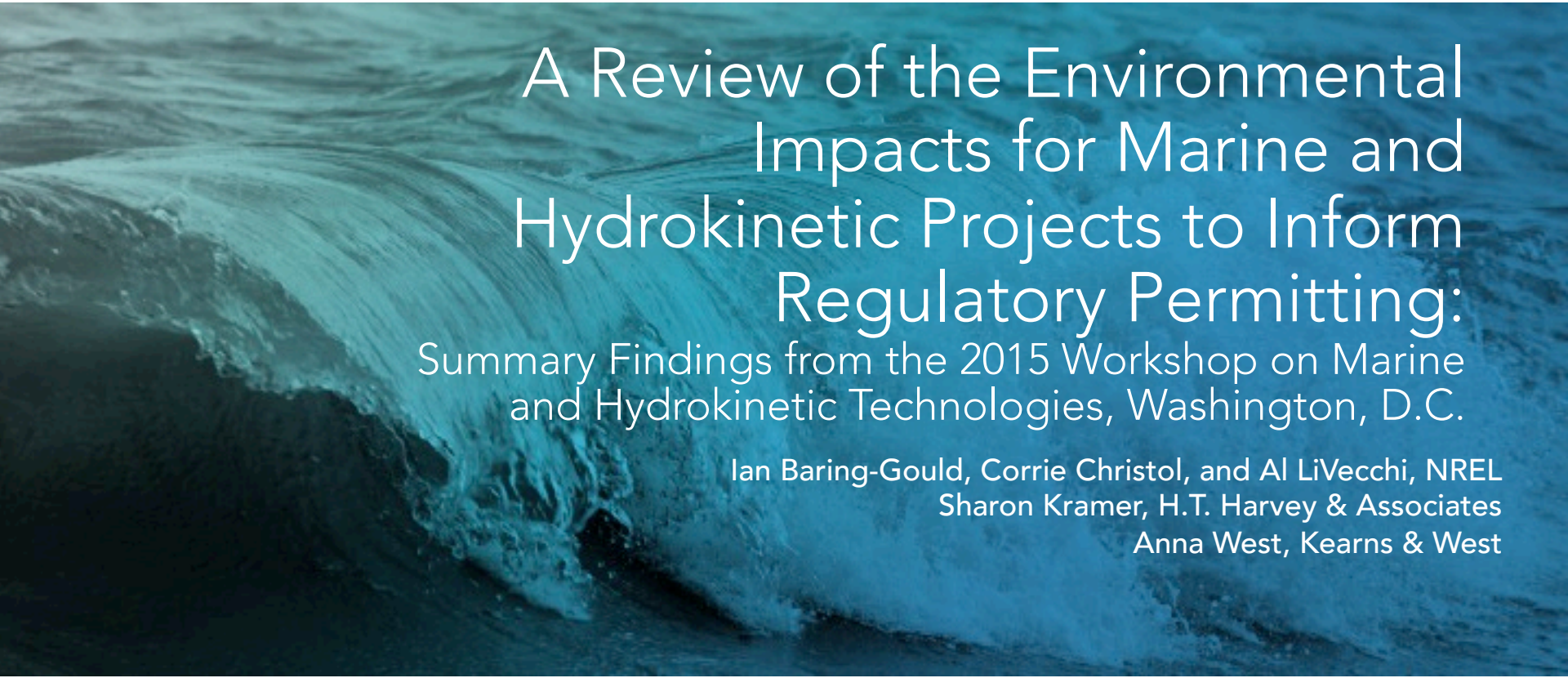

A Review of the Environmental Impacts for Marine and Hydrokinetic Projects to Inform Regulatory Permitting:

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

Ian Baring-Gould, Corrie Christol, and Al LiVecchi, NREL
Sharon Kramer, H.T. Harvey & Associates
Anna West, Kearns & West

Ocean Renewable Energy Conference XI
September 21-22, 2016

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Agenda, Day 1

- Regulatory Introduction: Roles and Responsibilities within the Permitting Process
- MHK Technology Overview
- Introduction and Overview of Environmental Issues and Processes
- Physical Interactions with MHK Devices
- Acoustic Output from MHK Devices
- Effects of MHK Development on Physical Systems
- IEA Annex IV and Tethys Database Demonstration

Agenda, Day 2

- Electromagnetic Force from Tidal and Wave Systems and its Impact on Marine Animals
- Lessons Learned from the Wind Industry
- Federal and State Agency Roundtable: Perspectives on the Permitting Process
- Information and Perspectives from Industry
- Adaptive Management Case Studies Roundtable
- Breakout Discussions: Knowledge Gaps and Research Needs

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Workshop discussions

- Observed and theorized impacts from MHK devices
- Evolving “best practices” for measurement and monitoring of key potential impacts
- Effective implementation of adaptive management practices and other “risk-based” approaches as part of the regulatory process for new MHK installations

Four areas of potential environmental impact

- Acoustic output impacts (Chris Bassett, UW/WHOI)
- EMF emissions (Andrew Gill, Cranfield)
- Physical interactions (Jocelyn Brown-Saracino, DOE)
- Environmental effects of MHK energy development on the physical environment (Jesse Roberts SNL, Craig Jones Integral)

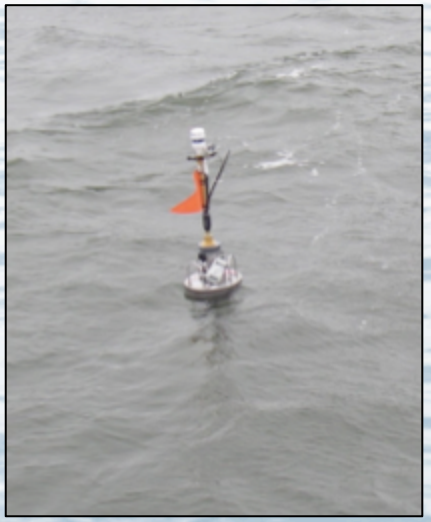
"Levels of consideration"

- "**Known Known**" topics in the technical presentations identified issues are understood well enough that no further monitoring is warranted.
- The "**Known Unknowns**" identified issues for which the research community has the knowledge and technology to study but for which the impact and cost of a study are uncertain.
- The "**Unknown Unknowns**," areas that have not been widely assessed, and whether it is necessary to further study the issue and make it known. For issues that should be studied further, presenters discussed when and how to address the issue and whether the technology exists to study it effectively.

	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
Operational Noise	Information collected to date indicates that operational devices are typically less noisy than other anthropogenic sources. Monitoring is generally not warranted as significant acoustic impacts are unlikely and difficult to distinguish from background noise.	Data collection at demonstration scales may be appropriate, if detectable, to inform modeling for larger-scale arrays. Research on biological and behavioral implications of sound and particle motion would be helpful.

What Should Be Measured to Enable Better Understanding of the Impacts?

- How should it be measured?
  - Hydrophones are a standard tool for sound measurements
  - Particle velocity measurements (difficult)
  - More on measurement approaches later…

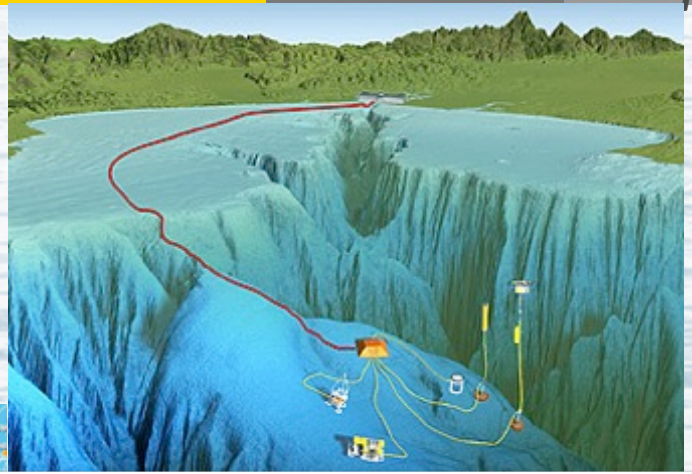


	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
Electromagnetic Fields	No significant effects to organisms have been observed to date. Monitoring is generally not warranted since EMFs are likely to be low intensity and approach background levels within a few meters from the source.	EMF emissions are relatively scalable as power and voltages increase but the responses of any receptive animals are not; thus research on single devices or small-scale arrays may not be directly transferable to larger-scale projects. Existing energy subsea cables can be utilized to assess EMF levels and animal behavioral responses.

Crossover from Other Industries

Known
Known

- Power generation companies
- Sub-sea cable companies and networks
- How relevant is this information?



http://subseaworldnews.com/

	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
Physical Interactions (Strike)	No physical interactions have been observed in the field. Lab experiments have found that fish can easily detect and avoid or swim around turbines and have very high survival rates when forced to pass through turbines. Any required monitoring should be based on risk posed at the project of interest and should consider that strike events are likely to be rare, difficult to detect, and very costly to monitor.	Research to better understand the risk of strike and development of predictive models (e.g., location in the water column relative to the device, avoidance and evasion behaviors) and identification of potential mitigation actions would be helpful.

What do we know, what questions remain, and how do we move forward?

- No observations to date of strike injury or mortality in the field from tidal turbines, but some limitations on monitoring to date
- General agreement among the scientific community that strike events are likely to be rare
- Rareness of strike events will make them inherently hard to observe and to prove out monitoring technologies (sample size issues)

	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
Impacts on Physical Systems	Numerical modeling consistently predicts that arrays <10 devices will have minimal impact on wave heights, flow patterns, and sediment transport. Monitoring is generally not warranted as impacts from a single device or small arrays will likely be minimal.	Impacts of larger arrays are unknown and will require more research. Data from eventual large arrays are needed to validate predictive models.

Summary of Findings

Numerical evaluations have been performed for both Current Energy Converters (CEC) and Wave Energy Converters (WEC)

- **Overall Findings**
  - Small arrays (~10) of CEC/WEC devices have minimal effect on the physical environment – SITE SPECIFIC
  - As array size increases, effects increase and require further study
- **Current Energy Converters**
  - Small arrays have localized effects on 'potential' benthic habitat and water column with minimal effect far-field
- **Wave Energy Converters**
  - Small offshore arrays (~10) have minimal near-field effects and minimal potential for affecting far-field transport patterns

Follow on needs

- The need for an umbrella collaborative or organization to serve as a central clearinghouse for global research and monitoring needs within the MHK industry
- Because natural variability in marine environments is high and events/interactions of concern are likely to be rare, the ability to detect effects using traditional monitoring tools is very low
- A NEPA/Permitting database could provide a useful source of information for future project permitting