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Annex IV Database

Annex IV Experts' Workshop #2
Dublin Ireland
October 15th 2012

Purpose of Annex IV Database

- Annex IV is designed to:
  - "*Facilitate efficient government oversight of ocean energy systems development by expanding our baseline knowledge of environmental effects and monitoring methods;*
  - *"Ensure that existing information and data on environmental monitoring are more widely accessible to those in the industry; national, state, and regional governments; and the public; and*
  - *"Facilitate knowledge and information transfer"*.

- The Annex IV database, housed in *Tethys* provides the basis for bringing together information from international sources on:
  - Monitoring results from deployed wave and tidal devices and arrays;
  - Results of research studies in the field, laboratory, and modeling; and
  - Provides a searchable, accessible, source of that information.

Tethys Home Page

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Tethys is a database and knowledge management system that provides access to information and research pertaining to the potential environmental effects of marine and hydrokinetic (MHK) and offshore wind development. Tethys also hosts data from Annex IV, an international collaboration to gather information on MHK environmental research worldwide.

Tethys Home

The Environmental Impacts Knowledge Management System (KMS) (dubbed "*Tethys*" after the mythical Greek titaness of the seas) supports the U.S. Department of Energy's Wind and Water Power Program.

As industry, academia, and government seek to develop new renewable energy sources from moving water and offshore wind, potential environmental effects must be evaluated and measured to ensure that aquatic and avian animals, habitats and ecosystem functions are not adversely affected, nor that important coastal and ocean uses are displaced.

Tethys seeks to gather, organize and make available information on potential environmental effects of marine and hydrokinetic and offshore wind energy development. Datasets, supporting documents, and other media are housed within *Tethys* in support of the following programs:

Marine and Hydrokinetic (MHK) Energy Development: MHK development is moving forward in U.S. and international waters, with projects that include the following devices:

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- Tethys FY11 Annual Report
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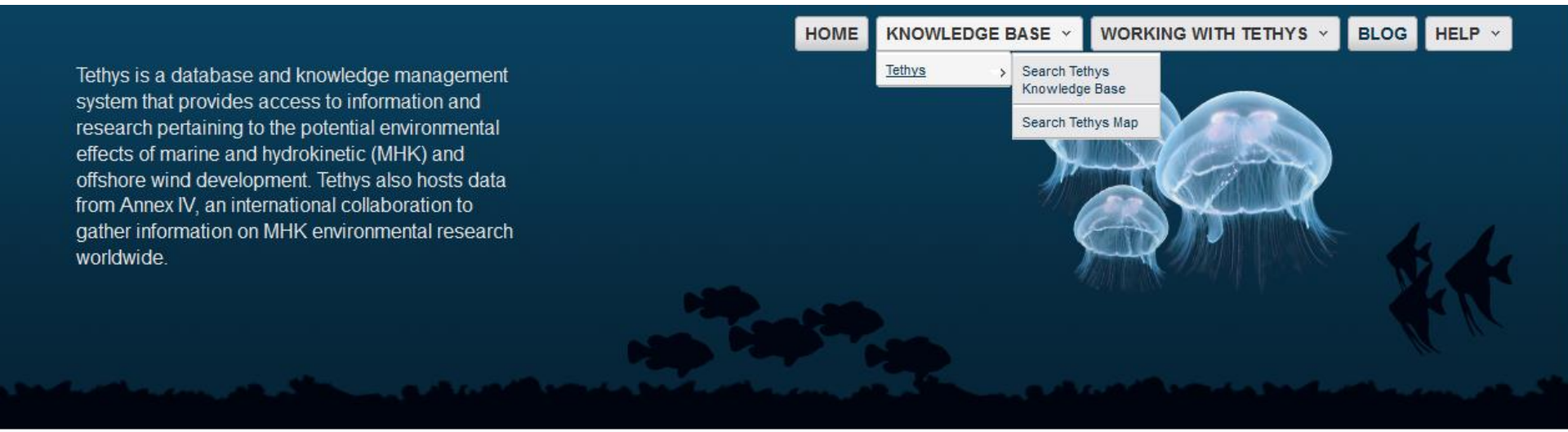

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TETHYS Annex IV Access

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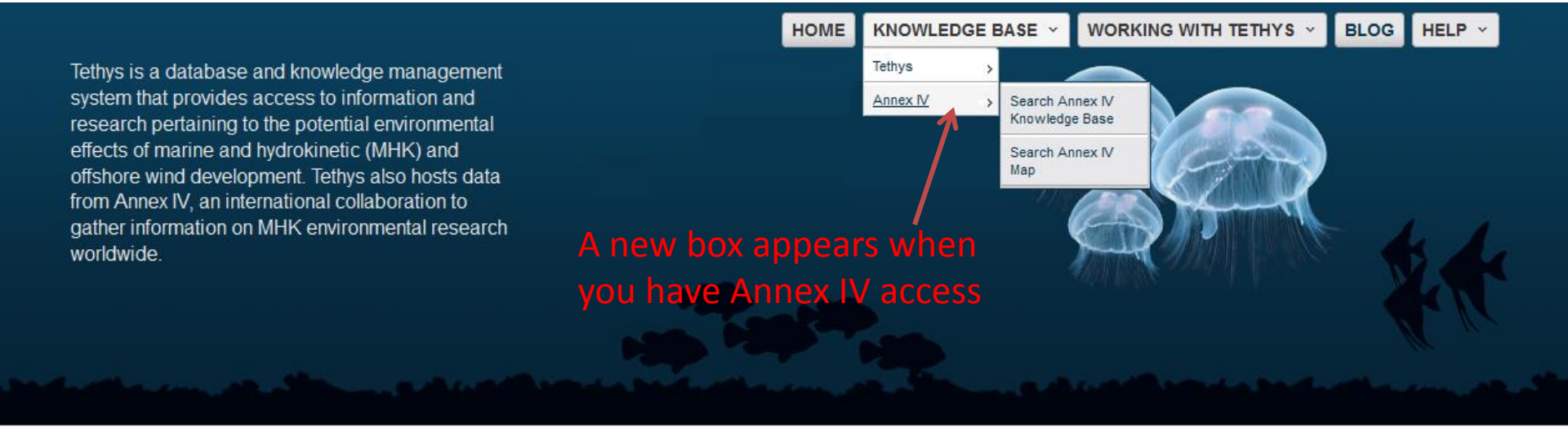

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Annex IV Metadata forms can be downloaded from the Featured Links

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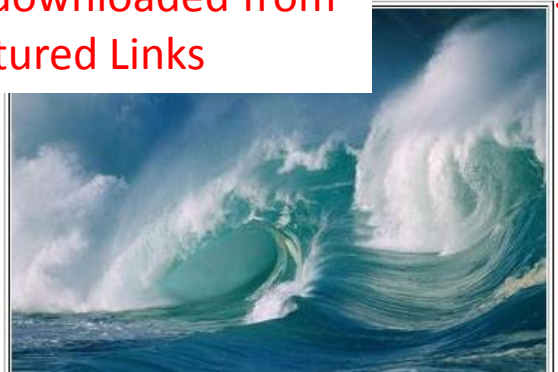

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mhk.pnnl.gov/wiki/index.php/Annex_IV_Knowledge_Base

Annex IV Metadata Forms

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Dear Member of the Ocean Energy Community:

I would like to request your assistance in gathering information on potential environmental effects of tidal, wave, and ocean current energy to assist with the development of a publically-available database, housing information from around the world. This US-led data collection process, known as Annex IV, is part of an internationally funded initiative under the Ocean Energy Systems Implementing Agreement[1]. Annex IV has two main goals; to produce a publicly accessible database to house ocean energy project information, and to use the database to analyze the current status of environmental issues important to marine renewable energy development worldwide.

The Annex IV effort consists of collecting metadata (general high level project information) on site-specific projects and experiments investigating potential environmental effects of ocean energy devices, mooring systems, anchors, and power cables on marine animals, habitats, and ecosystem processes. In the form below, we are requesting information regarding the types of environmental

Annex IV Metadata Forms

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WaveEnergy Centre

Marine Institute UNIVERSITY OF PLYMOUTH

1 ENVIRONMENTAL EFFECTS METADATA SURVEY FORM

Name of person filing the form (can opt to omit from on-line form)

Annex IV Participant

Date submitted

2012/10/15

Project name:

Project description:

Project Developer

Technology type

Resource (wave, tidal, wind)

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

Annex IV Metadata Forms

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General Description (Please keep brief, several sentences or less)	
Purpose	The purpose of this study was to...
Technology	☐ Wave ☑ Tidal ☐ Ocean Current ☐ Technology Neutral Description:
	☐ Physical Presence of device (static) ☐ Physical Presence of device (dynamic)

TETHYS Annex IV Access

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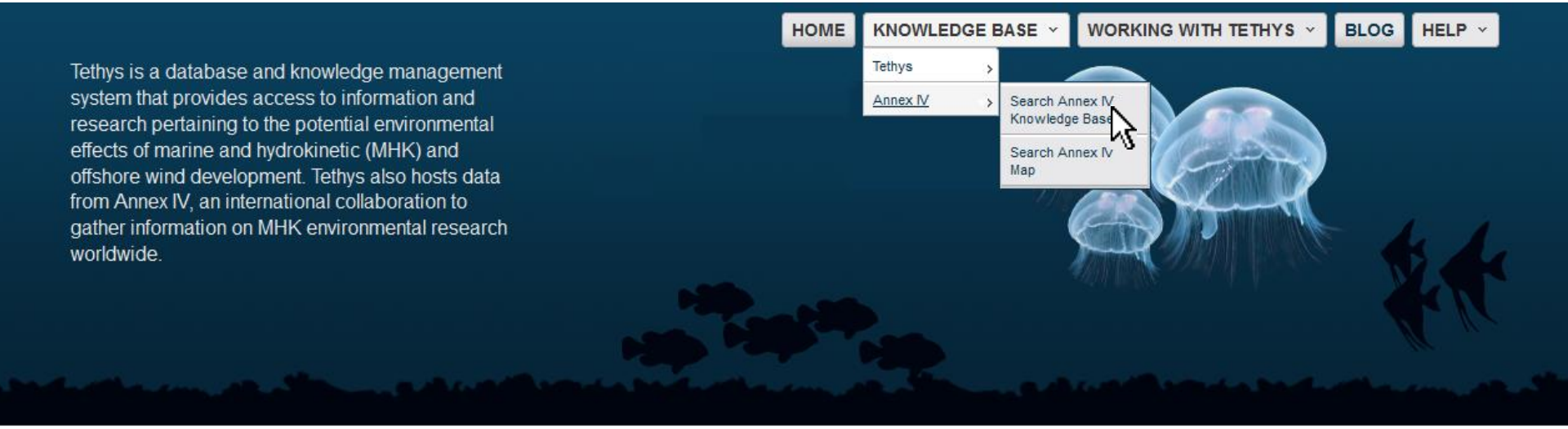

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Search

Technology Type

- 28 MHK
- 5 MHK (in-stream)
- 6 MHK (Ocean Current)
- 2 MHK (OTEC)
- 93 MHK (tidal)

Stressor

- 3 Chemical leaching
- 17 EMF
- 33 Energy removal
- 41 Noise
- 54 Physical presence

Receptor

- 33 Birds
- 14 Farfield environment
- 44 Fish
- 39 Invertebrates
- 44 Marine mammals

Document Type

- 4 Conference Paper
- 16 Journal Article
- 6 Presentation
- 61 Project Site
- 84 Research Study

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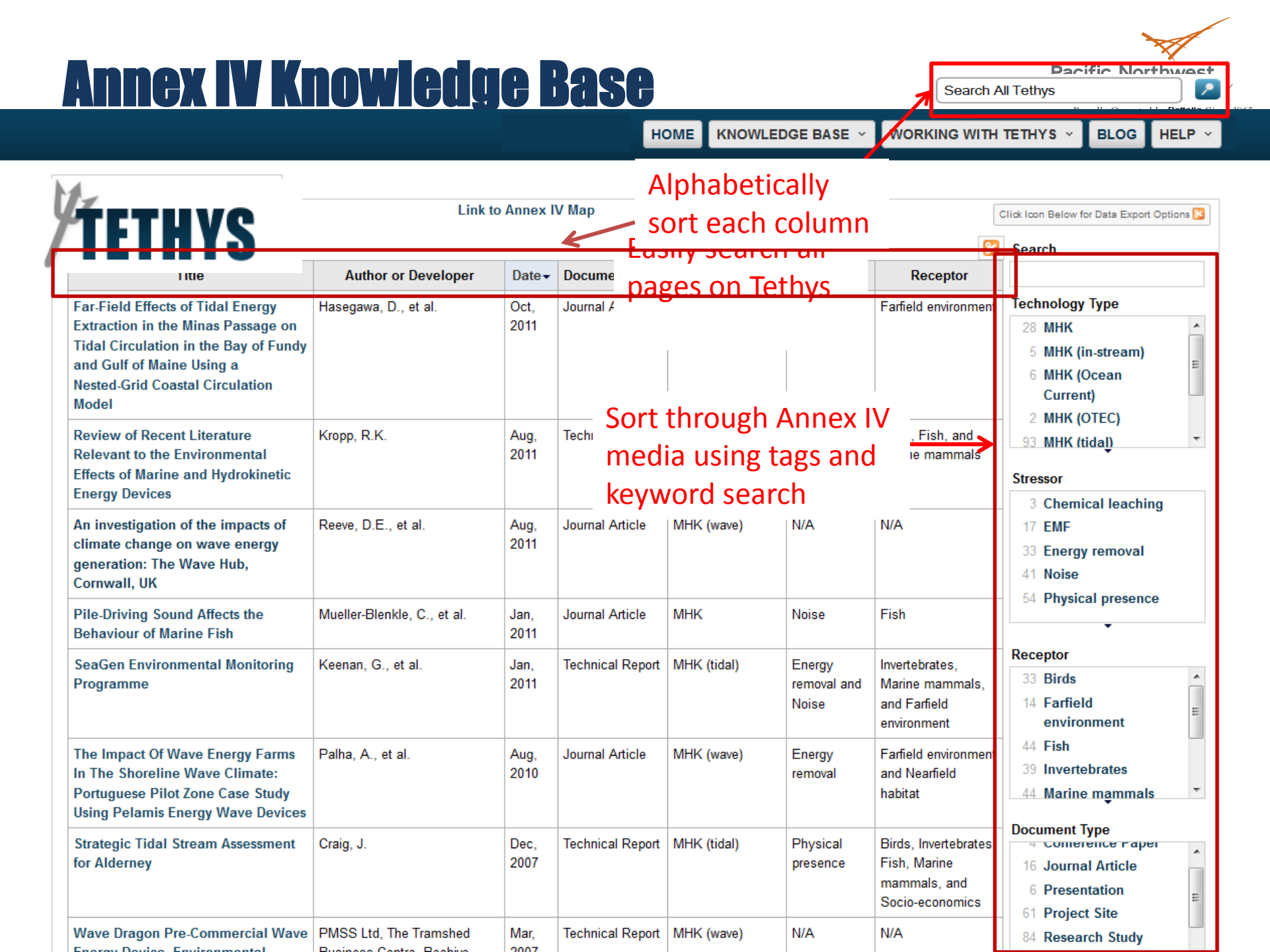

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140 Items

Document | Project Site | Research Study | Mixed

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Country

- 2 South Korea
- 3 Spain
- 4 Sweden
- 22 The United Kingdom
- 40 The United States

Developer

- 1 Alderney Renewable Energy
- 2 Aquamarine Power
- 2 Atlantis Resources Corporation
- 1 Carnegie Wave

Technology Type

- 4 MHK (Ocean Current)
- 1 MHK (OTEC)
- 76 MHK (tidal)
- 53 MHK (wave)

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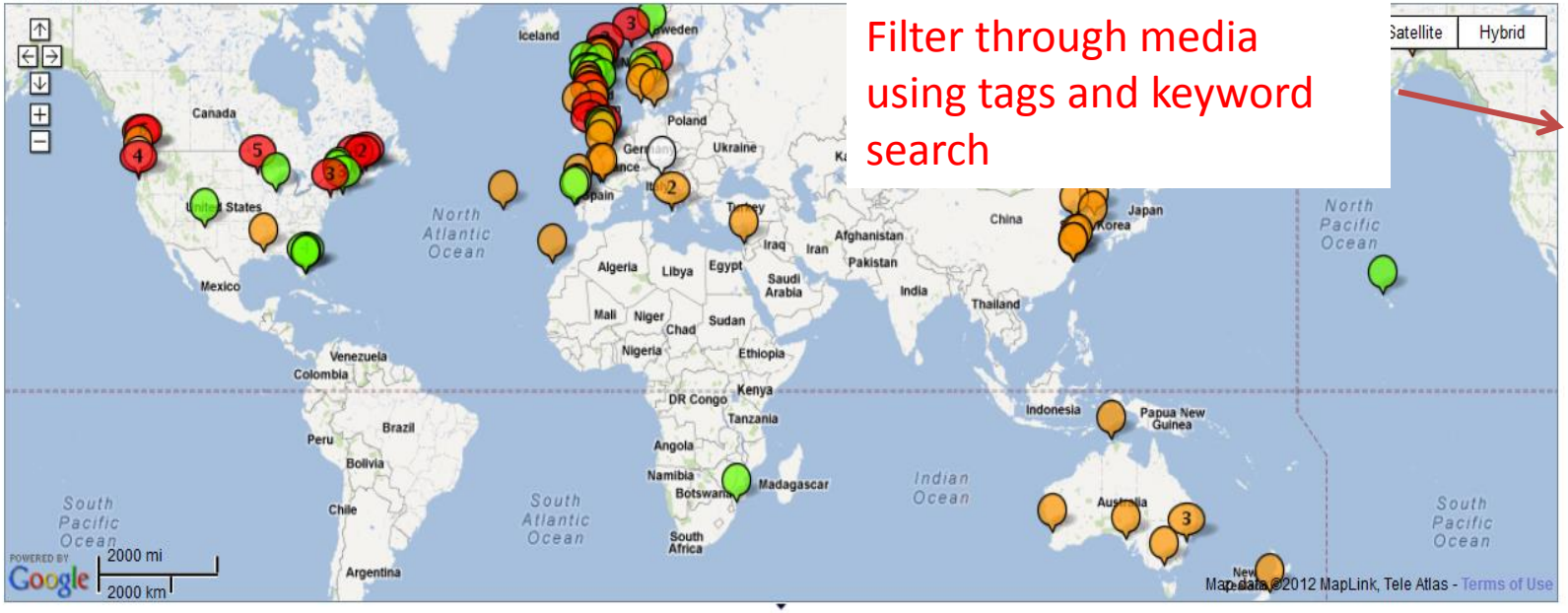

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New colors to represent the new media

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Media available for the N. America, Europe, Africa, Asia, and Australia/New Zealand

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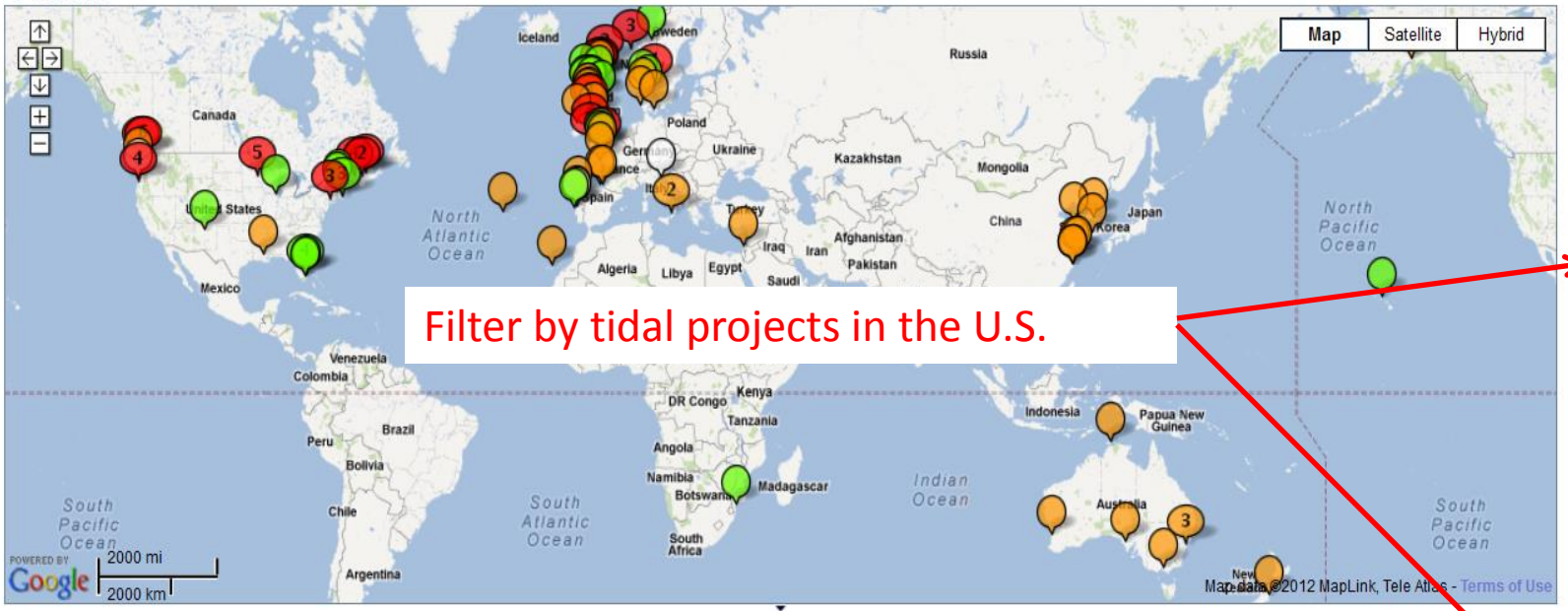

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Search

Country

- 2 South Korea
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- 22 The United Kingdom
- 40 The United States

Developer

- 1 Alderney Renewable Energy
- 2 Aquamarine Power
- 2 Atlantis Resources Corporation
- 1 Carnegie Wave

Technology Type

- 4 MHK (Ocean Current)
- 1 MHK (OTEC)
- 76 MHK (tidal)
- 53 MHK (wave)

Document | Project Site | Research Study | Mixed

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Pacific Northwest

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Annex IV Activities Around the World

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Link to Annex IV Knowledge Base

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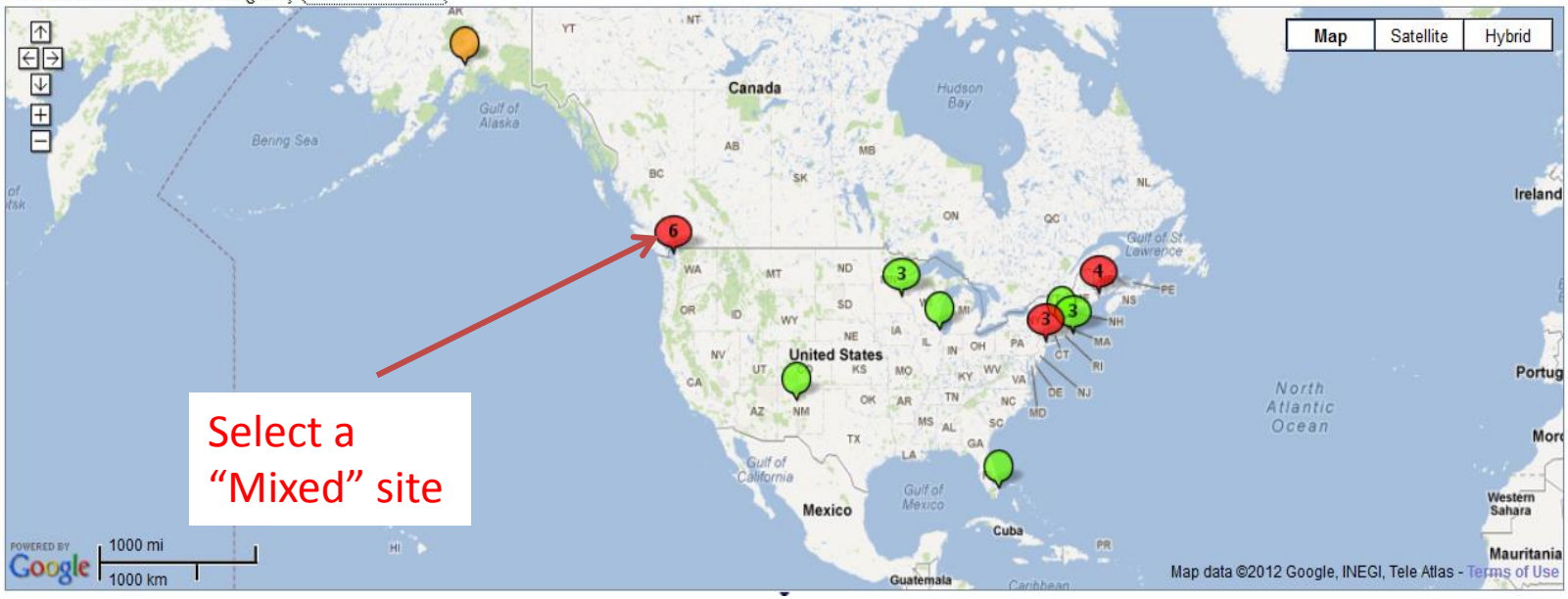

Select a "Mixed" site

Document | Project Site | Research Study | Mixed

Search

Country 1

- 3 Norway
- 14 Scotland
- 2 South Korea
- 12 The United Kingdom
- 24 The United States

Developer

- 2 Ocean Renewable Power Company, LLC
- 1 Public Utility District No. 1 of Snohomish County

Technology Type 1

- 4 MHK (Ocean Current)
- 1 MHK (OTEC)
- 24 MHK (tidal)
- 6 MHK (wave)

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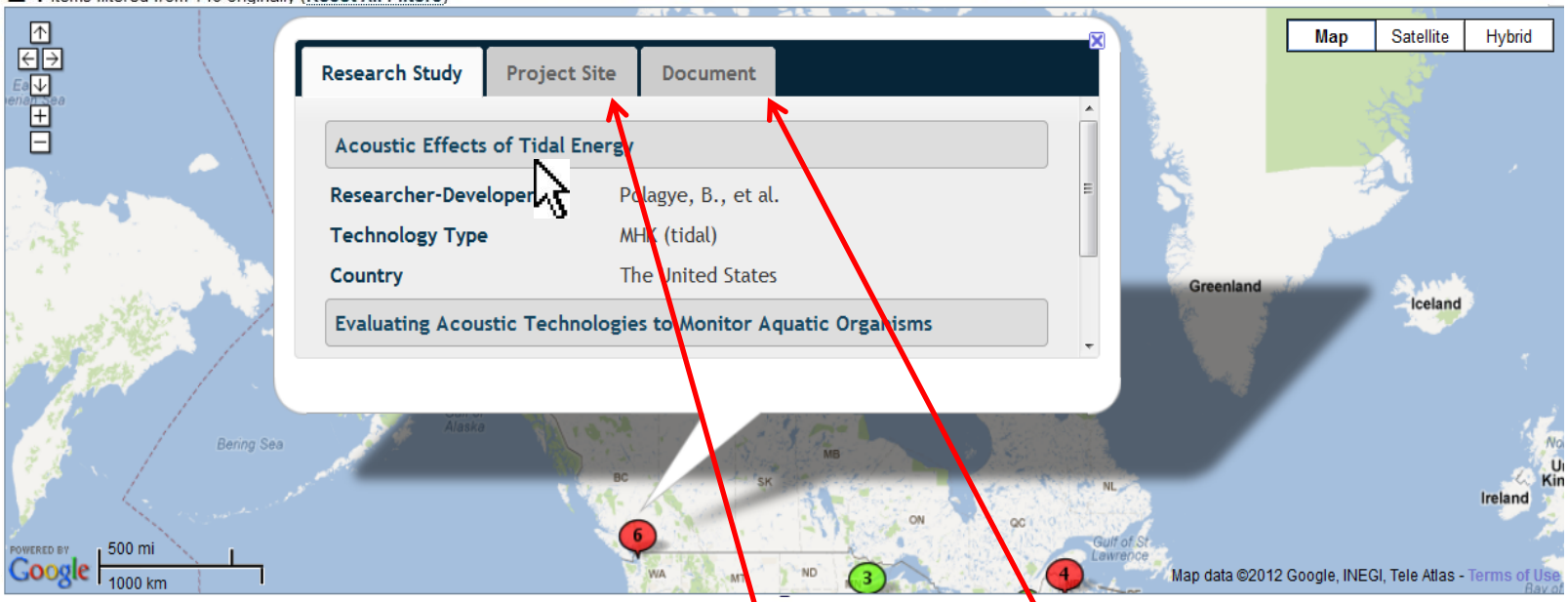

Document | Project Site | Research Study | Mixed

Search

Country 1

- 3 Norway
- 14 Scotland
- 2 South Korea
- 12 The United Kingdom
- 24 The United States

Developer

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- 1 Public Utility District No. 1 of Snohomish County

Technology Type 1

- 4 MHK (Ocean Current)
- 1 MHK (OTEC)
- 24 MHK (tidal)
- 6 MHK (wave)

Related Project Sites and Documents can be accessed through these tabs

Annex IV Research Metadata Form

Acoustic Effects of Tidal Energy

Title of Research

Acoustic Effects of Tidal Energy

Researcher(s)

Polagye, B., Thomson, J., Copping, A., Tollit, D., Bassett, C., Wood, J., Graber, J., Cavagnaro, R.

Contact Information

Address:
Box 3532600

Phone:
+1 206 543 7544

Email:
bpolagye@uw.edu

Institution

Northwest National Marine Renewable Energy Center; University of Washington

Partner Institutions

Snohomish Public Utility District; Pacific Northwest National Laboratory; Sea Mammal Research Unit, Ltd.

Funding Source

Subcontract through Snohomish Public Utility District via US Department of Energy competitive solicitation (2009)

Location of Research

Admiralty Inlet, Puget Sound, Washington

Date of Research

Annex IV Research

Title	Acoustic Effects of Tidal Energy
Date	2010/05/01
Country	The United States
Attachment	Original Form
Stressor	Noise
Receptor	Fish, Marine mammals
Technology Type	MHK (tidal)

Annex IV Research Metadata Form

Pacific Northwest NATIONAL LABORATORY
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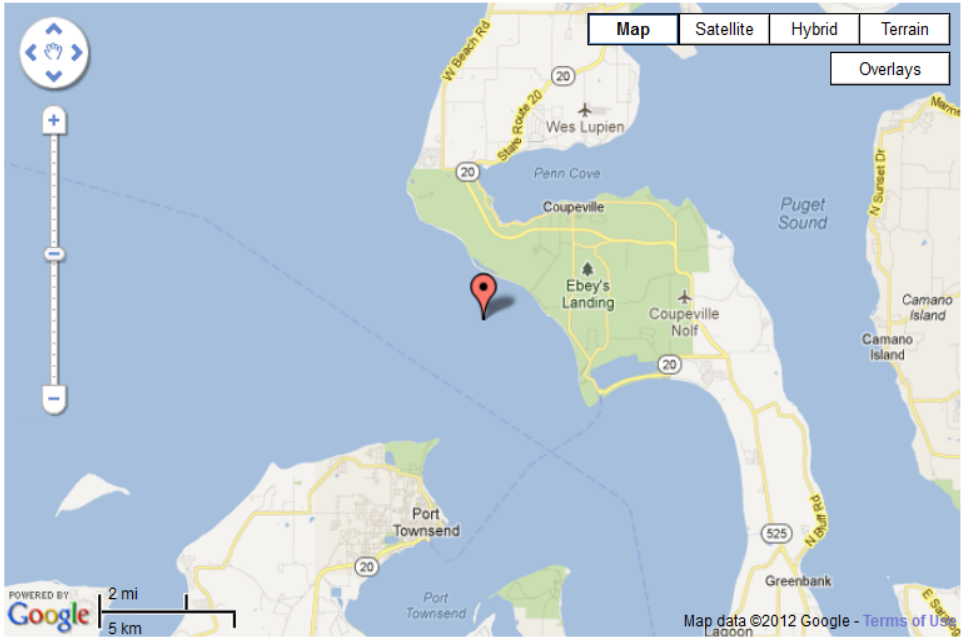
Date of Research

2010/05/01

GIS Resources

The project area has the following coordinates:



Acoustic Effects of Tidal Energy is located in The United States

Go back to the **sites map**.

General Description: Acoustic Effects of Tidal Energy	
Purpose	The purpose of this project is to better understand the acoustic effects of tidal energy devices through evaluation of the baseline environment (by prototyping several types of bottom-mounted and shore-based instrumentation), evaluating the implications of turbine noise at the site of a proposed pilot project in the context of existing ambient noise, using information from baseline monitoring to evaluate marine mammal behavior and responsiveness to existing sources of noise, and evaluate the effects that turbine noise could have on aquatic species through laboratory studies.
Technology	Technology: Tidal Description: Site of proposed pilot demonstration of two 6 m OpenCentre turbines developed by OpenHydro, Ltd

Annex IV Research Metadata Form

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	and responsiveness to existing sources of noise, and evaluate the effects that turbine noise could have on aquatic species through laboratory studies.
Technology	Technology: Tidal Description: Site of proposed pilot demonstration of two 6 m OpenCentre turbines developed by OpenHydro, Ltd.
Stressor	Stressor: Noise Description: Noise from device operation, specifically from two 6 m OpenCentre turbines, in the context of existing ambient noise. Noise from operation is generally "red" decreasing in intensity at 13 dB/decade with some higher intensity clusters at frequencies less than 1 kHz.
Receptor	Receptor: Fish, Marine Mammals Description: Several species of cetaceans (with auditory bandwidths that span the full range of expected noise from turbines), pinnipeds, and fish are known to be present in the proposed project area.
Key Findings	Baseline data collection (UW): • Bottom-mounted packages may be used to simultaneously deploy Doppler profilers and passive acoustic hydrophones (though some caution is warranted to prevent interference). • Shore-based AIS systems are effective at quantifying vessel traffic and, when paired with long-term hydrophone data, can be used to quantify the contribution of vessel traffic to the ambient noise budget. • Shore-based infrared cameras can be extend the periods in which observations can be conducted (night, light fog), but have insufficient resolution to detect and identify marine mammals further than a few hundred meters from shore, while maintaining a reasonably broad field of view. Turbine noise in the ambient context (UW) • The noise that would be generated by operating turbines has a considerable overlap with existing anthropogenic noise sources at this site. Any post-installation noise characterization or observations of marine mammal responsiveness to turbine noise must acknowledge this and employ careful study design to avoid confusing turbine noise (or effects thereof) with other sources of noise or stimuli. Marine mammal behavior (UW and SMRU, Ltd.): • Harbor porpoise are more commonly present at this site than at other proposed tidal energy developments. Generalized Linear Models suggest that echolocation activity is correlated with the time of day (many more clicks at night), current velocity (fewer clicks during periods of strong currents), ambient noise levels (fewer clicks during periods of elevated ambient noise), and stage of the tide (fewer clicks during spring than neap). However, such models have a large residual deviance, suggesting that, while these factors are statistically significant, they do not explain the majority of porpoise presence/absence at the site. • The local population of harbor porpoise may be habituated to periodically elevated noise due to omnipresent shipping and ferry traffic. Consequently, harbor porpoise at this location may not be responsive to turbine noise. Laboratory Study • Juvenile Chinook salmon exposed to high intensity turbine noise continuously for 24 h developed minor and biologically insignificant injuries. Since turbine noise will be cyclic with the tide any effects of actual turbine noise are likely to be more subtle and not result in harm to juvenile or adult salmon.
Publications	N/A

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Document | Project Site | Research Study | Mixed

Search

Country 1

- 3 Norway
- 14 Scotland
- 2 South Korea
- 12 The United Kingdom
- 24 The United States

Developer

- 2 Ocean Renewable Power Company, LLC
- 1 Public Utility District No. 1 of Snohomish County

Technology Type 1

- 4 MHK (Ocean Current)
- 1 MHK (OTEC)
- 24 MHK (tidal)
- 6 MHK (wave)

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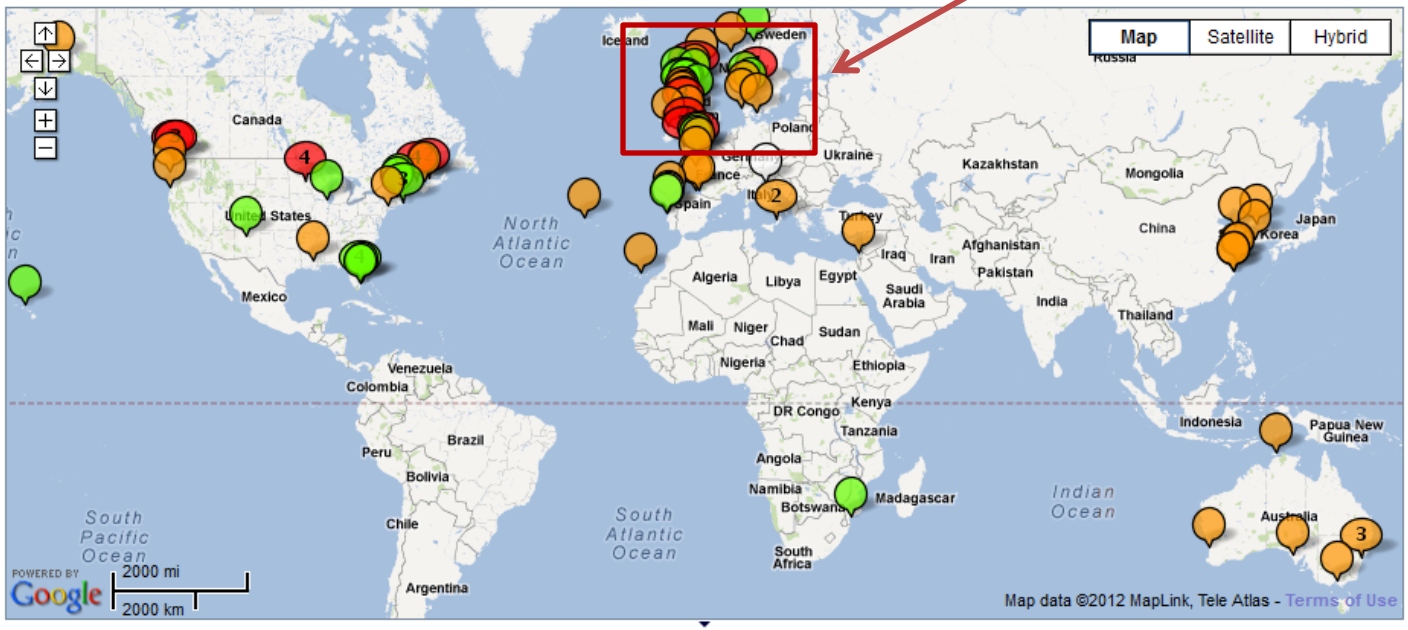
Link to Annex IV Knowledge Base

140 tems

Zoom here



Document | Project Site | Research Study | Mixed

Search

Country

- 6 Australia
- 1 Austria
- 5 Canada
- 5 China
- 4 Denmark
- France

Developer

- 1 Alderney Renewable Energy
- 2 Aquamarine Power
- 2 Atlantis Resources Corporation
- 1 Carnegie Wave

Technology Type

- 12 MHK
- 5 MHK (in-stream)
- 4 MHK (Ocean Current)
- 1 MHK (OTEC)
- 66 MHK (tidal)

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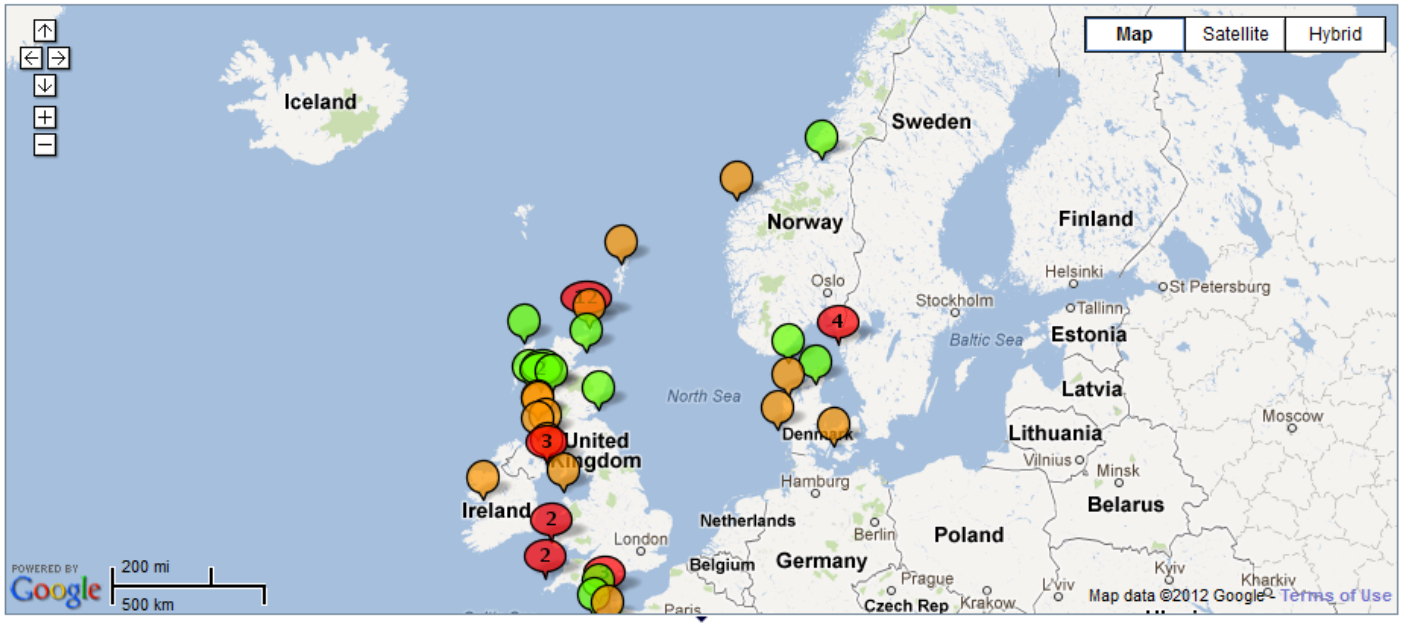

Document | Project Site | Research Study | Mixed

Search

Country

- 7 Australia
- 5 Canada
- 5 China
- 4 Denmark
- 3 France
- Ireland

Developer

- 1 Alderney Renewable Energy
- 2 Aquamarine Power
- 2 Atlantis Resources Corporation
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- 5 MHK (in-stream)
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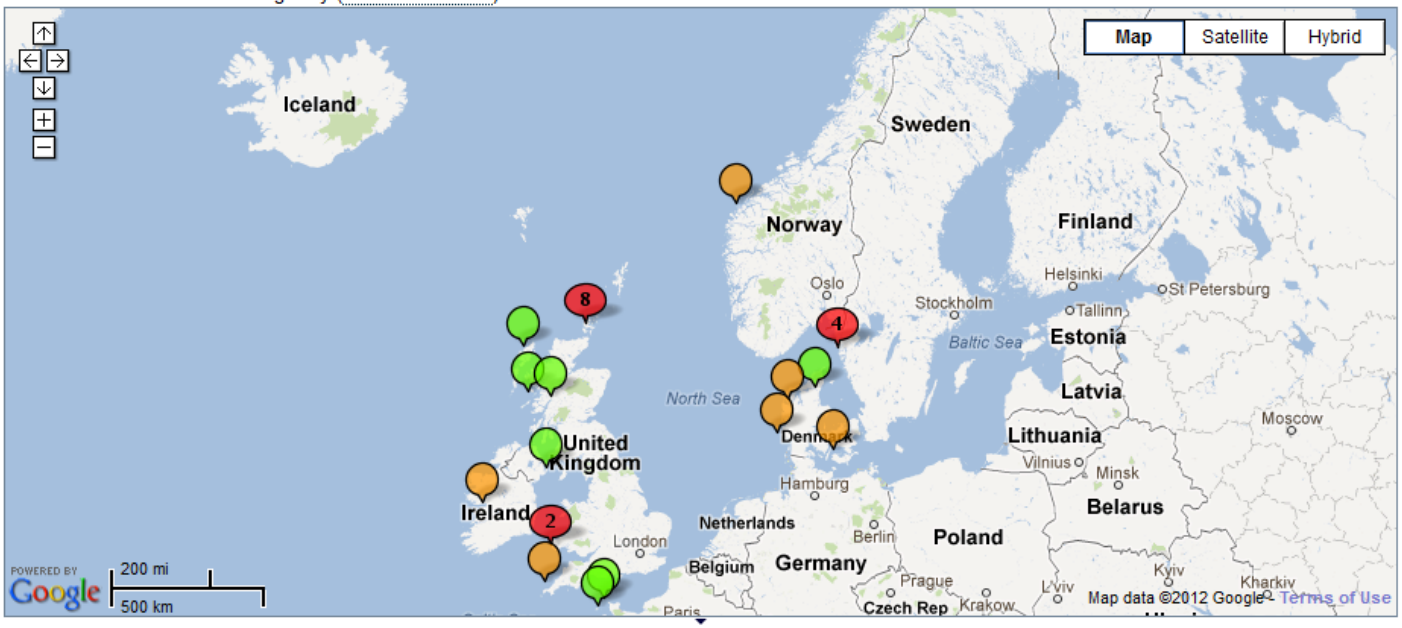

Document | Project Site | Research Study | Mixed

Search

Country

- 5 Australia
- 4 Denmark
- 1 France
- 1 Ireland
- 1 Israel
- 1 New Zealand

Developer

- 2 Aquamarine Power
- 1 Carnegie Wave Energy Limited
- 1 E. ON
- 1 Ecole Centrale de Nantes (ECN)

Technology Type 1☑

- 5 MHK (in-stream) ☐
- 4 MHK (Ocean Current) ☐
- 1 MHK (OTEC) ☐
- 66 MHK (tidal) ☐
- 46 MHK (wave) ☑

Filter by wave technology →

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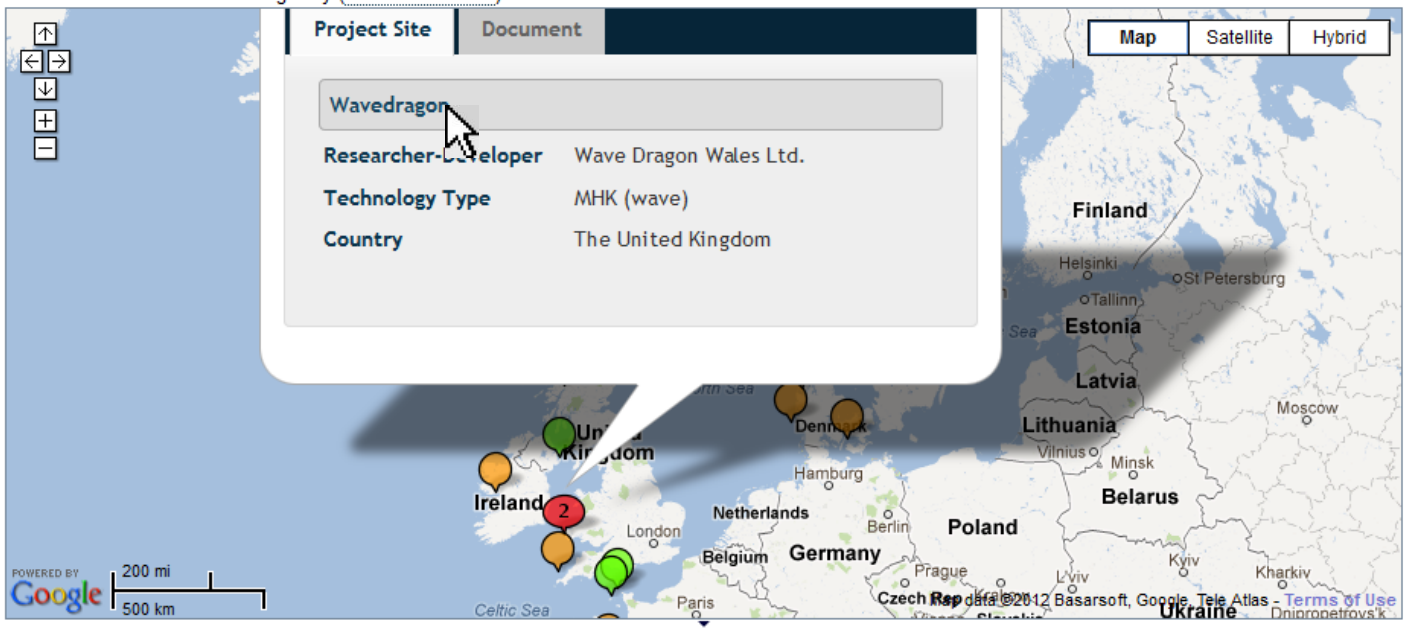

Document | Project Site | Research Study | Mixed

Search

Country

- 5 Australia
- 4 Denmark
- 1 France
- 1 Ireland
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Developer

- 2 Aquamarine Power
- 1 Carnegie Wave Energy Limited
- 1 E. ON
- 1 Ecole Centrale de Nantes (ECN)

Technology Type

- 5 MHK (in-stream)
- 4 MHK (Ocean Current)
- 1 MHK (OTEC)
- 66 MHK (tidal)
- 46 MHK (wave)

Annex IV Site Example

Wavedragon

Project Name

Wave Dragon Pre-commercial Demonstration Project

Description

Technology: Overtopping Device

Project scale: Full-Scale Prototype

Installed capacity: 7 MW

Additional Description: The Wave Dragon Pre-Commercial Demonstrator is a floating slack moored wave energy converter. It is moored (like a ship) in relatively deep water, i.e. more than 25 m to take advantage of the ocean waves before they lose energy as they reach the coastal area. The device allows ocean waves to overtop a ramp, which elevates water to a reservoir above sea level. This artificial 'head' of water is subsequently released through a number of turbines and in this way transformed into electricity. Water is returned to the sea through draft tubes in the base of the unit, which house the turbines, the only moving parts of the device. The unit comprises a central platform, with a curved ramp and a large water reservoir equipped with an array of hydro turbines, and two lateral curved wave reflecting wings which concentrate the power of incoming waves. The Wave Dragon device is designed to remain within a defined movement area regarding wave direction and tidal currents. It is fixed to a forward buoy that remains essentially stationary (in plan view). The mooring system of the device is feature between six and eight concrete gravity mooring blocks and a series of catenary mooring lines (steel chain) fixed to a buoy. In addition there will be one rear mooring block to stop the device from rotating too far in tidal currents.

Location

The site is approximately 1.7km (0.9 nautical miles) off the Pembrokeshire Coast at Long Point (the closest point on land), Wales, U.K.

Process Status

A 1:4.5 scale prototype launched in 2003 was deployed in Nissum Bredning (the Danish Wave Energy Test Center) a fjord in the northern part of Denmark. The prototype was tested continuously until January 2005. In 2006 a modified prototype was deployed to another test site with more energetic wave climate. In May 2008 maintenance and repairs were done and the prototype was re-deployed at the original test site in early autumn 2009 for final testing. The pre-commercial demonstrator (full scale) is planned to be installed in 2011/2012 in Wales and a 50 MW wave farm is considered for deployment in the Portuguese coast. However the financial crisis has caused a delay in the plans for deploying the first full scale device and Wave Dragon Ltd. is currently seeking venture capital.

Project Site

Name	Wave Dragon Pre-commercial Demonstration Project
Developer	Wave Dragon Wales Ltd.
Website	http://www.wavedragon.net/
Launch Date	2003/03/01
Country	The United Kingdom
Attachment	Original Form
Technology Type	MHK (wave)

Wave Dragon

Annex IV Site Example

Wavedragon

Created to look similar to the metadata forms, available here

Project Name

Wave Dragon Pre-commercial Demonstration Project

Description

Technology: Overtopping Device

Project scale: Full-Scale Prototype

Installed capacity: 7 MW

Additional Description: The Wave Dragon Pre-Commercial Demonstrator is a floating slack moored wave energy converter. It is moored (like a ship) in relatively deep water, i.e. more than 25 m to take advantage of the ocean waves before they lose energy as they reach the coastal area. The device allows ocean waves to overtop a ramp, which elevates water to a reservoir above sea level. This artificial 'head' of water is subsequently released through a number of turbines and in this way transformed into electricity. Water is returned to the sea through draft tubes in the base of the unit, which house the turbines, the only moving parts of the device. The unit comprises a central platform, with a curved ramp and a large water reservoir equipped with an array of hydro turbines, and two lateral curved wave reflecting wings which concentrate the power of incoming waves. The Wave Dragon device is designed to remain within a defined movement area regarding wave direction and tidal currents. It is fixed to a forward buoy that remains essentially stationary (in plan view). The mooring system of the device is feature between six and eight concrete gravity mooring blocks and a series of catenary mooring lines (steel chain) fixed to a buoy. In addition there will be one rear mooring block to stop the device from rotating too far in tidal currents.

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Launch Date	2003/03/01
Country	The United Kingdom
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Technology Type	MHK (wave)

Wave Dragon

Licensing Information

An offshore consent was submitted to the Department of Trade and industry (DTI) and two were submitted to the Department of Environmental, Food and Rural Affairs (DEFRA) together with the Environmental Statement in April 2007. The concerns arising would be then forwarded and discussed with Wave Dragon before a formal decision is made. Work with The Crown Estates and Pembrokeshire Coastal National Parks Authority towards a Lease and Planning Permission respectively was also planned. Wave Dragon Ltd. was planned to have successfully acquired consents and permissions by the end of 2010 and the constructions would begin at that time in order to deploy the device and connect it to the grid during 2011/2012.

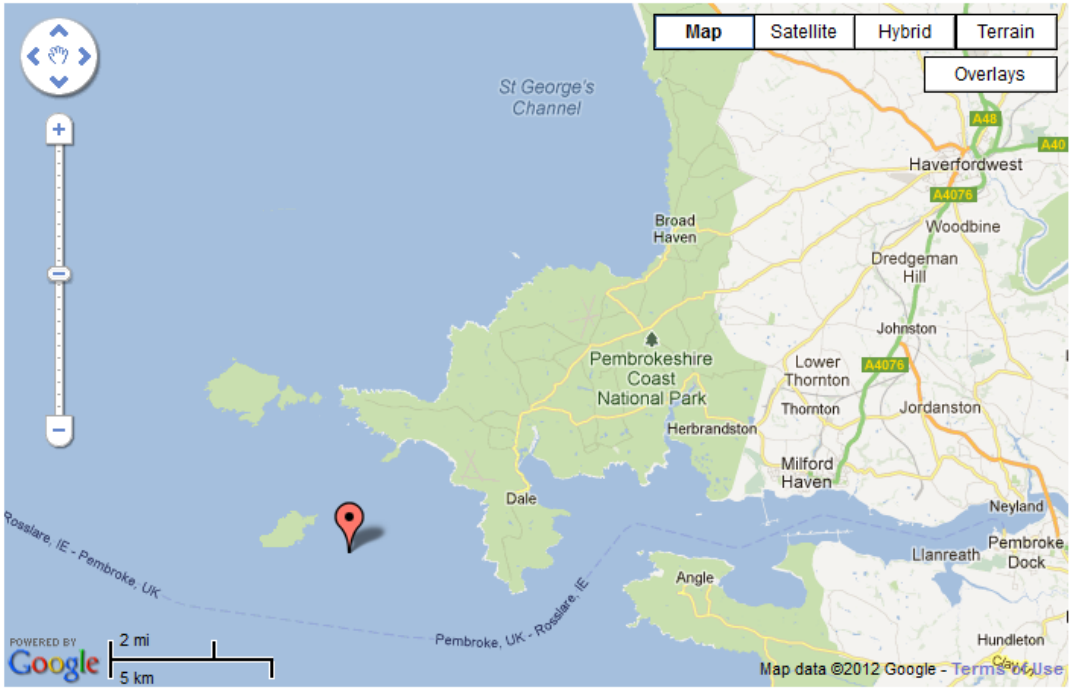
Key Environmental Issues

Although there is a specific webpage for environmental issues regarding this project, no documents are available for download.

Environmental Website: http://www.wavedragon.co.uk/eia-2.html

GIS Resources

The project area has the following coordinates:



Wave Dragon Pre-commercial Demonstration Project is located in The United Kingdom

Go back to the **sites map**.

Baseline and Project Effects Studies: Wave Dragon Pre-Commercial Demonstration Project				
Receptor	**Study Description**	**Design and Methods**	**Results**	**Status**
Physical Environment	Water and sediment quality	Desk based analysis and sediment sampling	High energy site with only small quantities of mobile sediment. The most waterborne pollutants will be readily dispersed. Sediments did not contain significant quantities of contaminants. No impact through elevated suspended sediments or contaminant suspension on existing water or sediment quality.	Completed
	Coastal Processes (sediments fluxes, waves and tidal currents.	Desk based and modelling study to describe the seabed processes impacts and effects of device deployment.	The seabed is primarily bed rock with pocket and gully deposits of coarse pebbles and cobbles, apart from the potential cable landfalls which will pass under the sand and gravel beaches. The site is exposed to high energy waves from the Atlantic making it a dynamic environment. The nearshore areas are designated for nature or geology conservation and are important as a recreational area. A moderate impact of the development on the waves close to the device is expected and some localized impact on the currents and beach processes in its immediate vicinity. There is unlikely to be any noticeable impacts further away from the device towards the shore.	Completed
	Onshore physical environment	Assessment of the potential impacts of the proposed development on the onshore physical environment	The geology and hydrology of the area could be sensitive to construction. However best practice and environmental management controls are implemented during the construction phase, the scheme will have no adverse effects on the onshore physical environment.	Completed
	Investigation into the mixing effects provided by the flow discharged from the system's turbines	Field measurements on water velocities and suspended sediments. Use of computational models to simulate the impacts of the submersion of surface water by the discharging vertical turbines.	In a worst case scenario with no tide or wave induced cross flow and maximum discharge through a turbine, there could be a localized heating effect from the submersion of surface water in summer. In a more realistic model, incorporating a tidal flow, there is little heating of the seabed and the benthic ecology should not be affected even in the local vicinity of the device. It appears from the models that there will be localized heating effects of the water body above the sea bed however. This may have an impact on pelagic species, the effect is likely to be similar in nature but on a far smaller scale to cooling water discharge from power stations. Predicted effects on biodiversity reduction and/or abundance increase of some warmer water organisms are said to be highly localized and unlikely to have a significant widespread impact on the local marine environment [8].	Completed
	Impact on designated sites	Assessment of the potential impacts of the device on designated sites in vicinity	The device will be deployed within an area designated as a conservation site known as the Pembrokeshire Marine Special Area of Conservation (SAC)	Completed
	Marine Ecology	Study at the existing environment and deployment site to assess the impacts of the deployment	**Installation Effects** Installation of the mooring system may increase the overall diversity of the local seabed communities by providing colonization areas. Potential impacts: ploughing action of cable burial, pinning of the cable over areas of bedrock and potential damage caused by anchors and anchor lines. It is not envisaged that these activities will have significant impact. **Operation Effects** Potential impacts: effect of the mooring chains and structures on sensitive and designated species attached to and protruding from bedrock reef habitat. To mitigate impacts blocks should be located out of sensitive areas. **Decommissioning Effects** Have some potential to impact on the marine communities however it is considered to be low.	Completed

Biological Environment	Fish	Desk based review and consultations to determine the fish species present in the area to assess any likely impacts to these species.	The area is rich in species such as dab and several species of shark were identified as using the area. Migratory species such as salmon and several internationally protected species such as river lamprey and basking shark are also using the site. Commercial species such as crab, lobster and crayfish are also present in the area. The effects on such species are considered to be negligible in the context of the extent of local fisheries. Fish are unlikely to pass over the ramp structure into the reservoir. Grills prevent large fish to pass through turbines and it is envisaged that they will flow back out of the reservoir unharmed. The turbines turn at a relatively slow speed so any fish small enough to pass through the grills should pass through the turbines unharmed.	Completed
	Electromagnetic Fields (EMF)	Assessment of the potential impacts of equipment electromagnetic fields on sensitive fish species	The Wave Dragon device power export cable would be no more than 2.3 km in length and would therefore represent a very small feature within the existing marine environment. The expected magnetic field from the cable is considered to be relatively low and given both the small scale of the project and the low magnitude of the anticipated magnetic field it is not anticipated that there is any likelihood of a significant impact for magnetically sensitive fish species.	Completed
	Marine Mammals	Desk based literature review and local consultations were undertaken in order to assess the potential for impacts on marine mammals, including cetaceans, seals, otters and marine turtles.	The immediate area of the installation site is not understood to be of high importance for marine mammals in a local context, though Pembrokeshire coastal waters are recognized as being of relatively high importance regionally and nationally. Impact to marine mammals mainly relates to noise issues both during installation and operation. Noise disturbance of marine mammals may occur up to several hundred meters from the noisiest construction activities for short periods of time within the construction period but this is not considered to be significant. There is the potential for greater effects on cetaceans in the area during installation but appropriate measures will be used to minimize noise during the construction process.	Completed
	Onshore and Intertidal Ecology	Combination of a walk-over survey and a desk study were used to provide information to support the impact assessment for the ecology in the inter-tidal zone and of onshore habitats and species in relation to potential cable landfall locations at Marloes Sands and Westdale Bay and in the vicinity of candidate onshore cable routes.	The Pembrokeshire coastline has a diverse range of shoreline habitats from exposed bedrock on headlands to sheltered sandy coves and sheltered mud in the estuaries. Hard substrate areas, for example on bedrock or boulders outcropping from sand, typically support communities of algae. The potential cable routes will pass through the Dale and Marloes Site of Special Scientific Interest (SSSI), which is a conservation site designated for its maritime grassland, heath, cliff crevice and ledge vegetation and coastal scrub. The project design aims to minimize disturbance and impacts to rocky reef or inter-tidal areas by avoiding these areas at the cable landfall therefore the impact is likely to be very small. Minor changes in beach profiles arising from the changes in the coastal processes during the operation of the device were found to be possible and may cause some habitat loss caused by moving sands. This impact would be temporary in nature and beach profiles are known to change significantly through natural processes. Certain important species, specifically Scaly Cricket, were identified by the studies in one of the landfall areas on Marloes Sands. These will be investigated further and the finalized design will take this into account. Scaly Cricket habitat will be avoided by moving temporary works away from sensitive areas.	Completed
	Birds	Desk based study, drawing on current knowledge and data to assess the potential for impacts to birds. Consultations were also undertaken with key representatives	The deployment area is proximate to three bird conservation areas and ten bird species were identified as being of importance, including the Manx Shearwater, and Red-billed Chough. For the ten key species assessed the impact was considered to be low. Both the deployment and operation phases indicated negligible negative effects and for species like Storm Petrel, Lesser Black-	Completed

		on bird populations in the area. Lighting required as aids to navigation was also assessed.	the area creating artificial lighting at night in the near shore environment, the addition of navigation lighting from the device scheme will present a negligible addition.	
Human Environment	Landscape and Seascape Assessment	Desk study and preliminary site survey, baseline seascape landscape and visual assessment (including field survey).	The land within the study area all forms part of the Pembrokeshire National Park and the coastline is designated as heritage coast. Two Landscapes of Historic Interest are located within the study area, Skomer Island and the Milford Haven Waterway. Within the 7 km radius study area and the main users of the area, key viewpoints and key features were identified. The presence of the offshore islands, together with the land form of the Dale Peninsula provides both enclosure and visual interest. It was noted that the absence of any land form in a south westerly direction allows long distance views across open sea. There are several Public Rights of Way routed throughout the mainland study area. Nine viewpoints were identified to be of high sensitivity. The device could be viewed from the setting units identified to the north and south i.e. to the north of Skomer Island, Milford Haven and Pickard. However, any views to the device would be restricted to coastal locations within these areas and any potential effects will be reduced due to the distance and the low height (above sea level) of the device. Sea users may be able to see the device at closer quarters; however this is dependent upon the route through the sea area that the users choose. The proposed development will be a temporary feature, expected to remain in place for up to five years. All readily visual components will be removed and effects to landscape and visual amenity, including seascape, will be reversed.	Completed
	Archeology and Cultural Heritage Assessment	Geophysical and desk based studies. The geophysical survey was undertaken of the offshore survey area and cable route to shore, covering both the cable route options to Marloes Sands and Dale including a 2km area of search buffer zone.	The marine survey area was found to contain seven wrecks and sites of archaeological interest; in addition there are 110 reported losses within the area for which there are no known seabed remains. There is the potential for archaeological remains within the deployment area and it is anticipated that the final position of the mooring blocks will need to be informed by a seabed inspection prior to installation. The onshore cable route corridor was found to contain 28 sites and monuments. Further studies will be required to assess the likely impacts to the onshore archaeology and cultural heritage through the onshore construction phase once onshore infrastructure has been further defined.	Completed
	Socio-Economics Assessment	Assessment of the social and economic environmental in the Pembrokeshire and West Wales region.	Employment in the area was found to be dominated by the service and public sector with tourism featuring as the dominant factor in the Pembrokeshire economy. It was noted that the region attracts large numbers of visitors for the outdoor and marine activities present in the region. The Pembrokeshire Coastal Path and marine leisure activities such as sailing, diving, kayaking and coasteering were all found to make major contributions to the area's economy. The study was unable to qualify any effects on the levels of tourism caused by the device, however considering surveys on tourism for other renewable energy projects suggest the possibility of the Wave Dragon device to become a tourist attraction. The resulting capital expenditure and direct and indirect job creation is likely to be complemented by additional reputation benefits for the region. It is envisaged that the development would provide employment for the equivalent of 70 people in the construction and deployment stage, and the equivalent employment of 18 people through indirect and induced benefits.	Completed
			Installation Phase Underwater noise generation as a result of ships propulsion systems, bow thrusters, rotating machinery, generators, dynamic positioning systems (if used) and ship echo-sounders. These sources are likely to dominate the underwater noise environment to a range of a few kilometers.	

	Noise Assessment	The underwater noise has been estimated from measurements of a single Kaplan turbine in a controlled laboratory environment, and compared to on-site measurements.	**Operating Phase** Noise will be mainly caused by increased vessel traffic in the region. The generator system may cause a behavioral response in marine mammals over a range of a few meters but this is not considered significant. Other mechanisms associated with wave interaction with the body of the device and hydraulic noise can also be considered insignificant. It is unlikely that the underwater noise, produced during any construction and operation activities will kill or cause direct physical injury to fish or marine mammal species. Disturbance to some sensitive species may occur in very close proximity to the deployment but this is considered to be insignificant.	Completed
	Commercial Fisheries Assessment	Desk study on commercial fishing activity and its value, areas of use and landing data from official records. Consultations with Fisheries organizations and individual fishermen in the region. This information was used to assist and supplement the official statistics. Visual records.	The maximum number of fishing vessels active on site at any one time is three, however these are not always the same vessels. The main impacts identified relate to the loss of access to grounds, restricted access through navigational controls, disruption to the industry through the cable laying and stabilization, loss of habitat (and potentially resource) and increased risk through the potential for accidents and collisions. There is some potential for enhanced fisheries through a mussel seeding scheme, attached to the device, however this is subject to the correct permissions being granted. It is considered that the impact of the deployment and operation of the device will be minimal, provided good liaison and clear early notification is given to the fishing industry.	Completed
	Navigation: Detailed Navigation Risk Assessment	Navigation Risk Assessment: Maritime traffic survey of the area supplemented by research of other available data sources as well as consultation with other navigational stakeholders.	The deployment location is away from the main shipping lanes in the area, which are associated with Milford Haven. The risk of a commercial ship drifting off course and colliding with the structure was assessed to be very low. There is large redundancy in the mooring system and hence there is negligible risk of mooring failure of the device causing it to come adrift. Even if this were to occur, contingency plans will be in place to alert shore-based personnel and respond to the emergency. Based on the best-estimate of fishing activity the frequency of fishing vessel collisions was estimated to be 1 in 100 years. To aid the identification of the device and minimize the likelihood of any collisions, the device will be appropriately lit and marked and awareness of the location of the device will be raised amongst local stakeholders. The generic risks of collision and cable snag are considered low, and risks of stranded personnel will be included within the Emergency Response Plan to be drafted prior to construction.	Completed
	Other Relevant Projects	Identification of marine activities or industries in areas surrounding the deployment location.	Six types of marine activities and industries were identified: • Offshore oil and gas • Marine aggregate extraction • Subsea cables and pipelines • Marine waste disposal and dumping • Military and civil aviation • Abandoned munitions	Completed
Reports or	• **Wave Dragon Wales (2007): Wave Dragon Pre-Commercial Wave Energy Device, Environmental Statement Volume 1: Non-Technical Summary, 36 pp (in English and Welsh)** • Wave Dragon Wales (2007): Wave Dragon Pre-Commercial Wave Energy Device, Environmental Statement Volume 2: Technical Report, 434 pp. • Wave Dragon Wales (2007): Wave Dragon Pre-Commercial Wave Energy Device, Environmental Statement Volume 3: Figures 7 pp + 123 figures			

Papers	• Iain Russell & Hans Chr. Soerensen: Wave Dragon: Results From UK, EIA and Consenting Process, Proceedings of the 7th European Wave and Tidal Energy Conference, Porto, Portugal, 2007, 8 pp • Capman, J., Masters, I., Willis, M., Fidler, R.: Investigation into the mixing effect of a 7MW overtopping wave energy converter, Swansea University, School of Engineering, April 2009, April 2008, 14 pp.
Research Projects	• CMACS: Wave Dragon pre-commercial Demonstrator; Benthic Environmental Impact assessment update Based on supplementary benthic information, document: J3045 v2, February 2008, 46 pp. • **Beels, C., Troch, P., De Visch, K., Kofoed, J. P., De Backer, G., 2010. Application of the time-dependent mild-slope equations for the simulation of wake effects in the lee of a farm of Wave Dragon wave energy converters. Renewable Energy, 35, 1644–1661.**

Monitoring and Adaptive Management: Wave Dragon Pre-Commercial Demonstration Project				
Receptor	**Monitoring Program Description**	**Design and Methods**	**Results**	**Status**
Physical Environment	Coastal processes monitoring to address any FEPA license conditions		N/A	Proposed
Benthos	Analysis of the ecological sensitivities on bedrock areas including cable routes.	Drop down camera and diver surveys focusing on: 1. nearby extensive bedrock areas that might be affected during the emplacement of the structures; in particular, if any significant colonies of pink sea fan *Eunicella verrucosa*, or other species of importance in their own right, were discovered in vulnerable situations, for example on the edges of bedrock where dragging blocks could potentially cause damage, or where jack up legs are likely to be placed, then these would be the subject of specific monitoring plans. 2. The mooring blocks themselves, in order to monitor the development of epifauna. The monitoring should be carried out by divers and should cover both horizontal and vertical faces of the blocks. Vertical faces should include examples facing in different directions to see if there are significant differences caused by variations in exposure to waves and currents. The conjunction between the block and the sediment should be monitored as part of this exercise. 3. Areas of sedimentary habitat upon which the mooring blocks are placed, including any significant areas of bedrock or more stable boulders within this area. Unless the site specific survey reveals any unexpected communities or species, monitoring of this habitat should take a relatively low priority since it is expected to be a scour tolerant community on mobile sediments with a large component of cobble.	N/A	Proposed
Fish	Post construction survey to monitor device effects on the fish species of the area. It is suggested that this program considers the Wave Dragon as a Fish Aggregating Device (FAD) and moorings as artificial reefs.	Diver surveys or ROV as part of any benthic monitoring program suggested and should be developed using statutory guidance and after consultation with the relevant statutory authorities e.g. Countryside Council of Wales (CCW) and Centre of Environment, Fisheries and Aquaculture Science (CEFAS)	N/A	Proposed
Marine Mammals	Marine mammal monitoring particularly common dolphin surveys.	Wave Dragon Ltd has expressed willingness to support ongoing marine mammal monitoring currently being undertaken in local Pembrokeshire waters by Sea trust. Sea Trust have indicated that their surveys could be tailored to take in a routine pass by the Wave Dragon deployment site, before, during and after construction, which would provide useful additional information on marine mammals usage of the immediate and surrounding area. These surveys would be based on visual observation from a boat, in line with previous work in the area reported in Earl et al. 2004 and 2005. It would	N/A	Proposed

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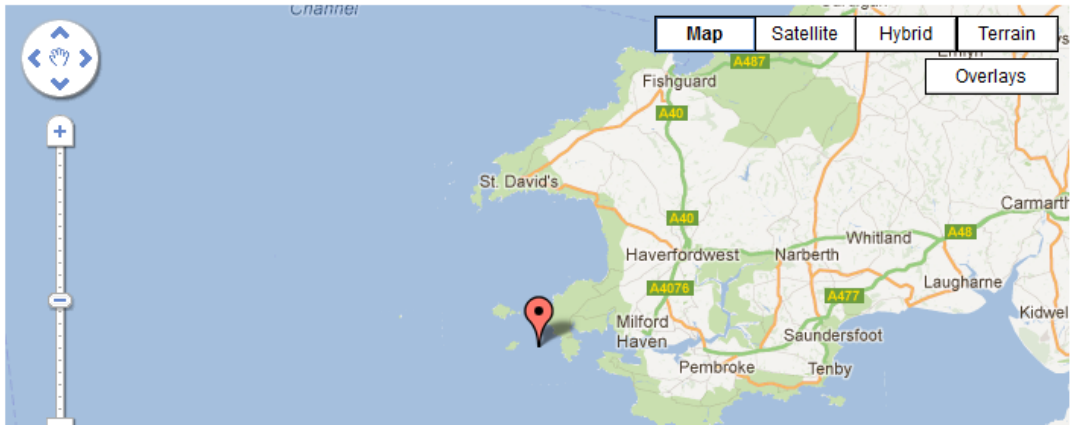
Abstract

Time-dependent mild-slope equations have been extensively used to compute wave transformations near coastal and offshore structures for more than 20 years. Recently the wave absorption characteristics of a Wave Energy Converter (abbreviated as WEC) of the overtopping type have been implemented in a time-dependent mild-slope equation model by using numerical sponge layers. In this paper the developed WEC implementation is applied to a single Wave Dragon WEC and multiple Wave Dragon WECs. The Wave Dragon WEC is a floating offshore converter of the overtopping type. Two wave reflectors focus the incident wave power towards a ramp. The focused waves run up the ramp and overtop in a water reservoir above mean sea level. The obtained potential energy is converted into electricity when the stored water drains back to the sea through hydro turbines. The wave reflectors and the main body (ramp and reservoir) are simulated as porous structures, exhibiting the same reflection, respectively absorption characteristics as obtained for the prototype Wave Dragon WEC. The wake effects behind a single Wave Dragon WEC are studied in detail for uni- and multidirectional waves. The shadow zone indicating the wake effect is decreasing with increasing directional spreading. The wake in the lee of a farm of five Wave Dragon WECs, installed in a staggered grid (3 WECs in the first row and 2 WECs in the second row), is calculated for three in-between distances of respectively D, 2D and 3D, with D the distance between the tips of the wave reflectors of a single WEC. As a result, a farm of five Wave Dragon WECs installed in a staggered grid with an in-between distance of 2D is preferred, when taking cost and spatial considerations into account.

GIS Resources

The project area has the following coordinates:



Journal Article

Title	Application of the time-dependent mild-slope equations for the simulation of wake effects in the lee of a farm of Wave Dragon wave energy converters
Author	Beels, C., Troch, P., DeVisch, K., Kofoed, J.P., DeBacker, G.
Date	2010/08/01
Journal	Renewable Energy
Volume	35
Number	8
Pages	1644-1661
Publisher	Elsevier
Attachment	Original Document
Stressor	Physical presence
Receptor	Nearfield habitat
Technology Type	MHK (wave)

Annex IV Knowledge Base

Pacific Northwest NATIONAL LABORATORY
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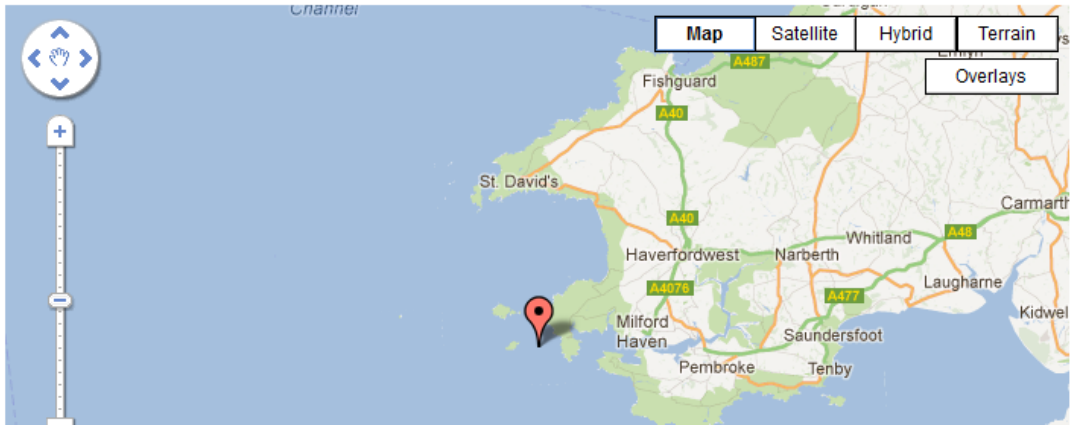

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Ability to access the PDF file for the journal article

Frequently Asked Questions

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Tethys Frequently Asked Questions

What is Tethys, and what is the advantage of using something like Tethys versus a normal search engine?

Tethys is a wiki-based knowledge management system providing a user friendly interface which allows visitors to search and browse for environmental and regulatory information related to marine renewable energy. Because it is a wiki page, *Tethys* also enables visitors to engage with the site through adding or modifying content using a simple markup language. This concept promotes topic associations between different pages and subjects; enhancing the site's searchability through creating linkages and updating pages as new words, phrases, and articles are linked to other related topics. The outcome of searching for information on wiki pages such as *Tethys* is that the user is provided with information related to their original search as well as other topics that may be connected in some other way.

For more information, please visit the **About Tethys** page.

Why is Tethys so important for marine renewable energies?

Tethys allows users to search for and access valuable data and information related to the environmental effects of offshore renewable energies. As a new source for renewable energy, there is still a lack of information and understanding on how to best proceed in developing these technologies. The goal of *Tethys* is to gather all the relevant information and data on marine renewable energies with the intent to expedite the development of these technologies and attempt to clarify the associated uncertainties.

Who is the target audience of Tethys?

From developers searching for environmental data, regulators, or general citizens wanting to learn more about marine renewable energy, *Tethys* can accommodate the needs of many different kinds of users.

What is Annex IV, and what is its relationship to Tethys?

Annex IV is an international collaboration amongst member nations of the IEA Ocean Energy Systems-Implementing Agreement to gather information on MHK environmental research worldwide. *Tethys* is working with the Annex IV to collect and disseminate this information within the Annex working group. Where appropriate, *Tethys* will also make portions of this information and data available to the broader audience.

What is the advantage of registering on Tethys and do I have to register to access information?

While anyone can access the *Tethys* knowledge base, registration on *Tethys* provides access to a small but growing number of **personalization and interaction features**. Currently, registered users can:

- provide comments on our [**Tethys Blog**]
- participate in threaded discussion forums about any article in the *Tethys* knowledge base
- request *Tethys* to send an e-mail notification each time a page is updated in the knowledge base

Additional personalization features are planned for the coming year, and will be announced via the [**Tethys Blog**] as they become available.

If I register, what happens to my personal information?

The personal information that is collected from users at registration (name, email and a user-selected *Tethys* password) is stored on the *Tethys* server and used solely for purposes of identifying users to allow the use of personalization features. The use of this information is solely for web site administrative purposes, and our policy is to not allow any non-administrative use by *Tethys* or third parties.

OK, I've registered on Tethys. How can I change or update my personal information?

Simply visit the **Special:Preferences** page to update your registration information

Glossary

Key Terms

Stressor: Components or structures of an ocean energy technology that can interact with or affect aquatic animals, habitats or ecosystem processes.

- **Chemical Leaching** - An acute spill or chronic release of chemicals over time.
- **EMF** - An electromagnetic field created by undersea cables.
- **Energy Removal** - Changes in water could remove energy from the system.
- **Physical Presence** - Can be classified as the static presence of the device or the dynamic presence of moving parts.
- **Noise** - Sounds created during construction and operation of device.

Receptors: Marine and avian organisms, habitats or ecosystem processes, that may be affected by the presence or operation of ocean energy devices.

- **Birds** - Seabirds foraging or roosting in the vicinity of the device or migrating birds passing by the device.
- **Invertebrates** - A broad term that encompasses cephalopods (squid, octopus), crustaceans (crabs, shrimp), molluscs (clams, barnacles), and various other benthic organisms.
- **Fish** - Resident fish living near the device and migratory fish passing through the area.
- **Marine Mammals** - A broad term that encompasses pinnipeds (seals, sea lions), cetaceans (dolphins and whales) and sea otters.
- **Reptiles** - The only reptiles that may interact with devices are sea turtles
- **Farfield Environment** - The large-scale effects of a device beyond those affecting the direct site.
- **Nearfield Habitat** - The physical environment surrounding a device.
- **Socio-economics** - The effects on the local society and economy.

Marine and Hydrokinetic Energy Development: The act of harnessing naturally occurring renewable energy in the ocean to generate electricity.

- **MHK** - Generic term that applies to all 'Marine and Hydrokinetic' energy.
- **In-Stream Energy** - The flow of the river is captured with either dams or independent turbines.
- **Ocean Current Energy** - Capturing oceanic currents with turbines.
- **Ocean Thermal Energy Conversion** - Utilizing temperature gradients in deep oceans to generate electricity.
- **Tidal Energy** - Capturing tidal fluctuations with turbines, tidal barrages, or tidal lagoons.
- **Wave Energy** - Capturing energy from waves with a point absorber buoy, surface attenuator, oscillating water column, or overtopping device.

Offshore Wind Energy Development: Harnessing **wind energy** offshore; either in fresh or saltwater environments.

- **Monopile Foundation** (0-30 m depth) - A steel pile is driven into the seabed.
- **Gravity Foundation** (0-30 m depth) - A heavy concrete or steel base is set on the seabed.
- **Tripod Fixed Bottom** (20-80 m depth) - A technology that is borrowed from the oil and gas industry, where three connected piles are driven into the seabed.
- **Floating Structure** (40-900 m depth) - The turbines are moored to the seabed and stabilized with either buoyancy principles or a ballast.

Contact

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Contact

Contents

[hide]

Contacts

If you would like to contact the *Tethys* team regarding the site, here's how:

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MHK and Offshore Wind Program Issues:

Andrea Copping
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Content Questions:

Luke Hanna
Pacific NW National Laboratory
luke.hanna@pnnl.gov

Contributing to Tethys

If you have research, data or information that you would like to be accessible through *Tethys*, please visit our **contributing to Tethys page.**

Tethys Home Page

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HOME | KNOWLEDGE BASE | WORKING WITH TETHYS | BLOG | HELP

Tethys is a database and knowledge management system that provides access to information and research pertaining to the potential environmental effects of marine and hydrokinetic (MHK) and offshore wind development. Tethys also hosts data from Annex IV, an international collaboration to gather information on MHK environmental research worldwide.

Tethys Home

The Environmental Impacts Knowledge Management System (KMS) (dubbed "*Tethys*" after the mythical Greek titaness of the seas) supports the U.S. Department of Energy's Wind and Water Power Program.

As industry, academia, and government seek to develop new renewable energy sources from moving water and offshore wind, potential environmental effects must be evaluated and measured to ensure that aquatic and avian animals, habitats and ecosystem functions are not adversely affected, nor that important coastal and ocean uses are displaced.

Tethys seeks to gather, organize and make available information on potential environmental effects of marine and hydrokinetic and offshore wind energy development. Datasets, supporting documents, and other media are housed within *Tethys* in support of the following programs:

Marine and Hydrokinetic (MHK) Energy Development: MHK development is moving forward in U.S. and international waters, with projects that include the following devices:

- Tidal turbines placed in coastal and estuarine areas;
- Riverine turbines in fast-moving rivers;
- Wave energy converters in open coastal areas with significant waves;
- Current turbines in the Gulf Stream; and
- Ocean Thermal Energy Converters in deep tropical waters.

Search All Tethys

Featured Links:

- News and Current Events
- Contributing to Tethys
- Annex IV Project Sites Metadata Form
- Annex IV Research Studies Metadata Form
- Ocean Energy System - Annex IV Experts' Workshop: 1
- DOE MHK Webinar Series
- Tethys FY11 Annual Report
- Tidal Energy Workshop Report

Database Breakout Groups

- Structure:
  - Four breakout groups, randomly chosen
  - Coloured dots on badge, four corners of the room
- Purpose:
  - Obtain feedback on the overall content, functionality, and potential uses for the *Tethys* and Annex IV database
  - *Detailed feedback should be provided in writing*
- Process:
  - 45 minutes to review at high level, focus on future expansion, uses, functions, report back
  - Facilitator and recorder in each group
- Outcome
  - Guidance for correcting, enlarging content of database
  - Suggestions for improved functionality
  - Potential new directions, uses, functionality of *Tethys*

Thank you!

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