Water Power Technologies Office

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

DOE Marine and Hydrokinetic Program Overview

BOEM California Ocean Renewable Energy Conference

November 1, 2016

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Marine and Hydrokinetic (MHK) Strategy Vision and Mission

Vision: A U.S. Marine and Hydrokinetic industry that expands and diversifies the nation's renewable energy portfolio by responsibly delivering energy from all high potential ocean and river resources

Mission: Increase MHK technology deployment in opportune markets by developing safe, reliable, and cost-competitive technologies and reducing deployment barriers.

The mission identifies two areas of opportunity:

- Deploying technologies in high cost, remote, and/or non-electric markets to prove technology in the near term and gain experience needed to further reduce costs
- Deploying array-scale technologies in lower cost utility-scale electricity markets over the longer term

Core Challenges for MHK Industry and DOE Approaches

Technology Maturity

- Testing Infrastructure
- Installation, grid integration, Operation & Maintenance
- Array configuration
- Design Optimization
- Evaluation Metrics

Deployment Barriers

- Regulatory Concerns
- Environmental Effects
- Availability of accurate unbiased information
- Competing uses of ocean space
- Deployment infrastructure

Market Development

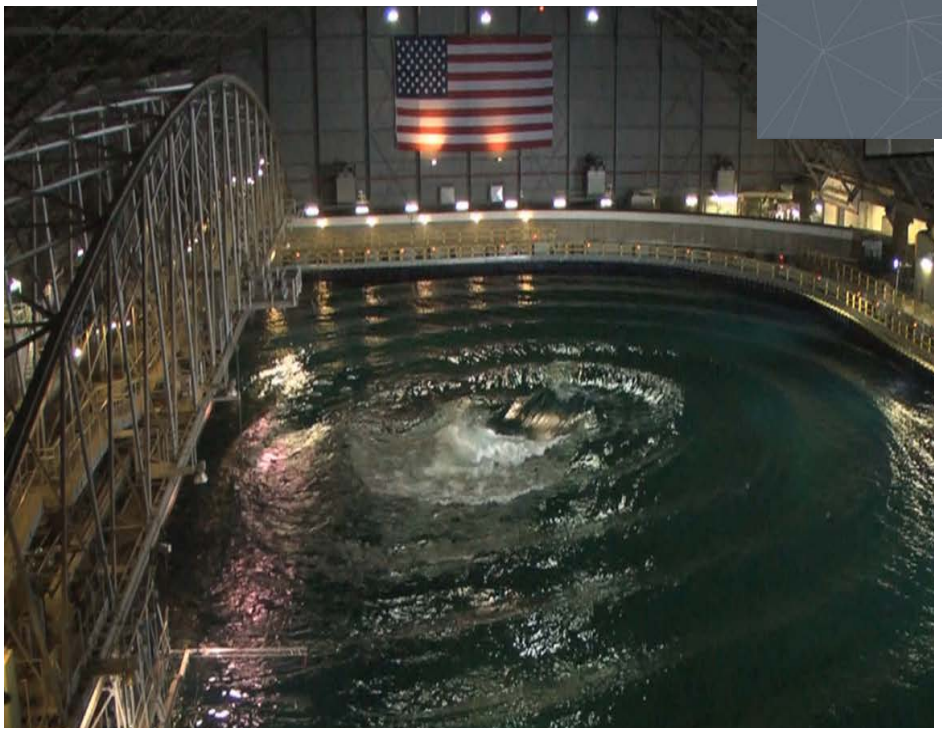
- Risk quantification
- Resource characterization
- Investor relations
- Incentives and policy measures
- Workforce development

WAVE ENERGY PRIZE

U.S. DEPARTMENT OF ENERGY

Wave Energy Prize Schedule

- August 1 to mid-October: Testing @ MASK basin
- November 16: Winner(s) Announced at the Wave Energy Prize Innovation Showcase



Q. WHAT ARE THE PRIZE'S OBJECTIVES?

A.

- Mobilize new and existing talent
- Yield game-changing solutions that exceed aggressive performance metrics
- Drive the development of WECs that double the state-of-the-art energy captured per unit structural cost
- Accelerate the pace of innovation
- Attract investors and create a strong foundation for future funding opportunities
- Rigorous comparison between device types

Finalists

AquaHarmonics (Portland, OR)

CalWave Power Technologies (Berkeley, CA)

M3 Wave (Salem, OR)

Oscilla Power (Seattle, WA)

RTI Wave Power (York, ME)

Sea Potential (Bristol, RI)

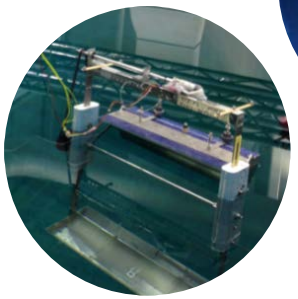
SEWEC (Redwood City, CA)

Harvest Wave Energy (Research Triangle Park, NC)

Waveswing America (Sacramento, CA)

Wave Energy Prize innovations

Broad bandwidth energy absorption



Geometry

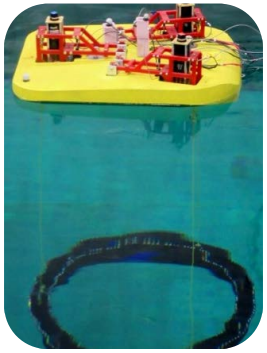
Flexible membranes

Controls

Materials

Power conversion

Sea state + wave state control



Multi mode energy absorption

Changing heights in water column

Use of new materials and manufacturing

Wave Energy Prize Updates

http://waveenergyprize.org/newsroom

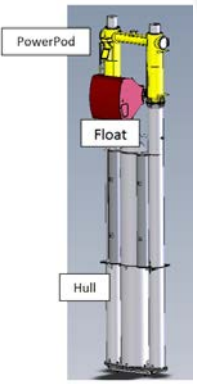
https://waveenergyprize.wordpress.com/

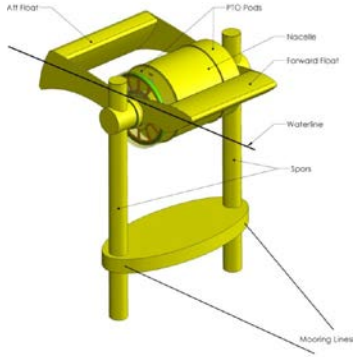
https://www.facebook.com/WaveEnergyPrize

WECs @ Hawaii Wave Energy Test Site (WETS)

DOE is supporting companies testing their WECs @ the Navy's WETS @ Marine Corps Base Hawaii, Kaneohe Bay, Hawaii for comparison of performance, reliability, and LCOE

Developer	Technology	WETS Test Location	Estimated FY Testing Dates	DOE Support
Northwest Energy Innovations	point absorber (1:2 scale)	shallow berth (30m)	Fall, 2015 (extended)	design, fabrication, and testing
Ocean Energy	OWC (1:1 scale)	deep berth (80 m)	2017 (spring) (12 months)	design, fabrication, and testing
Columbia Power Technologies	point absorber (1:1 scale)	deep berth (80 m)	2018 (12 months)	design, fabrication, and testing
Northwest Energy Innovations	point absorber (1:1 scale)	deep berth (80 m)	2017 (end) (12 months)	design, fabrication, and testing





FY16 New Awards-
MHK Energy Conversion & Environmental Monitoring Technology

<u>Topic Area 1:</u> Advanced Technology Integration and Demonstration ($16.05M)

Will help advance wave and current energy (ocean/tidal/river) technologies by supporting projects that integrate advanced MHK components into system designs and then demonstrate the improved systems in full-scale open-water tests for at least 1 year.

1. Integrate an MHK hardware and/or software technology into an optimized system
2. Fabricate a full-scale system prototype
3. Install and demonstrate the system during a 1-year open water testing campaign
4. Demonstrate credible improvements in AEP and LCOE

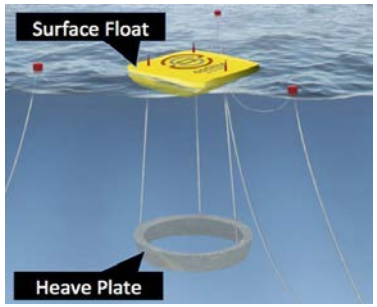
Selectees:

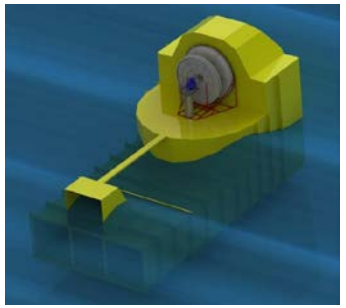
Wave Energy Converters

- Oscilla Power (Seattle, WA)
- Dresser-Rand (Wellsville, NY)

Tidal Energy Converter

- Ocean Renewable Power Company (Portland, ME)





FY16 New Awards-
MHK Energy Conversion & Environmental Monitoring Technology

<u>Topic Area 2:</u> Innovation, Testing, and Validation of MHK Environmental Monitoring Instrumentation Performance ($5.95M)

Will support the progressive testing, innovation and validation of instrumentation for cost-effectively monitoring potential environmental impacts of MHK devices.

Selectees:

Acoustic outputs

- Integral Consulting, Inc. (CA)
- University of Washington (WA)

Electromagnetic Fields

- Woods Hole Oceanographic Institution (MA)

Marine Organism Monitoring

- BioSonics, Inc. (WA)
- Florida Atlantic University (FL)

Benthic Monitoring and Mapping

- Integral Consulting, Inc. (CA)

Integrated Sensor Package

- University of Washington (WA)

8

FY16 Funding Opportunity Announcement (FOA) Open Water Test Infrastructure

To support the full-scale testing of MHK wave energy devices, the Water Power Program intends to fund a recipient to build and commission an open-water, grid-connected, fully energetic domestic wave test facility.

Total Amount to be Awarded	**Up to $40 million***
Period of Performance	60 months

Site Location & Resource Requirements:

- Located in U.S. Federal waters (territorial sea or contiguous zone) or state waters.
- Test berths subject to full (unprotected) oceanic wave regimes
- Wave average annual power density ≥ 30 kW/m
- Testing berth water depths ≥ 60m

Site Capacity:

- At least three testing berths, with sufficient infrastructure and support capacity to accommodate simultaneous testing of the corresponding number of WEC devices
- Rated test capacity of each berth to accommodate WEC devices approximately 1 MW in size
- Access & approval for grid interconnection with sufficient line capacity to operate all testing berths simultaneously at rated power

Facility Life-Span:

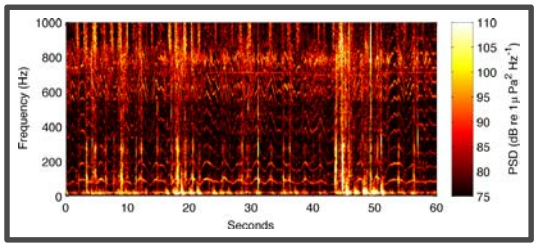
Any proposed facility developed and constructed under this FOA should be capable of supporting industry testing for a minimum of 20 years prior to decommissioning . EERE anticipates making awards that will run up to 60 months in length.

Market Acceleration & Deployment Program Goals

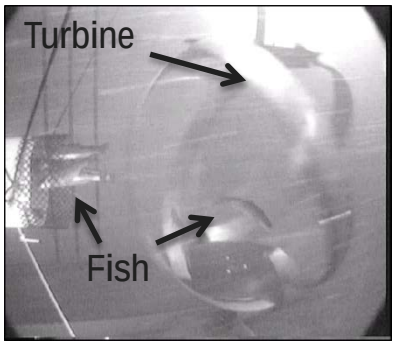
A DOE research strategy to proactively address the highest priority environmental information needs will reduced the time and cost of permitting and licensing for MHK projects

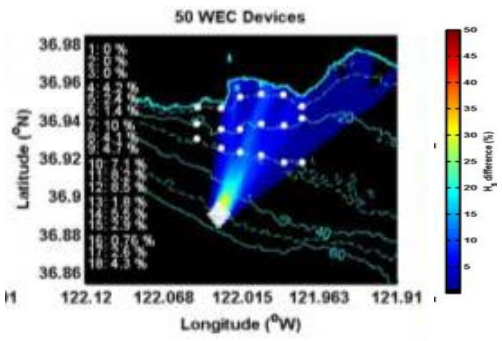
- Data Collection & Experimentation
- Monitoring & Mitigation Technologies and Techniques
- Information sharing & International Collaboration

Data Collection & Experimentation



Bassett, C., J. Thomson, B. Polagye, and K. Rhinefrank (2011) Underwater noise measurements of a 1/7th scale wave energy converter, MTS/IEEE Oceans 2011, Kona, HI, September 19-22.

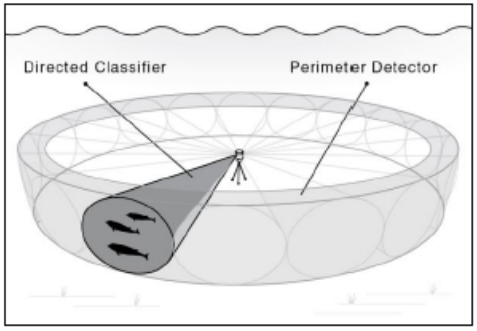


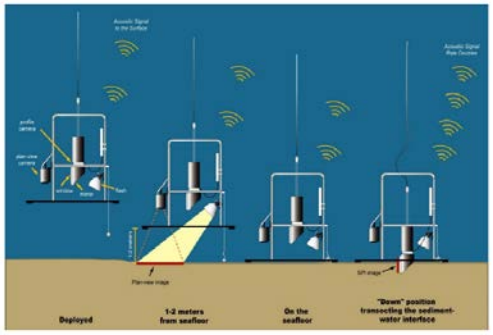


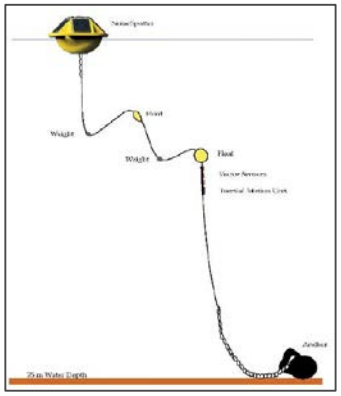
- Data collection around deployed MHK devices and surrogates
  - Fish behavioral response to tidal turbines
  - Marine organism susceptibility and response to EMF
  - Reefing effects
  - Acoustic signature of WECs
  - Marine mammal response to marine renewable energy converter noise
- Laboratory Experiments
  - Fish response to tidal turbine noise
  - Fish survival when passing through tidal turbines
- Numerical Modeling
  - Impacts of energy removal from Wave and Tidal Energy converters
  - Acoustic propagation of MHK-produced noise
  - Eulerian-Lagrangian Agent Method for modeling fish behavior near tidal turbines

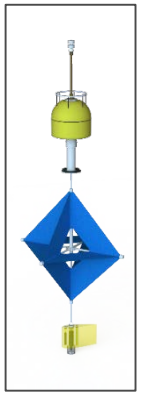
Monitoring & Mitigation Tools & Techniques

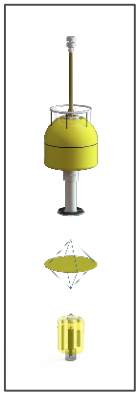
- Develop cost-effective, fit-for-purpose monitoring tools and techniques to address high priority regulatory concerns
  - Marine Organism Monitoring
  - Acoustic Outputs of MHK Devices
  - Electromagnetic Fields
  - Integrated Sensor Packages
  - Automated Data Processing

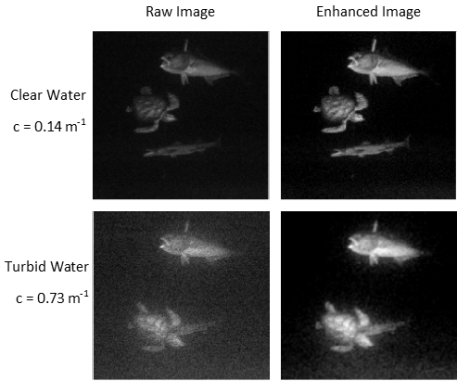


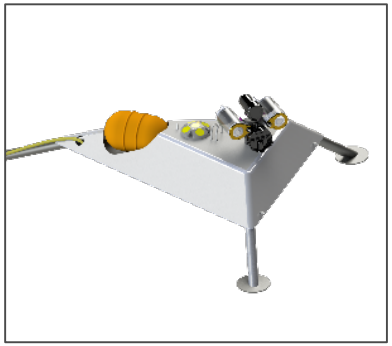




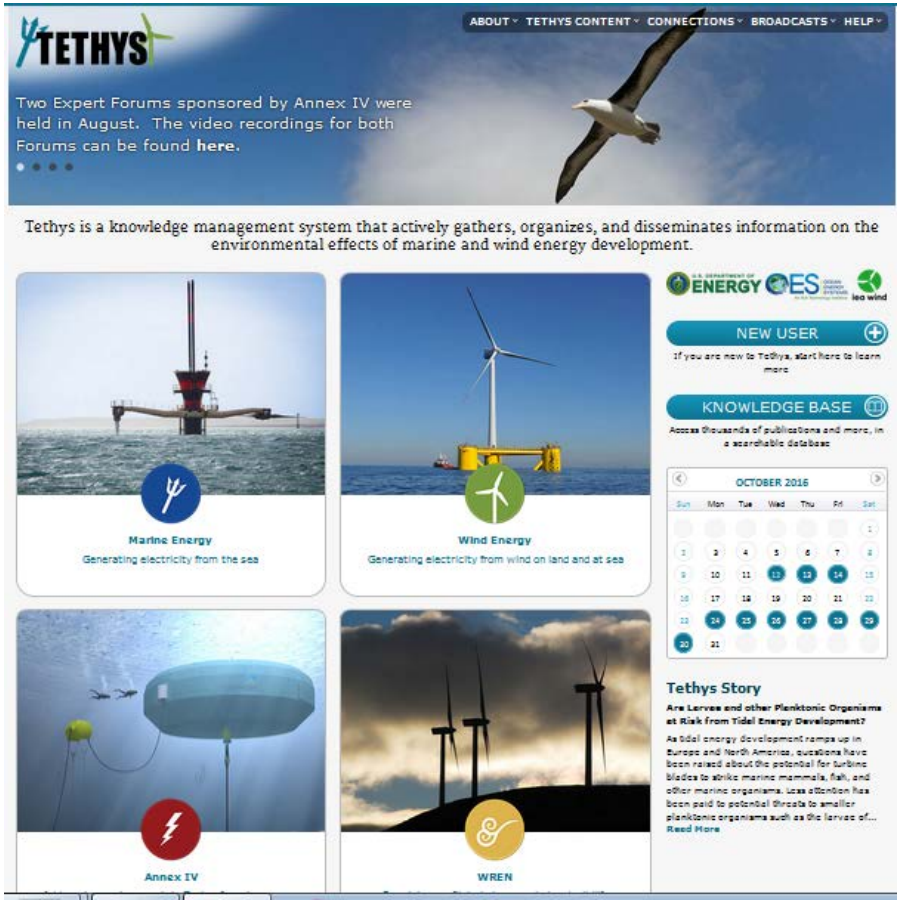








Information Sharing & International Collaboration



http://tethys.pnnl.gov

Annex IV

- International collaborative of the Ocean Energy Systems (OES), under the International Energy Agency (IEA) Technology Network
- Engage members of the Marine Renewable Energy community around key environmental interactions important to the siting and permitting of devices and arrays
- Provide useful, accessible information for regulators to reduce uncertainty around environmental effects

2016 Annex IV State of the Science Report

ENVIRONMENTAL EFFECTS OF MARINE ENERGY DEVELOPMENT AROUND THE WORLD

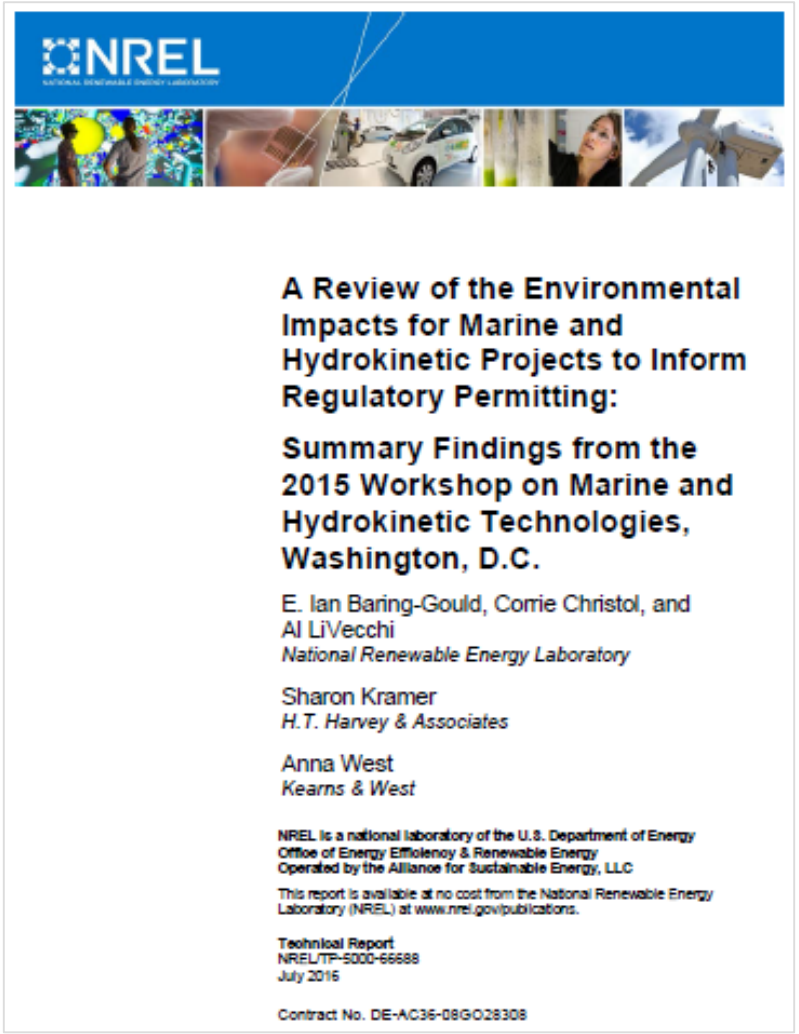
- This report is the **most comprehensive** synthesis of the state of scientific understanding of environmental research of marine renewable energy ever produced.
- Summarizes interactions and effects of MRE devices on the marine environment
- The report will be used to:
  - **retire environmental risk** for marine energy technologies;
  - **avoid duplication of research** and **monitoring** efforts;
  - **promote the sustainable development** of marine renewable energy technologies;
  - and to ensure that accurate and up-to-date **information is available** to regulators, industry members, and scientists worldwide.

http://tethys.pnnl.gov/publications/state-of-the-science-2016

MHK Regulator Workshop Report

Results from workshop held in Washington D.C. in 2015 with U.S. regulators and prominent scientific experts to review:

- Historical experiences related to environmental monitoring required fro U.S. deployments
- Existing information on the potential likelihood and severity of any environmental impacts
- Any recommendations for future shifts in regulatory considerations or approaches



NREL

A Review of the Environmental Impacts for Marine and Hydrokinetic Projects to Inform Regulatory Permitting:

Summary Findings from the 2015 Workshop on Marine and Hydrokinetic Technologies, Washington, D.C.

E. Ian Baring-Gould, Corrie Christol, and Al LiVecchi
National Renewable Energy Laboratory

Sharon Kramer
H.T. Harvey & Associates

Anna West
Kearns & West

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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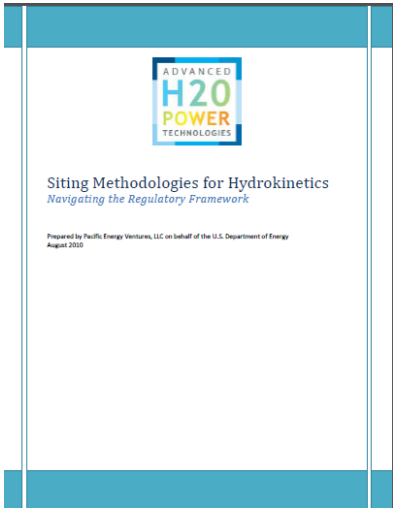
This report is available at no cost from the National Renewable Energy Laboratory (NREL) at www.nrel.gov/publications.

Technical Report
NREL/TP-5000-66688
July 2016

Contract No. DE-AC36-08GO28308

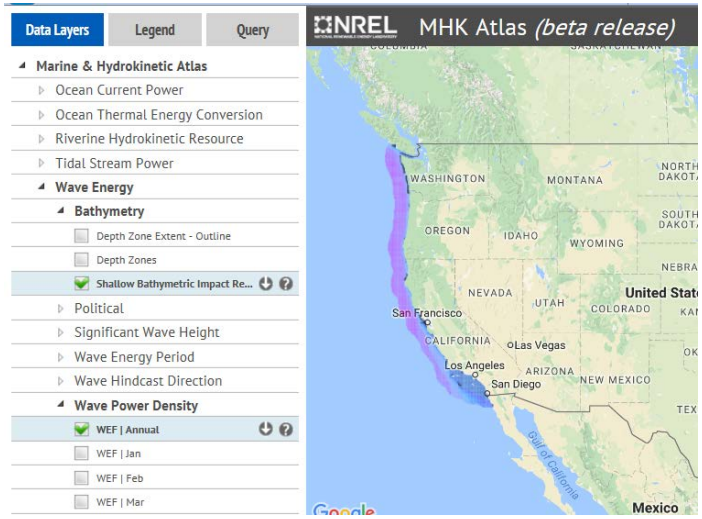
http://tethys.pnnl.gov/sites/default/files/publications/Baring-Gould-et-al-2016-Workshop.pdf

Other Useful Resources



Siting Methodologies for Hydrokinetics – Navigating the Regulatory Framework

- Will be updated in 2017
- http://tethys.pnnl.gov/sites/default/files/publications/PEV_2010_Siting_Methodologies.pdf



MHK Resource Assessments and Atlases

- http://www.nrel.gov/gis/mhk.html

Questions?

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