



# Annex IV Phase 3 DOE Work Plan DRAFT

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# Annex IV Phase 3 DOE Work Plan

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## 1 Background

Annex IV is a task led by the US under the Ocean Energy Systems (OES) which seeks to facilitate development of marine renewable energy through gathering and disseminating information on the potential environmental effects of MRE technologies and identifying methods for monitoring the interactions.

The first phase of Annex IV (2009-2012) included participation of seven OES nations and focused on creating a public, searchable, online knowledge base ([tethys.pnnl.gov](http://tethys.pnnl.gov)) featuring information on environmental effects of MRE. Efforts also included outreach and engagement with academic, scientific, and commercial organizations and institutions through activities such as webinars, workshops, and online meetings. Phase 1 concluded with a report summarizing the state of the understanding of environmental effects around wave and tidal devices<sup>1</sup>.

Phase 2 of Annex IV (2013-2016) included 13 OES member nations, led by the US. Expansion of the *Tethys* database through collection of scientific papers, reports, and metadata on MRE development and its relationship to potential environmental effects were expanded on during this phase. In addition, Phase 2 focused on bringing together the MRE community interested in the environmental focus of Annex IV by involving researchers, developers, regulators, and stakeholders in various activities. Outreach and engagement was supported via webinars delivered by subject matter experts and online expert forums which included small focus groups working toward resolving issues or developing a common understanding of problems facing the MRE sector. Workshops and conference support also help facilitate outreach and engagement with the MRE community focused on environmental issues and topics. Similar to Phase 1, Phase 2 concluded with the production of a report<sup>2</sup> on the state of the science which synthesized the knowledge of environmental research pertaining to MRE devices. The 2016 report includes 10 chapters, 14 authors, and 11 contributors. Executive summaries of the report have been translated into six languages.

Phase 3 of Annex IV (2016-2020) was proposed to the OES Executive Committee and accepted as a four year continuation of the work of previous phases, in May 2016.

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<sup>1</sup> Phase 1 state of the science report is available on *Tethys*: <http://tethys.pnnl.gov/sites/default/files/publications/Final-Annex-IV-Report-2013-v2.pdf>

<sup>2</sup> Phase 2 state of the science report is available on *Tethys*: <http://tethys.pnnl.gov/publications/state-of-the-science-2016>

## 2 OES Annex IV Goal and Objectives

Driven by the continued uncertainty and challenges surrounding the environmental effects of MRE development, the goal of Annex IV Phase 3 is to address several MRE deployment barriers, promote increased understanding and social acceptance of marine energy development.

OES Annex IV Phase 3 objectives:

1. Curate and expand the knowledge base hosted on *Tethys* to ensure that all relevant publications are represented and accessible.
2. Continue to update and collect metadata on all MRE projects, globally, for which environmental effects information has been collected.
3. Ensure that OES member nations are kept apprised of important findings pertaining to research and monitoring of the environmental effects of MRE development.
4. Form strategic relationships with other key programs to jointly plan and execute activities that support the siting and permitting/consenting of MRE devices.
5. Support the acceleration of scientific findings into the management and policy arena to help reduce uncertainty to sustainable MRE development.
6. Engage members of the MRE community and their organizations around key questions of environmental interactions that are of importance in the siting and consenting/permitting of devices and arrays, and provide information that is useful and accessible for regulators to reduce uncertainty around environmental effects.
7. Identify and disseminate information on environmental effects and uncertainties that continue to slow and complicate the development of the MRE industry through active outreach and engagement.

## 3 Purpose and Rationale of the Phase 3 Work Plan

The Annex IV efforts are largely guided by the goal and objectives outlined in the OES Phase 3 proposal. Additionally, the US Department of Energy's Wind and Water Power Technologies Office (WWPTO), has made significant investments to the Annex by supporting the Pacific Northwest National Laboratory's (PNNL) involvement in creating the *Tethys* and Annex IV knowledge bases. Annex IV activities undertaken by PNNL are outlined on an annual basis in the laboratory's Annual Operating Procedure (AOP). The work plan herein is not intended to supersede the OES proposal, nor the DOE-PNNL AOP. This plan has been developed as a means to provide a strategic approach for organizing and aligning objectives with Annex IV Phase 3 tasks and activities, and is one of several approaches necessary for success of the Annex. This strategic plan is organized around three themes that will guide many of the activities of phase 3 (2016-2020). However, objectives such as curation and expansion of the knowledge base within *Tethys*, the updates and maintenance of Annex IV metadata for MRE projects, and interaction with OES member nations are not readily binned into the themes for Phase 3. Activities supporting these objectives will continue to be implemented to support overarching program goals and objectives. It is worth noting that while the themes offer a means for organizing and demonstrating activities, this narrowed focus may give the perception of excluding certain activities that are not readily

binned into one of the themes. Phase 3 of Annex IV covers a four year period at a very key time for early commercialization and expansion of the MRE industry; it will be important to maintain flexibility and openness toward new topics and opportunities relevant to Annex IV as they arise, as these new topics and opportunities relate to increasing understanding and awareness of risks of environmental impacts to the marine environment, and toward retiring risks and supporting proportional monitoring and mitigation requirements associated with MRE development.

## **4 Thematic Approach for Implementing Annex IV Phase 3**

Despite a growing body of research, development of the MRE industry continues to be hampered by concerns and uncertainty around interactions between the marine environment and MRE devices and balance of station. The lack of directed research on some of these interactions, inconsistent methods for monitoring interactions, and questions pertaining to transferability of datasets poses significant challenges for resolving barriers for this developing industry. We propose to structure Annex IV activities around key themes for the purpose of streamlining outcomes and making impactful progress on resolving issues and questions pertaining to environmental interactions with the MRE industry. The themes will guide activities relevant to multiple OES Annex IV objectives noted above, and have particular relevance to forming strategic relationships with other key programs, supporting the acceleration of scientific findings, and outreach and engagement. The three themes include 1) collision risk of marine animals with MRE devices and systems; 2) reducing risk and uncertainty of interactions of MRE devices and the environment; and 3) socio-economic aspects of marine renewable energy development. Separate objectives have been established for each theme; the measure of success for implementing each theme will be measured against these objectives.

### **4.1 Collision Risk**

The risk of marine animals colliding with turbines continues to be the most intractable interaction associated with permitting tidal turbines.

#### **4.1.1 Background**

Considerable research has been directed towards collision risk for marine mammals and turbines, particularly in Europe and Canada, and around fish and turbines in the US and other nations. However, relatively little is yet definitively known about the magnitude of the risk, particularly among marine populations already under stress from climate change and other anthropogenic activities. To date, no collisions between marine mammals and turbines have ever been observed, and no fish collisions of consequence have been seen. Direct observation of the area of potential collisions around turbines is very challenging; efforts to estimate the number of animals likely to be in the vicinity of turbines and potentially at risk have not been found to be particularly accurate. Efforts to bring together the collective learning by researchers, and the needs of regulators to match regulatory certainty against realistic data collection have been examined through a series of workshops (Stornoway UK April 2014; Edinburgh UK February 2015) and have been collated into an action plan with the goal of retiring collision risk and ensuring that monitoring and mitigation activities are proportional to the risk. It is

clear that there is a missing piece to understanding the likely risk to animals and turbines; an extensive study is needed of the collision risk models used to estimate animals at risk in the vicinity of turbines and the datasets that have been collected to date. This assessment will move towards determining the most effective and provable match of models and validation data needed to determine the presence of animals at risk, and the potential for avoidance and attraction to MRE devices. The second key missing piece of information to help retire collision risk and seek proportional monitoring and mitigation efforts is the need to understand evasion of animals around turbines. Early datasets from Scotland and from Wales are becoming available, as are videos from river turbines. As acoustic and optical cameras around single tidal devices and arrays indicate the likelihood of marine mammals and fish interacting with turbines, great strides can be made in understanding collision risk.

#### **4.1.2 Objectives of Collision Risk Theme**

Annex IV will seek to increase knowledge of the mechanics and probability of collision risk, while decreasing uncertainty around the probability and consequence of a collision, in order to:

- Provide inputs to collision risk models for marine mammals and fish that account for avoidance and evasion of turbines, based on field data, expert elicitation, and ancillary modeling efforts;
- Support examination of collision risk models to determine the realism of models for describing interactions between marine animals and turbines;
- Provide input to planning of strategic research projects that will further the collection of field data, analyses of data, improved modeling and analysis of modeling outputs, and estimations of encounter risk for marine animals;
- Bring together key collision risk practitioners to work towards retiring the risk and/or determining proportional and practical monitoring and mitigation requirements for continuing risk through strategic research and expert elicitation; and
- Broadly disseminate collision risk findings in a timely fashion through short science summaries, webinars, expert forums, workshops, and conference tracks.

#### **4.1.3 Why Annex IV?**

Annex IV is in a unique position to continue to address the challenges of collision risk facing the MRE industry. By building on the work of the 2016 State of the Science (SoS), previously sponsored international workshops on collision risk, and collaborations in key MRE countries (e.g. the UK, US, and Canada), Annex IV activities will contribute to allaying concerns around collision risk and support the efficient planning, development, permitting, and operation of turbines.

## **4.2 Reducing/Retiring Risk**

Risk is perceived as the probability of an adverse outcome that accounts for the likelihood as well as the consequence of a particular event (Copping et al. 2015).

### **4.2.1 Background**

As a new industry, the interactions and potential consequences between MRE devices and marine animals or habitats have not been fully resolved. This uncertainty about consequences and outcomes

often leads to a heightened perception of risk by regulators and stakeholders. Separating real from perceived risk around MRE development is constrained by a paucity of data, as well as by a risk-averse regulatory system that has a low tolerance for uncertainty. Copping and Hutchinson (2016) assert that progress of the industry must be coupled with the development of a path for retiring risks and minimizing uncertainty. This path includes understanding where interactions reside along the continuum of uncertainty and risk, as perceived by regulators and stakeholders, and developing clear approaches for retiring certain risks. Reducing uncertainty will also be aided by maximizing opportunities to learn from datasets and research findings of early deployments and pilot projects. Additional opportunities to develop good practices for moving the industry forward while retiring risk also includes collaboration on research priorities, planning for strategic research, partnerships among organizations pursuing similar goals, and broad sharing of data and information. The overall strategy for addressing risk and uncertainty will vary with the particular audience needs and interests (for example: working with NOAA regulators will focus on risks under their purview such collision risk, changes in benthic habitat, acoustic effects on marine mammals and fish, etc.). It is likely that the MRE/marine environment interactions with highest likelihood of risk, as per the 2016 State of the Science report, will receive the most attention.

#### **4.2.2 Objectives of Reducing/Retiring Risk Theme**

Annex IV will seek to evaluate the state of knowledge of risks from interactions of MRE devices and the marine environment for key stressors that are driving permitting concerns, in order to:

- Ensure that present knowledge is broadly understood by regulators, developers, and other MRE practitioners through development and dissemination of short science summaries, webinars, expert forums, and opportunistic workshops and conferences;
- Collect, collate, and disseminate the data collection and research needs that regulators require to efficiently and effectively move permitting processes forward;
- Examine pathways to increase the transferability of datasets and associated information between and among development locations to reduce assessment and monitoring burdens in future development;
- Identify and encourage the use of standardized methods of data collection, where appropriate, for baseline and post-installation monitoring of environmental interactions of MRE devices; and
- Identify and evaluate the effectiveness of potential mitigation tools for use when it is determined that mitigation around MRE devices is necessary.

#### **4.2.3 Why Annex IV?**

Annex IV is well placed to continue broad dissemination of information on environmental effects of MRE development and to provide positive outcomes in support of the MRE industry by providing a greater focus on underserved audiences such as regulators and developers.

### **4.3 Social and economic impacts**

Interactions, potential conflicts, and benefits stemming from MRE development are not exclusively environmental and may also fall in the social and economic realms.

#### **4.3.1 Background**

To understand the suite of impacts of any MRE development, social and economic factors should be recognized and assessed. Social and economic impacts can range from impacts on fisheries, recreation, jobs and industries, and communities and cultures. While some social and economic impacts of MRE development can be seen as damaging or diminishing other ocean uses, there are also considerable social and economic benefits that may be realized from these developments, particularly in terms of local jobs, regional economic development, and training of professional and technical staff for marine careers. Both the potential positive and negative effects should be considered.

With each MRE development, different social and economic implications will arise that should be assessed in order to relay the benefits of a project, minimize conflicts or negative impacts, and gain stakeholder support. Most MRE projects do not specifically deal with social and economic impacts beyond what is needed for meeting regulatory requirements; however depending on the needs of local and regional communities, conflicting interest for space and resources has the potential to slow and complicate development of MRE. Proactive efforts to address social and economic impacts and share research can help continue to move the MRE industry forward.

#### **4.3.2 Objectives of Social and Economic Theme**

Annex IV will seek to identify and evaluate the range of social and economic interactions that may results from MRE development, in order to:

- Identify the range of social and economic benefits that may accrue to local and regional areas from MRE development, and determine strategic research that could assist with optimizing these benefits;
- Identify the range of local social and economic risks from MRE development and examine the degree to which these factors can be mitigated;
- Bring together social scientists and other interested parties to ensure that the best scientific methods are applied to interactions with MRE development; and
- Broadly disseminate findings of social and economic research among MRE practitioners throughout the Annex IV nations, through short science summaries, webinars, expert forums, workshop, and conferences.

#### **4.3.3 Why Annex IV?**

Annex IX member nations recognize the importance of addressing social and economic issues in the MRE space. Analysts have consistently expressed a strong interest in including socio-econ related topics in Annex IX efforts. Due to strong regional influences, social and economic related activities described below will rely heavily on Annex IV member participation. PNNL staff will work with Annex IV members to help facilitate activities in this work space.

## 5 Implementation

PNNL will lead and be responsible for the organization of all activities under phase 3 of Annex IV; however, it is expected that Annex IV country analysts will take greater responsibility for preparing products and executing additional portions of the work program than has been the case in previous phases. Although the mix of time and effort that each country analyst is likely to expend on any specific product or activity cannot be predicted at this time, the following table an estimate of allocation of effort among project collaborators.

Theme	Product or Activity	Implementation
Collision risk	Webinars Expert Forums Short Science Summaries Workshops	<u>Lead</u> : PNNL <u>Support</u> : Aquatera and other Annex IV nations, as appropriate
Reduction of risk and uncertainty	Webinars Expert Forums Short Science Summaries Workshops	<u>Lead</u> : PNNL <u>Support</u> : Aquatera and other Annex IV nations, as appropriate
Social and economic issues	Short Science Summaries Workshops Webinars Expert Forums	<u>Lead</u> : Annex IV nations <u>Support</u> : PNNL, as appropriate

## 6 Activities

Details of planned activities, and their timing, expected outputs and outcomes are outlined for each of the three themes.

### 6.1 Collision Risk

#### 6.1.1 Webinars

**Timing:** 1-2 per year, as part of quarterly webinar series

**Output:** Webinars will be designed to focus on specific aspects of collision risk. Examples include, collision risk mitigation measures, progress on research aimed at understanding collision risk, collision risk modeling.

**Outcome:** Sharing and disseminating new research findings, efforts aimed at model development, and overall progress on the elucidation of collision risk will lead to an increased understanding of the risk by regulators, researchers, and developers. This increased understanding will help to eliminate uncertainty and simplify permitting, monitoring, and mitigation.



### 6.1.2 Expert Forums

**Timing:** 1-2 per year, as needed and research expertise is available to lead.

**Output:** Sharing of monitoring methods, challenges, and data collection efforts, analytical findings and challenges.

**Outcome:** Better alignment of research plans and comparability of results to help retire risk.

### 6.1.3 Workshops

**Timing:** up to one per year, in coordination with an existing conference, such as EIMR, EWTEC.

**Output:** Bringing together of research expertise to tackle current important questions in collision risk that are holding up permitting. Written report of findings.

**Outcome:** Progress toward retiring collision risk and ensuring post-installation monitoring and mitigation measures are proportionate to risk.

### 6.1.4 Conferences

**Timing:** One or more per year. Relevant conferences include Environmental Interactions of Marine Renewable Energy Technologies (EIMR), the European Wave and Tidal Energy Conference (EWTEC), International Conference on Ocean Energy (ICOE), Marine Energy Technology Symposium (METS).

**Output:** Increased number of papers and sessions focused around environmental effects.

**Outcome:** Progress toward retiring collision risk and other risks, as well as insight into developing appropriate monitoring programs and mitigation measures. Also, sharing of environmental effects research with other portions of the MRE research and engineering community.

### 6.1.5 Short Science Summaries

**Timing:** Likely one in 2017, more as needed in out-years.

**Output:** A summary of existing research on the best available data and information on progress made toward understanding active and passive avoidance and evasion, or other timely outcomes in collision risk. This summary would be developed to accommodate regular updates on an as needed basis.

**Outcome:** Increased awareness and accelerated dissemination of research findings to policy makers to inform decision making. Researchers must be engaged in this summary to ensure that they are comfortable with the level of detail being released, often prior to peer-reviewed publication.

### 6.1.6 2020 State of the Science Report

**Timing:** Detailed planning and implementation will begin early 2019.

**Output:** State of the Science report that highlights progress toward describing, retiring, and mitigating risks that has been carried out since 2016 report.

**Outcome:** Progress toward retiring collision risk and ensuring that post-installation monitoring and mitigation measures are not hindering MRE development.

## 6.2 Reducing Risk and Uncertainty

### 6.2.1 Activity: Webinars

**Timing:** 1-2 per year, in addition to the quarterly webinar series

**Output:** The first webinar addressing this theme will provide regulators with what we know about risks and will include a dialog and feedback loop between regulators and researchers to determine what is feasible as well as what is desirable from the regulatory point of view. Particular focus will be given to how uncertainty influences perception of risk in the MRE industry. This content of this webinar will be driven by the 2016 SoS as well as new and relevant research. The target audience includes regulators as well as other members of the MRE community. Follow-on webinars will focus on sharing regulatory perspectives with developers and researcher – i.e. outcomes from other related activities described herein. In addition to sharing knowledge with regulators and other underserved audiences, these webinars (and other outreach activities) will be used to gather input from the audiences, to guide future outreach activities. In particular, regulators will be encouraged to share what they believe they need to regulate MRE installations with confidence and speed. Developers will be asked to share what baseline assessment, monitoring, and mitigation activities are of particular concern for them in development. Other audiences and their specific outreach needs will be determined as phase 3 unfolds. Where needed, individual interviews and surveys will be carried out with specific audiences, following the first webinar or contact, once it becomes clear what needs and gaps in understanding are present and likely to impede siting and permitting of MRE devices and arrays.

**Outcome:** Outreach to specific audiences will lead to an increased understanding of proportional risk, and identification of appropriate data collection targets to meet the needs of the specific audiences. Target audiences include regulators as well as other members of the MRE community such as developers and researchers.

### 6.2.2 Expert Forums

**Timing:** 1-2 per year, as needed

**Output:** Topics will vary depending on target audience; regulatory challenges among regulators for U.S. and other Annex IV nations; sharing information and advice on implementation of mitigation measures among researchers and developers.

**Outcome:** Sharing lessons learned and potential solutions to regulatory barriers to MRE development and accelerated learning and availability of science findings to inform policy.

### 6.2.3 Workshops

**Timing:** Up to one per year, in coordination with an existing conference.

**Output:** Engaging MRE community members (e.g. regulators and developers) not typically represented at previous Annex IV workshops. Two workshops tentatively planned for 2017 include 1) identification of mitigation measures associated with MRE deployments and 2) targeted interactions with regulators to share broad understandings of uncertainty and risk for key environmental topics. The first workshop is planned in conjunction with EIMR and will include researchers, Scottish regulators, and some developers. The second workshop may occur in conjunction with METs to take advantage of the opportunity for an in-person interaction with U.S. regulators.

**Outcome:** Increased understanding of mitigation measures and research challenges necessary for resolving regulatory needs. Additionally, outreach and engagement of regulators will provide opportunities to understand the challenges they face with regard to dealing with uncertainty under their respective regulatory frameworks.

#### 6.2.4 Conferences

**Timing:** One or more per year. Relevant conferences include Environmental Interactions of Marine Renewable Energy Technologies (EIMR), the European Wave and Tidal Energy Conference (EWTEC), International Conference on Ocean Energy (ICOE), Marine Energy Technology Symposium (METS).

**Output:** Contribution to environmental track and/or sessions, and engagement of regulators, developers, and researchers at those conferences.

**Outcome:** Progress towards retiring collision risk and other risks, as well as insight into developing appropriate monitoring programs and mitigation measures. Also, sharing of environmental effects research with other portions of the MRE research and engineering community.

#### 6.2.5 Short Science Summaries

**Timing:** Likely one in 2018, more as needed in out-years.

**Output:** A short summary detailing stressor/receptor relationships as informed by outreach and engagement with regulators and developers. Additional topics include risk-based consenting/permitting and approaches for defining acceptable levels of risk for population of organisms. These papers would be broadly disseminated to regulators, developers, and other key audiences.

**Outcome:** Progress towards retiring some risks, from the regulators' point of view, and determining the need to require only proportional monitoring and mitigation, based on that risk assessment. Increased awareness of proportional risk among developers as well as policy and management levels of regulatory agencies, and other members of the MRE community.

#### 6.2.6 2020 State of the Science Report

**Timing:** Detailed planning and implementation will begin early 2019.

**Output:** State of the Science report that highlights progress towards describing, retiring, and mitigating risks that has been carried out since 2016 report.

**Outcome:** Progress towards retiring some risks and ensuring that post-installation monitoring and mitigation measures aimed at other risks are not hindering MRE development.

### 6.3 Social and Economic Aspects of MRE

#### 6.3.1 Webinars

**Timing:** 1-2 per year, as part of quarterly webinar series.

**Output:** Key issues and topics as identified by Annex IV country analysts.

**Outcome:** Increased understanding of key social and economic issues as they influence and/or are influenced by MRE development.

### 6.3.2 Expert Forum

**Timing:** 1-2 per year, as needed

**Output:** Targeted discussions on research questions of specific social and economic issues which may ultimately inform webinar topics and other outreach activities.

**Outcome:** Achieve progress toward consensus on key social and economic research needs and strategic projects that minimize conflict with other ocean users.

### 6.3.3 Workshops

**Timing:** May include up to one per year, in coordination with an existing conference, subject to one or more Annex IV analysts taking the lead on organizing the workshop.

**Output:** Targeted work sessions addressing topics that respond to important social and economic research needs.

**Outcome:** Identification of research areas needed to evaluate social and economic risks and benefits of MRE development and allow coexistence with other ocean users. Leveraging from Annex IV analysts on country specific issues and achievements will provide for a broader understanding of how the MRE industry can fit within the scope of social and economic issues.

### 6.3.4 Conferences

**Timing:** One or more per year. Relevant conferences include Environmental Interactions of Marine Renewable Energy Technologies (EIMR), the European Wave and Tidal Energy Conference (EWTEC), International Conference on Ocean Energy (ICOE), Marine Energy Technology Symposium (METS).

**Output:** Increased focus on social and economic tracks and sessions.

**Outcome:** Bringing the social and economic research community together to plan cooperative strategic research and increase awareness of the importance of social and economic issues for MRE development.

### 6.3.5 Short Science Summaries/Position Papers

**Timing:** Likely one in 2018, more as needed in out-years.

**Output:** Development of a position paper and/or short science summary that defines and sets an agenda for social and economic research on MRE development. Paper development will be largely carried out by Annex IV country analysts.

**Outcome:** Helping to bring together and organize the social and economic research community to plan cooperative strategic research. Broad dissemination of a paper will lead to increased awareness of the importance of social and economic issues.

### 6.3.6 2020 State of the Science Report

**Timing:** Detailed planning and implementation will begin early 2019.

**Output:** State of understanding of key topics in social and economic risks and benefits of MRE development as of 2019.

**Outcome:** Definitive evaluation of key social and economic risks and benefits and potential conflicts of MRE development.

## 7 Outcomes

Within each theme, activities are sequenced to ensure that the state of knowledge is progressed and that key uncertainties are addressed in a logical manner. In addition, a degree of flexibility is built into the process to ensure that new research developments, emerging trends in monitoring data, and new findings within project development and research programs are used to guide Annex IV activities. The purposes of Annex IV are best served by ensuring that the collective wisdom and scientific findings of the participating nations guide the program. By understanding critical data gaps, sharing lessons learned, providing timely updates on research findings, and relating those findings to necessary regulatory processes, Annex IV can support and ultimately help shape the future of MRE development.

### 7.1 Collision Risk

Building on considerable past engagement in collision risk issues, Annex IV activities will continue to promote an increased understanding of how to: determine the risks to marine animals; measure potential animal/blade interactions; and, should they become necessary, identify, deploy, and evaluate effective mitigation methods. Examining and coalescing strategic research will help to retire collision risk and reduce deployment barriers for the industry. This theme, in particular, will continue to benefit from facilitating discussions among the international research community around specific aspects of collision risk monitoring, modeling, and potential mitigation, and relating those discussions to specific regulatory barriers that are stalling or slowing tidal and river turbine deployment and expansion. Involving MRE community members including researchers, regulators, and developers through outreach and engagement activities, as well as dissemination of key findings, will promote a common understanding of risks related to collision. Work under this theme will simplify and facilitate permitting, and ensure proportionality of monitoring and mitigation, in order to facilitate the development and expansion of the industry.

Successful outcome of this theme will entail:

- Providing inputs to and encouraging analyses of collision risk models to move towards retiring collision as a risk and/or ensuring proportionate levels of monitoring and mitigation are required;
- Developing directions for strategic research projects, with the consensus of the research community, as well as methods for encouraging research teams and funding of these projects; and
- Determining that the MRE community broadly is aware of and understands the state of knowledge of collision risk, including the degree to which key portions of the risk equation have been solved.

## **7.2 Reducing Risk and Uncertainty**

The 2016 State of the Science report set the stage for broadly assessing risks and uncertainties across all major potential interactions of MRE devices and the marine environment. Topics under this theme will focus on the most important of those key interactions by seeking to reduce risk and uncertainty. The most significant activities under this theme will focus on increasing understanding of proportional risk and targeted data collection efforts among regulators in the US and internationally. Efforts will focus on specific needs for data products and information identified by regulators as vital to moving forward with permitting of single devices and arrays. In addition to engaging regulators, work under this theme will necessitate interaction with researchers to ensure data and knowledge requests from regulators are feasible and useful for answering key questions. Developers will benefit from efforts aimed at minimizing uncertainty and generating a shared understanding of specific data and knowledge requests that will satisfy regulators' needs. Reducing risk and uncertainty will facilitate permitting, as well as promote targeted and proportional monitoring and mitigation requirements. These clear and proportional assessment, monitoring, and mitigation requests will help clarify requirements for the development community, and provide needed certainty for financing, in order to support the development and expansion of the industry.

Successful outcome of this theme will entail:

- Determining that the MRE community, particularly regulators, understand the state of knowledge of MRE effects on the marine environment, as well as outcomes of Annex IV and related expert elicitations;
- Collating and disseminating information on regulatory needs for data collection, modeling, and analysis efforts to ensure that permitting requirements are proportionate to the risks involved;
- Understanding the degree to which transferability of datasets and standardization of data collection is possible, as they may simplify permitting processes; and
- Understanding the range of effective mitigation measures that exist for key interactions of MRE device with the environment, should they be required in future.

## **7.3 Social and Economic Aspects of MRE**

Activities under the social and economic theme have been less explored in Annex IV, to date, and hence will focus more on defining the issues than is the case for the other two themes. The social and economic issues can be divided into those that will benefit from MRE development (the "positive" issues) and those that may be harmed by MRE development (the "negative" issues). Annex IV activities will focus on a means to enhance the potential positive outcomes, while exploring options to possibly mitigate potential negative outcomes. Activities under the social and economic theme will result in broad engagement of Annex IV country analysts and MRE community members to develop an increased understanding of the risks and benefits of these issues to the MRE industry. Activities will result in the identification of strategic social and economic research that minimizes conflict with existing and future uses of ocean space.

Successful outcome of this theme will entail:

- Identifying social and economic risks and benefits of MRE development that affect local and regional areas;
- Determining appropriate research to further understand the risks and benefits in order to mitigate risks and realize the benefits; and
- Ensuring that the MRE community understands the role that social and economic factors play in MRE development.

#### 7.4 2017 Activities

The activities planned for 2017 have been summarized with emphasis on particular objectives within a given theme.

Theme	Activity	Topic	Outcome
Collision Risk	Webinar	Development of algorithms to assess collision risk	Provide input to strategic research with increased understanding of data collection and analyses to improve understanding of collision risk.
	Webinar	Results of monitoring marine animals around turbines	Broad dissemination of research findings, lessons learned, remaining data gaps, and opportunities to retire risk.
	Expert Forum	Collision Risk Monitoring	Bring together key practitioners to work toward retiring risk and/or provide inputs to collision risk models
	Workshop	Management of Potential Effects of MRE	Bring together key collision risk practitioners to work towards retiring the risk and/or determining proportional and practical monitoring and mitigation requirements for continuing risk through strategic research and expert elicitation
Risk and Uncertainty	Webinar	MRE research: EMF from cables and fish interaction with devices	Broad dissemination of research findings, lessons learned, remaining data gaps, and opportunities to retire risk.

Theme	Activity	Topic	Outcome
	Webinar	Summary of data gaps and information needs from a regulatory perspective	Collect, collate, and disseminate data collection and research needs that regulators require to efficiently and effectively more permitting processes forward
	Expert Forum	U.S and international regulators: Data gaps, lessons learned, monitoring vs. research	Collect, collate, and disseminate data collection and research needs of regulators to minimize permitting barriers.
	Workshop	The role of uncertainty and risk in MRE development	Engagement and dissemination of state of understanding, understanding information gaps and needs from a regulatory perspective.
Social and Economic Aspects of MRE	Webinar	TBD <sup>1</sup>	Activities will collectively result in broad engagement of MRE community members and identification of strategic research that minimizes conflict with existing and future uses of ocean space.
	Webinar		
	Expert Forum		
	Workshop		

<sup>1</sup>Activities under this theme will rely primarily on implementation by Annex IV country analysts (see section 5).

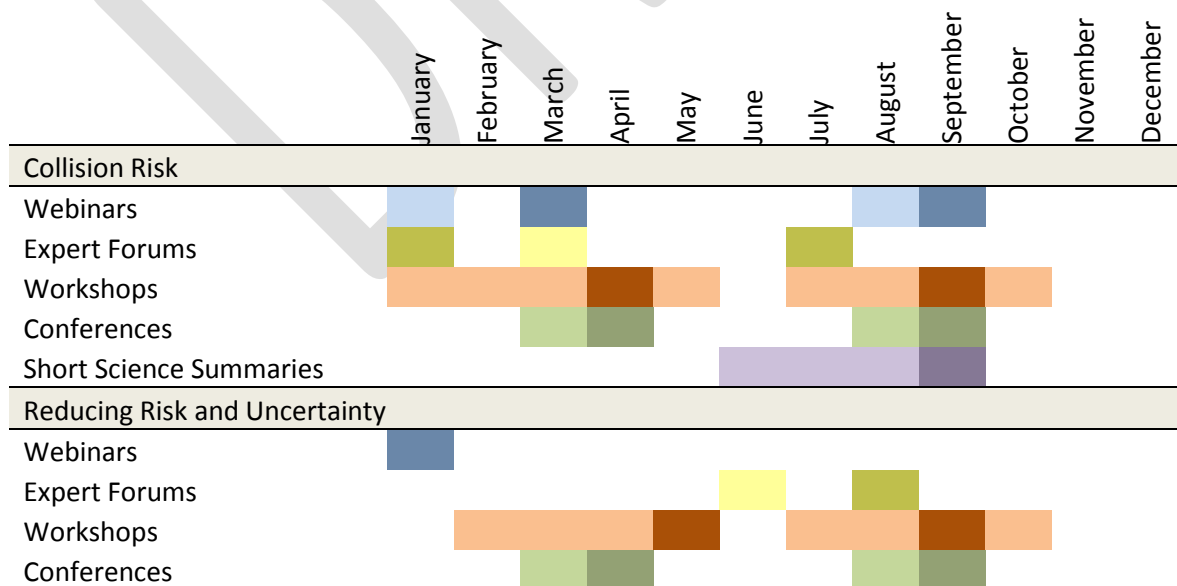


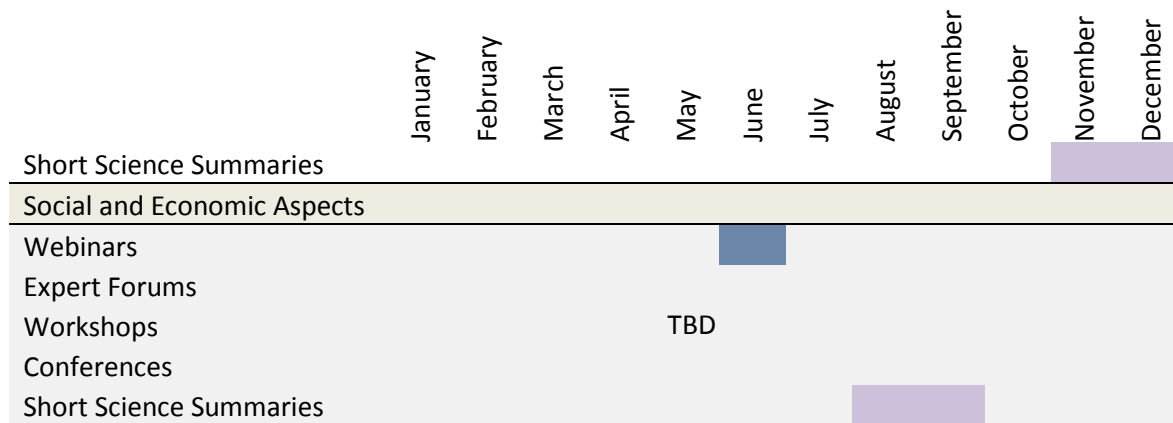
## 8 Schedule of Activities

**Table 1. General schedule of activities in a given year in support of implementing a theme-based approach for Annex IV Phase 3.**

Theme	Webinars	Expert Forums	Workshops	Conferences	Short Science Summaries	State of the Science Report
Collision Risk	1-2 per year, quarterly	1-2 per year, as needed	Up to 1 per year, in coordination with existing conference.	1 or more per year [EIMR, EWTEC, ICOE, METS]	Likely 1 in first year, more as needed in out-years	Planning in late 2018 and implementation in early 2019
Reducing Risk and Uncertainty	1-2 per year, quarterly	1-2 per year, as needed	Up to 1 per year, in coordination with existing conference.	1 or more per year [EIMR, EWTEC, ICOE, METS]	Likely 1 in second year, more as needed in out-years	
Social and Economic Aspects	1-2 per year, quarterly	1-2 per year, as needed	Up to 1 per year, in coordination with existing conference.	1 or more per year [EIMR, EWTEC, ICOE, METS]	Likely 1 in second year, more as needed in out-years	

**Table 2. Draft 2017 timeline**





\*Shaded cells indicate the event date. Colored cells before and/or after event dates indicate planning activities and/or follow-on activities that support the event.

\*This timeline is only representative of activities associated the execution of the themes. See sections 2 and 3 for a list of other Annex IV activities

## 9 References

Copping, A., Hanna, L.; Van Cleve, B.; Blake, K.; and Anderson, R. 2015. Environmental Risk Evaluation System – An Approach to Ranking Risk of Ocean Energy Development on Coastal and Estuarine Environments. *Estuaries and Coasts* 1-16. <<http://tethys.pnnl.gov/publications/environmental-risk-evaluationsystem-approach-ranking-risk-ocean-energydevelopment>>

Copping, A. and I. Hutchison. 2016. “Summary and Path Forward for Marine Renewable Energy Monitoring and Research.” In: *Annex IV 2016 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World*. Copping et al. pp. 185-199. <<https://tethys.pnnl.gov/publications/state-of-the-science-2016>>