Evaluating Environmental Risks of Marine and Hydrokinetic (MHK) Development

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CESA Webinar
August 19th 2010
Environmental Effects of MHK Energy Development

Project purpose: To address environmental issues needed to get MHK devices in the water through four tasks:

1. Classifying & evaluating environmental effects
   - Organize data into a “smart”, searchable database
   - Use risk assessment tools to determine the really important risks
   - This task integrates the other tasks in the project

2. Effects of energy removal from waterbodies

3. Effects on animals
   - Electromagnetic fields
   - Acoustic output
   - Physical interaction
     - Strike, entrainment, impingement
     - Attraction, avoidance

4. Siting constraints and opportunities
   - Stakeholder engagement and spatial planning
MHK Knowledge Management System, aka “Tethys”

- Named for Greek Titan goddess (daughter of Gaia, wife of Oceanus) who was seen as the embodiment of the oceans on earth
- Primary function of the system is as a knowledge base to support the risk framework (ERES)
  - Evidence collection and marshalling
  - Data navigation and management of risk model results
- Other functions expected to be important
  - Knowledge portal for various stakeholders
  - Portal to other knowledge sources (e.g., Annex IV database under construction)
  - Collaborative environment for MHK research
Tethys serves as knowledge management framework for MHK environmental studies.
Tethys platform features:

- Automated ingest of documents into a wiki-like environment
  - PDF files, Word documents, web pages, etc
  - Automatic semantic encoding of many meta-data fields
- Semantic “pipeline” processing to aid in recognizing and tagging key types of entities
  - People
  - Places
  - Specific vocabulary terms
- Rich annotation features
- Semantic search
Screen Shot 1: FERC permit data imported into map view
Tethys Screen Shots

Screen Shot 2: Drill-down to individual project
Tethys Screen Shots

Screen Shot 3: Doc association with FERC record via semantic link
Environmental Interactions of MHK Devices

Operational Phase

- Chemical releases
- Physical presence (static)
- Noise
- EMF
- Physical presence (dynamic)
- Catastrophic failure

Changes in Physical Environment: Near Field
- Animal Behavior
- Animal migration
- Animal injury and mortality - physical
- Chemical toxicity
- Habitat destruction

Changes in Physical Environment: Far Field

Population level effects
- Chronic stressors
- Intermittent stressors
- Episodic stressors

Community level effects
- Effects of concern

Ecosystem level effects

Large-scale, long-term effects
Environmental Risk Evaluation System (ERES) for MHK

- Decision support tool to address environmental issues and get devices in the water
- System for evaluating risk of an MHK project by attributes of:
  - Technology components
  - Waterbodies
  - Site characteristics
  - Receptors (aquatic animals, aquatic system response, etc.)
- Use of cases to compile risk-relevant attributes; multiple cases will help “span the analytical space”
- Accumulation of cases will define risk of MHK devices/arrays to create predictive power
- Risk will be assigned to attributes of cases using:
  - (initially) Expert opinion
  - (as they become available) Experimental, monitoring, and modeling data
What We Mean by Risk:

SCENARIOS
Sequences of Events with Adverse Impacts

EPISODIC
Vessel Impact

INTERMITTENT
Blade Strike

CHRONIC
Chemical Leaching

UNCERTAINTIES

Frequency of Scenario

Likelihood/Rate of Occurrence

Degree of Impact

Environmental / Ecological Effects
Process for Developing MHK Environmental Risk Evaluation System
ERES Case Selection Criteria

1. **Real/Readiness** (in water w/in 2 yrs; ready technology + ready project)
2. **Developer Willingness** (willing to share technology + project data)
3. **Diverse Representation** (does the case span the analytical space)
   a) Technology Type (tidal, wave, riverine)
   b) Technology Configuration (e.g. axial flow, horizontal flow)
   c) Climatic Zone (temperate, tropical, sub-arctic)
4. **National Interest** (e.g. recipient of DOE funding)
5. **Available Data** (environmental effects data available)

**Decision rules:**
- No/insufficient: Reconsider later or make improvements
- Yes/Optimal: Next question or select
Initial Case Selections

Three risk cases to screening analysis level in FY10; more cases in FY11-12

Cases drawn from real projects

One tidal, one wave, one riverine

1. TIDAL – Open Hydro in Admiralty Inlet, WA
   - Open-Center Turbine in Puget Sound, WA
   - Ducted, axial flow, gravity mounted
   - Temperate estuarine
   - Bidirectional water flow
   - Protected Southern Resident Killer Whales, other marine mammals, ESA listed species
FY10 Case Selections

2. RIVERINE - Free Flow Energy at Scotlandville Bend, Mississippi River
   • Ducted, axial flow, bottom-mounted, multiple units
   • Shallow riverine (comparatively)
   • Unidirectional water flow
   • Migrating birds, endangered sturgeon

3. WAVE - OPT PowerBuoy off Reedsport, OR
   • Point attenuator
   • Open coast continental shelf (< 3 mi offshore)
   • Dominant wave direction
   • Migrating whales, endangered fish
Process for Developing MHK Environmental Risk Evaluation System
Current ERES Work

Screening Analysis:
- Determine risk-relevance of each stressor/receptor interaction
- Determine “risk factors” to rank stressor/receptor interactions:
  - population size
  - affected life stage
  - proximity to device
- Work with scientists to rank risks for each receptor according to risk factors

Output = Three screening analyses by Oct 2010
Ranking Scheme

Take into account risk weighting:

- **Migrating fish**
  1. Blade strike *Tidal*
  2. Behavior, attraction *Wave*
  3. ...

- **Endangered marine mammals**
  1. Entanglement mooring lines *Wave*
  2. Blade strike *Tidal*
  3. Change in migration, avoidance *Wave*

- **Changes in water quality, sedimentation patterns**
  1. Scour of river bed *River*
  2. Hypoxia farfield *Tidal*
  3. Change in beach form *Wave*

- **Benthic habitats**
  1. Disturbance due to anchoring *Wave*
  2. Scour of river bottom *River*
  3. ...

Sort & rank

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Next Steps and Outcomes of ERES

- Risk modeling: (2010-2012)
  - Deterministic, probabilistic, impact assessment, sensitivity analysis
  - Output = risk scores
- Design of risk management, mitigation
- Risk Communication:
  - Guidance for regulators
  - Visualization tools
For More Information

Project website:  [www.advancedh2opower.com/PNNL](http://www.advancedh2opower.com/PNNL)
Annex IV

- **International Energy Agency – Ocean Energy Systems**
  - “Annex” is an agreement to carry out collaborative tasks

- **IEA Annex IV**
  - Eight member nations, U.S. is lead, DOE/MMS/FERC
  - Gather environmental effects data from member nations, evaluate effects, monitoring methods, mitigation strategies

- **PNNL will lead for U.S.**
  - Create portion of *Tethys* for Annex IV data
  - Contractor to assist with data collection, analysis
  - Experts’ workshop in Dublin in September
Acknowledgements & Contact Information

- This work supported by the US Department of Energy Office of Energy Efficiency and Renewable Energy’s Wind & Hydropower Technologies Office (WHTP)
- KEF development supported by the PNNL Technosocial Predictive Analytics Initiative (TPAI)

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