+Ocean+Energy.htm

- No issues associated with the development have been raised to date.

Development of monitoring tools

SEAI are funding a project on acoustic monitoring for ocean energy devices which will be carried out in two phases. IBM is the lead partner with support from an Irish company, Biospheric Engineering. The aim of this project is to develop an effective solution for real-time baseline/background monitoring of underwater acoustic noise in the marine environment. Phase 1 will concentrate on the design and specifications for a functional prototype platform (buoy-based) which will be built and tested initially in a sheltered location in Galway Bay. The monitoring platform will then be deployed and tested in the Galway Bay test site in Spiddal. Phase 2 of the project will involve the build-out of a full-scale system to be deployed at AMETS, Belmullet.

The Environmental Protection Agency and the Department of Environment, Community and Local Government (DECLG) have funded a one year (2012-2013) project on Ocean Noise Mapping and Monitoring (http://oceansoundmaps.ucc.ie/). It is a collaborative project between the Coastal and Marine Research Centre (CMRC) in University College Cork and Quiet Oceans. The ultimate aim of this project is to inform the implementation of the MSFD, specifically the noise descriptor. Quiet Oceans have developed the Quonops modelling framework that will be used to model propagation of underwater noise from shipping, construction (e.g. pile driving), and seismic surveying activities. The model outputs will be calibrated with in situ measurements to produce a Noise Atlas, representative of seasonal and oceanographic situations for Irish waters. The calibrated Noise Atlas will be combined with information on the distribution and abundance of marine mammals to create 'Noise Risk Maps' for marine mammals in Irish waters, and lessons learned about the structure of the noise will assist in defining a rational approach to, and strategy for, *in situ* measurement and monitoring.

Collection of baseline data

Other:

The SOWFIA project is continuing to populate a Data Management Platform (DMP) that collates environmental and socio-economic data from seven wave energy test centres across Europe in Ireland, France, Portugal, Spain, Sweden and the United Kingdom (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. The DMP can be accessed at: http://sowfia.hidromod.com/PivotMapViewer/

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3.5 Report for Spain

National roadmaps for wave and tidal energy development

Strategy and National Targets

The Spanish Renewable Energy Plan 2011–2020[1], approved in November 2011, includes targets for ocean energy (100 MW of installed power by 2020) however, these targets seem now difficult to achieve since the Spanish Government suspended feed-in tariff support to all the new renewable energy installations from January 2012.

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 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.

Spain is part, together with Portugal, France, Ireland and UK, of the Atlantic Forum, which together with the Directorate General for Maritime Affairs and Fisheries (DG MARE) of the European Commission is developing an action plan for the Atlantic Ocean region. This action plan will have possible projects for funding to support the blue economy and develop innovative ideas to face common challenges. Marine renewable energy will be one of the key sectors to be considered in this Atlantic Strategy.

[1] **http://www.idae.es/index.php/id.670/relmenu.303/mod.pags/mem.detalle**

One Spanish region has defined specific strategies and targets for ocean energy: the Basque Government approved in December 2011 its Energy Strategy for 2020 which includes a specific initiative to speed up technology and commercial development of weave energy and sets a target of 60MW by 2020.

Support Initiatives and Market Stimulation Incentives

The Spanish Renewable Energy Plan 2011–2020 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 for its stage of development.
- Planning of grid infrastructures to facilitate ocean energy integration.
- General dissemination and promotion campaigns amongst different stakeholders to improve social acceptance and to facilitate a new market.

Main Public Funding Mechanisms

The first Royal Decree of the Spanish Government in 2012 has meant a serious step back for ocean energy development with the suspension of the support through feed-in tariffs to all the new renewable energy installations.

The future of ocean energy in Spain would need key public support mechanisms, which are already outlined in 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 Legislation and Regulation

Apart from the Renewable Energy Plan and the suspension of feed-in tariffs, there are no additional changes in the current Spanish legislation regarding ocean energy: a

Royal Decree from 2007 establishes the administrative procedure to apply for an authorization for electricity generation installations at sea.

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 resource[2].

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 Armintza (Bizkaia), offers suitable wave conditions for device testing and a relatively low exposure to extreme waves that could damage the prototypes. BIMEP occupies a 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 authorisation 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, in November 2012 the first works started with the horizontal drilling for the installation of the submarine power cables.

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

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[2] http://www.idae.es/index.php/mod.documentos/mem.descarga?file=/documentos_11227_e13_olas_b31fcafb.pdf

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 modeling.

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. As expected, the first prototype has been successfully deployed in October 2012 at PLOCAN's test site (Gran Canaria) for operational assessment. This prototype will have grid connection by the end 2013 when the electrical infrastructure of PLOCAN is available.

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 design, build and deploy a new wave energy converter prototype with a capacity of 150 Kw connected to the grid by the end 2013 when the electrical infrastructure of PLOCAN is available. After completion of the mechanical and electrical design phase during 2012, as well as the studies related to the operation site, deployment is expected by October 2013.

AbencisSeapower 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 ¼-scale prototype will be used to design a demonstration power plant in the Atlantic Ocean during 2012.

Ocean Power Technologies (OPT) is developing a new wave energy device (PowerBuoy®) in the Spanish coast under the WavePort EU project. On this project, OPT is collaborating in a consortium with University of Exeter, UK Intelligent Systems Research Institute, FugroOceanor, Wave Energy Centre (WavEC) and Degima SA. The project will build, deploy and demonstrate a commercial scale PowerBuoy® Wave energy Converter with an innovative Real Time Wave by Wave Tuning System. Forward knowledge of the approaching wave-train delivered by the prediction system will allow advanced control of the PowerBuoy®, recovering more energy from the ocean and substantially improving the device efficiency. This will drive down the levelised cost of energy. The project is well progressed and the consortium forecasts deployment of the PowerBuoy and completion on the sea trials during 2013 and 2014.

Within the OceanLider project, NorventoEnerxía (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.

Abengoa (MCE: ABG), an international company that applies innovative technology solutions for sustainable development in the energy and environment sectors, has set up a new business unit for ocean energy: AbengoaSeapower. One of the first activities of AbengoaSeapower has been its participation in the launch of Nautimus, the first ocean energy engineering firm. Nautimus, based in Scotland, is the world's first engineering Services Company dedicated to wave and tidal energy. It has been established by Vattenfall, with support from Babcock and Abengoa. The company will fulfil the engineering, procurement, integration and construction (EPC) needs of wave power and tidal stream projects on behalf of utility clients.

Galicia Mar Renovables (GMR): During 2009, GMR tested in Ares Sea (A Coruña) a scaled 1:10 prototype of its wave energy converter: a floating point absorber with mechanical PTO. The next steps were the development and installation of a full-scale device in 2010 and a preindustrial prototype in summer 2011. This prototype generated 184 kWh with an installed capacity of 250 kW during some trials without optimal sea conditions. These tests were partially funded by the Spanish Ministry of Industry, Energy and Tourism. In 2012, GMR started the consenting process to install two wave energy farms in Ferrol and Gijón, including an agreement between GMR and InstitutoEnerxético de Galicia (INEGA). The Ferrol wave power plant is expected to be in operation in 2014.

The Ukrainian company KROK-1 has started the first steps for the installation of a wave power plant in Spain. The so called VOWEPP project is based on a wave energy concept with a range of relevant differences to other existing concepts and has been patented in Ukraine (patent №56481). It consists of a floating device with relative movements produced by hydrodynamic pressure that creates a torque on a working shafts connected to an electrical generator. The VOWEPP project has as main advantages a flexible energy-absorbing system that constantly changes its parameters under the influence of incoming waves of different period and height and high reliability in strong sea storms. These advantages lead to high efficiency conversion rates with low material use (up to 100 kg per kW) and low level of investment costs and cost of energy. More information available at www.vowepp.com.

UHINDAR, a new R&D project on wave energy has been approved by the Basque Government under its ETORGAI programme in 2012. The project is also led by "IberdrolaIngeniería y Construcción" with the participation of eight leading Basque companies: OCEANTEC Energias Marinas, Guascor Power, Ingeteam Power Technology, Itsaskorda, JEMA Energy, Obeki Electric Machines, VicinayCadenas and Corporacion ZIGOR, and the collaboration of TECNALIA as the main R&D subcontractor. The so called UHINDAR project, with a budget of 8 million Euros, aims at developing a floating wave energy converter and defining the electric infrastructure and mooring systems for a complete wave energy farm. In December 2012, the first wave tank trials of a small scale device have been performed.

Planning and consenting processes

Strategic Environmental Assessment (SEA)

An SEA for the offshore wind energy plan was completed in 2009[3]. An SEA of the Spanish Renewable Energy Plan 2011–2020 is currently underway[4].

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 41/2020 establish that any activity that intend to install facilities in the sea or in the seafloor 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 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

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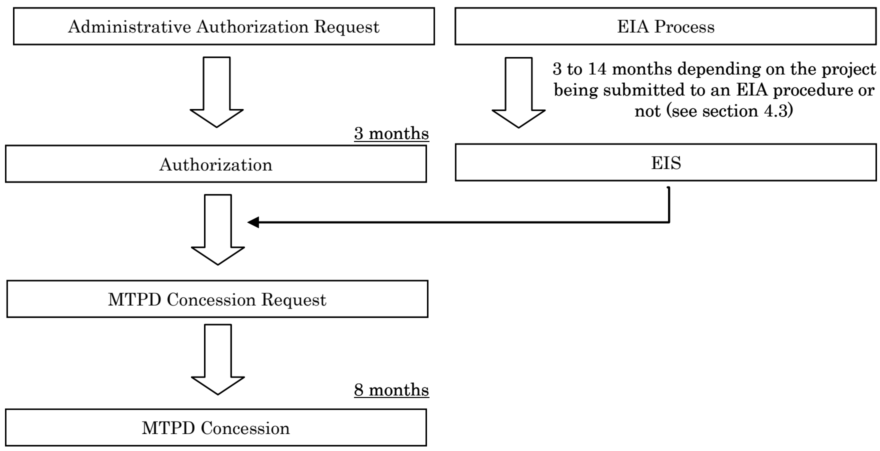
[3] http://www.minetur.gob.es/es-es/gabineteprensa/notasprensa/Paginas/Mapaeolicomarino200409.aspx

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

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 (EISt) 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 o Subdelegations 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 o 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 Policy 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.

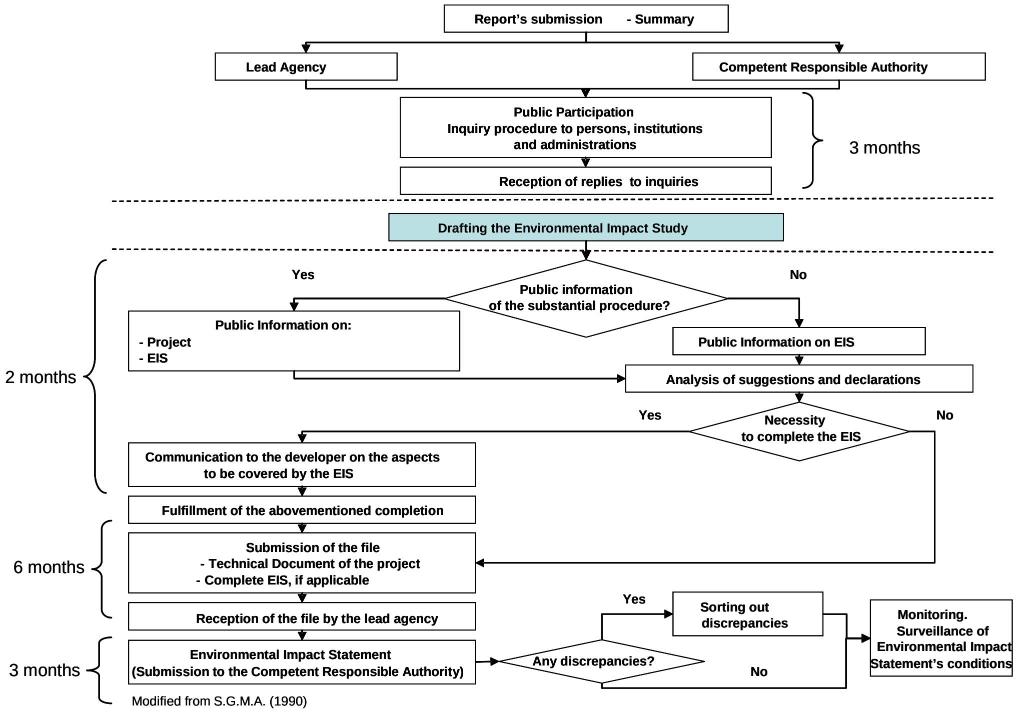
b) Determination of Environmental Impact Study (EIS) scope.

c) Development of EIS.

d) Public information and inquiries.

e) Environmental Impact Statement (EISt).

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



Modified from S.G.M.A. (1990)

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)

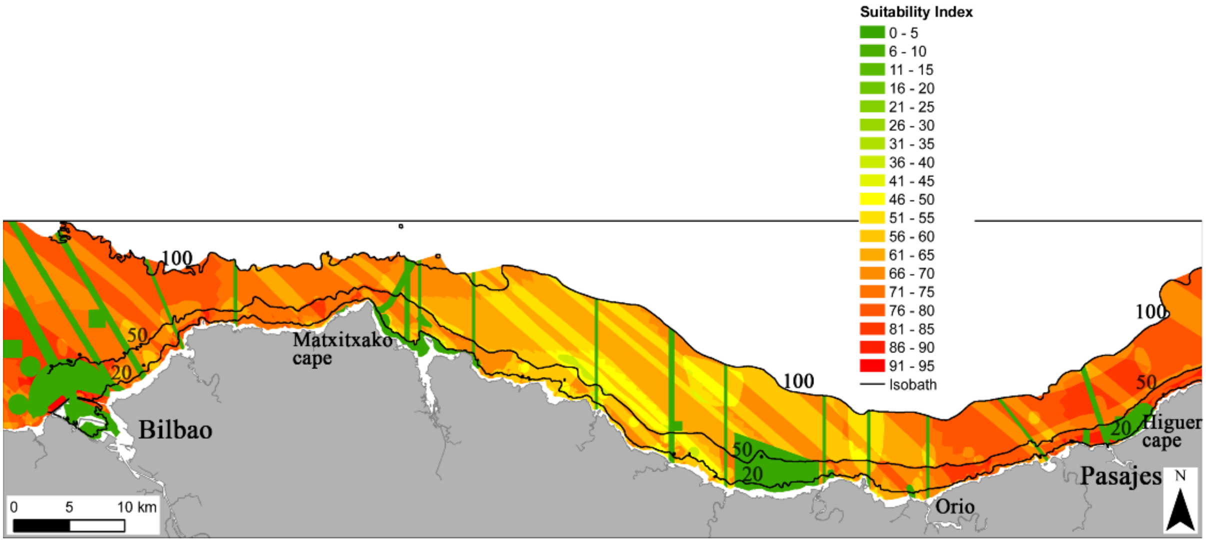
Supported by the Basque Energy Agency (EVE) and the European MESMA project (Monitoring and Evaluation of Spatially Managed Areas: 7th Framework Programme, Grant Agreement no: 226661), as far as we know, the unique place in Spain were a MSP approach for the installation of wave energy converters has been 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 socioeconomic 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 CO_2 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 (cofradias[5]) and environmental NGOs, amongst others.

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

[5]Spanish *cofradias* (fishing guilds) are institutions with and 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 *cofradias* 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 *cofradias*. It is a clear distinction between *cofradias* and other organizations such as boat owners associations or producer organizations. The *cofradias* are related exclusively to coastal fisheries while the other organizations deal with industrial fisheries. The *cofradias*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 and time closures. The rights of *cofradias* can be considered a form of territorial use rights in fisheries (TURFs).

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.

Once authorisation 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, in November 2012 the first works started with the horizontal drilling for the installation of the submarine power cables.

In 2011, the Promoter (EVE) proceeded to tackle the final step and obtain the concession of marine-terrestrial public domain which was granted on the 6th of February 2012.

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 to 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, fishermen 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 fishermen are still in progress and the compensation mechanism is yet to be defined.

The outcomes of the different consultation process have proved 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. Secondly, 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%202%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 “IberdrolaIngeniería y Construcción”, includes several R&D activities with a holistic perspective, covering the following research lines:

- identification and characterisation 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. Within the OceanLider project, companies such as NorventoEnerxía or a Cantabrian consortium coordinated by CT-Innova are developing their own concepts of wave energy converters.

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 provides data about 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 maximising 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 Network) 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.

The Spanish marine renewable energy sector has begun to benefit from MaRINET:

- A collaborative project on corrosion was approved under the first MaRINET Call. The project deals with the assessment and mitigation of marine corrosion in metallic components for marine energy devices and is led by CTC with the participation of CSIC-CENIM and TECNALIA.
- CT-INNOVA has tested a pendulum wave energy device, developed within the OceanLider project, in the wave tank of Aalborg University.
- EnerOcean tested sensor encapsulations for tidal devices installing 12 prototypes at Fraunhofer IWES in Helgoland. EnerOcean also supported the testing of the W2Power combined wind and wave concept through model testing at the University of Edinburgh curved wave tank, in the framework of long term collaboration with a Norwegian company that will continue with additional testing during 2013.

Spanish leadership in offshore multi-purpose platforms (MARINA)

With the leadership of the Spanish company AccionaEnergia, 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 optimisation 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 presently known proposed designs including (but not limited to) concepts originated by the project partners, to produce two or three realisations 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, www.troposplatform.eu) 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.

H2O2

The Spanish company AWS Truepower is leading the H2OCEAN project (www.h2ocean-project.eu) aimed at developing a wind-wave power open-sea platform equipped for hydrogen generation with support for multiple users of energy and uses such as multi-trophic aquaculture. The project started in January 2012, will run for 3 years and is also funded under the Ocean of Tomorrow 2011 call.

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, and 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 on-going 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 U.S. has the lead for Annex IV; and the U.S. 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 U.S. 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 (Tethys) 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 Centre/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.

EurostarsE!4449 Q-Sail (Qualification of sail-based power plant for production of electricity from the renewable energy of tidal streams)

Eurostars E!4449 Q-Sail, focused on the qualification of a tidal energy device based on sails. EnerOcean role was mainly in the first installations sites assessment and in the marinization and reliability aspects of the design. EnerOcean was supported by University of Cadiz and University of Málaga during the three years of this project. The project was approved in January 2009 and has a duration on 44 month and a cost of 3,5M€.

TidalsenseDemo

TidalsenseDemo (a FP7 project for SMEs funded in the 2011 call) is a 3 M€ demonstration project where the results of the previous research project Tidalsense(SME-2008-1 call, GA 232518) will be demonstrated in working tidal devices. The TidalSense Demo project is an industrial effort owned and led by a group of European technology SME's that aims to demonstrate a robust and efficient Condition Monitoring System (CMS) for the emerging tidal stream power industry. EnerOcean is one of the leading companies of a 12 entities consortium coordinated by InnotecUK, and that includes also the University of Cadiz. The project started in February 2012. In November 2012, EnerOcean participated in the sensor installation in Nautricity prototype which will be installed at EMEC in January 2013.

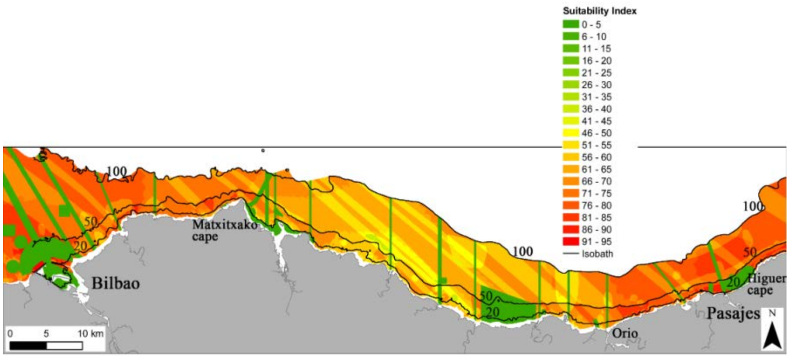
Decision-support tools

In Spain there are not 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).

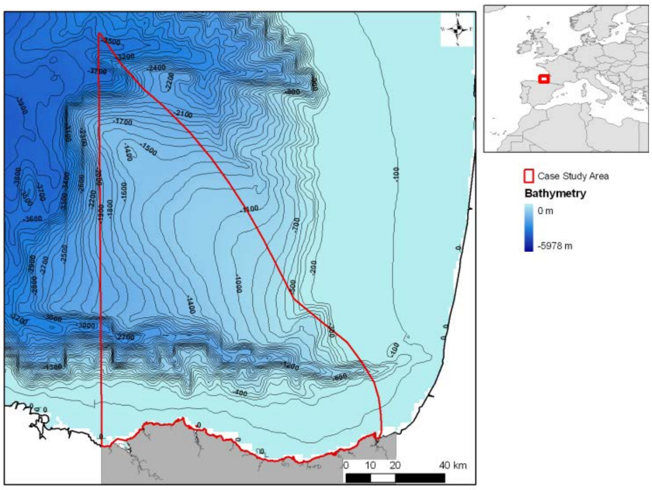
Galparsoro, I., Liria, P., Legorburu, I., Bald, J., Chust, G., Ruiz-Minguela, P., Pérez, G., Marqués, J., Torre-Enciso, Y., González, M., and Borja, A. 2012. A Marine Spatial Planning approach to select suitable areas for installing wave energy converters on the Basque continental shelf (Bay of Biscay).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

In Marine Spatial Planning seventeen information layers (among them 10 technical, 4 environmental, and 3 socioeconomical 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 south-eastern 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 Application of Integrated Ecosystem Approaches to management of renewable energy activities in the marine environment (ToR c)

4.1 Relevance of marine renewable energy to ecosystem services

A central concept for Ecosystem Approaches to management is Ecosystem Services, defined by Fisher & Turner (2008) as "aspects of ecosystems utilized (actively or passively) to produce human well-being". In an attempt to provide a first framework for examining the relevance of marine renewable energy to the application of an Ecosystem Approach to marine environmental management, SGWTE considered the potential interactions of MRE with Ecosystem Services categorised by Provisioning, Regulating and Cultural Services. The potential services have been adapted from tables produced by the Wales Environment Research Hubb (see Pagella and Russell, 2012). Relevance has been scored on a three point scale from some relevance (x) to highly relevant (xxx). Where appropriate, interactions have been identified with Good Environmental Status (GES) descriptors under the Marine Strategy Framework Directive (MSFD), which provides a legislative framework for the application of the Ecosystem Approach to the management of human activities which supports the sustainable use of marine goods and services. Annex 1 provides a list of eleven high level descriptors of GES:

1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
3) Populations of commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4) All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

5) Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.

6) Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

8) Concentrations of contaminants are at levels not giving rise to pollution effects.

9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.

10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

PROVISIONING SERVICES

Service	MRE interaction	Wave	Tidal Stream	Tidal barrage	Offshore wind	GES descriptors
Food (aquaculture)	Co-location potential				xx	3,4,9
	Habitat enhancement				xx	1,3,4
	Reduction in intertidal area for shellfish lays			xxx		3,4
Wild collected food (fisheries, wildfowl)	Habitat enhancement	x	x		xx	1,3,4
	Fish damage and mortality through collision		xx	xx		3
	Opportunities for NTZ, MPA and spatial management	xx	xx		xxx	1,3,4
	Reduction in intertidal area for shellfish production			xxx		3,4
	Loss of shooting for wildfowl			xx		4
	Barriers to migration			xx		1,4
Fuel	-					
Fibre	-					

PROVISIONING SERVICES						
SERVICE	MRE INTERACTION	WAVE	TIDAL STREAM	TIDAL BARRAGE	OFFSHORE WIND	GES DESCRIPTORS
Natural fluxes of energy	Wave shadowing	xx	x	xx	x	7
	Changes in large scale circulation patterns		xx	xxx		7
	Changes in wave climates	xxx		x		7
	Changes in tidal heights	x	x	xxx		7
Water	-					
Bio-chemicals and medicines	-					
Genetic resources	Via other mechanisms (e.g. changes in currents affecting transport of larvae)		x	x		1
Other (abiotic) raw materials	Availability of sea areas for aggregate extraction	x			xx	6
Navigation	Barriers to navigation (on, below and above the sea)	xx	xx	xx	xxx	
	Radar shadow				xxx	

REGULATING SERVICES						
SERVICE	MRE INTERACTION	WAVE	TIDAL STREAM	TIDAL BARRAGE	OFFSHORE WIND	GES DESCRIPTORS
Climate regulation (local)	Alterations to local wind speeds				xx	
Climate regulation (global)	Decarbonisation	x	x	xxx	xxx	
	Shelf and oceanic scale changes in circulation patterns		x	xx		7
Water regulation	Flood control			xx		7
	Flood risk affected by changes in tidal heights	x	x	xxx		7

REGULATING SERVICES

Service	MRE interaction	Wave	Tidal Stream	Tidal barrage	Offshore wind	GES descriptors
	Flood risk affected by changes in coastal processes	x	x	xx	x	7
Water, air and soil quality regulation	Sedimentation effects on water and intertidal sediment quality			x		7,8
Hazard regulation (erosion control)	Changes in coastal processes (sediment transport and deposition)	x	x	xx	x	7,8
	Increased local scour	xx	x		xxx	7
	Coastal protection	xx	x		xx	7
Disease and pest regulation	Spread of alien species	x	x		xx	2
Pollination	Changes in circulation patterns affecting transport of sea grass pollen		x	x		7
Waste assimilation	Effects on sediment dynamics			x		7,8
Noise regulation	Underwater noise	xxx	xxx			11

CULTURAL SERVICES

Service	MRE interaction	Wave	Tidal Stream	Tidal barrage	Offshore wind	GES descriptors
Natural settings (landscape and seascape)	Changes in estuary or seascape	x	x	xxx	xxx	
	Changes in coastal landscapes from onshore infrastructure	xx	xx	xxx	xx	
Accessible Green and Blue Space	Onshore infrastructure affecting access and footpaths	x	x	x	x	10
	Access and navigation across sea areas	xx	x		xxx	10

CULTURAL SERVICES						
Service	**MRE interaction**	**Wave**	**Tidal Stream**	**Tidal barrage**	**Offshore wind**	**GES descriptors**
Recreation and tourism	Surfing affected by changes in wave climate	xx		x		7,10
	Improved sea angling opportunities	x	x		xx	1,3,10
	Effects on river and estuarine angling resource			xx		1,3,10
	Scientific tourism	xx	xx	xx	x	10
	Via effects on natural settings	xx	xx	xxx	xxx	10
	Effects on recreational boating opportunities	x	x	xxx	x	10
	Increase mobility from river estuary crossings			xxx		10
Nature and wildlife (appreciation of)	Operational noise and collision impacts on wildlife populations	x	xx	xxx	x	1,4,11
	Attraction of wildlife to marine infrastructure	x	x	x	x	1,4
	MPA effects on wildlife distribution and abundance	x	x		xx	1,4
Tranquillity	Noise during construction and maintenance	x	x	xx	xx	11
	Landside development activities	xx	xx	xxx	xx	8
	Land transport to sites	x	x	x	x	8
Historical and cultural heritage	Effects on drowned landscapes	x	x		x	
	'Underwater Cultural Heritage' (including wrecks)	x	x		x	

CULTURAL SERVICES						
SERVICE	MRE INTERACTION	WAVE	TIDAL STREAM	TIDAL BARRAGE	OFFSHORE WIND	GES DESCRIPTORS
	Unexploded ordnance	x	x	x	x	
	Effects on coastal archaeology from onshore infrastructure and coastal protection	x	x	x	x	
Spiritual and religious values	Linked to effects on historical and cultural heritage	x	x	x	x	
	Effects on appreciation of land- and seascapes	x	x	xx	xx	
Educational and scientific opportunities	Research and co-use platforms	xx	xx	x	xx	
	Scientific tourism	xx	xx	xx	x	
	Education about decarbonisation	xx	xx	xx	xx	
	Marine monitoring	x	x	x	xxx	
	Informing better management	x	x	x	x	
	Learning from testing activities	xxx	xxx		x	

4.2 Structured approaches to risk analysis and ecosystem based management of marine activities

The Canadian Department of Fisheries and Oceans (DFO) is taking a lead in the development of structured approaches to risk analysis and ecosystem based management of marine activities. Information has been received from Roland Cormier that:

DFO is going ahead with the development of an ecosystem approach to management for all its program. It will largely use the risk management handbook being published as an ICES CRR [Cormier et al., 2013]. Further work will develop a set of ecosystem management outcomes, risk criteria for decision-making and a series of standardized regulatory and policy risk evaluation models using the BowTie ISO 31010 tool.

The BowTie is discussed in section 7.2.2 of the ISO 31010 handbook. The BowTie approach is basically a threat assessment which includes an assessment of existing management measures to identify management gaps or needs for enhancements. We are planning a collaboration with Alberta Department of the Environment to develop a national standardized BowTie template for coastal and oceans management for 2013-14. We are considering using MSFD GES Descriptors as the basis for ecosystem management outcome statements.

See Annex 7 below for more information on the development of this approach by DFO in Canada.

SGWTE considered that this was a very helpful approach to bringing together pressures from diverse sources and activities, but which all resulted in pressure of a similar nature affecting one or more desirable environmental characteristics such as those addressed by MSFD GES Descriptors. The position of wave and tidal energy developments, and their associated pressures, is often not well addressed in EIA or SEA documentation, and the potential impacts from renewable energy developments are often not placed into the context of existing or historical activities. The extension of the drivers (left hand extreme of the BowTie diagrams) to include renewable energy is not conceptually difficult and SGWTE supported the development of BowTie diagrams for other ICES countries, to include offshore energy where renewables projects are being considered

4.3 Risk Analysis – Short Canada and UK Comparative study

The requirements set by EU Directives e.g. Marine Strategy Framework Directive and Natura 2000 Regulations require an ecosystem-based approach to managing the marine environment. The Centre of Expertise on Coastal Management, based at the Gulf Fisheries Centre, Canada, has led the production of a detailed risk analysis framework as an ICES Cooperative Research Report (Cormier *et al.*, 2013). Marine Scotland, through the UK Natural Environment Research Council, has reviewed the ICES CRR to identify the strengths and limitations of the Ecosystem-based Risk Management Framework (EBRMF) that it describes with respect to the management of the environmental impacts of the marine renewable energy industry within Scottish waters (see Annex 8, below).

The ecosystem based risk analysis procedure and Habitats Regulations Appraisal (HRA) were mapped out, allowing for similarities and differences to be clearly distinguished. Case studies were reviewed to facilitate a more detailed comparison of the two systems and how they operate. Taking account of the differences and similarities between the two frameworks, the potential for an ecosystem-based risk management framework to operate in Scotland was discussed.

The key differences between the EBRMF and HRA were identified to be the objectives, assessments methods, communication/responsibility and spatial boundaries. The established and well managed connection between DFO and the scientific community, via CSAS, provides an effective and comprehensive decision making process, built on good knowledge of both environment and industry. The establishment of well-defined and separately managed large ecoregions is key to effectiveness of the EBRMF in Canadian waters, allowing a regional to both the definition of conservation objectives and the management of impacts.

In contrast, the HRA process is effectively a risk assessment activity, and therefore broadly equivalent to the (SSRP) process in the EBRMF. However, the HRA process is based on assessment of the potential and actual impacts of developments on defined protected sites of relatively small dimensions, primarily Special Areas of Conservations (SACs) and Special Protection Areas (SPAs), i.e. Natura2000 sites. Implementation of the Natura Regulations requires considerable effort to establish the degree of connectivity between the development site and relevant Natura sites. This has been found to be possible in some circumstances, such as central place foragers (e.g. breeding seabirds) but very difficult in other circumstances (e.g. dispersed seabirds outside the breeding season).

These fundamental differences between approaches to area and species management and protection lead initially to incompatibilities between the Canadian and European (UK) system for managing human impacts. An approach that utilises aspects of both could improve the effectiveness and practicality of licensing and environmental conservation.

References

Cormier, R., *et al*. 2013. Marine and coastal ecosystem-based risk management handbook. ICES Cooperative Research Report No. 317. 60 pp.

Fisher, B. and Turner, R. K. 2008. Ecosystem services: Classification for valuation. Biological Conservation, 141: 1167–1169.

Pagella, T., and Russell, S. 2012. Tools for application of the ecosystem approach – Sustainable Futures. Wales Environment Research Hub.

5 Proposed new ICES Working Group on Marine Renewable Energy

A recommendation of SGWTE in 2012 was that a new Working Group on marine renewable energy should be established to coordinate the flow of science from topic-based working groups to its application in a management context. SGWTE 2012 noted a wide range of interest in marine renewable energy across ICES Expert Groups, including topics such as diverse as mammal, benthic, seabird and fish ecology, marine spatial planning, aquaculture, hydrography, ocean observing, and ecosystem modelling and assessment. It was clear that these groups are interested in offshore wind and tidal barrages as well as the emerging wave and tidal stream technologies that have been the focus of SGWTE, and any new Working Group on marine energy should include the whole range of marine renewable energy technologies within its remit.

At its 2013 meeting SGWTE agreed that there is a need for a new Working Group that would include within its remit the synthesis of advice, reports and recommendations of other Expert Groups with respect to marine renewable energy. SGWTE recommends the establishment of a Working Group on Marine Renewable Energy (WGMRE) to meet for the first time in 2014 at Pasajes in Spain, chaired by Finlay Bennet of Marine Scotland, UK. A draft Category 2 resolution for multi-annual Terms of Reference is included at Annex 3 of this report. Proposed Terms of Reference for WGMRE are:

a) Provide summaries of the state of development of the marine renewable energy sector, covering offshore wind energy, in-stream tidal energy, wave energy and tidal barrages, updated on an ongoing basis, and including 'horizon scanning' to identify future issues for marine environmental management;

b) Report on developments in consenting procedures for marine renewable energy;

c) Report on the development of decision-support and management tools for planning and regulation of marine renewable energy developments, considering the relevance to new technology, cumulative effects and the application of risk-based ecosystem approaches to management;

d) Identify cross-sectoral issues involving marine renewable energy, for example opportunities for co-location, interactions with fishing, aquaculture, fisheries and Marine Conservations Zones;

e) Foster strong collaborative working relationships with other ICES Expert Groups, integrating recommendations across topic areas and identifying priority issues and science applications for thematic ICES Workshops based on regulatory and planning needs in relation to marine renewable energy.

Outputs from WGMRE would be in the form of live documents, databases and GIS outputs providing the ICES community with up-to-date information on the state of development of the marine renewable energy sector, associated environmental research activities and on planning, consenting and management procedures. Through collaborative work with other ICES Expert Groups, and particularly through thematic ICES Workshops, WGMRE would produce Cooperative Research Reports synthesising the available science on issues such as collision risks, management of noise impacts on marine mammals, integration of marine renewable energy in marine spatial planning and development of Marine Protected Areas.

Annex 1: List of participants

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Annex 2: Agenda

Agenda for SGWTE 2013, University College Cork, Cork, Ireland

TUESDAY 19 MARCH	
10:00	Arrival and coffee
10:30	Introduction and Terms of Reference
11:00	Links with other ICES groups
11:30	Special edition of *Ocean and Coastal Management* on wave and tidal energy
12:00	Updates on Country Reports for ICES nations (ToR a) – 15-20 minute presentation for each country, summarising: • state of development of wave and tidal energy industry; • associated environmental research programmes.
13:00	Lunch
14:00	Country report updates
15:30	Break
16:00	Discussion on database and bibliography formats for dissemination of data from country reports
17:00	Agree agenda for Wednesday and Thursday

Wednesday 20 March	
9:00	Arrival and coffee
9:15	Integrated Ecosystem Approaches to management of marine renewable energy (ToR c): • introduction to Integrated Ecosystem Approaches; • issues and applicability to marine renewable energy; • approaches used in ICES nations and worldwide.
10:45	Break
11:15	Individual work time (Country Reports, databases and bibliographies) and assignment of writing
13:00	Lunch
14:00	Customers for ICES science on marine renewables (ToR d): • review of relevant ICES groups; • review of customer groups – OSPAR, HELCOM, other commissions; • mechanisms of interaction.
15:30	Break
16:00	Individual work time
17:00	Round-up of progress and work plans for Thursday

Thursday 21 March	
9:00	Arrival and coffee
9:15	Plan for the day, identifying outstanding work tasks
9:30	Individual work time
10:30	Break
10:45	Proposed new ICES Working Group on Marine Energy (ToR b): • need for and roles of WGMRE; • interactions with other ICES Expert Groups; • identify priorities for theme workshops; • draft Terms of Reference and propose venue for WGMRE 2014 (Pasajes,

	Spain suggested); • propose Chair for WGMRE.
12:45	Round up, and agree plans for completion of SGWTE 2013 report
13:00	Meeting close Lunch and departure
14:00	Opportunity for additional individual work time

Annex 3: Multiannual Terms of Reference for a proposed new Working Group on Marine Energy

A **Working Group on Marine Renewable Energy** (WGMRE), chaired by Finlay Bennet, UK, will meet in Pasajes, Spain, xxx 2014, to work on ToRs and generate deliverables as listed in the Table below.

WGMRE will report on the activities of 2014 (the first year) by xxx 2014 to SSGHIE.

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Provide summaries of the state of development of the marine renewable energy sector, covering offshore wind energy, in-stream tidal energy, wave energy and tidal barrages, updated on an ongoing basis, and including 'horizon scanning' to identify future issues for marine environmental management	a) Science Requirements: the marine renewable energy sector is rapidly emerging as a new user of marine space. There is a need for up-to-date, spatially explicit information on developments and on current research activities to determine potential interactions with ecosystems and other sea users. b) Advisory Requirements: Advice to OSPAR and other customers requires access to latest research outcomes and experience of developments in this emerging science area. c) Requirements from other EGs: marine renewable energy developments will impact or interact with topics considered by other EGs, for example marine mammals, seabirds, benthos.	231,232,233	3 years	Live documents, database system and GIS outputs on marine renewable energy developments and associated research, updated and extended annually.
b	Report on developments in consenting procedures for marine renewable energy	As above	231,232,233	3 years	Live document, updated and extended annually

c	Report on the development of decision-support and management tools for planning and regulation of marine renewable energy developments, considering the relevance to new technology, cumulative effects and the application of risk-based ecosystem approaches to management	As above	231,232, 233, 312, 313, 314, 331, 333, 335, 341, 344	3 years	Live document, updated and extended annually
d	Identify cross-sectoral issues involving marine renewable energy, for example opportunities for co-location, interactions with fishing, aquaculture, fisheries and Marine Conservations Zones	As above	231, 232, 233, 331, 335, 341	1 year	Individual fact sheets on expected interactions and issues by sector, for use by other EGs and ICES customers. Produced in year 2.
e	Foster strong collaborative working relationships with other ICES Expert Groups, integrating recommendations across topic areas and identifying priority issues and science applications for thematic ICES Workshops based on regulatory and planning needs in relation to marine renewable energy	As above	Numerous, including 111, 122, 162, 231,232, 233, 243, 251, 312, 313, 314, 331,333, 334, 342, 343	3 years	Links established during year 1, Workshops held during years 2 and 3, CRRs produced as Workshop outputs.

Summary of the Work Plan

Year 1	- Agree the form of report, database and GIS outputs for ToR a, integrating information collated by SGWTE on development and research activities. - Draft summary reports on consenting processes and decision support tools by country (ToRs b & c). - Invite chairs and members of other EGs to participate in the WG meeting and otherwise identify cross-cutting issues; review relevant material in other EG reports. - Propose the first topic-based Workshop, jointly with one or more other EGs. - Review multi-annual ToRs for years 2 and 3 and adjust as appropriate.

Year 2	- Update and extend database, GIS outputs and reports on ToRs a, b & c. - Based on collaborations with other EGs, develop fact sheets on cross-sectoral interactions. - Plan and hold the first topic-based Workshop, with the outcome reported as a CRR. - Propose the second topic-based Workshop, jointly with one or more other EGs. - Review progress against multi-annual ToRs and adjust as appropriate for year 3.
Year 3	- Complete database, GIS outputs and reports on ToRs a, b & c. - Plan and hold the second topic-based Workshop, with the outcome reported as a CRR. - Identify science, advisory and other EG needs for continuation of WGMRE activities and formulate multi-annual ToRs as appropriate.

Supporting information

Priority	The activities of this group will promote the capacity of ICES to provide integrated advice and information on potential ecosystem impacts and management of marine renewable energy activities in the marine environment, especially with regard to Marine Spatial Planning and Integrated Coastal Zone Management. Consequently, these activities are considered to have a very high priority
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 marine renewable energy resources, environmental and socio-economic aspects of marine planning and regulation, and will include representatives of other EGs as appropriate.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There will be a very close working relationship with all the groups of SSGHIE. Close collaborative links will be made with a number of other EGs, notably WGMME, BEWG, WGMPCZM and WGSE.
Linkages to other organizations	OSPAR is interested in this issue.

Annex 4: Recommendations

Recommendation	Adressed to
1. SGWTE recommends the establishment of a new ICES Working Group on Marine Renewable 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.	SCICOM, SSGHIE

Annex 5: Summary information on wave and tidal energy developments

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Npower Siadar - Lewis</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>NW Lewis</td><td>Latitude (decimal):</td><td>58.42</td><td>Longitude (decimal):</td><td>-6.48</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td>Oscillating wave surge converter</td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="2">Total installed capacity (MW):</td><td>4MW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km²):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Consented to be built</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Aquamarine Power Ltd - Oyster 2 B & C</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>EMEC Billia Croo</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td></td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="2">Total installed capacity (MW):</td><td>1.6MW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="2">Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Consented to be built</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

<table>
<tr><td colspan="6">Country: UK (Scotland)</td></tr>
<tr><td colspan="6">Development: AlbaTern - EMEC</td></tr>
<tr><td colspan="6">Web-link:</td></tr>
<tr><td colspan="2">Location name: EMEC</td><td colspan="2">Latitude (decimal):</td><td colspan="2">Longitude (decimal):</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td colspan="2">Device type:</td><td colspan="2">Anchor type:</td><td colspan="2">Mooring strings:</td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="3">Total installed capacity (MW):</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km^2):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Undertaking EIA</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

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 (km^2):**	
Environmental data collected:			
Consenting process: Consented to be built, but redesign work in progress			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Scapa Flow - EMEC</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>EMEC</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td></td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="3">Total installed capacity (MW):</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km²):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Consented to be built</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:
This is a low energy wave site for the testing of deployment methods, scaled devices etc. The licence is generic, and can be applied to a wide range of device types</td></tr>
</table>

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 (km^2):**	
Environmental data collected:					
Consenting process: Consented to be built					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Nova Innovations -Bluemull Sound Shetland</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>Shetland</td><td>Latitude (decimal):</td><td>60.7</td><td>Longitude (decimal):</td><td>-0.98</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td>Horizontal axis turbine</td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="2">Total installed capacity (MW):</td><td>30KW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km²):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Phase 1 consented to be built. Phase 2 undertaking EIA.</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
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<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Aquamarine Power Ltd - Lewis</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>NW Lewis</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td></td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="2">Total installed capacity (MW):</td><td>40MW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="2">Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Awaiting Ministerial decision</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

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: Licence granted					
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 (km^2):**		
Environmental data collected:					
Consenting process: Awaiting announcement of Ministerial decision					
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:				

<table>
<tr><td colspan="6">Country: UK (Scotland)</td></tr>
<tr><td colspan="6">Development: Aquamarine Power Ltd - Oyster 2 A</td></tr>
<tr><td colspan="6">Web-link:</td></tr>
<tr><td colspan="2">Location name:</td><td colspan="2">Latitude (decimal):</td><td colspan="2">Longitude (decimal):</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td colspan="2">Device type:</td><td colspan="2">Anchor type:</td><td colspan="2">Mooring strings:</td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="3">Total installed capacity (MW): 800KW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km^2):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Constructed / Monitoring</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Wello Oy - EMEC</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>EMEC</td><td colspan="2">Latitude (decimal):</td><td colspan="2">Longitude (decimal):</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td colspan="2">Device type:</td><td colspan="2">Anchor type:</td><td colspan="2">Mooring strings:</td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="3">Total installed capacity (MW):</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km²):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Constructed / Monitoring</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

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 (km^2):**		
Environmental data collected:					
Consenting process: Constructed / Monitoring					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Atlantis - EMEC</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>EMEC</td><td>Latitude (decimal):</td><td>59.14</td><td>Longitude (decimal):</td><td>-2.82</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td>Horizontal axis turbine</td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="2">Total installed capacity (MW):</td><td>1MW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km^2):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Constructed / Monitoring</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

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 (km^2):**		
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 (km^2):**		
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 (km^2):**		
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: Undertaking EIA					
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 (km^2):**		
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: **This is a generic test site licence for a relatively low energy site for the field testing of scaled done devices of a range of types**					

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 (km^2):**		
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 (km^2):**		
Environmental data collected:					
Consenting process: Licensed and being tested					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Vattenfall (Pelamis device)				
Web-link:					
Location name:	EMEC Billia Croo	**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: Licensed					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Pelamis devices at Aegir (Shetland)				
Web-link:					
Location name:	Aegir	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:		**Deployment end date:**			
Device type:		**Anchor type:**		**Mooring strings:**	
Number of devices:		**Total installed capacity (MW):**	10 MW		
Test scale of devices:		**Deployment area (km^2):**			
Environmental data collected:					
Consenting process:	EIA being prepared				
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Pelamis devices at Farr Point, Caithness				
Web-link:					
Location name:	Farr Point	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:		**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	15 MW	
Test scale of devices:			**Deployment area (km²):**		
Environmental data collected:					
Consenting process: EIA being prepared					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	Pelamis devices				
Web-link:					
Location name:	West Orkney, South	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:		**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	10 MW	
Test scale of devices:			**Deployment area (km²):**		
Environmental data collected:					
Consenting process: EIA being prepared					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)		
Development:	Pelamis devices		
Web-link:			
Location name:	Bernera	**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: Pre-scoping			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)				
Development:	APL				
Web-link:					
Location name:	Brough head	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Oyster	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	50 MW	
Test scale of devices:			**Deployment area (km²):**		

Environmental data collected:

Consenting process:

EIA being prepared

Monitoring activities:

Research activities:

Spatial data available:

Additional information:

Country:	UK (Scotland)				
Development:	APL				
Web-link:					
Location name:	Marwick head	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:				**Deployment end date:**	
Device type:	Oyster	**Anchor type:**		**Mooring strings:**	
Number of devices:				**Total installed capacity (MW):**	49.5 MW
Test scale of devices:				**Deployment area (km^2):**	
Environmental data collected:					
Consenting process: Scoping					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:					
Web-link:					
Location name:	Costa head	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Wave	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	200 MW	
Test scale of devices:			**Deployment area (km^2):**		
Environmental data collected:					
Consenting process: EIA being prepared, but slowed due to device redesign					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:					
Web-link:					
Location name:	Westray South	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:				**Deployment end date:**	
Device type:	Tidal	**Anchor type:**		**Mooring strings:**	
Number of devices:				**Total installed capacity (MW):**	200 MW
Test scale of devices:				**Deployment area (km²):**	
Environmental data collected:					
Consenting process: EIA being prepared,					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country: UK (Scotland)			
Development:			
Web-link:			
Location name: Brough Ness	**Latitude (decimal):**		**Longitude (decimal):**
Deployment start:		**Deployment end date:**	
Device type: Tidal	**Anchor type:**		**Mooring strings:**
Number of devices:		**Total installed capacity (MW):**	
Test scale of devices:		**Deployment area (km²):**	
Environmental data collected:			
Consenting process: Scoping, but delayed,			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

<table>
<tr><td colspan="2">Country: UK (Scotland)</td></tr>
<tr><td colspan="2">Development:</td></tr>
<tr><td colspan="2">Web-link:</td></tr>
<tr><td colspan="2">Location name: Cantick head | Latitude (decimal): | Longitude (decimal):</td></tr>
<tr><td>Deployment start:</td><td>Deployment end date:</td></tr>
<tr><td colspan="2">Device type: Tidal | Anchor type: | Mooring strings:</td></tr>
<tr><td>Number of devices:</td><td>Total installed capacity (MW): 200 MW</td></tr>
<tr><td>Test scale of devices:</td><td>Deployment area (km²):</td></tr>
<tr><td colspan="2">Environmental data collected:</td></tr>
<tr><td colspan="2">Consenting process:
Scoping</td></tr>
<tr><td colspan="2">Monitoring activities:</td></tr>
<tr><td colspan="2">Research activities:</td></tr>
<tr><td colspan="2">Spatial data available:</td></tr>
<tr><td colspan="2">Additional information:</td></tr>
</table>

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

Country:	UK (Scotland)			
Development:	Bluewater			
Web-link:				
Location name:	EMEC Falls of Warness	**Latitude (decimal):**		**Longitude (decimal):**
Deployment start:			**Deployment end date:**	
Device type:	Tidal	**Anchor type:**		**Mooring strings:**
Number of devices:			**Total installed capacity (MW):**	
Test scale of devices:			**Deployment area (km^2):**	
Environmental data collected:				
Consenting process: Licensed				
Monitoring activities:				
Research activities:				
Spatial data available:				
Additional information:				

Country:	UK (Scotland)		
Development:	HSUK		
Web-link:			
Location name:	EMEC Falls of Warness	**Latitude (decimal):**	**Longitude (decimal):**
Deployment start:		**Deployment end date:**	
Device type:	Tidal	**Anchor type:**	**Mooring strings:**
Number of devices:		**Total installed capacity (MW):**	
Test scale of devices:		**Deployment area (km^2):**	
Environmental data collected:			
Consenting process: Licensed			
Monitoring activities:			
Research activities:			
Spatial data available:			
Additional information:			

Country:	UK (Scotland)				
Development:	Nautricity				
Web-link:					
Location name:	EMEC Falls of Warness	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Tidal	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**		
Test scale of devices:			**Deployment area (km^2):**		
Environmental data collected:					
Consenting process: Licensed					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)			
Development:				
Web-link:				
Location name:	Mull of Kintyre	**Latitude (decimal):**		**Longitude (decimal):**
Deployment start:			**Deployment end date:**	
Device type:	Tidal	**Anchor type:**		**Mooring strings:**
Number of devices:			**Total installed capacity (MW):**	
Test scale of devices:			**Deployment area (km^2):**	
Environmental data collected:				
Consenting process: EIA being prepared				
Monitoring activities:				
Research activities:				
Spatial data available:				
Additional information:				

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">Blue Energy Canada</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>Churchill Barrier, Orkney</td><td colspan="2">Latitude (decimal):</td><td colspan="2">Longitude (decimal):</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td>Tidal</td><td colspan="2">Anchor type:</td><td colspan="2">Mooring strings:</td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="3">Total installed capacity (MW):</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km^2):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
Pre-screeing</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

<table>
<tr><td>Country:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td>Development:</td><td colspan="5">DP Marine Energy</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>Islay Tidal array</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td>Tidal</td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="3">Number of devices:</td><td colspan="2">Total installed capacity (MW):</td><td>30 MW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="3">Deployment area (km²):</td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:
EIA being prepared</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

Country:	UK (Scotland)				
Development:					
Web-link:					
Location name:	Kyle Rhea	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Tidal	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	8 MW	
Test scale of devices:			**Deployment area (km²):**		
Environmental data collected:					
Consenting process: Application submitted					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:	MEYGEN				
Web-link:					
Location name:	Sound of Stroma	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Tidal	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	61 MW +	
Test scale of devices:			**Deployment area (km^2):**		
Environmental data collected:					
Consenting process: Application submitted					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:					
Web-link:					
Location name:	Duncansby Ness	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Tidal	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	95 MW	
Test scale of devices:			**Deployment area (km²):**		
Environmental data collected:					
Consenting process: Scoping					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	UK (Scotland)				
Development:					
Web-link:					
Location name:	Argyll Tidal array	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Tidal	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (MW):**	3 MW	
Test scale of devices:			**Deployment area (km²):**		
Environmental data collected:					
Consenting process: EIA being prepared					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

<table>
<tr><td>Country:</td><td colspan="5">UK (Wales)</td></tr>
<tr><td>Development:</td><td colspan="5">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.</td></tr>
<tr><td>Web-link:</td><td colspan="5">http://www.tidalenergyltd.com/?page_id=650</td></tr>
<tr><td>Location name:</td><td>Ramsey Sound Pembrokeshire</td><td>Latitude (decimal):</td><td>51.8775</td><td>Longitude (decimal):</td><td>-5.326</td></tr>
<tr><td colspan="2">Deployment start:</td><td>Spring / summer 2013</td><td colspan="2">Deployment end date:</td><td>Spring / summer 2014</td></tr>
<tr><td>Device type:</td><td>Triangular gravity base foundation
3 fixed pitch blades per nacelle, 3 nacelles per device (i.e. one at each corner of base)</td><td>Anchor type:</td><td>Up to 8</td><td>Mooring strings:</td><td>2 sinkers</td></tr>
<tr><td colspan="2">Number of devices:</td><td>1 (3 nacelles)</td><td colspan="2">Total installed capacity (MW):</td><td>1.2</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td>36m triangular base, 15m diameter blades.</td><td colspan="2">Deployment area (km²):</td><td>Approx 0.5 , plus sinkers and anchors</td></tr>
<tr><td colspan="6">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 (incl. harbour porpoise and grey seal) and seabirds</td></tr>
<tr><td colspan="6">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 por-</td></tr>
</table>

poise / 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 on-shore 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, in order 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 finalising 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 (km^2):**	150 (m^2)	
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 environmentally 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 is no systematic monitoring regarding environmental issues however an acoustic monitoring survey has been carried out to characterise both airborne and underwater noise levels.					
Research activities: The underwater noise characterisation 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 inter-relation 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 sea-bed
Number of devices:	1			**Total installed capacity (MW):**	3 x 100 kW
Test scale of devices:				**Deployment area (km²):**	410 m^2

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 colonisation 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 (shore-line)	**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)				
Weblink:	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; realised 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, RundeEnv. 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. and

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., and Kvalsund, R. 2010. The MAREN wave power test site off the island of Runde, Norway. Environmental Monitoring Programme Annual Report. May 7, 2010.

<table>
<tr><td>Country:</td><td colspan="5">Norway</td></tr>
<tr><td>Development:</td><td colspan="5">Fred Olsen Ltd Buldra / BOLT, Wave Energy Converter</td></tr>
<tr><td>Web-link:</td><td colspan="5">http://www.fredolsen-renewables.com/</td></tr>
<tr><td>Location name:</td><td>Risør</td><td>Latitude (decimal):</td><td>58.685</td><td>Longitude (decimal):</td><td>9.323</td></tr>
<tr><td colspan="2">Deployment start:</td><td colspan="2">2009</td><td>Deployment end date:</td><td>2010</td></tr>
<tr><td>Device type:</td><td>Point absorber</td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="2">Number of devices:</td><td colspan="2">1</td><td>Total installed capacity (MW):</td><td>0.045</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td colspan="2">1:3</td><td>Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected: ?</td></tr>
<tr><td colspan="6">Consenting process: ?</td></tr>
<tr><td colspan="6">Monitoring activities: ?</td></tr>
<tr><td colspan="6">Research activities: ?</td></tr>
<tr><td colspan="6">Spatial data available: ?</td></tr>
<tr><td colspan="6">Additional information:
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.
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 south-east 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. (http://www.ocean-energy-systems.org/country-info/norway/)</td></tr>
</table>

<table>
<tr><td>Country:</td><td colspan="5">Norway</td></tr>
<tr><td>Development:</td><td colspan="5">E-Co Seahorse, Wave Energy Converter</td></tr>
<tr><td>Web-link:</td><td colspan="5">http://www.e-co.no/English/E-CO_Energi/About_E-CO/
http://www.ocean-energy-systems.org/country-info/norway/</td></tr>
<tr><td>Location name:</td><td>Runde</td><td>Latitude (decimal):</td><td>62.3984</td><td>Longitude (decimal):</td><td>5.6855</td></tr>
<tr><td colspan="2">Deployment start: 2011</td><td colspan="4">Deployment end date: 2012,</td></tr>
<tr><td>Device type:</td><td>Point absorber</td><td>Anchor type:</td><td>Deadweight anchor</td><td>Mooring strings:</td><td>Fixed to sea-bed</td></tr>
<tr><td colspan="2">Number of devices: 1</td><td colspan="4">Total installed capacity (MW): 0.003</td></tr>
<tr><td colspan="2">Test scale of devices: prototype</td><td colspan="4">Deployment area (km²): 0.3</td></tr>
<tr><td colspan="6">Environmental data collected:
Wave height, frequency</td></tr>
<tr><td colspan="6">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).</td></tr>
<tr><td colspan="6">Monitoring activities:
no</td></tr>
<tr><td colspan="6">Research activities:
no</td></tr>
<tr><td colspan="6">Spatial data available:
Yes (RundeEnv. Centre)</td></tr>
<tr><td colspan="6">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/)</td></tr>
</table>

<table>
<tr><td>Country:</td><td colspan="5">Norway</td></tr>
<tr><td>Development:</td><td colspan="5">Langlee, Wave Energy Converter</td></tr>
<tr><td>Web-link:</td><td colspan="5">http://www.langleewavepower.com/global-projects.html</td></tr>
<tr><td>Location name:</td><td>Svåhei, Egersund</td><td>Latitude (decimal):</td><td>58.371</td><td>Longitude (decimal):</td><td>5.969</td></tr>
<tr><td colspan="2">Deployment start:</td><td>2013</td><td colspan="2">Deployment end date:</td><td>?</td></tr>
<tr><td>Device type:</td><td>Oscillating wave surge converter</td><td>Anchor type: Using fish farm anchoring and mooring systems :</td><td>Other fixing type</td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="2">Number of devices:</td><td>1</td><td colspan="2">Total installed capacity (MW):</td><td>0.05 MW</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td>Full Scale E1 device</td><td colspan="2">Deployment area (km^2):</td><td><1km2</td></tr>
<tr><td colspan="6">Environmental data collected:
Not yet</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">Monitoring activities:
Required by funders and operators: production and performance monitoring, no other type of monitoring planned as of yet</td></tr>
<tr><td colspan="6">Research activities:
Not determined yet</td></tr>
<tr><td colspan="6">Spatial data available:
See Eigersundkommuneplan</td></tr>
<tr><td colspan="6">Additional information:
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 the summer of 2012, Langlee will deploy</td></tr>
</table>

its own demo unit outside Egersund, Norway, for testing and verification. The Turkish company Ünmaksan has also a co-operation 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.

http://www.ocean-energy-systems.org/country-info/norway/

Telephone conversation with CathrineBryøen, Business development manager (Cathrine@langlee.no); Tel: +47 92630726

<table>
<tr><td>Country:</td><td colspan="5">Norway</td></tr>
<tr><td>Development:</td><td colspan="5">Intentium, IOWEP (Intentium Offshore Wave Energy Project)</td></tr>
<tr><td>Web-link:</td><td colspan="5">http://www.proexca.es/Informacion/Ponencias/2011.11.14-seminario-hispanonoruego/Intentium.pdf</td></tr>
<tr><td>Location name:</td><td>n/a</td><td colspan="2">Latitude (decimal):</td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="2">Deployment start:</td><td>n/a</td><td colspan="2">Deployment end date:</td><td>n/a</td></tr>
<tr><td>Device type:</td><td>Point absorber</td><td colspan="2">Anchor type:</td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="2">Number of devices:</td><td></td><td colspan="2">Total installed capacity (MW):</td><td></td></tr>
<tr><td colspan="2">Test scale of devices:</td><td></td><td colspan="2">Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected:
?</td></tr>
<tr><td colspan="6">Consenting process:
?</td></tr>
<tr><td colspan="6">Monitoring activities:
?</td></tr>
<tr><td colspan="6">Research activities:
Patented, wave tank testing</td></tr>
<tr><td colspan="6">Spatial data available:
n/a</td></tr>
<tr><td colspan="6">Additional information:
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/)</td></tr>
</table>

<table>
<tr><td>Country:</td><td colspan="5">Norway</td></tr>
<tr><td>Development:</td><td colspan="5">OWC Power AS, Wave Energy Converter</td></tr>
<tr><td>Web-link:</td><td colspan="5">http://www.owcpower.com/index.php?parent=193&groupid=195</td></tr>
<tr><td>Location name:</td><td>n/a</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="2">Deployment start:</td><td colspan="2">2012?</td><td>Deployment end date:</td><td></td></tr>
<tr><td>Device type:</td><td>Oscillating water column (offshore)</td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="2">Number of devices:</td><td colspan="2"></td><td>Total installed capacity (MW):</td><td></td></tr>
<tr><td colspan="2">Test scale of devices:</td><td colspan="2"></td><td>Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected:
?</td></tr>
<tr><td colspan="6">Consenting process:
?</td></tr>
<tr><td colspan="6">Monitoring activities:
?</td></tr>
<tr><td colspan="6">Research activities:
Wave tank testing</td></tr>
<tr><td colspan="6">Spatial data available:
n/a</td></tr>
<tr><td colspan="6">Additional information:
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/)</td></tr>
</table>

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:

Havkraft AS

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/)

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 co-operation 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 the fall of 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 pre-tested 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:	Mutriku OWC Plant				
Web-link:	http://www.eve.es/web/Energias-Renovables/Energia-marina.aspx				
Location name:	Mutriku	**Latitude (decimal):**	43º18.527N	**Longitude (decimal):**	2º22.651W
Deployment start:	July 2011		**Deployment end date:**	2036	
Device type:	Oscillating water column (shoreline)	**Anchor type:**		**Mooring strings:**	
Number of devices:	**16 turbines**		**Total installed capacity (MW):**	300kW	
Test scale of devices:			**Deployment area (km²):**		
Environmental data collected:					
Consenting process: Completed in 2008					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

Country:	Spain				
Development:	Mutriku OWC Plant				
Web-link:	http://www.eve.es/web/Energias-Renovables/Energia-marina.aspx				
Location name:	Mutriku	**Latitude (decimal):**	43º18.527N	**Longitude (decimal):**	2º22.651W
Deployment start:	July 2011		**Deployment end date:**	2036	
Device type:	Oscillating water column (shoreline)	**Anchor type:**		**Mooring strings:**	
Number of devices:	16 turbines		**Total installed capacity (MW):**	296kW	
Test scale of devices:			**Deployment area (km²):**		
Environmental data collected:					
Consenting process: Completed in 2008					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

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):**	43º27.835N	**Longitude (decimal):**	2º52.905W
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:

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:

a) Physical Environment:
   a. 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 FugroOceanor) in March 2009, current meters and other buoys were employed. Shoreline wave attenuations of 0-10% might be expected.
   b. Sediment characterization (29 sampling stations): granulometry and organic content
   c. 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.
   d. Bathymetry: Seabed characterisation with a multi-beam echo sounder.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.
   e. Landscape characterization: Characterization based on the catalogue of Basque Landscapes. There exist some significant landscape places near bimep.

b) Biotic Environment:
   a. 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.

   b. Fish: No specific data available. Thus, an extensive bibliographic and web source information search was done.
   c. Marine mammals: Some data coming from sightings of AZTI-Tecnalia personnel in different sampling campaigns. Common dolphin (Delphinusdelphis), Bottlenose Dolphin (Tursiops truncates), Fin whale (Balaenopteraphysalus) and long-finned pilot whale (Globicephalamelas) are common species in the bimep area.
   d. Marine Birds communities characterization: No specific data available. Thus, an extensive bibliographic and web source information search was done.

c) Socioeconomic environment:
   a. 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 fishermens.
   b. Archaeological resources: Consult on the Subaquatic Archaeological Catalogue of the Basque Government. A sunken vessel was identified near the bimep area.

Consenting process:

a) 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 2011 in their pre-operational phase and will be undertaken by AZTI-Tecnalia.

b) Administrative authorisations

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.Once authorisation 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, in November 2012 the first works started with the horizontal drilling for the installation of the submarine power cables

In 2011, the Promoter (EVE) proceeded to tackle the final step and obtain the **concession of marine-terrestrial public domain.** This concession was finally granted on the 6th of February 2013.

Monitoring activities:

The Preoperational monitoring phase started in August 2011:

a) Physical Environment:
    - Hydrodynamic characterization: Two Nortek profilers were 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 were undertaken.

- Underwater Noise: for this purpose, a design and installation of one buoy equipped with high and low frequency hydrophone was 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 was anchored and it has continuously registered the sound environment in different periods, during day and night, rendering the previous reference noise level to the installation.
- Landscape: a characterisation 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 characterisation and base visual analysis

b) Biotic environment:

- Benthic communities: benthic communities sampling with grab in soft sediments and analysis with AZTI Marine Biotic Index was undertaken. For hard bottom communities, sampling was undertaken in several intertidal sampling stations. Additionally a visual inspection with underwater cameras attached to a Remote Operated Vehicle (ROV) was carried out in the submarine cable route and in the areas where harnessing devices will be placed.
- Icthyofauna: five active acoustic sensors were placed in the bimep area. These sensors recorded biomass estimates of fish shoals. Additionally, visual inspections by divers were undertaken.
- Marine mammals: same methodology than those proposed for underwater noise.

c) Socioeconomic environment:

- Fisheries: commercial fisheries study (based on fish landing statistics, fisheries surveillance data, academic studies, previous fisheries reports) and consultation with local fishermen was done.
- 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):**	43º18.527N	**Longitude (decimal):**	2º22.651W
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:					

<table>
<tr><td>Country:</td><td colspan="5">Spain</td></tr>
<tr><td>Development:</td><td colspan="5">Santoña Test Centre</td></tr>
<tr><td>Web-link:</td><td colspan="5"></td></tr>
<tr><td>Location name:</td><td>Santoña (Northern part of Spain)</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="2">Deployment start:</td><td colspan="2">July 2011</td><td>Deployment end date:</td><td>2036</td></tr>
<tr><td>Device type:</td><td>Point absorber</td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="2">Number of devices:</td><td colspan="2">10</td><td>Total installed capacity (MW):</td><td>1.5</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td colspan="2"></td><td>Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

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 (km^2):**	
Environmental data collected:				
Consenting process:				
Monitoring activities:				
Research activities:				
Spatial data available:				
Additional information:				

<table>
<tr><td>Country:</td><td colspan="5">Spain</td></tr>
<tr><td>Development:</td><td colspan="5">WELCOME project and PIPO Systems</td></tr>
<tr><td>Web-link:</td><td colspan="5">www.pipoystems.com//EN/welcome.php</td></tr>
<tr><td>Location name:</td><td>Canary Islands</td><td colspan="2">Latitude (decimal):</td><td colspan="2">Longitude (decimal):</td></tr>
<tr><td colspan="2">Deployment start:</td><td>2008</td><td colspan="2">Deployment end date:</td><td>2011</td></tr>
<tr><td>Device type:</td><td></td><td colspan="2">Anchor type:</td><td>Mooring strings:</td><td>Fixed to sea-bed</td></tr>
<tr><td colspan="2">Number of devices:</td><td>1</td><td colspan="2">Total installed capacity (kW):</td><td>100-150</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td>1:5</td><td colspan="2">Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

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 sea-bed
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:	AbencisSeapower		
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:	NorventoEnerxía			
Web-link:	www.norvento.com			
Location name:		**Latitude (decimal):**		**Longitude (decimal):**
Deployment start:			**Deployment end date:**	
Device type:	Point absorber	**Anchor type:**		**Mooring strings:**
Number of devices:			**Total installed capacity (MW):**	
Test scale of devices:	1		**Deployment area (km²):**	
Environmental data collected:				
Consenting process:				
Monitoring activities:				
Research activities:				
Spatial data available:				
Additional information:				

<table>
<tr><td>Country:</td><td colspan="5">Portugal, Spain, UK, Norway, USA</td></tr>
<tr><td>Development:</td><td colspan="5">Waveport</td></tr>
<tr><td>Web-link:</td><td colspan="5">www.wavec.org/index.php/81/waveport</td></tr>
<tr><td>Location name:</td><td>Santoña</td><td colspan="2">Latitude (decimal):</td><td colspan="2">Longitude (decimal):</td></tr>
<tr><td colspan="3">Deployment start:</td><td colspan="3">Deployment end date:</td></tr>
<tr><td>Device type:</td><td>Point absorber</td><td colspan="2">Anchor type:</td><td colspan="2">Mooring strings:</td></tr>
<tr><td colspan="2">Number of devices:</td><td>1</td><td colspan="2">Total installed capacity (kW):</td><td>150kW</td></tr>
<tr><td colspan="3">Test scale of devices:</td><td colspan="2">Deployment area (km²):</td><td></td></tr>
<tr><td colspan="6">Environmental data collected:</td></tr>
<tr><td colspan="6">Consenting process:</td></tr>
<tr><td colspan="6">Monitoring activities:</td></tr>
<tr><td colspan="6">Research activities:</td></tr>
<tr><td colspan="6">Spatial data available:</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

Country:	Spain				
Development:	Galicia Mar Renovables				
Web-link:	http://gmrenovables.com/index.html				
Location name:	Ares (A Coruña)	**Latitude (decimal):**		**Longitude (decimal):**	
Deployment start:			**Deployment end date:**		
Device type:	Point absorber	**Anchor type:**		**Mooring strings:**	
Number of devices:			**Total installed capacity (kW):**	250kW	
Test scale of devices:	1:10		**Deployment area (km²):**		
Environmental data collected:					
Consenting process:					
Monitoring activities:					
Research activities:					
Spatial data available:					
Additional information:					

<table>
<tr><td>Country:</td><td colspan="5">Sweden</td></tr>
<tr><td>Development:</td><td colspan="5">The Sotenas project – Commercial</td></tr>
<tr><td>Web-link:</td><td colspan="5">www.seabased.com / www.fortum.com</td></tr>
<tr><td>Location name:</td><td>Sotenas</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="2">Deployment start:</td><td>2012/13</td><td colspan="2">Deployment end date:</td><td>20 year(~2035)</td></tr>
<tr><td>Device type:</td><td>Point absorber Seabased</td><td>Anchor type:</td><td>Gravity concrete foundation</td><td>Mooring strings:</td><td>None – but wires bw buoys and generators placed on seabed</td></tr>
<tr><td colspan="2">Number of devices:</td><td>420</td><td colspan="2">Total installed capacity (MW):</td><td>10 MW</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td>1:1</td><td colspan="2">Deployment area (km^2):</td><td>~ 0.8</td></tr>
<tr><td colspan="6">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</td></tr>
<tr><td colspan="6">Consenting process:
Full scale EIA also including court application, application according to “Electrical law”, building permits etc.</td></tr>
<tr><td colspan="6">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</td></tr>
<tr><td colspan="6">Research activities:
See above under Monitoring</td></tr>
<tr><td colspan="6">Spatial data available:
Yes</td></tr>
<tr><td colspan="6">Additional information:</td></tr>
</table>

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 under way.

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

<table>
<tr><td colspan="2">Country: UK (England)</td><td colspan="2"></td></tr>
<tr><td colspan="4">Development: Solent Ocean Energy Centre (SOEC)</td></tr>
<tr><td colspan="4">Web-link:</td></tr>
<tr><td colspan="2">Location name:</td><td>Latitude (decimal):</td><td>Longitude (decimal):</td></tr>
<tr><td colspan="2">Deployment start:</td><td colspan="2">Deployment end date:</td></tr>
<tr><td colspan="2">Device type: Tidal stream</td><td>Anchor type:</td><td>Mooring strings:</td></tr>
<tr><td colspan="2">Number of devices:</td><td colspan="2">Total installed capacity (MW): None</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td colspan="2">Deployment area (km²): 5</td></tr>
<tr><td colspan="4">Environmental data collected:
Baseline surveys of noise, marine ecology, fisheries and coastal processes.</td></tr>
<tr><td colspan="4">Consenting process:</td></tr>
<tr><td colspan="4">Monitoring activities:</td></tr>
<tr><td colspan="4">Research activities:
See website</td></tr>
<tr><td colspan="4">Spatial data available:
See website</td></tr>
<tr><td colspan="4">Additional information:
See website</td></tr>
</table>

<table>
<tr><td>Country:</td><td colspan="5">UK (England)</td></tr>
<tr><td>Development:</td><td colspan="5">Wave Hub</td></tr>
<tr><td>Web-link:</td><td colspan="5">www.wavehub.co.uk</td></tr>
<tr><td>Location name:</td><td>Cornish Coast</td><td>Latitude (decimal):</td><td>50 20.700 N
50 22.830 N
50 20.860 N
50 22.980 N</td><td>Longitude (decimal):</td><td>05 37.230 W
05 37.760 W
05 35.560 W
05 36.100 W</td></tr>
<tr><td colspan="2">Deployment start:</td><td>2007</td><td colspan="2">Deployment end date:</td><td>2036</td></tr>
<tr><td>Device type:</td><td>Other wave device</td><td>Anchor type:</td><td>Percussion / driven pile</td><td>Mooring strings:</td><td>Other mooring</td></tr>
<tr><td colspan="2">Number of devices:</td><td>One</td><td colspan="2">Total installed capacity (MW):</td><td>None</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td></td><td colspan="2">Deployment area (km²):</td><td>8</td></tr>
<tr><td colspan="6">Environmental data collected:
Baseline surveys and construction monitoring of noise, marine ecology, fisheries and coastal processes.</td></tr>
<tr><td colspan="6">Consenting process:
FEPA and Section 36</td></tr>
<tr><td colspan="6">Monitoring activities:
Pre-construction baseline followed by construction monitoring and post construction monitoring</td></tr>
<tr><td colspan="6">Research activities:
See website</td></tr>
<tr><td colspan="6">Spatial data available:
See website</td></tr>
<tr><td colspan="6">Additional information:
See website</td></tr>
</table>

Country:	UK (England)				
Development:	Neptune Tidal Device				
Web-link:	www.neptunerenewableenergy.com				
Location name:	Humber Estuary	**Latitude (decimal):**	53 37.500 N 53 37.490 N 53 37.480 N 53 37.490 N 53 37.120 N	**Longitude (decimal):**	00 08.760 E 00 08.750 E 00 08.760 E 00 08.770 E 00 09.460 E
Deployment start:	2011		**Deployment end date:**	2013	
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 (km^2):**	<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: Neptune liquidated in February 2013 after disappointing device performance.					

Country:	UK (Northern Ireland)				
Development:	DP Energy Fair Head Tidal Energy project				
Web-link:	http://www.dpenergy.com/tidal/fairhead/index.html and www.fairheadtidal.com				
Location name:	Fair Head, Co. Antrim, N. Ireland	**Latitude (decimal):**	Unknown	**Longitude (decimal):**	Unknown
Deployment start:	???		**Deployment end date:**	???	
Device type:	Tech. neutral at this time	**Anchor type:**		**Mooring strings:**	
Number of devices:	100 x 1 MW		**Total installed capacity (MW):**	100 MW	
Test scale of devices:	Full, commercial		**Deployment area (km²):**		

Environmental data collected:

EIA scoping work underway

Consenting process:

Crown Estate Agreement for Lease granted in October 2012. Scoping work underway March 2013. Marine licence application expected to be made in May 2014

Monitoring activities:

Yes, EIA-related

Research activities:

Currently looking at constraints assessment, resource assessment, grid capacity, baseline information and designated areas.

Spatial data available:

Not known

Additional information:

Clodagh McGrath, Environmental Manager, DP Marine Energy Ltd.,

DP Energy Marine: Simon De Pietro +353 22 23955 simon.depietro@dpenergy.com

DBE: Guy Pomphrey +32 477 326335 pomphrey.guy@deme.be

Country:	UK (Northern Ireland)				
Development:	Tidal Ventures project Torr Head				
Web-link:	http://www.tidalventures.com/ (under construction)				
Location name:	Torr Head, Co. Antrim, N. Ireland	**Latitude (decimal):**	Unknown	**Longitude (decimal):**	Unknown
Deployment start:	???		**Deployment end date:**	???	
Device type:	OpenHydro and BordGáis	**Anchor type:**	Unknown	**Mooring strings:**	Unknown
Number of devices:	Undecided		**Total installed capacity (MW):**	100 MW	
Test scale of devices:	Full, commercial		**Deployment area (km^2):**	Unknown	

Environmental data collected:

EIA Scoping study has been completed and published in March 2013. Further environmental baseline studies and characterisation will continue from mid-2013 to 2014.

Consenting process:

Crown Estate Agreement for Lease granted in October 2012. Scoping study published in March 2013. Marine licence and planning permission applications expected to be submitted subsequent to EIA.

Monitoring activities:

EIA-related e.g. 2 year bird and mammal survey requirement

Research activities:

Unknown

Spatial data available:

Not known

Additional information:

Donal O'Sullivan, BordGáis Energy, 2nd floor, City Quarter, Lapps Quay, Cork, Ireland T: +353 21 490 7207 F: +353 21 490 7201 www.bordgaisenergy.ie

Kieran O' Malley, OpenHydro, Muchgrange, Greenore, Co. Louth, Ireland T: + 353 42 934 9051 kieran.omalley@openhydro.com

Country:	Ireland			
Development:	Atlantic Marine Energy Test Site (AMETS)			
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 (km^2):**	21km^2	
Environmental data collected: See text in Country Report for Ireland				
Consenting process: Full EIA carried out. Foreshore Lease application made. Grid connection offer secured.				
Monitoring activities: Yes. Due to end in March 2013.				
Research activities: Yes.				
Spatial data available: Only that relating to EIA work.				
Additional information: Declan Meally or Graham Brennan, SEAI, Dublin.				

<table>
<tr><td>Country:</td><td colspan="5">Ireland</td></tr>
<tr><td>Development:</td><td colspan="5">WestWave</td></tr>
<tr><td>Web-link:</td><td colspan="5">http://www.westwave.ie/</td></tr>
<tr><td>Location name:</td><td>West coast (final location not decided yet)</td><td>Latitude (decimal):</td><td></td><td>Longitude (decimal):</td><td></td></tr>
<tr><td colspan="2">Deployment start:</td><td>Tbc</td><td colspan="2">Deployment end date:</td><td>2016</td></tr>
<tr><td>Device type:</td><td></td><td>Anchor type:</td><td></td><td>Mooring strings:</td><td></td></tr>
<tr><td colspan="2">Number of devices:</td><td>Tbc</td><td colspan="2">Total installed capacity (MW):</td><td>5 MW</td></tr>
<tr><td colspan="2">Test scale of devices:</td><td>Full</td><td colspan="2">Deployment area (km^2):</td><td>tbc</td></tr>
<tr><td colspan="6">Environmental data collected:
See text in Country Report for Ireland</td></tr>
<tr><td colspan="6">Consenting process:
Site investigation studies carried out at three sites.</td></tr>
<tr><td colspan="6">Monitoring activities:
Yes</td></tr>
<tr><td colspan="6">Research activities:
Yes, development related.</td></tr>
<tr><td colspan="6">Spatial data available:
Only in related reports.</td></tr>
<tr><td colspan="6">Additional information:
James Tedd, ESBI.</td></tr>
</table>

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

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">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</td></tr>
<tr><td>Research providers:</td><td colspan="6">Marine Scotland</td></tr>
<tr><td>Framework:</td><td colspan="6">N/A</td></tr>
<tr><td>Funding sources:</td><td colspan="6">Scottish Government</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">2010</td><td colspan="2">End date:</td><td colspan="2">2011</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">Scottish waters</td><td colspan="2">Topical relevance:</td><td colspan="2">Migratory fish</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
N/A</td><td>Baselines:
High</td><td>Impacts:
Medium</td><td colspan="3">Socio-economics:
High</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
High</td><td>Installation:
Medium</td><td>Operation:
High</td><td>Maintenance:
Low</td><td colspan="2">Decommissioning:
Low</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
Low</td><td>Ecological processes:
Low</td><td>Direct seabed impacts
Low</td><td>Direct wildlife impacts
High</td><td>New ecological space
Low</td><td>Interactions with other sea-users:
Medium</td></tr>
<tr><td colspan="7">Project description: .
To establish potential for interactions between turbine arrays and salmon entering FW SACs. Covers review of behaviour, depth preference etc</td></tr>
<tr><td colspan="7">Project deliverables:
Report</td></tr>
<tr><td colspan="7">Spatial data generated: Some</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
</table>

Countries:	UK (Scotland)						
Project title:	Strategic sea bed 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				
Project type:	**Resource assessment:** Low	**Baselines:** High	**Impacts:** Low	**Socio-economics:** High			
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** High	**Operation:** Low	**Maintenance:** Low	**Decommissioning:** Medium		
Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** High	**Direct seabed impacts** High	**Direct wildlife impacts** Medium	**New ecological space** Low	**Interactions with other sea-users:** Medium	

Project description:

Multi-beam acoustic surveys and supporting drop frame video and still images of the sea bed in potential wave and tidal development areas

Project deliverables:

Bathymetric maps, viseo, stills

Spatial data generated:

As above

Bibliography of outputs:

All available through Marine Scotland Interactive

Countries:	UK (Scotland)					
Project title:	Review of potential impacts of wave and tidal renewable energy developments on Scotland's marine environment					
Research providers:	Aquatera					
Framework:						
Funding sources:	Scottish Government					
Web-link:						
Start date:	2009	**End date:**	2011			
Geographical relevance:	Wide	**Topical relevance:**	Environmental impacts, birds, mammals, sea bed			
Project type:	**Resource assessment:** N/A	**Baselines:** Low	**Impacts:** High	**Socio-economics:** Medium		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** High	**Operation:** High	**Maintenance:** Low	**Decommissioning:** Low	
Nature of impact / study:	**Physical processes:** Medium	**Ecological processes:** High	**Direct seabed impacts** High	**Direct wildlife impacts** High	**New ecological space** Low	**Interactions with other sea-users:** Low

Project description:

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, sea bed

	Resource assessment:	**Baselines:**	**Impacts:**	**Socio-economics:**
Project type:	Low	High	High	Low

	Planning and pre-development survey:	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
Development life-cycle stage:	High	Medium	High	Medium	Low

	Physical processes:	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
Nature of impact / study:	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 develoers 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

<table>
<tr><td colspan="2">Countries:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td colspan="2">Project title:</td><td colspan="5">Wave test site acoustic monitoring programme</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="5">EMEC</td></tr>
<tr><td colspan="2">Framework:</td><td colspan="5"></td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="5">Scottish Government</td></tr>
<tr><td colspan="2">Web-link:</td><td colspan="5"></td></tr>
<tr><td colspan="2">Start date:</td><td>2010</td><td colspan="2">End date:</td><td colspan="2">2012</td></tr>
<tr><td colspan="2">Geographical relevance:</td><td>Wide</td><td colspan="2">Topical relevance:</td><td colspan="2">Acoustic, noise, wave</td></tr>
<tr><td>Project type:</td><td colspan="2">Resource assessment:
N/A</td><td>Baselines:
High</td><td>Impacts:
High</td><td colspan="2">Socio-economics:
Low</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
High</td><td>Installation:
Low</td><td>Operation:
High</td><td>Maintenance:
Low</td><td colspan="2">Decommissioning:
Low</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
High</td><td>Ecological processes:
Medium</td><td>Direct seabed impacts
Low</td><td>Direct wildlife impacts
High</td><td>New ecological space
Low</td><td>Interactions with other sea-users:
Low</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Project deliverables:
A monitoring protocol, and field data from wave and tidal text sites</td></tr>
<tr><td colspan="7">Spatial data generated:
Nil</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
</table>

<table>
<tr><td colspan="3">Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td colspan="3">Project title:</td><td colspan="6">Pentland Firth Bird Monitoring Project</td></tr>
<tr><td colspan="3">Research providers:</td><td colspan="6">APEM</td></tr>
<tr><td colspan="3">Framework:</td><td colspan="6"></td></tr>
<tr><td colspan="3">Funding sources:</td><td colspan="6">Scottish Government</td></tr>
<tr><td colspan="3">Web-link:</td><td colspan="6"></td></tr>
<tr><td colspan="2">Start date:</td><td>2010</td><td colspan="3">End date:</td><td colspan="3">2012</td></tr>
<tr><td colspan="2">Geographical relevance:</td><td>Pentland and Orkney area</td><td colspan="3">Topical relevance:</td><td colspan="3">Birds</td></tr>
<tr><td>Project type:</td><td colspan="2">Resource assessment:
N/A</td><td colspan="2">Baselines:
High</td><td colspan="2">Impacts:
High</td><td colspan="2">Socio-economics:
Low</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
High</td><td>Installation:
Medium</td><td colspan="2">Operation:
Medium</td><td colspan="2">Maintenance:
Low</td><td colspan="2">Decommissioning:
Low</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
Low</td><td>Ecological processes:
Low</td><td>Direct seabed impacts
Low</td><td>Direct wildlife impacts
High</td><td colspan="2">New ecological space
Low</td><td colspan="2">Interactions with other sea-users:
Low</td></tr>
<tr><td colspan="9">Project description:
Aerial surveys of seabird distribution in the Pentland Firth and Orkney waters strategic area</td></tr>
<tr><td colspan="9">Project deliverables:
Strategic information on the use of this area by sea birds</td></tr>
<tr><td colspan="9">Spatial data generated:
Maps of sea bird distribution</td></tr>
<tr><td colspan="9">Bibliography of outputs:
Marine Scotland website</td></tr>
</table>

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:** N/A	**Baselines:** High	**Impacts:** High	**Socio-economics:** Low		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Medium	**Operation:** Medium	**Maintenance:** Low	**Decommissioning:** Low	
Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Low	**Direct seabed impacts** Low	**Direct wildlife impacts** High	**New ecological space** Low	**Interactions with other sea-users:** 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 sea birds and mammals						
Spatial data generated: Maps of sea bird and mammal distribution						
Bibliography of outputs: Marine Scotland website						

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Estimates of collision risk of harbour porpoises and marine renewable energy devices at sites of high tidal stream</td></tr>
<tr><td>Research providers:</td><td colspan="6">Scottish Association for Marine Science (SAMS)</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">Scottish Government</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">2009</td><td colspan="2">End date:</td><td colspan="2">2012</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">Wide</td><td colspan="2">Topical relevance:</td><td colspan="2">mammals</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
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<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
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<tr><td>Nature of impact / study:</td><td>Physical processes:
Low</td><td>Ecological processes:
Low</td><td>Direct seabed impacts
Low</td><td>Direct wildlife impacts
High</td><td>New ecological space
Low</td><td>Interactions with other sea-users:
Low</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Project deliverables:
Report</td></tr>
<tr><td colspan="7">Spatial data generated:
Few</td></tr>
<tr><td colspan="7">Bibliography of outputs:
Marine Scotland website</td></tr>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
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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

	Resource assessment:	**Baselines:**	**Impacts:**	**Socio-economics:**
Project type:	N/A	High	High	Low

	Planning and pre-development survey:	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
Development life-cycle stage:	High	Medium	Low	Low	Medium

	Physical processes:	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
Nature of impact / study:	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 firstly 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 BilliaCroo 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:**	**Maintenance:**	**Decommissioning:**
	Low	Low	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	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:**	Sea birds		
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 sea birds to wave and tidal projects

Spatial data generated:

No

Bibliography of outputs:

SNH website

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Low</td><td>Direct wildlife impacts
Low</td><td>New ecological space
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<tr><td colspan="7">Project description:
Survey of inshore fisheries – locations, gears, species, values etc</td></tr>
<tr><td colspan="7">Project deliverables:
Maps of characteristics of inshore fisheries</td></tr>
<tr><td colspan="7">Spatial data generated:
Maps of characteristics of inshore fisheries</td></tr>
<tr><td colspan="7">Bibliography of outputs:
To be published on Marine Scotland website</td></tr>
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Countries:	UK (Scotland), UK (Northern Ireland), Ireland
Project title:	Irish-Scottish Links on Energy Study (ISLES)
Research providers:	
Framework:	INTERREG IVA
Funding sources:	EU
Web-link:	http://www.islesproject.eu/

Start date:	2009	**End date:**	2011
Geographical relevance:	UK, Ireland	**Topical relevance:**	Energy supply

Project type:	**Resource assessment:** High	**Baselines:** Low	**Impacts:** Low	**Socio-economics:** High

Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** High	**Operation:** Low	**Maintenance:** Low	**Decommissioning:** Low

Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Low	**Direct seabed impacts** Medium	**Direct wildlife impacts** Low	**New ecological space** Low	**Interactions with other sea-users:** High

Project description:

ISLES is a collaborative project between the Scottish Government, the Northern Ireland Executive and the Government of Ireland. Funded mainly by the EU's INTERREG IVA Programme managed by the Special EU Programmes Body (SEUPB), it is assessing the feasibility of creating an offshore interconnected transmission network and subsea electricity grid based on renewable energy sources off the coast of western Scotland and in the Irish Sea/North Channel area.

The target area has huge potential for capturing wind, wave and tidal energy. However, each region's electricity network has not been developed as an offshore grid to exploit this major marine renewable resource and grid infrastructure is poor. As a result,the capacity to generate electricity is not matched by the ability to collect and transport that energy to market.

Project deliverables:

http://www.scotland.gov.uk/Topics/Business-

Industry/Energy/Action/leading/iles/exec-summary-draft/
Spatial data generated: Some
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 characterisation; (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 devises, 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 enabling 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 flow field through a tidal turbine; A Trajectory model to simulate organisms interacting with the turbine and resultant flow field; 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:**			
Project type:	**Resource assessment:** n/a	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** n/a	**Operation:**	**Maintenance:** n/a	**Decommissioning:** 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:**			
Project type:	**Resource assessment:** n/a	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** n/a	**Operation:** n/a	**Maintenance:** n/a	**Decommissioning:** 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: Utilisation 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:						

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<tr><td colspan="3">Countries:</td><td colspan="9">UK (Scotland)</td></tr>
<tr><td colspan="3">Project title:</td><td colspan="9">Marine Energy Spatial Planning Group research activities on the direct impact on marine birds</td></tr>
<tr><td colspan="3">Research providers:</td><td colspan="9">SNH</td></tr>
<tr><td colspan="3">Framework:</td><td colspan="9">Marine Energy Spatial Planning Group (MESPG)</td></tr>
<tr><td colspan="3">Funding sources:</td><td colspan="9">The Scottish Government (Marine Scotland)</td></tr>
<tr><td colspan="3">Web-link:</td><td colspan="9">http://www.snh.org.uk</td></tr>
<tr><td colspan="6">Start date:</td><td colspan="6">End date:</td></tr>
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High</td><td colspan="2">New ecological space
Low</td><td colspan="2">Interactions with other sea-users:
n/a</td></tr>
<tr><td colspan="12">Project description:</td></tr>
<tr><td colspan="12">Project deliverables:
Assessment methodology for determining cumulative impacts of marine renewable energy devices (excluding offshore wind farms) on marine birds
Assessment methodology for determining collision risk of marine renewable energy devices (excluding offshore wind farms) on marine birds
Surveys of marine birds in and around marine areas proposed for wave and tidal energy developments off the west coast of Scotland
The determination of foraging range and diving depths by diving seabirds, especially in the Orkney and Pentland Firth wave and tidal resource areas
Review of techniques to detect seabird presence and movement below the sea surface and determine potential application in the vicinity of tidal turbines
Analysis and assessment of marine habitats and species surveyed by Marine Scotland</td></tr>
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in Pentland Firth, Orkney, and additional surveys of Islay and west of Hebrides
Spatial data generated:
Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Guidance on Survey and Monitoring in relation to marine (wave and tide) renewable deployments in Scotland</td></tr>
<tr><td>Research providers:</td><td colspan="6">SNH, Marine Scotland</td></tr>
<tr><td>Framework:</td><td colspan="6">Marine Energy Spatial Planning Group (MESPG)</td></tr>
<tr><td>Funding sources:</td><td colspan="6">The Scottish Government (Marine Scotland)</td></tr>
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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:** High	**Baselines:** Medium	**Impacts:** High	**Socio-economics:** Medium			
Development life-cycle stage:	**Planning and pre-development survey:** Medium	**Installation:** Medium	**Operation:** High	**Maintenance:** Low	**Decommissioning:** Low		
Nature of impact / study:	**Physical processes:** High	**Ecological processes:** High	**Direct seabed impacts** Medium	**Direct wildlife impacts** Low	**New ecological space** Low	**Interactions with other sea-users:** 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:** n/a	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a

Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** n/a	**Operation:** High	**Maintenance:** n/a	**Decommissioning:** n/a

Nature of impact / study:	**Physical processes:** Medium	**Ecological processes:** High	**Direct seabed impacts** n/a	**Direct wildlife impacts** n/a	**New ecological space** n/a	**Interactions with other sea-users:** n/a

Project description:

Development of monitoring tools to detect ecological responses to extraction of energy from waves and tides

Project deliverables:

Spatial data generated:

Littoral biotopes on west coast of Orkney Mainland

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Passive acoustic monitoring of diving seabirds</td></tr>
<tr><td>Research providers:</td><td colspan="6">Heriot-Watt University (ICIT), RSPB, EMEC, UK</td></tr>
<tr><td>Framework:</td><td colspan="6">Marine Renewable Energy Development in Scotland (MREDS) Work Package 5</td></tr>
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<tr><td colspan="7">Project description:
Detection and identification of diving bird activity by ‘Sonobuoy’ mounted hydrophones</td></tr>
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<tr><td>Project title:</td><td colspan="6">Monitoring and Evaluation of Spatially Managed Areas (MESMA)</td></tr>
<tr><td>Research providers:</td><td colspan="6">IMARES (NL), University College London (UK), Senckenberg (DE), Ughent (BE), HCMR (GR), IO-BAS (BG), IMR (NO), HMRC-UCC (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)</td></tr>
<tr><td>Framework:</td><td colspan="6">FP7</td></tr>
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High</td></tr>
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Development of generic tools for Marine Spatial Planning. Aims to produce integrated management tools for monitoring, evaluation and implementation of Spatially Managed Areas</td></tr>
<tr><td colspan="7">Project deliverables:
Available from project website.</td></tr>
<tr><td colspan="7">Spatial data generated:
Collation of data for nine case studies. Portal for spatial data at http://mesma.ucc.ie/geonetwork/srv/en/main.home</td></tr>
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Bibliography of outputs: See website

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<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">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</td></tr>
<tr><td>Research providers:</td><td colspan="6">Heriot-Watt University (ICIT), UK</td></tr>
<tr><td>Framework:</td><td colspan="6">SuperGen Marine 2, PhD Studentship</td></tr>
<tr><td>Funding sources:</td><td colspan="6">UK Engineering and Physical Sciences Research Council</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">2008</td><td colspan="2">End date:</td><td colspan="2">2011</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">All regions</td><td colspan="2">Topical relevance:</td><td colspan="2">Wave energy measurement</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td>Impacts:</td><td colspan="3">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
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High</td><td>Maintenance:
n/a</td><td colspan="2">Decommissioning:
n/a</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
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High</td><td>Direct seabed impacts
n/a</td><td>Direct wildlife impacts
n/a</td><td>New ecological space
n/a</td><td>Interactions with other sea-users:
n/a</td></tr>
<tr><td colspan="7">Project description:
PhD Studentship developing and demonstrating inexpensive and efficient device to measure level and dominant directions of wave exposure on rocky shores at biologically meaningful spatial scales</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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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:** Low	**Baselines:** n/a	**Impacts:** Low	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** n/a	**Installation:** n/a	**Operation:** High	**Maintenance:** Low	**Decommissioning:** n/a	
Nature of impact / study:	**Physical processes:** n/a	**Ecological processes:** n/a	**Direct seabed impacts** n/a	**Direct wildlife impacts** Low	**New ecological space** n/a	**Interactions with other sea-users:** n/a

Project description:

Investigations of unsteady flow over tidal turbine rotors

Project deliverables:

Spatial data generated:

Bibliography of outputs:

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<tr><td>Research providers:</td><td colspan="6">Heriot-Watt University</td></tr>
<tr><td>Framework:</td><td colspan="6">Marine Renewable Energy Development in Scotland (MREDS) Work Package 4</td></tr>
<tr><td>Funding sources:</td><td colspan="6">Total</td></tr>
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<tr><td>Geographical relevance:</td><td colspan="2">All regions</td><td colspan="2">Topical relevance:</td><td colspan="2">Hydrographic modelling</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td>Impacts:</td><td colspan="3">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td>Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
Investigations into wave-current interactions, boundary layers and turbulence conditions in a tidal energy resource. Based on ADCP data from EMEC tidal test site.</td></tr>
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<tr><td colspan="7">Spatial data generated:</td></tr>
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<tr><td>Project title:</td><td colspan="6">Hebridean Marine Energy Futures</td></tr>
<tr><td>Research providers:</td><td colspan="6">University of the Highlands and Islands (LCC, ERI, SAMS), Heriot-Watt University (ICIT), Strathclyde University, University of Edinburgh, UK</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">Scottish Funding Council, Pelamis Wave Power, Aquamarine, Scottish Power Renewables, E.on UK, Voith Hydro Wavegen, RWE npower renewables, Comhairle nan EileanSiar</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.hebmarine.com/</td></tr>
<tr><td>Start date:</td><td colspan="2">2011</td><td colspan="2">End date:</td><td colspan="2">2014</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">Regional</td><td colspan="4">Topical relevance:</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
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Medium</td><td>Impacts:
High</td><td colspan="3">Socio-economics:
Low</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
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High</td><td>Maintenance:
Low</td><td colspan="2">Decommissioning:
Low</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
High</td><td>Ecological processes:
High</td><td>Direct seabed impacts
High</td><td>Direct wildlife impacts
High</td><td>New ecological space
Low</td><td>Interactions with other sea-users:
Low</td></tr>
<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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<table>
<tr><th>Countries:</th><td colspan="6">UK (Scotland)</td></tr>
<tr><th>Project title:</th><td colspan="6">Marine Renewable Energy and the Environment (MaREE)</td></tr>
<tr><th>Research providers:</th><td colspan="6">University</td></tr>
<tr><th>Framework:</th><td colspan="6"></td></tr>
<tr><th>Funding sources:</th><td colspan="6">EU European Regional Development Fund, Scottish Funding Council and Highlands and Islands Enterprise</td></tr>
<tr><th>Web-link:</th><td colspan="6">http://www.eri.ac.uk/MaREEP2722.asp</td></tr>
<tr><th>Start date:</th><td colspan="2">2010</td><th colspan="2">End date:</th><td colspan="2">2013</td></tr>
<tr><th>Geographical relevance:</th><td colspan="2">All regions</td><th colspan="2">Topical relevance:</th><td colspan="2">Resource and risk, environmental impacts, management for sustainability</td></tr>
<tr><th>Project type:</th><td>Resource assessment: High</td><td colspan="2">Baselines: High</td><td>Impacts: High</td><td colspan="2">Socio-economics: High</td></tr>
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<tr><th>Nature of impact / study:</th><td>Physical processes: High</td><td>Ecological processes: High</td><td>Direct seabed impacts High</td><td>Direct wildlife impacts High</td><td>New ecological space Low</td><td>Interactions with other sea-users: High</td></tr>
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Project description:

Focussed on environmental issues surrounding the development of marine renewable energy and the socio-economic impacts of such technologies. Three research work package themes: (i) Resource and Risk, including tidal resource assessment, wave climate assessment, modelling device-environment physical interaction (including turbulence and array effect), weather windowing; (ii) Environmental Impacts, including ecology study design, marine acoustics and interaction of marine mammals and fish with devices, currents, sediments and associated ecological change, marine aggregation / disaggregation by accident / design, seabird interaction, visual observations of benthic and pelagic communities; (iii) Towards Sustainable Management - policies and communities, including marine policy / spatial planning. sustainable development, community engagement.

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:** n/a	**Baselines:** n/a	**Impacts:** Low	**Socio-economics:** n/a			
Development life-cycle stage:	**Planning and pre-development survey:** n/a	**Installation:** n/a	**Operation:** High	**Maintenance:** High	**Decommissioning:** n/a		
Nature of impact / study:	**Physical processes:** n/a	**Ecological processes:** n/a	**Direct seabed impacts** n/a	**Direct wildlife impacts** n/a	**New ecological space** Low	**Interactions with other sea-users:** n/a	

Project description:

Experimental studies into biofouling - devices and infrastructure to independently test whole range of coatings available

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (England)						
Project title:	Energy and environment theme – offshore wind						
Research providers:	Plymouth Marine Laboratory, UK						
Framework:	UKERC						
Funding sources:	UK Natural Environment Research Council						
Web-link:							
Start date:	2009	**End date:**	2012				
Geographical relevance:	All regions	**Topical relevance:**	Development of socio-economic methods				
Project type:	**Resource assessment:** n/a	**Baselines:** n/a	**Impacts:** n/a	**Socio-economics:** High			
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** n/a	**Operation:** n/a	**Maintenance:** n/a	**Decommissioning:** n/a		
Nature of impact / study:	**Physical processes:** n/a	**Ecological processes:** n/a	**Direct seabed impacts** n/a	**Direct wildlife impacts** n/a	**New ecological space** n/a	**Interactions with other sea-users:** High	
Project description: Focus on methods development for ecosystem services valuation for offshore wind - methods transferable to wave and tidal							
Project deliverables:							
Spatial data generated:							
Bibliography of outputs:							

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<tr><td colspan="2">Countries:</td><td colspan="6">UK (Scotland and England)</td></tr>
<tr><td colspan="2">Project title:</td><td colspan="6">Understanding How Marine Renewable Device Operations Influence Fine Scale Habitat Use & Behaviour of Marine Vertebrates (RESPONSE)</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="6">Sea Mammal Research Unit, University of the Highlands and Islands (SAMS), Loughborough University, University of Aberdeen, Cranfield University, University of Edinburgh, UK</td></tr>
<tr><td colspan="2">Framework:</td><td colspan="6">NERC Marine Renewables Sandpit</td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="6">UK Natural Environment Research Council</td></tr>
<tr><td colspan="2">Web-link:</td><td colspan="6">http://www.nerc.ac.uk/research/programmes/mre/facts.asp</td></tr>
<tr><td colspan="2">Start date:</td><td colspan="2">2011</td><td colspan="2">End date:</td><td colspan="2">2014</td></tr>
<tr><td colspan="2">Geographical relevance:</td><td colspan="2">All regions</td><td colspan="2">Topical relevance:</td><td colspan="2">Sea mammals, collision risks</td></tr>
<tr><td>Project type:</td><td colspan="2">Resource assessment:
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n/a</td><td>Impacts:
High</td><td colspan="2">Socio-economics:
n/a</td></tr>
<tr><td>Development life-cycle stage:</td><td colspan="2">Planning and pre-development survey:
High</td><td>Installation:
n/a</td><td>Operation:
High</td><td colspan="2">Maintenance:
n/a</td><td>Decommissioning:
n/a</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
n/a</td><td>Ecological processes:
n/a</td><td>Direct seabed impacts
n/a</td><td>Direct wildlife impacts
High</td><td>New ecological space
n/a</td><td colspan="2">Interactions with other sea-users:
n/a</td></tr>
<tr><td colspan="8">Project description:
The RESPONSE project is a multi-disciplinary study focusing on causal links between marine renewable devices (MRD) and changes in the fine-scale distribution and behaviour of marine vertebrates. The overall aim of the project is to identify and quantify actual risk of negative consequences and therefore remove one key layer of uncertainty in the scale of risk to the industry and natural environment.</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
<tr><td colspan="8">Spatial data generated:</td></tr>
<tr><td colspan="8">Bibliography of outputs:</td></tr>
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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 under water, 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:

Scott, Beth; Philpott, Evelyn; Langton, Rebecca and Waggitt, James, 2012. **Seabirds and marine renewables: Are we asking the right questions?**The Environmental Interactions Of Marine Renewable Energy Technologies, EIMR International Conference, 1 - 3 May 2012, Kirkwall, Orkney.

Benjamin Williamson, Philippe Blondel, 2012. Multibeam imaging of the environment around marine renewable energy devices.European Conference on Underwater Acoustics (ECUA) 2012, 2nd - 6th July, 2012, Edinburgh, UK. The Powerpoint slides from this talk can be downloaded as a PDF here.

Bell, Paul; Lawrence, John; Norris, Jennifer. 2012 Determining currents from marine radar data in an extreme current environment at a tidal energy test site. In: *Proceedings of the IEEE International Geoscience and Remote Sensing Symposium 2012*. IEEE, July 22-27 2012, Munich.

Countries:	UK (Scotland, England)
Project title:	Optimising 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

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
	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 maximised. 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

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
	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

Nature of impact / study:	**Physical processes:**	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
	Low	Medium	n/a	High	High	High

Project description:

The principal aim of the proposed research is to quantify the extent to which 'spillover' of bioresource abundance (fish and invertebrate species) enhances adjacent areas as a consequence of fishing exclusions within and around Marine Renewable Energy Installations (MREIs). The focus of the research is to use novel technologies for determining the spatial movements of fish and shellfish across a wide-range of spatio-temporal scales (spanning metres to 100s of kilometres, and minutes to years). Space use will be related quantitatively to the changing physical and biological environment and will inform an understanding of the effects of fish spatial dynamics on field monitoring derived estimates of abundance of fish and macroinvertebrates comprising the community assemblage found within and adjacent to MREI sites. Empirical and spatial modelling estimates of biological spillover from MREIs will be made, and the social and economic costs of MREIs on fisheries assessed, which together with the novel combination of tracking technologies and environmental sampling will allow

the first test of the importance of potential spillover to regions adjacent to MREIs.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

Countries:	UK (Scotland, Wales)					
Project title:	Large scale Interactive coupled 3D modelling for wave and tidal energy resource and environmental impact (TeraWatt)					
Research providers:	MASTS Consortium: Heriot-Watt University (ICIT), University of Edinburgh, University of Strathclyde, University of the Highlands and Islands (LCC, SAMS), Marine Scotland Science, University of Swansea, UK					
Framework:	SuperGen Marine Challenge call					
Funding sources:	UK Engineering & Physical Sciences Research Council, University					
Web-link:	http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/J010170/1					
Start date:	2012	**End date:**	2015			
Geographical relevance:	Regional	**Topical relevance:**	Hydrographic modelling, ecological modelling, energy extraction scenarios			
Project type:	**Resource assessment:** High	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** n/a	**Operation:** High	**Maintenance:** n/a	**Decommissioning:** n/a	
Nature of impact / study:	**Physical processes:** High	**Ecological processes:** High	**Direct seabed impacts** High	**Direct wildlife impacts** n/a	**New ecological space** n/a	**Interactions with other sea-users:** n/a

Project description:

The research programme has been designed to specifically respond to questions posed by Marine Scotland Science, the organisation responsible for providing scientific advice to the licensing authority. In particular to the following questions: (1) What is the best way to assess the wave and tidal resource and the effects of energy extraction on it? (2) What are the physical consequences of wave and tidal energy extraction? (3) What are the ecological consequences of wave and tidal energy extraction? The overarching objective of the research is to generate a suite of methodologies that can provide better understandings of, and be used to assess, the alteration of the resource from energy extraction, and of the physical and ecological consequence.

Illustration of the use of these in key development area, such as the Pentland Firth and Orkney Waters, and their availability as tools will enable the acceleration of array deployments.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

Countries:	UK (Scotland)		
Project title:	Continuation of land-based wildlife monitoring programmes at the tidal and wave test sites at EMEC		
Research providers:	Marine Scotland		
Framework:			
Funding sources:	Marine Scotland		
Web-link:			
Start date:	12/1/2010	**End date:**	3/1/2012
Geographical relevance:	North Coast & Islands	**Topical relevance:**	Wave & Tidal, Marine Mammals, Birds, Cetaceans, Seals, Basking Sharks, Physicial Interactions

Project type:	**Resource assessment:** N/A	**Baselines:** Low	**Impacts:** High	**Socio-economics:** Low	
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Low	**Operation:** High	**Maintenance:** Low	**Decommissioning:** Low

Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Medium	**Direct seabed impacts** Low	**Direct wildlife impacts** High	**New ecological space** Low	**Interactions with other sea-users:** Low

Project description:

To establish whether the presence and operation of wave and tidal devices causes displacement of surface-visible wildlife and seeks to identify any discernible changes to wildlife behaviour.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td colspan="2">Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td colspan="2">Project title:</td><td colspan="6">Land-based visual observations at the Scapa Flow nursery site and Shapinsay Sound tidal nursery site.</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="6">Marine Scotland</td></tr>
<tr><td colspan="2">Framework:</td><td colspan="6"></td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="6">Marine Scotland</td></tr>
<tr><td colspan="2">Web-link:</td><td colspan="6"></td></tr>
<tr><td colspan="2">Start date:</td><td colspan="2">12/1/2012</td><td colspan="2">End date:</td><td colspan="2">3/1/2012</td></tr>
<tr><td colspan="2">Geographical relevance:</td><td colspan="2">North Coast & Islands</td><td colspan="2">Topical relevance:</td><td colspan="2">Wave & Tidal, Marine Mammals, Birds, Cetaceans, Seals, Basking Sharks, Physicial Interactions</td></tr>
<tr><td>Project type:</td><td colspan="2">Resource assessment:
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High</td><td colspan="2">Maintenance:
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low</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
Low</td><td>Ecological processes:
Medium</td><td>Direct seabed impacts
Low</td><td>Direct wildlife impacts
High</td><td>New ecological space
Low</td><td colspan="2">Interactions with other sea-users:
Low</td></tr>
<tr><td colspan="8">Project description:
To establish whether the presence and operation of wave and tidal devices causes displacement of surface-visible wildlife and seeks to identify any discernible changes to wildlife behaviour, using surface observations from a land-based observer.</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
<tr><td colspan="8">Spatial data generated:</td></tr>
<tr><td colspan="8">Bibliography of outputs:</td></tr>
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Countries:	UK (Scotland)					
Project title:	Baseline acoustic characterisation of the EMEC wave and tidal nursery sites					
Research providers:	Marine Scotland					
Framework:						
Funding sources:	Marine Scotland					
Web-link:						
Start date:	3/1/2011	**End date:**	4/1/2012			
Geographical relevance:	North Coast & Islands	**Topical relevance:**	Wave & Tidal, Acoustics, Baseline values			
Project type:	**Resource assessment:** N/A	**Baselines:** High	**Impacts:** Low	**Socio-economics:** Low		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Low	**Operation:** Low	**Maintenance:** Low	**Decommissioning:** Low	
Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Low	**Direct seabed impacts** Low	**Direct wildlife impacts** Low	**New ecological space** Low	**Interactions with other sea-users:** Low

Project description:

To provide a baseline acoustic characterisation of the wave and tidal nursery test sites at St Mary's and Shapinsay Sound respectively.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (Scotland)						
Project title:	Analysis of wildlife observation data						
Research providers:	SNH						
Framework:							
Funding sources:	SNH						
Web-link:							
Start date:	11/1/2010	**End date:**	6/1/2011				
Geographical relevance:	North Coast & Islands	**Topical relevance:**	Wave & Tidal, Generic, Marine operations				
Project type:	**Resource assessment:** N/A	**Baselines:** Medium	**Impacts:** Medium	**Socio-economics:** Low			
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Low	**Operation:** Medium	**Maintenance:** Medium	**Decommissioning:** Low		
Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Medium	**Direct seabed impacts** Low	**Direct wildlife impacts** Medium	**New ecological space** Low	**Interactions with other sea-users:** Low	

Project description:

Analysis of wildlife observation data from the tidal test site: Fall of Warness (July 2005 to date) and the wave test site: Billia Croo (March 2009 to date) at the EMEC facility.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (Scotland)					
Project title:	Peer review of land-based visual monitoring methods and protocols for wave and tidal test sites					
Research providers:	SNH					
Framework:						
Funding sources:	SNH					
Web-link:						
Start date:	11/1/2010		**End date:**	6/1/2011		
Geographical relevance:	N/A		**Topical relevance:**	Wave & Tidal, Generic, Protocol/Methodology Development, Physicial Interactions		
Project type:	**Resource assessment:** N/A	**Baselines:** Low	**Impacts:** High	**Socio-economics:** Low		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Low	**Operation:** Medium	**Maintenance:** Low	**Decommissioning:** Low	
Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Medium	**Direct seabed impacts** Low	**Direct wildlife impacts** High	**New ecological space** Low	**Interactions with other sea-users:** Low

Project description:

Detailed review of the existing wildlife monitoring programme at the tidal and wave test sites at the EMEC facility to determine their capacity to detect impacts, if any, sustained by local wildlife populations.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (Scotland)						
Project title:	Marine Mammal Requirement for scientific support						
Research providers:	Marine Scotland						
Framework:							
Funding sources:	Marine Scotland						
Web-link:							
Start date:	4/1/2010	**End date:**	4/1/2012				
Geographical relevance:	N/A	**Topical relevance:**	Wave & Tidal, Marine Mammals, Technology and model development, Mitigation, Protocol/Methodology Development, Physicial Interactions				
Project type:	**Resource assessment:** N/A	**Baselines:** High	**Impacts:** Medium	**Socio-economics:** Low			
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Low	**Operation:** Low	**Maintenance:** Low	**Decommissioning:** Low		
Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Medium	**Direct seabed impacts** Low	**Direct wildlife impacts** High	**New ecological space** Low	**Interactions with other sea-users:** Low	

Project description:

1) To provide a source of advice for industry and regulators on marine mammal interactions and possible mitigation measures, 2) to recalibrate existing data on abundance and distribution of marine mammals. Test prevention using ADD's.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td colspan="2">Countries:</td><td colspan="5">UK (Scotland)</td></tr>
<tr><td colspan="2">Project title:</td><td colspan="5">Cetacean monitoring in the Pentland Firth tidal energy area</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="5">Marine Scotland</td></tr>
<tr><td colspan="2">Framework:</td><td colspan="5"></td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="5">Marine Scotland</td></tr>
<tr><td colspan="2">Web-link:</td><td colspan="5"></td></tr>
<tr><td colspan="2">Start date:</td><td>3/1/2010</td><td colspan="2">End date:</td><td colspan="2">7/1/2011</td></tr>
<tr><td colspan="2">Geographical relevance:</td><td>North Coast & Islands</td><td colspan="2">Topical relevance:</td><td colspan="2">Wave & Tidal, Technology and model development, Cetaceans, Mitigation, Baseline values, Physicial Interactions</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
N/A</td><td>Baselines:
High</td><td>Impacts:
Medium</td><td colspan="3">Socio-economics:
Low</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
High</td><td>Installation:
Low</td><td>Operation:
Low</td><td colspan="2">Maintenance:
Low</td><td>Decommissioning:
Low</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
Low</td><td>Ecological processes:
Medium</td><td>Direct seabed impacts
Low</td><td>Direct wildlife impacts
High</td><td>New ecological space
Low</td><td>Interactions with other sea-users:
Low</td></tr>
<tr><td colspan="7">Project description:
To provide a toolset for monitoring cetaceans in and around Pentland Firth to collect baseline data on cetacean behaviour and distribution and enable effects of installed devices to be explored and minimise possible impacts on cetaceans.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	UK (Scotland)					
Project title:	Wave and Tidal Plan Development - Habitats Regulations Appraisal					
Research providers:	Specialist Contractor					
Framework:						
Funding sources:	Marine Scotland					
Web-link:						
Start date:	9/1/2011	**End date:**	3/1/2012			
Geographical relevance:	N/A	**Topical relevance:**	Wave & Tidal, Generic			
Project type:	**Resource assessment:** Medium	**Baselines:** Medium	**Impacts:** Medium	**Socio-economics:** Medium		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Low	**Operation:** Low	**Maintenance:** Low	**Decommissioning:** Low	
Nature of impact / study:	**Physical processes:**	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**

Project description:

HRA of the Initial Plan Framework for wave and tidal energy in Scottish seas

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Wave and Tidal Plan Development - Strategic Environmental Assessment</td></tr>
<tr><td>Research providers:</td><td colspan="6">Scottish Government</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">Marine Scotland</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
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<tr><td>Project type:</td><td>Resource assessment:
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<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
Strategic Environmental Assessment of the Initial Plan Framework for wave and tidal energy in Scottish seas</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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<tr><td colspan="2">Countries:</td><td colspan="10">UK (Scotland)</td></tr>
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<tr><td colspan="2">Research providers:</td><td colspan="10">Specialist Contractor</td></tr>
<tr><td colspan="2">Framework:</td><td colspan="10"></td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="10">Marine Scotland</td></tr>
<tr><td colspan="2">Web-link:</td><td colspan="10"></td></tr>
<tr><td colspan="2">Start date:</td><td colspan="4"></td><td colspan="3">End date:</td><td colspan="3"></td></tr>
<tr><td colspan="2">Geographical relevance:</td><td colspan="4">North Coast & Islands</td><td colspan="3">Topical relevance:</td><td colspan="3">Wave & Tidal, Technology and model development, Visual/seascape</td></tr>
<tr><td>Project type:</td><td colspan="2">Resource assessment:
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high</td><td colspan="4">Socio-economics:
high</td></tr>
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<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td colspan="2">Direct seabed impacts</td><td colspan="2">Direct wildlife impacts</td><td colspan="2">New ecological space</td><td colspan="3">Interactions with other sea-users:</td></tr>
<tr><td colspan="12">Project description:
Project to model impact upon seascape of planned renewable activities and to determine economic value of seascape and any change in this as a result of renewable activities</td></tr>
<tr><td colspan="12">Project deliverables:</td></tr>
<tr><td colspan="12">Spatial data generated:</td></tr>
<tr><td colspan="12">Bibliography of outputs:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Larval supply and settlement of rocky shore barnacles in open coast and sheltered environments</td></tr>
<tr><td>Research providers:</td><td colspan="6">University of St Andrews</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">NERC</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">11/1/2003</td><td colspan="2">End date:</td><td colspan="2">2/28/2007</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">North Sea - North</td><td colspan="2">Topical relevance:</td><td colspan="2">Wave & Tidal, Benthos, Hydrodynamics, Technology and model development</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
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High</td><td colspan="2">Impacts:</td><td colspan="2">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
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Medium</td><td>Ecological processes:
High</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
development of a means of quantifying larval flux for barnacle larvae that is effective in wave crash environments.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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<tr><td>Project title:</td><td colspan="6">Proof of concept for methods for monitoring marine mammals.</td></tr>
<tr><td>Research providers:</td><td colspan="6">University of Aberdeen</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">Marine Scotland</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2"></td><td colspan="2">End date:</td><td colspan="2">3/1/2012</td></tr>
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<tr><td>Project type:</td><td>Resource assessment:
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<tr><td colspan="7">Project description:
Project to establish the most efficient and cost effective way to count marine mammal populations in sea areas.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	UK (Scotland)						
Project title:	Hydro-dynamic and coastal process modeling.						
Research providers:	Specalist Contractor						
Framework:							
Funding sources:	Marine Scotland						
Web-link:							
Start date:		**End date:**					
Geographical relevance:	North Coast & Islands, North Sea - North, UK Atlantic - North	**Topical relevance:**	, Hydrodynamics, Technology and model development				
Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**			
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**		
Nature of impact / study:	**Physical processes:** High	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**	
Project description:							
modification of an existing model to allow current system modelling for West Offshore Wind Plan regions, as well as current system modelling for the areas identified through Regional Locational Guidance for marine renewable development.							
Project deliverables:							
Spatial data generated:							
Bibliography of outputs:							

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<tr><td>Countries:</td><td colspan="7">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="7">Concrete Base Research work</td></tr>
<tr><td>Research providers:</td><td colspan="7">Specalist Contractor</td></tr>
<tr><td>Framework:</td><td colspan="7"></td></tr>
<tr><td>Funding sources:</td><td colspan="7">Marine Scotland</td></tr>
<tr><td>Web-link:</td><td colspan="7"></td></tr>
<tr><td>Start date:</td><td colspan="3"></td><td>End date:</td><td colspan="3"></td></tr>
<tr><td>Geographical relevance:</td><td colspan="3">N/A</td><td>Topical relevance:</td><td colspan="3">, Ecological Interactions, Artificial Reefs</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td colspan="2">Impacts:
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High</td><td>Installation:
medium</td><td>Operation:</td><td colspan="2">Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:
High</td><td>Direct seabed impacts
Medium</td><td>Direct wildlife impacts
Medium</td><td colspan="2">New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="8">Project description:
Investigation in to the potential effects of concrete bases in the marine environment.</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
<tr><td colspan="8">Spatial data generated:</td></tr>
<tr><td colspan="8">Bibliography of outputs:</td></tr>
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Countries:	UK (Scotland)					
Project title:	From MAPs to MPAs: ecologically-rigorous design principles for offshore Marine Protected Areas based on sea mammal distribution and abundance					
Research providers:	SMRU					
Framework:						
Funding sources:	NERC					
Web-link:						
Start date:	10/1/2008		**End date:**	9/30/2012		
Geographical relevance:	North Coast & Islands, North Sea - North, North Sea - South, UK Atlantic - North, UK Atlantic - Centre, UK Atlantic - South, South Coast & Islands, Irish Sea, Inner Hebridies		**Topical relevance:**	, Marine Mammals, Technology and model development, Protocol/Methodology Development, Physicial Interactions		
Project type:	**Resource assessment:**	**Baselines:**	**Impacts:** Medium	**Socio-economics:**		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**	
Nature of impact / study:	**Physical processes:**	**Ecological processes:** Medium	**Direct seabed impacts**	**Direct wildlife impacts** Medium	**New ecological space**	**Interactions with other sea-users:**
Project description:						
investigating how to use maps of marine mammal distribution and abundance to inform policy decisions, namely the development of offshore marine protectedareas (MPAs). 1-develop a model, 2-inform model, 3-investigate impact, 4-develop criteria.						

Project deliverables:
Spatial data generated:
Bibliography of outputs:

<table>
<tr><td colspan="3">Countries:</td><td colspan="4">UK (Scotland)</td></tr>
<tr><td colspan="3">Project title:</td><td colspan="4">Marine landscape classification of UK regional seas</td></tr>
<tr><td colspan="3">Research providers:</td><td colspan="4">SMRU</td></tr>
<tr><td colspan="3">Framework:</td><td colspan="4"></td></tr>
<tr><td colspan="3">Funding sources:</td><td colspan="4">DEFRA</td></tr>
<tr><td colspan="3">Web-link:</td><td colspan="4"></td></tr>
<tr><td colspan="2">Start date:</td><td>12/1/2004</td><td colspan="2">End date:</td><td colspan="2">4/30/2006</td></tr>
<tr><td colspan="2">Geographical relevance:</td><td>North Coast & Islands, North Sea - North, North Sea - South, UK Atlantic - North, UK Atlantic - Centre, UK Atlantic - South, South Coast & Islands, Irish Sea, Inner Hebridies</td><td colspan="2">Topical relevance:</td><td colspan="2">, Generic, Protocol/Methodology Development</td></tr>
<tr><td>Project type:</td><td colspan="2">Resource assessment:</td><td>Baselines:
High</td><td>Impacts:</td><td colspan="2">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
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<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
To provide the marine equivalent of a ‘countryside map’ of the seabed by extending the marine landscape classification undertaken by the Irish Sea Pilot to other regional seas in UK waters (subject to agreement of devolved administrations).</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
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Spatial data generated:
Bibliography of outputs:

Countries:	UK (Scotland)		
Project title:	Marine artificial habitat manipulation: prediction and measurement of environmental impacts.		
Research providers:	SAMS		
Framework:			
Funding sources:	NERC		
Web-link:			
Start date:	11/19/2001	**End date:**	11/18/2004
Geographical relevance:	Inner Hebridies	**Topical relevance:**	, Technology and model development, Artificial Reefs, Physicial Interactions

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
			High	

Development life-cycle stage:	**Planning and pre-development survey:**	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
	High				

Nature of impact / study:	**Physical processes:**	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
	Medium	High	Low	Medium		

Project description:

develop, test and modify predictive models of the effects of large-scale artificial marine interventions.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (Scotland)		
Project title:	Behavioural and physiological responses of marine mammals to prey density and accessibility: An experimental approach.		
Research providers:	SMRU		
Framework:			
Funding sources:	NERC		
Web-link:			
Start date:	2/3/2003	**End date:**	2/2/2004
Geographical relevance:	N/A	**Topical relevance:**	, Marine Mammals, Ecological Interactions, Technology and model development

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
		Low		

Development life-cycle stage:	**Planning and pre-development survey:**	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
	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:

test and modify diving models and provide a framework for analysis of natural diving behaviour to assess foraging success.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (Scotland)						
Project title:	Potential ecological impacts of a small scale tidal device at the Isle of May SAC						
Research providers:	SNH						
Framework:							
Funding sources:	SNH						
Web-link:							
Start date:	10/1/2008	**End date:**	8/1/2013				
Geographical relevance:	North Sea - North	**Topical relevance:**	Tidal, Generic				
Project type:	**Resource assessment:**	**Baselines:** Low	**Impacts:** High	**Socio-economics:**			
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**		
Nature of impact / study:	**Physical processes:** Low	**Ecological processes:** Medium	**Direct seabed impacts**	**Direct wildlife impacts** High	**New ecological space**	**Interactions with other sea-users:**	

Project description:

PhD project to establish the feasibility, and implications for the natural heritage, of deploying a small tidal energy convertor within the Isle of May SAC, designated for seabirds, reefs and grey seals.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Estimating seal encounter rate and collision risk with tidal turbines</td></tr>
<tr><td>Research providers:</td><td colspan="6">SNH</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">SNH</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">6/1/2011</td><td colspan="2">End date:</td><td colspan="2">12/1/2011</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">N/A</td><td colspan="2">Topical relevance:</td><td colspan="2">Tidal, Technology and model development, Seals, Collisions, Physicial Interactions</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td colspan="2">Impacts:
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<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
High</td><td>Installation:</td><td>Operation:</td><td>Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts
High</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
To review and refine existing approaches to estimating the encounter rate between seals (grey & harbour) and horizontal axis tidal stream devices wth exposed blades, to improve estimates of collision risk.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	UK (Scotland)
Project title:	Marine Survey in Orkney, Shetland and Pentland Firth.
Research providers:	MSS
Framework:	
Funding sources:	MSS
Web-link:	
Start date: 9/1/2009	**End date:** 10/1/2009
Geographical relevance: North Coast & Islands	**Topical relevance:** Tidal, Benthos, Baseline values

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
		High		

Development life-cycle stage:	**Planning and pre-development survey:**	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
	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:

Suvey work to provide general description of tidal resource areas to create a better benchmark against which specific sites can be compared in the future.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Sound of Islay Demonstration Pilot</td></tr>
<tr><td>Research providers:</td><td colspan="6">Specialist Contractor</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">Marine Scotland</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">1/1/2013</td><td colspan="2">End date:</td><td colspan="2"></td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">Inner Hebridies</td><td colspan="2">Topical relevance:</td><td colspan="2">Tidal, Marine Mammals, Seals, Marine operations, Physicial Interactions</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:
High</td><td colspan="2">Impacts:
High</td><td colspan="2">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:
High</td><td>Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts
High</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
The Sound of Islay demonstration (tidal) project presents an opportunity to study the disturbance of seals (e.g. pup abandonment, disuse of haul out sites) caused by vessel movements and construction activity during the installation of tidal turbines.
Approaches being considered include the development of sophisticated tags to track the underwater movement of seals in greater detail or imaging equipment being placed on the turbines which can detect the movement of seals around them.</td></tr>
<tr><td colspan="7">Project deliverables:
Seal Disturbance Monitoring
Development of methods for direct observations of seal collisions</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	UK (Scotland)
Project title:	Interactions of flow, tidal stream turbines and local sediment bed under combined wave and tidal conditions (INSTRON)
Research providers:	University of Dundee
Framework:	
Funding sources:	EPSRC
Web-link:	

Start date:	4/1/2012	**End date:**	3/31/2015
Geographical relevance:	N/A	**Topical relevance:**	Tidal, Hydrodynamics, Technology and model development, Sediment Transport

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
			High	

Development life-cycle stage:	**Planning and pre-development survey:**	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
	High				

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:

The main aim of the proposed research is to develop advanced computational tools to overcome the above knowledge gaps, in order to predict the consequences of complex interactions between tidal flow, tidal stream turbines and the sea floor sediment.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (Scotland)					
Project title:	Great Race Eddies and Turbulence					
Research providers:	SAMS					
Framework:						
Funding sources:	NERC					
Web-link:						
Start date:	2/1/2010	**End date:**	1/31/2013			
Geographical relevance:	Inner Hebridies	**Topical relevance:**	Tidal, Hydrodynamics, Technology and model development			
Project type:	**Resource assessment:** Medium	**Baselines:** High	**Impacts:**	**Socio-economics:**		
Development life-cycle stage:	**Planning and pre-development survey:** High	**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:

Understanding eddies, turbulance and mixing in highlyitidal environments using cutting edge technology and instrumentation.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (Scotland)
Project title:	WP4 - Environmental Interactions of Wave Energy Convertors
Research providers:	ERI, SAMS, ICIT
Framework:	
Funding sources:	SFC, E.ON, SPR
Web-link:	

Start date:	4/1/2011	**End date:**	3/1/2014
Geographical relevance:	UK Atlantic - North	**Topical relevance:**	Wave, Marine Mammals, Birds, Benthos, Acoustics, Physicial Interactions

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
			High	

Development life-cycle stage:	**Planning and pre-development survey:**	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
	High				

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	High		

Project description:

assessing the potential impacts of WEC's including environmental interaction assessments (on birdlife, marine mammals, noise progression and the seabed)

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (Scotland)</td></tr>
<tr><td>Project title:</td><td colspan="6">Inshore Surveys</td></tr>
<tr><td>Research providers:</td><td colspan="6">Specialist Contractor</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">Marine Scotland</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">4/1/2011</td><td colspan="2">End date:</td><td colspan="2">3/1/2014</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">North Coast & Islands</td><td colspan="2">Topical relevance:</td><td colspan="2">Wave, Bathymetry, baseline values</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:
High</td><td>Impacts:</td><td colspan="3">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
High</td><td>Installation:</td><td>Operation:</td><td>Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
Phase 1: West of Lewis bathymetry survey: survey work required by Marine Scotland in support shallow water renewables development. The sites of interest for shallow water work are to the west of the outer Hebrides.
Phase 2: second tranche of geo-survey (sub-bottom profiling) work in areas of prime importance for marine renewables. wave sites associated with the Round 1 leases and the southwest Shetland lease area.
Phase 3: Focus on collection of bathymetric data for the south west of Shetland, building on the limited data collected by FRV Scotia during 2011.</td></tr>
<tr><td colspan="7">Project deliverables:
Bathymetry data</td></tr>
<tr><td colspan="7">Spatial data generated:
High resolution bathymetry maps</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	UK (Scotland)
Project title:	Scottish Shelf Model development
Research providers:	Halcrow and NOCL
Framework:	
Funding sources:	Marine Scotland
Web-link:	

Start date:	2012	**End date:**	2014
Geographical relevance:	North Coast & Islands	**Topical relevance:**	Wave, Bathymetry, baseline values

Project type:	**Resource assessment:** High	**Baselines:** High	**Impacts:** Medium	**Socio-economics:**

Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**

Nature of impact / study:	**Physical processes:** High	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**

Project description:

The provision of an FVCOM hydrodynamic model for the Scottish shelf and a number of area scale models at higher resolution.

Project deliverables:

Scottish Shelf model using FVCOM

A number of smaller area models including Pentland Firth and Orkney Waters (PFOW)

Development of a methodology for representing wave and tidal energy extraction within FVCOM models.

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (England), France</td></tr>
<tr><td>Project title:</td><td colspan="6">Marine Energy in Far Peripheral and Island Communities (MERiFIC)</td></tr>
<tr><td>Research providers:</td><td colspan="6">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, PôleMer, Technopole Brest Iroise (France)</td></tr>
<tr><td>Framework:</td><td colspan="6">INTERREG</td></tr>
<tr><td>Funding sources:</td><td colspan="6">EU</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.merific.eu/</td></tr>
<tr><td>Start date:</td><td colspan="2">2011</td><td colspan="2">End date:</td><td colspan="2">2014</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">Regional</td><td colspan="2">Topical relevance:</td><td colspan="2">Marine renewable energy for remote and island communities</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
Medium/High</td><td>Baselines:
Medium</td><td colspan="2">Impacts:
Medium</td><td colspan="2">Socio-economics:
High</td></tr>
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Medium</td><td>Maintenance:
Medium</td><td colspan="2">Decommissioning:
Low</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
Medium</td><td>Ecological processes:
Medium</td><td>Direct seabed impacts
Medium</td><td>Direct wildlife impacts
Medium</td><td>New ecological space
Medium</td><td>Interactions with other sea-users:
High</td></tr>
<tr><td colspan="7">Project description:
MERiFIC objectives: Share engineering know how, policy and good practice; Produce a tool kit to share our knowledge; Identify marine energy hotspots, prioritising island communities; Investigate the needs for energy generation and distribution; Promote marine energy; Encourage business opportunities – developing the supply chain; Engage with communities, helping them to see the need for renewable energy.</td></tr>
<tr><td colspan="7">Project deliverables:
Reports; GIS database; workshops</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
</table>

GIS database covering Iroise Sea and Scilly islands areas
Bibliography of outputs:

<table>
<tr><td colspan="2">Countries:</td><td colspan="6">UK (Wales)</td></tr>
<tr><td colspan="2">Project title:</td><td colspan="6">Marine Renewable Energy Strategic Framework</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="6">Various</td></tr>
<tr><td colspan="2">Framework:</td><td colspan="6"></td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="6"></td></tr>
<tr><td colspan="2">Web-link:</td><td colspan="6">http://mresf.rpsgroup.com/</td></tr>
<tr><td colspan="2">Start date:</td><td colspan="2"></td><td colspan="2">End date:</td><td colspan="2"></td></tr>
<tr><td colspan="2">Geographical relevance:</td><td colspan="2"></td><td colspan="2">Topical relevance:</td><td colspan="2"></td></tr>
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<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td colspan="2">Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td colspan="2">Interactions with other sea-users:</td></tr>
</table>

Project description:

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 in3 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. JER3688100428SK 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:	UK (Wales)					
Project title:	Marine Energy Development Programme					
Research providers:	Bangor University, Swansea University, Cardiff University, Swansea Metropolitan, Pembrokeshire College, UK, Aberystwyth University					
Framework:	Low Carbon Research Institute					
Funding sources:	WEFO / ERDF					
Web-link:	www.lcrimarine.org.uk/					
Start date:	2010	**End date:**	2013			
Geographical relevance:	All regions	**Topical relevance:**	Sediment dynamics, larval dispersal, acoustic monitoring, hydro-environmental monitoring, coastal processes, marine mammals, fish			
Project type:	**Resource assessment:** Medium	**Baselines:** High	**Impacts:** n/a	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** High	**Operation:** High	**Maintenance:** High	**Decommissioning:** High	
Nature of impact / study:	**Physical processes:** High	**Ecological processes:** High	**Direct seabed impacts** High	**Direct wildlife impacts** n/a	**New ecological space** n/a	**Interactions with other sea-users:** Low

Project description:

Sediment dynamics, larval dispersal, acoustic monitoring, hydro-environmental monitoring, coastal processes, marine mammals, fish, environmental modelling

Project deliverables:

Spatial data generated:

Data collected from Ramsey Sound will be publically available (ADCP, fish, noise)

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="7">UK(Wales)</td></tr>
<tr><td>Project title:</td><td colspan="7">Sustainable Expansion of the Applied Coastal and Marine Sectors</td></tr>
<tr><td>Research providers:</td><td colspan="7">Bangor University, Swansea University, Aberystwyth University</td></tr>
<tr><td>Framework:</td><td colspan="7">SEACAMS</td></tr>
<tr><td>Funding sources:</td><td colspan="7">WEFO/ERDF</td></tr>
<tr><td>Web-link:</td><td colspan="7">www.seacams.ac.uk/</td></tr>
<tr><td>Start date:</td><td colspan="2">2010</td><td colspan="2">End date:</td><td colspan="3">2015</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">National</td><td colspan="2">Topical relevance:</td><td colspan="3">Aquaculture and marine energy, marine mammals</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td>Impacts:
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<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:
Low</td><td>Maintenance:</td><td colspan="3">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space
Low</td><td colspan="2">Interactions with other sea-users:
Medium</td></tr>
<tr><td colspan="8">Project description:</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
<tr><td colspan="8">Spatial data generated:</td></tr>
<tr><td colspan="8">Bibliography of outputs:</td></tr>
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Countries:	Finland, Germany and Portugal
Project title:	SURGE – Simple Underwater Renewable Generation Electricity
Research providers:	Bosch Rexroth GmbH – Germany, Estaleiros Navais de Peniche – Portugal, Eneólica SA – Portugal, WaveEnergy Centre – Portugal , Instituto Hidrografico – Portugal, Câmara municipal de Peniche – Portugal
Framework:	FP7 – Cooperation program
Funding sources:	European Commission
Web-link:	http://fp7-surge.com/

Start date:	October 2009	**End date:**	To be defined
Geographical relevance:		**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:

The goal of the project is to build a grid connected wave energy converter which will be deployed in Peniche, Portugal. The project aims to access the WaveRoller device in a holistic manner and consequently, besides the performance, it includes an environmental program in order to evaluate some of the environmental impacts that it may have. It should be noted that these studies go beyond the legal requirements for the project implementation and they aim to proactively identify, target and address the potential impacts, both positive and negative, derived from the installation of the Waveroller device. Two aspects, were considered priority considering the characteristics of the device, were selected: underwater noise generation during operation and alterations on macrobenthic communities and sediment characteristics.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">Portugal</td></tr>
<tr><td>Project title:</td><td colspan="6">Wave Energy Acoustic Monitoring</td></tr>
<tr><td>Research providers:</td><td colspan="6">Wave Energy Centre and CINTAL – University of Algarve</td></tr>
<tr><td>Framework:</td><td colspan="6">PTDC programme of FCT</td></tr>
<tr><td>Funding sources:</td><td colspan="6">Fundação para a Ciência e Tecnologia (FCT)</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.siplab.fct.ualg.pt/proj/weam.shtml</td></tr>
<tr><td>Start date:</td><td colspan="2">November 2007</td><td colspan="2">End date:</td><td colspan="2">April 2011</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">All regions</td><td colspan="2">Topical relevance:</td><td colspan="2"></td></tr>
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<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">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 pre-determined configurations.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="6">UK, Ireland, France, Spain and Portugal</td></tr>
<tr><td>Project title:</td><td colspan="6">Future of the Atlantic Marine Environment</td></tr>
<tr><td>Research providers:</td><td colspan="6">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)</td></tr>
<tr><td>Framework:</td><td colspan="6">Atlantic Area Program – European territorial cooperation (INTERREG)</td></tr>
<tr><td>Funding sources:</td><td colspan="6">EU</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.fameproject.eu/en/</td></tr>
<tr><td>Start date:</td><td colspan="2">November 2007</td><td colspan="2">End date:</td><td colspan="2">April 2011</td></tr>
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<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td>Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
Oceans and marine life define the Atlantic Area. The protection of key areas for biodiversity at sea is not as widespread as on land. Each country is at a different stage in the process of designating marine protected areas (MPAs), and so there are opportunities to learn from other's experiences. The partners will monitor and track seabirds throughout the Area and, by combining this data with oceanographic information, produce comprehensive maps to inform the designation of MPAs. The partners will communicate with a range of stakeholders in the marine environment, to minimise the impact of man's activities on important areas for marine biodiversity. This will be done through an interactive GIS website, conferences, workshops and publications. The project will also develop recommendations on the future management of MPAs.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="6">Norway</td></tr>
<tr><td>Project title:</td><td colspan="6">MAREN – Environmental Monitoring Programme</td></tr>
<tr><td>Research providers:</td><td colspan="6">Runde Environmental Centre</td></tr>
<tr><td>Framework:</td><td colspan="6">BACI-type study (Before-After-Control-Impact) of benthos, fish, birds & marine mammals around the pilot study site of MAREN</td></tr>
<tr><td>Funding sources:</td><td colspan="6">Project owner: Vattenfall AB</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.swedishtrade.se/PageFiles/165419/Norsk%20Handelskammer%20FINAL%20(091119%20LU).pdf?epslanguage=sv</td></tr>
<tr><td>Start date:</td><td colspan="2">2008</td><td colspan="2">End date:</td><td colspan="2">2010</td></tr>
<tr><td>Geographical rele-relevance:</td><td colspan="2">Local</td><td colspan="2">Topical relevance:</td><td colspan="2">Benthos, Fish, (Birds, Marine mammals)</td></tr>
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<tr><td>Nature of impact / study:</td><td>Physical processes:
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High</td><td>Direct seabed impacts
High</td><td>Direct wildlife impacts
High</td><td>New ecological space
High</td><td>Interactions with other sea-users:
High</td></tr>
<tr><td colspan="7">Project description:

In 2009, MAREN (MARineENergy) 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 focussed on fish and benthic communities to date, but will include seabirds as well. In addition, the potential effects of noise on</td></tr>
</table>

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 colonisation 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, bi-annual informal reports, final annual report
Spatial data generated: Fish abundance (echo sounding), 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.

<table>
<tr><td>Countries:</td><td colspan="7">Portugal</td></tr>
<tr><td>Project title:</td><td colspan="7">Wave Energy Planning and Marketing (Waveplam)</td></tr>
<tr><td>Research providers:</td><td colspan="7">EVE, WavEC, Portugal</td></tr>
<tr><td>Framework:</td><td colspan="7">Intelligent Energy Europe (IEE)</td></tr>
<tr><td>Funding sources:</td><td colspan="7">EC-IEE 2007</td></tr>
<tr><td>Web-link:</td><td colspan="7"></td></tr>
<tr><td>Start date:</td><td>2007</td><td>End date:</td><td colspan="5">2010</td></tr>
<tr><td>Geographical relevance:</td><td>All regions</td><td>Topical relevance:</td><td colspan="5"></td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td>Impacts:</td><td colspan="4">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td>Maintenance:</td><td colspan="3">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td colspan="2">Interactions with other sea-users:</td></tr>
<tr><td colspan="8">Project description:
Not research but discussion of extent to which environmental impacts can be show-stoppers; Del. 2.2: Non-technological Barriers to Wave Energy Implementation</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
<tr><td colspan="8">Spatial data generated:</td></tr>
<tr><td colspan="8">Bibliography of outputs:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="6">Portugal</td></tr>
<tr><td>Project title:</td><td colspan="6">Equitable Testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact (Equimar)</td></tr>
<tr><td>Research providers:</td><td colspan="6">WaveEC (WP6 lead), Portugal</td></tr>
<tr><td>Framework:</td><td colspan="6">FP7</td></tr>
<tr><td>Funding sources:</td><td colspan="6">EU</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">2008</td><td colspan="2">End date:</td><td colspan="2">2011</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">National</td><td colspan="2">Topical relevance:</td><td colspan="2"></td></tr>
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<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">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).</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="7">Sweden</td></tr>
<tr><td>Project title:</td><td colspan="7">Sotenas project</td></tr>
<tr><td>Research providers:</td><td colspan="7">Developers/constructors/operators</td></tr>
<tr><td>Framework:</td><td colspan="7">Commercial project – to be run by utility Fortum AB (Ltd)</td></tr>
<tr><td>Funding sources:</td><td colspan="7">Fortum AB, Seabased AB (developer) & Swedish Energy Agency
Most ecological/environmental studies to be performed by Uppsala University, to some extent by consultancies.</td></tr>
<tr><td>Web-link:</td><td colspan="7">www.fortum.comwww.seabased.com</td></tr>
<tr><td>Start date:</td><td colspan="3">2012/13</td><td colspan="2">End date:</td><td colspan="2">20 years operation</td></tr>
<tr><td>Geographical relevance:</td><td colspan="3">Local/National/Regional/ all regions</td><td colspan="2">Topical relevance:</td><td colspan="2">Hydrodynamics, marine ecology impact, fisheries impact, seabed and noise impact</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
n/a</td><td>Baselines:
n/a</td><td>Impacts:
High</td><td colspan="4">Socio-economics:
Medium</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
n/a</td><td>Installation:
Meduim</td><td>Operation:
High</td><td>Maintenance:
Medium</td><td colspan="3">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
Low</td><td>Ecological processes:
High</td><td>Direct seabed impacts
High</td><td>Direct wildlife impacts
Low/Medium</td><td>New ecological space
Low/Medium</td><td colspan="2">Interactions with other sea-users:
Low</td></tr>
<tr><td colspan="8">Project description:
Commercial project, located ca 10 km off the Swedish west coast, ca 120 km N of Gothenburg in the Skagerak.</td></tr>
<tr><td colspan="8">Project deliverables:
Economical Renewable Energy! Results from working offshore renewable installations!
Environmental data – data/info on little/no impact on Norwegian lobster, little/no effect on benthic fauna, data on sound/noise emissions, no or positive (reef effects) on fish fauna.</td></tr>
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Spatial data generated: 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

	Resource assessment:	**Baselines:**	**Impacts:**	**Socio-economics:**
Project type:	Medium	Medium	High	Low

	Planning and pre-development survey:	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
Development life-cycle stage:	n/a	Low	High	Low	n/a

	Physical processes:	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
Nature of impact / study:	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 metier and by year to compare with existing / new TCE datalayers .

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="7">UK (England)</td></tr>
<tr><td>Project title:</td><td colspan="7">Monitoring ambient noise for the Marine Strategy Framework Directive</td></tr>
<tr><td>Research providers:</td><td colspan="7">CEFAS</td></tr>
<tr><td>Framework:</td><td colspan="7"></td></tr>
<tr><td>Funding sources:</td><td colspan="7">DEFRA</td></tr>
<tr><td>Web-link:</td><td colspan="7"></td></tr>
<tr><td>Start date:</td><td colspan="3">2010</td><td colspan="2">End date:</td><td colspan="2">2012 ?/ 13</td></tr>
<tr><td>Geographical relevance:</td><td colspan="3">UK</td><td colspan="2">Topical relevance:</td><td colspan="2">Baseline noise levels</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td colspan="2">Baselines:</td><td colspan="2">Impacts:</td><td colspan="2">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td colspan="2">Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td colspan="2">Interactions with other sea-users:</td></tr>
<tr><td colspan="8">Project description:
Methods development for monitoring ambient noise, field measurements and recommendations for implementation of MSFD</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
<tr><td colspan="8">Spatial data generated:</td></tr>
<tr><td colspan="8">Bibliography of outputs:</td></tr>
</table>

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:**				
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 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:**

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 deliverables:
Spatial data generated:
Bibliography of outputs:

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<tr><td colspan="2">Project title:</td><td colspan="6">Spawning and nursery areas of fish of commercial and conservation importance</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="6">CEFAS</td></tr>
<tr><td colspan="2">Framework:</td><td colspan="6"></td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="6">DEFRA / MMO</td></tr>
<tr><td colspan="2">Web-link:</td><td colspan="6"></td></tr>
<tr><td colspan="4">Start date:</td><td colspan="4">End date:</td></tr>
<tr><td colspan="4">Geographical relevance:</td><td colspan="4">Topical relevance:</td></tr>
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<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td colspan="2">Installation:</td><td>Operation:</td><td colspan="2">Maintenance:</td><td>Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td colspan="2">Interactions with other sea-users:</td></tr>
<tr><td colspan="8">Project description:</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
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<tr><td colspan="8">Bibliography of outputs:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="6">UK (England)</td></tr>
<tr><td>Project title:</td><td colspan="6">Low-cost VMS data analysis: Assessment and applications</td></tr>
<tr><td>Research providers:</td><td colspan="6">SEAFISH</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">DEFRA</td></tr>
<tr><td>Web-link:</td><td colspan="6"></td></tr>
<tr><td>Start date:</td><td colspan="2">2010</td><td colspan="2">End date:</td><td colspan="2">2012 ?</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2"></td><td colspan="2">Topical relevance:</td><td colspan="2"></td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td>Impacts:</td><td colspan="3">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td>Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="6">UK, Ireland, Belgium, Spain, Portugal, France and Sweden</td></tr>
<tr><td>Project title:</td><td colspan="6">Streamlining of Ocean Wave Farms Impact Assessment (SOWFIA)</td></tr>
<tr><td>Research providers:</td><td colspan="6">University of Plymouth (UK), WavEC (Portugal), Inabensa (Spain), University of Exeter (UK), European Ocean Energy Association (Belgium), EcoleCentrale de Nantes (France), EVE (Spain), Hidromod (Portugal), HMRC - UCC (Ireland), University of Uppsala (Sweden)</td></tr>
<tr><td>Framework:</td><td colspan="6">EU Intelligent Energy Europe</td></tr>
<tr><td>Funding sources:</td><td colspan="6">EU</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.sowfia.eu/</td></tr>
<tr><td>Start date:</td><td colspan="2">October 2010</td><td colspan="2">End date:</td><td colspan="2">September 2013</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">EU</td><td colspan="2">Topical relevance:</td><td colspan="2">EIA</td></tr>
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X</td><td>Impacts:
X</td><td colspan="3">Socio-economics:
X</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:
X</td><td>Installation:
X</td><td>Operation:
X</td><td>Maintenance:
n/a</td><td colspan="2">Decommissioning:
n/a</td></tr>
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Data only</td><td>Ecological processes:
Data only</td><td>Direct seabed impacts
Data only</td><td>Direct wildlife impacts
Data only</td><td>New ecological space
Data only</td><td>Interactions with other sea-users:
Data only</td></tr>
<tr><td colspan="7">Project description: The project aims to achieve the sharing and consolidation of pan-European experience of consenting processes and environmental and socio-economic impact assessment (IA) best practices for offshore wave energy conversion developments. Studies of wave farm demonstration projects in each of the collaborating EU nations are contributing to the findings. The study sites comprise a wide range of device technologies, environmental settings and stakeholder interests. Through project workshops, meetings, ongoing communication and networking amongst project partners, ideas and experiences relating to IA and policy are being shared, and co-ordinated studies addressing key questions for wave energy development are being carried out. The overall goal of the SOWFIA project is to provide recommendations for approval process streamlining and European-wide streamlining of IA processes, thereby helping to remove legal, environmental and socio-economic barriers to the development of offshore power generation from waves. By utilising the findings from</td></tr>
</table>

technology-specific monitoring at multiple sites, SOWFIA will accelerate knowledge transfer and promote European-wide expertise on environmental and socio-economic impact assessments of wave energy projects. In this way, the development of the future, commercial phase of offshore wave energy installations will benefit from the lessons learned from existing smaller-scale developments.
Project deliverables: All available to download from:http://www.sowfia.eu/
Spatial data generated: See http://sowfia.hidromod.com/PivotMapViewer/
Bibliography of outputs: On website http://www.sowfia.eu/

<table>
<tr><td>Countries:</td><td colspan="6">Spain</td></tr>
<tr><td>Project title:</td><td colspan="6">OCEANLIDER</td></tr>
<tr><td>Research providers:</td><td colspan="6">Iberdrola, Acciona, Tecnoambiente, igeotest,arina,GMV, IBAIA, IDESA. ONGETEAM, NEM Solutions, Norvento, Oceantec, Praesentis, PROES, Seaplace, Sener, Vicinay, Tecnologías Auxiliares de Fundición</td></tr>
<tr><td>Framework:</td><td colspan="6">Projec`s aim is the research in breakthrough technologies needed for setting up of integrated facilities for the use or renewable ocean energy (wave energy, currents and hybrid systems: wave/wind energy and currents/wind energy)</td></tr>
<tr><td>Funding sources:</td><td colspan="6">Ministry of Science and Innovation</td></tr>
<tr><td>Web-link:</td><td colspan="6">www.oceanlider.com</td></tr>
<tr><td>Start date:</td><td colspan="2">2009</td><td colspan="2">End date:</td><td colspan="2">2012</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">National</td><td colspan="2">Topical relevance:</td><td colspan="2">Site selection, technology development, distribution, transportation, transformation and quality of electricity, management, maintenance and intelligent communication systems, environmental impact</td></tr>
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High</td><td colspan="2">Impacts:
High</td><td colspan="2">Socio-economics:
High</td></tr>
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Medium</td><td>Installation:
Medium</td><td>Operation:
Low</td><td colspan="2">Maintenance:
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Low</td></tr>
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High</td><td>Direct seabed impacts
High</td><td>Direct wildlife impacts
High</td><td>New ecological space
High</td><td>Interactions with other sea-users:
High</td></tr>
<tr><td colspan="7">Project description:
OceanLider, led by "IberdrolaIngeniería y Construcción", includes several R&D activities with a holistic perspective, covering the following research lines:
• Identification and characterisation of suitable sites and optimum resource</td></tr>
</table>

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.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">Spain</td></tr>
<tr><td>Project title:</td><td colspan="6">ENOLA</td></tr>
<tr><td>Research providers:</td><td colspan="6">IH-Cantabria Institute of the Cantabria University,</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">Ministry of Industry, Tourism and Commerce of the Spanish Government</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.ihcantabria.com/enola/</td></tr>
<tr><td>Start date:</td><td colspan="2">2009</td><td colspan="2">End date:</td><td colspan="2">2012</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">National</td><td colspan="2">Topical relevance:</td><td colspan="2">Atlas of Wave Energy Ressource of the Spanish Coast</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
High</td><td>Baselines:
High</td><td colspan="2">Impacts:
n/a</td><td colspan="2">Socio-economics:
n/a</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td colspan="2">Maintenance:</td><td>Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:
High</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="7">Project description:
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 Ressource of the Spanish Coast (http://www.ihcantabria.com/enola/). This atlas provides data about wave energy at different depths and seasons of the year.</td></tr>
<tr><td colspan="7">Project deliverables:
GIS based wave energy atlas</td></tr>
<tr><td colspan="7">Spatial data generated:
Wave energy at different depths</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	Spain, Portugal, France, Sweden, UK, Ireland, etc.
Project title:	European Energy Research Alliance (EERA) Joint Programme on Ocean Energy
Research providers:	Led by University of Edinburgh with participants from SuperGen Marine, Tecnalia, Fraunhofer IWES, ENEA, IFREMER, HMRC-UCC, WavEC, SINTEF/MARINTEK and NTU, IFREMER.
Framework:	EU
Funding sources:	Existing 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:** High	**Baselines:** High	**Impacts:** High	**Socio-economics:** High

Development life-cycle stage:	**Planning and pre-development survey:** X	**Installation:** X	**Operation:** X	**Maintenance:** X	**Decommissioning:** n/a

Nature of impact / study:	**Physical processes:** X	**Ecological processes:** X	**Direct seabed impacts** X	**Direct wildlife impacts** X	**New ecological space** X	**Interactions with other sea-users:** X

Project description:

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 maximising complementarities and synergies. In 2011, a Joint Research Programme (JP) on ocean energy was launched. 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 Impacts, Socio-economic Impacts and

Research Infrastructure, Education and Training. Of particular relevance to the ICES SGWTE is the work going on under the environmental and socio-economic themes.
Project deliverables: Workshops on each thematic area have been held and the associated outputs are available to download from http://www.eera-set.eu/index.php?index=29
Spatial data generated: N/A
Bibliography of outputs: As above (under deliverables)

Countries:	Spain, Portugal, France, Sweden, UK, Ireland, Germany, Italy, Belgium, Brazil.						
Project title:	MaRINET - Marine Renewables Infrastructure						
Research providers:	HMRC-UCC, Tecnalia, EVE, WavEC, UNIFI-CRIA CIV, CNR-INSEAN, UNI-TUS, ECN, Ifremer, USTUTT, 1_TECH, Franhofer-IWES, LHU, RISOE DTU, AAU, EMEC, University of Strathclyde, QUB, SEAI-OEDU						
Framework:	FP7						
Funding sources:	FP7						
Web-link:	www.fp7-marinet.eu						
Start date:	2011	**End date:**	2015				
Geographical relevance:	All regions	**Topical relevance:**	EC-funded consortium of 20 partners bringing together 42 marine renewable energy testing facilities in a network and offers access to these facilities at no cost to research groups and companies				
Project type:	**Resource assessment:** X	**Baselines:** n/a	**Impacts:** n/a	**Socio-economics:** n/a			
Development life-cycle stage:	**Planning and pre-development survey:** X	**Installation:** X	**Operation:** X	**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:

EU-funded consortium of 20 partners bringing together 42 marine renewable energy testing facilities in a network offering access to those facilities at no cost to research groups and companies. Also offers a number of training courses each year for early stage researchers and industry professionals.

Project deliverables: Relate to standardisation and best practice and will be available on the website.
Spatial data generated: No
Bibliography of outputs: N/A

Countries:	Spain, Portugal, France, Norway, UK, Ireland, Germany, Italy, Greece, Brazil.
Project title:	Marina
Research providers:	HMRC-UCC, University of Edinburgh, NTNU, Statoil, Dong Energy, RISOE, Fraunhofer, BVMNB, CWC, 1-Tech, Technip, ECN, Acciona, Technalia, Universidade do Algarve, Progeco and NKUA.
Framework:	FP7
Funding sources:	FP7
Web-link:	www.marina-platform.info

Start date:	2010	**End date:**	2014
Geographical relevance:	All regions	**Topical relevance:**	European MARINA-Platform project will establish a set of equitable and transparent criteria for the evaluation of multi-purpose platforms for marine renewable energy

Project type:	**Resource assessment:** High	**Baselines:** Medium	**Impacts:**	**Socio-economics:**

Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** High	**Operation:** High	**Maintenance:** High	**Decommissioning:** 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:

Research in the MARINA Platform project aims to develop a set of equitable and transparent criteria for the evaluation of multi-purpose platforms for marine renewable energy (MRE). Using these criteria, the project will produce a novel, whole-system set of design and optimisation tools addressing, for example, new platform design, component engineering, risk assessment, spatial planning, platform-related grid connection concepts, all focussed on system integration and reducing costs. These tools will be used, incorporating into the evaluation all presently known proposed designs including (but not limited to) concepts originating from the project partners, to produce two or three realisations of multi-purpose renewable energy platforms.

Project deliverables: www.marina-platform.info/dissemination.aspx
Spatial data generated: Yes, still in development (Resource Assessment and Site Selection related only)
Bibliography of outputs: See website

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<tr><td>Project title:</td><td colspan="6">TROPOS</td></tr>
<tr><td>Research providers:</td><td colspan="6">See partners in Web Page</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6"></td></tr>
<tr><td>Web-link:</td><td colspan="6">http://tropos.plocan.eu/index.php</td></tr>
<tr><td>Start date:</td><td colspan="2"></td><td>End date:</td><td colspan="3"></td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">All regions</td><td>Topical relevance:</td><td colspan="3">The objective of this project is to design multiuse offshore platforms where ocean energy plays a key role</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td colspan="2">Impacts:</td><td colspan="2">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td colspan="2">Maintenance:</td><td>Decommissioning:</td></tr>
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<tr><td colspan="7">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.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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<table>
<tr><td>Countries:</td><td colspan="6">See web page</td></tr>
<tr><td>Project title:</td><td colspan="6">WAVETRAIN2</td></tr>
<tr><td>Research providers:</td><td colspan="6">See partners in Web Page</td></tr>
<tr><td>Framework:</td><td colspan="6">FP7</td></tr>
<tr><td>Funding sources:</td><td colspan="6">FP7</td></tr>
<tr><td>Web-link:</td><td colspan="6">www.wavetrain2.eu</td></tr>
<tr><td colspan="2">Start date:</td><td colspan="5">End date:</td></tr>
<tr><td>Geographical relevance:</td><td>All regions</td><td>Topical relevance:</td><td colspan="4">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</td></tr>
<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td>Impacts:</td><td colspan="3">Socio-economics:</td></tr>
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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</td></tr>
</table>

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.
Project deliverables:www.wavetrain2.eu
Spatial data generated:
Bibliography of outputs:

Countries:	Spain, Sweden, Portugal, New Zealand, UK, Ireland, Canada, Norway, Korea, U.S.A.						
Project title:	OES-IA Annex IV- Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems						
Research providers:	Too numerous to list						
Framework:	OES-IA (Implementing Agreement on Ocean Energy Systems of the International Energy Agency)						
Funding sources:	Member Country subscriptions to 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:

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, analyze those data to understand effects, identify potential monitoring and mitigation strategies to address those effects, and share those results and data broadly. The U.S. has the lead for Annex IV; and the U.S. 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 U.S. 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 (Tethys) 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 Centre/University of Plymouth – WEC/UP) in the collection and analysis of the Annex IV data.
Project deliverables: Tethys database: http://mhk.pnnl.gov/wiki/index.php/Tethys_Home
Spatial data generated: Tethys database: http://mhk.pnnl.gov/wiki/index.php/Tethys_Home
Bibliography of outputs: n/a

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<tr><td>Framework:</td><td colspan="6">FP7</td></tr>
<tr><td>Funding sources:</td><td colspan="6">EU</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.h2ocean-project.eu/index.php</td></tr>
<tr><td>Start date:</td><td colspan="2">2012</td><td colspan="2">End date:</td><td colspan="2">2014</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">All regions</td><td colspan="2">Topical relevance:</td><td colspan="2">Multi-use open-sea platform</td></tr>
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Choose an item.</td><td>Baselines:
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Choose an item.</td><td>Installation:
Choose an item.</td><td>Operation:
Choose an item.</td><td colspan="2">Maintenance:
Choose an item.</td><td>Decommissioning:
Choose an item.</td></tr>
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Choose an item.</td><td>Ecological processes:
Choose an item.</td><td>Direct seabed impacts
Choose an item.</td><td>Direct wildlife impacts
Choose an item.</td><td>New ecological space
Choose an item.</td><td>Interactions with other sea-users:
Choose an item.</td></tr>
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<tr><td colspan="7">H2OCEAN is a project aimed at developing an innovative design for an economically and environmentally sustainable multi-use open-sea platform. Wind and wave power will be harvested and part of the energy will be used for multiple applications on-site, including the conversion of energy into hydrogen that can be stored and shipped to shore as green energy carrier and a multi-trophic aquaculture farm.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
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<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	Spain, Italy, UK, Germany, France, etc.					
Project title:	TidalsenseDemo					
Research providers:	See http://www.tidalsensedemo.eu/					
Framework:	FP7					
Funding sources:	EU					
Web-link:	http://www.tidalsensedemo.eu/					
Start date:	2012		**End date:**	2014		
Geographical relevance:	All regions		**Topical relevance:**	Advanced condition monitoring for tidal energy devices		
Project type:	**Resource assessment:** High	**Baselines:** Choose an item.	**Impacts:** n/a	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** Choose an item.	**Installation:** Choose an item.	**Operation:** Choose an item.	**Maintenance:** Choose an item.	**Decommissioning:** Choose an item.	
Nature of impact / study:	**Physical processes:** Choose an item.	**Ecological processes:** Choose an item.	**Direct seabed impacts** Choose an item.	**Direct wildlife impacts** Choose an item.	**New ecological space** Choose an item.	**Interactions with other sea-users:** Choose an item.

Project description:

The TidalSense Demo project is an industrial effort owned and led by a group of European technology SME's that aims to demonstrate a robust and efficient Condition Monitoring System (CMS) for the emerging tidal stream power industry.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (England)					
Project title:	WaveHub benthic research methods development					
Research providers:	University of Plymouth, UK					
Framework:						
Funding sources:	South West Regional Development Agency					
Web-link:						
Start date:	2009		**End date:**	2011		
Geographical relevance:	All regions		**Topical relevance:**	Methods for assessing benthic impacts		
Project type:	**Resource assessment:** n/a	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Medium	**Operation:** Medium	**Maintenance:** n/a	**Decommissioning:** n/a	
Nature of impact / study:	**Physical processes:** n/a	**Ecological processes:** High	**Direct seabed impacts** High	**Direct wildlife impacts** n/a	**New ecological space** Medium	**Interactions with other sea-users:** Medium

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 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:** n/a	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a		
Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** Medium	**Operation:** Medium	**Maintenance:** n/a	**Decommissioning:** n/a	
Nature of impact / study:	**Physical processes:** n/a	**Ecological processes:** High	**Direct seabed impacts** n/a	**Direct wildlife impacts** High	**New ecological space** n/a	**Interactions with other sea-users:** n/a
Project description: Baseline habitat mapping in advance of deployment of WECs at Wave Hub site.						
Project deliverables:						
Spatial data generated:						
Bibliography of outputs:						

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<tr><td>Research providers:</td><td colspan="5">University of Plymouth, UK</td></tr>
<tr><td>Framework:</td><td colspan="5"></td></tr>
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<tr><td colspan="7">Project description:
Baseline water column characterisation - upstream - downstream CTD, microstructure, ADCP, ecology.</td></tr>
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<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	UK (England)
Project title:	WaveHub modelling
Research providers:	Plymouth Marine Laboratory, UK
Framework:	
Funding sources:	UK Natural Environment Research Council
Web-link:	

Start date:	2011	**End date:**	2012
Geographical relevance:	Site	**Topical relevance:**	Array scale modelling

Project type:	**Resource assessment:** n/a	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a

Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** n/a	**Operation:** High	**Maintenance:** n/a	**Decommissioning:** n/a

Nature of impact / study:	**Physical processes:** High	**Ecological processes:** High	**Direct seabed impacts** High	**Direct wildlife impacts** n/a	**New ecological space** n/a	**Interactions with other sea-users:** n/a

Project description:

Baseline ecological water column characterisation for input to generic ecosystem models

Project deliverables:

Spatial data generated:

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:** n/a	**Baselines:** High	**Impacts:** High	**Socio-economics:** n/a

Development life-cycle stage:	**Planning and pre-development survey:** High	**Installation:** High	**Operation:** High	**Maintenance:** Low	**Decommissioning:** Low

Nature of impact / study:	**Physical processes:** n/a	**Ecological processes:** n/a	**Direct seabed impacts** n/a	**Direct wildlife impacts** Medium	**New ecological space** High	**Interactions with other sea-users:** High

Project description: Landers to be deployed, plus tagging of commercially significant species.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

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Focus on methods development for ecosystem services valuation for offshore wind - methods transferable to wave and tidal</td></tr>
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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:** n/a	**Baselines:** n/a	**Impacts:** High	**Socio-economics:** n/a

Development life-cycle stage:	**Planning and pre-development survey:** n/a	**Installation:** n/a	**Operation:** High	**Maintenance:** n/a	**Decommissioning:** n/a

Nature of impact / study:	**Physical processes:** n/a	**Ecological processes:** n/a	**Direct seabed impacts** n/a	**Direct wildlife impacts** High	**New ecological space** n/a	**Interactions with other sea-users:** n/a

Project description:

Developing standards for device noise.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

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Producing VMS datalayers and producing them by metier and by year to compare with existing / new TCE datalayers .</td></tr>
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<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td colspan="2">New ecological space</td><td>Interactions with other sea-users:</td></tr>
<tr><td colspan="8">Project description:
Methods development for monitoring ambient noise, field measurements and recommendations for implementation of MSFD</td></tr>
<tr><td colspan="8">Project deliverables:</td></tr>
<tr><td colspan="8">Spatial data generated:</td></tr>
<tr><td colspan="8">Bibliography of outputs:</td></tr>
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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:**

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 deliverables:
Spatial data generated:
Bibliography of outputs:

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<tr><td colspan="2">Project title:</td><td colspan="6">The impact of anthropogenic noise on fish and invertebrates at the individual, population and community level</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="6">University of Newcastle</td></tr>
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<tr><td colspan="2">Funding sources:</td><td colspan="6">DEFRA</td></tr>
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<tr><td colspan="2">Countries:</td><td colspan="8">UK (England)</td></tr>
<tr><td colspan="2">Project title:</td><td colspan="8">Spawning and nursery areas of fish of commercial and conservation importance</td></tr>
<tr><td colspan="2">Research providers:</td><td colspan="8">CEFAS</td></tr>
<tr><td colspan="10">Framework:</td></tr>
<tr><td colspan="2">Funding sources:</td><td colspan="8">DEFRA / MMO</td></tr>
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</table>

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:**				
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 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

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 impact that arrays of wave and tidal devices may have on the flow-field together with possible resulting effects on marine ecosystem processes is unknown. Forecasting the hydrodynamic changes resulting from array installation is difficult but is a core requirement of the industry; considerable effort is being put in to this field by commercial and academic research groups. Ecological surveys and studies to investigate ecological effects are time consuming and costly and are generally reactive; a more efficient approach is to develop 2 and 3D linked hydrodynamic-ecological modelling which has the potential to be proactive and to allow forecasting of the effects of array installation. Therefore the overall aim of the project is to demonstrate the ability to numerically model the change in ambient hydrodynamics resulting from the installation of wave and tidal device arrays and to couple the model output to associated ecological models to allow prediction of associated changes in benthic habitats and dynamics, plankton growth and fish communities.

The proposal fully recognises the complexity of ecological processes. An initial objective of the project will therefore be to parameterise the relevant biological processes, especially relating to benthic detrital dynamics, plankton growth and fish population dynamics, in order to effectively run a coupled hydrodynamic-ecological model. These parameterisations will then be tested to give realistic results with respect to inter- and intra-annual variation of tidal and wave climate conditions without the presence of any Marine Energy Converters (MECs) before application to situations involving array deployments. Special focus will be given to the potential positive effects of array deployments arising from the changes in the hydrodynamics and establishment of no-fishing zones.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

Countries:	UK (England and N. Ireland)					
Project title:	Interactions of Flow, Tidal Stream Turbines and Local Sediment Bed Under Combined Waves and Tidal Conditions					
Research providers:	University of Dundee Professor Ping Dong					
Framework:						
Funding sources:	EPSRC					
Web-link:						
Start date:	2012		**End date:**	2015		
Geographical relevance:			**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: Tidal stream energy is more predictable and continuous than wind energy. It has the potential to provide 20 per cent of the UK's electricity demand. Although the technology is still in its infancy, the UK has a head start over its international competitors in tidal and wave power, with seven of the world's eight full-scale prototype devices installed in UK waters.

It is known that flow passing Tidal Stream Turbines (TST) support structure combined with the rotation of the turbine rotors produces a turbulent downstream wake that can be sufficiently energetic to disturb the sediments on the sea bed on which the turbine is constructed and affect the sediment suspension. This may have significant impact on the sea floor topography and adverse consequences for the indigenous marine flora and fauna. Thus far, little is known about the nature of the turbulent wakes of the rotors and the mechanisms by which these wake flows perturb the sediments in water and on the seabed. For cases in which several tidal stream turbines are constructed in an array, the configuration of the sea bed sediments is subjected to

complex pressure distributions arising from each of the constituent installations and the prediction of sea floor sediment response is even more uncertain.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

Countries:	UK (England and N. Ireland)
Project title:	**Extreme Loading of Marine Energy Devices Due to Waves, Currents, Flotsam and Mammal Impact (X-MED)**
Research providers:	University of Manchester; Professor Peter Stansby
Framework:	
Funding sources:	EPSRC
Web-link:	

Start date:	2012	**End date:**	2015
Geographical relevance:		**Topical relevance:**	Hydrodynamics mammals / basking shark impacts

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: Tidal flows particularly in areas of high velocity attractive for energy extraction are however bathymetry dependent. For example headlands and islands cause large-scale unsteady eddy structures affecting extreme loads. To complicate matters further tidal turbulence in the horizontal plane has length scales about six times those in the vertical giving a horizontal length scale of about half the water depth, similar to a typical turbine diameter. This will affect extreme loading to an uncertain degree and is not understood. In addition waves superimposed on currents cause unsteadiness which penetrates below the water surface; this may be due to long swell waves or breaking waves where concentrated, generally oblique, vortex structures propagate downwards.

The effect of breaking waves is an important component of this project. Breaking waves also have a major impact on extreme loads on wave energy devices and it is appropriate to apply physical knowledge obtained from experiments and modelling

to both tidal stream and generic wave devices. We consider only a moored, floating wave energy device as fixed structures have high costs likely to inhibit at least large scale deployment. Floating structures may also be used for tidal turbine deployment. Extreme loading will also be strongly influenced by impacts due to flotsam, debris and marine mammals or sharks. Such occurrence is highly uncertain but the impact will be high if it occurs. Risk is normally defined as the product of probability and cost of damage and so this is of particular concern for tidal turbine blades which are vulnerable since they must be slender. In this project we will not investigate the likelihood of occurrence of impact at large scale but will identify the possibility and magnitude of impact when there is flotsam or marine life in the flow. Flotsam is generally slightly buoyant, floating at the water surface, and in normal conditions of little danger to turbines. However in breaking conditions downwards jet-like flow is generated and entrained flotsam is likely to impact turbines. This has not been researched to our knowledge. This will be investigated experimentally and using a numerical modelling method known as smoothed particle hydrodynamics SPH which is well suited to handling debris (represented as small bodies in the flow).
Project deliverables:
Spatial data generated:
Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (England)</td></tr>
<tr><td>Project title:</td><td colspan="6">TeraWatt - large scale interactive coupled 3D modelling for wave and tidal energy resource and environmental impact</td></tr>
<tr><td>Research providers:</td><td colspan="6">Heriot Watt University, Professor Jonathan Side</td></tr>
<tr><td colspan="7">Framework:</td></tr>
<tr><td colspan="7">Funding sources:</td></tr>
<tr><td colspan="7">Web-link:</td></tr>
<tr><td>Start date:</td><td colspan="2">2012</td><td>End date:</td><td colspan="3">2015</td></tr>
<tr><td colspan="3">Geographical relevance:</td><td>Topical relevance:</td><td colspan="3">Impact of energy extraction</td></tr>
<tr><td>Project type:</td><td>Resource assessment:
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Y</td><td>Impacts:
Y</td><td colspan="3">Socio-economics:
N</td></tr>
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<tr><td>Nature of impact / study:</td><td>Physical processes:
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Y</td><td>Direct seabed impacts
?</td><td>Direct wildlife impacts
?</td><td>New ecological space
N</td><td>Interactions with other sea-users:
N</td></tr>
</table>

Project description:

As part of the licensing arrangements for wave and tidal arrays, environmental effects in the immediate vicinity of devices and arrays will be addressed in the EIA (Environmental Impact Assessment) process that each developer must undertake. The regulatory authorities need to understand, however, how a number of multi-site developments collectively impact on the physical and biological processes over a wider region.

The objectives of TeraWatt are fourfold: Firstly to minimise delays in array licensing by providing answers to 3 specific questions faced by the regulatory authorities, responsible for the licensing of wave and tidal developments; and secondly to collect the methodologies used to answer these into a methods toolbox that can be more widely utilised for such assessments, and in which the marine developer community has confidence.

1. What is the best way to assess the wave and tidal resource and the effects of en-

ergy extraction on it? 2. What are the physical consequences of wave and tidal energy extraction? 3. What are the ecological consequences of wave and tidal energy extraction? 4. The assembly of all appropriate methods, their review, and synthesis in a standardised methods toolbox
Project deliverables: Key outputs will be the development of computer based numerical models to simulate the effects of extracting energy using wave and tidal renewable energy devices. TeraWatt will offer decision makers specific, targeted predictions of the impact individual developments may have and where they should be allowed to be sited. The project will use the Pentland Firth and the waters around Orkney to develop models which will help to predict the physical and ecological consequences of wave and tidal energy extraction.
Spatial data generated:
Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (England)</td></tr>
<tr><td>Project title:</td><td colspan="6">ECOWATT 2050</td></tr>
<tr><td>Research providers:</td><td colspan="6">Heriot Watt University, Professor Jonathan Side</td></tr>
<tr><td colspan="7">Framework:</td></tr>
<tr><td colspan="7">Funding sources:</td></tr>
<tr><td colspan="7">Web-link:</td></tr>
<tr><td>Start date:</td><td colspan="2">2013</td><td colspan="2">End date:</td><td colspan="2">2016</td></tr>
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<tr><td>Project type:</td><td>Resource assessment:</td><td>Baselines:</td><td>Impacts:</td><td colspan="3">Socio-economics:</td></tr>
<tr><td>Development life-cycle stage:</td><td>Planning and pre-development survey:</td><td>Installation:</td><td>Operation:</td><td>Maintenance:</td><td colspan="2">Decommissioning:</td></tr>
<tr><td>Nature of impact / study:</td><td>Physical processes:</td><td>Ecological processes:</td><td>Direct seabed impacts</td><td>Direct wildlife impacts</td><td>New ecological space</td><td>Interactions with other sea-users:</td></tr>
</table>

Project description:

The Scottish Government is committed to promoting substantial sustainable growth in its marine renewable industries. Agreements for sea bed leases are already in place for 2GW of wave and tidal developments, and projects are progressing through the licensing process. Strategic marine planning for future phases of wave, tidal and offshore wind development is now in progress. For marine renewables to significantly contribute to the low-carbon energy mix towards 2050, significant offshore development in the form of very large scale arrays will be needed.

In planning for such a future, the Government must consider the mix of technologies, the locations and configurations of very large scale arrays and their performance, and the implications of anticipated changes to the marine environment from climate change. In establishing its strategic policy positions, the Government must also ensure that legal obligations are met, particularly those under the European Marine Strategy Framework Directive (MSFD) to achieve Good Environmental Status (GES) by 2020.

The EcoWatt2050 consortium has been established through the auspices of the Marine Alliance for Science and Technology for Scotland (MASTS) with Heriot-Watt University and the Universities of Edinburgh, Aberdeen, Strathclyde, Swansea and the Highlands and Islands, the National Oceanography Centre (Liverpool) and with Marine Scotland Science (MSS), the organization responsible for providing scientific advice to the Scottish Government on all aspects of marine renewable energy development, policy and planning. The research programme has been specifically designed to respond to questions posed by MSS: (1) How can marine planning be used to lay the foundation for the sustainable development of very large scale arrays of marine renewable energy devices? (2) What criteria should be used to determine the ecological limits to marine renewable energy extraction, and what are the implications for very large scale array characteristics? (3) How can we differentiate the effects of climate change from energy extraction on the marine ecosystem? (4) Are there ways in which marine renewables development may ameliorate or exacerbate the predicted effects of climate change on marine ecosystems? The overarching objective is thus to determine ways in which marine spatial planning and policy development, can enable the maximum level of marine energy extraction, while minimizing environmental impacts and ensuring that these meet the legal criteria established by European law. The research is structured in 5 workstreams. The first led by MSS will monitor progress and set out scenarios for the mix of technologies, very large scale array configurations, and environmental acceptance criteria. The second led by Edinburgh University will develop the hydrodynamic models necessary to examine the physical changes brought about by very large scale energy extraction, including under conditions anticipated from climate change. These outputs feed directly into workstreams 3 and 4 led by HWU and Aberdeen University respectively. These extend this work to examine changes in availability and location of critical habitats for benthic and mobile marine species, and to determine the consequences of changes in critical habitat for the ecosystem as a whole. Finally, workstream 5 led by MSS provides a synthesis of this research, quantifying the balance between energy extraction and environmental change and acceptance criteria to be used in marine spatial planning and policy development. EcoWatt2050 builds in direct participation from industry in various aspects of its work, and has a number of wider knowledge exchange and stakeholder engagement activities planned.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (England)</td></tr>
<tr><td>Project title:</td><td colspan="6">Guidelines for data acquisition to support marine environmental assessments for offshore renewable energy projects</td></tr>
<tr><td>Research providers:</td><td colspan="6">CEFAS</td></tr>
<tr><td>Framework:</td><td colspan="6"></td></tr>
<tr><td>Funding sources:</td><td colspan="6">DEFRA / MMO</td></tr>
<tr><td>Web-link:</td><td colspan="6">http://www.marinemanagement.org.uk/licensing/groups/documents/orelg/e5403.pdf</td></tr>
<tr><td>Start date:</td><td colspan="2">2010</td><td>End date:</td><td colspan="3">April 2012</td></tr>
<tr><td colspan="3">Geographical relevance:</td><td colspan="4">Topical relevance:</td></tr>
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<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
</table>

Countries:	UK (England)		
Project title:	ME5210: Monitoring ambient noise for the Marine Strategy Framework Directive		
Research providers:	Cefas		
Framework:	Defra Science and Research projects		
Funding sources:	Defra		
Web-link:			
Start date:	October 2010	**End date:**	March 2013
Geographical relevance:	General	**Topical relevance:**	Noise impacts

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:**
	Low	High	High	Medium	Medium

Nature of impact / study:	**Physical processes:**	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
	n/a	Low	n/a	High	n/a	n/a

Project description:

Objectives: To provide information on the current state of ambient (continuous low frequency) noise in UK marine waters and to identify baseline values for different environmental conditions. To collect data on ambient noise at strategic sites to assess site specific sound levels and to investigate seasonal variations in noise.

This project will provide the data needed for the ambient noise indicator for measuring Good Environmental Status under descriptor 11 in the EU Marine Strategy Framework Directive. It will be used to assess the monitoring effort needed by the Directive for underwater noise, including the location of monitoring stations, the equipment necessary and the most cost effective way of monitoring.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

<table>
<tr><td>Countries:</td><td colspan="6">UK (England)</td></tr>
<tr><td>Project title:</td><td colspan="6">ME5205: Effects of underwater noise on coastal fish and crustaceans: behavioural responses in the field</td></tr>
<tr><td>Research providers:</td><td colspan="6">Subacoustech Environmental Ltd, Loughine Ltd, Newcastle University, University of Hull</td></tr>
<tr><td>Framework:</td><td colspan="6">Defra Science and Research projects</td></tr>
<tr><td>Funding sources:</td><td colspan="6">Defra</td></tr>
<tr><td colspan="7">Web-link:</td></tr>
<tr><td>Start date:</td><td colspan="2">September 2010</td><td colspan="2">End date:</td><td colspan="2">August 2013</td></tr>
<tr><td>Geographical relevance:</td><td colspan="2">General</td><td colspan="2">Topical relevance:</td><td colspan="2">Noise impacts</td></tr>
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High</td><td colspan="2">Maintenance:
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n/a</td><td>Direct wildlife impacts
High</td><td>New ecological space
n/a</td><td>Interactions with other sea-users:
n/a</td></tr>
<tr><td colspan="7">Project description:
Objectives: To carry out experiments to obtain data on the direct effects of human-generated noise on a number of commercially important fish and crustacean stocks, including trying to define harm/disturbance and the sources and sound levels. To provide an evidence-based tool to forecast the effects of human-generated noise on marine species.
This project will increase understanding of the effects of sound on fish and shellfish behaviour. It will inform Defra policy making and provide evidence for the assessing and setting targets for Good Environmental Status under the EU Marine Strategy Framework Directive. It will also inform industry and guide regulatory and consenting agencies, such as the Marine Management Organisation, in assessing applications for activities. It may lead to more precise valuations for cost benefit exercises when conflicting interests arise from the multiple uses and users of the UK's coastal areas.</td></tr>
<tr><td colspan="7">Project deliverables:</td></tr>
<tr><td colspan="7">Spatial data generated:</td></tr>
<tr><td colspan="7">Bibliography of outputs:</td></tr>
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Countries:	UK (England)
Project title :	Sustainable pathways to low carbon energy (SPLiCE)
Research providers:	
Framework:	
Funding sources:	DEFRA / DECC / TCE / LWEC
Web-link:	

Start date:	**End date:**
Geographical relevance:	**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: Project scoping workshop Feb 2013 – awaiting report
Project deliverables:
Spatial data generated:
Bibliography of outputs:

Countries:	UK (England)		
Project title :	Evaluation of the potential for co-location of activities and interests in Marine Plan (MMO 1010)		
Research providers:	Unknown		
Framework:	N/A		
Funding sources:	MMO		
Web-link:	http://www.marinemanagement.org.uk/evidence/index.htm		
Start date:	Sept 2012	**End date:**	March 2013
Geographical relevance:	England and Wales	**Topical relevance:**	Planning

Project type:	**Resource assessment:** N	**Baselines:** N	**Impacts:** N	**Socio-economics:** Y

Development life-cycle stage:	**Planning and pre-development survey:** Y	**Installation:** N	**Operation:** N	**Maintenance:** N	**Decommissioning:** N

Nature of impact / study:	**Physical processes:** N	**Ecological processes:** N	**Direct seabed impacts** N	**Direct wildlife impacts** N	**New ecological space** N	**Interactions with other sea-users:** Y

Project description : The aim of this project is to provide a comprehensive evidence base to inform the opportunities for co-locating current and future activities in Marine Plan areas, with specific emphasis on the East of England.

Project deliverables:

Spatial data generated:

Bibliography of outputs:

Countries:	UK (England)		
Project title :	Four related projects (1) Future analysis for each sector and three reports on (2) spatial trends in aquaculture potential, in (3) shipping activity and (4) marine recreational activity with a specific focus on the MMO's marine plan areas		
Research providers:	Multiple		
Framework:	N/A		
Funding sources:	MMO		
Web-link:	http://www.marinemanagement.org.uk/evidence/index.htm		
Start date:	Sept 2012	**End date:**	End March 2013
Geographical relevance:	MMO inshore / offshore marine plan areas	**Topical relevance:**	Sectoral interactions -Planning

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
	N/A	Y	N/A	Y

Development life-cycle stage:	**Planning and pre-development survey:**	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
	Y	N	N	N	N

Nature of impact / study:	**Physical processes:**	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
	N	N	N	N	N	Y

Project description :

(1) To conduct a review the past trends and projections for the next 6 and 20 years for each selected industry sector which is active in the South marine plan areas.

(2) This project aims to spatially delineate areas that have potential for [future] aquaculture development in the MMO's South and East Coast Inshore and Offshore Marine Plan Areas and assign an estimate of the potential economic return of aquaculture development in these areas.

(3) The aim of the project is to create spatial data products which describe spatial trends in shipping activity throughout England to provide context to marine planning decisions made at a plan area scale. The project will also focus on ensuring the delivery of high quality data with improved descriptive and spatial resolution in the

MMO's South Inshore and Offshore Marine Plan Areas. (4) The aim of the project is to create or enhance data which describes spatial trends in recreational activity throughout England. A specific focus will also be taken to ensure the delivery of high quality data with improved descriptive and spatial resolution in the MMO's South Coast Inshore and Offshore Plan Areas.
Project deliverables:
Spatial data generated:
Bibliography of outputs:

Countries:	UK (England)					
Project title :	Strategic Initiative for Ocean energy (SI OCEANS)					
Research providers:						
Framework:						
Funding sources:	EU Intelligent Energy					
Web-link:	http://www.si-ocean.eu/en/Project/Overview/					
Start date:			**End date:**			
Geographical relevance:	MMO inshore / offshore marine plan areas		**Topical relevance:**	Planning		
Project type:	**Resource assessment:** Y	**Baselines:** N	**Impacts:** N	**Socio-economics:** N		
Development life-cycle stage:	**Planning and pre-development survey:** Y	**Installation:** N	**Operation:** N	**Maintenance:** N	**Decommissioning:** N	
Nature of impact / study:	**Physical processes:** N	**Ecological processes:** N	**Direct seabed impacts** N	**Direct wildlife impacts** N	**New ecological space** N	**Interactions with other sea-users:** N

Project description :

The International Energy Agency Ocean Energy Systems (OES-IA) vision document, "An International Vision for Ocean Energy", has forecasted a global wave and tidal deployment potential of 337GW by 2050. Reaching these deployment targets would see long-term benefits including a reduction in carbon emissions, greater security of supply, and economic benefits through job creation and inward investment. If Europe is to maintain a global lead in ocean energy and gain the benefits associated with meeting these targets, an aggressive deployment trajectory will be required.

The goal of this project is to engage a large number of European stakeholders to identify **practical solutions to removing a range of barriers to large scale wave and tidal energy deployment**.

A key focus will be on increasing participation and input from the commercial sector, namely utilities, large industrial organizations and technology developers. Their expertise and practical experience will build on the knowledge already cultivated by research centres and academic institutions.
Project deliverables: The SI OCEAN project, supported by the Intelligent Energy Europe Program, aims to deliver a common strategy for maximizing the capacity of wave and tidal energy installations by 2020 and to pave the way for exponential market growth (2030/2050). The Atlantic Arc has been identified as the area offering the greatest potential for wave and tidal deployment in the EU. Therefore, SI OCEAN will focus on resources in the territorial waters of Portugal, Spain, France, United Kingdom, Ireland and Denmark. The main areas of work and outputs are focussed on assessment of the resource, technology assessment, policy framework and market conditions and market deployment strategy.
Spatial data generated:
Bibliography of outputs:

Countries:	Wales, Ireland, Spain, France and Portugal		
Project title:	MAREN - Marine Renewable Energy, Energy Extraction and Hydro-environmental Aspects		
Research providers:	Hydro-environmental Research Centre (HRC), Cardiff University, Wales; NUI Galway, Ireland; Centre for Marine Technology and Engineering (CENTEC), Portugal; Ifremer, France; IH Cantabria, Spain.		
Framework:	INTERREG IV B		
Funding sources:	INTERREG IV B		
Web-link:	http://www.marenproject.eu/eng/		
Start date:	2011	**End date:**	2013
Geographical relevance:	All regions	**Topical relevance:**	

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:**
	X	X	X	

Development life-cycle stage:	**Planning and pre-development survey:**	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**
	X				

Nature of impact / study:	**Physical processes:**	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**
	X					

Project description:

This project aims to provide information on the energy extraction potential of the Atlantic Area coastal waters and enable the prediction of both the impact of marine renewable energy devices on the environment (natural and human) and the impact of the environment on the performance of these devices. Environmental assessment methodologies will be developed and applied to sites that have realistic potential for the exploitation of marine renewable energy, with partners in each country selecting a single demonstrator site. Case studies will be undertaken by each partner at these sites and results and techniques used in these studies disseminated to all partners; inter-comparisons will be carried out on the results for all of the case studies. This work will also result in the development of a common methodology for Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) in all types of renewable energy fields and situations. The project will also investigate the impact of climate change on the CO_2 reduction figures, including CO_2 release resulting from increased storminess and flooding. A series of climate change scenarios will

be simulated and design requirements for marine renewable energy devices developed for predicted altered hydrodynamic conditions present in coastal waters as a result of the impacts of climate change.
Project deliverables: See http://www.marenproject.eu/eng/publications/
Spatial data generated: Check website
Bibliography of outputs: Check website

Countries:	Spain, UK, Ireland, France, Portugal.
Project title:	Atlantic Power Cluster
Research providers:	SODERCAN, Spain; Foundation University of La Corũna, Spain; Galway County Council, Ireland; Bretagne Développement Innovation, France; Asturias Energy Agency, Spain, Regional Council of Basse-Normandie, France; CPMR-Atlantic Arc Commission, France; NMCI-CIT, Ireland, EVE, Spain; WavEC, Portugal; INEGI, Portugal; Scottish European Green Energy Centre (SEGEC); Pôle des Eco-Industries de Poitou Charantes, France; L'Agence Régionale Pays de la Loire, France; Regional Council of Aquitaine, France; Spanish Environment Energy Research Centre, Spain; Plymouth University, UK.
Framework:	INTERREG
Funding sources:	INTERREG
Web-link:	http://atlantic-power-cluster.eu/index.php/en/

Start date:	2012	**End date:**	
Geographical relevance:	All regions	**Topical relevance:**	

Project type:	**Resource assessment:**	**Baselines:**	**Impacts:**	**Socio-economics:** X

Development life-cycle stage:	**Planning and pre-development survey:** X	**Installation:**	**Operation:** X	**Maintenance:**	**Decommissioning:**

Nature of impact / study:	**Physical processes:**	**Ecological processes:**	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:** X

Project description:

Building a transnational marine energy strategy in the Atlantic Area creating an adequate political and social environment for the marine energies enhancing the competitiveness and innovation capacities of the industrial community in the Atlantic regions. Dedicated work packages on public awareness and social acceptance of MRE;

Project deliverables:
Available from project website.
Spatial data generated:
No
Bibliography of outputs:
See website

Countries:	Northern Ireland, and (Republic of) Ireland.						
Project title:	Benthic community change and current velocities						
Research providers:	Queen's University Belfastand NUI Galway						
Framework:	Technology Strategy Board (TSB) and QUB						
Funding sources:	Technology Strategy Board (TSB) and QUB						
Web-link:	No website						
Start date:	January 2013	**End date:**	December 2013				
Geographical relevance:	All regions	**Topical relevance:**	Benthic ecology				
Project type:	**Resource assessment:**	**Baselines:** X	**Impacts:** X	**Socio-economics:**			
Development life-cycle stage:	**Planning and pre-development survey:** X	**Installation:**	**Operation:**	**Maintenance:**	**Decommissioning:**		
Nature of impact / study:	**Physical processes:** X	**Ecological processes:** X	**Direct seabed impacts**	**Direct wildlife impacts**	**New ecological space**	**Interactions with other sea-users:**	
Project description:							
This project investigates the effect that the strength and characteristics of marine currents have on benthic communities by sampling the benthos in locations with a range of different flow conditions.							
Project deliverables:							

• Correlation of benthic habitat distribution and current velocities • Methodology
Spatial data generated: The data generated will provide a comprehensive knowledge of the benthic communities within the narrows of Strangford Lough. The information obtained will then be directly related to the flow fields as determined by the high resolution Strangford Lough hydrodynamic model.
Bibliography of outputs: Partitioning the effect of current speed on benthic biotope distribution in Strangford Lough Narrows (in prep.).

Annex 7: Structured approaches to risk analysis and ecosystem based management of marine activities

The Canadian Dept of Fisheries and Oceans is taking a lead in the development of structured approaches to risk analysis and ecosystem based management of marine activities. Roland Cormier writes that:

DFO is going ahead with the development of an ecosystem approach to management for all its programs. It will largely use the risk management handbook being published as an ICES CRR[6]. Further work will develop a set of ecosystem management outcomes, risk criteria for decision-making and a series of standardized regulatory and policy risk evaluation models using the BowTie ISO 31010 tool.

The BowTie is discussed in section 7.2.2 of the ISO 31010 handbook. The BowTie approach is basically a threat assessment which includes an assessment of existing management measures to identify management gaps or needs for enhancements. We are planning a collaboration with Alberta Department of the Environment to develop a national standardized BowTie template for coastal and oceans management for 2013-14. We are considering using MSFD GES Descriptors as the basis for ecosystem management outcome statements.

The Bowtie approach is described in ISO 31010:

B.21.4 Process

The bow tie is drawn as follows:

a) A particular risk is identified for analysis and represented as the central knot of a bow tie.

b) Causes of the event are listed considering sources of risk (or hazards in a safety context).

c) The mechanism by which the source of risk leads to the critical event is identified.

d) Lines are drawn between each cause and the event forming the left-hand side of the bow tie. Factors which might lead to escalation can be identified and included in the diagram.

e) Barriers which should prevent each cause leading to the unwanted consequences can be shown as vertical bars across the line. Where there were factors which might cause escalation, barriers to escalation can also be represented. The approach can be used for positive consequences where the bars reflect 'controls' that stimulate the generation of the event.

f) On the right-hand side of the bow tie different potential consequences of the risk are identified and lines drawn to radiate out from the risk event to each potential consequence.

g) Barriers to the consequence are depicted as bars across the radial lines. The approach can be used for positive consequences where the bars reflect 'controls' that support the generation of consequences.

[6] Cormier, R., *et al*. 2013. Marine and coastal ecosystem-based risk management handbook. *ICES Cooperative Research Report No. 317*. 60 pp.

h) Management functions which support controls (such as training and inspection) can be shown under the bow tie and linked to the respective control. Some level of quantification of a bow tie diagram may be possible where pathways are independent, the probability of a particular consequence or outcome is known and a figure can be estimated for the effectiveness of a control.

However, in many situations, pathways and barriers are not independent and controls may be procedural and hence the effectiveness unclear. Quantification is often more appropriately carried out using FTA and ETA.

B.21.5 Output

The output is a simple diagram showing main risk pathways and the barriers in place to prevent or mitigate the undesired consequences or stimulate and promote desired consequences (e.g. Figure 1).

B.21.6 Strengths and limitations

Strengths of bow tie analysis:

- it is simple to understand and gives a clear pictorial representation of the problem;
- it focuses attention on controls which are supposed to be in place for both prevention and mitigation and their effectiveness;
- it can be used for desirable consequences;
- it does not need a high level of expertise to use.

Limitations include:

- it cannot depict where multiple causes occur simultaneously to cause the consequences (i.e. where there are AND gates in a fault tree depicting the left-hand side of the bow);
- it may over-simplify complex situations, particularly where quantification is attempted.

DFO have used the MSFD GES as the consequences of the analysis (outcomes) showing where on the pathways to impact there are regulation, BMP's, SOP, thresholds or targets that can prevent or mitigate the events (Figure 2). The events were written as an alteration the natural regime. In terms of the GES, DFO find that Descriptor 1: Biodiversity could be considered as an "Ultimate Outcome" while Descriptor 3: Commercial fisheries could be considered as an "Intermediate Outcome". The others would be considered as an "Immediate Outcome" of management and program actions. DFO focus on the "Result Chain" aspect of our program delivery as a means of demonstrating to Parliament achievement and service to Canadians. In doing so, we focus our work on prevention, control and mitigation of risk. Although the work related to the GES is in terms of predicting and reporting "Good Environmental Status" based on monitoring, indicators and thresholds, we see the descriptors as a description of environmental outcomes at the end of the pathway (Figure 3).

The construction of Bowties requires that there is understanding of the logic models that link the activities (drivers) through pressures to impacts on outcomes (GES descriptors). Below is a set of definitions used to build logic models of programs and management strategies used by the Canadian Government.

Results Chain (Logic Model)

Implementation of the Program is expected to contribute to a set of intended outcomes. The progression from the key program elements to higher level outcomes is also called a "results chain", and can be expressed in terms of a logic model. The Program Logic Model consists of the following elements:

- **Activities**: The operations or work processes internal to the organisation, intended to produce specific outputs (e.g. products or services). Activities are the primary link in the chain though which outcomes are supported. They describe a collection of functions that identify the primary focus of the Program.
- **Outputs**: Direct products or services stemming from the activities of the Program's policies and initiatives, and delivered to target groups or populations. They provide evidence that the activity did occur. Outputs are described as **things you can count** and things you can control.
- **Outcomes**: Desired states to which the Program policies and initiatives are connected and that are considered significant in relation to its commitments. **A good outcome statement represents the type of influence that is desired, includes references to the target population or intended beneficiary and does not include reference to the how.** Program Managers and staff usually don't have control over outcomes and the further away on the chain of outcomes, the less control a program Manager or staff will have.
    - ***Immediate Outcomes* –** Immediate Outcomes are those outcomes over which the program or initiative has some significant degree of influence. They are generally necessary precursors to contribute to higher-level outcomes.
    - ***Intermediate Outcomes* –** Intermediate Outcomes are those that the program or initiative can merely influence and where other intermediaries (targeted groups, partners and other stakeholders or factors) are usually involved.
    - ***Ultimate Outcome(s)* –** Also called Final Outcome(s), they reference the long-term enduring benefits for Canadians or internal to DFO or government clients that can be attributed, at least in part, to a program or initiative. This level of outcome may be subject to many influences beyond the program itself and is also at a more strategic level. There should be clear and logical linkages between the ultimate outcome(s) of a program and the outcomes of higher-level programs to which it is associated in the Program Activity Architecture and at least one Strategic Outcome of the department. Otherwise stated, every program in the department should align to, and support the Strategic Outcomes, even if only in a small or specific way.

The Program's Logic Model describes the linkages between Activities, Outputs and Outcomes. The implementation of the Program will contribute to the desired states or outcomes that are identified in the Logic Model. The Logic Model also identifies linkages between the Oceans Management Program results and inputs from other sectors of the department, providing clarity on required working relationships.

In a BowTie, escalation factors are events or issues that will hamper if not cause the management measures to fail. Climate change would be considered as an Escalation factor that would be counterproductive to any management of alien species given that the climate change would allow species to gradually move into new niches.

In building these Pathways and BowTie, DFO have identified that they also need to develop guidance into the application of these from an environmental management perspective such as MSP in terms of cause and effects, barriers (management measures), risk event, escalation factors and consequences.

DFO are planning to develop a list of threats for energy, fisheries and alien species in addition to nutrients, sediments, benthic habitat and collisions and noise that they have already addressed. DFO will be using the BowTie approach to identify the cause and effect pathways and the effectiveness or gap of control and mitigation measures along the pathway.

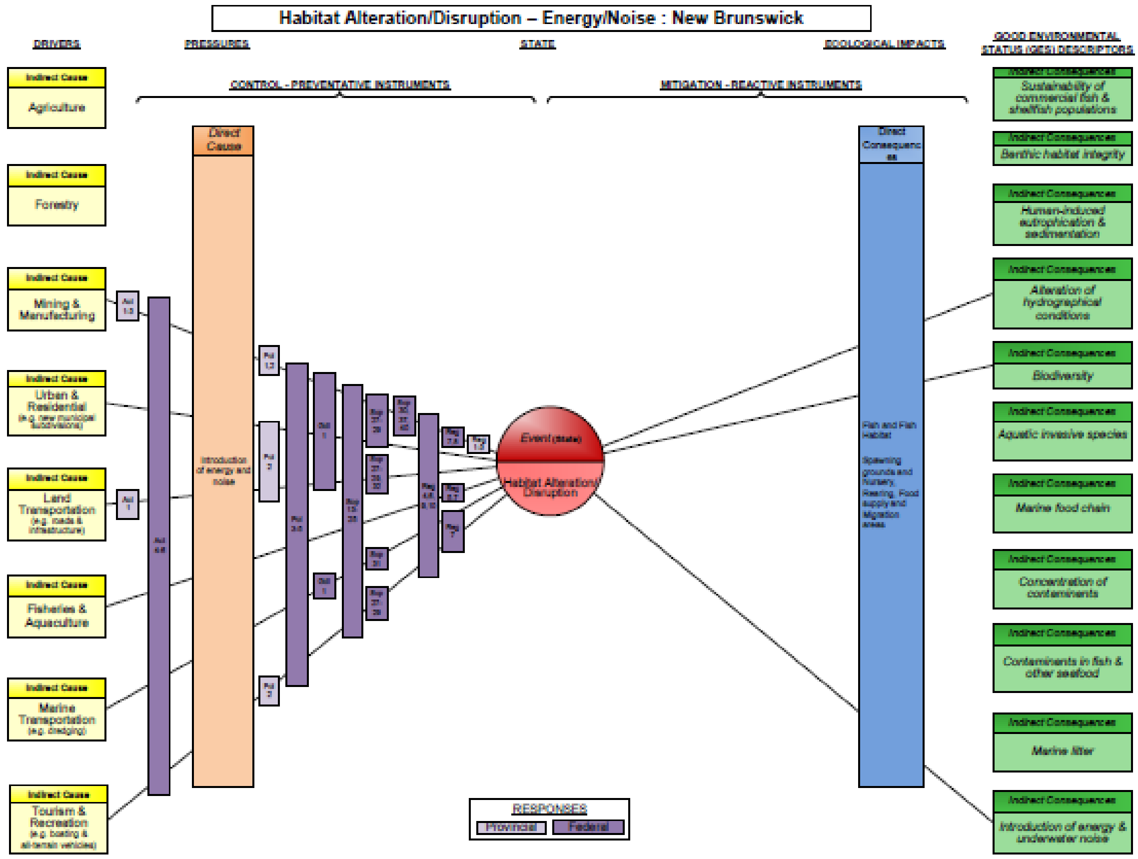


Figure 1. Bowtie diagram for sources of noise and impacts of noise on GES descriptors. Response bars/blocks refer to regulatory control points.

Ecosystem Management Outcomes

Ecosystem Management Outcome	Ecosystem Management Outcome
Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.	*Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.*

Ecosystem Objectives: Biological

All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

Ecosystem Objectives: Biological

Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.

Ecosystem Objectives: Physical Habitat

Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

Ecosystem Objectives: Physical Habitat

Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

Ecosystem Objectives: Physical Habitat

Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Ecosystem Objectives: Marine Environmental Quality

Human-induced eutrophication and sedimentation is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.

Ecosystem Objectives: Marine Environmental Quality

Concentrations of contaminants are at levels not giving rise to pollution effects.

Ecosystem Objectives: Marine Environmental Quality

Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

Ecosystem Objectives: Food Safety

Contaminants in fish and other seafood for human consumption do not exceed levels established by or other relevant standards.

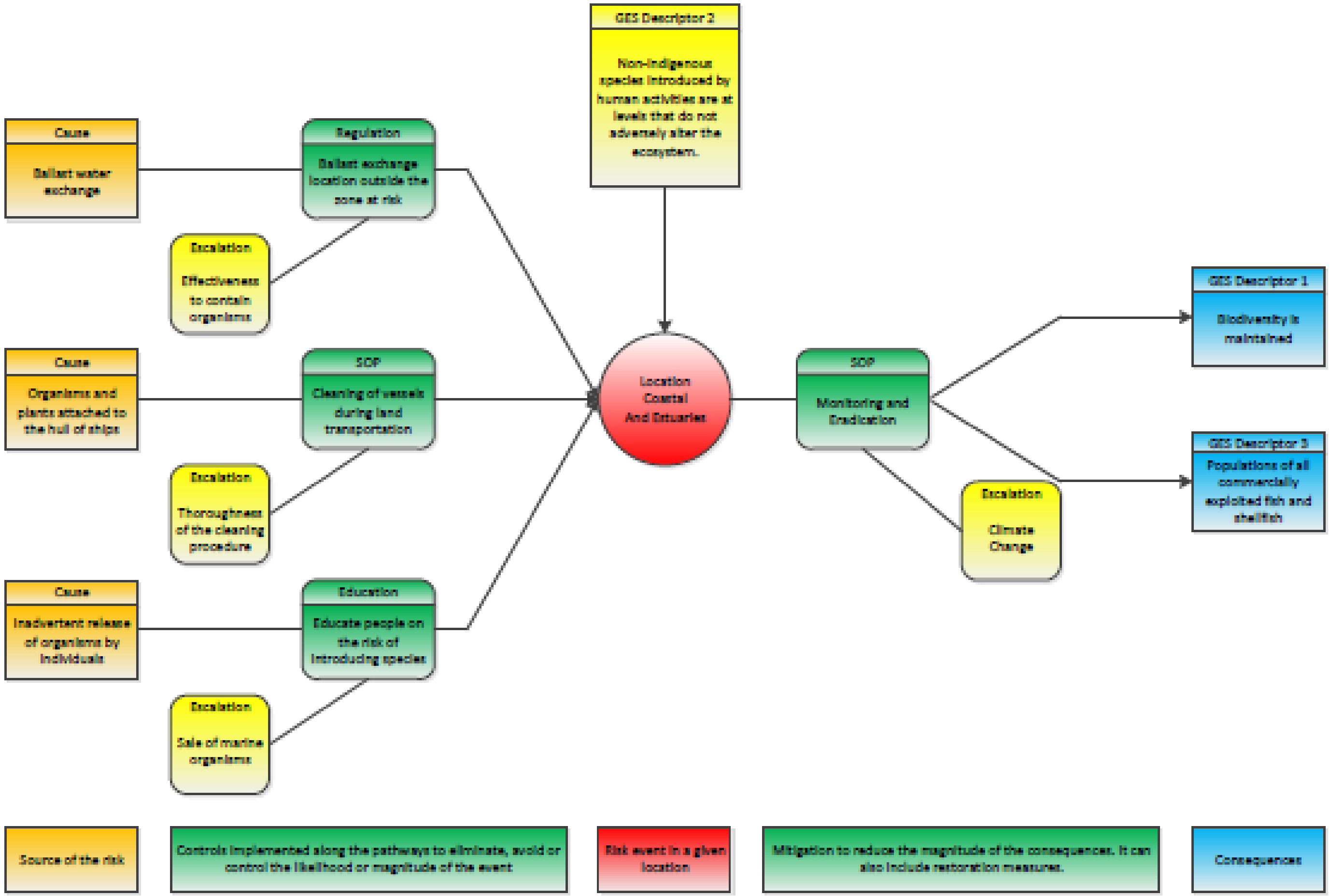
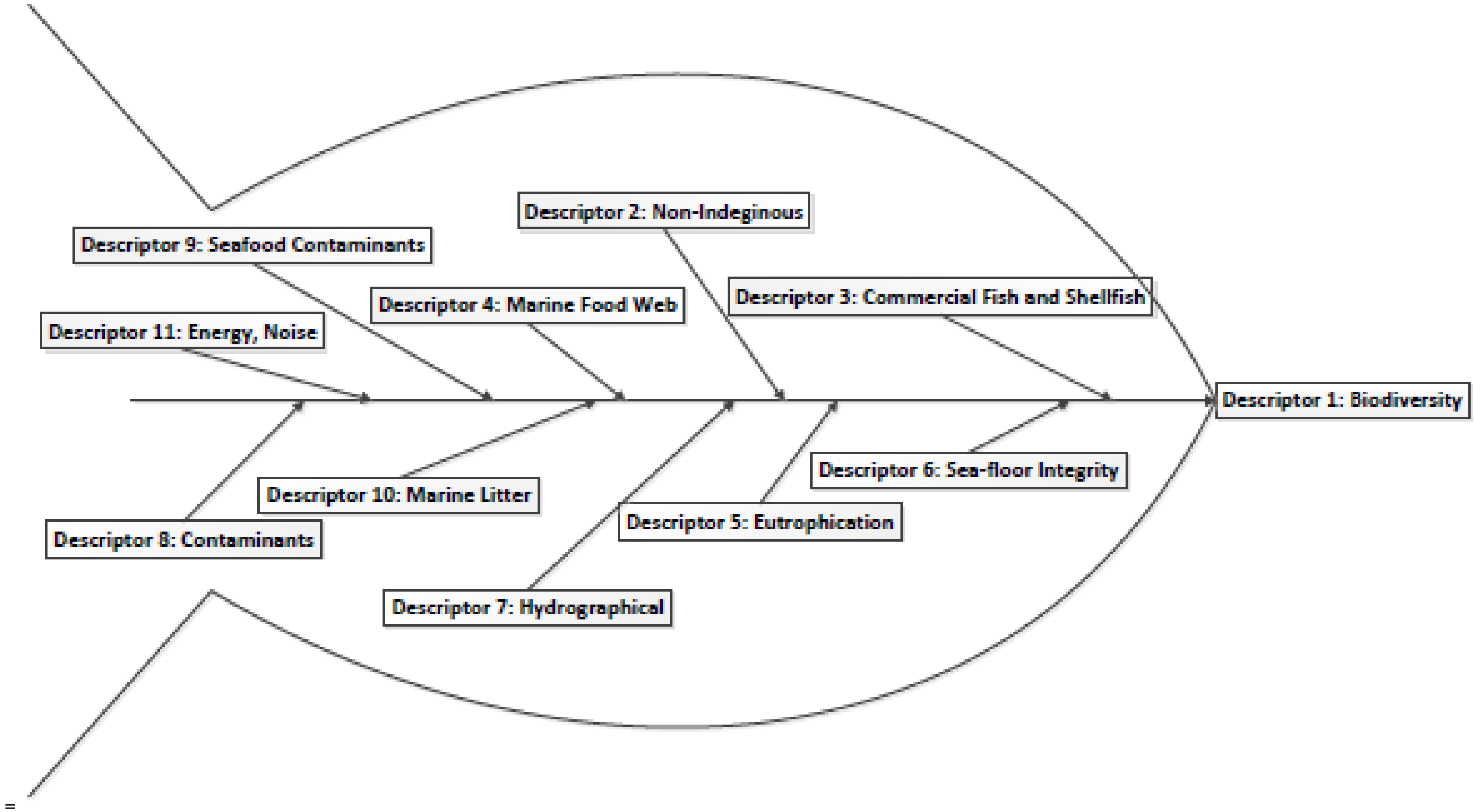


Figure 2. Relationships between Causes, Escalation factors, regulation and GES Descriptors, and between Descriptors.

Descriptor 1: Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climate conditions.
Descriptor 2: Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem.
Descriptor 3: Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
Descriptor 4: All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
Descriptor 5: Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
Descriptor 6: Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
Descriptor 7: Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
Descriptor 8: Concentrations of contaminants are at levels not giving rise to pollution effects.
Descriptor 9: Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
Descriptor 10: Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
Descriptor 11: Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.



Annex 8: Risk Analysis – Short Canada and UK Comparative study – Draft report

Outline

The report on which this summary is based was prepared during a one month placement by Fraser MacDonald at Marine Scotland Science, Aberdeen as part of the UK NERC Marine Renewable Energy Knowledge Exchange Programme. The purpose of the report was to produce a short comparative study, reviewing the newly produced Marine and Coastal Ecosystem-based Risk Analysis Procedures, proposed by Department of Fisheries and Oceans, Canada, and published in the ICES Cooperative Research Report series (Cormier *et al.*, 2013). The aim was to explore the potential for an ecosystem-based risk management framework, such as that in the ICES CRR, to be adopted within Scotland to assist in the management of marine renewable energy developments.

Introduction

The project compared the Canadian risk analysis framework (EBRMF)with the UK Habitats Regulations Appraisal (HRA) in the context of Marine Renewable Energy Installation (MREI). Both frameworks have been put in place as a means of addressing the management of risks in our marine environment.

The EBRMF procedures aim to provide a comprehensive, structured and succinct risk management tool, which takes into account ecosystem and coastal management requirements, and to assist in the design and delivery of any marine ecosystem-based management strategy.

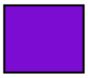
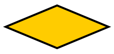
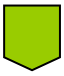
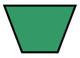
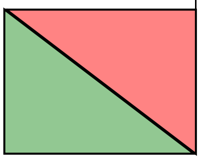
The Marine (Scotland) Act 2010 has ensured that there is the necessary framework in place for managing competing use of Scotland's marine space, placing environmental risk management alongside economic development. The requirements set by EU Directives e.g. Marine Strategy Framework Directive and Natura 2000 Regulations require an ecosystem-based approach to managing the marine environment. This existing governance structure and statutory context is designed to enable an effective ecosystem risk management approach within the UK.

In line with the EC Habitats Directive (Article 6(3)), Scotland has adopted a HRA process regulated by Marine Scotland in accordance with Natura2000. The appraisal process ensures that proposed plans and developments are assessed against their likelihood of impacting the integrity of any SPA and/or SAC. It is essentially a site-based management approach. The HRA and its tools, which are adopted for identifying, analysing and managing environmental risk, potentially provide a useful comparison against the Canadian ecosystem based risk framework. Both frameworks were compared against one another, illustrating the key differences between the two approaches, and developmental opportunities.

Risk Analysis Procedures

The EBRMF and HRA frameworks have different scopes and are therefore not easily comparable. To facilitate comparison, the HRA was mapped out similar to the EBRMF, identifying Context, Risk Identification and Analysis stages. In doing so, fuller analogous comparison of both frameworks was feasible. Figures 1 and 2 provide illustrations of these processes, which have been simplified to help inform the consideration of risk based frameworks in the Scotland and Canada. Table 1 provides the definitions for the pictograms used within both figures.

Table 1. Definitions of pictograms used within Figures 1 and 2.

Pictogram	Definition
	Refers to the process of outlying the project details i.e. the Parameters of the project that is subjected to assessment. Otherwise known as the 'Context'. Shading illustrates responsibility.
	Refers to a stage in the risk assessment process as outlined in the procedural handbook.
	Refers to an outcome of analysis.
	Refers to the addition of external information to the risk assessment process. i.e. Mitigation or Cumulative Impacts.
	Refers to a process of assessment
	Refers to a tool used for the decision making process.
	Shading illustrates specific responsibility. The group represented by the colour is identified within each figure.

Scotland

Illustrating the HRA as a risk assessment procedure facilitated comparison of the methods used to assess specific risks to Natura2000 sites and species against the EBRMF framework. In practice, HRA provides a risk identification and assessment procedure for marine developments, when the development does not directly contribute to the conservation of the relevant designations. The HRA is not normally reviewed in the terms of a risk assessment procedure and Figure 1 provides a simplified outline of this process.

Any development (or plan) must undergo a screening process which seeks to identify if there is a requirement for further risk analysis. SNH are normally consulted during this process to ensure that the decisions made are in keeping with the requirements of the HRA and Marine Licensing.

The screening process looks to acquire information on the European sites that need to be considered, determining if the development poses a risk to any SPA or SAC. The screening process may be considered a form of risk identification. In turn, it is possible that, following screening, a development may not require further risk analysis. This may occur where the proposed development is considered to have no likely significant effect on any designated feature of a Natura site.

Appropriate Assessment

Experience of marine renewables developments is that HRA usually results in requirement for Appropriate Assessment. If a development is considered to have a likely significant effect, it is necessary to undertake an appropriate assessment (AA). During the AA it is up the plan or project owner to determine if the proposed development will impact on the structure and functioning of the ecological system and/or affect the ability to meet conservation objectives. This is otherwise known as 'site integrity'.

Mitigation

Mitigation measures can be introduced by the developer incorporated into the HRA process following the identification of likely significant effects. By incorporating the addition of mitigation measures at this level it is possible to reduce or remove any effects on nearby European sites. In cases that incorporate the latter, it is then possible to avoid pursuing with an AA subject to consultation with SNH. Mitigation measures may also be incorporated following completion of the AA. This process allows any risks to be reduced, should the development fail to show evidence of not affecting the site integrity following the appropriate assessment.

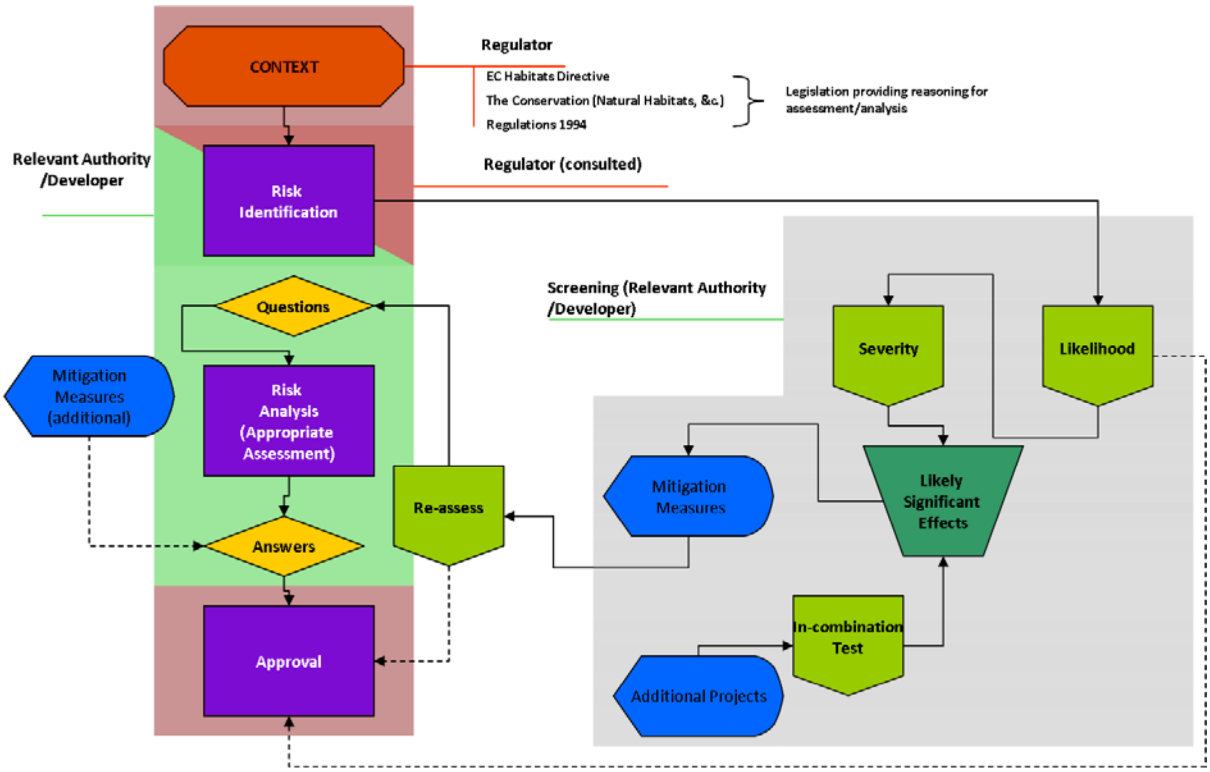


Figure 1. Simplified outline of the HRA process adopted by Scotland.

Cumulative Impacts

Cumulative impacts are addressed within the HRA via 'in-combination' testing, which aims to establish the combined impacts of any additional plans or developments. The 'in-combination test' is carried out during the screening process and usually follows the identification of mitigation measures. The objective is to ensures that any potential cumulative effects are accounted for. Following this process, the developer may apply additional mitigation measures to address cumulative effects prior to reviewing the requirement for AA.

Canada

The Ecosystem-Based Risk Management Framework (EBRMF) bridges ecosystem management to the ISO 31000 Risk Management framework. The procedural handbook provides a full breakdown of EBRMF. Although covering context, identification, analysis, evaluation and treatment, the scope of this study solely focused on risk identification and analysis. It is important to clarify that the framework is yet to be fully integrated into oceans management around Canada, however close liaison with DFO has enabled a number of historic reports to be categorised within the EBRMF.

A simplified outline of the Science Special Response Process (SSRP) is illustrated in figure 2. This process was used as it is the most analogous to the HRA. The SSRP provides a method of addressing issues, identified during the risk identification process, when there urgent deadline requirements(DFO, 2012) i.e. time constraints for a development. In the absence of a working example of the framework being used within development of MREI, case studies involving SSRP and the potential interactions between marine mammals and marine infrastructure construction were studied.

The SSRP is carried out by the Canadian Science Advisory Secretariat (CSAS) whom act on behalf of the scientific community, peer reviewing scientific issues for DFO. CSAS work to a framework based on six principles, ensuring any decisions are informed by sound science (GC,2000). The connection between DFO and CSAS within the EBRMF is key to the progression of risk identification, analysis and subsequent management.

The risk identification process takes into account a vulnerability profile, which provides a spatial-temporal outline of the risks that need to be considered within the analysis stage. This vulnerability profile forms the bases of the vulnerability assessment and is ecoregion specific, focussing on the environmental effects that are known for that particular area. In turn, the vulnerability assessment acts a tool for identifying problems that need to be addressed by the scientific community.

Use of the vulnerability profile provides a method of problem formulation. Within the SSRP problem formulation is out as a set of questions relating to the risks that have been identified as needing analysed. The risks are prioritised and addressed by means of an Ecoregion Risk Profile (ERP). Differing from the vulnerability profile, the ERP provides a tool for predicting the highest risks based on likelihood and severity on ecosystem components together with the inclusion of socio-economic goods and services (i.e. tourism and fishing). Again, this tool is ecoregion specific and provides a present state view of the area with existing management measures in place, and drives the decision making process with regards to the final outcome of the risk assessment and management options.

Mitigation

The EBRMF is focused on identifying the best mitigation measures to reduce risk. As illustrated in figure 2, mitigation measures are considered during the initial stages of risk identification. The later consideration of ecoregion specific mitigation measures coincides with the implementation of a risk profile. Assessment of the achievability of further mitigation/management measures against the risk profile provides a means of assessing the possible outcomes from different options. The results of the analysis provide the required management measures to ensure that risk is reduced to a tolerable level.

Cumulative Impacts

As the EBRMF has not yet been fully adopted within the Canadian risk framework there is not detailed information on how the handling of cumulative impacts will be implemented at a project level. Information relating to addition project is identified during the risk identification, prior to problem formulation. The information processed during risk identification is then assessed during the risk analysis stage prior to development of the risk profile.

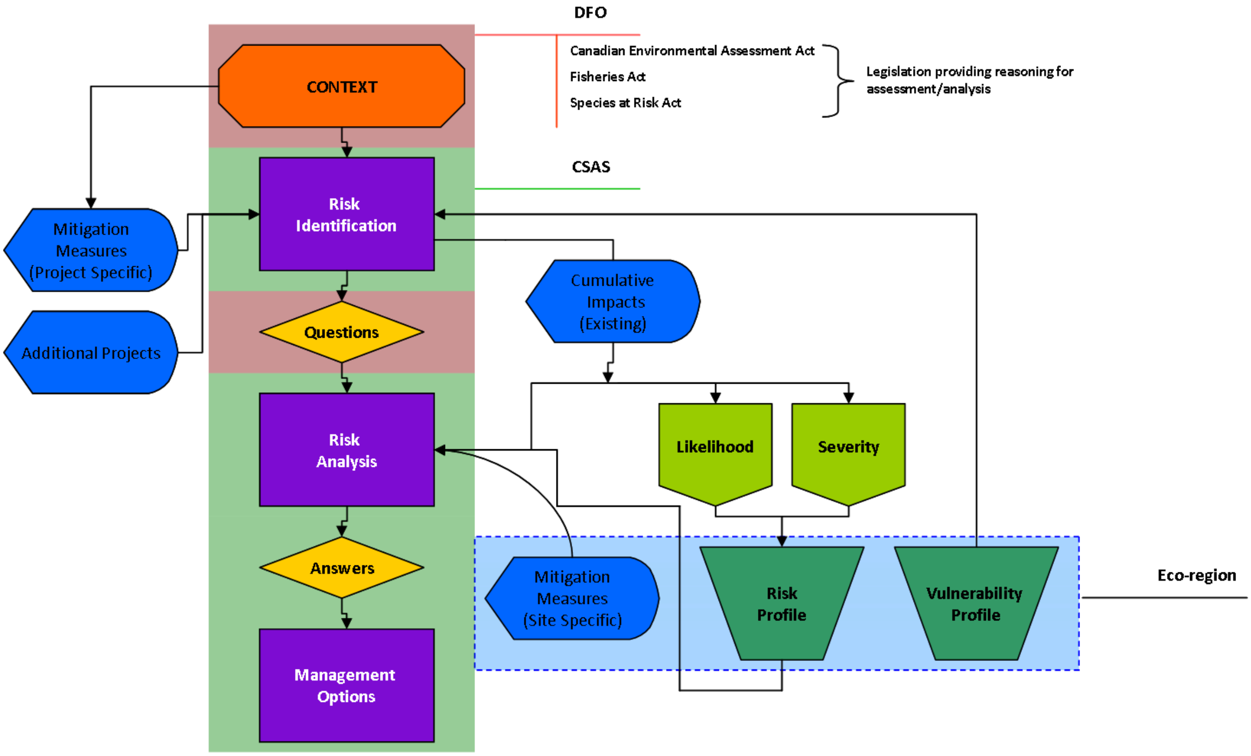


Figure 2. Simplified outline of the SSRP process adapted to meet the requirements of the new EBRMF.

Key Differences/Similarities

Objectives

The EBRMF has been proposed within the context of an environmental management tool providing a method of applying a management framework which adopts the requirements of the MSFD. It is evident from the onset that the HRA framework addresses a much more specific issue, at a much smaller scale. The HRA process could be viewed as single element of an EBRMF. In turn, issues arise when trying to introduce an EBRMF into Scottish waters because qualifying interests define the boundaries of SPAs and SACs. It therefore becomes difficult to establish separate management areas that will encompass whole, pre-defined, designated sites.

Assessment Methods

A significant difference between the two approaches is the adoption of differing assessment methods during both risk identification and analysis. Within the ERMBF, the use of vulnerability profiles is a key element to the understanding of risks within an ecosystem. These profiles provide a qualitative method of determining risks within the environment, based on a pathway of effects conceptual model (DFO, 2011).

In contrast, the screening process in the HRA during risk identification may adopt either a qualitative or quantitative approach. This is also the case in relation to the appropriate assessment where modelling has often been used as a means of assessing likelihood and severity of impacts on specific species.

Communication/responsibility

In Scotland, the developer prepares a draft HRA, together with the requirement to complete specific monitoring and predictive modelling. Consultation and guidelines, provided by SNH, ensures that the manner in which screening and AA are conducted comply with legislative requirements. It is, therefore, up to the developer to actively seek information that will increase the knowledge base for the assessment, together with the management of monitoring for the production of an AA.

In contrast, the DFO actively use the Canadian Science Advisory Secretariat (CSAS) to manage and deliver advisory information with regards to risk management requirements. CSAS papers can also form the bases of subsequent consultation processes with stakeholders and advisory bodies (ICES, 2012). Within a SSRP, risk identification, via a vulnerability profile, leads to problem formulation. DFO are then in a position to request that CSAS provide an analysis of the risks based on the context of the project under consideration. CSAS can then provide suitable management strategies to reduce risk to the surrounding environment.

In comparison, the Scottish Governments' marine science department, MSS, act as an external advisory and are under no obligation to formally advise during the HRA process for a MREI development. There have been circumstances, however, where MSS has acted when the developer was incapable of performing the required AA.

Spatial boundaries

The EBRMF is dependent on the establishment of ecoregions. These predefined areas of marine space form the bases of setting vulnerability and risk profiles. All risk assessments and subsequent management options are based on environmental knowledge contained within each ecoregion, including designations and conservation objectives.

Surrounding Canada's coastline, ecoregions have been defined by number of qualifying factors. Large Ocean Management Areas (LOMAs) set the large-scale boundaries, with sub regions providing a more detailed resolution for distinguishing Ecologically and Biologically Significant Areas (EBSA). Overlaying and prioritising a range of ecological components within definitive areas generate conservation objectives within LOMAs. Firstly, conservation priorities are set based on a hierarchal scale, taking into consideration Ecologically Significant Species (ESS), Ecologically Significant Community Properties (ESCP), EBSA's, depleted or rare species and degraded areas (CSAS, 2007b). The formation of conservation objectives forms the basis for generating a vulnerability profile, used within risk identification. Based on the outcome of the vulnerability profile, development outputs and existing mitigation measures are included to generate a risk profile for risk assessment.

The focus for the HRA framework is SAC and SPA designations. Within Scotland there are a number of SAC's and SPA's with specific focus on the protection of the marine environment, namely seals, cetaceans, birds and their associated feeding and breeding sites. The boundaries used within the risk assessment process are defined by the proximity of a site to these designations, i.e. the connectivity of the development site to the designated sites for different species. The screening process forms the bases of risk identification, in which it is derived whether or not a development will be likely to result in a significant effect. The priorities for the risk assessment utilise the conservation objectives defined via the favourable conservation status.

The HRA process therefore has a much narrower scope than the EBRMF. However, setting boundaries for SPAs and SACs is driven by individual species and habitats. Within the EBRMF, protected areas are defined not only by habitats and species but are brought into a vulnerability profile alongside socio-economic goods and services contained within an eco-region.

Discussion

It is evident from the onset that the HRA framework addresses a much more specific issue than the EBRMF. However, the aim of both frameworks is to identify, analyse and manage risk in the marine environment. The EBRMF is yet to be utilised in relation to the development of MREI and it may be that the framework may have difficulties with such a new and untested technology.

Scotland currently has the most activity in the development of wave and tidal energy projects, and yet there are uncertainties in knowledge of the effects of full commercial-scale deployments. The experience of the Scottish model is that although having good knowledge of environmental parameters is key, it is also essential that the technology, and its potential pressures are fully managed and understood. In turn, the HRA framework adopts quantitative approaches as well as qualitative, taking account of known industry and environmental parameters. Something that, arguably, cannot be incorporated so easily into a vulnerability profile.

The introduction of the MSFD within the EU will require that an ecosystem based approach to coastal management is adopted, taking into account socio-economic factors alongside ecological conservation. What is clear from the EBRMF is that by defining management boundaries prior to establishing conservation objectives has made it possible to establish an effective means of managing a whole ecosystem. The development of a National Marine Plan and subsequent Regional Marine Plans could provide the initial framework for the development of ecoregions around the Scottish coastline. However, careful planning will be required to ensure that Natura2000 sites, already defined by the EU, are incorporated into a region specific conservation priority objectives.

What has been identified by this study is that the HRA can be viewed as an effective risk assessment process when reviewed aside the EBRMF. The effective use of both quantitative and qualitative assessments within the HRA provides a useful decision making tool. One which will become more effective as our knowledge of the developing marine renewable industry improves. It is therefore evident that novel application of the HRA process into an ecosystem based management process is something that should be considered within future management frameworks.

Conclusion

This report has provided a novel method of comparing one of Scotland's current risk management procedures and the new EBRMF. Although the EBRMF is comprehensive, no procedure can be applied in practice without encountering issues. There are some key differences between both frameworks and It is clear that practical understanding and careful analysis are required if this ecosystem based risk framework is to be applied within Scotland. The main differences between the two methods were identified to be objectives, assessments methods, communication/responsibility and spatial boundaries.

The established and well managed connection between DFO and the scientific community, via CSAS, provides an effective and comprehensive decision making process. It would appear that this process is built on good knowledge of both environment and industry. Within Scotland, there has been an accelerated progression in the development of MREI's. For an effective EBRMF to be able to take account of marine renewable energy there needs to be an established and up to date knowledge base concerning the industries effect on the surrounding environment.

Adopting a quantitative and qualitative approach to assessment, as used within the HRA, has its advantages with a new and developing industry. It is also clear that the formation of well-defined and separately managed ecoregions is essential for establishing an effective EBRMF. The adoption of a new framework will require the incorporation of Natura2000 sites. This will require novel application of the existing HRA structure if it is to meet the demands of a developing marine renewable industry.

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