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Sharing Information on Environmental Effects – Tethys Knowledge Base and the International Annex IV Initiative

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Seattle and Richland, WA

Recent Developments in Research on the Environmental Effects of MHK Technologies
Washington DC
April 9th 2013

Today….

- Environmental effects of marine energy development
  - Addressing information needs nationally and internationally: *Tethys* and Annex IV
- Information available on *Tethys*: a tour of the website
- Annex IV report:
  - Marine animals and turbine blades
  - Effect of noise on marine animals
  - Removing energy from marine systems
- Future of Annex IV

Environmental Effects of Marine Energy

- Clear drivers for marine energy development BUT
- Stakeholders have concerns about potential impacts
- Regulatory/consenting processes are not well established

RESULTING IN:

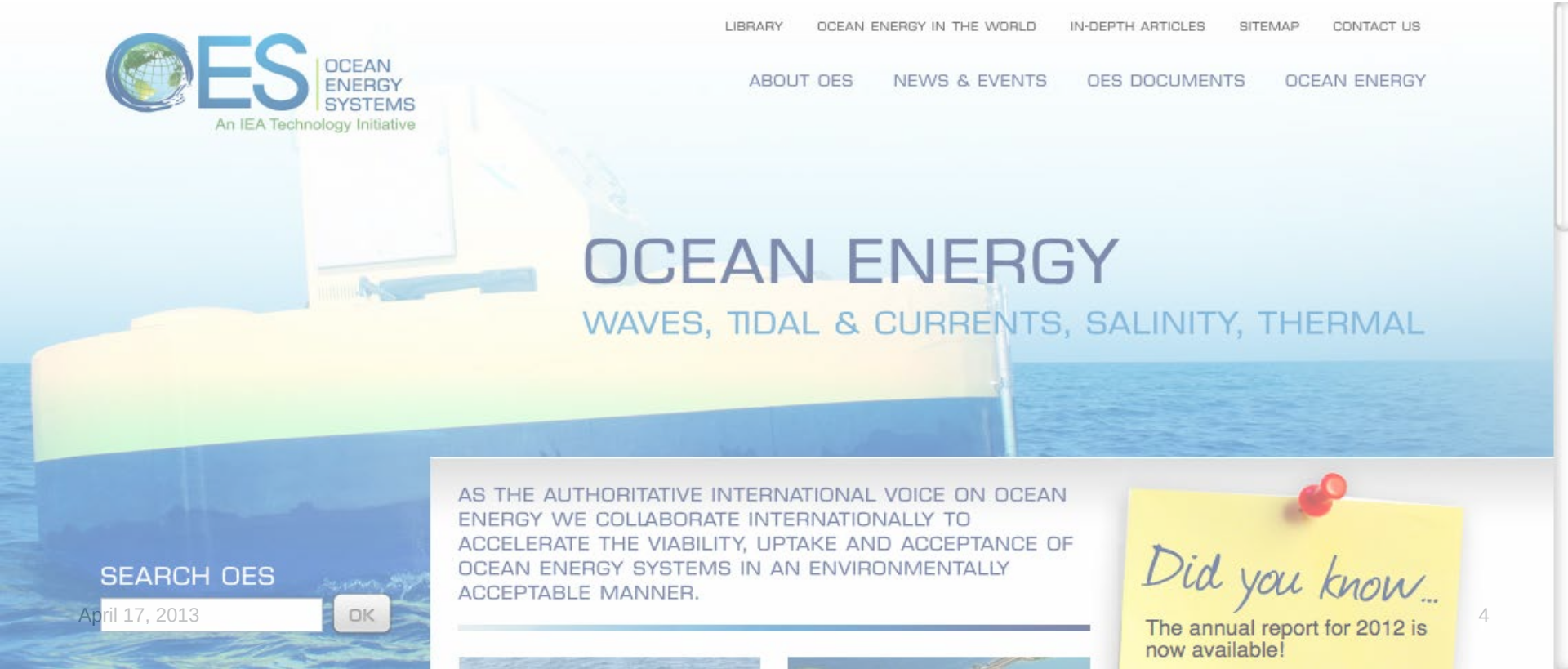
- Need for good information on potential effects
- Sharing of information broadly

THIS

- Lead WWPTO to direct PNNL to develop *Tethys* (online knowledge management system)
- International community (lead by US) to develop Annex IV

Annex IV – A Concept in Sharing Information and Analyses Internationally

- OES ExCo approved Annex IV in 2009
- Proposed by US; US Dept of Energy as Operating Agent
- Other US federal partners: BOEM, FERC, NOAA
- Seven Annex IV nations: US, New Zealand, Canada, Denmark, Spain, Ireland and South Korea



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.

Home Page

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- Search Knowledge Base
- Search Map

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

U.S. DEPARTMENT OF ENERGY | OES OCEAN ENERGY SYSTEMS An IEA Technology Initiative

Tethys was created by PNNL to support DOE and OES programs

Easily search the entire site for keywords

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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.

Please **contact us** if you would like to contribute any MHK information or research to *Tethys*.

Search All Tethys

Featured Links:

- Final Annex IV Report 2013
- 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
- Tidal Energy Workshop Report
- Wave Energy Workshop Report
- West Coast Environmental Protocols

Knowledge Base

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Knowledge Base

The Knowledge Base compiles all relevant documents, U.S. permitting sites, and international *Annex* headers, while results can be narrowed by keyword searches and by selecting values in the boxes to entries will load as you scroll down.

e sorted alphabetically by clicking on the box by selecting the small checkboxes. More

Alphabetically sort each column by clicking the header

Link to Tethys Map

1061 Items

Title	Author*	Date**	Document Type	Technology Type	Stressor	Receptor	Collection
Epifauna Dynamics at an Offshore Foundation - Implications of Future Wind Power Farming in the North Sea	Krone, R., et al.	Mar, 2013	Journal Article	Offshore Wind	Chemical leaching	Invertebrates	Tethys
Cobscook Bay Tidal Energy Project: 2012 Environmental Monitoring Report	ORPC Maine	Mar, 2013	Technical Report	MHK			Tethys
North Atlantic Right Whale Distribution and Seasonal Occurrence in Nearshore Waters off New Jersey, USA, and Implications for Management	Whitt, A.D., et al.	Mar, 2013	Journal Article	N/A	N/A		
Methodology for Tidal Turbine Representation in Ocean Circulation Model	Roc, T., et al.	Feb, 2013	Journal Article	MHK (tidal)	Energy removal	Farfield environment	Tethys
Estimation of Tidal Power Potential	Walters, R.A., et al.	Feb, 2013	Journal A				Tethys
U.S. Offshore Wind Manufacturing and Supply Chain Development	Navigant Consulting, Inc	Feb, 2013	Technical			cio-economics	Tethys
Offshore Wind Market and Economic Analysis	Navigant Consulting, Inc	Feb, 2013	Technical Report	Offshore Wind	N/A	Socio-economics	Tethys
Danish Offshore Wind Key Environmental Issues - A Follow-up	Danish Energy Agency	Jan, 2013	Technical Report	Offshore Wind	Physical presence and Noise	Birds, Fish, and Marine mammals	Tethys

Apply keyword searches within the knowledge base

Data export options available

Filter items by selecting categories from these lists

Click Icon Below for Data Export Options

Search Documents

Collection
249 Annex IV
810 Tethys

Technology Type
165 MHK
96 MHK (in-stream)
12 MHK (Ocean Current)
11 MHK (OTEC)
45 MHK (tidal)

Stressor
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79 EMF
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199 Fish
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Link to Tethys Map

Click Icon Below for Data Export Options

11 Media

Title	Author*	Date**	Document Type	Technology Type	Stressor	Receptor	Collection
Cobscook Bay Tidal Energy Project: 2012 Environmental Monitoring Report	ORPC Maine	Mar, 2013	Technical Report	MHK (tidal)	Energy removal, Physical presence, and Noise	Invertebrates, Fish, Marine mammals, Farfield environment, and Nearfield habitat	Tethys
West Coast Environmental Protocols Framework: Baseline and Monitoring Studies	Klure, J., et al.	Aug, 2012	Technical Report	MHK (tidal), MHK (wave), and Offshore Wind	EMF, Energy removal, Physical presence, and Noise	Birds, Invertebrates, Fish, Marine mammals, Nearfield habitat, and Reptiles	Tethys
Admiralty Inlet Final License Application	Snohomish County Public Utility District No. 1	Feb, 2012	Technical Report	MHK (tidal)	Chemical leaching, EMF, Energy removal, Physical presence, and Noise	Invertebrates, Fish, Marine mammals, and Socio-economics	Tethys
Birds and Wave & Tidal Stream Energy: An Ecological Review	McCluskie, A.E., et al.	Dec, 2011	Technical Report	MHK (tidal) and MHK (wave)	Chemical leaching, Energy removal, Physical presence, and	Birds	Tethys
Effects of Tidal Turbine Noise on Fish	Halvorsen, M.B., et al.	Aug, 2011	Dataset				Tethys
Screening Analysis for the Environmental Risk Evaluation System - Environmental Effects of MHK Energy	Copping, A.E., et al.	Aug, 2011	Technical Report		Physical presence, and	Nearfield habitat, and Reptiles	

Search Documents

Collection 1
- 20 Annex IV
- 11 Tethys

Technology Type 1
- 14 MHK
- 1 MHK (OTEC)
- 11 MHK (tidal)
- 9 MHK (wave)
- 47 Offshore Wind

Stressor 1
- 5 Chemical leaching
- 6 EMF
- 13 Energy removal
- 11 Noise
- 15 Physical presence

Receptor 2
- 6 Birds
- 8 Farfield environment
- 9 Fish
- 8 Invertebrates
- 11 Marine mammals

Content Type

Select multiple categories to specialize your search

Document

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Cobscook Bay Tidal Energy Project: 2012 Environmental Monitoring Report

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Abstract

ORPC Maine, LLC, a wholly-owned subsidiary of Ocean Renewable Power Company, LLC (collectively ORPC), submits this 2012 Environmental Monitoring Report for Phase I of the Cobscook Bay Tidal Energy Project (Project), in compliance with the Federal Energy Regulatory Commission (FERC) pilot project license P-12711-005. This report represents a significant achievement for the Project and its Adaptive Management Plan and demonstrates improved knowledge of our TidGen™ Power System's installation, operation and interaction with the marine environment.

ORPC is using this licensed pilot project to advance, demonstrate, and accelerate deployment of its tidal-current based marine hydrokinetic energy conversion technology, associated power electronics, interconnection equipment, and environmental monitoring program within a replicable full-scale, interconnected array of devices capable of reliably delivering electricity to the domestic power grid. The Project consists of designing, building, installing and monitoring a commercial-scale array of multiple grid-connected TidGen™ devices on the sea floor in Cobscook Bay off Eastport and Lubec, Maine in two phases.

The implementation of the environmental monitoring pla of working regularly in the marine environment (i.e., limited visibility, high veloc surface); and the start-up, conditioning, and maintenance issues associa nmental monitoring instrumentation, especially the components that repres

To overcome these challenges ORPC took the following approach to ensure consistency with the Project's license:

- Data was collected in accordance with the approved environmental monitoring plans and Adaptive Management Plan and in conjunction with the installed infrastructure and operational status of the TGU.

- Where deficiencies in equipment and methodologies were identified, ORPC engaged technical advisors, consulting scientists, manufacturer representatives, and qualified inhouse personnel to troubleshoot issues and develop improvement plans, as necessary.

Download a PDF version of the report

GIS Resources

The project area has the following coordinates:

Automatically generated citation

Technical Report

Title	Cobscook Bay Tidal Energy Project: 2012 Environmental Monitoring Report
Author	ORPC Maine
Publication Date	2013/03/26
Institution	Ocean Renewable Power Company
Pages	653
Publisher	ORPC Maine
Published City	Portland, ME
URL	http://www.orpc.co/permitting_doc/environmentalreport_Mar2013.pdf
Attachment	Access Document
Stressor	Energy removal, Physical presence, Noise
Receptor	Invertebrates, Fish, Marine mammals, Farfield environment, Nearfield habitat
Technology Type	MHK (tidal)

APA 6th Citation:

ORPC Maine. (2013). Cobscook Bay Tidal Energy Project: 2012 Environmental Monitoring Report. (pp. 653), Ocean Renewable Power Company.

Map Viewer

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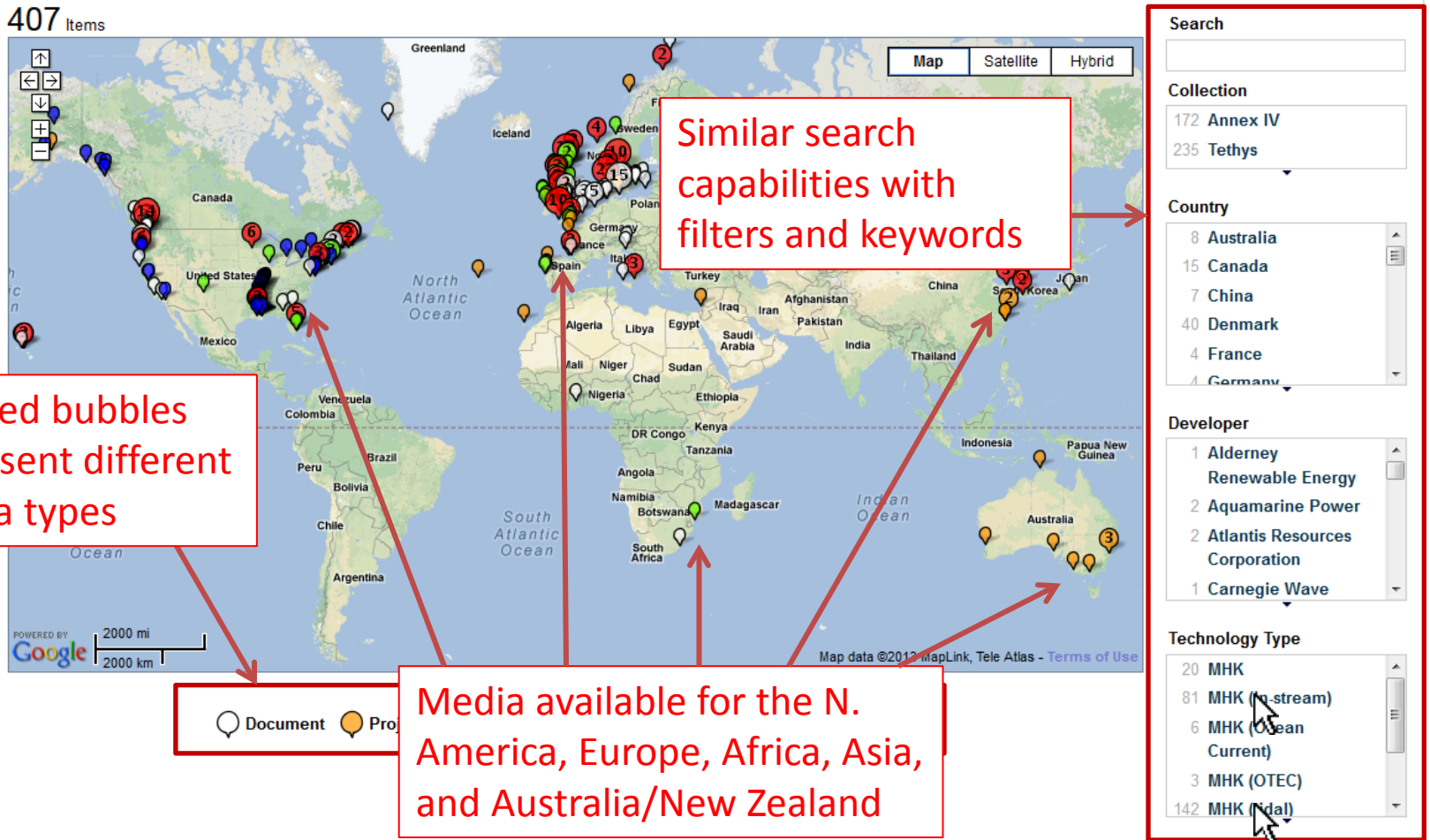
Link to Tethys Knowledge Base



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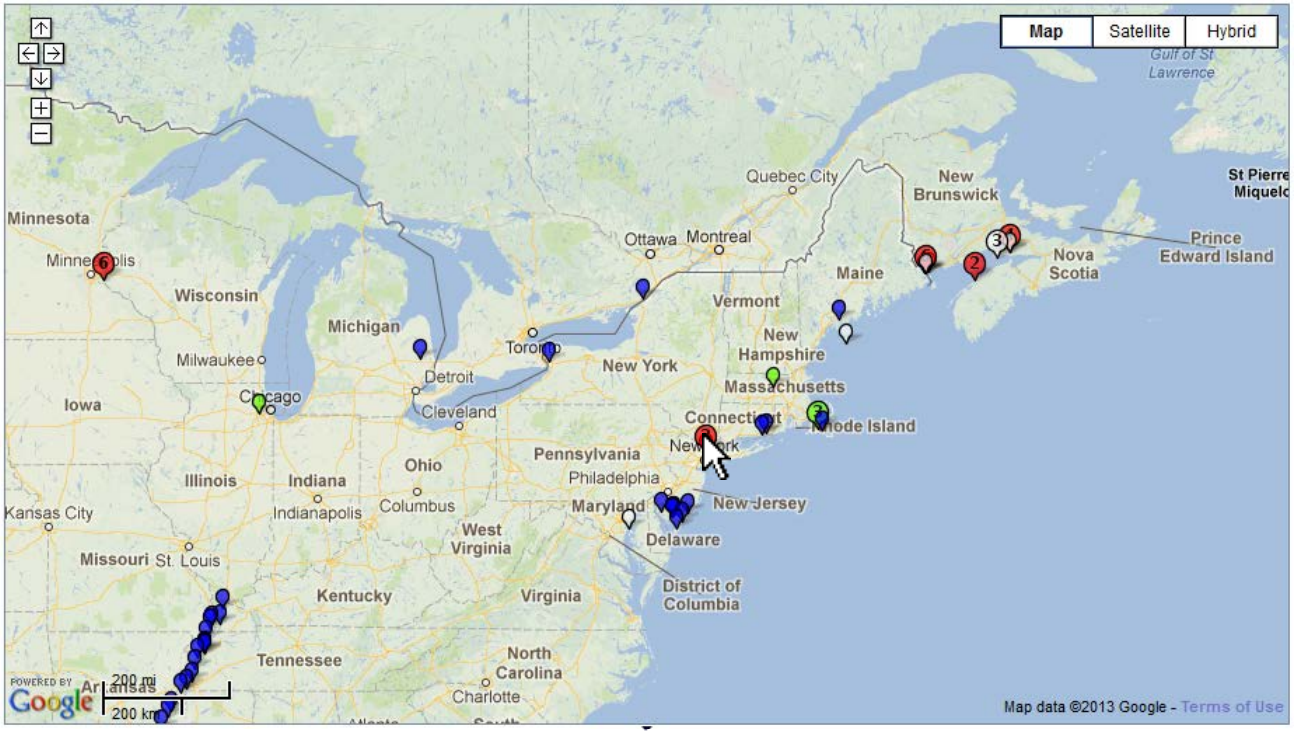
219 Items



Document | Project Site | Research Study | US Permitting Site | Multiple

Search

Collection

- 88 Annex IV
- 131 Tethys

Country

- 2 Australia
- 13 Canada
- 7 China
- 3 France
- 1 Ghana
- 5 Ireland

Developer

- 1 Alderney Renewable Energy
- 2 Atlantis Resources Corporation
- 1 China Guodian Corporation

Technology Type 2☑

- 20 MHK ☐
- 81 MHK (in-stream) ☑
- 6 MHK (Ocean Current) ☐
- 3 MHK (OTEC) ☐
- 142 MHK (tidal) ☑

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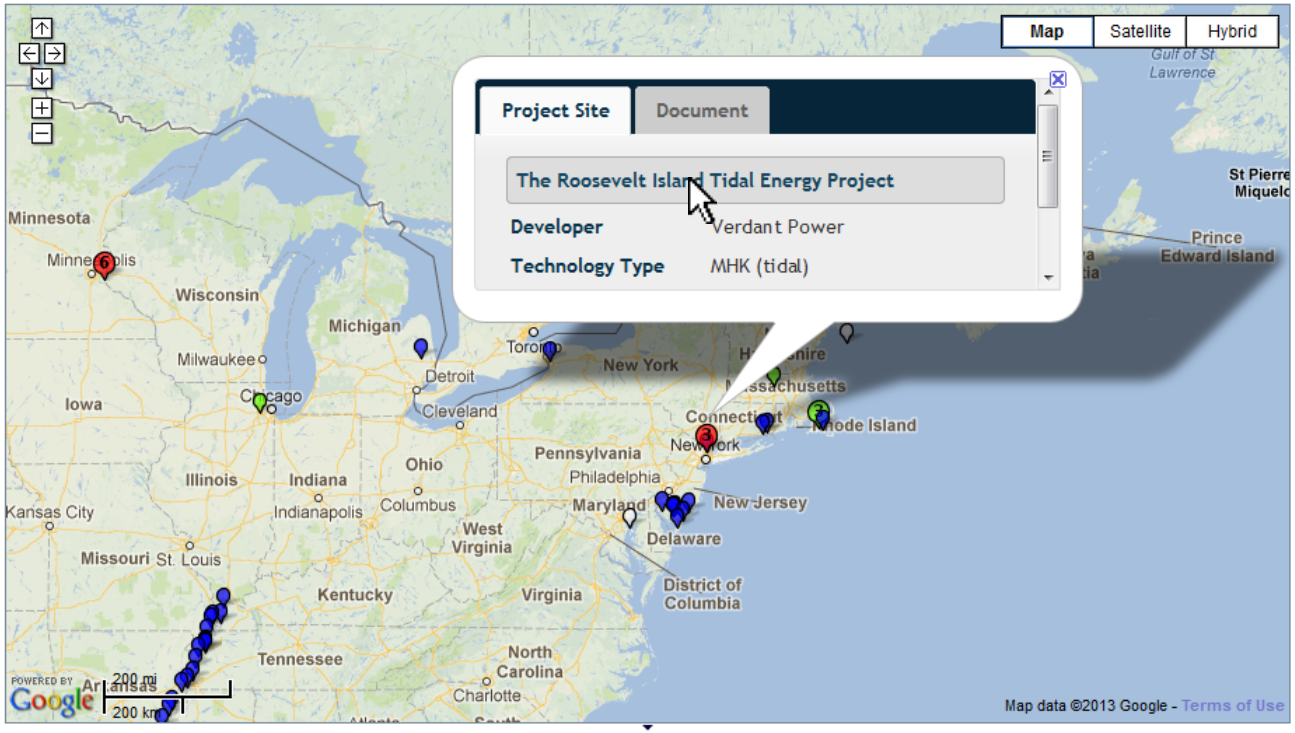

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US Permitting Site

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The Roosevelt Island Tidal Energy Project

Project Name

The Roosevelt Island Tidal Energy Project

Description

Technology: 3-bladed, horizontal axis turbine: Gen5 Kinetic Hydropower System (KHPS)

Project Scale: Commercial array

Installed Capacity: 1.05 MW

Additional Description: The RITE ... onstration that was developed from 2005-08. The R...

1. A Project boundary of approx...
2. Project works consisting of:
    1. Thirty 35-kW, 5-meter...
    2. Ten triframe mounts, e...
    3. 480-volt underwater cables from each turbine to the shoreline switchgear vaults that will interconnect to a control room and interconnection points, and
    4. Appurtenant faculties for navigation and operation.

In accordance with the FERC Pilot Project License, the RITE Project will be installed in stages with commensurate environmental monitoring as follows:

Install A: (performed under existing FERC Verdant Order and existing permits): Install two Gen5 Turbines on existing monopiles to verify machine performance targets and further environmental compatibility;

Install B-1: Install a single triframe, consisting of three Gen5 turbines;

Install B-2: Install up to three additional triframes, consisting of up to nine Gen5 turbines;

Install C: Install up to six additional triframes, consisting of up to eighteen Gen5 turbines (for total installation of no more than 30 Gen5 turbines).

Location

Water Body: East Channel of East River - tidal strait connecting Long Island Sound to Atlantic Ocean through New York Harbor

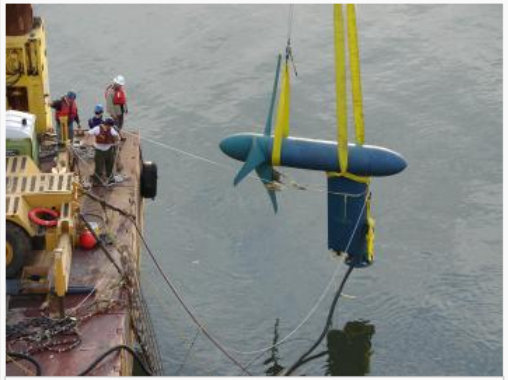
Closest City: New York, NY, USA

Depth: 10 meters

Access to all documentation for this project via the link to the FERC website

Annex IV Project Site

Name	The Roosevelt Island Tidal Energy Project
Developer	Verdant Power
Website	http://verdantpower.com/what-initiative/
Launch Date	2006/12/01
FERC Docket Number	P-12611 (FERC Disclaimer)
State	New York
Country	The United States
Attachment	Original Form
Technology Type	MHK (tidal)



Gen5 Kinetic Hydropower System

Connections

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Institution Connections

Institution Connections

This list of contacts is not exhaustive, and will continue to change with time. If you notice any outdated/incorrect information or wish to add a contact, please email jonathan.whiting@pnnl.gov with corrections.

University	Name	Department	Specialization	Email	Phone	Country	Source
Aalborg University	Lucia Margheritini	Civil Engineering	Wave devices	lm@civil.aau.dk	+45 9940-2924	Denmark	Link
Aalborg University	Jørgen Nørgaard	Civil Engineering	Overtopping, barriers	jhn@civil.aau.dk	+45 9940-8478	Denmark	Link
Aarhus University	Jakob Tougaard	Bioscience	Bioacoustics, neuroethology	jat@dmu.dk	+45 8715-8706	Denmark	Link
Acadia University	Graham Daborn	Biology	Estuaries, sediments	graham.daborn@acadiau.ca	+1 902-585-1118	Canada	Link
Acadia University	Richard Karsten	Mathematics and Statistics	Tidal resource assessment, modelling	richard.karsten@acadiau.ca	+1 902-585-1608	Canada	Link
Acadia University	Anna Redden	Biology	Estuaries	anna.redden@acadiau.ca	+1 902-585-1732	Canada	Link
Acadia University	Michael Stokesbury	Biology	Fisheries and fish ecology	michael.stokesbury@acadiau.ca	+1 902-585-1195	Canada	Link
Bangor University	Simon Neill	Ocean Sciences	Numerical modelling, sediment transport	ucsa03@bangor.ac.uk	+44 01248-383938	United Kingdom	Link
Cornwall College	Peter McGregor	Applied Zoology	Behavior, ecology	peter.mcgregor@cornwall.ac.uk	+44 07775-821231	United Kingdom	Link
Cranfield University	Andrew Gill	Aquatic Ecology	Fish	a.b.gill@cranfield.ac.uk	+44 0123-475-0111	United Kingdom	Link
Dalhousie University	Christopher Taggart	Oceanography	Fisheries	chris.taggart@dal.ca	+1 902-494-7144	Canada	Link
Florida State University	Alexandra Bozec	Oceanography	Global circulation	abozec@coaps.fsu.edu	+1 850-645-1253	United States	Link
Heriot-Watt University	Michael Bell	Petroleum Engineering	Fisheries, shellfish	m.c.bell@hw.ac.uk		Scotland	Link
Laval University	Guy Dumas	Mechanical Engineering	CFD optimization, oscillating-foils	gdumas@gmc.ulaval.ca	+1 418-656-7854	Canada	Link
Newcastle University	Melissa Bateson	Ethology	Ethology, cognitive psychology	melissa.bateson@ncl.ac.uk	+44 0191-222-5056	United Kingdom	Link

Connections

Database Connections

This list of databases is not exhaustive, and will continue to change with time. If you notice any outdated/incorrect information or wish to add a database, please email luke.hanna@pnnl.gov with corrections.

Database Name	URL	Description
Marine and Hydrokinetic Technology Database	http://water.energy.gov/hydrokinetic/	The U.S. Department of Energy's Marine and Hydrokinetic Technology Database provides up-to-date information on marine and hydrokinetic renewable energy, both in the U.S. and around the world. The database includes wave, tidal, current, and ocean thermal energy, and contains information on the various energy conversion technologies, companies active in the field, and development of projects in the water.
Ocean Renewable Energy	http://www.oceanrenewableenergy.com/	This Knowledge base provides information on the environmental, regulatory and socioeconomic ramifications of offshore renewable energy. Ocean Renewable Energy also provides current news and events regarding offshore renewable energy developments. More information can be found [here http://www.oceanrenewableenergy.com/aggregator/categories/1]
The Multipurpose Marine Cadastre	http://www.marinecadastre.gov/default.aspx	The Multipurpose Marine Cadastre (MMC) is an integrated marine information system that provides ocean information such as energy potential, offshore boundaries, infrastructure, and biological data sets.
FERC eLibrary	https://www.ferc.gov/docs-filing/elibrary.asp	FERC's eLibrary maintains a record of all permit-related documents for sites under FERC's jurisdiction which includes all U.S. MHK projects. Users can conduct general searches or enter a specific docket number to search through the eLibrary. Note the eLibrary contains MHK filings, as well as conventional hydrokinetic project filings. Both hydrokinetic and MHK projects with FERC filings in the eLibrary are denoted by blue pins on the Tethys map.
The Crown Estate Data Management System	http://data.offshorewind.co.uk/	Source for the environmental data and information generated under the Crown Estate's second Licensing Round for offshore renewables.
SOWFIA	http://sowfia.hidromod.com/	The SOWFIA Project (Streamlining of Ocean Wave Farms Impact Assessment) has collected information on the Environmental Impact Assessment activities being carried out at a range of marine renewable energy test and research sites across Europe. The information has been input to the preliminary project-centred Data Management Platform (DMP) which facilitates instantaneous access to the information collected from diverse sources and enables complex enquiries to be carried out.
MHK Tech Papers Blog	http://mhktechpapers.wordpress.com/	The purpose of this blog is to aggregate and organize technical papers as they relate the the development of Marine and Hydrokinetic (MHK) technologies.
ESPIS	http://www.data.boem.gov/homepg/data_center/other/espis/espismaster.asp?appid=1	The Environmental Studies Program Information System (ESPIS) makes all completed BOEM environmental studies reports available on-line as full electronic pdf documents, including images and graphics. Technical summaries of over 700 BOEM-sponsored environmental research projects, as well as full pdf documents of over 2,000 research reports, are available for online full text search.
4C Offshore	http://www.4coffshore.com/windfarms/	4C Offshore is an international offshore wind farm database which contains locations, primary stakeholders stakeholders, news and port information for 1299 offshore wind projects in 38 different countries. The database also

Regulatory Connections

This information included in this document does not represent a complete record of the regulatory requirements that all hydrokinetic projects may need, nor is it correct to assume that all th authorizations contained herein necessarily apply to all such projects. This information is intended for general purposes only and should not be construed as legal advice or a legal opinion. information may change with time, please email jonathan.whiting@pnnl.gov with any corrections for outdated/incorrect information.

Australia

Environmental review is carried out by the Australian Government under the **Environment Protection and Biodiversity Conservation Act 1999** and requires an environmental assessment. Marine energy projects can obtain consent under the **Coastal Management Act 1995**. Consent is then administered at the state level.

Victoria has the most developed process to date, structured by the **Department of Sustainability and Environment (DSE)**

Belgium

Planning of activities in the Belgian Part of the North Sea (BNPS) is covered by legal rules and procedures allowing or rejecting a license or concession for the planned activity. The permit system covers concessionary rights and exploitation authorization, including environmental impact assessments (EIAs).

The permit system and the regulating authorities involved reflect the sectoral legal framework. Four permits are required for offshore wind parks: Domain Concession, Environmental permit, Authorization for the construction and operation, offshore cable buiding permitare. Four authorities are in charge of the permitting procedure: Ministry of Energy, **FPS Environment**, **MUMM**, and Flemish planning administration. Offshore cable buiding permit is delivered by DG Energy within the Federal Ministry of Energy.

Rules and procedures have been adapted to stimulate and facilitate the process. The permit system is clearly defined and reasonable short (less than 1 year).

Canada

The regulation of offshore renewable energy projects in Canada is a shared responsibility between federal and provincial/territorial governments. Provincial/territorial requirements for project approval can vary across Canada. With regards to federal oversight, all projects will need to adhere to applicable federal legislation regardless of where the project is located , e.g., ***Canadian Environmental Assessment Act, 2012 (CEAA 2012)***; ***Canadian Environmental Protection Act, 1999***; ***Fisheries Act***; ***Migratory Birds Convention Act***; ***Navigable Waters Protection Act and Species at Risk Act***. For information on the type of projects that may trigger a federal environmental assessment under CEAA 2012, please refer to the **Canadian Environmental Assessment Agency's website**. For a complete list of acts, orders and regulations, please refer to **Justice Canada's website**.

China

The 2010 **Renewable Energy Law of the People's Republic of China (Amendment)** outlines a policy to accelerate and promote the development of renewable energy projects. **The Ministry of Finance** launched the special funding program for marine renewable energy projects in 2010. The **State Oceanic Administration (SOA)** created the Administrative Centre for Marine Renewable Energy (ACMRE) to coordinate and manage the special funding programme for marine renewable energy under the leadership of the Ministry of Finance and SOA. The special funding programme has entered the third round, with a total funding of ¥600 million since 2010. In 2012, the SOA promulgated the National Marine Functional Zoning (2011-2020) to arrange the sea-area utilization including the marine renewable energy devices. **The National Energy Administration (NEA)** has drafted the 12th Five-Year Plan for Marine Renewable Energy jointly with SOA since 2011.

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  - 18.1 Scotland
  - 18.2 England
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  - 18.4 Northern Ireland
- 19 United States of America

Connections

Contact

Contacts

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

Web site issues:

Scott Butner
Pacific NW National Laboratory
scott.butner@pnnl.gov

MHK and Offshore Wind Program Issues:

Andrea Copping
Pacific NW National Laboratory
andrea.copping@pnnl.gov

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.**

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Annex IV Final Report

Environmental Effects of Marine Energy Development around the World
Annex IV Final Report

January 2013

Content of the Report:

- Background on Annex
- Objectives, Case Studies
- Database description
- Data collection methods
- Three Case Studies:
  - Interaction of Marine Animals with Turbine Blades
  - Effects of Acoustic Output from Tidal and Wave Devices on Marine Animals
  - Effects on Physical Systems

Case Study Process

- Objectives
  1. Collect data on the specific interaction from installed marine energy projects;
  2. Collect additional information from research studies in laboratories, in the field and from models;
  3. Evaluate information to determine what we know about the interaction; and
  4. Identify key gaps in data and studies.

- Lines of Evidence
- Conclusions of Analyses
- Data Gaps and Research Needs

Lines of Evidence - Interaction of Marine Animals with Turbine Blades

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- Field Studies
  - SeaGen observations of marine mammals in Strangford Lough, Northern Ireland (MCT)
  - Observations of fish around a tidal turbine in Cobscook Bay, Maine, USA (ORPC)
  - Fish passage through a hydrokinetic river turbine on the Mississippi River, USA (Hydro Green)
  - Video observations of fish around a tidal turbine at the European Marine Energy Center, Scotland (OpenHydro)
  - Acoustic measurements of fish and birds around tidal turbines, New York, USA (Verdant)
- Laboratory Experiments
  - Alden Lab flume studies
  - Conte Lab open water flume studies
- Modeling encounters between Animals and Hydrokinetic Turbines
  - Fish and Harbor Porpoise Encounter Model (SAMS)
  - Estimating the consequences of encounter with a tidal turbine (PNNL/SNL)

Conclusions: Interaction of Marine Animals with Turbine Blades

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- No evidence to date suggests direct interaction of marine mammals, birds, or fish with tidal turbine blades likely to be a significant problem.
- Attraction of animals to turbines could increase risk.
- Data collected from short deployments may not scale to large long term deployments.
- Monitoring around multi-turbine arrays needed

Conclusions: Effects of Acoustic Output from Tidal and Wave Devices on Marine Animals

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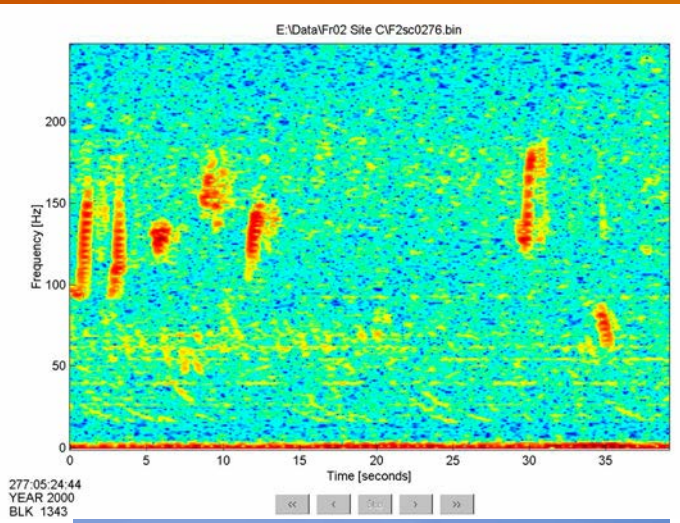
- Field deployments need to measure ambient sound and propagation prior to deployment, to measure the sound of the device.
- Dose/response relationships needed to understand potential responses of animals.
- Have to determine if sound from multiple devices is additive or multiplicative
- Acoustic outputs and effects are needed for a range of devices, as well as the anchors, moorings, and foundations.



Conclusions: Effects on Physical Systems

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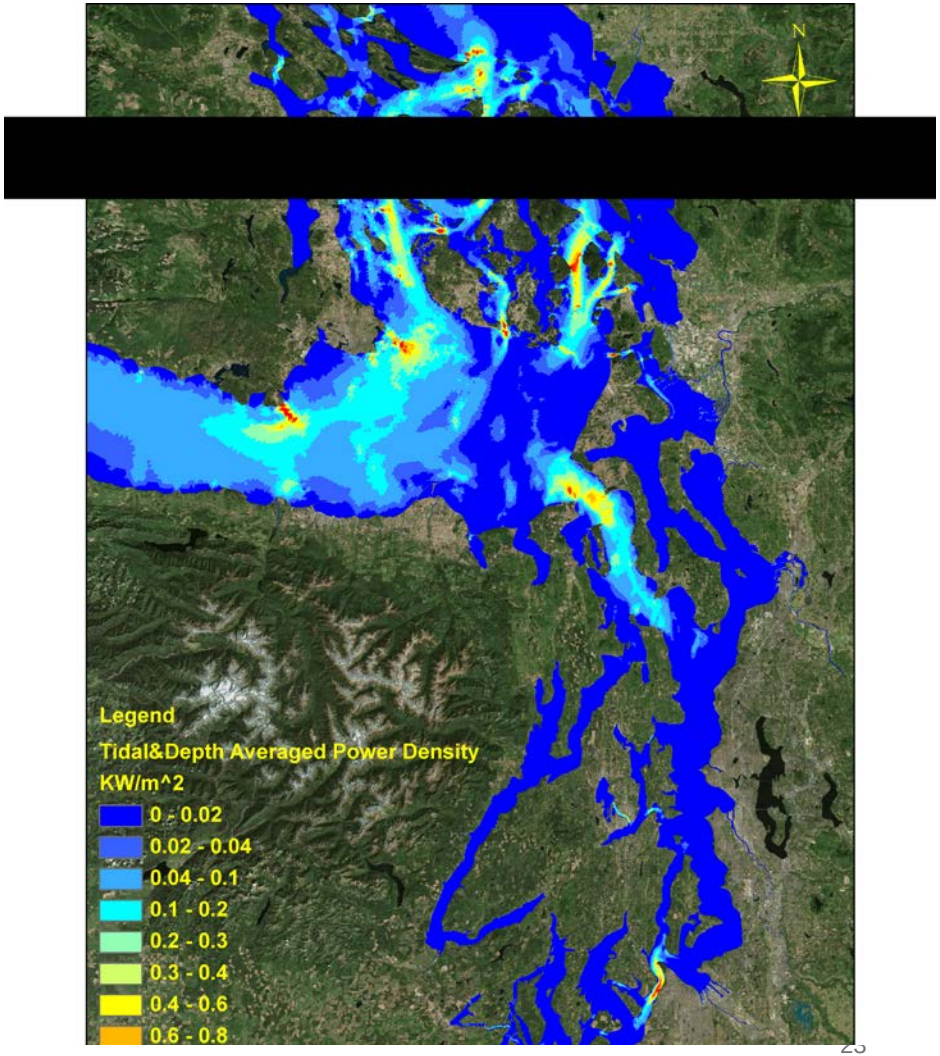
- Great measurements challenges:
  - Model validation
  - Turbulence
  - Effects from specific marine energy devices
  - Coupling nearfield with farfield
  - Cumulative effects
- Nearfield changes not likely at the small pilot but could occur at large scale.
- It is not known if a tipping point exists for farfield changes that might affect the overall waterbody;
- Need better measurements of turbulence and inflow to devices for estimating environmental changes.



The Future of Annex IV

- Input from experts' workshop (Sept 2012) and from discussions with other nations = much remains to be done
- US committed to continuing effort
- Proposal going to OES ExCo in May to request additional 3 years
- Scope:
  - Continued collection and analysis of project monitoring data and research information
  - Push to create Tethys/Annex IV as a commons for collaboration for researchers, developers, regulators, stakeholders
  - More direct hands-on participation by scientists in other nations
  - Support for international conference on environmental effects of marine energy (like EIMR in Orkney April 2012)
- Hope to have more and more nations join the effort!

Thank you for your attention!

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