



# Annex IV – International Collaboration to Investigate Environmental Effects of Wave and Tidal Devices

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# Why do we need to understand environmental effects (of marine energy)?

▶ Drivers of marine energy development are clear  
BUT

▶ Stakeholders continue to have concerns about potential impacts.

DRIVEN BY:

▶ New, largely unknown technologies with unknown potential for harm.

▶ New use of ocean space, many other users.

▶ Insufficient knowledge of ocean environment in high energy areas.

▶ Concerns about marine species already under stress.

RESULTING IN:

▶ Regulatory/consenting processes that respond to those risks that are least understood, those with the greatest uncertainty.

GREAT ADVANTAGE IN:

▶ Bringing together what we know, determining what we still need to know.

▶ Sharing internationally



# Annex IV – A concept in sharing information and analyses internationally

- ▶ OES ExCo approved Annex IV phase 1 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
- ▶ Phase 1 Annex IV: 2010-2013



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## OCEAN ENERGY

WAVES, TIDAL & CURRENTS, SALINITY, THERMAL

SEARCH OES

OK

AS THE AUTHORITATIVE INTERNATIONAL VOICE ON OCEAN ENERGY WE COLLABORATE INTERNATIONALLY TO ACCELERATE THE VIABILITY, UPTAKE AND ACCEPTANCE OF OCEAN ENERGY SYSTEMS IN AN ENVIRONMENTALLY ACCEPTABLE MANNER.

*Did you know...*

The annual report for 2012 is now available!

# Purpose and components of Annex IV

- ▶ 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”.*
  
- ▶ Annex IV outcomes include:
  - Information collected worldwide on environmental effects, housed on Tethys, online knowledge management system
  - Analysis of existing information on specific topics:
    - **Marine animals and turbine blades**
    - **Effect of noise on marine animals**
    - **Removing energy from marine systems**



Environmental Effects of Marine Energy Development  
around the World  
Annex IV Final Report  
January 2013




Approved for Release by the National Security Council on 08-08-2013 pursuant to E.O. 13526, which is hereby approved for release to the public.



### Environmental Effects of Renewable Energy from the Sea

Welcome to Tethys
What is MHK?
What is Annex IV?
What is Offshore Wind?

As industry, academia, and government seek to develop new renewable energy sources from tides, waves, 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 is a knowledge management system that gathers, organizes, and provides access to information on the environmental effects of marine and hydrokinetic (MHK) and offshore wind development. This information is made available by collaboration at local, national, and international levels. Tethys, named after the mythical Greek titaness of the seas, supports programs at the U.S. Department of Energy's [Wind](#) and [Water](#) Power Technologies Office.

Tethys also supports a growing community of MHK and offshore wind researchers, regulators, and developers through outreach and communication channels including the [Tethys blog](#), links to pertinent [research institutions](#), other [databases](#) with similar missions, and [broadcasts](#) of presentations, webinars, seminars, and symposia relating to the environmental effects of marine energy and offshore wind. As the Tethys community expands and more users [create accounts](#), each user's personal interests and areas of expertise may be catalogued upon request to facilitate more communication amongst Tethys community members.

Welcome to Tethys!

### Featured Links

- [EIMR International Conference 2014](#)
- [Final Annex IV Report 2013](#)
- [New Features](#)
- [Contributing to Tethys](#)

### Recently Added

- [The Effects of a Severn Barrage on Wave...](#)
- [Experimental Study of the Turbulence...](#)
- [Experimental Study of the Turbulence...](#)
- [Soaring Migratory Birds Avoid Wind Farm...](#)

### Recent Blog Articles

- [Admiralty Inlet Pilot Tidal Project](#)
- [Whale Interactions with Wave Device...](#)
- [Floating Offshore Wind Sound Analysis](#)
- [London Array is Inaugurated as the...](#)

### Find Us On...



### Reach Us

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





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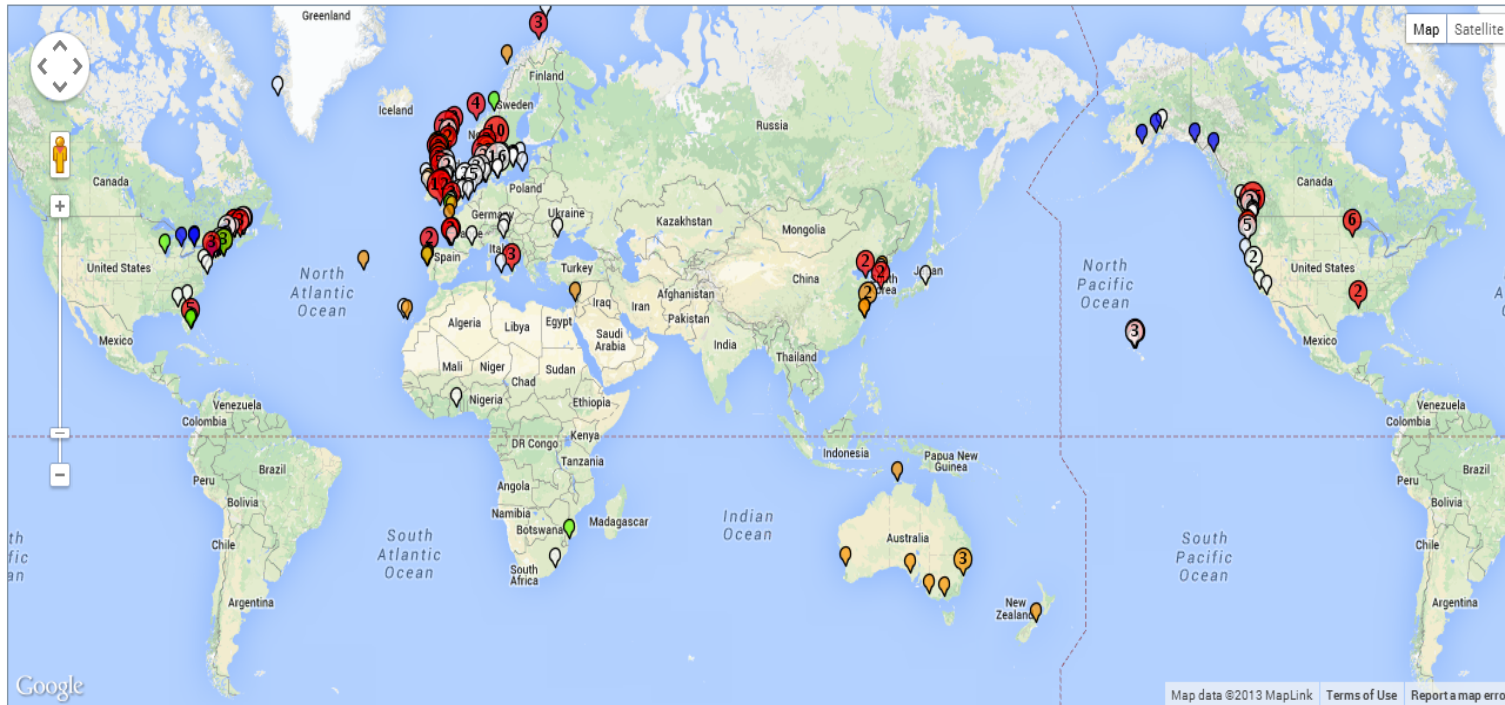
HELP

## Map Viewer

The Map Viewer compiles documents, U.S. permitting sites, and international Annex IV project sites and research studies that are associated with a geographic location. This view allows panning and zooming, while results can be narrowed by keyword searches and by selecting values in the boxes to the right. You can select multiple values for each box by selecting the small checkboxes. Clicking on a bubble will open a dialogue box with more information that links to the document page.

[Link to Tethys Knowledge Base](#)

375 Items



### Search

### Collection

- 180 Annex IV
- 195 Tethys

### Technology Type

- 20 MHK
- 12 MHK (in-stream)
- 5 MHK (Ocean Current)
- 4 MHK (OTEC)
- 140 MHK (tidal)

### Country

- 8 Australia
- 1 Belgium
- 15 Canada
- 6 China
- 50 Denmark
- 5 France

### Developer

- 1 Alderney Renewable Energy
- 2 Aquamarine Power
- 2 Atlantis Resources Corporation
- 1 AW Energy

○ Document   ● Project Site   ● Research Study   ● US Permitting Site   ● Multiple

# Analysis (“Case Study”) process

## Process:

1. Data on the specific interaction from installed devices;
2. Additional information from research studies in laboratories, in the field and from models;
3. Determine what is known about the interaction; and
4. Identify key gaps.

### ▶ Lines of Evidence

### ▶ Conclusions of Analysis

### ▶ Data Gaps and Research Needs

### ▶ Each case study includes:

- Problem statement
- Available evidence from monitoring and/or research studies,
- Discussion of lessons learned and
- Data gaps
- References cited

# Lines of evidence - Interaction of marine animals with turbine blades

- ▶ **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)

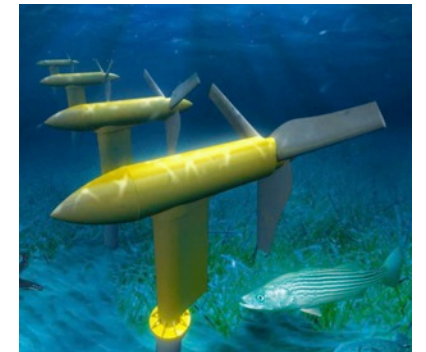


# Conclusions & Data Gaps: Interaction of marine animals with turbine blades

- ▶ 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.

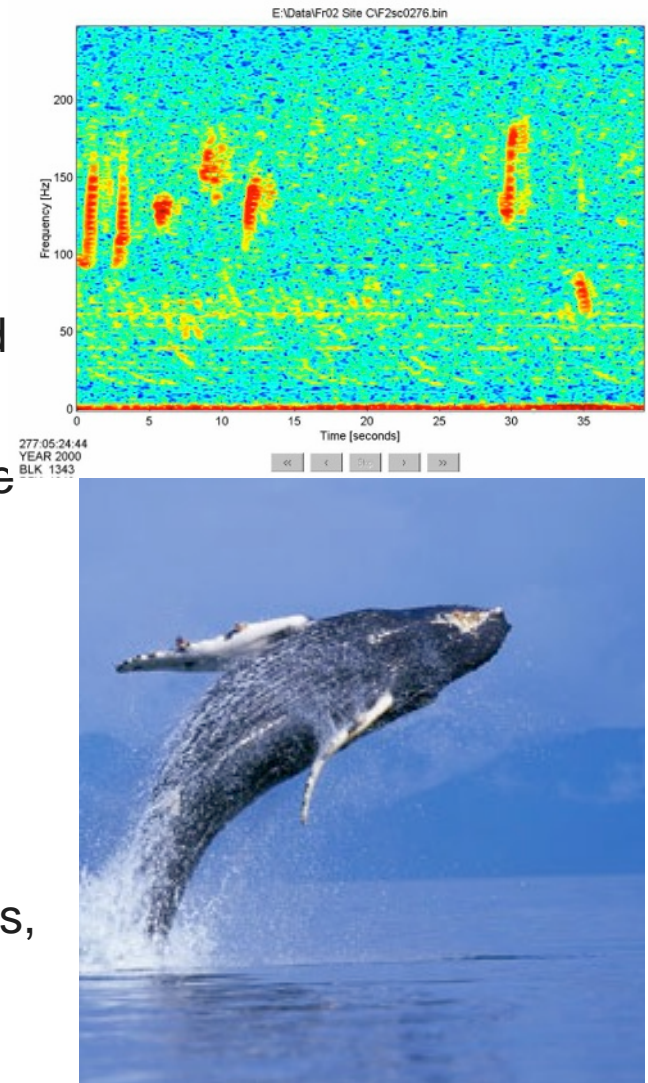
## Data Needs:

- ▶ Monitoring around single devices, and later around multi-turbine arrays.
- ▶ Continued laboratory studies of fish and turbines.
- ▶ Physical and biological interaction models to determine outcome of encounters.



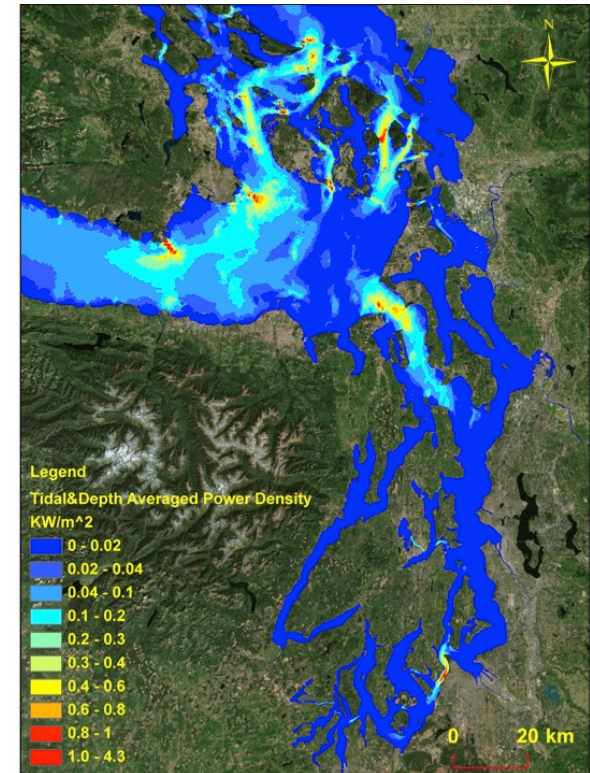
# Conclusions & Data Gaps: : Effects of acoustic output from tidal and wave devices on marine animals

- ▶ Insufficient field evidence to reach conclusions on effects of sound; what is needed is:
- ▶ Field deployments should measure ambient sound and propagation prior to deployment.
- ▶ Dose/response relationships needed to understand potential responses of animals.
- ▶ Determine if sound from multiple devices is additive or multiplicative.
- ▶ Need information on sound propagation potential within waterbodies, uncertainty of effect on marine animals.
- ▶ Need to measure acoustic outputs and effects on animals for range of devices, as well as the anchors, moorings, and foundations.



# Conclusions: Effects on physical systems

- ▶ Large temporal and spatial scales present 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.



# Annex IV Workshop – Best Practices for Environmental Monitoring

## Interactions for wave and tidal devices:

- Blade interaction
- Attraction
- Avoidance/barrier effects
- Mooring line interactions

## Top outcomes:

- ▶ Monitoring programs that are commensurate with risk to animals, and affordable, require:
  - Good baselines of animal movement and behavior, and
  - Targeted research studies to determine nature of the risk.
- ▶ Integrated package of instruments to observe blade interaction possible but very costly.
- ▶ Differences between regulatory regimes in different countries will drive certain monitoring requirements.
- ▶ Report to follow!

# The future of Annex IV

- ▶ Input from experts' workshop (Sept 2012) and discussions with other nations = much remains to be done.
- ▶ Second phase of Annex IV authorized by OES for an additional 3 years.
- ▶ Scope:
  - Continued collection and analysis of project monitoring data and research information
  - Create Annex IV as a commons for collaboration for researchers, developers, regulators, stakeholders
  - Webinars, online research forums, social media
  - More direct hands-on participation by scientists in other nations
  - Support for international conference on environmental effects of marine energy
- ▶ Eleven nations involved in Phase 2, Annex IV.



# Thank you!

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