ANNEX IV

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Annex IV Webinar

Environmental Effects of MRE Development: Application to Permitting

Presented by: Andrea Copping

March 29th 2017

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

OES OCEAN ENERGY SYSTEMS

iea Energy Technology Network 1975-2015 Accelerating results for 40 years

Today….

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- Drivers of Marine Renewable Energy (MRE)
- Need for environmental effects information
- Main sources of information
  - 2016 State of the Science Report[1]
  - OWET Workshop Report - Risk Dashboards [2]
  - MHK regulators workshop [3]
- Input from all of you

[1] 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.

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

[3] 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.

Environmental Effects of Marine Energy

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- Drivers of marine energy development are clear:
  - Need for reliable low carbon energy sources, mitigate CC
  - Renewable energy standards in many nations, regions
  - Secure energy generated locally

BUT

- Stakeholders have concerns about potential impacts
- Regulatory/consenting processes are not well established

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

IMPROVED INFORMATION CAN:

- Simplify, shorten the time to permit deployment of devices and arrays, but site-specific knowledge will still be needed.

ENVIRONMENTAL EFFECTS OF MARINE ENERGY DEVELOPMENT AROUND THE WORLD

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

2016 State of the Science (SoS)

- Marine Renewable Energy (MRE):
  - Industry in early stages of development, deployment, and commercialization
  - Need to streamline siting and permitting/consenting
- State of the Science helps:
  - 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

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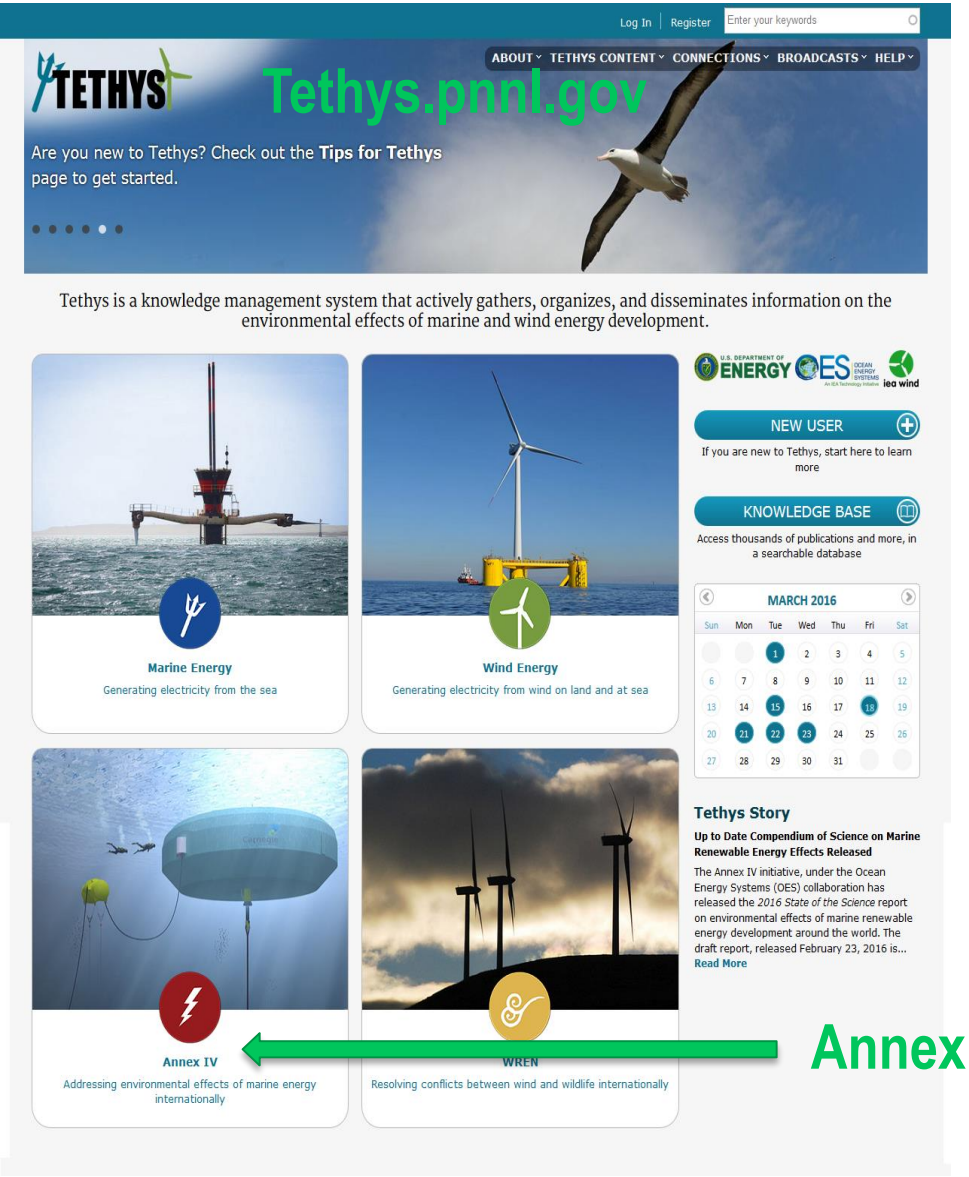
- Annex IV is a collaborative initiative of the Ocean Energy Systems (OES), under the International Energy Agency (IEA) Technology Network

Canada	China	Denmark	Ireland	Japan	New Zealand	Norway
Portugal	South Africa	Spain	Sweden	United Kingdom	United States	

- Annex IV is led by the US, with 12 partner nations, and 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"*

Read more about Annex IV on the Tethys website: https://tethys.pnnl.gov/about-annex-iv

Tethys (tethys.pnnl.gov)



- Functions of *Tethys* website (https://tethys.pnnl.gov/):
  - To facilitate the exchange of information on environmental effects of MRE and wind technologies.
  - To enhance the connectedness of the MRE community by serving as a commons for MRE and wind practitioners.
- Annex IV collects, curates, archives:
  - Knowledge base – scientific literature, reports, etc.,
  - ~3,500 entries, ~1,700 specific to MRE
  - Metadata on projects and research studies
  - Webinars, expert forums
  - Workshops, conference tracks
  - Interactive calendar
  - *Tethys* Blast and *Tethys* Stories

ENVIRONMENTAL EFFECTS OF MARINE ENERGY DEVELOPMENT AROUND THE WORLD

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

Interactions around MRE Devices

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.

Environmental Effects of Marine Renewable Energy Development around the World 9

- 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

MRE Stressors and Receptors

- Any portions of MRE devices or systems that may cause harm animals, habitats or ecosystem processes are termed **Stressors**
- Animals, habitats or ecosystem processes that may be affected by the presence or operation of MRE devices are termed **Receptors**
- Risk can be characterized at the intersection of specific **Stressors** and **Receptors**

Summary Risk Table of MRE Stressors

LOW RISK green
MEDIUM RISK yellow
HIGH RISK orange

Stressor	Single Device Deployment	Small-Scale Commercial	Large-Scale Commercial
Static Device			
Dynamic Device (Tidal)			
Dynamic Device (Wave)			
Acoustic			
Energy Removal			
EMF			
Chemical Leaching			

Collision with Tidal Turbines

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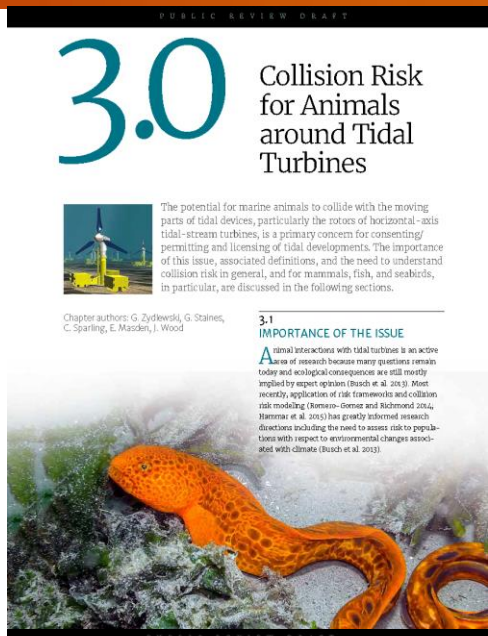
- Animals considered to be at potential risk include:
  - marine mammals
  - fish
  - diving seabirds
- No observations have ever been made of a collision of a marine mammal or seabird with a device, fish interactions have shown no harm.
- Technologies to observe collision are not well developed and 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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3.0 Collision Risk for Animals around Tidal Turbines

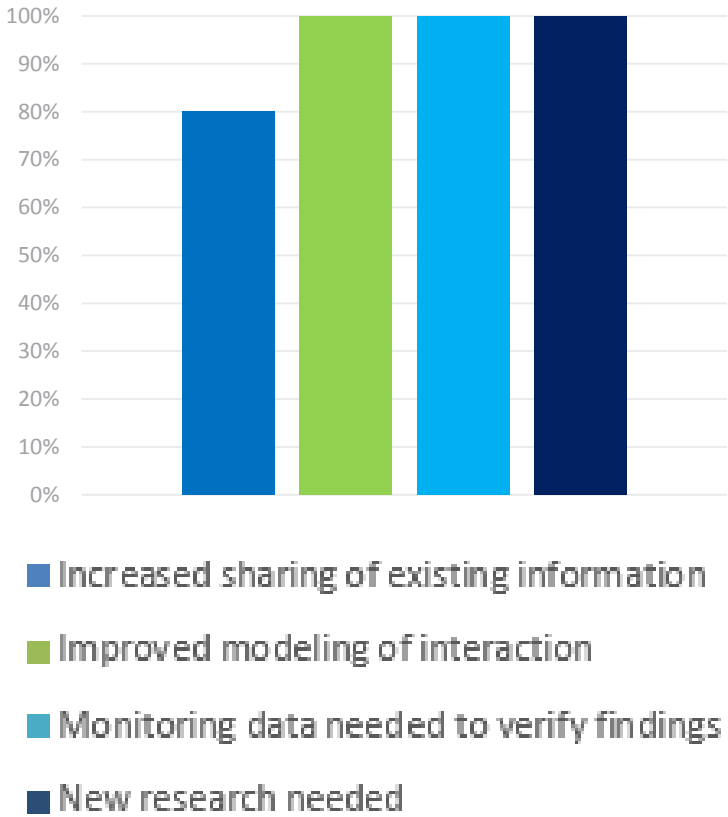
The potential for marine animals to collide with the moving parts of tidal devices, particularly the rotors of horizontal-axis tidal-stream turbines, is a primary concern for consenting/permitting and licensing of tidal developments. The importance of this issue, associated definitions, and the need 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).

Collision Risk (tidal) - Dashboard



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

Underwater Noise

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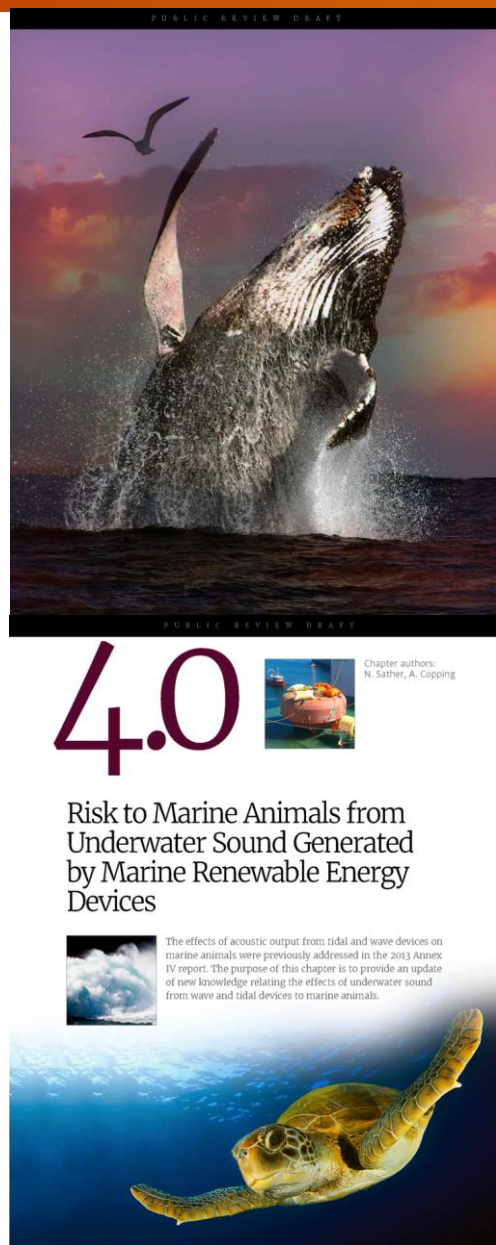
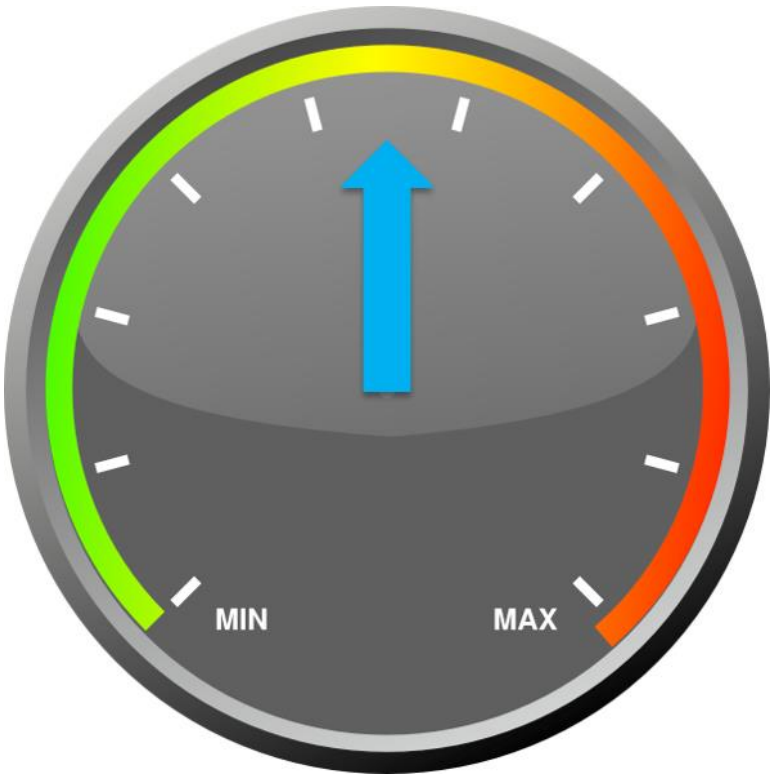
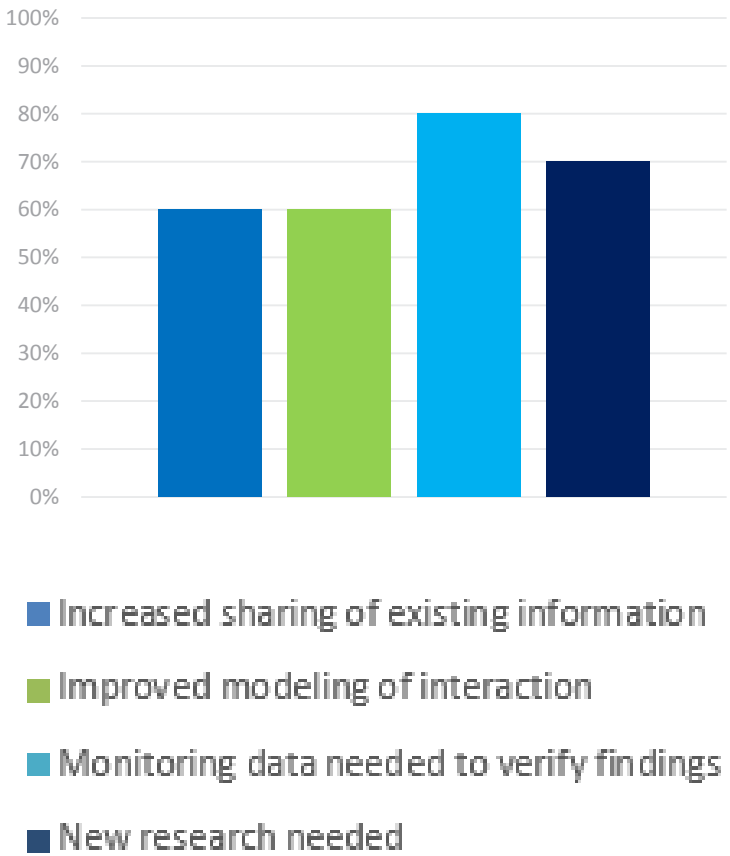
- Marine animals use underwater sound for navigation and communication.
- Sound from MRE devices may add to other anthropogenic sounds and could disturb animals, especially marine mammals and fish.
- Noise from single turbines and WECs are being measured, and predictions can be made about what arrays 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.



Acoustic Output (Noise) - Dashboard





Changes in Physical Systems

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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.

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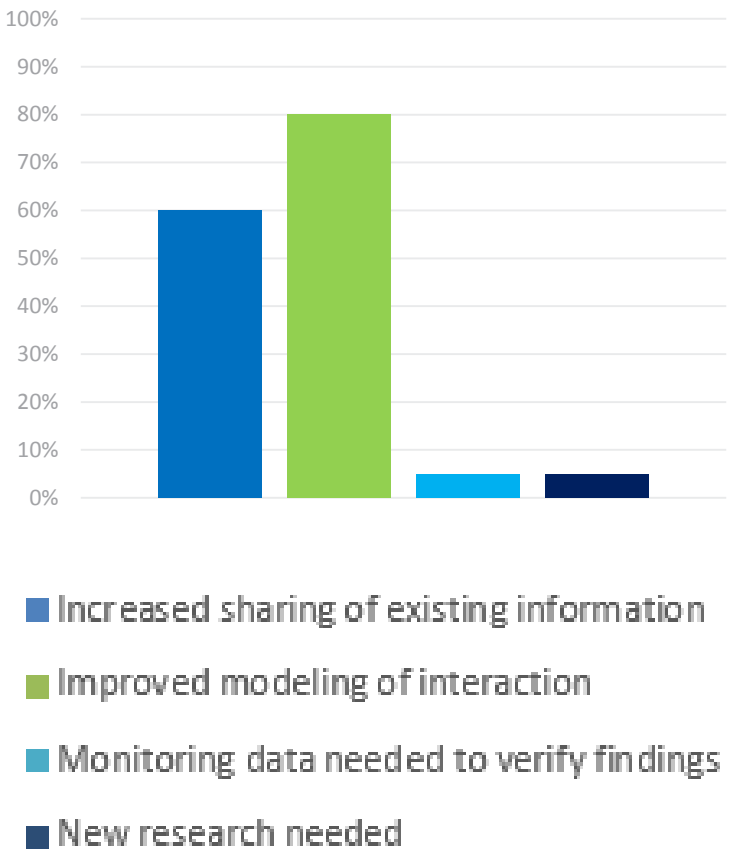
- Placement of MRE devices in the oceans can change circulation and remove energy from the system, as well as potentially change patterns of sediment movement.
- The amount of change that will occur from single devices or small arrays is likely to be immeasurably small.
- Numerical models suggest that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

Physical Changes - Dashboard



Electromagnetic Fields

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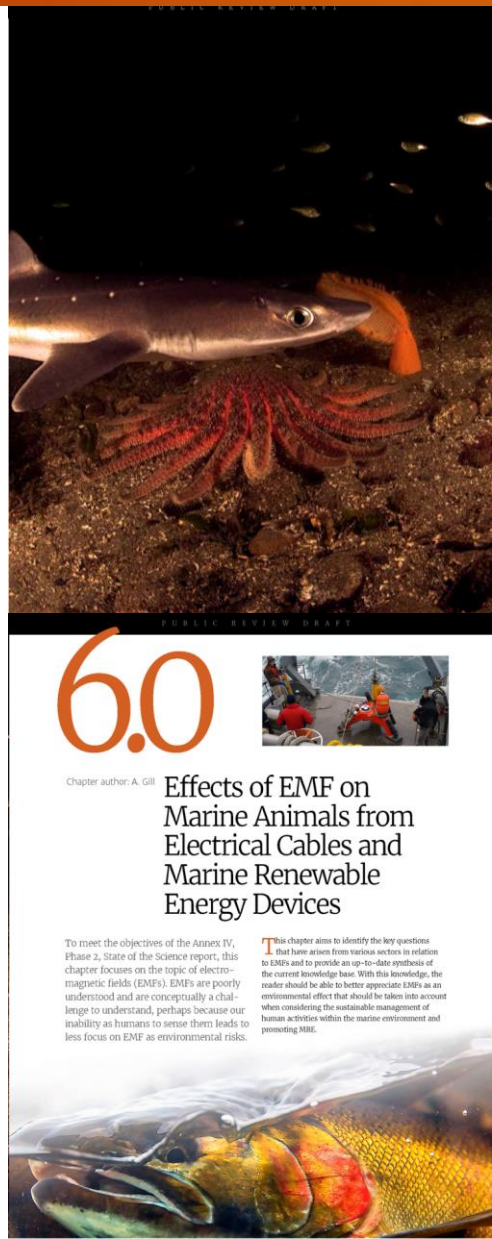
- Additions of EMFs from power export cables and energized parts of devices can add to naturally-occurring magnetic fields, have the potential to disturb certain marine animals.
- Some animals including some elasmobranchs and invertebrates, are known to be electro- or magneto-sensitive and could be disturbed 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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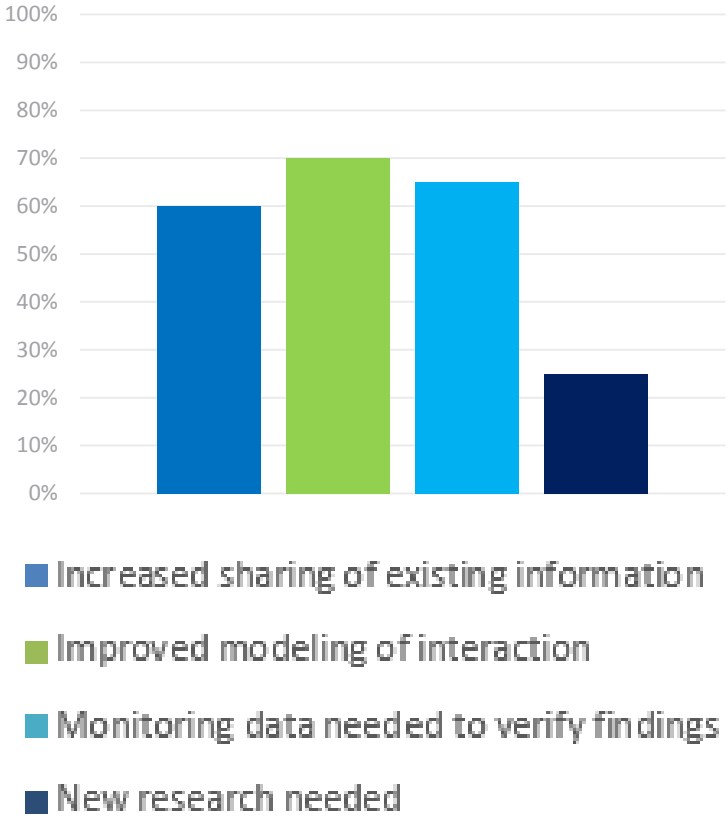
Chapter author: A. Gill

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

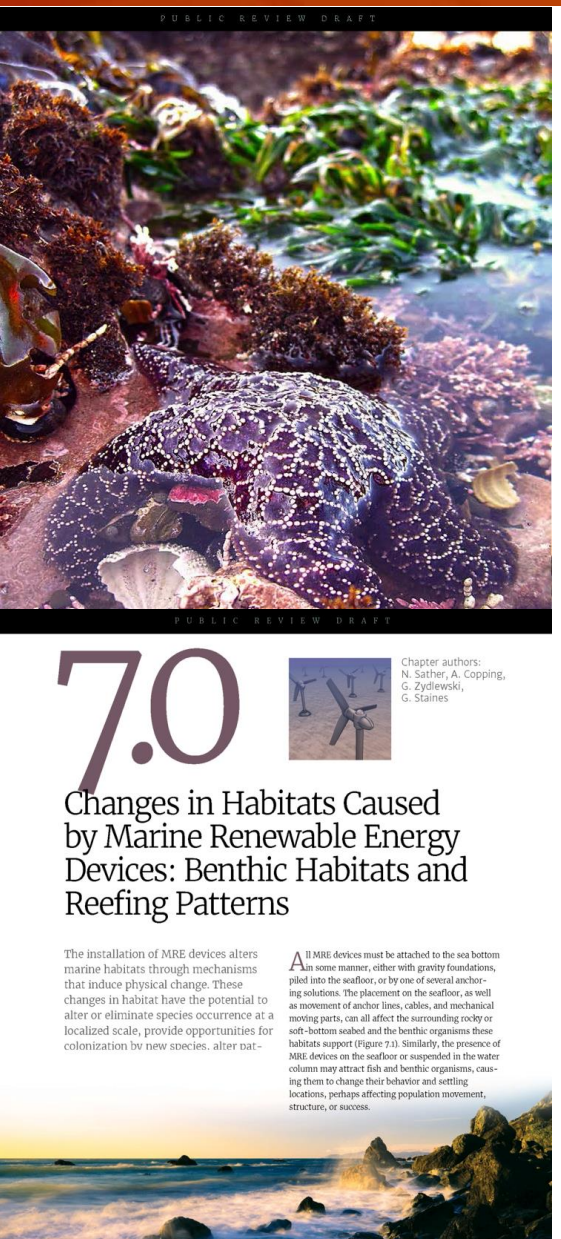
To meet the objectives of the Annex IV, Phase 2, State of the Science report, this chapter focuses on the topic of electromagnetic fields (EMFs). EMFs are poorly understood and are conceptually a challenge to understand, perhaps because our inability as humans to sense them leads to less focus on EMF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

Electromagnetic Fields - Dashboard



Changes in Habitats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7.0

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

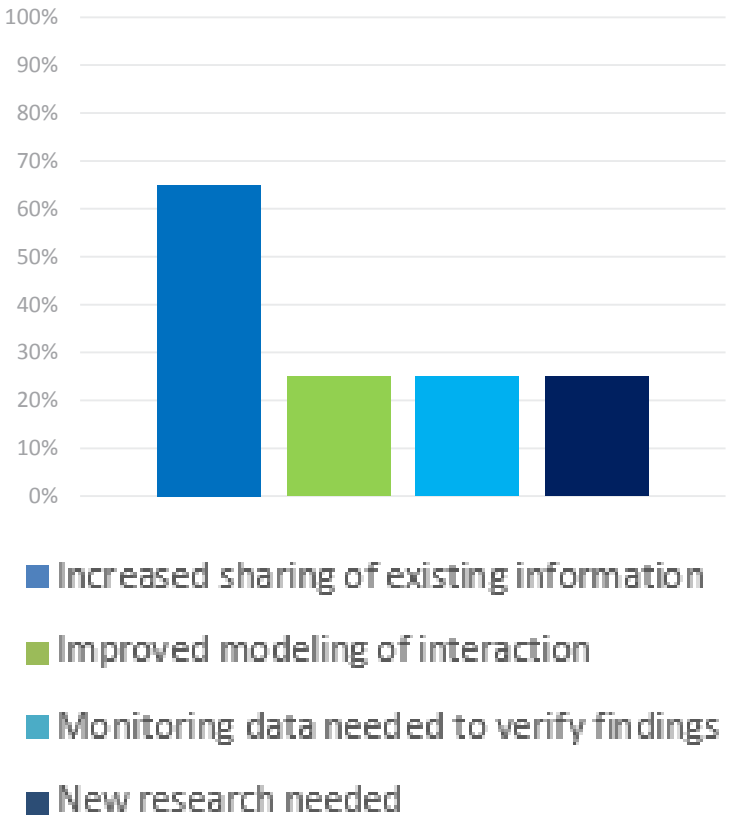
Changes in Habitats Caused by Marine Renewable Energy Devices: Benthic Habitats and Reefing Patterns

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.

- 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 to date of significant negative effects occurring to benthic areas around MRE developments, or that marine animals reefing around devices will harm fish populations.

Changes in Habitats - Dashboard



Entanglement and Debris - Dashboard

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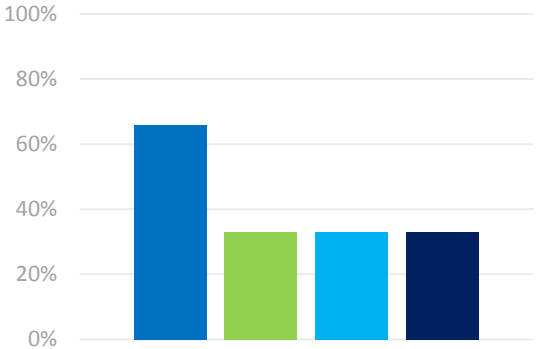
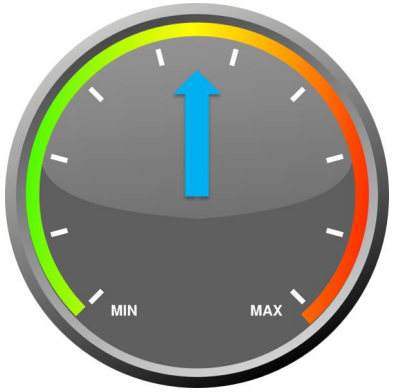
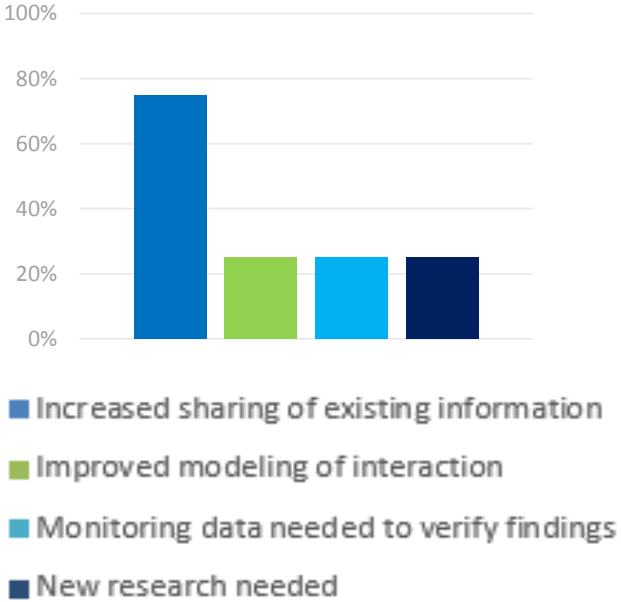
- Ecological Effects of Entanglement



- Entanglement of Fishing Gear





Marine Spatial Planning (MSP)

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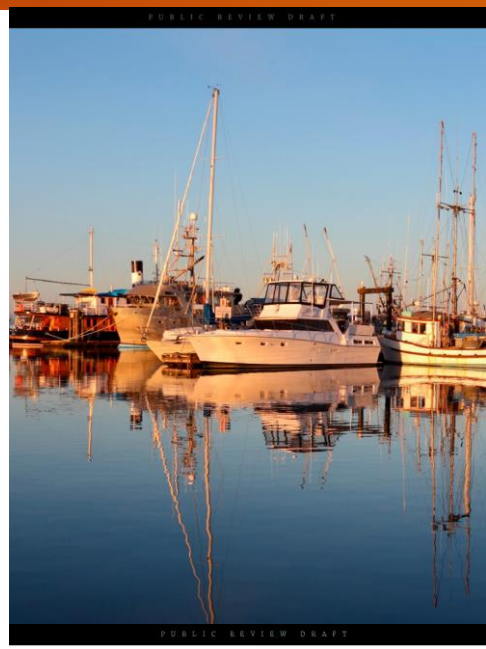
- MSP involves planning and managing sea uses and users to support sustainable development of marine areas:
  - Can work to decrease cumulative environmental impacts by planning uses properly
- Annex IV representatives were surveyed about use of MSP in their nations.
- Several nations have formal MSP 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.



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).

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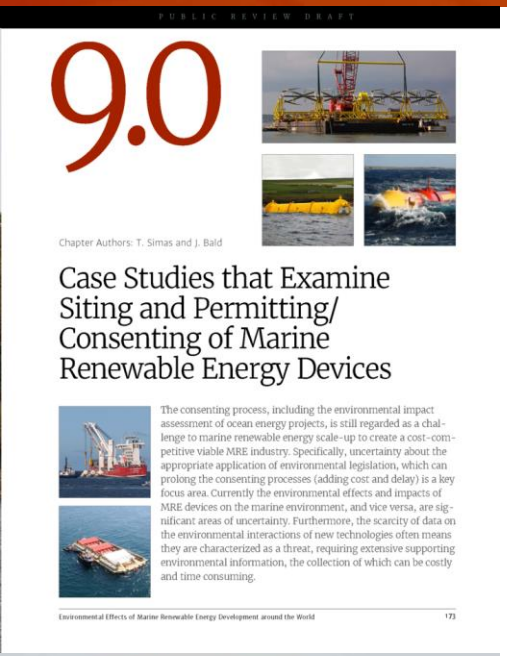
Lessons from Case Studies



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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.

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- Permitting processes were reviewed for four projects:
  - WaveRoller wave technology (Portugal)
  - TidGen® Power System tidal technology (US)
  - SeaGen tidal technology (Northern Ireland)
  - BIMEP (Biscay Marine Energy Platform), a designated wave test site (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.

Path Forward

- 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

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.

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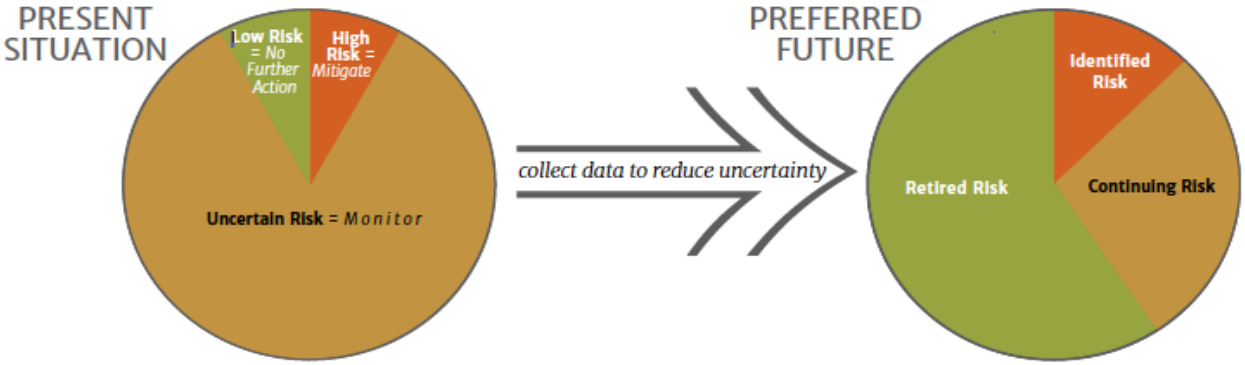

Questions and Comments

- What are challenges in permitting?
- What environmental impacts information is needed to make permitting processes more efficient/effective?

- Usefulness of this meeting, need for additional online meetings

- Next step: follow up with 1-on-1 phone interviews, please email mikaela.freeman@pnnl.gov if you DO NOT want to be contacted for the survey.

- Telephone surveys will start in the next couple of weeks

THANK YOU!

- If you would like to join the Tethys mailing list for information on environmental impacts, upcoming webinars and more, sign up at **https://tethys.pnnl.gov/tethys-blasts/join**

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