Marine Renewable Energy Environmental Regulatory Workshop Report: Moving to Better Information and Risk Retirement

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Pacific Ocean Energy Trust
May 17 2017

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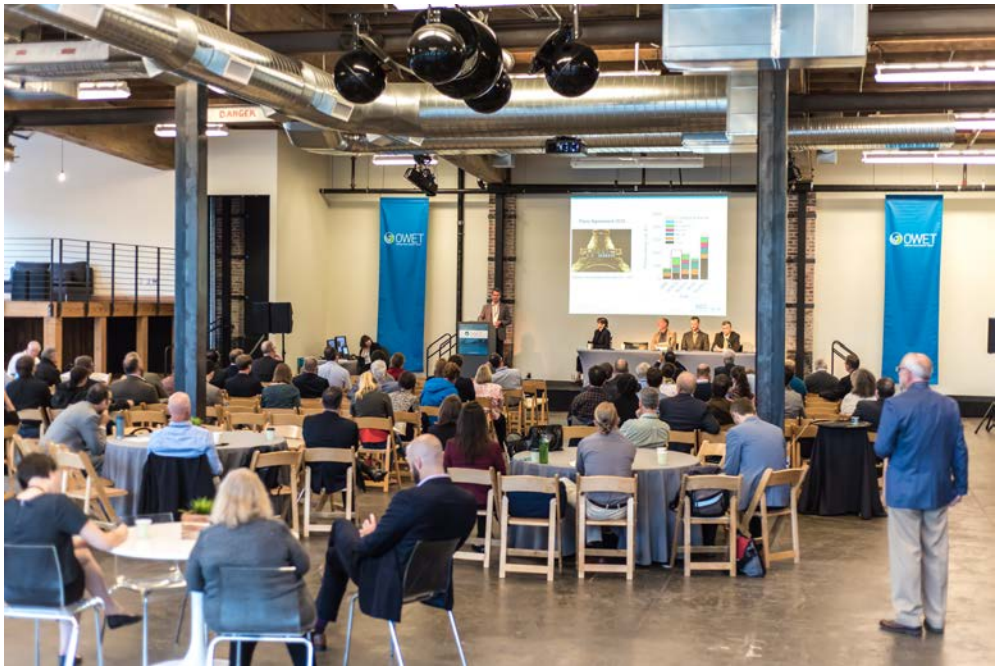
Purpose and Need

- MRE industry concerns about permitting processes being long, drawn out, challenging, and expensive
- Regulator concerns about level of risk associated with key interactions of devices with marine animals, habitats, and ecosystem processes
- In response: OWET/POET workshop held 21 September 2017 in Portland Oregon



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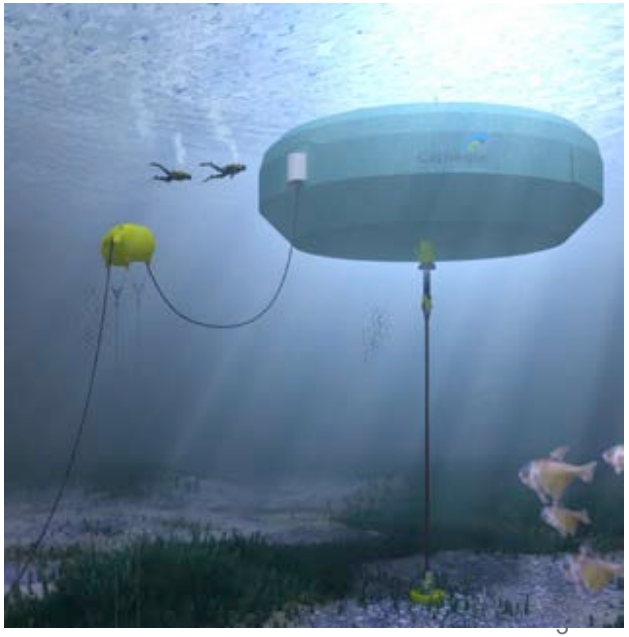
Approach

- Goal: examine the most recent research findings and established open lines of communication among the regulatory, development, and research community about the environmental effects of MRE development
- Overviews:
  - 2016 OES Annex IV State of the Science report
  - 2016 report on the 2015 MHK Environmental Effects Workshop in DC
- Dashboard approach
- Industry/applicant and Regulator panels
- Next steps



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2016 Annex IV State of the Science Report

ENVIRONMENTAL EFFECTS OF MARINE ENERGY DEVELOPMENT AROUND THE WORLD

Andrea Copping
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OES OCEAN ENERGY SYSTEM
An IEA Technology Initiati
ANNEXIV

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

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

State of the Science Report – Annex IV

- State of Science report summarizes interactions and effects of MRE devices on the marine environment, the animals that live there, and the habitats that support them.

- State of the Science is intended to:
  - Inform regulators and researchers about potential risks from tidal and wave installations;
  - Assists MRE developers in developing engineering, siting, operational strategies, and monitoring options for projects that minimize encounters with marine animals and/or diminish the effects if such encounters occur.

- State of Science includes 10 chapters, 13 authors, 6 countries
- Annex IV is a collaborative initiative of the Ocean Energy Systems (OES), under the International Energy Agency (IEA) Technology Network.

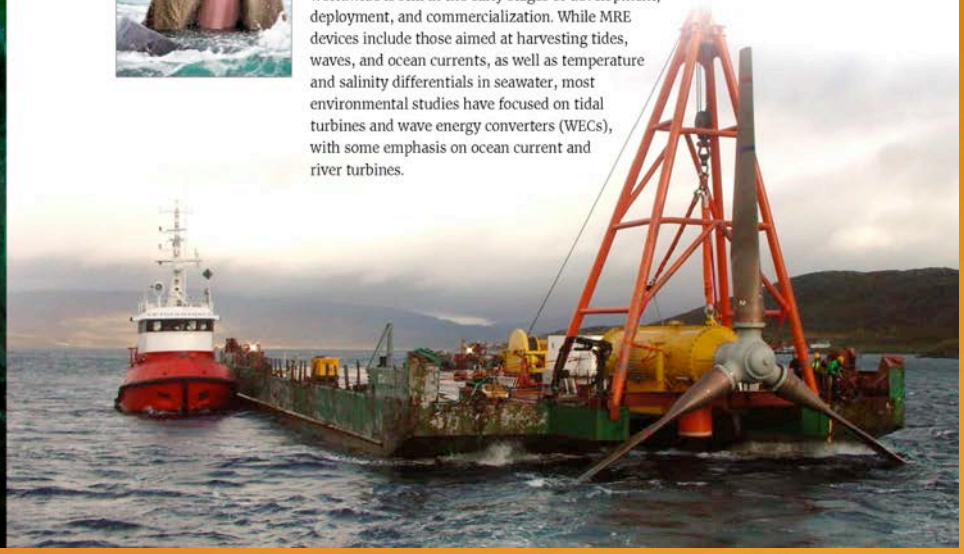
PUBLIC REVIEW DRAFT

1.0 Introduction

Chapter author: A. Copping

This report summarizes the state of the science of interactions and effects of marine renewable energy (MRE) devices on the marine environment, the animals that live there, and the habitats that support them. This report serves an update and a complement to the 2013 Annex IV report that can be found at *http://tethys.pnnl.gov/publications/final-annex-iv-report-2013*.

MRE development is also referred to as ocean energy development, or marine and hydrokinetic energy development; we use the acronym MRE throughout this document for consistency. MRE development worldwide is still in the early stages of development, deployment, and commercialization. While MRE devices include those aimed at harvesting tides, waves, and ocean currents, as well as temperature and salinity differentials in seawater, most environmental studies have focused on tidal turbines and wave energy converters (WECs), with some emphasis on ocean current and river turbines.



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2.0

Summary of Potential Environmental Interactions Associated with the Deployment of Marine Renewable Energy Devices

Chapter authors: L. Hanna, A. Copping

As MRE technologies are installed, they will interact with and affect the surrounding marine environment in a variety of ways. Depending on the specific technology, certain stressors or components of each device may affect marine animals and habitats, also referred to as environmental receptors. Table 2.1 lists the key potential stressor-receptor interactions associated with MRE technologies (Boehlert and Gill 2010; Copping et al. 2013; Aquatera Limited 2012), and provides a brief description of each potential interaction.

Chapter 2 – Interactions around MRE Devices

Focus:

- Overall risk of MRE devices to marine animals and habitats

Highlights:

- Scientific uncertainty drives much of the risk perceived now; more data collection and research can help to reduce uncertainty.
- Most important and potentially highest risk interactions include:
  - Collision of animals with tidal turbines,
  - Underwater noise from MRE devices on animals,
  - EMF from cables and devices.
- Generally little impact expected from single devices, larger arrays will require more investigation.

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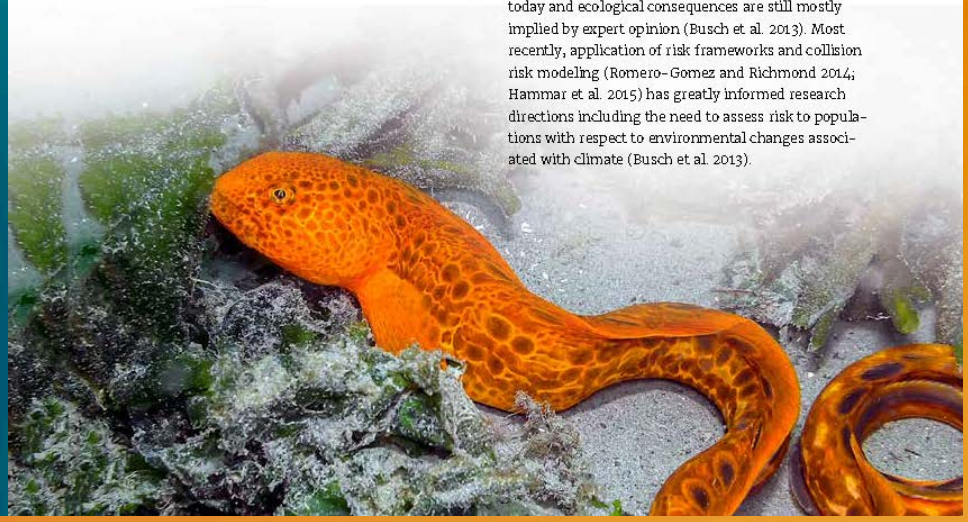
3.0 Collision Risk for Animals around Tidal Turbines

The potential for marine animals to collide with the moving parts of tidal devices, particularly the rotors of horizontal-axis tidal-stream turbines, is a primary concern for consenting/permitting and licensing of tidal developments. The importance of this issue, associated definitions, and the need to understand collision risk in general, and for mammals, fish, and seabirds, in particular, are discussed in the following sections.

Chapter authors: G. Zydlewski, G. Staines, C. Sparling, E. Masden, J. Wood

3.1 IMPORTANCE OF THE ISSUE

Animal interactions with tidal turbines is an active area of research because many questions remain today and ecological consequences are still mostly implied by expert opinion (Busch et al. 2013). Most recently, application of risk frameworks and collision risk modeling (Romero-Gomez and Richmond 2014; Hammar et al. 2015) has greatly informed research directions including the need to assess risk to populations with respect to environmental changes associated with climate (Busch et al. 2013).



Chapter 3 – Collision with Tidal Turbines

Focus:

- Risk to animals from collision with the blades of a tidal turbine

Highlights:

- Animals considered to be at potential risk include marine mammals, fish, and diving seabirds.
- No observations have ever been made of a marine mammal collision with a device, significant collisions by fish.
- Technologies to observe collision are not well developed and difficult to operate in high-energy environments.
- Important to quantitatively estimate number of animals potentially in area of turbines, and to understand their capability to sense and evade devices.
- Collisions with tidal turbines are examined for individual animals; results must be put in context of risk to populations.

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4.0

Chapter authors:
N. Sather, A. Copping

Risk to Marine Animals from Underwater Sound Generated by Marine Renewable Energy Devices

The effects of acoustic output from tidal and wave devices on marine animals were previously addressed in the 2013 Annex IV report. The purpose of this chapter is to provide an update of new knowledge relating the effects of underwater sound from wave and tidal devices to marine animals.

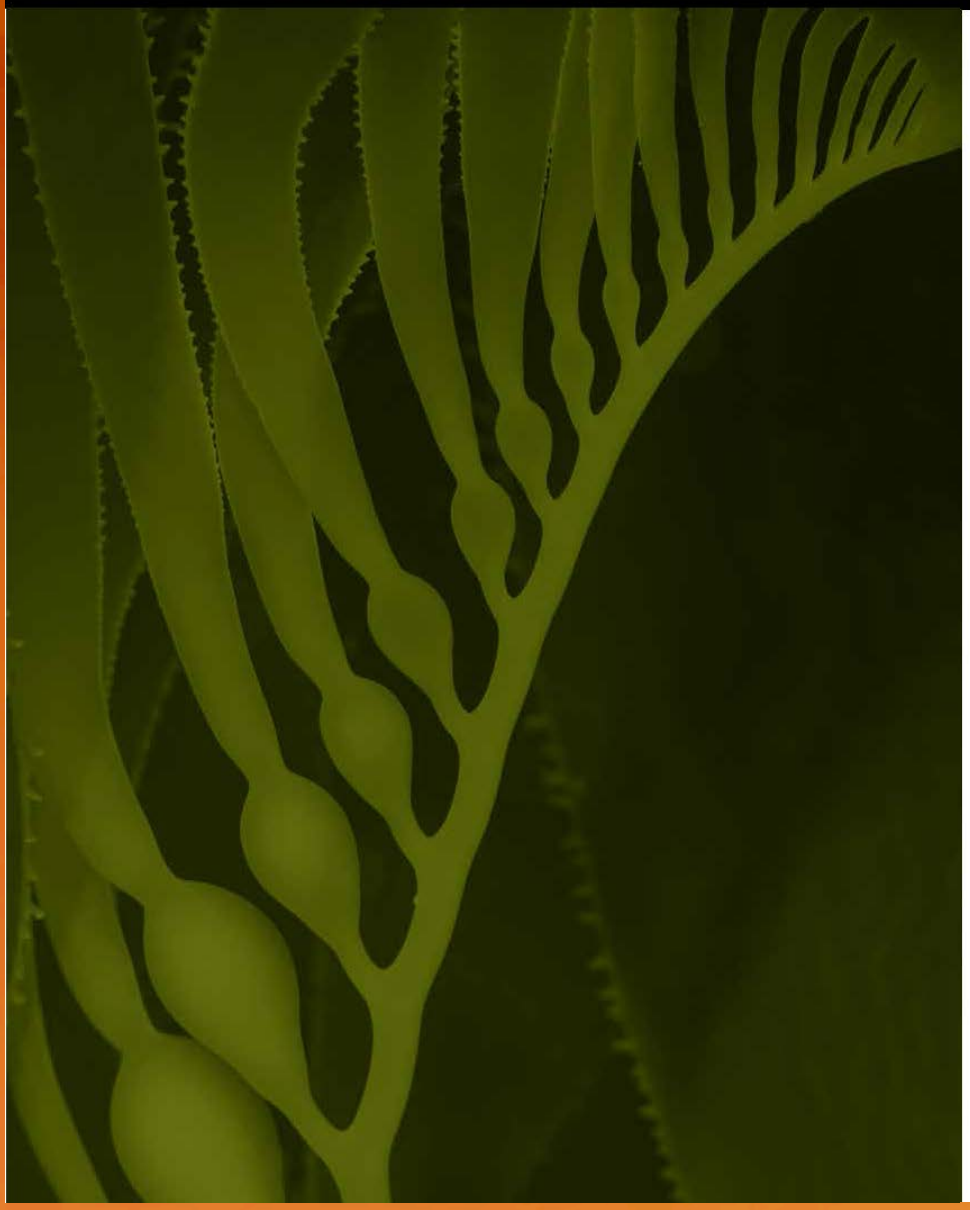
Chapter 4 – Underwater Noise

Focus:

- Potential effects of underwater noise on marine animals from wave and tidal devices.

Highlights:

- Marine animals use underwater sound as terrestrial animals use light to see, especially for navigation and communication.
- Sound from MRE devices may add to other anthropogenic sounds and could disturb animals, especially marine mammals and fish.
- Noise from single turbines and WECs are being measured, and predictions can be made about what arrays may sound like to marine animals.
- Excess underwater noise could cause physical harm including loss of hearing ability, physical harm to tissues, and/or behavioral changes.
- Additional data are needed to understand how sounds may affect animals.



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5.0

Chapter authors: J. Whiting, A. Copping

Changes in Physical Systems: Energy Removal and Changes in Flow

The effects of altering natural water flows and removing energy from physical systems in the ocean by the installation and operation of MRE devices were previously addressed in the 2013 Annex IV report (Copping et al. 2013). The purpose of this chapter is to summarize previous information about flow changes and energy removal caused by wave and tidal devices, including changes in sediment transport and water quality, and to update these findings with new knowledge.

5.1 GOAL AND OBJECTIVES

The goal of this chapter is summarize the state of knowledge of changes in the physical ocean systems caused by MRE projects worldwide. Objectives include the following:

- Identify recent wave and tidal projects with a monitoring program that addresses physical changes in the environment.
- Analyze details of recent laboratory experiments and numerical modeling simulations that help to inform the understanding of potential physical effects from MRE devices.
- Compare the cumulative understanding from recent studies with knowledge gaps identified in the previous Annex IV report to identify progress.
- Diagnose persisting knowledge gaps based on a review of available research.

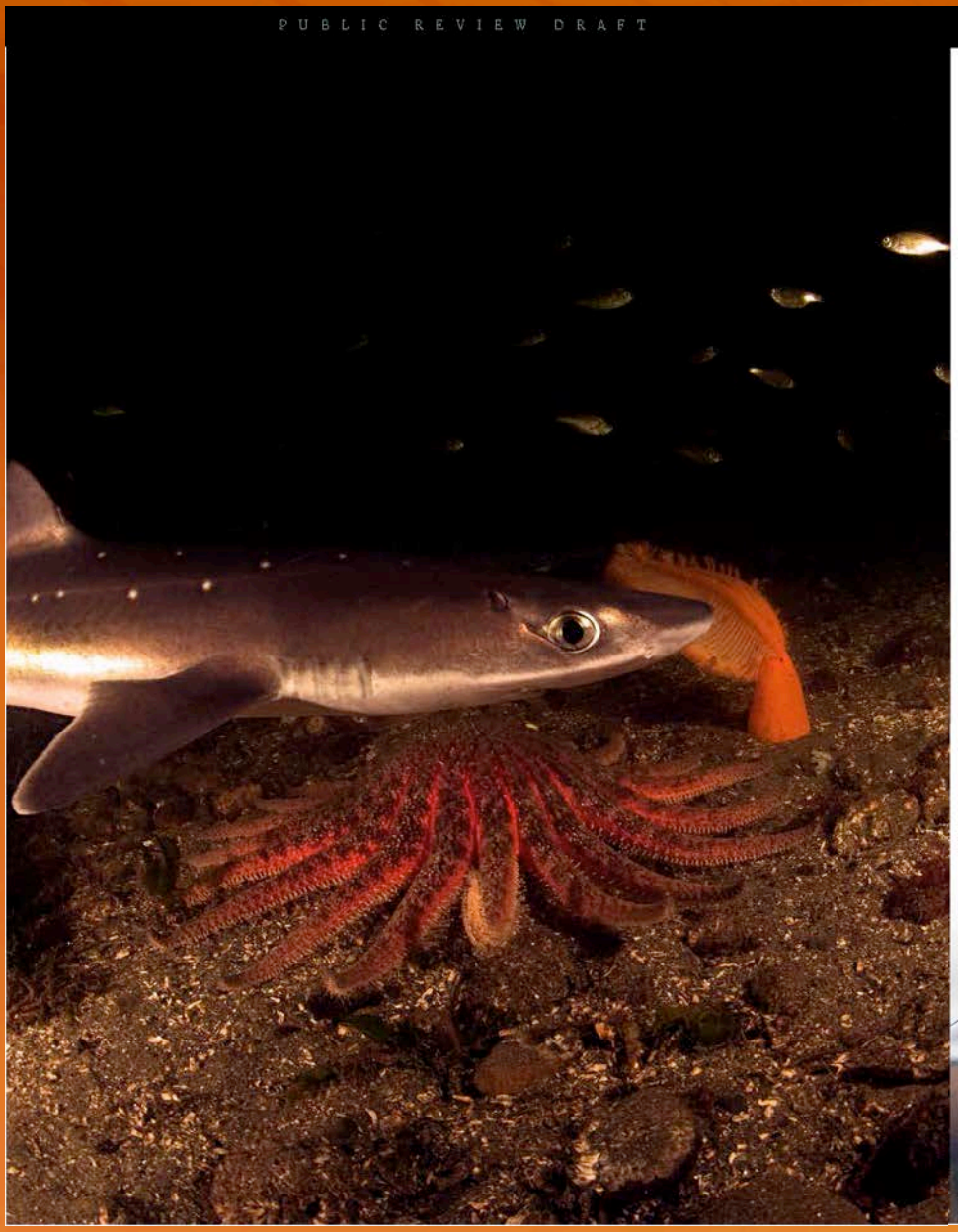
Chapter 5 – Changes in Physical Systems

Focus:

- Effects on ocean waters of MRE development.

Highlights:

- Placement of MRE devices in the oceans can change circulation and remove energy from the system, as well as potentially change patterns of sediment movement.
- The amount of change that will occur from single devices or small arrays is likely to be immeasurably small.
- Numerical models suggest that changes may be measureable only with the operation of very large arrays that are probably too large to be realistically considered for most waterbodies.



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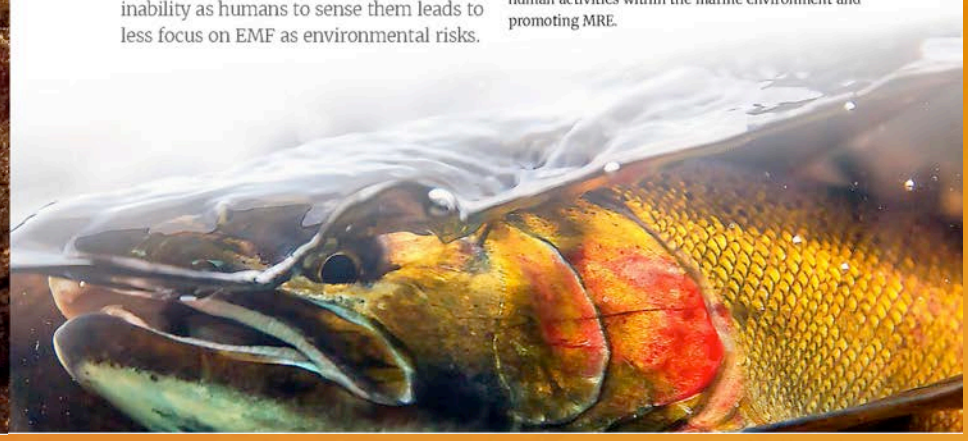
Chapter author: A. Gill

Effects of EMF on Marine Animals from Electrical Cables and Marine Renewable Energy Devices

To meet the objectives of the Annex IV, Phase 2, State of the Science report, this chapter focuses on the topic of electromagnetic fields (EMFs). EMFs are poorly understood and are conceptually a challenge to understand, perhaps because our inability as humans to sense them leads to less focus on EMF as environmental risks.

This chapter aims to identify the key questions that have arisen from various sectors in relation to EMFs and to provide an up-to-date synthesis of the current knowledge base. With this knowledge, the reader should be able to better appreciate EMFs as an environmental effect that should be taken into account when considering the sustainable management of human activities within the marine environment and promoting MRE.



Chapter 6 – Electromagnetic Fields

Focus:

- Effects of EMF on Marine Animals from Electrical Cables and Devices

Highlights:

- Additions of EMFs from power export cables and energized parts of devices can add to naturally-occurring magnetic fields, and have the potential to disturb certain marine animals.
- Some animals including some elasmobranchs and invertebrates, are known to be electro- or magneto-sensitive and could be disturbed by EMFs from MRE devices.
- Power cables will generally be buried and effectively shield the environment from EMF.
- Most studies to date have focused on behavioral responses of animals to EMF.
- Lab and field studies have shown no evidence that EMFs, at the levels expected from MRE devices, will have an effect on any species.

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7.0

Chapter authors:
N. Sather, A. Copping,
G. Zydlewski,
G. Staines

Changes in Habitats Caused by Marine Renewable Energy Devices: Benthic Habitats and Reefing Patterns

The installation of MRE devices alters marine habitats through mechanisms that induce physical change. These changes in habitat have the potential to alter or eliminate species occurrence at a localized scale, provide opportunities for colonization by new species, alter pat-

All MRE devices must be attached to the sea bottom in some manner, either with gravity foundations, piled into the seafloor, or by one of several anchoring solutions. The placement on the seafloor, as well as movement of anchor lines, cables, and mechanical moving parts, can all affect the surrounding rocky or soft-bottom seabed and the benthic organisms these habitats support (Figure 7.1). Similarly, the presence of MRE devices on the seafloor or suspended in the water column may attract fish and benthic organisms, causing them to change their behavior and settling locations, perhaps affecting population movement, structure, or success.

Chapter 7 – Changes in Habitats

Focus:

- Changes in benthic habitats and reefing of fish, due to MRE devices.

Highlights:

- MRE devices can change the bottom habitats by disturbing sediments under their foundations, as well as around anchors and mooring lines.
- Devices will attract fish and invertebrates, that will remain around the parts of the devices and systems.
- No evidence collected to date shows that significant negative effects will occur to benthic areas around MRE developments, or that marine animals reefing around devices will harm fish populations.

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8.0

Marine Spatial Planning and Marine Renewable Energy

Chapter authors:
A.M. O'Hagan

Marine spatial planning (MSP) is a comparatively recent approach to planning and managing sea uses and users in a way that helps achieve sustainable development of marine areas. The rationale for MSP is to provide a stable and transparent planning system for maritime activities and users within agreed-upon environmental limits to ensure marine ecosystems and their biodiversity remain healthy.

MSP works across multiple sectors, within a specified geographic context, to facilitate decision-making about the use of resources, development, conservation, and the management of activities in the marine environment both now and in the future. To be effective, MSP should be integrated across sectors, ecosystem-based, participatory, strategic, adaptive, and tailored to suit the needs of a predetermined marine area. Currently, marine activities tend to be managed on a sector by sector basis, thereby limiting the consideration that can be given to other marine activities likely to occur in the same space, as well as the effects of that activity on the receiving environment. Processes such as environmental assessments address the impacts of an activity on the environment before a development or activity occurs, but this can be limited to a specific site and cumulative impacts remain a challenge for those processes. Failure to take a more holistic approach to planning can result in conflicts between different marine users and activities and also conflicts with the physical environment (Figure 8.1). Conflicts usually result in "reactive" management rather than more proactive management where agreed-upon desired outcomes can be facilitated.

Figure 8.1. Representation of different potential marine users and conflicts of interest (Sutherland 2005).

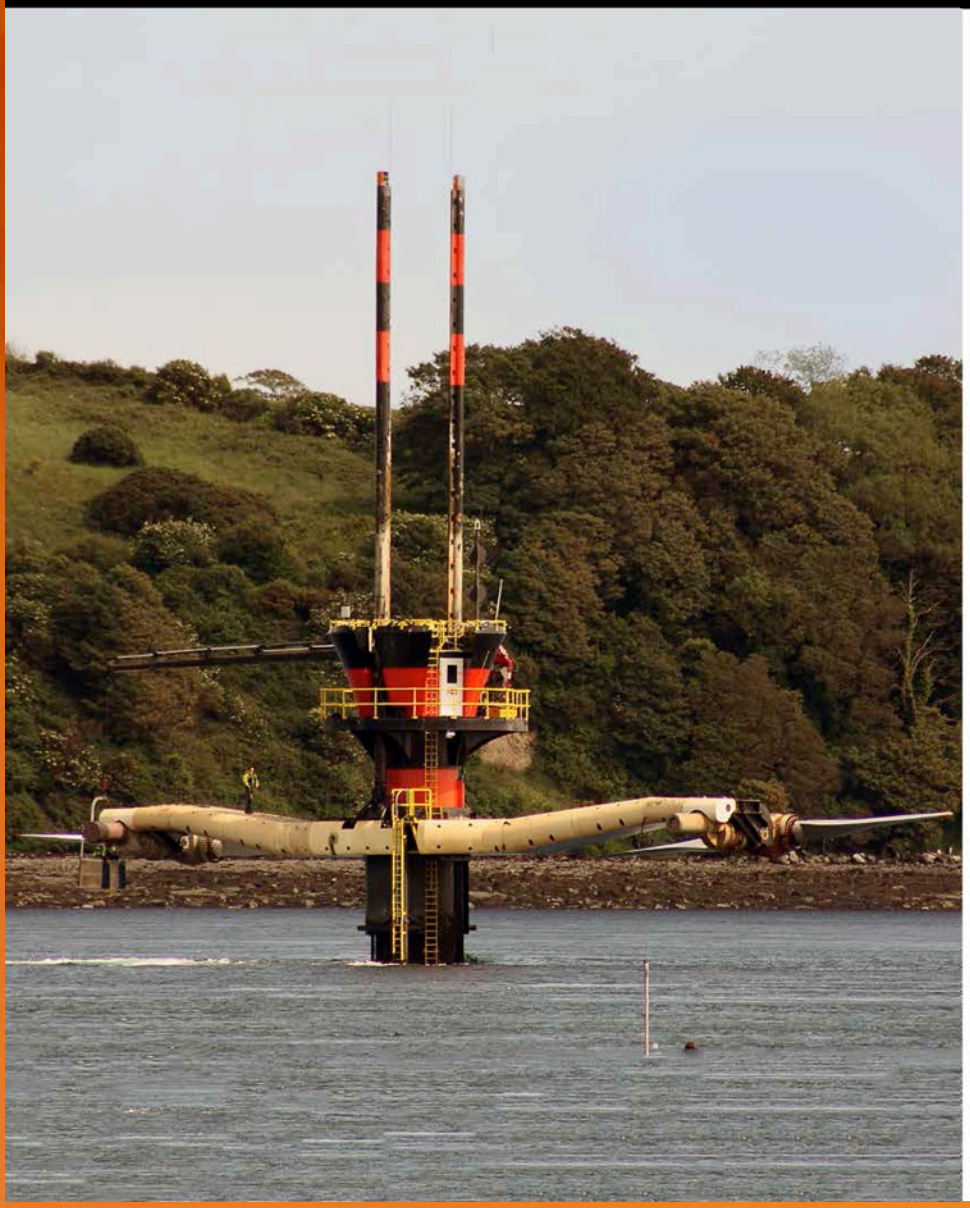
Chapter 8 – Marine Spatial Planning

Focus:

- Marine Spatial Planning (MSP) and the role of MRE development.

Highlights:

- MSP involves planning and managing sea uses and users to support sustainable development of marine areas.
- Annex IV representatives were surveyed about use of MSP in their nations.
- Several nations have formal MSP processes, others have coastal management plans that embody principles of MSP, and several have no MSP in place.
- MSP must use a stable and transparent planning system for maritime activities and users within agreed environmental limits, working across multiple sectors, including the MRE industry.



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Chapter Authors: T. Simas and J. Bald

Case Studies that Examine Siting and Permitting/ Consenting of Marine Renewable Energy Devices

The consenting process, including the environmental impact assessment of ocean energy projects, is still regarded as a challenge to marine renewable energy scale-up to create a cost-competitive viable MRE industry. Specifically, uncertainty about the appropriate application of environmental legislation, which can prolong the consenting processes (adding cost and delay) is a key focus area. Currently the environmental effects and impacts of MRE devices on the marine environment, and vice versa, are significant areas of uncertainty. Furthermore, the scarcity of data on the environmental interactions of new technologies often means they are characterized as a threat, requiring extensive supporting environmental information, the collection of which can be costly and time consuming.

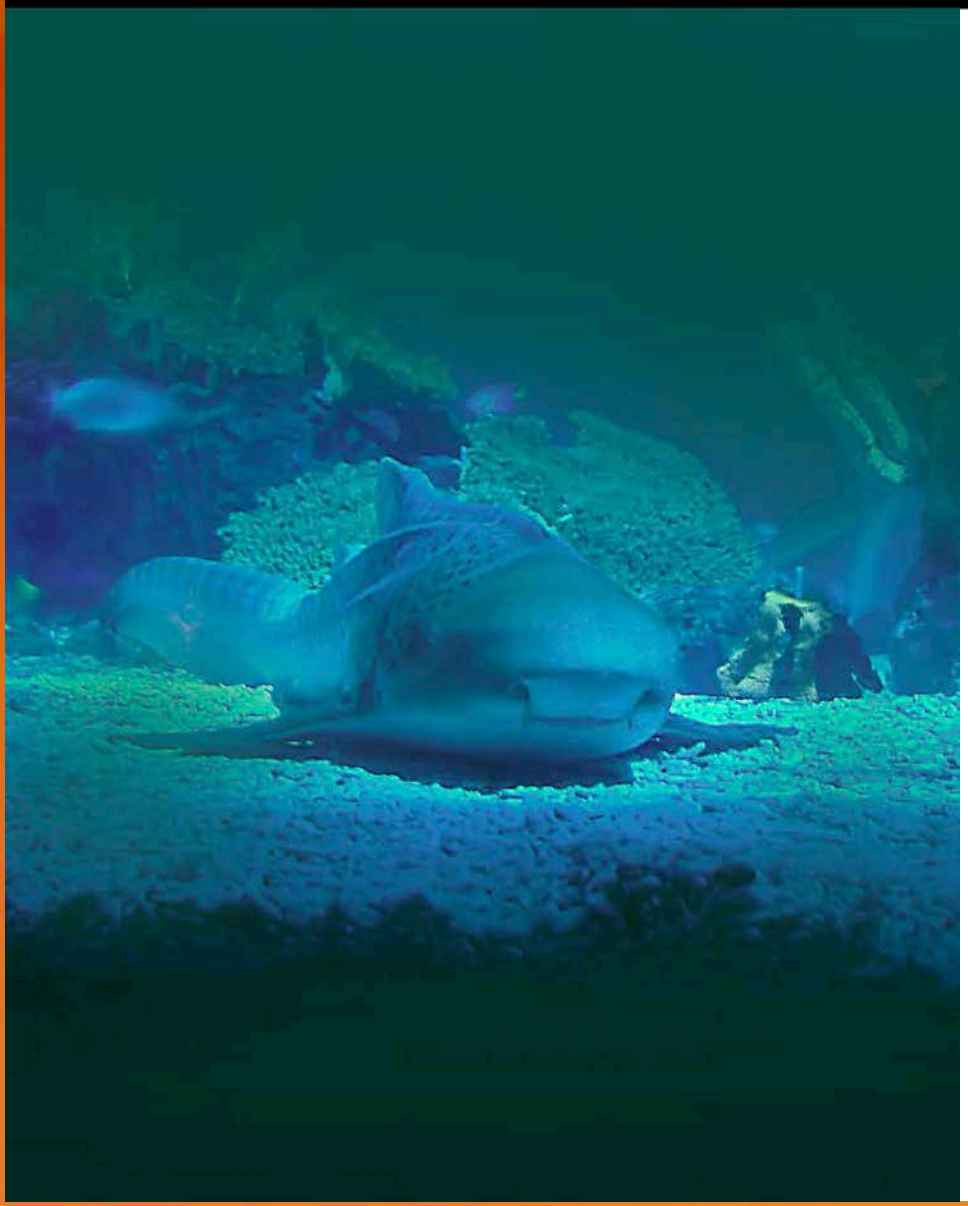
Chapter 9 – Consenting Case Studies

Focus:

- Examined four consented projects to learn lessons to help MRE development.

Highlights:

- Consenting processes were reviewed:
  - WaveRoller wave technology, installed in Portugal;
  - TidGen® Power System tidal technology, installed in the United States;
  - SeaGen tidal technology installed in Northern Ireland; and
  - BIMEP (Biscay Marine Energy Platform), a designated wave test site in the Basque country, Spain.
- Project success is supported by:
  - Carrying out strong stakeholder outreach throughout the process.
  - Developing robust monitoring plans, adaptive management strategies, and a sound Environmental Impact Assessments.
- At present, there are no dedicated policies that streamline development of wave and tidal projects.



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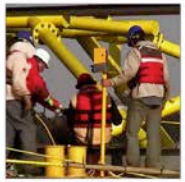
Summary and Path Forward for Marine Renewable Energy Monitoring and Research

10.0

Chapter authors: A. Copping, I. Hutchison

This report has summarized and placed in context information about the environmental effects of MRE development, to the extent that the information is publicly available. The lessons learned, research gaps, and recommendations from each of the chapters in this report are summarized in the ensuing sections. A path forward in the face of scientific uncertainty is also discussed. A path forward in the face of scientific uncertainty is also discussed.



10.1 POTENTIAL INTERACTIONS OF MRE DEVICES WITH THE ENVIRONMENT

(Chapter 2)

Uncertainty associated with interactions between MRE devices and marine animals and/or habitats continues to cause a high degree of risk for permitting/consenting pathways, which in turn causes uncertainty and delays in establishing the industry. By examining all of the possible interactions that might occur, a set of high-priority interactions has been identified. In most cases, interactions that most concern regulators and stakeholders are also the focus of the efforts of researchers working in this field, as well as the focus of work undertaken by developers during the consenting/permitting process. These researchers are actively seeking to understand the high-priority interactions, determining appropriate methods for recording or observing the interactions, and collaborating to develop appropriate instrumentation and data analysis methods to cost-effectively collect data during the life of MRE projects. Monitoring required of developers also focuses largely on these highly uncertain and unknown interactions.

Chapter 10 – Path Forward

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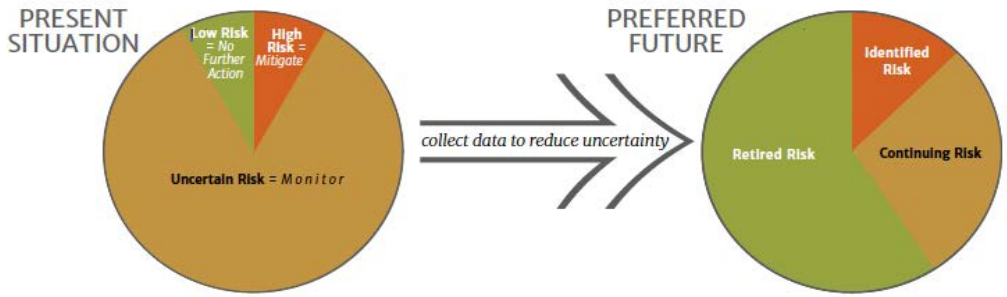
Focus:

- Summary of document and a path forward for the industry in the face of scientific uncertainty.

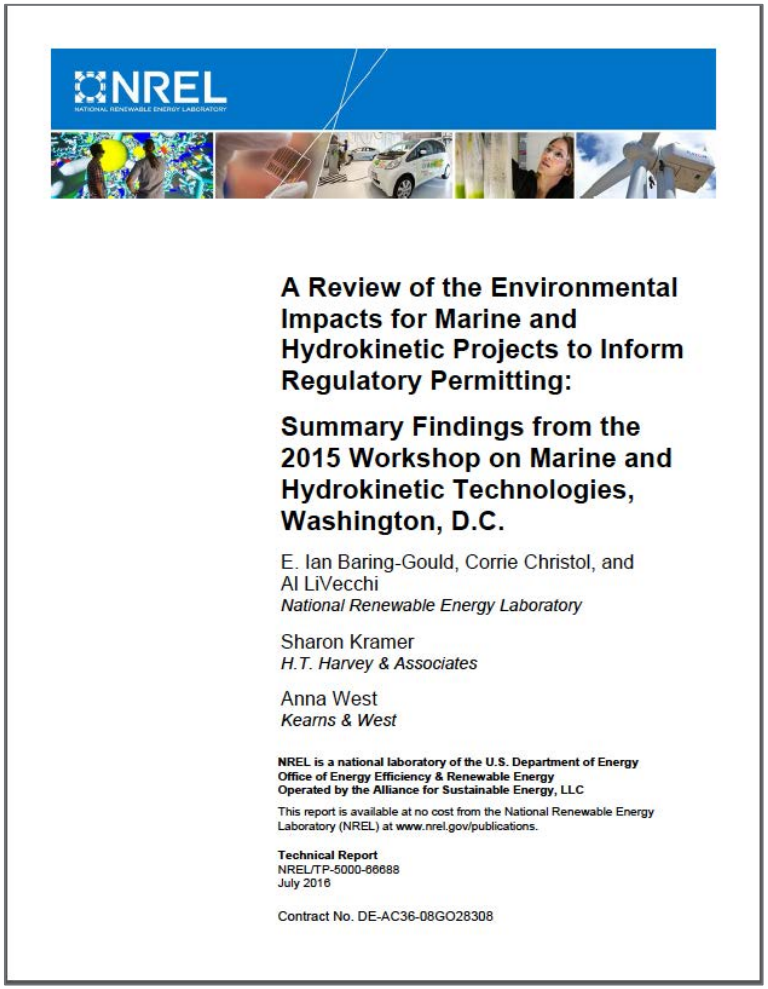
Highlights:

- Interactions with MRE devices are perceived to be risky largely due to uncertainty.
- Additional information will help to retire insignificant risks, while other risks may be determined to need mitigation. Monitoring requirements will be reduced as we learn more.
- There are no methods for monitoring certain interactions now; these require strategic research investments to proceed.



MHK Regulators Workshop

- Experts in MHK fields discussed the current state of scientific understanding of observed (or unobserved) impacts from MHK devices world-wide.
- A forum for key MHK stakeholders to present and discuss evolving “best practices” for measurement and monitoring of key potential impacts, and for regulators to share their perspective.
- To provide knowledge sharing opportunities for Federal and State representatives.



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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
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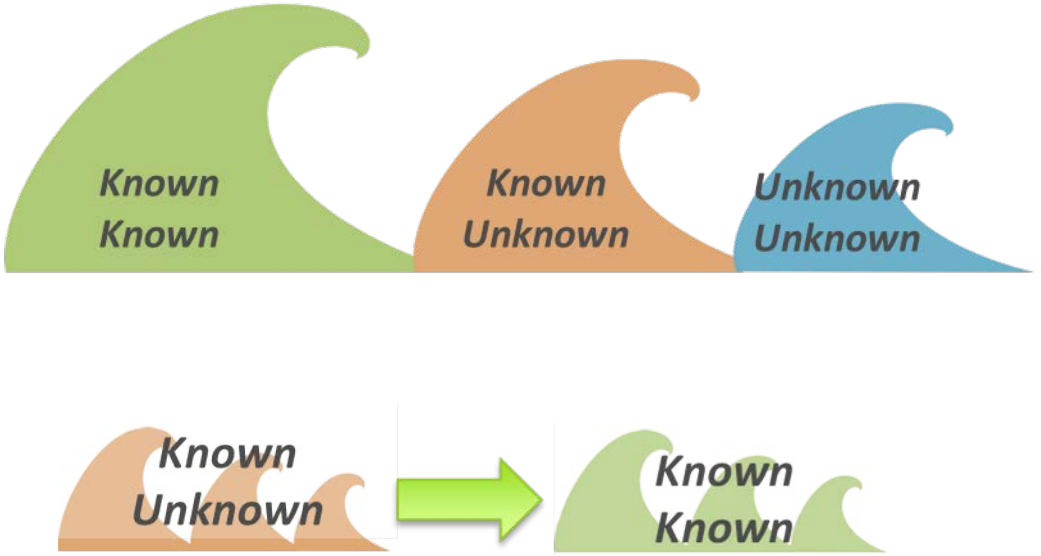
Technical Report
NREL/TP-5000-66688
July 2016

Contract No. DE-AC36-08GO28308

MHK regulators workshop DC

- "Known Known: issues are understood well, no further monitoring is warranted.
- "Known Unknowns": issues that we have knowledge and technology to study but for which the impact and cost of a study are uncertain.
- "Unknown Unknowns": areas not widely assessed, and may not be necessary to study the issue to make it known. Does technology exists to study it effectively? Do we need to know it?



MHK regulators workshop DC topics

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

MHK Regulator Workshop DC: Sound

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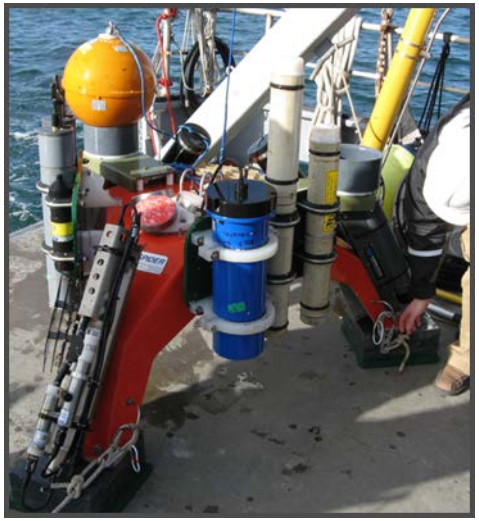
	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
Operational Noise	Information collected to date indicates that operational devices are typically less noisy than other anthropogenic sources. Monitoring is generally 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.



MHK Regulator Workshop DC: EMF

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	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.

MHK Regulator Workshop DC: Interaction

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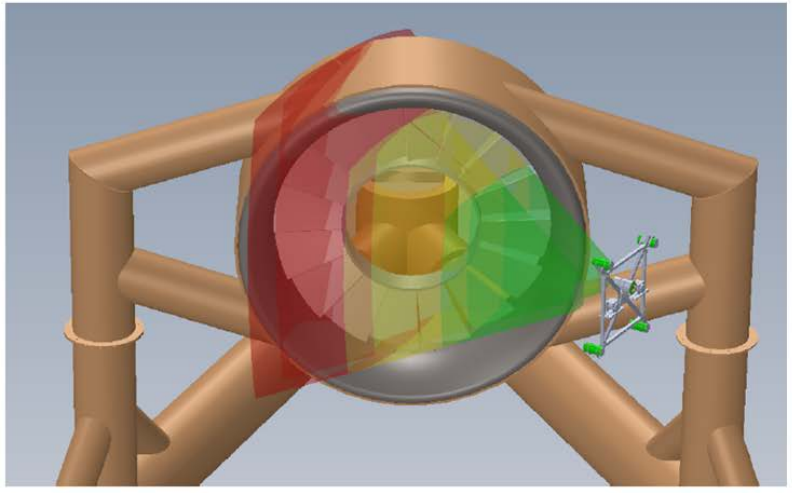
	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
Physical Interactions (Strike)	No physical interactions have been observed in the field. Lab experiments have found that fish can easily detect and avoid or swim around 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.



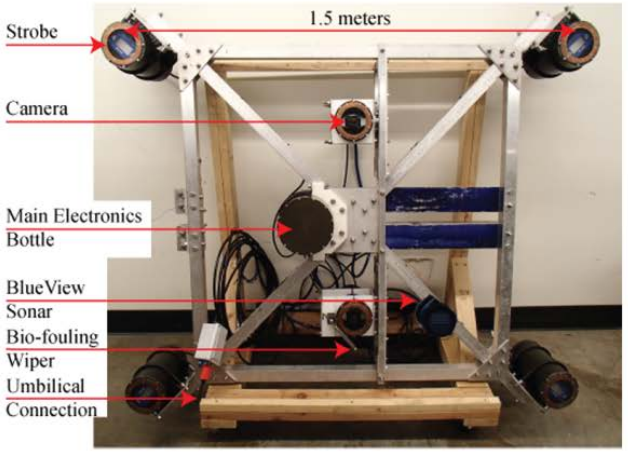


Fig. 1: Prototype imaging system showing principal components and scale

MHK Regulator Workshop DC: Physical

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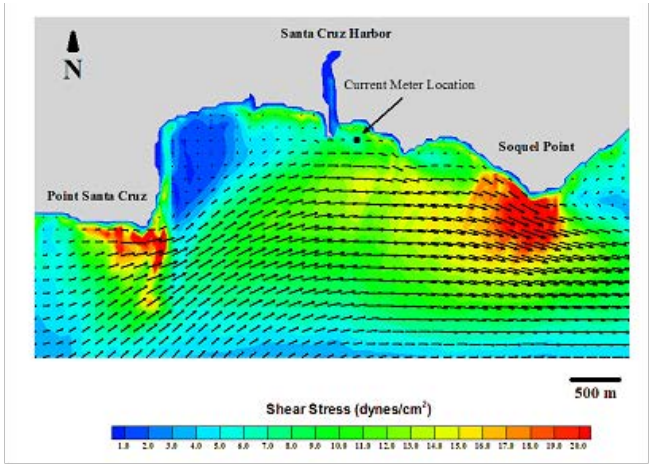
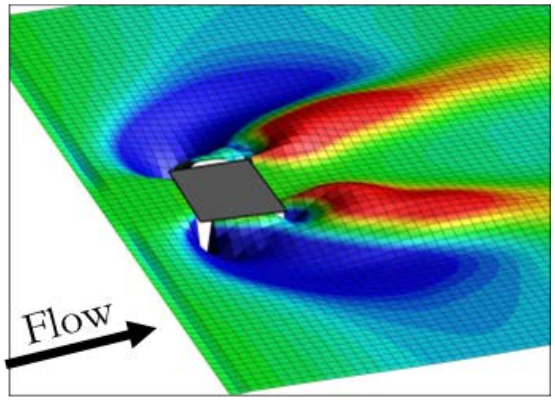
	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
Impacts on Physical Systems	Numerical modeling consistently predicts that arrays <10 devices will have minimal impact on wave heights, flow patterns, and sediment transport. 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.





MHK Regulator Workshop DC: Physical

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	Monitoring for Single Devices/Demonstration-Scale Projects	Research for Single-Device/Demonstration-Scale or Commercial-Scale Projects
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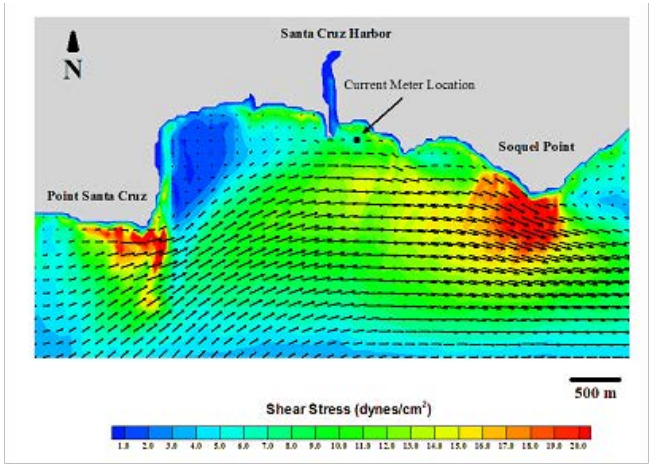
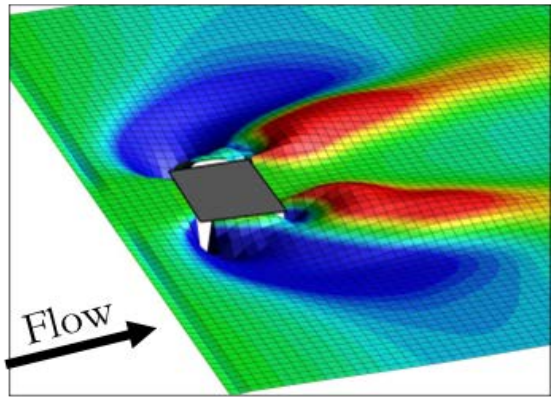




MHK Regulator Workshop DC: Conclusions

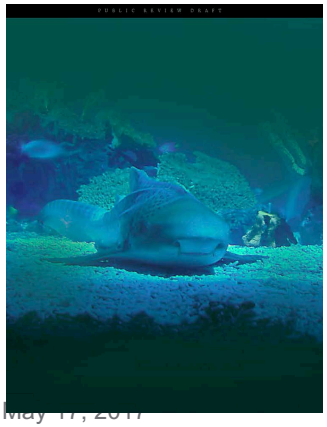
- Collaborative interchange of project permitting and research
- Umbrella collaborative or organization to serve as a central clearinghouse for global research and monitoring needs within the MHK industry
- Because natural variability in marine environments is high and events/interactions of concern are likely to be rare, the ability to detect effects using traditional monitoring tools is very low
- There is a role for modeling and simulation to address uncertainties

Delineating and Dealing with Risk

- Few wave and tidal devices in the water, no long-term post-installation data sets
- Perceived and potential risks continue to worry regulators, stakeholders
- Continued regulatory requirements for extensive data collection
- Financial burden on developers, projects
- Not clear if data collection efforts aimed at most important/highest risk interactions
- Need to delineate and track changes in perception of these risks to move industry forward

Perceived Risks of MRE Development

1. Collision risk: tidal, current, offshore wind
2. Underwater noise
3. Electromagnetic fields (EMFs)
4. Physical changes/energy removal
5. Changes in habitats/artificial reefs
6. Entanglement (ecological risk, fishing gear)



A Strategy for Understanding Risk - Dashboards

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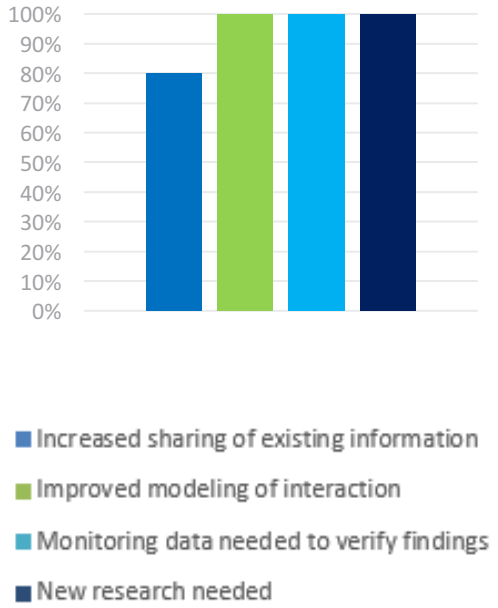
- Purpose and use of the dashboards:
  - Allow MRE community to gage the level of uncertainty and risk about key interactions
  - Reflect results of ongoing investigations
  - Can be updated as new info becomes available
  - Can be shared to gain common understanding

- Actions that could decrease level of risk, change dashboards:
  - Increased sharing of existing information,
  - Improved modeling of interactions,
  - Monitoring data needed to verify findings, and
  - New research needed.

Collision Risk

- Marine mammals, fish, seabirds of concern – high stakes
- Tidal and river turbines
- Lacking instruments to observe collisions, little evidence of collision
- Models are lacking but improving, little link to populations



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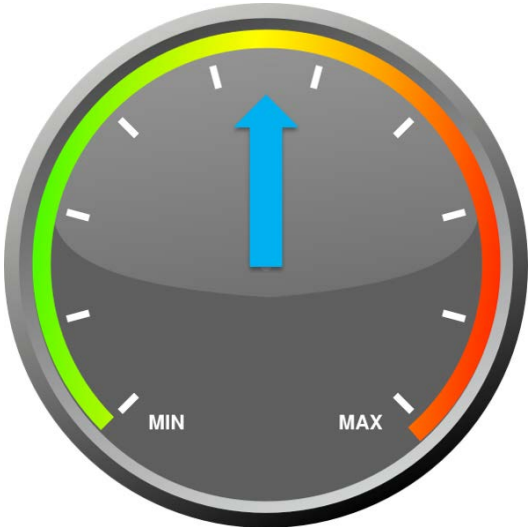
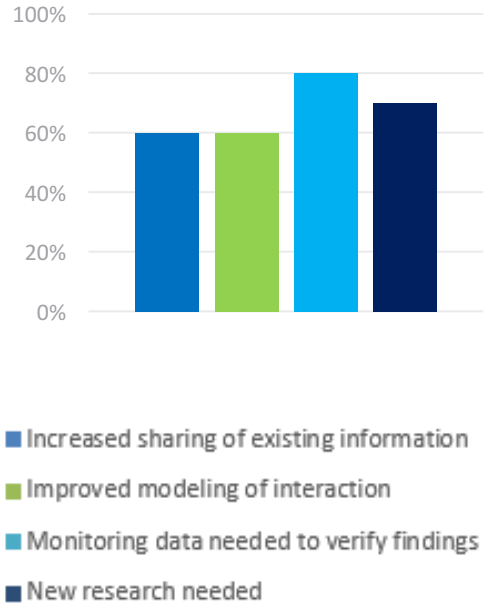
Acoustic Output (Noise)

- Noise from MRE devices may interrupt navigation, communication
- Additive with other anthropogenic sources
- Can measure noise from single devices, model for arrays
- Reactions of animals to noise from devices unknown





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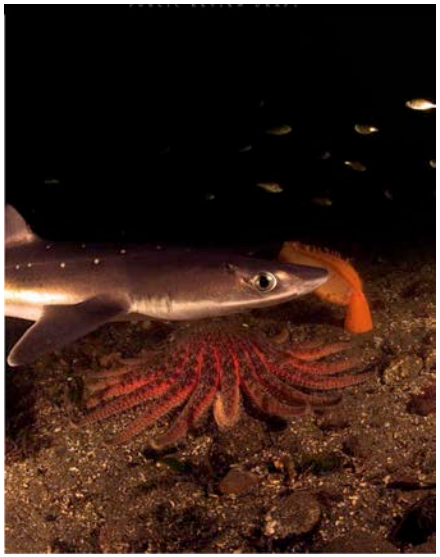
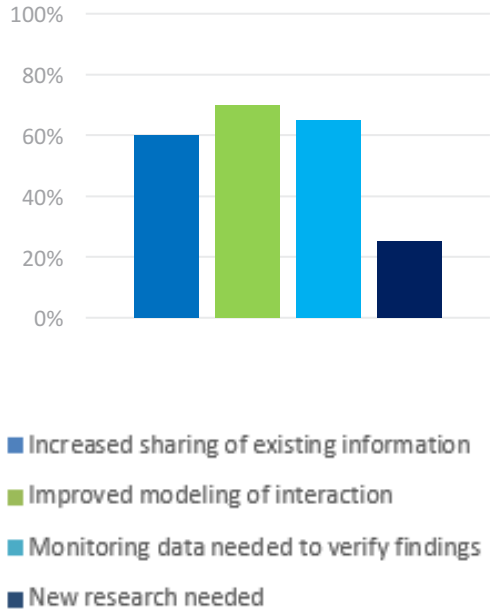
Electromagnetic Fields

- EMF from cables, energized devices, add to natural fields
- Electro- and magneto-sensitive animals: elasmobranchs, invertebrates
- Power cables can be buried
- Lab/field results indicate levels are unlikely to be harmful





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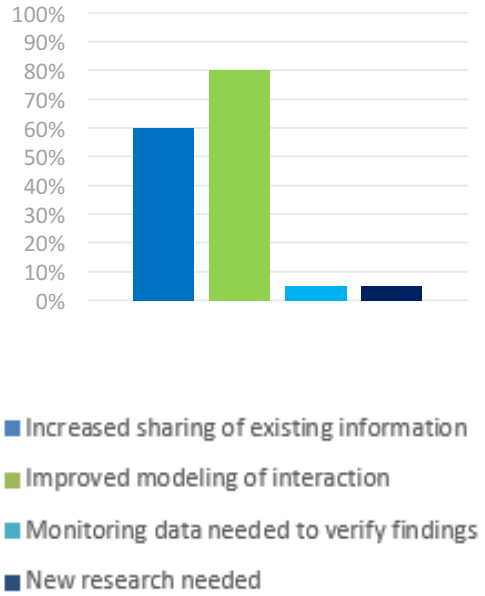
Changes in Physical Systems

- Placement and operation can change flows, remove energy, disrupt sediment transport
- Very small effects until large arrays, maybe
- Numerical models help us here



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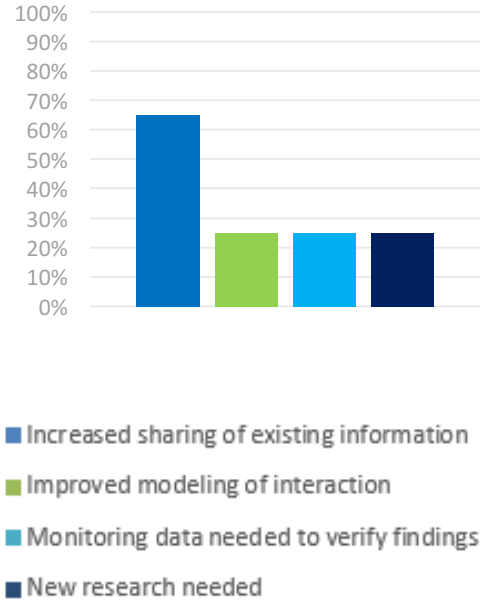
Changes in Habitats/Artificial Reef Effect

- Devices can change bottom habitat, around mooring lines, anchors
- Fish and other animals congregate around objects in ocean
- No mechanism of harm seen, could provide some beneficial habitat
- Potential interaction of concern with fisheries



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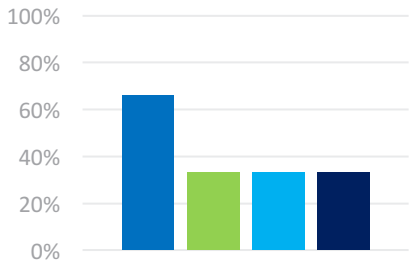
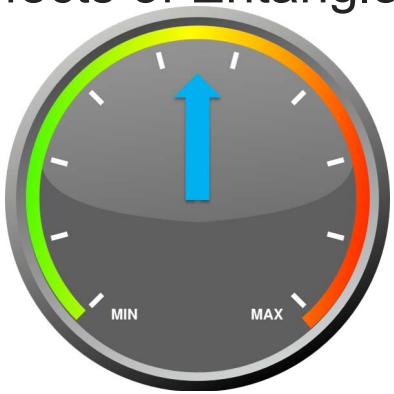
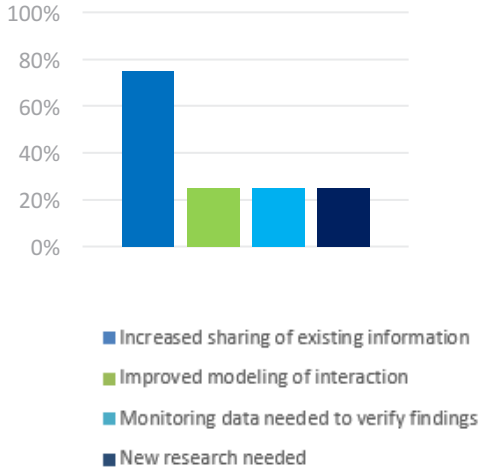
Entanglement and Debris

- Mooring line entanglement of marine mammals, sea turtles
- Also hanging up lost fishing gear



- Ecological Effects of Entanglement

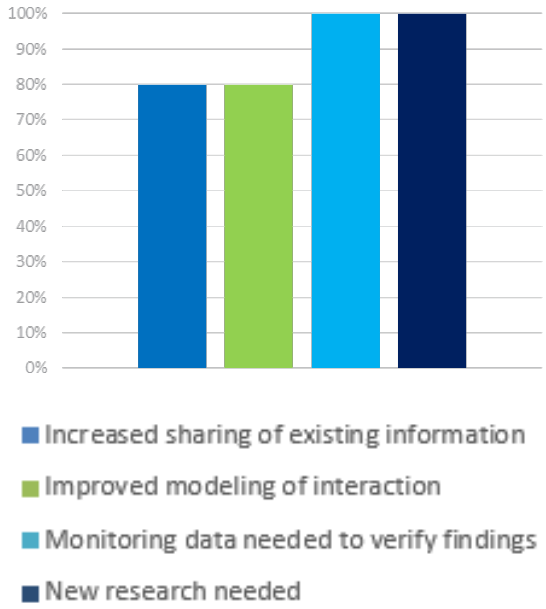




- Entanglement of Fishing Gear

Collision and Avoidance: Offshore Wind

- Seabird and bat collision with moving and stationary structures
- Avoidance of projects in migration pathways
- Improvements to instrumentation for monitoring
- Models being adapted from terrestrial applications

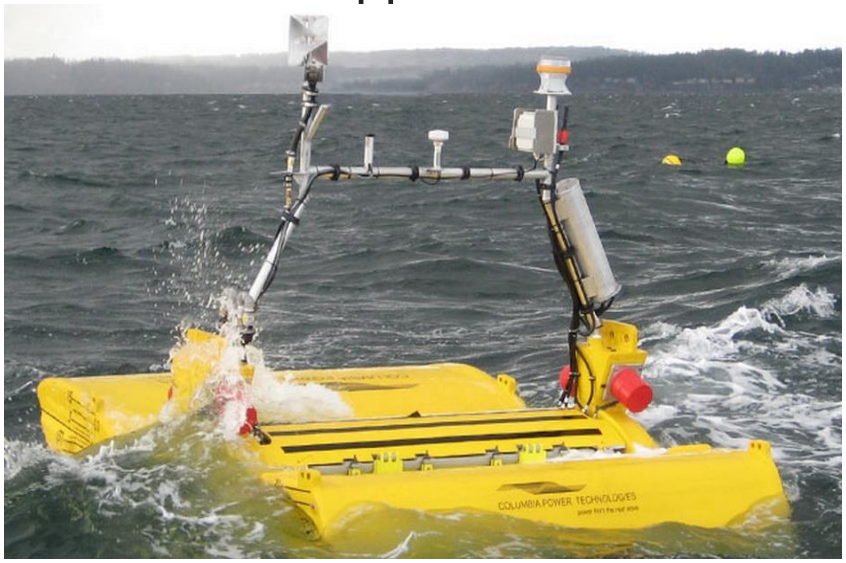


Regulators Panel

- Need for standardizing data collection methods to help streamline regulatory evaluations (improving)
- Need for studies that will inform MRE technology development and allow devices to be engineered to lessen their potential effects on the environment (e.g., EMF and acoustics).
- Real-time monitoring appropriate for understanding the interaction of devices with the environment, and could be useful for developing appropriate mitigation measures.

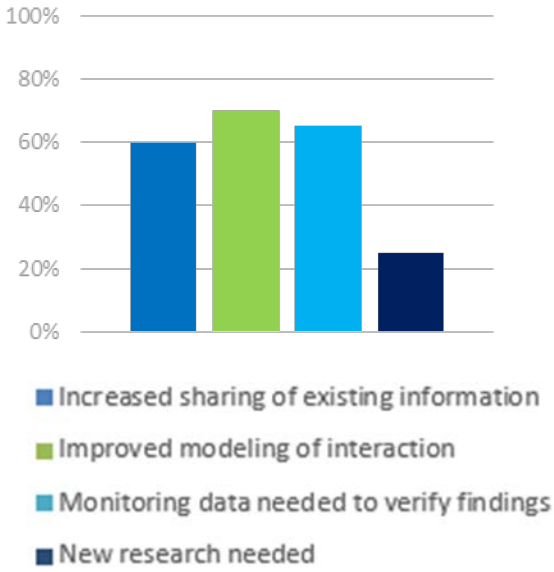
Applicants Panel

- Need to be able to address and understand how much uncertainty around potential interactions with devices is allowable.
- Need to address how to handle uncertainty, as well as the acceptability of transferring environmental monitoring data sets from other locations and/or other industries.
- Inconsistent application of laws and regulations in different regions.



Discussion

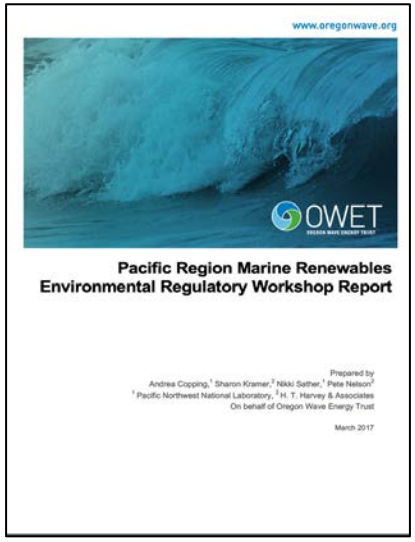
- Dial settings on the dashboards are a good indication of the level of investment needed for each topic, as well as the level of risk associated with each topic.
- Collision risk continues to be the most difficult issue for tidal energy.
- Acoustic impacts will require better information on behavioral response.
- Greatest concerns for wave energy development are noise and entanglement.
- EMF understanding has improved greatly, and may be one that can be retired.

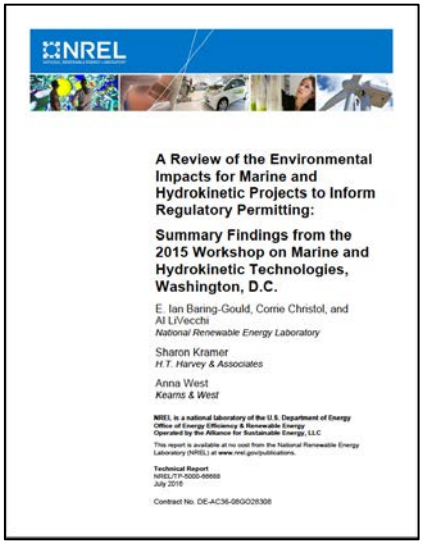


Path Forward with Dashboards

- Moving forward:
  - Input on dashboards
  - Process for reviewing, updating
  - Regional focus/transferability
  - As we reduce risk, what problematic issues remain that effect permitting?
  - Standardization?
  - Learning from other industries
  - Availability of datasets
- Let's talk! Looking for discussions, input, disagreements, new paradigms for visualization, quantification
- Follow up workshop in September 2017 at OWET/POET
  - Continued dialog from regulators, project applicants
  - Updates on major new information

For more information:





Copping, A.; Sather, N.; Hanna, L.; Whiting, J.; Zydlewski, G.; Staines, G.; Gill, A.; Hutchison, I.; O'Hagan, A.; Simas, T.; Bald, J.; Sparling, C.; Wood, J.; Masden, E. (2016). Annex IV 2016 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. pp 224.

Copping, A.; Kramer, S.; Sather, N.; Nelson, P. (2017) Pacific Region Marine Renewables Environmental Regulatory Workshop Report.

Baring-Gould, E.; Christol, C.; LiVecchi, A.; Kramer, S.; West, A. (2016) 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. Report by H.T. Harvey & Associates, Kearns & West, and National Renewable Energy Laboratory (NREL). Pp. 70. National Renewable Energy Laboratory, Boulder, Colorado, USA.

THANK YOU!

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