PNNL-27995

Pacific Northwest NATIONAL LABORATORY

Data Transferability and Collection Consistency in Marine Renewable Energy

September 2018

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U.S. DEPARTMENT OF ENERGY

Prepared for the U.S. Department of Energy
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Summary

Concerns about the potential effects of tidal turbines and wave energy devices on the marine environment continue to slow siting and permitting/consenting of single devices and arrays worldwide. While research studies and early results from post-installation monitoring over the past decade have informed interactions between marine renewable energy (MRE) devices, marine animals, and habitats, regulators still demonstrate considerable reluctance to accelerate the permitting/consenting process for devices and arrays. Furthermore, the MRE industry is struggling with the high costs of baseline assessments and post-installation monitoring, as well as long timelines for obtaining permits, which leads to uncertainty and risk related to project financing. Regulators require assessment and monitoring information to allow them to carry out the necessary analyses to describe, permit/consent, and manage the environmental risks associated with new MRE technologies and new uses of ocean space. One way to reduce risks to the industry and the environment and to allow for acceleration of the permitting/consenting process could be to transfer learning, analyses, and data sets from one country to another, among projects, and across jurisdictional boundaries. In addition, data are collected around early-stage MRE devices using many different methods, instruments, and measurement scales. If similar parameters and accessible methods of data collection were used for baseline assessments and post-installation monitoring around all early-stage devices and MRE developments, the results would be more readily comparable. This comparability would lead to a decrease in scientific uncertainty and support a common understanding of the risk of MRE devices to the marine environment. This in turn would facilitate more efficient and shorter permitting/consenting processes, which would decrease the financial risk for MRE project development.

As a means of addressing the concept of transferring data (information, learning, analyses, and data sets) among projects and collecting data consistently, Annex IV has developed a data transferability process that has been socialized with the MRE community, which includes regulators, industry, developers, consultants, and researchers. The data transferability process consists of five components:

1. A *Data Transferability Framework* brings together data sets in an organized fashion, compares the applicability of each data set for use on other projects, and guides the process of data transfer
2. A *Data Collection Consistency Table* provides preferred measurement methods or processes, reporting units, and the most common methods of analysis or interpretation and use of data
3. A *Monitoring Data Sets Discoverability Matrix* allows a practitioner to discover data sets based on the approach presented in the Framework
4. *Best Management Practices* (BMPs) include five BMPs related to data transferability and collection consistency
5. An *Implementation Plan* presents an approach for implementing and applying the data transferability process.

This report documents the background and development of the data transferability process and associated components and summarizes the next steps needed to successfully implement and apply the data transferability process. The successful implementation of the data transferability process within the MRE community will accomplish the following:

- Ensure that regulators have access to data sets and processes for transferring data from already permitted/consented projects to future projects (as per the process outlined in the Implementation Plan).

- Assist regulators in understanding the applicability of these processes through an active outreach and engagement process.
- Provide technical assistance to help regulators implement the data transferability process using Annex IV and *Tethys* to facilitate the exchange of relevant data and information.
- Ensure developers and their consultants are active participants in Annex IV’s outreach and engagement efforts to ensure their familiarity with and acceptance of the data transferability process
- Provide added value to the data transferability process through engagement activities and the consistent collection of data around MRE devices.

Acknowledgments

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We are grateful for the continuing support we receive from the DOE WPTO, particularly the help that Samantha Eaves provides us. We are also very grateful for the support we receive from Ocean Energy Systems (OES) and the continuing guidance from Ana Brito e Melo and the OES Executive Committee.

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Preface

Annex IV was established by the International Energy Agency Ocean Energy Systems in January 2010 to examine environmental effects of marine renewable energy (MRE) development. The United States leads the Annex IV effort, with the U.S. Department of Energy (DOE) serving as the Operating Agent and partnered with the U.S. Bureau of Ocean Energy Management (BOEM) and the U.S. National Oceanic and Atmospheric Administration (NOAA). Pacific Northwest National Laboratory (PNNL) implements Annex IV, using *Tethys* as the platform on which Annex IV activities are coordinated and archived. PNNL develops and maintains the *Tethys* knowledge management system that provides open access to information about the environmental effects of MRE.

Currently, there are 14 partner nations for the Annex IV effort: Canada, China, Denmark, France, India, Ireland, Japan, Norway, Portugal, South Africa, Spain, Sweden, United Kingdom, and United States. Each country has an Annex IV country analyst ("Ambassador") who commits 20 hours per quarter to Annex IV. Some of the responsibilities include an online Annex IV Ambassador meeting every 2 to 3 months, Annex IV Ambassador outreach activities within the respective nations, and engagement at workshops and other meetings.

The MRE industry is relatively new and has faced regulatory challenges associated with potential environmental effects that are not well understood. Annex IV is mobilizing information and practitioners from Ocean Energy Systems' nations to coordinate research that can progress the industry in an environmentally responsible manner.

Annex IV is currently in Phase 3 (2016–2020), which includes a strong emphasis on working with regulators to facilitate permitting/consenting processes. In addition, Annex IV is focusing attention on collection of information about socioeconomic issues. The phase will culminate with the *2020 State of the Science* report.

Acronyms and Abbreviations

AC	alternating current
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
DC	direct current
DOE	U.S. Department of Energy
EMF	electromagnetic field
ICOE	International Conference on Ocean Energy
MREPA	marine renewable energy project archetype
MRE	marine renewable energy
PNNL	Pacific Northwest National Laboratory
WPTO	Water Power Technologies Office

Contents

Figures

Tables

1.0 Introduction

As the marine renewable energy (MRE) industry advances around the world, the increasing demand for data and information about how MRE technologies (wave and tidal devices) may interact with the marine environment continues. Our understanding of the potential environmental effects of MRE development is slowly increasing, informed by monitoring data collected around devices in several nations and a growing body of research studies. However, information derived from monitoring and research is published in scientific journals and technical reports, which may not be readily accessible or available to regulators and other stakeholders.

Regulators in all jurisdictions must satisfy legal and regulatory mandates in order to grant permission to deploy and operate MRE devices. Inherent in these laws and regulations is a concept of balancing risk to the environment and human uses of public resources against economic development and human well-being. Research efforts related to the potential effects of MRE development are focused on this concept of risk; the interactions between devices and the environment most likely to cause harm, or those for which the greatest uncertainty exists, are garnering the most attention (Copping et al. 2016). The components of risk—probability of occurrence and consequence of occurrence—are fundamental to the process by which regulators evaluate project compliance with environmental statutes. The concept of risk also provides an excellent context for discussing research outcomes and assisting regulators in learning more about potential effects.

The MRE industry is struggling with the high costs of baseline assessments and post-installation monitoring, as well as long timelines for obtaining permits or licenses, all of which lead to uncertainty and risk related to project financing. Regulators require assessment and monitoring information to allow them to carry out the necessary analyses to describe, permit/consent, and manage the environmental risks associated with new MRE technologies and new uses of ocean space. One way to reduce risks to the industry and the environment and to allow for acceleration of this new form of low carbon energy could be the ability to transfer learning, analyses, and data sets from one country to another, among projects, and across jurisdictional boundaries.

1.1 Background on Data Transferability

As the MRE industry matures, the ability to readily transfer research and monitoring results, data, study designs, data collection methods, and best practices from project to project will lead to cost reductions for baseline environmental studies and post-installation monitoring. Regulators and stakeholders currently lack access to synthesized and contextualized data emerging from existing projects, and there are no mechanisms by which to apply data and information across geographically distinct projects. This leads to each individual project bearing the full burden of information requirements on a site-by-site basis. In addition, data are collected around early-stage MRE devices using many different methods, instruments, and measurement scales. If similar parameters and accessible methods of collection were used for baseline and post-installation monitoring around all early-stage devices, the results would be more readily comparable. This comparability would lead to a decrease in scientific uncertainty and support a common understanding of the risk of MRE devices to the marine environment. This in turn would facilitate more efficient and shorter permitting/consenting processes, which would decrease financial risk for MRE project development.

There continue to be high costs and long timelines for permitting/consenting MRE devices. The ability to learn from early projects to inform permitting/consenting processes can help to lower costs and requirements for extensive data collection and subsequently move deployment of wave and tidal devices forward more rapidly.

1.2 MRE Stressors on the Marine Environment

The purpose of examining the potential for data transferability and data collection consistency is to shorten regulatory timelines and provide greater standardization in baseline and post-installation data requested to support permitting/consenting of MRE projects across multiple jurisdictions, with the amount of data requested being proportional to the risk to the environment. After the publication of the 2016 State of the Science Report (Copping et al. 2016) and as a result of extensive discussions with relevant stakeholders, six stressors[1] between MRE devices and the marine environment were identified as those most commonly associated with permitting/consenting processes that are challenging for both single MRE devices and arrays:

– Collision risk: The potential for marine animals to collide with tidal or river turbine blades, resulting in injury or death is a primary concern for permitting/consenting turbines. There is a high degree of uncertainty around the probability and the consequence of collision, especially for populations afforded special protection.

– Underwater noise: The potential for the acoustic output from operational wave or tidal devices to mask the ability of marine mammals and fish to communicate and navigate remains uncertain, as does the potential to cause physical harm or to alter animal behavior. Noise from installation, particularly pile driving, may cause short-term harm; the risks that this report focuses on are the longer-term operational sound of devices.

– Electromagnetic fields (EMF): EMFs emitted from power export cables and energized portions of MRE devices are thought to potentially affect EMF-sensitive species by interrupting their orientation, navigation, and hunting. Cables have been deployed in the ocean for many decades, but uncertainty remains around the effects of cables associated with MRE devices due to the lack of monitoring data available around MRE devices.

– Changes in habitat: Placement of MRE devices in the marine environment may alter or eliminate surrounding habitat, which can reduce the extent of the habitat and affect the behavior of marine organisms. Habitat changes, including the effects of fish and other organisms reefing around devices and buoys, are well-studied in the marine environment from other industries, and the small footprint of MRE devices are unlikely to affect animals or habitats differently than those from other industries, but regulators and stakeholders continue to express concern.

– Displacement of marine animal populations: While the placement of single MRE devices in the marine environment is unlikely to cause displacement of marine animal populations, as larger arrays are deployed, there are concerns that animals could be displaced from critical foraging, mating, rearing, or resting habitats (DOE/EERE 2009; Boehlert and Gill 2010; Dolman and Simmonds 2010). Large arrays might also cause a barrier effect, preventing animals from crossing a line of devices, navigating around an array, or crossing a cable to reach their preferred or essential habitats.

– Changes in physical systems: MRE devices may alter natural water flows and remove energy from physical systems, which could result in changes in sediment transport, water quality, and other effects on far field habitats. Numerical models provide the best estimates of potential effects; however, any potential effect from a small numbers of devices will be lost in the natural

[1] Specifically, it is the interactions of these stressors with specific receptors that Annex IV is examining.

variability of the system. Once larger arrays are in operation, field data will be needed to validate the models.

1.3 Potential for Data Transferability

It is also important for MRE regulators to be able to examine and apply data and information gathered from other industries to MRE interactions, where appropriate. For example, information about reefing of fish around buoys and platforms placed in the ocean for a variety of purposes provides indications about the potential interaction of fish around wave energy devices, and the presence and emissions from telecom and inter-island subsea power cables provides information about potential EMF effects from MRE power export cables. It is also important to understand when information from other industries is not applicable to potential effects of MRE, such as the effects of conventional hydropower turbines on fish and commercial vessel propellers on marine mammals, both of which rotate at much higher speeds than tidal or river turbines, making them poor analogs for determining the potential effects of tidal or riverine turbines (Copping 2018).

As a means of addressing the concept of transferring data and information[2] among projects and collecting data consistently, Annex IV has engaged with relevant stakeholders[3] through surveys, focus groups, and the Annex IV Data Transferability and Collection Consistency Workshop in June 2018. A discussion of these engagement and outreach efforts is described in Section 2.0. Feedback received during these engagement and outreach efforts informed the development of the formal data transferability process and associated components are described in Section 3.0. Conclusions and next steps are summarized in Section 4.0.

[2] *Could be* raw or quality controlled data, but *more likely* analyzed data and information (includes synthesized data to reach some conclusion, information, learning, analyses, data sets, etc.)
[3] *Relevant stakeholders* include the Annex IV community, along with MRE regulators, MRE device and project developers, researchers, consultants, and other stakeholders.

2.0 Developing the Data Transferability Process

Through discussions with regulators in the U.S. and abroad, and based on the experience of early-stage MRE developers, it is not clear that the state of knowledge of the environmental effects of MRE technologies has been clearly communicated and understood by many regulators. Additionally, there was a perception that regulators in many jurisdictions are not eager to rely on data sets, information, and outcomes generated from other already permitted/consented projects to make permitting/consenting decisions due to their lack of familiarity with the MRE technologies, types of data collected, and methods of data collection. As a first step toward developing a data transferability process that may reduce uncertainty and support a common understanding of the risk of MRE devices to the marine environment, the U.S. regulatory community was surveyed to determine the level of understanding of MRE technologies, priorities for permitting/consenting risk, and their appetite to engage in a data transferability process (Section 2.1). In addition, recent permits and licenses in the U.S. and abroad have been examined for useful data and information.

The survey results helped to tailor material and methods to engage regulators on the proposed approach to data transferability, which resulted in the development of a data transferability white paper (Section 2.2). The white paper also included an in-depth literature review of data transferability and collection consistency frameworks and approaches. U.S. regulators were further engaged through a series of regulator focus groups, which aimed to present MRE data that could be transferred and assess regulators' ability to use such data from another project to permit/consent a project in their jurisdictions (Section 2.3). The international research and development community was then brought together at an Annex IV workshop held in June 2018 (in conjunction with the International Conference on Ocean Energy [ICOE]) to gather additional feedback on the data transferability process, to review and modify proposed best management practices (BMPs), and to discuss ways to implement the data transferability process (Section 2.4). The following sections discuss these outreach and engagement activities.

2.1 Regulator Survey

The U.S. regulatory community was engaged and surveyed to understand their knowledge of MRE technologies and their perceptions of risk for certain interactions with the marine environment. The outcome of the survey was used to design a series of focus groups to understand the challenges of interpreting data and analyses from already permitted/consented MRE projects and the limitations relative to transferring data to future projects in the regulators' jurisdictions. Regulatory concerns highlighted in the survey also informed the development of a data transferability white paper, discussed in the following section.

A mailing list of over 200 U.S. federal and state regulators was compiled and has been used to invite regulators to participate in webinars, the survey, and focus groups and to disseminate information. Regulators included on the mailing list are federal regulators and coastal state regulators whose states have MRE potential and who are or would be responsible for leasing, permitting, or consulting on MRE permits. Such regulators were identified by searching Regional Ocean Councils and Bureau of Ocean Energy Management (BOEM) State Renewable Energy Task Forces for regulators who had engaged in these processes and by searching federal and state agencies for employees who would be involved in permitting/consenting MRE developments. Once a preliminary list was compiled, key regulators in each state (generally selected by who had engaged in Regional Ocean Councils or BOEM State Task Forces) were emailed to see if there was anyone else who should be added to the outreach list. The regulator mailing list has continued to be updated as new U.S. regulators engage in the process.

Following an online Annex IV webinar on *Environmental Effects of Permitting MRE Developments* held in March 2017 during which the state of the science of environmental effects was discussed, an online survey was developed to further understand needs and challenges faced when permitting MRE developments. An invitation to participate in the survey was sent to the U.S. regulators (federal and state) from the regulator mailing list. The survey focused on understanding the familiarity of regulators with MRE technologies, their perceptions of environmental risks for specific interactions of devices and the environment, and thoughts on best approaches to MRE development and data transferability. The survey results and next steps based on the findings were shared with regulators during a second Annex IV webinar, *Environmental Effects of Permitting MRE Developments: Regulator Survey Results and Next Steps* in November 2017. Results of the regulatory survey informed the selection of the six stressors previously discussed and revealed that regulators were open to using data from already permitted/consented projects to inform future projects, especially with increased knowledge of the MRE technologies, types of data collected, and methods of data collection. The full report on the regulator survey is provided in Appendix A.1.

2.2 Data Transferability White Paper

A white paper entitled *Marine Renewable Energy: Data Transferability and Collection Consistency* (Appendix B) was developed in January 2018 to define the challenges associated with data transferability and collection consistency and to propose a preliminary approach to data transferability that could be discussed and socialized with relevant stakeholders. Specifically, the white paper sought to accomplish the following:

- Determine methods, criteria, and guidance for allowing the use of MRE environmental effects data collected for already permitted/consented projects for a future project.
- Outline a process for creating best practices for transferring data from an already permitted/consented project to a future project.
- Explore a pathway for developing best practices for data collection to encourage the collection of consistent data types to address each major MRE stressor.

The white paper includes a literature review to understand how challenges related to data transferability and data collection consistency have been addressed in other industries. The literature that proved to be most pertinent came from a wide range of fields, including economics, transportation, ecology, and land system science. Of particular interest and relevance, Václavík et al. (2016) investigated the transferability potential of research from 12 regional projects that focused on issues of sustainable land management across four continents. The study used a previously developed concept of land system archetypes (Václavík et al. 2013) to estimate the transferability potential of project research by calculating the statistical similarity of locations across the world to the project archetype, assuming a higher degree of transferability in locations that had similar land system characteristics. The proposed transferability framework presented by Václavík et al. (2016) provides a blueprint for research programs that are interested in investigating the transferability potential of place-based studies to other geographic areas, while also assessing possible gaps in research efforts. The full literature review is provided in the data transferability white paper in Appendix B.

The white paper also presents a proposed framework for data transferability that is based on the examined literature and feedback gathered from the regulator survey described above. The development of the proposed framework is guided by the six[4] stressors (described previously) that are commonly associated

[4] The data transferability white paper (Appendix B) only incorporates five of the six stressors. An additional stressor (displacement of marine animal populations) was added after the white paper was developed and has been incorporated into the final data transferability process.

with the permitting/consenting processes that are challenging for both single MRE devices and arrays. The proposed framework incorporates aspects of the transferability methodology and framework developed by Václavík et al. (2016) for sustainable land management purposes. The authors' concept of defining a project "archetype" based on a variety of indicators can be applied to other place-based studies, including MRE studies. By adopting the concept of an "MRE project archetype" (MREPA), a combination of stressors, site conditions, MRE technologies, and receptors can be applied to help meet MRE regulatory needs. More detail on the proposed framework and MREPAs can be found in the data transferability white paper in Appendix B; the data transferability process presented in Section 3.0 includes a revised version of the framework and MREPAs presented in the white paper, based on feedback from relevant stakeholders.

The concepts behind the data transferability white paper were presented to U.S. regulators through a series of focus groups, as discussed in Section 2.3, to understand regulator acceptance of and concerns about data transferability, to articulate the real-world challenges regulators face in applying data from already permitted/consented projects to future projects, and to solicit feedback on the proposed data transferability framework. Feedback from the focus groups was used to refine the concepts in the white paper, which was subsequently reviewed by relevant stakeholders at the Annex IV Data Transferability and Collection Consistency workshop in June 2018, as discussed in Section 2.4. Suggestions and feedback received from these outreach and engagement activities were used to further refine the data transferability process, which is presented in Section 3.0.

2.3 Regulator Focus Groups

A series of focus groups for U.S. regulators was held from February to April 2018 to introduce regulators to data transferability and the framework presented in the white paper. The focus groups included U.S. state and federal regulators drawn from the regulator mailing list and included an in-person focus group in Portland, Oregon, as well as online focus groups held by region in California, Hawaii, the East Coast, and the Pacific Northwest and Alaska. The regional focus groups were tailored to discuss interactions and regulatory concerns that are specific to each region.

The goal of the regulator focus groups was to understand regulator acceptance, concerns, and real-world challenges with data transferability by assessing existing data sets, and to gain feedback on the usefulness of the proposed data transferability framework. To achieve this, each regulator focus group was conducted to provide information and seek feedback as follows:

- Understand regulators' real-world challenges for interpreting data and analyses for MRE projects (or analogous industry projects in the absence of significant experience with MRE applications).
- Introduce the concept and background information on data transferability, as applied to the current status of the MRE industry and how it could help advance the industry.
- Share with the regulators existing data sets on each of the five environmental stressors[5] to increase their understanding of potential environmental effects and obtain their feedback on their perceived limitations for accepting data generated for already permitted/consented project for their own regulatory analyses.
- Present the data transferability framework, including MREPAs and Guidelines for Transferability, to receive feedback on the usefulness of the framework and understand how the framework might be improved.

[5] The sixth stressor, displacement, was not included because to date there are no data on this stressor from wave or tidal arrays.

- Integrate lessons learned from the variety of federal and state regulators who are constrained by different legal and regulatory regimes for permitting/consenting activities in a variety of waterbodies and geographic regions.

At the core of the focus groups was sharing environmental stressor data on collision risk, underwater noise, EMF, habitat changes, and physical systems changes (Appendix A.2). Doing so provided the opportunity for regulators to see what data and information exist and could be transferred for each of the stressors and the associated context relevant to regulators, so that their willingness to use such data for permitting/consenting in their jurisdictions could be assessed. After reviewing data for each stressor, regulators were asked a series of questions to identify what they regarded as being applicable to their jurisdictions, what data they considered to be missing, and what metadata or background information they would need to provide relevant context for data usage.

To solicit feedback from regulators, these questions about the existing data/information, as well as a series of questions about the proposed data transferability framework, were posed to the regulators. To capture all feedback, the following three strategies were employed for regulators to respond to the questions:

- in-person feedback during the regulator forum when the questions were posed.
- a series of questions included in material sent by email prior to the workshop describing the process and stressors that would be covered in the focus groups; the questions were also reiterated during the focus group.
- an online survey, sent out shortly after the focus group, for online feedback after the focus group.

Collecting responses through in-person feedback during the focus groups was by far the most successful of the three strategies; out of the 21 regulators who attended the focus groups only one regulator used the handout and only one regulator used the online survey. However, the feedback provided on the handout and through the online survey were important and allowed those regulators additional time to respond to the questions.

Based on the feedback received, several themes appeared. Regulators are not necessarily looking for raw data but data that they can interpret and easily understand. For example, when shown underwater noise data, most regulators had a preference for graphs of sound frequency and amplitude, rather than sound clips plotted over time. They also found it helpful to be presented with video clips of the movement of MRE devices in the water, audio clips of the sound from operational tidal turbines and wave energy devices, and synthesized data and information about other stressors. Several regulators stressed the importance of using data and outcomes from analogous industries and the difficulty in identifying and accessing relevant data and information. Throughout the focus groups, there was strong support from regulators for the data transferability framework and MREPA concept; many stated that they needed a method for data set discoverability to find comparable data sets with which to inform their permitting/consenting decisions.

A summary of the regulator focus groups is provided in Appendix A.2.

2.4 Annex IV Data Transferability and Collection Consistency Workshop, June 2018

Input and feedback gathered from U.S. regulators was incorporated into the proposed data transferability framework to produce a revised framework, and BMPs for data transferability and collection consistency were drafted. The revised data transferability framework and BMPs were presented at an Annex

IV/Offshore Renewables Joint Industry Programme workshop held in concert with ICOE 2018 in France. Participants at the workshop included Annex IV analysts, consultants, developers, researchers, and government representatives from eight countries. The purpose of the workshop was to gather additional feedback on the proposed data transferability framework, to review and modify proposed BMPs, and to discuss implementation of the data transferability process. To accomplish this, the workshop included the following:

- a discussion of data transferability and collection consistency and how they can alleviate challenges to the MRE industry and regulators;
- a presentation of feedback and lessons learned from the U.S. regulator focus groups and the revised data transferability framework along with the data collection consistency table (further described in Section 3.0) and associated draft BMPs;
- discussions of improving and/or accepting the framework, data collection consistency, and the BMPs;
- a brainstorm session to begin developing implementation strategies for the data transferability process.

Overall, the participants thought the data transferability framework would help regulators and developers get MRE developments permitted/consented and that the BMPs were well developed and applicable. They noted that it is necessary to have both regulators and developers buy in to the process by making it practical for developers and attractive for regulators. Additionally, consultants who write environmental impact assessments and researchers who may provide data and information must also be included in the process. For each of these groups, the outreach conducted must be tailored to their current state of knowledge in order to gain participation across the industry. The need for existing data to be available and accessible was pervasive throughout the workshop, and participants felt an online tool that could provide such data for regulators and developers to use for permitting/consenting processes for future projects would be very useful.

When discussing how to implement the data transferability process, several ideas emerged. The first was using case studies to “test” the data transferability framework and BMPs to understand how they might be applied or implemented, their efficacy, and any gaps that remained. Along similar lines, gathering examples of successful MRE data transfer or lessons learned from data transfer in other industries was also suggested to further inform the BMPs and aid the development of an implementation plan. Additionally, participants agreed that the BMPs should be implemented with a plan to continue to validate/update them over time, potentially on an annual basis. Lastly, the group suggested convening two groups: (1) a group of international representatives from across the MRE community to provide technical assistance in using the data transferability process and to help gauge success, and (2) a group of targeted regulators to understand potential gaps and help conduct outreach to other regulators.

Appendix C includes relevant documents pertaining to the Annex IV workshop, including the Annex IV Workshop Plan (Section C.1), background information distributed to workshop participants (Section C.2), and the final Annex IV Workshop Notes that summarize the discussions conducted during the workshop (Section C.3).

3.0 Data Transferability Process

Feedback and input solicited from the regulator survey, regulator focus groups, and Annex IV workshop (as discussed in Section 2.0) were incorporated into the proposed data transferability framework presented in the initial white paper, *Marine Renewable Energy: Data Transferability and Collection Consistency*, and informed the development of the overall *data transferability process.* As shown in Figure 1, the process of data transferability consists of five components:

1. **Data Transferability Framework (Framework) –** brings together data sets in an organized fashion, compares the applicability of each data set for use in other locations, and guides the process of data transfer
2. **Data Collection Consistency Table –** provides preferred measurement methods or processes, reporting units, and the most common methods of analysis or interpretation/use of data
3. **Monitoring Data Sets Discoverability Matrix –** allows a practitioner to discover data sets based on the approach presented in the Framework
4. **Best Management Practices –** five BMPs related to data transferability and collection consistency
5. **Implementation Plan –** the approach for implementing the Framework and BMPs.

Detailed discussions of each of the five components of the data transferability process are presented in the following sections.

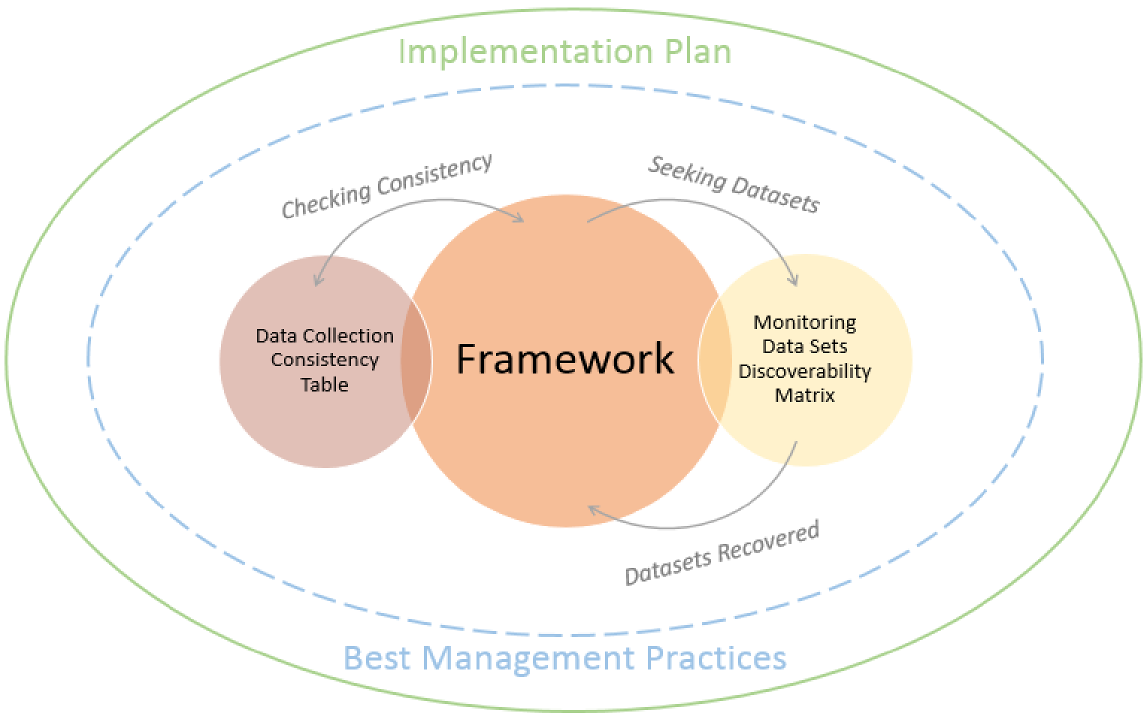

Figure 1. Data transferability process.

3.1 Data Transferability Framework

The Framework was originally derived from the data transferability white paper, then revised and updated based on feedback and input from U.S. regulators and the Annex IV workshop participants. The Framework:

- brings together data sets from already permitted/consented projects in an organized fashion.
- compares the applicability of each data set for use in permitting/consenting future projects.
- assures data collection consistency through preferred measurement methods or processes.
- guides the process for data transfer.

The Framework can be used to accomplish the following:

- Develop a common understanding of data types and parameters to determine and address potential effects.
- Engage regulators to test the Framework.
- Create a set of BMPs for data transferability and collection consistency.
- Set limits and considerations for how BMPs can be applied to assist with effective and efficient siting, permitting/consenting, post-installation monitoring, and mitigation.

The full *Data Transferability Framework* report is provided in Appendix D.

3.1.1 Marine Renewable Energy Project Archetypes

As previously discussed, the Framework establishes the concept of an MREPA (MRE project archetype) that can be applied to help describe MRE projects. Each project MREPA is defined by four variables: stressor, site condition, MRE technology type, and receptor group. A series of tables has been developed for each of the six stressors that can be applied to an already permitted/consented project and proposed future projects. From each table, an MREPA can be identified for a particular project or set of data that might be useful for transfer. For example, the MREPA table for collision risk indicates 22 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 1). Defining the project MREPA is the first step in determining the ability to transfer data from already permitted/consented projects to future projects. The tables for the six stressors are provided in the appendix of the *Data Transferability Framework* report in Appendix D.

Table 1. Marine renewable energy project archetype (MREPA) table for collision risk.

Site Condition[(a)]	Technology	Receptors
Shallow and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Shallow and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals

Site Condition[(a)]	Technology	Receptors
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds

(a) Shallow channels are defined as having a depth less than 40 m. Deep channels are defined as having a depth greater than 40 m. Narrow channels are defined as having a width of less than 2 km. Wide channels are defined as having a width greater than 2 km.

3.1.2 Applying the Framework

The purpose of applying the Framework is to classify projects by archetype to enable discovery of existing data sets that are comparable in order to determine the potential risks of future projects. Once comparable data sets have been discovered and reviewed using the *Monitoring Data Sets Discoverability Matrix* discussed in Section 3.3, there is a strong potential that trends and conclusions about specific stressors and risks from the existing data sets can inform future projects, resulting in a decrease in need for site-specific data collection and enabling more efficient permitting/consenting.

To apply the Framework, the following *Guidelines for Transferability* have been laid out as a hierarchy (Figure 2). The hierarchy of guidelines for transferring data and information from already permitted/consented projects to future projects includes five steps that range from critical, or necessary, to those that are desirable but perhaps not always necessary. The first step (same MREPA and data collected consistently) is necessary (and is the minimum requirement for transferability), while Steps 2 through 5 (same project size, same receptor species, similar technology, similar wave/tidal resource) range from important to desirable. Each step for applying the guidelines is described below.

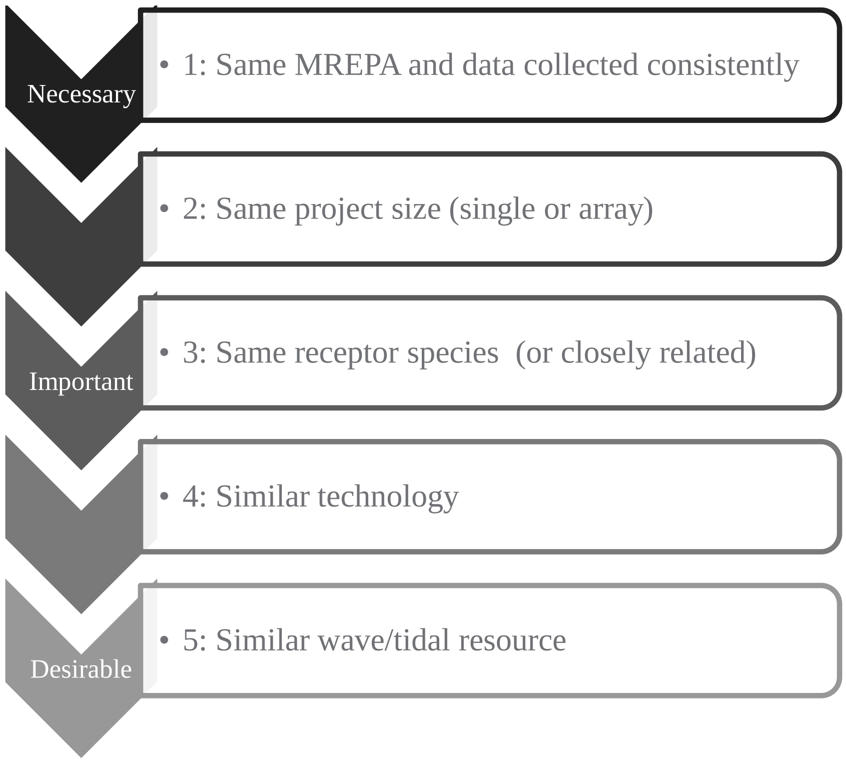

Figure 2. Guidelines for Transferability.

Step 1 – Characterize the MREPA of the future project by examining the stressor, site condition, MRE technology type, and receptor. Figure 3 provides an example of characterizing a project for collision risk for marine mammals. Compare the MREPA of the future project with those of already permitted/consented projects to determine the similarity of the MREPAs. The two projects must share the same MREPA, thereby ensuring that the two projects share the same stressor, site condition, MRE technology type, and receptor. Furthermore, the data must be collected consistently in order for the data to be transferred (see Section 3.2 about data collection consistency).

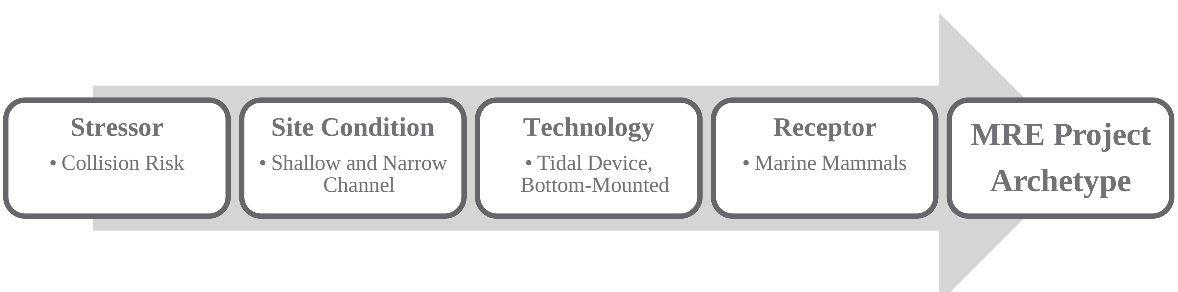

Figure 3. Example of an MREPA for an already permitted/consented project.

Step 2 – Compare the project size (single device or array). Data will best be transferred among projects with small numbers of devices, or among small arrays, or among large commercial arrays. However, because the MRE industry is fairly young and most deployments are single devices or small test arrays, there data on the environmental impacts of arrays is lacking. Until the industry can progress to a point at which enough data can be collected around small arrays and large commercial arrays, consideration should be given to transferring data from projects involving single MRE devices to inform projects involving arrays of MRE devices.

Step 3 – Compare the receptor species between the already permitted/consented project and the future project. This comparison will allow an evaluation of how comparable the data might be. As described for Step 1, the same receptor group is necessary between the two projects, but the species might differ. For example, when using marine mammals as the receptor group, transferring learning among seal species may be appropriate, but little may be learned about the effects on a seal species from data related to whale species.

Step 4 – Compare the particular type of tidal turbine or wave energy technology between the already permitted/consented project and the future project. For example, it would be best to compare point absorber data from an existing project to a future point absorber project, rather than comparing it to an oscillating water column device.

Step 5 – Compare outcomes from an already permitted/consented project to future project outcomes for areas with similar tidal or wave resources. For example, comparing high-velocity tidal currents (>3 m/s) among projects is preferable to comparing a high-velocity tidal current project (>3 m/s) to a lower-velocity current (<1.5 m/s) project.

3.1.3 Use of the Framework

The Framework has been developed to provide a background against which discussions with regulators can proceed to enhance the understanding of the limits of transferability, based on the confidence individual regulators have to accept data and information collected for already permitted/consented projects for information analyses in support of applications for MRE developments in her/his jurisdiction. The Framework will also facilitate initial permitting/consenting discussions between developers and regulators to determine data collection and pre-installation monitoring efforts needed to permit/consent a project and to determine post-installation operational monitoring needs.

By implementing the *Data Transferability Framework*, the siting and permitting/consenting processes for installation of single MRE devices and MRE arrays may be shortened and scarce funding resources may be directed toward environmental interactions that remain most uncertain.

3.2 Data Collection Consistency

Inherent in the effort to enable the transfer of monitoring data about MRE devices and their applications from already permitted/consented projects in one jurisdiction to future projects in another jurisdiction is the need to understand how similar the data might be. Ensuring that the data used from an already permitted/consented project are compatible with the needs of future projects, and that multiple data sets from one or more projects can be pooled or aggregated, requires an evaluation of the degree to which the data are consistent. To date, few efforts have prescribed or compared collection methods, instrumentation, or analyses.

MRE is an international industry, with permitting/consenting processes and research norms that differ from country to country, region to region, and among research and commercial data collection efforts. It would be extremely difficult to enforce the use of specific protocols or instruments to collect all data for pre- or post-installation monitoring. However, encouraging the use of consistent processes and units for the collection of monitoring data could increase confidence in the transfer of data or learning from already permitted/consented projects to future projects. For the six stressors previously discussed, a set of processes, reporting units, and general analysis or reporting methods are proposed in the *Data Collection Consistency Table* (Table 2). For each stressor, the preferred measurement methods or processes are reported, along with preferred reporting units and the most common methods of analysis or interpretation and use of the data.[6]

Table 2. Data Collection Consistency Table.

Stressor	Process or Measurement Tool	Reporting Unit	Analysis or Interpretation
Collision Risk	Sensors include: – Active acoustic only – Active acoustic + video – Other	Number of visible targets in field of view, number of collisions	Number of collisions and/or close interactions of animals with turbines used to validate collision risk models
Underwater Noise	Fixed or floating hydrophones	- Amplitude dB re 1 μPa at 1 m - Frequency: broadband or specific frequencies	Sound outputs from MRE devices compared against regulatory action levels. Generally reported as broadband noise unless guidance exists for specific frequency ranges.
EMF	Source: – cable – other – shielded or unshielded	– AC or DC – voltage – amplitude	Measured EMF levels used to validate existing EMF models around cables and other energized sources.
Habitat Change	Underwater mapping with – sonar – video Habitat characterization from – mapping – existing maps	Area of habitat altered, specific for each habitat type	Compare potential changes in habitat to maps of rare and important habitats to determine if they are likely to be harmed.
Displacement/Barrier Effect	Population estimates by: – human observers – passive or active acoustic monitoring – video	Population estimates for species under special protection	Validation of population models, estimates of jeopardy, loss of species for vulnerable populations
Changes in Physical Systems	Numerical modeling, with or without field data validation	No units. Indication of data sets used for validation, if any.	Data collected around arrays should be used to validate models.

More information about data collection consistency can be found in the *Data Transferability Framework* report provided in Appendix D.

[6] The information presented in the *Data Collection Consistency Table* was compiled by PNNL and Aquatera subject matter experts. The information has been presented to US regulators for review and will be presented to the larger MRE community as well as Annex IV country analysts for further review and assessment.

3.3 Data Discoverability

As a companion to the Framework, a *Monitoring Data Sets Discoverability Matrix* is being developed to classify monitoring data sets from already permitted/consented projects for the six stressors previously discussed. The matrix will be linked to key metadata features of each data set (i.e., data parameters, collection location, collection methods, contact, etc.). The matrix will allow regulators and/or developers to discover data sets based on the MREPA, and evaluate the consistency of information and therefore the ability to transfer data from an already permitted/consented project to future projects.

The *Monitoring Data Sets Discoverability Matrix* is in the initial stages of development and will be completed in fiscal year 2019. When completed, the matrix will be available as an interactive tool made available on the Data Transferability and Collection Consistency *Tethys* webpage. Updates to the matrix will be annual or as additional permitted/consented project data sets become available.

3.4 Best Management Practices

As outlined in *Marine Renewable Energy: Best Management Practices for Data Transferability and Collection Consistency* (Appendix E), four BMPs have been proposed to meet the *Guidelines for Transferability* (Figure 2) using the six stressors. Each BMP is accompanied by a purpose and set of process steps to clarify its use. In order for a data set or body of learning to be considered for transfer, the following practices should be followed:

BMP 1	**Meet the necessary requirements in the *Guidelines for Transferability* to be considered for data transfer from an already permitted/consented project to a future project.**		
	Purpose This practice (coupled with BMP 2) will ensure that the minimum requirements in the *Guidelines for Transferability* (same MREPA and data collected consistently) are met for similarity and comparability between the data sets from already permitted/ consented projects to those of future projects. For this BMP, the MREPA of the new project, and that of the already permitted/ consented projects, will be determined.	**Process** Determine MREPA(s) for the future project site. Search for similar MREPAs in the *Monitoring Data Sets Discoverability Matrix*, and choose data sets from permitted/consented projects that match.	**Intended Party** This practice is intended for those within the MRE community looking to transfer data from already permitted/consented projects to a future project (e.g., developers, consultants, regulators).

BMP 2	Determine likely data sets that meet data consistency needs and quality assurance requirements.		
	Purpose This practice will help determine the validity of comparing data from an already permitted/ consented project and a future project as it ensures that the methods used to collect and analyze data from an already permitted/ consented project follows data consistency and compatibility needs of those required for future projects.	**Process** Use the *Data Collection Consistency Table*, and determine whether data collection methods and quality assurance requirements for existing data sets are sufficiently similar and adequate.	**Intended Party** This practice is intended for those within the MRE community looking to transfer data from already permitted/consented projects to a future project (e.g., developers, consultants, regulators).

BMP 3	Use models in conjunction with and/or in place of data sets.		
	Purpose This practice encourages the use of numerical models to simulate interactions when adequate monitoring data are not available. Using numerical models will help alleviate the need for extensive data collection for each interaction for every future project. Use of models will also allow regulators and other stakeholders to predict the potential effects of future projects.	**Process** Once sufficient data exist for an interaction, create models to describe the interaction, when applicable; these models will begin to take the place of larger field data collection efforts. In some cases (for example, to determine changes in physical systems) models may be used prior to collection of field data. For each model used, note the type of model, whether it has been validated with field data, and the associated major stated assumptions and limitations.	**Intended Party** This practice is intended for those within the MRE community who develop and use numerical models (e.g., researchers, analysts).

BMP 4	Provide context and perspective for the data sets to be transferred.		
	Purpose This practice encourages the use of available and pertinent data sets to enhance the interpretation of data and information. The use of ancillary data sets does not in any way imply that collection of the data is necessary for pre- or post-installation monitoring around MRE devices.	**Process** Where available, identify and assess ancillary data sets to provide context for the MRE interaction data. These data sets might include behavioral studies of animals, the hydrodynamics and wave climate of the site and surrounding area locations, habitat maps, etc.	**Intended Party** This practice is intended for those within the MRE community looking for context and perspective for the data sets to be transferred (e.g., developers, consultants, regulators, and researchers).

More information about the development and implementation of the above BMPs can be found in *Marine Renewable Energy: Best Management Practices for Data Transferability and Collection Consistency* in Appendix E.

3.5 Implementation Plan

An approach for applying the data transferability process, including the Framework and BMPs, is presented in the *Implementation Plan for the Data Transferability Process* (Appendix F). The successful execution of the Implementation Plan will (1) ensure that regulators have access to data sets and processes for transferring data from already permitted/consented projects to future projects; (2) assist regulators in understanding the applicability of these processes through an active outreach and engagement process; (3) provide technical assistance to help regulators implement the Framework and BMPs; (4) ensure developers and their consultants are familiar with and accepting of the Framework, data collection consistency, and BMPs; and (5) provide added value to the data transferability process through engagement activities (such as ongoing training and educational outreach) and the consistent collection of data around MRE devices.

Details about the activities and efforts that will be undertaken to ensure relevant stakeholders are familiar with the data transferability process, have the opportunity to provide input and feedback, and have access to the guidance and material needed to implement the data transferability process can be found in the *Implementation Plan for Data Transferability* in Appendix F.

.

4.0 Conclusion and Next Steps

As a means of addressing the concept of transferring data and information among MRE projects and collecting data consistently, a data transferability process has been developed that consists of a data transferability framework, approaches and recommendations for data collection consistency and data discoverability, BMPs, and implementation efforts. The process provides a background against which discussions with regulators can proceed as we come to understand the limits of transferability, based on the confidence individual regulators have to accept data and information collected for already permitted/consented projects for information analyses in support of applications for MREs in her/his jurisdiction. The data transferability process will facilitate initial permitting/consenting discussions between developers and regulators to determine data collection and monitoring efforts needed to permit/consent a project and determine operational monitoring needs.

Soliciting input and feedback on the data transferability process is an ongoing effort. The data transferability process will be extended internationally to Annex IV countries, with Annex IV analysts acting as outreach agents to their respective regulators to introduce the process and solicit feedback in their respective countries. National and international focus groups, workshops, and webinars are being planned to continue the dialog with relevant stakeholders and ensure their concerns are heard. Once the data transferability process is finalized, it will be presented to the MRE community at workshops and conferences and will be published in relevant journals, if applicable. The refinement of the *Monitoring Data Sets Discoverability Matrix* will also be an ongoing effort. A series of validation case studies will be compiled to test the data transferability process and for training purposes, and the MRE community will be continuously engaged to identify other relevant data and information available for already permitted/consented projects, as discussed in the Implementation Plan.

A virtual collaborative group of international representatives across the MRE communities may be formed. The purpose of this group will be to (1) share progress in understanding and permitting/consenting MRE projects, (2) provide technical assistance in using the data transferability process, and (3) gauge the success of the data transferability initiative.

Through the successful development and implementation of the data transferability process, Annex IV will continue its efforts of continuous outreach and engagement with relevant stakeholders to further the knowledge and understanding of potential environmental effects of MRE devices, in order to accelerate the siting and permitting/consenting process for MRE developments.

5.0 References

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Appendix A

Regulator Engagement Documents

A.1 Regulator Survey Report

MRE REGULATOR SURVEY

Report on the PNNL study of MRE regulator perceptions on permitting MRE devices

Prepared by Stacia Dreyer, PhD
August 2017

Table of Contents

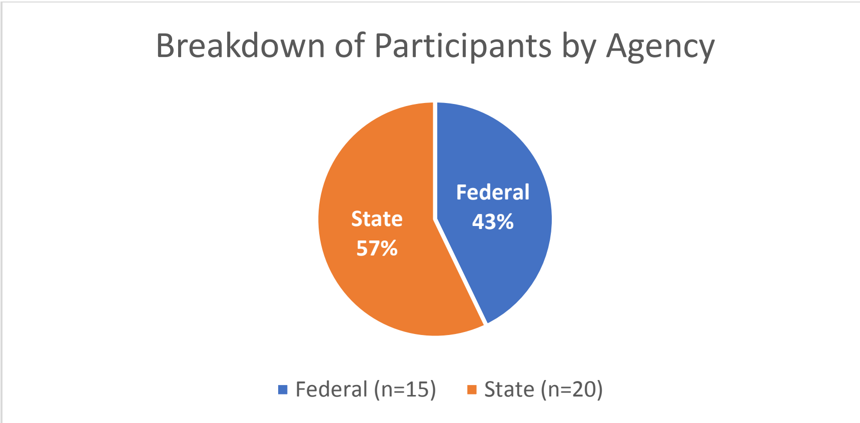
Introduction

As the marine renewable energy (MRE) industry moves forward around the world, there continues to be concerns about potential environmental effects of devices and systems on marine animals, habitats, and ecosystem processes. Much of this perceived risk may be due to the large uncertainties about how tidal and wave devices might interact with the environment, and how marine mammals and other species may behave around single devices or arrays of energy converters. This makes the regulatory and consenting process for permitting MRE developments challenging, especially as permitting processes are not well established for wave and tidal developments. Additionally, other marine uses also create concerns for marine species. This, coupled with insufficient knowledge of ocean environments in high energy areas, creates caution during permitting and consenting processes for MRE devices.

This cautious approach to permitting and consenting process may hinder the ability of the MRE industry to advance their technologies to the same degree as other, lower cost renewable energy sources. To better understand views on risks, conflicts, and challenges associated with potential environmental effects of MRE devices, United States regulators (both federal regulators and those from coastal states) who may be involved in permitting MRE devices were engaged. Following an online webinar on Environmental Effects of Permitting MRE Developments where the state of the science of environmental effects was discussed, an online survey was developed to further understand needs and challenges faced when permitting an MRE development. An invitation to participate in the survey was sent out to the regulators who were invited to the webinar. The survey aimed to understand the familiarity of regulators with MRE technologies, perceptions of environmental challenges, and thoughts on best approach to MRE development and data transferability. The survey also included some questions to gather *Tethys* user data.

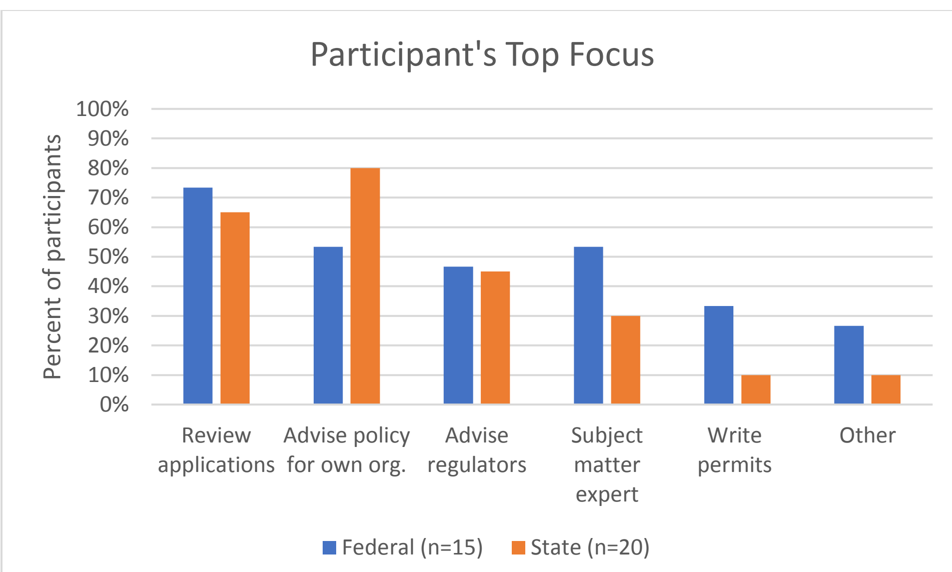
Participants

Email invitations to participate in the survey were sent to 200 individuals known to be working in the MRE regulation field. 36 participants completed the survey, an 18% response rate, however only 35 participants' responses were retained for analysis due to a significant portion of incomplete data in 1 response. Of these 35, 15 participants worked in federal agencies and 20 worked for state agencies. No participants indicated they worked at the county or local level. The majority of participants have directly participated in the environmental permitting of an MRE device (60% federal, 65% state).



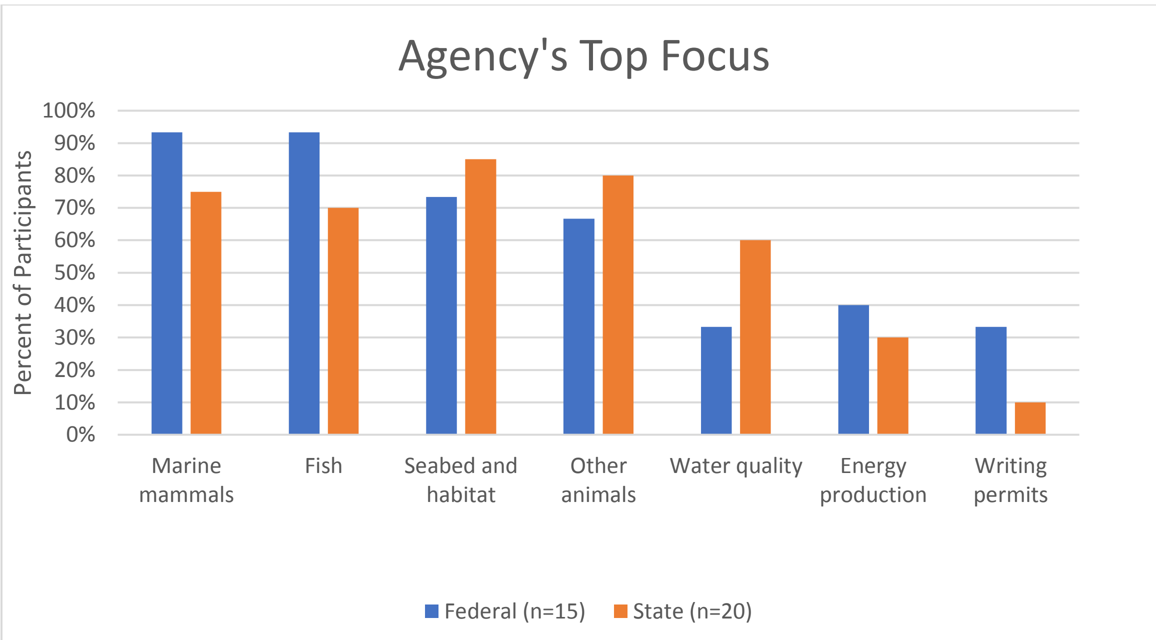
Top focus for participant and participant's agency

Participants were asked to indicate the top focus of their own role in permitting MRE developments among 6 choices: write permits, advise regulators, review applications, advise policy level decisions in your agency, subject matter expert, and other. Reviewing applications and advising policy in their organizations were the top two roles. Writing permits was the bottom focus for participants in both federal and state agencies, excepting the "other" category. Items listed in the other category for federal agencies were: conduct consultation on federal actions, manage ESA consultations for actions involving MRE, regulatory, and review permits after written. The items listed for state agencies were coastal consistency certifications issued and CZMA federal consistency.



Note: This was a "select all that apply" question, so percentages exceed 100%. Percentage was calculated per group, for example, the number of participants who reviewed applications was divided by 15 in the federal group and 20 in the state group. Similar calculations are used throughout this report.

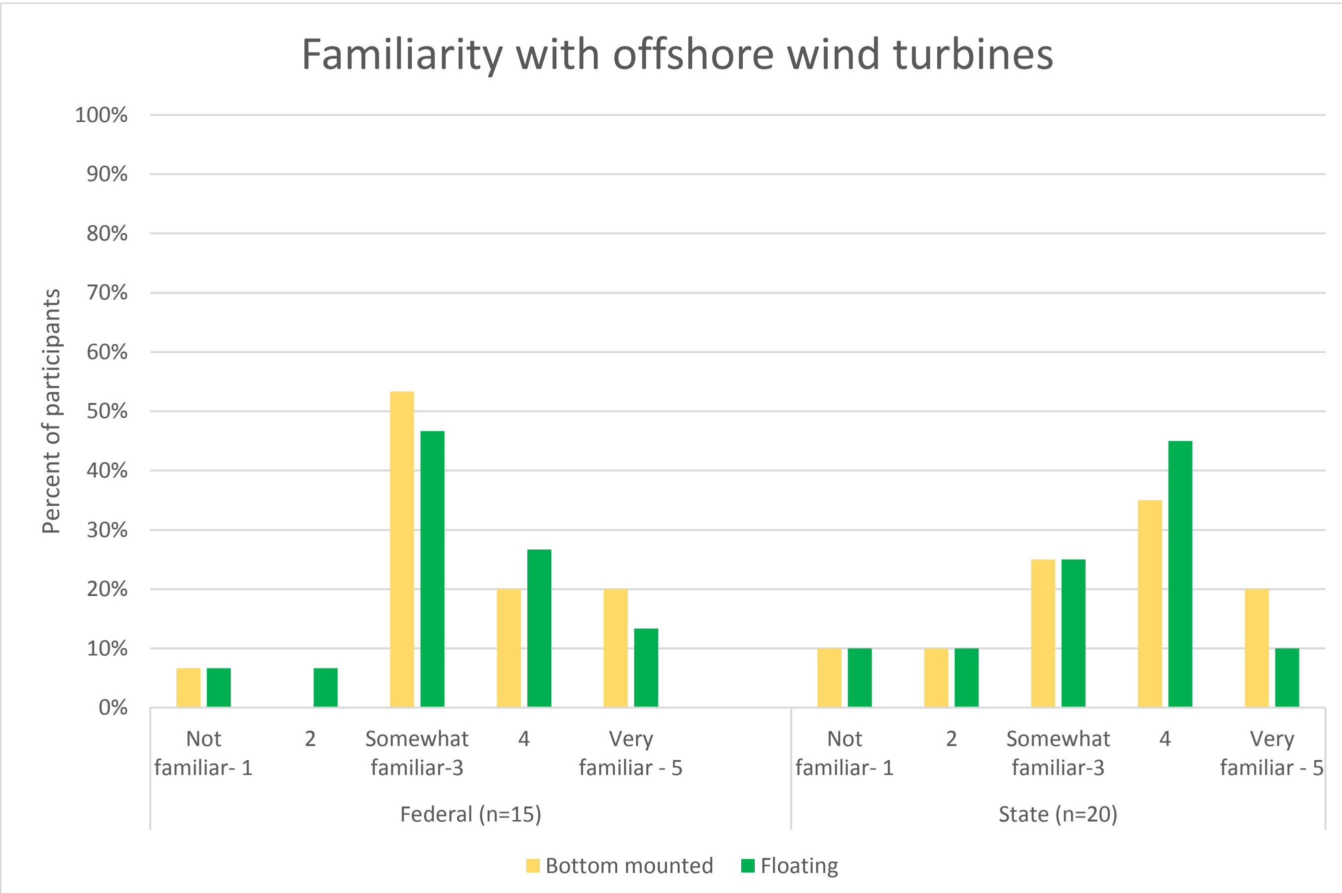
There were eight options for the top focus for agencies: water quality, marine mammals, fish, other animals, seabed and habitat, energy production, and other. The top focus for agency varied depending upon federal or state designation. For federal agencies, marine mammals and fish were the top focus when permitting MRE developments. For state agencies, seabed and habitat and other animals were the top focus. It is likely that the other animals that came to mind for these regulators were birds, sea turtles, and/or invertebrates. In the "other" category, one federal regulator wrote “turtles where applicable.”

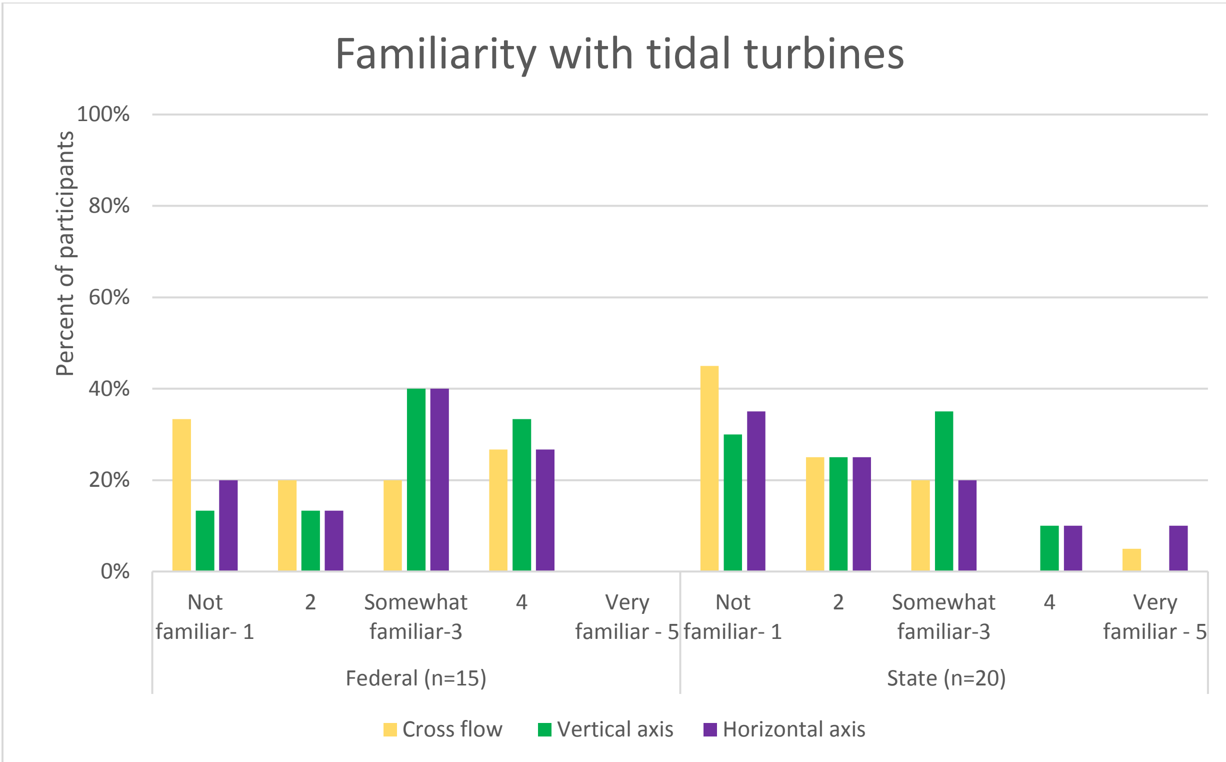


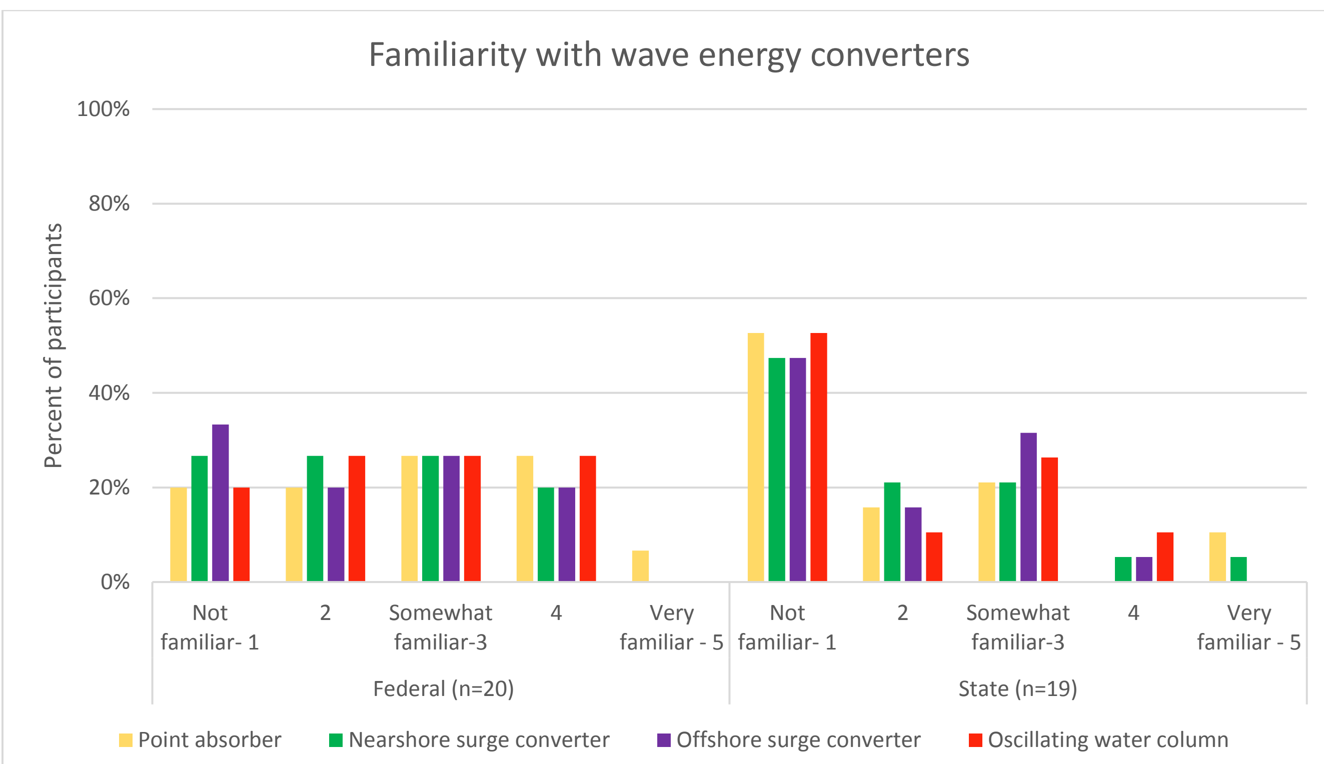
Note: This was a “select all that apply” question, so percentages exceed 100%.

Familiarity with MRE technologies

Overall, familiarity with specific technologies was low. However, offshore wind technologies were the most familiar to participants. It was expected that federal participants would be more familiar with these technologies and in general this seems to be true but it is less clear in the case of offshore turbines.




Familiarity with tidal turbines
Percent of participants
100%
80%
60%
40%
20%
0%
Not familiar- 1
2
Somewhat familiar-3
4
Very familiar - 5
Federal (n=15)
State (n=20)
Cross flow
Vertical axis
Horizontal axis


Familiarity with wave energy converters
Percent of participants
100%
80%
60%
40%
20%
0%
Not familiar- 1
2
Somewhat familiar-3
4
Very familiar - 5
Federal (n=20)
State (n=19)
Point absorber
Nearshore surge converter
Offshore surge converter
Oscillating water column

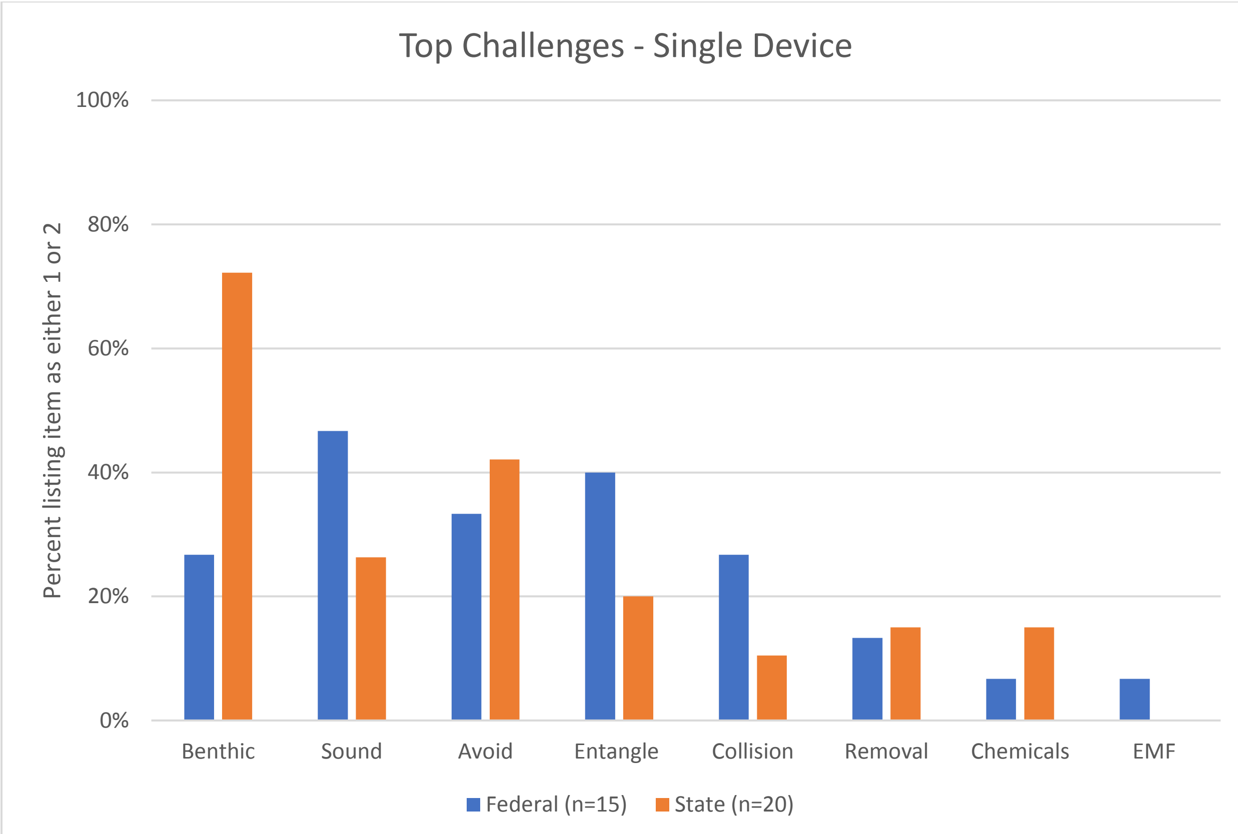
Top challenges

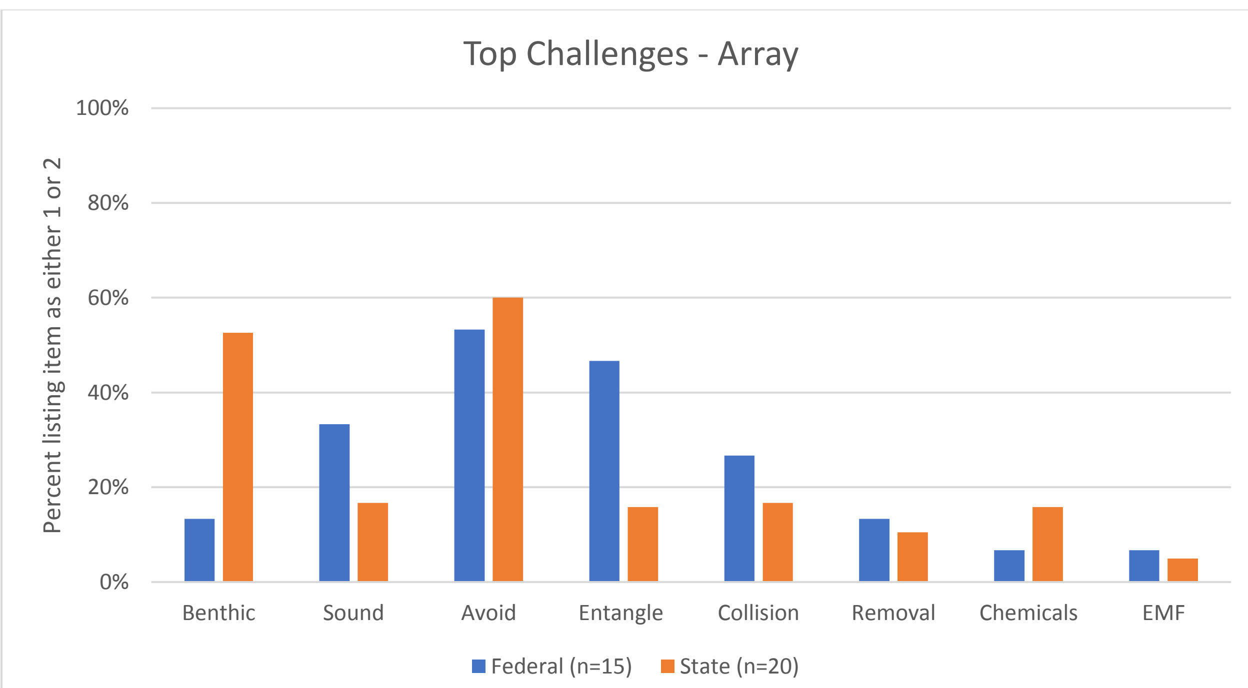
Participants were asked to rank the challenges for permitting a single device and then an array. They were given 8 challenges and asked to rank them from 1 (most important) to 8 (least important). The charts below show the percentage of participants that ranked each challenge as either a 1 or a 2 (most important or second most important). For ease of reading, the charts use the following shorthand on the X axis.

Shorthand abbreviations for challenges	
Benthic	Benthic/ habitat destruction
Sound	Effects of underwater sound emissions from devices on animals
Avoid	Avoidance, attraction, and/or displacement of animals
Entangle	Entanglement of animals with lines and cables
Collision	Risk of animals colliding with underwater devices
Removal	Energy removal and effects of changes in flow on the ecosystem
Chemicals	Chemical releases and water quality degradation
EMF	Electromagnetic field (EMF) effect on animals

Ratings vary both by federal or state agency and by device vs array. For federal agencies, "Effects of underwater sound emissions from devices on animals" was the most important challenge for a single device, whereas for an array "Avoidance, attraction, and/or displacement of animals" became the most important. For state agencies, the focus differed for a single device. "Benthic/habitat destruction" was the most important challenge for a single device whereas "Avoidance, attraction, and/or displacement of animals" was the most important for an array. No difference is noted for the most important challenge for an array between state and federal.

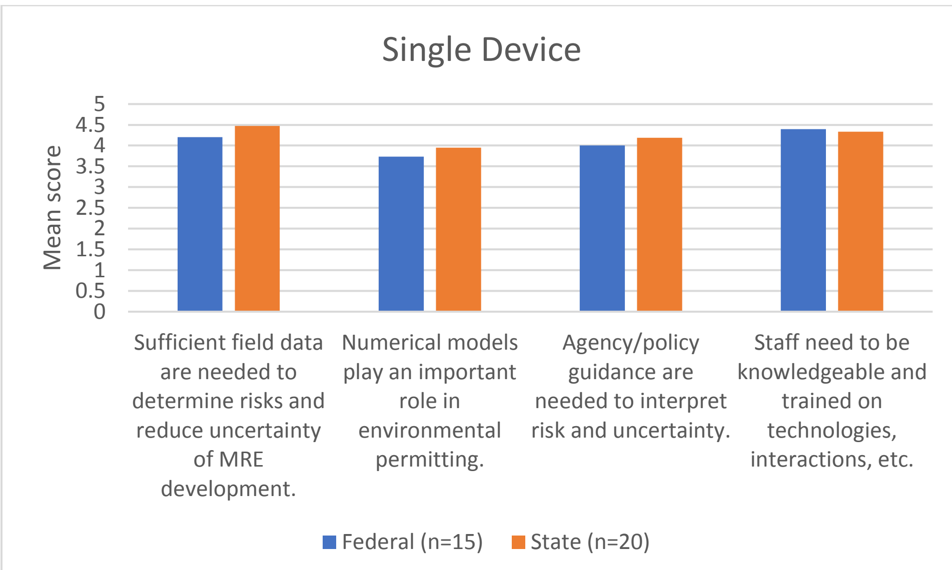
These tables only show what the two most important challenges were, and it is possible a different pattern might arise if looking at the rankings of all the challenges. Appendix A includes two matrices designed to show how all participants ranked all the challenges, split by federal and state regulators for both a single device and an array. The individual responses back up the pattern seen for the top challenges.


Top Challenges - Single Device
Percent listing item as either 1 or 2
100%
80%
60%
40%
20%
0%
Benthic
Sound
Avoid
Entangle
Collision
Removal
Chemicals
EMF
Federal (n=15)
State (n=20)

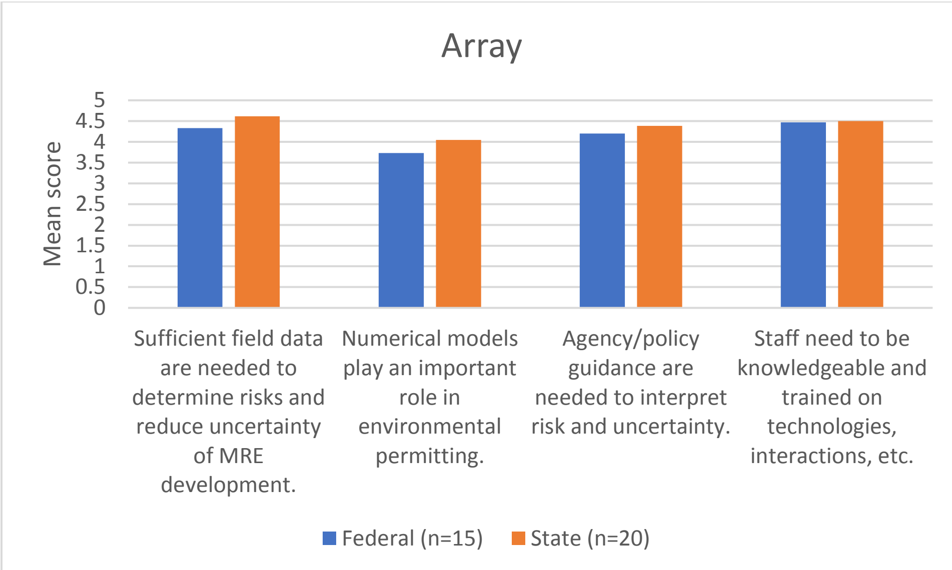

Top Challenges - Array
Percent listing item as either 1 or 2
100%
80%
60%
40%
20%
0%
Benthic
Sound
Avoid
Entangle
Collision
Removal
Chemicals
EMF
Federal (n=15)
State (n=20)

Perceptions of challenges for permitting single device and array

Participants were asked how strongly they agreed or disagreed[1] with 4 different statements concerning their top challenge (indicated in the previous question) for permitting a single device as well as an array. No notable differences existed between state and federal or single device or an array. There was a high level of agreement across all statements, but especially that “sufficient field data are needed to determine risks and reduce uncertainty of MRE development” and “staff need to be knowledgeable and trained on technologies, interactions, etc.”

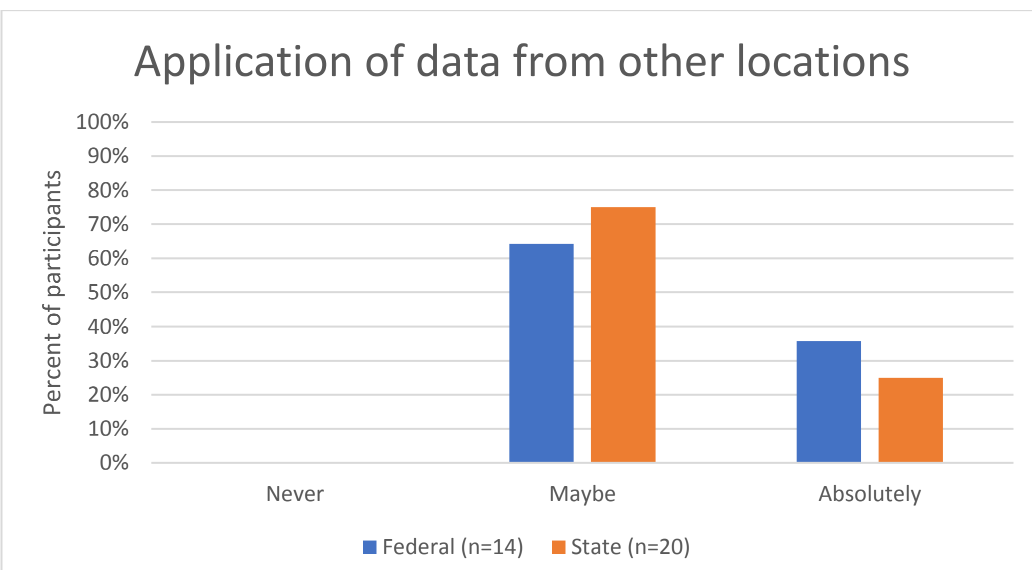


[1] 5 = strongly agree



Application of data from other locations

Survey participants were asked “can data collected from other locations be applied towards environmental permitting within your jurisdiction?” They were given the option of “never” “maybe” and “absolutely.” None of the participants chose the never category. Interestingly, whereas more state regulators thought “maybe,” slightly more federal regulators thought “absolutely.”

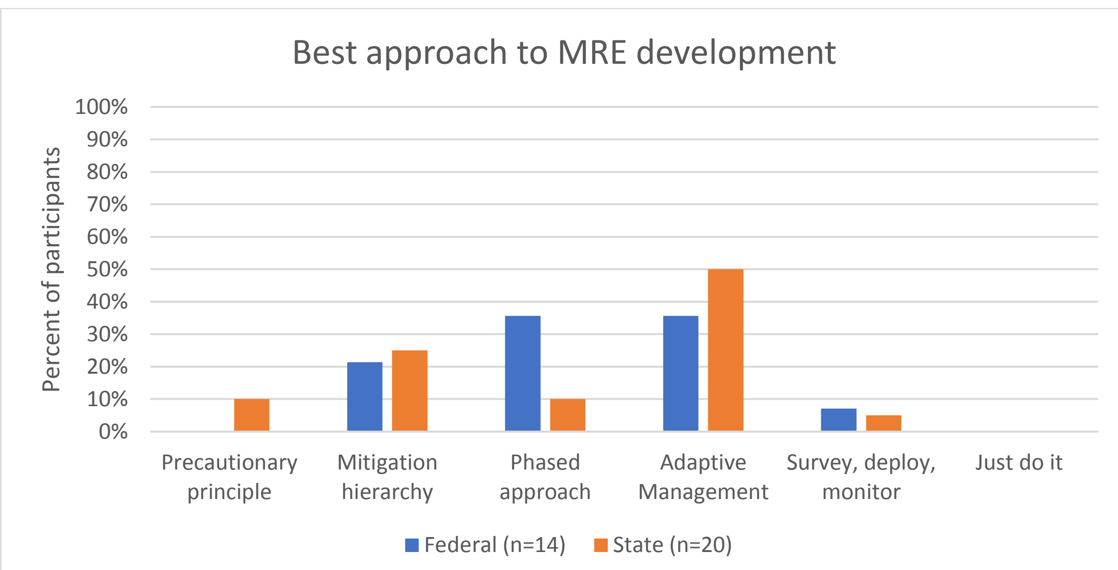


Best approach to MRE development

Participants were asked, "which of the following approaches best describes your vision of how the MRE industry should develop? (Choose one)." The options were:

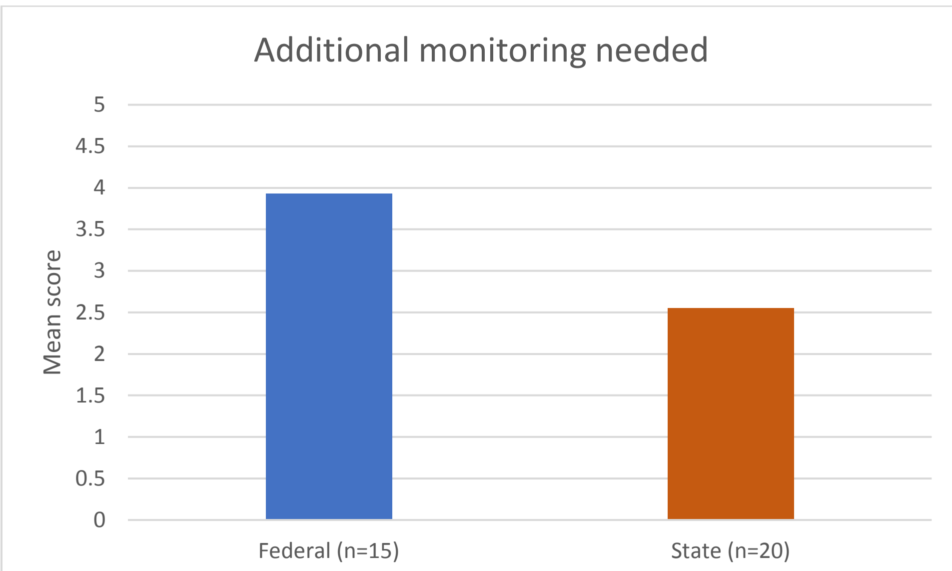
a. **Precautionary principle.** There is a high degree of uncertainty and potentially negative outcomes associated with MRE deployment and operation. Measures should be taken to avoid the negative outcome by proceeding very cautiously or not pursuing projects at all.
b. **Mitigation hierarchy.** Impacts or risks should be systematically limited by taking actions to avoid, minimize, mitigate and/or compensate for risks through siting and/or mitigation measures.
c. **Phased approach**. Single devices should be deployed first, followed by slowly ramping up to array scale after potential risks are better understood and managed.
d. **Adaptive management.** A learning-based management approach should be applied that includes adapting monitoring and mitigation over time to understand risks, decrease uncertainty, and mitigate for impacts.
e. **Survey, deploy, monitor.** The area of a proposed project should be surveyed before deployment, coupled with monitoring around the device before deployment can proceed.
f. **Just do it.** Risks to the marine environment are almost certainly low, so development should be able to move forward.

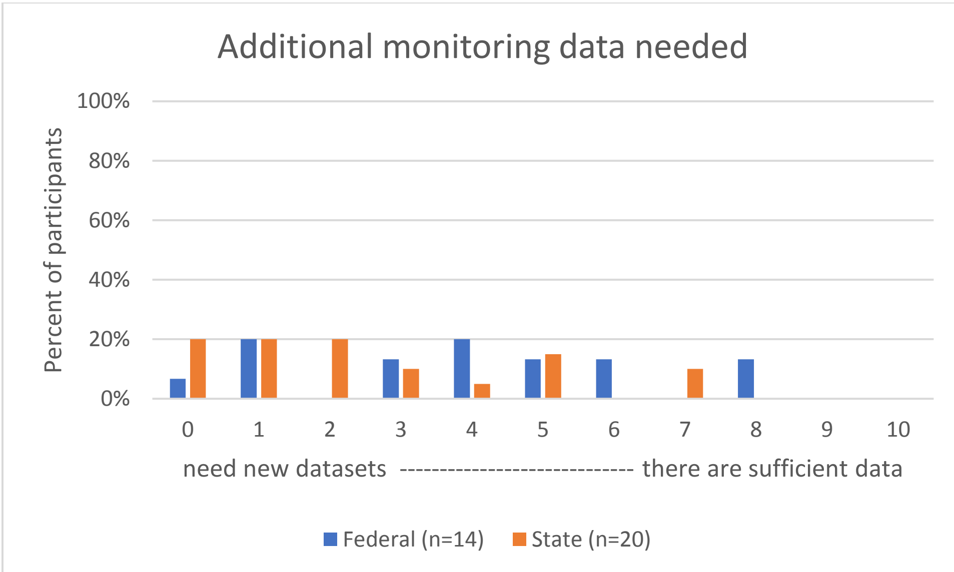
For federal regulators, phased approach and adaptive management were equally preferred. For state regulators, adaptive management was the preferred approach.



Participants were then asked, “How strongly do you feel additional monitoring data are needed (to decrease scientific uncertainty)?” They were prompted to respond based on their answers for the single device question. They responded on a sliding cursor, with labels assigned at the left hand side of the scale “need new datasets (high level of uncertainty)” (0) and the right hand of the scale “There are sufficient data (very low uncertainty)” (10).

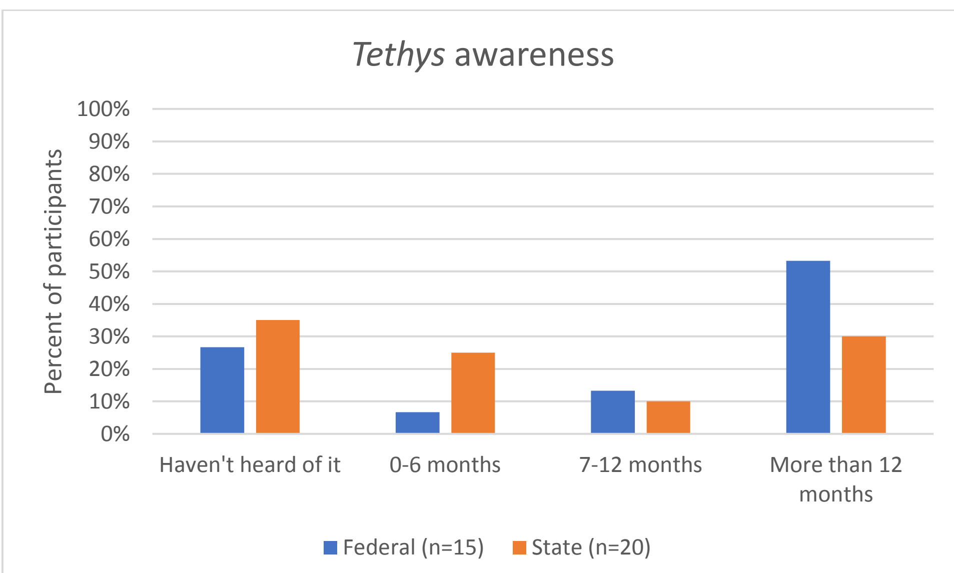
Mean scores varied with federal regulators feeling less strongly that additional monitoring was necessary (federal 3.93(2.49) and state 2.55(2.26) respectively). No regulator, federal or state, believed that we currently had sufficient data. Given the large standard deviation for these mean scores, this finding should be interpreted with caution. Median score for federal regulators was 4, for state regulators it was 2. Also included is a chart that shows the distribution across the values of the sliding scale from 1 (need new datasets) to 10 (there are sufficient data).



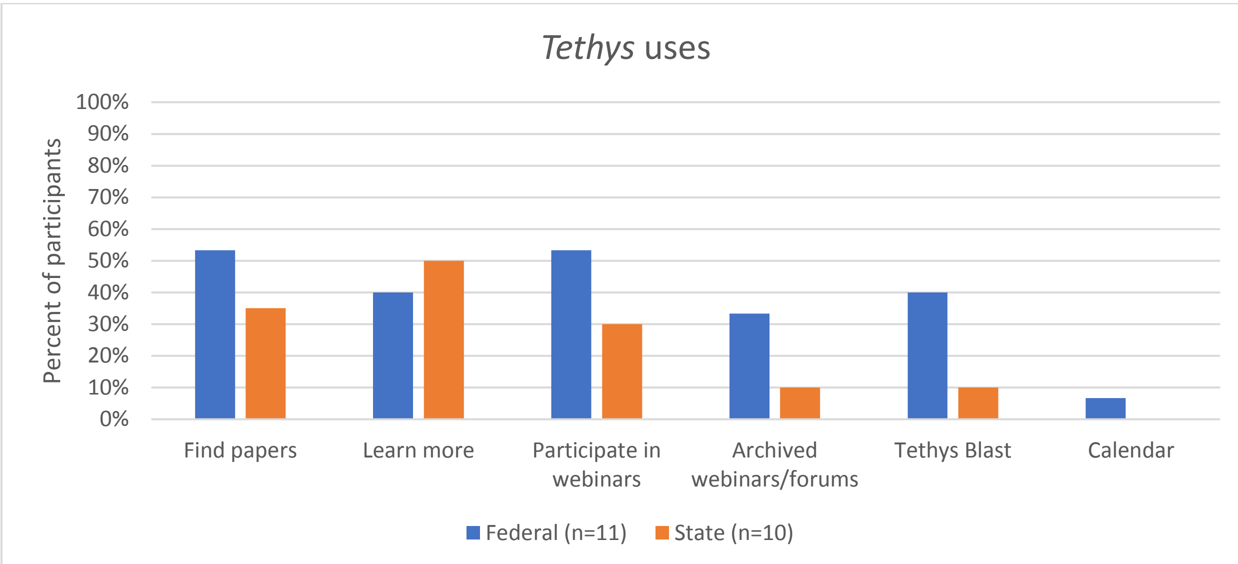


The use of *Tethys*

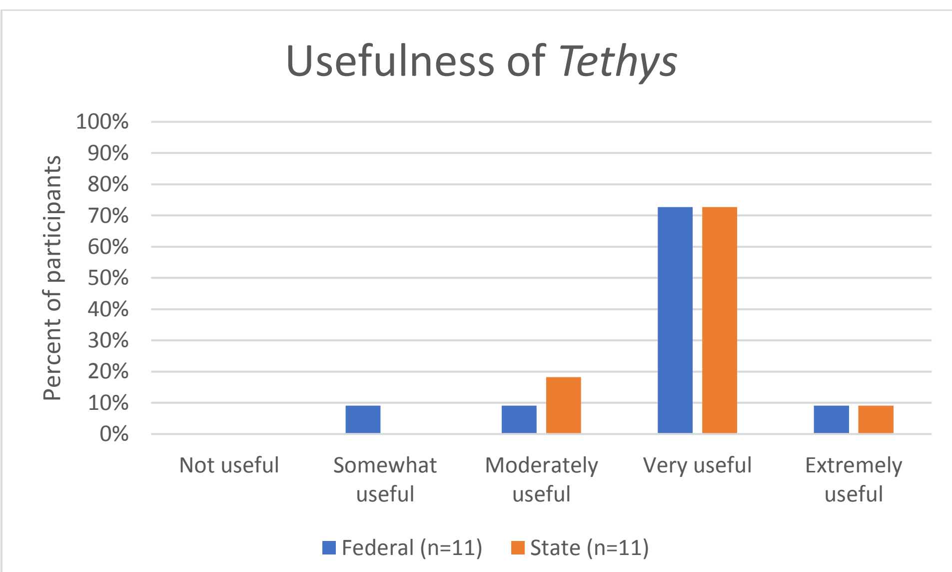
Participants were asked how long they had been aware of *Tethys*, if at all. Participants varied in the length of time they had known of *Tethys*, with the majority of federal regulators knowing about it for more than 12 months. State regulators were equally split at 33.3% between never hearing of it to more than 12 months, with an even smaller percent ranging from 0-6 and 7-12 months.



Participants who had heard of *Tethys* were asked how they used *Tethys*. They could select as many uses that were applicable. Overall, more federal regulators indicated use of *Tethys* than their state counterparts. One exception is that state regulators were more likely to use *Tethys* to learn more about the environmental effects of the MRE industry.

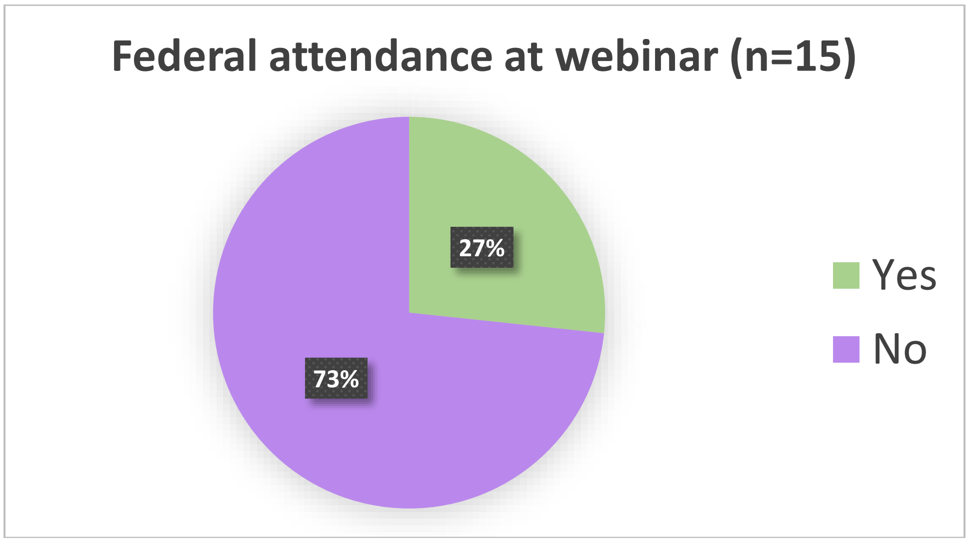


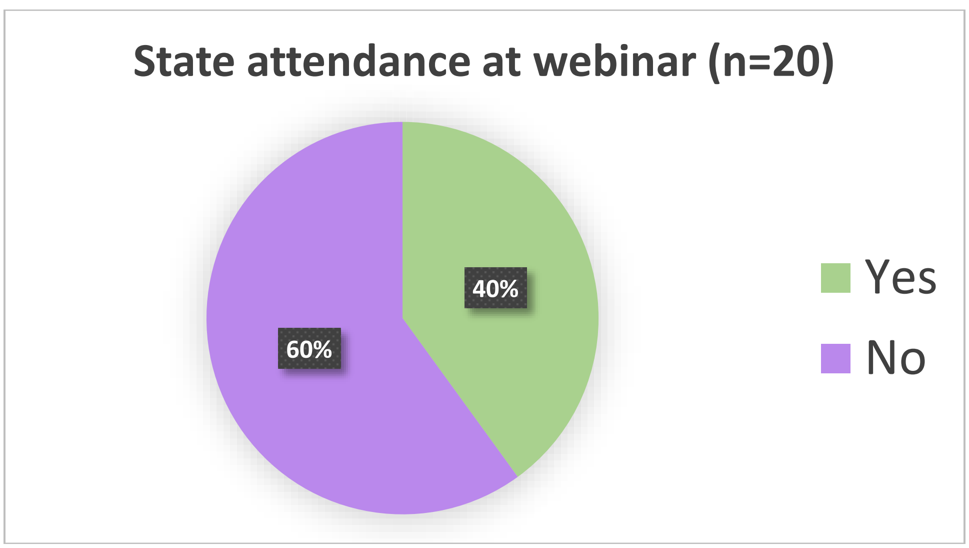
In general, participants who had heard of *Tethys* found *Tethys* to be very useful. Federal and state regulators had similar scores, except for one federal participant indicating that *Tethys* was somewhat useful.



Attendance at webinar

The Environmental Effects of Permitting MRE Deployments Webinar was held on March 29th, 2017. Participants were asked if they either attended or viewed the webinar on line. 27% of federal regulators and 38% of state regulators attended or viewed the webinar.





Discussion

This findings in this report indicate how familiar state and federal regulators are with various types of MRE and what the top challenges are. It makes sense that the top challenges differed for state and federal regulators, as the responsibilities of these agencies differ. The state has jurisdiction over submerged waters and commonly researches benthic habitats. Therefore, it is no surprise that benthic and habitat destruction emerges as a top challenge for a single device for the state.

There is indication that all participants perceive a difference in impact between a single device and an array as different challenges come into focus. Avoidance, attraction, and displacement of animals was the top challenge for both and state regulators at the level of an array. This highlights the importance of scale and the necessity to specify whether one is asking about the challenges/impacts of one device, a small array of 10 or so, or a much larger commercial scale array. Scale matters.

It may also be assumed that perceived risk increases with scale, however we do not have the data to test that hypothesis here. However, the preferred approach for management may serve as a proxy for participants risk tolerance/aversion. The more risk tolerant one is, the more likely they would favor survey, deploy, monitor where as a risk averse regulator may favor the precautionary principle. More research is needed to test perceived risk and risk tolerance.

The idea of transferability is worth further exploring. No participants indicated that data collected from other locations could "never" be applied towards environmental permitting within their jurisdiction. Furthermore, 25% of state and 36% of federal regulators indicated that it could "absolutely" be applied. Data transferability could reduce challenges and timely and expensive monitoring in regard to permitting.

This study does have a few limitations. In asking about the challenges, we did not separate out tidal, wave, or offshore wind. It may be that offshore wind is driving the responses due to the familiarity with wind. It is advisable that future studies separate these out, and perhaps not include wind at all, if tidal and/or wave energy is the main interest.

Another limitation is potentially the way in which the question, "How strongly do you feel additional monitoring data are needed (to decrease scientific uncertainty)" was asked. Results from this question were hard to interpret and should be taken with caution. Future research should pilot better ways to understand whether participants believe more monitoring data is needed to reduce uncertainty.

Next Steps for Outreach

Results from this study and from multiple PNNL meetings discussing this topic highlight a few areas for outreach efforts to be concentrated.

1. Continued outreach focused on familiarity with wave and tidal technologies. Particularly state regulators indicated less familiarity with wave and tidal technologies. In order for regulators to be able to successfully permit MRE developments they need to fully understand the technologies that they are regulating and permitting. By educating regulators, and specifically state regulators, we hope to improve their understanding of wave and tidal technologies, which can help better understand environmental effects and perceived risks versus actual risks.

2. Education outreach focused on highly rated challenges. The highest rated challenges were effects of underwater noise and benthic/habitat destruction for single devices and avoidance, attraction and/or displacement of animals for arrays. Gaining an understanding of why regulators feel these are the biggest challenges can help focus education outreach. Also conducting education outreach where concern does not match actual risks would be beneficial.

3. Better information regarding the thresholds for certainty. This includes understanding how much uncertainty is acceptable as well as how this compares to other energy industries. For instance, is the MRE industry being held to greater demand of certainty than other energy industries? One example of this is the industry being asked to provide data that there is no collision risk for tidal devices, however the cost of monitoring is high and the chance of getting data on a collision event is unlikely. Some see it as trying to prove the negative). Having a good understanding of how much certainty is enough (or how much uncertainty is acceptable) to retire a risk will aid in developing monitoring plans for MRE developments and future research needs.

4. Opportunities to discuss data transferability and collection consistency. No regulators felt that data collected from other locations can never be applied towards environmental permitting within their jurisdiction. This is a good starting point to begin discussing data transferability, especially as 25% of state and 35% of federal regulators said they would absolutely use data from other locations. Collecting monitoring data for MRE developments can be timely and costly, and improving the potential to transfer data from one location to another can help decrease barriers to MRE developments.

Appendix

This appendix includes three tables. The first is the shorthand abbreviations for the challenges that the respondents ranked for both a single turbine and an array. The second and third tables are color coated matrices designed to better understand patterns in the top challenges by showing how all participants ranked their challenges, split by federal and state regulators. Top challenges are ranked as “1” and are represented by the boldest red color whereas the lowest challenges are ranked as “8” and are represented by the lightest color. Empty grey cells indicate no response on that rating by the participant. The second table contains all the rankings from each respondent for each challenge for a single turbine. The third table is the same as the second, except it corresponds to challenges for an array.

Shorthand abbreviations for challenges	
Benthic	Benthic/ habitat destruction
Sound	Effects of underwater sound emissions from devices on animals
Avoid	Avoidance, attraction, and/or displacement of animals
Entangle	Entanglement of animals with lines and cables
Collision	Risk of animals colliding with underwater devices
Removal	Energy removal and effects of changes in flow on the ecosystem
Chemicals	Chemical releases and water quality degradation
EMF	Electromagnetic field (EMF) effect on animals

Single Turbine Challenges Ranked by Respondent								
	Sound	Avoid	Benthic	Cable	Collision	Energy	EMF	Chemicals
Federal	3	2	5	1	8	6	4	7
	2	7	4	1	3	5	6	8
	2	1	4	3	7	5	8	6
	1	3	6	4	5	2	7	8
	5	3	1	4	2	8	7	6
	3	5	4	1	7	6	2	8
	3	6	4	5	1	2	8	7
	3	5	1	2	6	7	4	8
	7	5	2	4	3	6	8	1
	1	3	2	8	4	5	7	6
	2	3	6	5	1	8	7	4
	2	1	3	5	7	8	6	4
	1	4	6	2	7	8	3	5
	3	2	6	4	1	7	5	8
	4	1	5	2	3	7	8	6
State	7	4	1	5	8	6	3	2
	5	2	1	6	3	8	4	7
	5	6	8	3	4	2	7	1
	3	1	2	4	8	6	5	7
	7	1	3	5	4	2	8	6
	5	1	2	4	7	8	3	6
	2	3	1	5	4	8	7	6
	1	3	5	2	6	7	4	8
	2	6	1	5	4	8	3	7
	3	1	2	4	8	6	7	5
	3	4	1	2	5	6	8	7
	4	1	6	3	2	8	5	7
	3	1	2	6	4	7	5	8
	7	3	1	4	6	8	5	2
		8		6	7	2		3
	5	3	2	4	1	6	7	8
	2	1	3	4	7	6	5	8
	5	4	1	2	3	7	6	8
	6	5	1	2	3	8	7	4
	2			3		4	6	5

Array Challenges Ranked by Respondent

	Sound	Avoid	Benthic	Cable	Collision	Energy	EMF	Chemicals
Federal	3	2	6	1	8	4	5	7
	3	7	4	1	5	2	6	8
	2	1	5	4	6	3	8	7
	1	3	5	6	4	2	7	8
	6	2	1	3	4	8	5	7
	2	7	5	1	6	4	3	8
	3	1	4	5	2	6	8	7
	7	3	1	5	2	4	6	8
	8	4	5	2	3	7	6	1
	4	1	6	2	3	5	8	7
	6	3	4	1	2	7	8	5
	2	1	3	5	7	8	6	4
	1	5	6	3	4	8	2	7
	4	2	6	3	1	7	5	8
	4	2	5	1	3	7	8	6
State	7	4	1	5	8	6	3	2
	5	1	2	7	3	6	4	8
	5	6	8	3	4	2	7	1
	3	1	4	7	8	6	2	5
	7	2	3	5	4	1	8	6
	5	1	2	3	7	8	4	6
	5	1	2	3	4	8	6	7
	1	2	6	4	7	3	5	8
	4	6	3	1	2	8	5	7
	3	1	2	4	5	8	7	6
	4	3	1	2	6	7	5	8
	4	1	6	3	2	5	8	7
	1	2	6	7	4	5	3	8
	3	4	1	5	6	8	7	2
		7		5			6	3
	4	3	2	5	1	6	7	8
	2	1	3	6	4	7	5	8
	6	2	1	4	3	5	7	8
	6	1	3	2	5	8	7	4
		3	2			4	7	

A.2 Regulator Focus Group Summary

Data Transferability Regulators Focus Group Summary

Main Points:

- Not necessarily looking for raw data, but data that they can interpret and easily understand
- Great to see videos and have recordings – increase understanding of impacts
    - Especially seeing non-lethal marine life interactions with devices and hearing audio
- Weren't aware of monitoring happening, really helpful to see
- May need more data on location specific information in addition
- Collision risk data corroborates what seeing at another site, which is helpful and could inform future reviews
- EMF is a concern of stakeholders, will get lots of questions
- Framework and MREPA would be useful and data collection consistency would be great
    - Will need to get buy-in here
- Part of the problem is with familiarity of what is out there, so would be helpful to have a readily available tool to lead people to data/information
    - Gives a sense of where to start and what could be applied to a specific project site or what may/may not be needed

Focus Group Summaries:

Portland

- Agreed that regulators are not looking for raw data
- Thought it was helpful to be shown the video clips/data/information to increase understanding of devices and how small/large impacts may be – for example, noise data helped them understand what turbines actually sound like
- Thought the framework/MRE Project Archetypes would be helpful to find data/information that can be transferred and used in permitting

California

- Great to have recordings of sound from devices – need to figure out how to present and represent what the sound actually sounds like underwater
- Good to know sound outputs/effects on longer time frame since continuous sound
- EMF doesn't seem as a present issue, but one that will get a lot of questions about
- Idea of having data that is compatible with one another is great

Hawaii

- Weren't aware of info/monitoring happening, so was great to know about everything
- Appreciated the videos and thought they were relevant
    - Seeing video, audio, sonar, etc. makes it more real
    - Seeing non-lethal marine life interaction with underwater devices

- May need more data on location-specific species to be able to use data/info in jurisdiction or to satisfy baseline/monitoring requirements
- Framework makes sense
- Big proponent of looking at what's been done before that can be applied
- Could add in socio-economics/amount and type of human activity into hierarchy

East Coast

- Collision risk data corroborates what seeing at another site, which is helpful and could inform future reviews
- Developers can ask ahead what info agency needs to help streamline the process
- Great information on EMF – some constituency concern of EMF still
- Standards for collecting data that can be applied across industries is helpful
- Visual surveys have been more informative for habitat changes (recovery)
- Information on sensitivity and validity is helpful when dealing with models
- Framework sounds useful as part of the problem is with familiarity of what is out there
    - Helpful to have a readily available tool to lead people to data/information
    - Gives a sense of where to start and what could be applied to a specific project site or what may/may not be needed
- Might think of things in terms of impacts in data – how to characterize impact to determine risks and if it is a true risk to the resource

AK, OR, WA

- Collision risk videos were helpful and can provide information to help reduce public perceptions of risk and from a PR perspective
- Site specific data is great, but the information provided here is useful
- With underwater noise, concern is that the noise exposure is extended, chronic, and continual
- Habitat changes – in Maine, a de facto marine protected area was created around the turbine (no fishing) so environment benefitted
- Framework sounds like it could be really useful
- Need to get buy-in on framework and how you should collect and report data; and develop a community and advertise so people are aware of the framework and database

Data Sets Shared:

Collision Risk (videos clips of turbines)

- Atlantis Andritz turbine at EMEC (UK) – showed movement/speed of turbine
- Voith turbine at EMEC (UK) – showed interaction of fish with operational turbine
- ORPC turbine in Igiugig, Alaska – showed interaction of fish with operational and non-operational turbine
- Adaptable Monitoring Package at NNMREC (Sequim Bay, US) – showed monitoring for collision risk with example of seal and bird approaching monitoring package

Underwater Noise

- OpenHydro turbine at EMEC (UK) – sound graph and audio clip of operational turbine
- NEWI Azura at Hawaii WETS – video of device and spectrograph (not sure this is the correct term) + sound graph + audio clips of operational turbine

- Fred Olsen Lifesaver at Hawaii WETS – spectrograph + sound graph + audio clips of operational turbine and turbine with damaged bearing
- Regulatory thresholds for harm/injury to marine mammals and fish
- Shipping noise sound graphs to compare with previous sound graphs

EMF

- EMF Literature Studies: Normandeau et al. 2011
- EMF Laboratory Studies: Schultz et al. 2010; Wilson and Woodruff 2011; Woodruff et al. 2013
- EMF Field Studies: Impacts on fish (Gill et al. 2009); Impacts on European Eel (Westerberg and Lagenfelt 2008); in situ Power Cable Observations (Love et al. 2016); BOEM MaRVEN experiments at sea with offshore wind turbines and cables (Thompsen et al. 2015); Impacts of Elasmobranchs and American Lobster; Impacts on Crab Harvest; Impacts on Migratory Fish Behavior
- Results of BOEM experiments at sea
- Combined with PNNL lab experiments

Habitat Changes

- PMEC – OR, USA: continental shelf, soft bottom
- Greys Harbor – WA, USA: continental shelf, soft bottom
- Admiralty Inlet Puget Sound – WA, USA: cobbled bottom, fast current

Physical System Changes

- Yang and Wang 2016: model findings of physical systems changes with 20 turbines in Puget Sound (WA, USA)

References

Update in progress.

Appendix B

Data Transferability White Paper

Marine Renewable Energy: Data Transferability and Collection Consistency

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Pacific Northwest National Laboratory

January 2018

Table of Contents

Abbreviations

EMEC	European Marine Energy Test Centre
EMF	electromagnetic field
ICOE	International Conference on Ocean Energy
MRE	marine renewable energy
MREPA	marine renewable energy archetype
PNNL	Pacific Northwest National Laboratory

Introduction

Background

As the marine renewable energy (MRE) industry progresses in US and waters worldwide, the increasing demand for data and information about how MRE technologies (wave and tidal devices) may interact with the marine environment continues. Our understanding of the potential environmental effects of MRE development is slowly increasing, informed by monitoring data collected around devices in several nations and a growing body of research studies. Information derived from monitoring and research is published in scientific journals and technical reports, which may not be readily accessible or available to regulators and other stakeholders.

Regulators at the federal and state level in the US, and analogously in other nations, must satisfy legal and regulatory mandates in order to grant permission to deploy and operate MRE devices. Inherent in these laws and regulations is a concept of balancing risk to the environment and human uses of public resources against economic development and human well-being. Research efforts related to the potential effects of MRE development are focused on this concept of risk, and the interactions between devices and the environment most likely to cause harm, or those for which the greatest uncertainty exists, are garnering the most attention (Copping et al. 2016). The components of risk—probability of occurrence and consequence of occurrence—are fundamental to the process by which regulators evaluate project compliance with environmental statutes. The concept of risk also provides an excellent context for discussing research outcomes and assisting regulators in learning more about potential effects.

The MRE industry is struggling with the high costs of baseline assessments and post-installation monitoring, as well as long timelines for obtaining permits, which lead to uncertainty and risk related to project financing. Regulators require assessment and monitoring information to allow them to carry out the necessary analyses to describe, permit, and manage the environmental risks associated with new MRE technologies and new uses of ocean space. One way to reduce risks to the industry and the environment, and to allow for acceleration of this new form of low carbon energy, could be the ability to transfer learning, analyses, and data sets from one country to another, among projects, and across jurisdictional boundaries.

As the MRE industry matures, the ability to readily transfer research and monitoring results, data, study designs, data collection methods, and best practices from project to project will lead to cost reductions for baseline environmental studies and post-installation monitoring. Regulators and stakeholders currently lack access to synthesized and contextualized data emerging from early-stage projects and there are no mechanisms by which to apply data and information across geographically distinct projects. This leads to each individual project bearing the full burden of information requirements on a site-by-site basis. In addition, data are collected around early-stage MRE devices using many different methods, instruments, and measurement scales. If similar parameters and accessible methods of collection were used for baseline and post-installation monitoring data around all early-stage devices, the results would be more readily comparable. This comparability would lead to a decrease in scientific uncertainty and support a common understanding of the risk of MRE devices to the marine environment. This in turn would facilitate more efficient and shorter permitting processes, which would decrease financial risk for MRE project development.

Purpose of the White Paper

This white paper defines the challenge of data transferability and data collection consistency by applying the state of the knowledge of environmental research, as well as analogous research from other marine industries.

Specifically, this white paper seeks to accomplish the following:

1. Determine methods, criteria, and guidance for allowing the use of MRE environmental effects data collected in one location or jurisdiction to be applied to consenting/permitting processes in another location or jurisdiction.
2. Outline a process for creating best practices for transferring data from one location or project to another.
3. Explore a pathway to developing best practices for data collection to encourage the collection of consistent data types to address each major MRE effect.

State of Knowledge of MRE Environmental Effects

The 2016 Annex IV State of the Science (Copping et al. 2016) report provides the best assessment of the state of knowledge of MRE environmental effects worldwide. The State of Science report was developed using published research, monitoring studies, and the best scientific judgment available at the time; additional papers and reports published since January 2016 have been examined to augment the original assessment. Based on this state of knowledge, it is clear that considerable progress has been made in understanding specific interactions between MRE devices and marine animals, habitats, and ecosystem processes. It is also clear that considerable work is yet to be accomplished: certain interactions need to be discounted or “retired” in order to simplify siting and permitting processes; other interactions will likely require mitigation in order to reduce potential harm to the marine environment.

Through discussions with regulators in the US and abroad, and based on the experience of early-stage MRE developers, it is not clear that the state of knowledge has been clearly communicated and understood by many regulators. It appears that regulators in many jurisdictions are not eager to rely on data sets, information, and outcomes generated from other locations to make permitting decisions.

Needs of the Regulatory Community

The Annex IV team at Pacific Northwest National Laboratory (PNNL) has engaged with the regulatory community in the US (federal and state regulators, resource managers, and advisers) through a webinar held in March 2017, a survey of regulators’ knowledge of and preferences related to permitting MRE development, a second webinar in November 2017, and informal interactions. Through these interactions, it has become clear that there is still a need and an appetite for additional outreach and engagement to ensure that existing information is well known. It is also clear from the survey results and subsequent discussions that data transferability is of interest to the regulators, but most have no clear understanding of how this might work.

Based on the interactions with the regulatory community, progress can be made through three distinct pathways:

1. Information Dissemination – There is a need for wide dissemination of what is known about MRE interactions with the marine environment, and that knowledge needs to be put into context to ensure that regulators and other members of the MRE community have a common understanding of the risks.
2. Data Transfer – A case should be made with regulators that data can be transferred from one MRE project to another, and a set of best practices for data transfer data collection consistency should be developed and promulgated.
3. New Research – Outstanding questions remaining about interactions of MRE developments and the marine environment will require new research. These questions will be collated throughout the process of regulator engagement and the workshop and made available to funding sources.

The Need for Consistency in Data Collection

Inherent in the effort to enable the transfer of monitoring data about MRE devices and their applications from one jurisdiction to another is the need to understand how similar the data might be. Ensuring that the data used from one (origin) location are compatible with the needs of another (target) location, and that multiple data sets from one or more locations can be pooled or aggregated, requires an evaluation of the degree to which the data are consistent. To date, few efforts have prescribed or compared collection methods, instrumentation, or analyses. A key example of this is shown in data collected to evaluate acoustic output from wave devices to evaluate the potential deleterious effects the noise might have on marine animals (Table 1; Copping et al. 2016).

Table 1. Field measurements of acoustic data from Copping et al. (2016) to illustrate the variety of measurements used when collecting environmental effects data.

Project Location	Device Type	Developer, Project/ Device Name	Project Phase	Project Scope	Sound Levels and Pressure Spectral Densities	Organism Type	Results
Strangford Lough, Northern Ireland	Tidal; two 16 m open-bladed rotors, attached to a pile in the seabed in 26.2 m of water	MCT (Marine Current Turbines) SeaGen™	Ambient	Used hydrophones to measure ambient noise	Range of 115 to 125 dB re 1 µPa	NA	High frequencies (200 Hz – 70 kHz) attributed to sound of tidal flow.
			Construction	Measure noise levels of construction activities and marine mammal response to construction noise	• Driving pin-piles: 136 dB 1 µPa at 28 m; 110 dB 1 µPa at 2130 m • Drilling: 20-100 Hz. Equiv. to background noise at 464 m	Harbor porpoise	Temporary displacement of harbor porpoises during construction. Baseline abundances resumed following completion of construction.
			Construction	Calculate the perceived noise levels by marine animals during drilling	• Harbor seal: 59 dB_{ht} at 28 m and 30 dB_{ht} at 2130 m • Herring: 62 dB_{ht} at 28 m and 25 dB_{ht} at 2130 m	Harbor seals, harbor porpoise, herring, dab, trout	Perceived levels of sound from pin-pile driller were generally lower than ambient levels of sound in the narrows. Calculations of perceived noise suggest marine animals in Strangford Lough were unlikely to be disturbed at distances more than 115 m from drilling.
			Operation	Determine harbor seal behavior in area of operating device	Ambient plus device signature	Harbor seals	No significant displacement of seals or porpoises. Marine mammals swam freely in the Lough during operation. Noted evasion at channel center during turbine operation.
Cobscook Bay, Maine, USA	Tidal; a single, barge-mounted, cross-axis turbine generator unit in 26m of water	Ocean Renewable Power Company, Cobscook Bay Tidal Energy Project	Operation	Measure noise levels of the barge-mounted turbine	Less than 100 dB re $\mu Pa^2/Hz$ at 10m	NA	At 200 to 500 m from the turbine, sound was not detectable above ambient noise within the bay.
East River, New York, USA	Tidal; six three-bladed unducted turbines bottom-mounted in 10 m of water	Verdant Power, Roosevelt Island Tidal Energy Project	Operation	Measure noise levels around the array of tidal turbines	Up to 145 dB re 1µPa @ 1m from the array	14 fish species in the area	During the study, blades on one turbine were broken and another turbine was failing, resulting in more noise generation than would be expected. Conclude sound at damaged turbine array did not reach levels known to cause injury for 13 species of fish examined.
Puget Sound, Washington, USA	Wave; 1/7th-scale wave buoy	Columbia Power Technologies, SeaRay™	Ambient and Operation	Measure sound signature of the wave device and surrounding area	• Ambient: 116-132 dB re 1µPa in frequency of 20 Hz to 20 kHz when ships were nearby. • Device: 126 dB re 1µPa	NA	Ambient noise levels masked the wave device sound. Sound from the SeaRay was closely correlated to the wave period.

Overall Roadmap for Data Transferability

We have examined recent permits and licenses in the US and abroad, and conducted a literature review, allowing us to examine and learn about elements of data transferability and collection consistency. We have used this background to develop a plan that will further the community's ability to use MRE environmental data collected from one project location at another.

The data transferability plan consists of the following steps:

1. Develop a framework for examining MRE monitoring data, based on what has been learned from the literature and our familiarity with available MRE data;
2. Gather examples of data for the major interactions of marine animals and habitats with MRE devices, based on State of the Science priorities;
3. Engage with the US regulatory community to determine their impressions of the adequacy and applicability of data collected to date; we expect the reviewers to examine these data within the context of their needs for reviewing and accepting permit applications in their areas of responsibility. We hope to understand their assumptions and concerns about specific aspects of the proposed data transferability and collection consistency, and to understand their appetites for risk, in order to predict their willingness to extend the use of datasets from one location to another. We also intend to introduce the framework to the regulators to garner their impressions of its usefulness.
4. Adjust the context and details of the framework to take into account the knowledge base, impressions, and risk appetite of the regulators.
5. Prepare background material on data transferability, data collection consistency, and the framework for participants in a workshop to be held in conjunction with ICOE in June 2018.
6. Engage workshop participants, with the intent of incorporating their input, to develop a draft best practices document, targeted for September 2018.

Implementation of the plan will be undertaken after sufficient review and acceptance among participants and Annex IV analysts. It is expected that the interactions with US regulators will encourage other Annex IV analysts to carry out similar interactions with their regulators.

Literature Review

Data Transferability

A literature review was conducted to understand how challenges related to data transferability and data collection consistency have been addressed in other industries. The literature review was conducted by reviewing articles found via Google Scholar and Web of Science. Search terms used for the literature review included "data transferability," "environmental data transferability," "data transferability framework," "transferability framework," "data consistency," "data management," "environmental data management," and "data model transferability." This review allowed us to investigate potential data transferability frameworks, models, and approaches, and to determine the limits of data collection consistency in supporting data transferability. The literature that proved to be most pertinent came from a wide range of fields, including economics, transportation, ecology, and land system science. Summaries of the seminal papers are provided in Appendix A.

Several of the reviewed studies focused on data needs and best practices related to data transferability. For example, Briassoulis (2001) presents a policy-oriented analysis of data needs for integrated land-use change. The evaluation concluded that policy-oriented analysis of land-use change requires the following:

- Data must be spatially and temporally compatible, consistent, reliable, easily and inexpensively available and georeferenced.
- Systematic, compatible, consistent, and reliable definitions must be used.
- Compatible, consistent, reliable, easy, and inexpensive data collection procedures must be followed.

A report prepared by the Volpe National Transportation Systems Center (2005) summarizes the results of a peer exchange on data transferability organized and sponsored by the US Federal Highway Administration. The exchange brought together representatives of state and local departments of transportation, metropolitan planning organizations, academics, and transportation consultants. Significant discussions focused on the following topics: developing transferability guidelines to encourage proper data transfer; determining whether certain variables were more transferable than others; and developing requirements for testing data comparability. Drummond et al. (2009) summarized the conclusions and recommendations of the task force that was assembled to investigate the transferability of economic data. The summary recommends several good research practices related to transferability, including recommendations for statistical analyses and modeling, along with guidance when considering the appropriateness of data derived from different jurisdictions.

In addition to data needs and best practices, much of the reviewed literature evaluated statistical methods, models, and frameworks related to data transferability. Vanreusel et al. (2007) investigated the transferability of habitat-based predictive distribution models for two regionally threatened butterflies in northern Belgium. One conclusion of the study was that models depending on area-specific conditions (e.g., landscape structure, microclimate, soil type) may be over fitted to the local conditions, which could limit their transferability. The authors hypothesize that models based on combined data could possibly have greater potential for generalization, leading to a higher potential for transferability. Wenger and Olden (2012) proposed a method for evaluating ecological model transferability through the application of trout species distribution modeling. The authors concluded that traditional linear models have greater transferability, while machine-learning techniques such as random forests and artificial neural networks can produce models with excellent in-sample performance but poor transferability (unless complexity is constrained). Heikkinen et al. (2012) investigated 10 modeling techniques related to (1) species distributions of birds, butterflies, and plants, and (2) climate and land cover in Finland to determine whether good model interpolative prediction accuracy comes at the expense of transferability. The results showed that the machine-learning techniques (MAXENT) and the generalized boosting method (GBM), along with generalized additive models (GAM; a regression-based method), had a desirable combination of good prediction accuracy and good transferability. The authors noted that the challenge of model transferability is due to the need to include all relevant environmental variables without having the model become too complex or over fitted. Rashidi et al. (2013) evaluated the effectiveness of Bayesian updating to synthesize travel demand data as a means of reliably transferring distribution models to areas where data collection is too costly or unfeasible. Of particular interest and relevance, Václavík et al. (2016) investigated the transferability potential of research from 12 regional projects that focused on issues of sustainable land management across four continents. The study used a previously developed concept of land system archetypes (Václavík et al. 2013) to estimate the transferability potential of project research by calculating the statistical similarity of locations across the world to the project archetype, assuming a higher degree of transferability in locations that had similar land system characteristics. The results showed that areas of high transferability potential are often clustered around project locations; however, high transferability potentials can be found in geographically distant locations, especially when the values of the considered variables are close to the global mean or when the project archetype is driven by large-scale conditions (e.g., environmental, socioeconomic). The proposed transferability framework presented by Václavík et al. (2016) provides a blueprint for research programs that are interested in investigating the transferability potential of place-based studies to other geographic areas, while also assessing possible gaps in research efforts.

Data Collection Consistency

Many of the papers reviewed for data transferability stressed the need for data collection consistency. Biassoulis (2001) explained that different data collection procedures that produce a variety of data, or in this case were collected using different measurements, can greatly affect the transferability of data. Transferability can also be affected by the spatial scale, temporal scale, definition, and context of the data collected (Briassoulis 2001; Volpe National Transportation Systems Center 2005). While admitting that it is not realistic to expect that the same instruments and measurements will be used in the wide array of studies and environmental monitoring, the Volpe National Transportation Systems Center (2005) pointed out that developing common standards for data collection can aid in the comparability of findings and data transferability.

Briassoulis (2001) recommended compatible, consistent, reliable, easy, and inexpensive data collection procedures be followed, but also noted that adopting standardized and uniform procedures is often not realistic unless it is coordinated internationally or by a single agency. In order for collection consistency to be possible for an industry, researchers and developers need to work together to develop best practices for measurements and procedures, at the same time communicating with policy-making bodies or agencies to ensure data collection procedures and measurements produce policy-relevant data that are compatible for use in permitting and consenting (Briassoulis 2001). Volpe National Transportation Systems Center (2005) provided a research plan for "*Identifying Needs and Approaches for Standardization of Travel Model Input Data*" that offers a valuable model for assessing the need for and benefits of collection consistency, associated costs, and practical implementation. The model might be applicable to environmental effects data collected by the MRE industry.

Framework for Data Transferability

From examining the literature, and listening to regulator concerns, it appears that a framework is needed to guide how data generated in one location can be transferred for regulatory use in another location. Such a framework will bring together data sets in an organized fashion, compare the applicability of each data set for use in other locations, and guide the process for comparison and data transfer. The framework proposed here can be used to accomplish the following:

- Develop a common understanding of data types and parameters that are most useful in determining and addressing the potential effects of MRE development.
- Create a set of best practices that will harmonize the consistent collection of data that address key interactions between MRE installations and the marine environment.
- Engage regulators in testing the framework and soliciting input to test the limits of their appetites to embrace data transfer.
- Set limits and considerations for how best practices can be applied to assist with effective and efficient siting, permitting, post-installation monitoring, and mitigation.

Choosing Variables and Data Sets for Transfer

The choice of variables and data sets that might be considered for transfer from one location to another must be driven by regulatory requirements; studies and analyses to date have concentrated broadly on applicable regulations and permit guidelines (Copping et al. 2016). From these studies and analyses, it is clear that a common and consistent set of key interactions can be identified in almost all countries (Table 2); this set of variables and interactions will guide the development of the data transferability framework.

Table 2. Interactions and variables that act as stressors derived from MRE devices and applicable MRE technology types.

Interaction or Variable (Stressor)	Applicable MRE Technology
Risk of marine animals colliding with turbine blades	Tidal
Effects of acoustic output from devices on marine animal behavior	Wave and tidal
Effects of electromagnetic fields from cables and devices on marine animals	Wave and tidal
Changes in nearfield habitat, including reefing of marine animals because of the presence and operation of devices	Wave and tidal
Changes in flow fields, sediment transport, and effects on farfield habitats because of the presence and operation of devices	Wave and tidal

Drivers for Developing a Data Transferability Framework

Examination of the scientific literature about data transferability, discussions with regulators, and examination of recent permits and licenses in the US and abroad clearly indicate that criteria need to be developed for use in transferring data between locations. These criteria will guide the choice of data sets for transfer, form the basis for developing best practices, and help give regulators confidence that their needs are being met. These criteria must include the following:

- comparability of parameters and methods for how the data were collected;
- sufficient description of the physical, chemical, and biological environment to determine comparability among sites;

- assessment of the similarity of MRE technology devices and balance of station; and
- description of the application of the data set for siting and regulatory purposes, at the location of origin.

Framework Outline

The proposed framework will consist of

- a method for describing the environment and evaluating the comparability of data sets (MRE project archetypes);
- a series of steps that will describe the applicability of the framework to MRE technologies; and
- a method for describing the application of a data set from one site to another, to support regulatory processes.

MRE Project Archetypes

The most promising transferability methodology and framework that might be applied to MRE permitting is gleaned from the literature presented by Václavík et al. (2016) for sustainable land management purposes. The authors' concept of defining a project "archetype" based on a variety of indicators can be applied to other place-based studies, including MRE studies. By adopting the concept of an "MRE project archetype" (MREPA), a combination of stressors, site conditions, MRE technologies, and receptors can be applied to help meet MRE regulatory needs. The comparability between archetypes at the location of origin of the data set and the location to which data will be transferred must be evaluated.

Defining MRE Project Archetypes

The key premise of the MREPA concept is that MRE projects with like MREPAs will have the highest potential for data transferability. Four variables that define each project MREPA are the stressors, site conditions, MRE technology types, and receptor groups.

Stressors

Portions of MRE devices or other system components affect environmental receptors, such as marine mammals and habitats (Copping et al. 2016). These stressors include

- collision risk;
- effects of underwater noise;
- effects of electromagnetic fields (EMFs);
- changes in nearfield habitats and reefing patterns; and
- changes in physical systems, sediment transport, and farfield environmental effects.

Site Conditions

Information about site conditions at the site of origin and the target site to which data will be transferred is pertinent when determining the data transferability potential. Site conditions have been defined as follows for each of the stressors listed above:

- For collision risk (tidal turbine), the site can match one of four conditions: (1) shallow and narrow channel, (2) deep and wide channel, (3) shallow and wide channel, and (4) deep and narrow channel.
- For effects of underwater noise, site conditions include (1) insolated/quiet environments and (2) noisy environments (acoustic peaks above US regulatory standards for thresholds, broadband).
- For effects of EMFs, site conditions include (1) buried cables, (2) unburied cables laid on the seafloor, (3) shielded cables, and (4) unshielded cables.
- For changes in nearfield habitat and reefing patterns, site conditions include (1) hard bottom habitats, (2) soft-bottom habitats, and (3) in the water column.
- For changes in physical systems, sediment transport, and farfield habitat changes, site conditions include (1) enclosed basins and (2) open coastlines.

MRE Technologies

Each stressor listed can be related to specific MRE technology types, as follows:

- Collision risk can be related to a tidal device that is (1) bottom-mounted or (2) suspended in the water column (floating).
- Effects of acoustic noise can be related to either (1) tidal devices or (2) wave devices.
- Effects of EMFs can be related to (1) seafloor cables or (2) draped cables.
- Changes in nearfield habitats and reefing patterns can be related to (1) foundations/anchors or (2) floats/mooring lines.
- Changes in physical systems can be related to (1) tidal devices or (2) wave devices.

Receptors

Each stressor and MRE technology type has the potential to have an effect on a particular group of environmental receptors:

- For collision risk, receptors include (1) marine mammals, (2) fish, and (3) diving birds.
- For effects of acoustic noise, receptors include (1) marine mammals and (2) fish.
- For effects of EMFs, receptors include (1) elasmobranchs and (2) mobile/sedentary invertebrates.
- For changes in nearfield habitat and reefing patterns, receptors include (1) benthic invertebrates, (2) demersal fish, and (3) shoaling fish.
- For changes in physical systems, receptors include (1) sediment transport and (2) water quality/food web.

MRE Archetype Matrices

A series of matrices have been developed for each stressor that identify the potential site conditions, MRE technology types, and receptors that can be applied to an MRE project at the origin site and at the target site (Table 3–Table 7). From each matrix, an MREPA can be identified for a particular project or set of data that might be useful for transfer. For example, projects related to collision risk have the potential to be classified as one of 22 possible MREPAs based on the project site conditions, MRE technology types, and receptors. Defining the project

MREPA is the first step in determining the transferability potential of data from a project, as discussed in the following section.

Table 3. Marine Renewable Energy Project Archetype (MREPA) Matrix for Collision Risk.

Site Condition [(a)]	Technology	Receptors
Shallow and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Shallow and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds

(a) Shallow channels are defined as having a depth less than 40 m. Deep channels are defined as having a depth greater than 40 m. Narrow channels are defined as having a width of less than 2 km. Wide channels are defined as having a width greater than 2 km.

Table 4. MREPA Matrix for Effects of EMFs.

Site Condition	Technology	Receptors
Buried Cables	Seafloor Cables	Elasmobranchs
		Mobile /Sedentary Invertebrates
Cables Laid on Seafloor	Seafloor Cables	Elasmobranchs
		Mobile/Sedentary Invertebrates
Shielded Cables	Seafloor Cables	Elasmobranchs
		Mobile/Sedentary Invertebrates
Unshielded Cables	Seafloor Cables	Elasmobranchs
		Mobile/Sedentary Invertebrates
	Draped cables	Elasmobranchs
		Mobile/Sedentary Invertebrates

Table 5. MREPA Matrix for Effects of Acoustic Noise.

Site Condition	Technology [(a)]	Receptors
Isolated/Quiet Environment	Tidal Device	Marine Mammals
		Fish
	Wave Device	Marine Mammals
		Fish
Noisy Environment	Tidal Device	Marine Mammals
		Fish
	Wave Device	Marine Mammals
		Fish

(a) Sound levels generally caused by specific portions of each technology: tidal device sound from blade and rotor rotation, as well as power take offs; wave device sound from power take offs. In addition, some lower levels of sound may be generated by mooring systems and interactions between the device and the surface waters, but these sounds were considered to be of less amplitude and unlikely to be of concern for marine mammals (Copping et al. 2016). Isolated/Quite Environments are those with noise measuring less than 80 db. Noisy Environments are those with noise measuring greater than 80 db,

Table 6. MREPA Matrix for Nearshore Changes to Habitat and Reefing Patterns.

Site Condition	Technology	Receptors
Hard Bottom Habitat	Foundation/Anchors	Benthic Invertebrates
		Demersal Fish
		Shoaling Fish
Soft-Bottom Habitat	Foundation/Anchors	Benthic Invertebrates
		Demersal Fish
		Shoaling Fish
Water Column	Floats/Mooring Lines	Marine Mammals and Sea Turtles
		Demersal Fish
		Shoaling Fish

Table 7. MREPA Matrix for Changes to Physical Systems and Farfield Habitat Changes.

Site Condition	Technology	Receptors
Enclosed Basin	Tidal Device	Sediment Transport
		Water Quality/Food Web
Open Coast	Wave Device	Sediment Transport
		Water Quality/Food Web

Applying the Framework

The preferred outcome of applying the data transferability framework is characterization of the level of risk associated with each key MRE technology interaction with the marine environment, simplification of the questions associated with these key interactions, and hence decreased need for extensive onsite data collection or ancillary research studies to elucidate the level of risk. By implementing the data transferability framework, the siting and permitting processes for installation of single MRE devices and arrays could be shortened and scarce funding resources could be directed toward the interactions that remain most uncertain.

Characterize Origin Project

The first step in determining the transferability of data sets from an MRE project is identifying the MREPA for the origin project by examining the stressors, site conditions, MRE technology types, and receptors, as defined above. Figure 1 provides an example of characterizing data from an origin project that investigates collision risk for marine mammals, specifically harbor seals. By following the matrix provided in Table 6, the project is characterized by stressor, site conditions, MRE technology, and receptor.

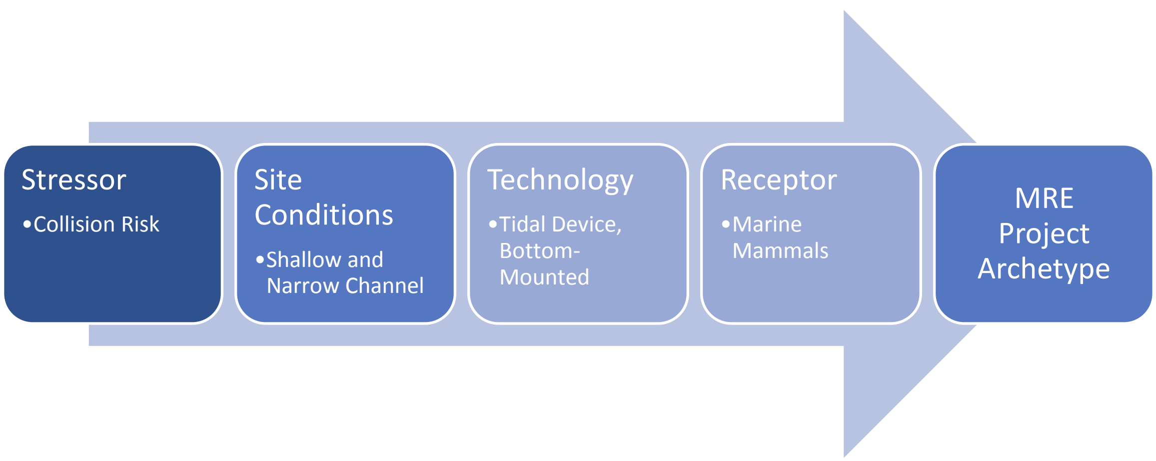

Figure 1.Example of an MREPA for a project site of origin.

Characterize Target Project

Once the MREPA of the origin project site is characterized, the MREPA for the target site also needs to be evaluated. As an example, the potential target project site might require investigation of collision risk to marine mammals, such as endangered killer whales (orca). This comparison assures that the MREPA for the target site is identical to the MREPA of the origin project shown in Figure 1.

Transferability Potential

Rules have been developed to evaluate the potential transferability of data between an origin project site and a target project site (Figure 2). In order for data transferability to be considered, the origin and target project site *must share the same MREPA*, thereby ensuring that the two locations share the same stressors, site conditions, MRE technology types, and receptors. Sharing an MREPA means there is potential for transferring data from the origin project to the target project. Next, the degree of transferability should be evaluated by examining the receptor species, specific technology types, wave or tidal resource, and geographical proximity of the projects to one another. The more variables the origin and target project sites have in common, the more transferable data will be from the origin site to the target project site.

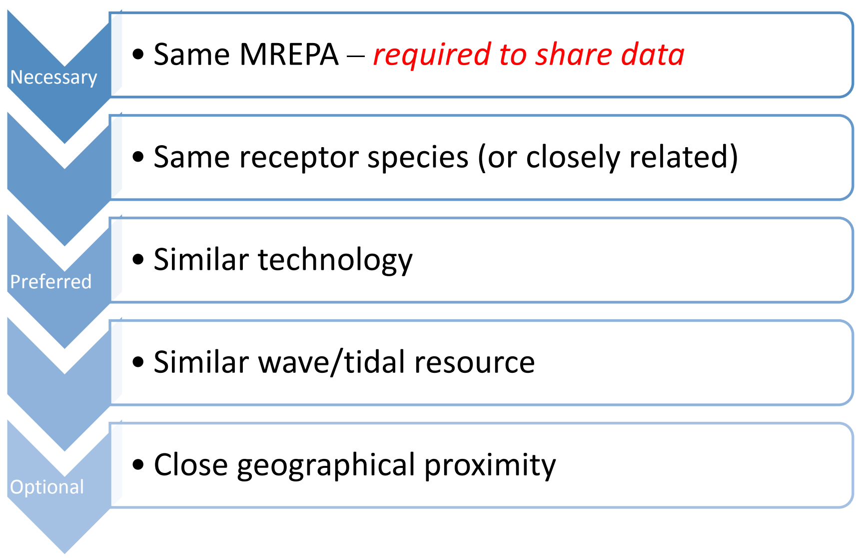

Figure 2. Rules of transferability to evaluate transferability potential.

Interacting with Regulators

The framework is developed to provide a background against which discussions with regulators can proceed to understand the limits of transferability, based on the confidence individual regulators have to accept data and information collected in one location for information analyses of applications for MREs in her/his jurisdiction. The framework will also help to understand where additional data collection, analysis, and interpretation can help increase the degree of data transferability. The following plan lays out the steps and processes for achieving these goals.

Plan for working directly with regulators

The active outreach and engagement plan described here is organized around regulator focus groups. The purposes of the regulator focus groups are as follows:

- Understand regulators' real-world challenges for interpreting data and analyses for MRE projects (or analogous industry projects in the absence of significant experience with MRE applications).
- Share existing data sets with regulators and obtain their feedback on their perceived limitations for accepting data generated in other locations and other jurisdictions for their own regulatory analyses.
- Develop methods for transferring data sets from one project to another.
- Integrate lessons learned from the variety of federal and state regulators who are constrained by differing legal and regulatory regimes for permitting activities in a variety of waterbodies and geographic regions.

Preparation of Data Sets and Example Projects

In preparation for meeting with regulators, synthetic data sets will be acquired and prepared for sharing with the regulators. These data sets will simulate the types of data and information that could be available from the locations of early MRE deployments, representing the origin projects, as described in the framework. The purpose of developing and sharing the data sets is to elicit impressions from the regulators, to understand which aspects of the data they might be comfortable with including in their regulatory analyses, and to understand which aspects continue to concern them.

The MREPA for from which the data are acquired (the origin project) will be constructed and an example project, drawn from the jurisdiction of the participating regulators (the target project), will be constructed for use in demonstrating the framework.

Synthetic data sets will be collected for each of the key stressors (collision risk, effects of underwater noise, EMF effects, nearfield benthic habitat changes, and physical changes), and specific data sets will be targeted for each stressor (Table 8). We will work with Annex IV partners, member nation analysts, and other collaborators to acquire the data.

Table 8. Synthetic data sets to be acquired for interaction with regulators on data transferability.

Stressor	Data Set or Information Source	Comments
Collision risk	Video clips taken around turbines at the European Marine Energy Test Centre (EMEC), other locations in the UK, and Kvichak River.	Clips of both fish and marine mammals
Effects of underwater noise	Sound outputs from wave energy converters at the Wave Energy Test Site and turbines at EMEC; compare to regulatory thresholds.	Marine mammal and fish thresholds

Effects of EMF	Results of Bureau of Ocean Energy Management field experiments and PNNL lab experiments.
Changes in nearfield habitat,	Video clips of outer continental shelf to show consistent soft-bottom habitat from the Pacific Marine Energy Center; video from Admiralty Inlet to show rocky/cobble habitat.
Changes in physical systems	Numerical models of tidal areas and WEC wave energy converter deployment locations.

Regulator Focus Groups

Regulator focus groups will be made up of US state and federal regulators, drawn from existing contacts and those who engaged during the 2017 outreach and survey process.

The goal of the regulator focus groups is to understand regulator acceptance of and concerns about data transferability, and to articulate the real-world challenges regulators have about applying data from origin projects to projects in their jurisdictions. Regulator focus groups may be held in person or online, by region, or by the major concentrations of regulators' requirements (i.e., marine animals, water quality, habitat, etc.).

Each regulator focus group will be conducted to provide information and seek feedback as follows:

- The concept and background information about data transferability will be introduced, as they apply to the current status of the MRE industry.
- Regulators will be asked to articulate their field of regulatory focus, in terms of MRE development.
- The synthetic data sets pertinent to the particular regulators will be presented; the regulators will be asked to identify what they regard as being applicable to their jurisdiction, and what they would still be lacking after viewing the data.
- The concept of the MREPAs will be introduced, along with the rules for acceptance of data sets and information from other projects, and the regulators will be asked to react to the use of the framework.
- Discussions of the need for data collection consistency will be held to ensure that the regulators understand the need to encourage consistent data collection for pre- and post-installation monitoring within a single project and among projects, and so they can provide their input.
- Additional recommendations will be sought from regulators about how we might accomplish the task of data transferability.

Applying Regulator Focus Group Learning and Next Steps

After the regulator focus groups, the knowledge gained from the groups will be brought together and a process for sharing the information at an ICOE workshop developed. The goal of the workshop will be to provide input to a set of best practices for data transferability and consistent data collection, and to provide a semi-quantitative output of the process. Attendance at the workshop will be solicited through direct invitation to key researchers and

MRE developers, as well as Annex IV and Ocean Energy Systems Executive Committee members. ICOE will also advertise the workshop and invite interested registrants.

Logistical preparation for the workshop at ICOE will proceed after the focus groups have concluded. The workshop participants will be provided with a summary of the input from the regulator focus groups, including:

- impressions from US regulators about when and where data sets and other learning can be transferred from one location or project to another;
- challenges noted by the regulators to carrying out that transfer of data; and
- examples where US regulators believe that transferability of data would assist with their regulatory analyses.

The workshop will share the MREPA concept for classifying projects and project sites. Feedback will be sought on improvement of the matrices and rules of use. A semi-quantitative process for evaluating the transferability potential for specific data types will be attempted. Discussions will be held around the need for consistent data collection and particular parameters that are deemed most important to be collected for each key stressor. The primary outcome will be the capture of workshop results that will serve as the foundation for continued work toward development of best practices for transferring data between and among projects.

Next Steps

After the workshop at ICOE, a report will be prepared that summarizes the outcomes of the literature review, preparation and examination of synthetic data sets, regulator focus groups, and the workshop discussions. The report will provide an outline for best practices for data transferability and data collection consistency. Regulators who participated in the process and workshop participants will have the opportunity to review the draft report and their input will be considered during development of the final report in late 2018.

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Appendix – Literature Review – Summary of Seminal Papers

Transferability of Economic Evaluations Across Jurisdictions: ISPOR Good Research Practices Task Force Report

Michael Drummond, Marco Barbieri, John Cook, Henry A. Glick, Joanna Lis, Farzana Malik, Shelby D. Reed, Frans Rutten, Mark Sculpher, Johan Severens
Value in Health, Volume 12, No. 4, 2009

In 2004, a task force was put together to investigate the transferability of economic data. Their objectives were (1) to review what national guidelines for economic evaluation say about transferability; (2) to discuss which elements of data could potentially vary from setting to setting; and (3) to recommend good research practices for dealing with aspects of transferability (including analytic strategies and guidance for considering the appropriateness of evidence from other countries). The following is a summary of the conclusions and recommendations of the task force:

- Simple descriptive statistics should be used to examine potential differences among jurisdictions before statistical modeling occurs.
- The level of sophistication of subsequent statistical modeling (i.e., fixed effects vs. random effects) should be guided by the following criteria: (1) number of jurisdictions (e.g., countries, clinical centers); (2) exchangeability or nonexchangeability of data; and (3) the availability of covariates (e.g., at center and country level). With more jurisdictions, partial exchangeability of data, and greater availability of covariates, hierarchical modeling is to be preferred.
- Analysts should carefully consider which parameters need to be jurisdiction specific, wherever possible justifying assumptions with empirically derived data.
- Analysts should use scenario analysis (a form of multiway sensitivity analysis) to explore the implication of different assumptions about economic data transferability.
- There should be more investment in data collection for those parameters that are thought to differ most from place to place.

Effectiveness of Bayesian Updating Attributes in Data Transferability Applications

Taha H. Rashidi, Joshua Auld, Abolfazi (Kouros) Mohammadaian
Transportation Research Record: Journal of the Transportation Research Board, No. 2344, 2013

This paper presents methods for applying Bayesian updating to model the household total number of work trips per day. Bayesian updating has been recognized as having great potential for use in the transportation field, and this paper cites many examples. For local areas where comprehensive data collection is too costly and infeasible, Bayesian updating can be used to synthesize travel demand data. The Bayesian updating method - which gives an updated probability distribution of some variable, model parameter, or other element of interest through a combination of a current sample of data about the attribute and some prior knowledge of its distribution - presents an approach for reliable transfer of models in a scientifically valid way. This study shows that, in general, updating small local samples of travel attribute data with prior information from national data sources provides an improved estimate of local travel attributes compared with using the local sample only. However, including all available historical data in the prior distributions does not necessarily improve the quality of the updating results.

Transferability of Species Distribution Models: a Functional Habitat Approach for Two Regionally Threatened Butterflies

Wouter Vanreusel, Dirk Maes, Hans Van Dyck
Conservation Biology, Volume 21, No.1, 2007

This study tested the transferability of habitat-based predictive distribution models for two regionally threatened butterflies within and among three nature reserves in northern Belgium. The study adopted a functional resource-based concept where a species requires a set of specific resources and conditions to survive and reproduce. The authors used resources directly related to ecological functions (host plants, nectar resources, shelter, microclimate) rather than environmental surrogate variables. All models were transferable among the independent areas within the same broad geographical region. The authors argue that habitat models based on essential functional resources could transfer better in space than models that use indirect environmental variables.

Other general conclusions/observations:

- Models based on combined data could possibly have a greater potential for generalization
- Most predictive distribution models for birds, insects, or other species are landscape-scale models that use large-scale and abiotic variables, including topography and climate. Abiotic variables explain animal distributions most indirectly through correlations of the variables with functional ecological resources. When these correlations depend on area-specific conditions (landscape structure, microclimate, soil type, topography), models could be over fitted to the local conditions. This can be one potential explanation of poor transferability.
- The authors hypothesize that models based on combinations of functional relations are likely to have good transferability among areas given that resource use and resource distribution are similar. For example, the good transferability of fish models compared with models for terrestrial organisms might be due to the fact that fish microhabitat variables such as stream characteristics are similar in range of variation among stream and have a more direct functional relationship to the study species than terrestrial abiotic or biotic variables.

Summary Report for the Peer Exchange on Data Transferability: Held December 16, 2004

Prepared by the Volpe National Transportation Systems Center (US Department of Transportation)

This report summarizes the results of a peer exchange on data transferability organized and sponsored by the Federal Highway Administration (FHWA) Travel Model Improvement Program (TMIP) and co-sponsored by the TRB Committees on Urban Transportation Data and Information Systems (ABJ30), Traveler Behavior and Values (ADB10), and National Transportation Data Requirements and Programs (ABJ10). The exchange brought together representatives of state and local departments of transportation (DOTs), metropolitan planning organizations (MPOs), academics, and transportation consultants. It consisted of presentations on data transferability topics, followed by a discussion of data transferability issues structured around a set of questions prepared prior to the meeting. The following sections summarize the relevant peer exchange discussions.

1. *What are your ideas about data transferability for travel demand/activity models? How do you define "transferability spatially and temporally?*

   Participants agreed there are several "layers" of transferability: (1) a conceptual layer which consists of the modeling structure or mechanisms, (2) the parameters layer, and (3) the outcomes layer.
   Participants felt that data transferability guidelines would be helpful for the entire travel demand modeling community for preventing technically invalid data transfers while encouraging proper data transfer. Standards for transferability of data would lay out criteria and guidelines on what data are transferable, define a correct method to conduct data transfer, and provide a method for measuring whether data transfer was performed successfully and correctly (beyond data matching).
   The importance of determining whether certain variables or types of variables are more transferable than others was also discussed.
2. *For which types of applications does data transferability already occur, and how has the transfer been achieved? Was it successful? What applications have data/parameters that are not typically transferred currently, but might be difficult to estimate originally due to future data limitations? What are some new and different applications for which transferability of data/parameters might work?*

   Participants stated that a prerequisite for successful data transfer is that the source data set and the target data set be comparable. To determine if two data sets are comparable, one should combine the data sets and perform usability and reasonability tests, such as testing whether a variable works the same way before and after the data set combination. One common mistake is to overlook scaling of the data. It would be beneficial to have an outline of some basic requirements for testing data comparability.
3. *What types of data/parameters can be transferred or should not be transferred?*
   Some participants felt that, although temporal transferability is currently used regularly, its validity has not been sufficiently studied by modelers. A controlled study of temporal

transferability would help the industry learn how to model temporal changes such as increases in trip rates. Trends over time should also be analyzed to determine whether the context of the data is changing.

Panelists all believed that there are probably key or core variables in travel demand modeling that are transferable and that there are context sensitive variables that are less transferable. Some participants suggested that for the time being, until further research is performed, the most stable variables could be transferred with reasonable confidence.

There are currently some elements for which modelers have little understanding and which are difficult to transfer. For example, care should be taken with constants as they represent factors that the data may not explicitly explain.

4. *How are data/parameters transferred in current applications? What are correct methods for data/parameter transfer?*

   Ideally, modelers should have data from both the source and recipient areas to determine the suitability of the data transfer for each specific case. It is very important that there is a basic understanding of the source and recipient circumstances before transferring data, such as understanding of what type of errors are associated with the source data.
   Modelers should also perform a “goodness of fit” test to determine whether data can be transferred. To aid users in identifying transferability, it would be beneficial to come up with a set of supplementary model specification tests for transferability.
   Agencies should be careful when transferring results from models written using different software. The software being used for modeling can affect the resulting value of the coefficients.
   Data are also sometimes transferred as distributions instead of averages.
5. *What are the implications in using transferred data (e.g. need to use same input variables)?*

   For transferability to be successful, modelers must understand the context in which transferred data were gathered and the context in which models and parameters were estimated. The data generation process could be standardized to include the required context so that data from different regions can be pooled and exchanged.

The following research topics and scopes were chosen by the group for advancing the concepts of data transferability:

A. Identifying needs and approaches for standardization of travel model input data
B. Use of standardized metadata in improving the documentation and transferability of Spatial and travel model data
C. Analysis of temporal stability and dynamics in activity-travel behavior
D. Part 1: Regional impact on travel behavior

Part 2: Drivers of travel behavior
Part 3: Facilitation of travel data and model transferability

E. A guidebook that outlines data transferability issues and guides a user step-by-step through evaluating data transferability
F. Simulation of household activities and travel behavior data
G. Employment data and transferability issues in modeling

Assessing transferability of ecological models: an underappreciated aspect of statistical validation

Seth J. Wenger, Julian D. Olden
Methods in Ecology and Evolution, Volume 3, 2012

This study proposes a method for evaluating ecological model transferability based on techniques currently in use in the area of species distribution modeling. The method involves cross-validation in which data are assigned non-randomly to groups that are spatially, temporally or otherwise distinct, thus using heterogeneity in the data set as a surrogate for heterogeneity among data sets. The authors present an example by applying the method to distribution modeling of brook trout and brown trout in western US. The show that machine-learning techniques such as random forests and artificial neural networks can produce models with excellent in-sample performance but poor transferability, unless complexity is constrained. The authors have found that traditional linear models have greater transferability. Other conclusions of the study include:

- Predictor-response relationships that have a sound ecological basis and direct causal linkages are likely to be more transferable than those based on indirect relationships or pure correlation
- In devising a transferability assessment, the researcher must make several key decisions requiring a degree of professional judgment
    - Deciding how many groups into which to divide the data set which is essentially a decision on how conservative a test to run. The authors found that for the example they present, the fewer the groups, the more conservative the assessment. They expect this to be a general rule and to be true regardless of the size of the data set.
    - Deciding how to assign data to the groups
        - All of the fitting data sets should cover a large portion of the range of variability of the predictor variables of interest.
        - The heterogeneity among the groups (in terms of predictor-response relationships) should be in the range of the expected heterogeneity between the full data set and other locations or the data sets for which inferences are of interest.
- With small data sets, where it is possible for a particular grouping to significantly affect the outcome, it may be useful to repeat the transferability assessment multiple times with different group assignments in a form of ensemble prediction.
- If projections and inferences do not extend beyond the conditions represented by the data used to fit the model, transferability is less relevant.
- Dividing the data into subsets provides some inferences into how a model will perform with a new data set (e.g., a different region or time period), but the actual performance could be substantially better or worse.

Does the interpolation accuracy of species distribution models come at the expense of transferability?

Risto K. Heikkinen, Mathieu Marmion, Miska Luoto
Ecography, Volume 35, 2012

This study investigated 10 modeling techniques on both (1) species distribution of birds, butterflies, and plants and (2) climate and land cover in Finland to investigate whether good interpolative prediction accuracy for models comes at the expense of transferability. Results show that extrapolation to new areas is a greater challenge for all included modeling techniques than simple filling of gaps in a well-sampled area, but there are also differences among the techniques in the degree of transferability. Among the machine-learning modeling techniques, MAXENT, generalized boosting methods (GBM), and artificial neural networks (ANN) showed good transferability while the performance of GARP and random forest (RF) decreased notably in extrapolation. Among the regression-based methods, generalized additive models (GAM) and generalized linear models (GLM) showed good transferability. A desirable combination of good prediction accuracy and good transferability was evident for three modeling techniques: MAXENT, GBM, and GAM. However, examination of model sensitivity and specificity revealed that model types may differ in their tendencies to either increased over-prediction of presences or absences in extrapolation, and some of the methods show contrasting changes in sensitivity versus specificity (e.g., ANN and GARP).

The authors note that the challenge of model transferability is related to the general problem of developing species distribution models that include all important environmental variables yet still are not too complex or overfitted. Model complexity may arise from two sources. First, techniques that effectively fit non-linear trends may be susceptible to producing unrealistically complex response functions between species and environmental factors that do not necessarily generalize to other others. Second, model complexity may arise as a result of inclusion of too many predictor variables. Some methods automatically include all predictor variables in the models and may therefore be inherently prone to overfitting. In theoretical terms, the most overfitting-prone techniques might be those that both allow for complex non-linear responses and automatically include all predictor variables in the models, such as some recent machine-learning techniques.

Policy-Oriented Integrated Analysis of Land-Use Change: An Analysis of Data Needs

Helen Briassoulis

Environmental Management, Volume 27, No. 1, 2001

This paper offers an analysis of the main data issues for the integrated land-use change in the perspective of their utilization in supporting policy design for sustainable land use. The main dimensions of the data are: (1) system of spatial reference, (2) system of temporal reference, (3) definitions, and (4) data collection procedures. The initial evaluation concluded that policy-oriented integrated analysis of land-use change requires that for the most important variables, at least, data are spatially and temporally compatible, consistent, reliable, easily and inexpensively available and georeferenced; that systematic, compatible, consistent, and reliable definitions are used; and that compatible, consistent, reliable, easy, and inexpensive data collection procedures are followed. The following is a summary of each data dimension.

- Spatial dimension: Systems of spatial reference are rarely compatible in terms of level of spatial resolution, coverage, and spatial definition. Different jurisdictions often employ different systems of spatial reference. Additionally, changes in spatial references over time force the analyst to make assumptions to disaggregate available data, which results in the variable itself as well as its relation to other variables being treated inconsistently.
- Temporal dimension: Systems of temporal reference have similar issues as the spatial dimension, where there may be differences in the unit of temporal aggregation, spacing and number of observations, etc. Systems of temporal reference change over time, and if the transition from one system to another is not planned and indicated, data from different systems should be treated differently.
- Definitions: Definitions pertain to the particular ways concepts are expressed and measured. Definitions may vary between jurisdictions and can change over time, which creates problems in the compatibility of data as they may refer to the same variable but are measured differently. The problems are increased when explicit definitions are not given, when changes in definitions are not indicated, or when data from different sources are combined.
- Data collection: Data collection procedures and rules (even for the same variable) differ between agencies as well as between countries unless they are standardized internationally. Data collection procedures change over time with changes in technology, organizations, etc., and they affect the quality of available data.

The author proposed framework guidelines to address the above challenges and data needs.

- Spatial dimension: A system of spatial reference should be established that is GIS-based and should incorporate clear and transparent aggregation algorithms for consistency in applications and spatial transferability of data. Moreover, GIS may provide finer levels of spatial aggregation and a reasonable degree of easy and inexpensive data retrieval. If standardized systems of spatial reference are used internationally, reliable comparisons among different geographical areas can be performed. Once in place, the common spatial system should be used by all disciplines for data collection and reporting.

- Temporal dimension: Systems of temporal reference used by different disciplines should be harmonized so that different types of variables can be analyzed simultaneously. Common denominators for the temporal scales employed in different disciplines should be found as all as rules for valid aggregations of temporal data. Moreover, rules for the dates of data collection should be adopted so that the use of data collected at various dates does not seriously distort the temporal order of the real events. The standardization of the temporal systems should be common to all countries to facilitate comparison and policy-making for and over different geographical areas at different time periods. Temporal standardization should be done, ideally, in conjunction with spatial standardization to secure spatiotemporal compatibility and consistency.
- Definitions: Standardization of conceptual and operation definitions is an absolute necessity. For past data, "translation" rules have to be devised to assist in their consistent use in analyses.
- Data collection: Standardization of several aspects of data collection should be done in conjunction with the suggested standardization of classification systems. At a minimum, the following must be harmonized for the variables concerned: system of spatial and temporal reference for data collection; operational definitions at each level of detail; dates, method (census, survey), and format of data collection; techniques for data cleaning, coding, recording, and updating; technological infrastructure (computers, GIS); and training personnel. Qualitative data collection, especially for past time periods, requires special attention on issues such as: (1) georeferencing the existing historic information, (2) spatial and temporal aspects of historic data, (3) operational definitions of the data collected, and (4) harmonization of historic and qualitative information with quantitative information for the same variable(s). Effective data collection following the proposed guidelines requires a coordinating data management body with a lattice organizational structure; i.e., it will operate horizontally to cover the diverse types of data needed and vertically from the international to the local level.

Investigating potential transferability of place-based research in land system science

Tomáš Václavík, Fanny Langerwisch, Marc Cotter, Johanna Fick, Inga Häuser, Stefan Hotes, Johannes Kamp, Josef Settele, Joachim H Spangenberg, and Ralf Seppelt
Environmental Research Letters, Volume 11, 2016

This study utilizes a previously developed concept of land system archetypes (LSAs) to investigate potential transferability of research from 12 regional projects implemented in a large joint research framework that focus on issues of sustainable land management across four continents. For each project, the authors characterize its project archetype, i.e. the unique land system based on a synthesis of more than 30 datasets of land-use intensity, environmental conditions, and socioeconomic indicators. They estimate the transferability potential of project research by calculating the statistical similarity of locations across the world to the project archetype, assuming higher transferability potentials in locations with similar land system characteristics. Results show that areas with high transferability potentials are typically clustered around project sites but for some case studies can be found in regions that are geographically distant, especially when values of considered variables are close to the global mean or where the project archetype is driven by large-scale environmental or socioeconomic conditions. Using specific examples from the local case studies, the authors highlight the merit of their approach and discuss the differences between local realities and information captured in global datasets. The proposed method provides a blueprint for large research programs to assess potential transferability of place-based studies to other geographical areas and to indicate possible gaps in research efforts.
Study assumptions, details, and conclusions include:

- The authors assume that similarity of land systems constitutes the potential for transferability (i.e. the more similar two sites are in terms of land use, environmental, and socioeconomic conditions), the higher the probability that methods, results, and conclusions from a project site prove applicable at a similar site.
- The authors estimated the transferability potentials for 12 regional projects by calculating the statistical similarity of all 5 arc-min pixels across the world to the unique land system present in each project study areas. They assumed that if the project study area overlaps with a specific LSA, then its research is potentially relevant for other geographical regions that belong to the same archetype.
- First, they analyzed the conditions in each project as reflected by the considered variables and determined the 'project archetype" (i.e. the unique land system in the study area).
- Second, they calculated statistical similarity of the project archetype (represented by each grid cell within the project) to each global grid cell in the multi-dimensional space defined by considered variables, assuming higher transferability potentials in locations with similar land systems. An 'absolute distance' was used as a measure of similarity.kep
- Third, using the inverse of the absolute distance, they mapped the gradient of transferability potentials for each project in the geographical space.

- The authors used ordinary least square regression analysis to examine the relationship between the total variability of conditions in the study area (calculated as the sum of standard deviations for all variables) and the extent of the ‘high’ transferability level.
- To illustrate the potential effects that differences in global versus local data may have on the final analysis, they replaced the values of 6 original variables (from datasets with a global extent) with those for the same variables from local distances.
- The mapped levels of transferability potential varied regionally, often exhibiting spatial clustering of highly similar conditions around project sites. This patterns suggests that considered land-use intensity, environmental, and socioeconomic conditions are spatially dependent (i.e. autocorrelated) and that calculated statistical distance partially corresponds to geographical distance.
- In contrast, highly similar conditions were found for a number of projects in locations that are geographically distant from the study sites. This was typical for projects where variable values were close to the global mean or where the project archetype was driven by large-scale environmental or socioeconomic conditions.
- The refined analysis of transferability potentials revealed dependency of the results on the resolution and accuracy of the considered input data. Despite the considerable improvements in global-scale geospatial datasets, the main sources of uncertainty remain in the quality of input data and the availability of socio-cultural information in a globally standardized format.
- This new approach illustrates that rather than offering a way to test local-scale transferability of specific findings *per se*, the authors’ approach provides a starting point to identify broad-scale regions with potential transferability of place-based research by calculating envelopes that define the general boundaries of projects’ relevance outside of their study areas.

Appendix C

Annex IV Workshop Documents

C.1 Annex IV Workshop Plan

International Environmental Data Sharing Initiative (Annex IV and Tethys Database)
Data Transferability and Collection Consistency

2018 International Conference on Ocean Energy
Workshop Execution Plan

Workshop Title: *Extending Learning from Early Marine Renewable Energy Projects*

Summary and Workshop Objectives

This document in an **internal** execution plan for the Annex IV workshop on Data Transferability and Collection Consistency, scheduled for June 12, 2018 in conjunction with the International Conference on Ocean Energy (ICOE), in Cherbourg, France. This workshop plan is a DOE progress measure within PNNL's International Environmental Data Sharing Initiative; the workshop itself follows from Annex IV literature review activities and regulatory outreach earlier in FY 2018 to define challenges, develop a set of best management practices/criteria, and an analytical "framework" (Framework White Paper) to consider pathways to resolve data transferability and collection consistency challenges. The workshop will focus on refining the Framework and associated draft Best Management Practices (BMPs)/criteria; the intended outcome is consensus among participants on challenges and pathways to transfer learning, analyses, and data sets from one project-region-country to another.

The objectives of the workshop are to:

- Discuss data transferability and collection consistency and how it can alleviate challenges to the MRE industry and regulators;
- Present feedback from regulators on the ability to use transferred data/information/learning for permitting and to present our data transferability framework;
- Refine best management practices for data transferability and collection consistency; and
- Brainstorm implementation strategies for best management practices.

This plan provides logistical details, describes the workshop purpose and structure, identifies the intended audience, and notes potential challenges associated with the plan. Appendix A contains the draft agenda, Appendix B an invitation list and invitation email text, Appendix C a draft background document to be sent to workshop participants, and Appendix D a high level set of draft best management practices.

Workshop Logistics

Date and Time: Tuesday June 12, 9:00am to 12:30pm CEST

Location: Cherbourg, France. La Cité de la Mer (*City of the Sea)*, the same venue as ICOE 2018. Rooms TBD.

Room Configuration: The workshop venue has provided two rooms that hold a total capacity of 40 people. The larger room will be used for plenary workshop activities; both rooms will be used during breakouts.

Personnel: Andrea Copping, Mikaela Freeman (PNNL), Ian Hutchison (Aquatera), and Carrie Schmaus (DOE WPTO) will staff the workshop. Andrea Copping and Ian Hutchison will facilitate the main sessions and breakout groups. Mikaela Freeman and Carrie Schmaus will take notes and provide logistical support.

Materials: The appendices contain draft workshop materials to be sent to participants ahead of time (agenda, backgrounder, draft BMPs). These documents are still in draft form; the BMP document in particular is under development and when final will incorporate parts of the framework. At the workshop itself, the PNNL team will present power point presentations to provide the following:

- Context and challenges associated with data transferability and collection consistency;
- Introduce the Framework White Paper, and BMPs.
- Describe the structure of the breakout groups.

Flipcharts, marker pens, notecards, and nametags will also be brought to the workshop venue by PNNL. Additionally, PNNL will bring Annex IV outreach materials to encourage use of *Tethys* and participation in future online activities and webinars associated with the data transfer and collection consistency theme.

Audience/Invites

ICOE attracts an international audience of industry, government, and science professionals engaged in ocean energy development, research, and regulation. Our goal is to target representatives from each of these groups; the reality is that industry and researchers will likely be overrepresented, given the composition of the ICOE conference. PNNL staff sent out an initial email to approximately 100 potential participants (see Appendix B). Should there be remaining space after the preferred attendees are invited, a broader email invitation will be sent two weeks after the initial email. The invitation email was sent along with a two page background document (Appendix C). Ahead of the workshop, registrants will be sent a draft set of BMPs (Appendix D).

Workshop Structure

See Appendix A for the draft agenda. This is intended to be an intimate workshop with a maximum of 40 participants drawn from ICOE registered attendees. The workshop is structured to provide opportunities for all personality types to engage (those that like to participate in large groups, breakout discussions, and individual thinking). Discussion will center on the draft BMPs and the data transferability framework; but we also set aside time for participants to contribute thoughts outside of the structured content through an initial brainstorming exercise.

Brainstorm: The workshop starts with an initial introductory and contextual session followed by a warm-up “brainstorming” exercise. The brainstorming exercise is intended to engage participants before they’ve ingested too much information from the PNNL team—we’re looking for their unconditioned thoughts on “what is needed to transfer data and learning among multiple sites”? The exercise is designed to encourage creative thinking and access ideas from participants who may be less willing to speak in a larger group format.

Participants will be asked to form groups of ~10; each group will be provided notecards. The PNNL team will ask participants to take 5-10 minutes to consider the question quietly and record their thoughts. Following that, we'll request each group to spend 15 minutes working together to distill a set of "needs" representative of the group. Each group will then quickly report back to the group as a whole. Each group leader will capture these thoughts in the notes.

Introduce Framework and BMPs: Andrea Copping will present a summary of PNNL's draft data transferability framework and describe the draft BMP's prepared ahead of the workshop. The goal of this presentation is to set up a productive breakout session to follow. The presentation itself will be brief to give the group a chance to ask questions and discuss both the framework and the BMPs. <u>Because we only have 30 minutes for this, every effort will be made to stress the need for participants to examine the BMPs ahead of time and come ready with their thoughts.</u>

BMP Breakouts: Following a 15 minute break, the group will be divided in two (one group in each room) with a facilitator (Copping and Hutchison) and note taker (Freeman and Schmaus) assigned to each. Groups will be divided and assigned so that there is as equal representation of industry, researchers, regulators, and consultants in each group as possible. Both groups will be asked to consider the following to help us refine BMPs (see Appendix D):

1. Minimum requirements
2. Data collection consistency table
3. Useful models
4. Ancillary data/studies

The objective of the breakout session is to refine proposed BMPs, engage collective thinking to consider if there are other BMPs or subcategories we've missed, and describe potential pathways towards implementation.

Following 60 minutes of discussion, groups will report out. Andrea Copping will then facilitate a full group brainstorming discussion focusing on implementation—how do we move forward to apply BMPs and better facilitate data transfer and collection consistency?

<u>**Potential Challenges**</u>

Our primary challenge will be lack of time. Initially we'd planned for a full day workshop to provide space for participants to fully engage with background material and contribute their own creativity to our process. The ICOE conference organizers were unable to meet our request for space for a full day, and travel challenges associated with the venue make Tuesday prior to the start of the conference the best option. To address this challenge, we've compressed our agenda and will emphasize the need for participants to prepare ahead of time. We also need to be clear about our expectation for success: we're not asking participants to tell us what needs to be done, we're looking to understand their degree of acceptance/discomfort with our framework and draft BMPs and to provide useful amendments and additions. That being said, we have built in focused exercises for "blue sky thinking" in order to access ideas we hadn't previously considered.

Background on Workshop Purpose (From FY 2018 AOP)

Problem Statement and Opportunity for Data Transferability and Collection Consistency: "The ability to readily transfer research and monitoring results, data, study design, and best practices from project to project will lead to cost reductions for baseline environmental studies and post-installation monitoring, as the MHK industry matures. Currently, regulators and stakeholders lack access to synthesized and contextualized data emerging from early stage projects and there are no mechanisms to apply data and information across geographically distinct projects. This leads to each individual project bearing the full burden of information requirements on a site by site basis. Similarly, data are collected around early stage devices using many different methods, instruments, and measurement scales. If data were collected in a consistent way around all early stage devices, regardless of exact methods, the comparability of the results would decrease uncertainty and facilitate common understanding to accelerate the permitting process."

AOP Workshop Description (for reference): "PNNL will collaborate with subcontractor Aquatera, Annex IV Analysts, and the DOE WPTO to plan a day long workshop at the International Conference on Ocean Energy (ICOE), in Normandy, France in June 2018. PNNL will work closely with Aquaterra, Annex IV analysts, and the DOE WPTO in quarters 2 and 3 to identify and invite participants from the MHK research community, industry experts, and regulatory experts attending ICOE. The purpose of the workshop will be to determine the applicability of the draft criteria and best practices that were developed following literature review and regulatory analysis activities. The draft criteria and best practices document will be provided to participants approximately 30 days before the workshop, and feedback will be solicited to help contextualize the workshop process. Workshop participants will further refine the criteria and best practices and provide input to improve consistency, standardization, and mechanisms for cross project transferability. Following the workshop, PNNL will plan and carry out an online "expert forum" to finalize the criteria and best practices from the workshop, allowing further input from those who could not attend the workshop."

APPENDIX A

ICOE Draft Agenda

Tuesday, June 12th 9:00 am – 12:30 pm

Cherbourg, Normandy, France

9:00 – 9:20 am Introductions

9:20 – 9:30 am Present Challenges and Data Transferability + Collection Consistency (broad context)

9:30 – 10:00 am Brainstorm (10 people per group)

10:00 – 10:30 am Introduce Framework + BMPs + Discussion on Framework + Direction for Breakouts

10:30 – 10:45 am Break

10:45 – 11:45 am Breakouts

Address:

1. Minimum requirements
2. Data collection consistency table
3. Useful models
4. Ancillary data/studies

11:45 am – 12:00 pm Report Out

12:00 – 12:20 pm Implementation Brainstorm

12:20 – 12:30 pm Next steps

APPENDIX B

INVITATION EMAIL

Colleagues:

Annex IV – the environmental effects of MRE task under the Ocean Energy Systems collaborative - is organizing a workshop on **Extending Learning from Early MRE Projects** on Tuesday June 12th from 900 to 1230. in Cherbourg, France. This event will be held at La Cité de la Mer (*City of the Sea*), the same venue as the ICOE 2018. More information on the objectives of the workshop is attached.

As someone with expertise and interest in the field of marine renewable energy, with an emphasis on understanding the potential environmental effects associated with consenting (permitting) the development of wave and tidal farms, I invite you to register for the workshop. Space is limited, so please take this opportunity to send an email to mikaela.freeman@pnnl.gov to reserve your spot by May 10th. You will be sent more information closer to the time of the workshop, including material to enable your active participation.

I hope to see you in Cherbourg!

Cheers

Andrea Copping

For more information on Annex IV, please visit https://tethys.pnnl.gov/about-annex-iv

APPENDIX C

Data Transferability and Collection Consistency Workshop

June 12th, 2018
9:00am to 12:30pm CEST
La Cité de la Mer, Cherbourg, Normandy - France

The workshop will bring together marine renewable energy (MRE) researchers, developers, and other stakeholders to discuss ways to "transfer" data, information, and learning on environmental effects of early MRE projects. The purpose of the data transfer is to reduce the high costs of environmental monitoring and accelerate consenting for future projects. The workshop will focus on refining best management practices for data transfer and collection consistency, building on information collected from MRE regulators.

Background on Data Transferability and Collection Consistency

As the MRE industry progresses in waters worldwide, there continues to be an increasing demand for data and information about how MRE technologies (wave and tidal) may affect the marine environment. While understanding of potential environmental effects of MRE development is increasing, continued uncertainty leads to high costs of baseline assessments and post-installation monitoring, as well as protracted timelines for obtaining licenses and permits. In addition, data collected around early-stage MRE devices use many different methods, instruments, and measurement scales that make comparability of results challenging or impossible.

Both data transferability and collection consistency can help reduce these risks to the industry. Transferring learning, analyses, and datasets from one country to another, among projects, and across jurisdictional boundaries can aid regulators in consenting processes and provide increased peace of mind to stakeholders. Additionally, if similar parameters and accessible methods were used to collect baseline and post-installation monitoring data, the results would be more readily comparable leading to a decrease in scientific uncertainty, support for a common understanding of the risk of MRE devices to the marine environment, and an easier ability to transfer data between projects.

What do we mean by "data transferability"? Using data from an early stage MRE project or analogous industry to be "transferred" to inform potential environmental effects and consenting for a new MRE project. Data can include raw or quality controlled data, but more likely it will be analyzed or synthesized data and information (in the form of reports, research studies, etc.).

The Annex IV team has engaged with the regulatory community in the US and through these interactions it has become clear that data transferability and collection consistency is of interest to regulators and could be used to help consent new MRE developments. After gaining feedback from regulators, we now want to hear from MRE researchers and developers regarding data transferability and collection consistency and work together to develop best management practices that can aid the MRE industry as it continues to advance.

The objectives of the workshop are to:

- Discuss data transferability and collection consistency and how it can alleviate challenges to MRE industry and regulators;
- Present feedback from regulators on the ability to use transferred data/information/learning for consenting and present our data transferability framework;
- Refine best management practices for data transferability and collection consistency; and
- Brainstorm implementation strategies for best management practices.

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APPENDIX D
DRAFT BMPs

Preliminary Draft – High Level

Best Management Practices for MRE Environmental Monitoring Data

Focus on Data Transferability and Collection Consistency

For the purposes of these BMPs, we define data transferability as data and/or information[1] collected through research studies and/or monitoring from other projects that can be used to inform new projects. We define collection consistency as the collection of monitoring data that informs environmental effects in a prescribed manner that allows comparison among datasets.

It is assumed that all datasets and information that is transferred from one project or jurisdiction to another must meet all national/regional/local laws and regulations.

Best Management Practices:

1. Meet the minimum requirements (framework hierarchy + MREPAs) to be considered for data transfer from one location or project to another.

2. Determine likely datasets using the *Data Collection Consistency Table*.

3. Use models in conjunction with and/or in place of datasets. Note the type of model, whether the model has been validated with field data, and the major stated assumptions and limitations of the model.

4. Provide context and perspective for data. This includes all ancillary data and studies that are applicable including: behavioral studies, hydrodynamics and wave climate of collection locations, etc.

[1] *Could be* raw or quality controlled data but *more likely* analyzed data, synthesized data to reach some conclusion, reports, etc.

Data Collection Consistency Table

Stressor/Interaction	Process or Measurement	Reporting Unit	Analysis or Interpretation
Collision Risk	Sensors include: acoustic only, acoustic + video, other	Number of visible targets in field of view, number of collisions	
Underwater Noise		Amplitude dB re 1µPa at 1 m Frequency: broadband or specific frequencies	
EMF	Source: cable; other; shielded or unshielded	AC or DC; voltage; amplitude	
Habitat Change	Underwater mapping with sonar; video; other. Habitat characterization from mapping; existing maps.	Area of habitat altered, specific for each habitat type.	
Changes in Physical Systems	Modeling, with or without validation	No units. Indication of datasets used for validation, if any.	

Minimum Requirements for Data Transferability

In order to consider transferring data from one project to a future project using the *Data Framework for Transferability*, the metadata for the two projects must:

1. Share the same archetype (same stressor, same site conditions, same technology, same receptor). It is preferable that they share several of the next steps in the framework as well (same species, similar technology, same wave/tidal conditions, close geographic proximity).

2. The data must have been collected in a consistent manner (from Data Collection Consistency Table).

C.2 Annex IV Workshop Background Information

OCEAN ENERGY SYSTEMS

ANNEX IV

Data Transferability and Collection Consistency Workshop

June 12th, 2018
9:00am to 12:30pm CEST
La Cité de la Mer, Cherbourg, Normandy - France

The workshop will bring together marine renewable energy (MRE) researchers, developers, and other stakeholders to discuss ways to "transfer" data, information, and learning on environmental effects of early MRE projects. The purpose of the data transfer is to reduce the high costs of environmental monitoring and accelerate consenting for future projects. The workshop will focus on refining best management practices for data transfer and collection consistency, building on information collected from MRE regulators.

Background on Data Transferability and Collection Consistency

As the MRE industry progresses in waters worldwide, there continues to be an increasing demand for data and information about how MRE technologies (wave and tidal) may affect the marine environment. While understanding of potential environmental effects of MRE development is increasing, continued uncertainty leads to high costs of baseline assessments and post-installation monitoring, as well as protracted timelines for obtaining licenses and permits. In addition, data collected around early-stage MRE devices use many different methods, instruments, and measurement scales that make comparability of results challenging or impossible.

Both data transferability and collection consistency can help reduce these risks to the industry. Transferring learning, analyses, and datasets from one country to another, among projects, and across jurisdictional boundaries can aid regulators in consenting processes and provide increased peace of mind to stakeholders. Additionally, if similar parameters and accessible methods were used to collect baseline and post-installation monitoring data, the results would be more readily comparable leading to a decrease in scientific uncertainty, support for a common understanding of the risk of MRE devices to the marine environment, and an easier ability to transfer data between projects.

What do we mean by "data transferability"? Using data from an early stage MRE project or analogous industry to be "transferred" to inform potential environmental effects and consenting for a new MRE project. Data can include raw or quality controlled data, but more likely it will be analyzed or synthesized data and information (in the form of reports, research studies, etc.).

The Annex IV team has engaged with the regulatory community in the US and through these interactions it has become clear that data transferability and collection consistency is of interest to regulators and could be used to help consent new MRE developments. After gaining feedback from regulators, we now want to hear from MRE researchers and developers regarding data transferability and collection consistency and work together to develop best management practices that can aid the MRE industry as it continues to advance.

The objectives of the workshop are to:

- Discuss data transferability and collection consistency and how it can alleviate challenges to MRE industry and regulators;
- Present feedback from regulators on the ability to use transferred data/information/learning for consenting and present our data transferability framework;
- Refine best management practices for data transferability and collection consistency; and
- Brainstorm implementation strategies for best management practices.

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C.3 Annex IV Workshop Notes

Data Transferability and Collection Consistency Workshop Notes

Co-located with International Conference on Ocean Energy
Cherbourg, France
June 12th 2018

Attendees:

Andrea Copping, Mikaela Freeman (PNNL), US
Ian Hutchinson, Jennifer Fox (Aquatera), UK
Carrie Schmaus (US DOE), US

Bruce Cameron (Envigor Policy Consulting Inc.), Canada
Carys Burgess (Atlantis), Canada
Célia Le Lièvre (University College Cork), Ireland
Anne Marie O'Hagan (University College Cork), Ireland
Craig Chandler (Mersey Consulting Ltd.), Canada
Liz Foubister (Xodus), UK
Blandine Battaglia (Sabella), France
Teresa Simas (WavEC), Portugal
Pedro Vinagre (WavEC), Portugal
Erica Cruz (WavEC), Portugal
Takero Yoshida (University of Tokyo)
Caitlin Long (EMEC), UK
Nolwenn Quillien (France Énergies Marines), France
Maelle Nexer (France Énergies Marines), France
Tony Rice (FORCE), Canada
Russell Dmytriw (OERA), Canada

Agenda:

900 – 920	Introductions
920 – 930	Present challenges and introduce data transferability and collection consistency
930 – 1000	Brainstorm data transferability needs
1000 – 1030	Data Transferability Framework and Best Management Practices
1030 – 1045	Break
1045 – 1145	Breakout sessions: 1. Minimum requirements for data transferability 2. Data collection consistency table 3. Best Management Practices
1145 – 1200	Report out from breakout sessions
1200 - 1220	Implementation brainstorm
1220 - 1230	Next steps and closing remarks

Challenges and Introduction to Data Transferability and Collection Consistency:

During this session, the challenges to both the MRE industry and regulators who consent/permit MRE devices were presented. The concept of data transferability, combined with data collection consistency, as a means to combat these challenges and help progress the industry and aid regulators was introduced. The Annex IV team also talked about the work done engaging regulators through webinars, a survey, and focus groups to better understand their challenges consenting environmental effects of MRE devices and their willingness to transfer data for consenting developments in their jurisdiction. Following the presentations, the group discussed these challenges and the ability to use data transferability and collection consistency.

Main Points:

1. We have to guide regulators as they are not trained in this area and they cannot be expected to have knowledge, but they are open to learning and it would be helpful if we make previous datasets available/accessible, make it easy for them to transfer data.
2. We need to make sure that the data transferability process is well developed and thought out so that we don't give regulators an easy way out of participating in the process where they can say data can't be transferred or the process won't work.
3. We must have both regulator and industry buy-in for this to work; we want to make data transferability practical for developers and attractive to regulators. We want to get to the point where regulators articulate what data/information they want to see and developers are comfortable sharing this information.

Brainstorm:

The brainstorm session divided the workshop participants into three small groups to discuss needs for data transferability and thoughts on best management practices for data transferability and collection consistency. During this session, participants discussed these topics prior to presentations on the Data Transferability Framework and Best Management Practices by the Annex IV team.

Main Points:

Data Collection Consistency:

1. May be easier to standardize and transfer methodologies (in some instances).
2. We need to define parameters under which data should be collected, identify units that can transfer, define specific criteria for collection and for a given impact, have a scientific basis behind requirements for data collection.
3. Would be very useful to have existing datasets available, especially stranded/lost data, and some sort of standardization in place.
4. Information presented to regulators is interpreted data, which may not be consistent and can create problems for comparability.

Data:

5. Probably don't need all the data, so need to think of why, when, and where we need data and create incentives/give visibility to companies for sharing.
6. Develop a list of what could be available for transfer and explain where it may save time and money.
7. Using an umbrella term of data may cause confusion, especially since we mean reports, conclusions, experiences, etc.

Regulators and Developers:

8. Need to take into account that the priorities for regulators and developers may be different, and there may be a difference between project and technology developers.
9. There has been resistance to transferability from regulators and stakeholders including rejection of work done in other regions and the underlying sense that you have to prove it in the location first
10. Understanding under what conditions/circumstances regulators would accept information from other jurisdictions is important to ask/assess during scoping.

Data Transferability Framework and Best Management Practices:

The Annex IV team presented the Data Transferability Framework and Best Management Practices (BMPs) for Data Transferability and Collection Consistency.

Main Points:

1. Undersea cables have been around for a long time and they aren't different for MRE, but potential effects of EMF mostly concern animal behavior; it is hard to do behavioral studies
    a. BOEM has funded a lot of research and think this risk is close to being retired (other US agencies and other jurisdictions may not agree).
    b. But we are less sure of the effect of cables in the water column and how to measure impacts – maybe they can be studied separately (for example draped cables that can't be shielded)
2. Maybe the process and measurement tool should be split between pre- and post-installation; perhaps add some guidance on what type of data collection should be required
3. Need to think about different strategic levels and projects levels when providing guidance for the permitting/consenting process.

Breakout Groups:

Two breakout groups were formed to delve into minimum requirements for data transferability, the data collection consistency tables, and the BMPs. The breakout groups reported out on their discussions afterwards.

Main Points:

Blue Group

1. Requirements for data collection depends on the project, some requirements will be based on the stressors and some will be based on the site conditions, but don't want to be too prescriptive on how to use this tool.
    a. Interest in how comparable each site and its conditions are, especially for larger projects.
2. Probably have some quick wins regarding the environmental impacts and can retire some risks.
3. Everyone agreed that the BMPs should be implemented, but need to be:
    a. Realistic as to how applicable these are on a global, regional, and local scale,
    b. Need to communicate and disseminate data through knowledge transfer,
    c. Industry-driven, but endorsed by regulators, and
    d. Looked at from a systems level and designed for the entire project cycle
4. Need to revisit the guidance, maybe on an annual basis, to ensure the process is still applicable and have existing groups that could do this (even outside Annex IV and ORJIP).

Red Group

1. The online tool should be searchable under different filters and include a key word checklist.
2. Important to have data collected with the same units/metrics to help ensure similar outcomes; an outcome based approach is probably best.
    a. There is a difference between metrics that can be standardized (acoustics) and those that can't, which may vary by stages and stressors
3. Might want to consider dividing the data collection consistency table by project stage and maybe consider more detail between stressors.
4. Take the process in bite-sized chunks to find the gaps, as it will take too long to solve the entire problem.
5. Include regulators from the beginning and provide direct outreach to
    a. Will take too long to solve entire problem
    b. Need to include regulators from the beginning
6. Should consider how to reach different audiences:
    a. Regulators: include from the beginning and provide direct outreach
    b. Researchers: papers and conferences
    c. Consultants: use *Tethys*, so make it easy/accessible; answer to requests of regulators so regulators need to request the use of the same datasets
    d. Developers: often have consultants do EIAs, environmental advisors within each company that can probably come together, need to have regulators tell them what they want
7. Next steps include looking at case studies to help with BMPs and framework, and can also guide implementation, outreach.
    a. Consider the language barrier that may arise when thinking about using the process in other countries.

Implementation Brainstorm:

The workshop participants discussed steps for implementing the Data Transferability Framework and BMPs:

Main Points:

1. Regulator to regulator discussion is essential, but need to manage expectations and flag potential issues ahead of time (group disproportionally represented geographically, etc.)
2. Case studies for consented projects will help to validate, provide feedback, identify gaps, and help the process develop
3. Can learn from stories of data transfer:
    a. Successful projects that show data transfer can provide lessons learned and show what would have happened without data transfer (including analogs from other industries)
    b. Understanding that some data that are collected aren't helpful or pinpointing where something went wrong
4. It is easy to focus initially on the device technology, but we should think about what is common across all projects and what will aid data transfer.

Appendix

Additional Workshop Discussion Summaries

Challenges/Intro Discussion Summary:

- We need to get the regulators to buy-in and cannot give them an out where they can say data aren't transferable or it won't work
- Annex IV survey of regulators ranking environmental consenting challenges most important to them.
    - They were open to learning, worried about the consequences, and not trained in this area.
    - Helpful if we made it easy for them to take learning from existing projects and apply it to future projects
    - Need to work on making previous data available and accessible for regulators
    - Played sound clips for regulators and they were interested in soundscape and that it stayed below threshold levels for the devices measured
- Have to guide regulators, can't be expected to have the knowledge
- Need regulators and industry to buy-in so the process is:
    - practical for developers and attractive to regulators
    - regulators say what data/information want to see, developers comfortable sharing
- IP could be a problem with developer and being comfortable sharing information
    - Not time for competition, but to build an industry, especially with sharing of environmental info
- Data need a common collection standard so they are comparable
    - Don't know if we will get to standards for environmental data, so talking about BMPs and narrowing the boundaries and closing the gap between how data are collected and how they are consumed/understood
    - Collection of acoustic data is a good example of the need to be working together to decide how data collection can be standardized, as these data are colleted in many different non comparable ways
- There are some issues that we don't know how to monitor/measure yet and are leaning how best to do so
- Think/hope we can retire some environmental risk – EMF and underwater noise.

Brainstorm Discussion Summary:

- Can be easier to standardize/transfer methodologies and metadata, which will make writing standards for data and data transferability easier.
    - Transferring data is harder because it can include local features and specifics, which is more difficult to standardize
- Could have issues with confidentiality or IP issues for companies
    - May not want to share data after they have paid for it, reveal their methods, or share negative data
    - Can result in "lost" data
    - Should find strategic opportunities for data sharing and gathering
- Need to give visibility or have incentive to companies for collecting and sharing of data

- Some issues with data transferability include units, duration, frequency of data collection, amount of data, how to display data (plots, charts, GIS, etc.), and other criteria (where to store data)
- Need to direct data collection using specific criteria (still to be defined) so data can be compared
    - We know enough to define what the parameters should be, so collection can be standardized
    - If you can define parameters under which data should be collected and units that can be transferred, the data would be more comparable
    - Could have a common index for information that includes units, types of analysis, species, etc.
    - Data collection consistency requirements need to have a scientific basis
- There are stranded data that needs to be collected
- Using the umbrella term "data" may cause confusion
    - When we say data transferability we are actually talking about reports, conclusions, experiences, etc.
- Develop a list of things that could be available for transfer
    - Explain where it may save time and money
    - Makes sure everything has a purpose and is proportionate
    - Risk reduction is the point of data transfer
    - Probably don't need all the data – need to think of why, when, and where we need data
- Usually information presented to regulators is interpreted data, which may not be consistent between datasets or doesn't use same criteria and creates problems for comparability
- We have to define what can be compared (feeding levels, tropic groups, etc.) for data transferability and may need some preliminary work to understand this
    - For example, underwater noise is probably different with depths and need to define different depths that can be compared
- Always new information being produced and there is already lots of information, but there is a lack of analysis on how to transfer and compare
    - Missing having researchers work in standardized ways to analyze huge sets of information
    - Takes a lot of time to look across results, hard to understand what is missing, and more difficult to compile and analyze existing information - but would be very useful to have
    - Need to look at the body of work and see what fills the criteria for a given impact and measure for the environment – this is the work we are missing
- Resistance to transferability from regulators and stakeholders, rejection of work done in other regions, and underlying sense that you have to prove it in the location first
- Should know under what conditions/circumstances regulators would accept information from other jurisdictions; should be done during scoping
- Need to take into account priorities for regulators and developers, and that they can be different
- Also requirements between regulators may differ
- Project developers are different from technology developers, should consider differentiating expectations
    - Need to look at their means and financial situation – many small scale devices will not be able to deal with burden of environmental monitoring (time and money)
- The onus to develop the data is consistently underestimated by developers as their focus is on the technology itself

- Framework feels simplified and doesn't capture nuances
- Could classify environmental effects by device
- Need to figure out who delivers the message and how we get regulators to learn from each other
    - Could hold a regulator forum online and meet if possible – look to oil and gas regulator forum as a model
- FORCE is a demonstration project for demonstrating technologies, but also for regulators to learn how to regulate devices
    - Demonstration has a goal of focusing on risk with transparent and open sharing protocols
- EMEC have differentiated minimum requirements for one device and regulators have so far stuck by this
- In Scotland and Canada, regulators have reasonable requirements
    - In Scotland, have seen a shift in the expectations from developers themselves. Also developers have to produce reports, but not raw data
    - In Canada, onus of environmental monitoring is on the developers and if don't publish data, you don't go in the water

Breakout Groups Discussion Summary:

Group 1 (Blue Group):

- Need to present and communicate everything consistently in a way that can be understood
    - Presenting data that makes sense based on where you are in different jurisdictions – can map what is needed in different countries/jurisdictions
- US regulators showed a strong preference for specific types of data (i.e., sound files of turbine or WECs)
    - There needs to be trust built before regulators can trust us and say we don't need to see the data, but only want the summary data
    - The State of the Science has lots of data/information that has been used for consenting applications, lots of time and work put in for regulators to trust and done with lots of support from Annex IV
    - Need strategic and project level support as well
- Need regulators to be brought into the loop for this process
- Data must be freely available, but they aren't yet
    - In Europe, project publicly funded for creating data – EMEC is working on collaborating across funding sources as well as projects
- With the framework, we need an informative tool that regulators can put in components and MREPAs to show corresponding datasets so they know what projects are similar to their future project
- What is the most important MREPA hierarchy?
    - Stressors aren't that important to those have talked to, site conditions would be more important, but hard to get similar site conditions and would need to be well populated
    - Site characterization isn't everything
- Part of best practices is asking researchers who else could use the data (or what else you can do with the data) and provide comments for the data
    - Those who fund research play a role that we don't often talk about – try to encourage funding agencies to think about the end use of what their funded projects produce

- Knowing what the data was collected for is very important (for example, having enough contextual information provided in reports) and understanding social, economic, political environment under which it was collected
- Need to be clear that just because someone can't gather data the same, doesn't mean that the other data isn't useful
- May need to think about transferability in terms of factors of risk
    - A lot of Ireland data is collected to satisfy environmental requirements
    - Environmental monitoring data should be collected to inform future sites/projects
- Need minimum requirements on an impact basis, for example, this will be different for collision risk and for acoustics
    - If have minimum requirements, need to be proportionate (one device vs. array)
- Do regulators in different countries focus on specific topics (water quality, marine mammals, etc.)
    - Ireland: depends on where it is
    - Scotland: yes, but more on the technical side
    - Canada: yes, but with a geographical focus; different regulators on East vs. West Coast
    - US: similar to Canada
- Intereg NW Europe has a project that is trying to develop standards with agencies. EMEC involved, UW involved in acoustics. Has another year and a half, but should be some standards at the end of it
- Data collection consistency table should include a column for the use of the data and its impact to describe why the data what collected and what can transfer it for (outcomes column)
- Maybe there needs to be a meeting of the developers to agree on standards for data collection consistency
    - If developers agree and industry recommends best practices/standards, then the regulators will fall in line (industry driven, endorsed by regulators) – someone needs to put in the first effort
    - Can start with developers who work internationally and would have a bigger interest in transferability
- We are trying to decide all these things when still in developing/pre-commercial phase, but in 5-10 years if a developer has good information on their device and impacts that puts them ahead of other groups who don't have the same information
    - Think about a timeline for how these things can evolve, especially as we start to retire risks think about the new impacts that could come up as the industry moves to arrays
- Think we need to start developing BMPs, if we wait too long there is potential for things to get mixed up as we move through the process
    - It would help developers and regulators
    - BMPS need to be updated annually and validated
    - But may depend on the country, for example Irish regulators are not on the same plane as Scottish regulators
- Can put BMPs in place around framework guidance – why you're transferring data, explain technologies used to monitor. Start with stressors, such as noise
    - Scotland: noise would be good to start. Collision risk is one of the most critical and one of the biggest questions from stakeholders/regulators
- Guidance note around what to do for certain risks would be helpful (for example, single turbine collision risk modelling isn't useful)
- Life cycle of a data set and of a project and where different data comes is should be considered

- Discussion with OERA and FERN who do regulator updates and manage and update information over long periods of time would be good
- Push back from regulators that environment is different – look to Scotland/EMEC and FORCE to see how the process works
- Capturing a few stories on how data has been transferred and what impact it has would be useful
  - US regulator story where data wasn't available from the industry that working on permitting so used data from another industry to inform permitting
  - Group pulled together New Providence Act and met with other groups for what other countries did and used that information to develop what was put in Nova Scotia
- Include BMP that data should be collected in a way that could be transferred (outcome oriented)
- As knowledge grows, can become more specific in the BMPs
  - Start with design of data collection, how to execute design, analyze data, and what and how to report – take it though whole life cycle
  - Depending on level of knowledge and experience have general to detailed
- BMPs around methodologies as well as guidance
- Data transfer from other sectors is important
  - Lots of research in aquaculture on acoustic deterrent devices, try to see if we can use these for collision risk
  - Caution here on oil and gas as bias towards those industries because more money and industry that is already contributing to degradation of the environment
  - Could look to offshore wind for learning, especially for appropriate monitoring technologies
  - Can use other sectors to populate missing data
  - Can use other sectors and focus on each sector, create working groups to work on how we collect data – similar to other strategic groups
- *Tethys* bringing in relevant work on data transfer

Group 2 (Red Group):

- Should developers look at archetypes that apply only to their technology
  - If the matrix was searchable by both site characteristics and technology. For example, for acoustics only the signature matters, so archetype would be less of a consideration
  - For the databased the archetype would be defined by parameters, but if you could search by stressor or resource, etc. then why even define archetype?
  - The archetypes are a first cut at classification, from literature and other sciences this seemed like a good first step to define what is relevant – the purpose is to provide help and guidance to regulators
  - Archetypes are important if you are looking how to go about your study
- Perhaps the hierarchy should either not be ordered, or be re-ordered – maybe start with the key site characteristics and then what species are present
  - After this, you may find that the same type of project are deployed at similar sites because the devices are so site-specific
  - Site characterizes may influence what technology is deployed and how the site is monitored
- The online tool, should be searchable where you can define the criteria that the user is looking for – once a regulator knows what they are looking for they can find what information they need

    - Need to include a user manual in regulator’s terms, which would need to be tailored to specific jurisdictions
    - Also would be useful for developers preparing for a new project
    - Important to have consultants who write the EIA for regulators using this as well
    - Outreach to all groups and tailored to the group/their current state of knowledge
- Data collection consistency table should split between pre-, during, and post-installation
    - Create stages for each kind of data and need to ensure data in all stages are collected in the same way
- Need to know the end use of the data to ensure it is collected in a practical way
- Need more detail for the stressor (such as what class of stressor) so the analysis makes sense and so you know if the impact is significant for that particular stressor
- Need to differentiate between number of turbines as the impact data/analysis would be different
    - Also revisit parameters and validate models once large arrays are installed
- Could establish a baseline for different stressors so that the monitoring and data collection doesn’t become unmanageable and balancing between nuances and over-classification is important
- The current MREPA tables are a very good start
    - Need to make sure to keep the tables up to date
- Could start by selecting some reliable case studies and seeing how the framework and BMPs work, identifying gaps, and determining efficacy of program
- BMPs as written make sense, but make sure to look for gaps here
- Next steps: use case studies and continue outreach, including regulator to regulator online forum (could include regulators from more mature industries)
- Need to acknowledge that this is all gear towards English-speaking countries, may need to translate
- Acknowledge different regions and countries will prioritize different aspects of the environment

Appendix D

Data Transferability Framework

Data Transferability Framework

Background

As the marine renewable energy (MRE) industry advances around the world, the increasing demand for data and information about how MRE technologies (wave and tidal devices) may interact with the marine environment continues. Our understanding of the potential environmental effects of MRE development is slowly increasing, informed by monitoring data collected around devices in several nations and a growing body of research studies. However, information derived from monitoring and research is published in scientific journals and technical reports, which may not be readily accessible or available to regulators and other stakeholders.

Regulators in all jurisdictions must satisfy legal and regulatory mandates in order to grant permission to deploy and operate MRE devices. Inherent in these laws and regulations is a concept of balancing risk to the environment and human uses of public resources against economic development and human well-being. Research efforts related to the potential effects of MRE development are focused on this concept of risk; the interactions between devices and the environment most likely to cause harm, or those for which the greatest uncertainty exists, are garnering the most attention (Copping et al. 2016). The components of risk—probability of occurrence and consequence of occurrence—are fundamental to the process by which regulators evaluate project compliance with environmental statutes. The concept of risk also provides an excellent context for discussing research outcomes and assisting regulators in learning more about potential effects.

The MRE industry is struggling with the high costs of baseline assessments and post-installation monitoring, as well as long timelines for obtaining permits or licenses, all of which lead to uncertainty and risk related to project financing. Regulators require assessment and monitoring information to allow them to carry out the necessary analyses to describe, permit/consent, and manage the environmental risks associated with new MRE technologies and new uses of ocean space. One way to reduce risks to the industry and the environment and to allow for acceleration of this new form of low carbon energy could be the ability to transfer learning, analyses, and data sets from one country to another, among projects, and across jurisdictional boundaries.

As the MRE industry matures, the ability to readily transfer research and monitoring results, data, study designs, data collection methods, and best practices from project to project will lead to cost reductions for baseline environmental studies and post-installation monitoring. Regulators and stakeholders currently lack access to synthesized and contextualized data emerging from existing projects, and there are no mechanisms by which to apply data and information across geographically distinct projects. This leads to each individual project bearing the full burden of information requirements on a site-by-site basis. In addition, data are collected around early-stage MRE devices using many different methods, instruments, and measurement scales. If similar parameters and accessible methods of collection were used for baseline and post-installation monitoring around all early-stage devices, the results would be more readily comparable. This comparability would lead to a decrease in scientific uncertainty and support a common understanding of the risk of MRE devices to the marine environment. This in turn would facilitate more efficient and shorter permitting/consenting processes, which would decrease financial risk for MRE project development.

There continue to be high costs and long timelines for permitting/consenting MRE devices. The ability to learn from early projects to inform permitting/consenting processes can help to lower costs and requirements for extensive data collection and subsequently move deployment of wave and tidal devices forward more rapidly.

As a means to address the concept of transferring data and information[1] among projects and collecting data consistently, Annex IV has developed a data transferability process that has been socialized with relevant stakeholders[2]. The data transferability process, including the Data Transferability Framework, are described in the following sections.

Data Transferability Process

The purpose of examining the potential for data transferability and data collection consistency is to shorten regulatory timelines and provide greater standardization in baseline and post-installation data requested to support permitting/consenting of MRE projects across multiple jurisdictions, with the amount of data requested being proportional to the risk to the environment. After the publication of the 2016 State of the Science Report (Copping et al. 2016) and as a result of extensive discussions with relevant stakeholders, six stressors[3] between MRE devices and the marine environment were identified as those most commonly associated with permitting/consenting processes that are challenging for both single MRE devices and arrays:

- <u>Collision risk</u>: The potential for marine animals to collide with tidal or river turbine blades, resulting in injury or death is a primary concern for permitting/consenting turbines. There is a high degree of uncertainty around the probability and the consequence of collision, especially for populations afforded special protection.
- <u>Underwater noise</u>: The potential for the acoustic output from operational wave or tidal devices to mask the ability of marine mammals and fish to communicate and navigate remains uncertain, as does the potential to cause physical harm or to alter animal behavior. Noise from installation, particularly pile driving, may cause short-term harm; the risks that this report focuses on are the longer-term operational sound of devices.

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[1] *Could be* raw or quality controlled data, but *more likely* analyzed data and information (includes synthesized data to reach some conclusion, information, learning, analyses, data sets, etc.)
[2] *Relevant stakeholders* include the Annex IV community, along with MRE regulators, MRE device and project developers, researchers, consultants, and other stakeholders.
[3] Specifically, it is the interactions of these stressors with specific receptors that Annex IV is examining.

- Electromagnetic fields (EMF): EMFs emitted from power export cables and energized portions of MRE devices are thought to potentially affect EMF-sensitive species by interrupting their orientation, navigation, and hunting. Cables have been deployed in the ocean for many decades, but uncertainty remains around the effects of cables associated with MRE devices.
- Changes in habitat: Placement of MRE devices in the marine environment may alter or eliminate surrounding habitat, which can reduce the extent of the habitat and affect the behavior of marine organisms. Habitat changes, including the effects of fish and other organisms reefing around devices and buoys, are well-studied in the marine environment from other industries, and the small footprint of MRE devices are unlikely to affect animals or habitats differently than those from other industries, but regulators and stakeholders continue to express concern.
- Displacement of marine animal populations: While the placement of single MRE devices in the marine environment is unlikely to cause displacement of marine animal populations, as larger arrays are deployed, there are concerns that animals could be displaced from critical foraging, mating, rearing, or resting habitats (DOE/EERE 2009; Boehlert and Gill 2010; Dolman and Simmonds 2010). Large arrays might also cause a barrier effect, preventing animals from crossing a line of devices, navigating around an array, or crossing a cable to reach their preferred or essential habitats.
- Changes in physical systems: MRE devices may alter natural water flows and remove energy from physical systems, which could result in changes in sediment transport, water quality, and other effects on far field habitats. Numerical models provide the best estimates of potential effects; however, any potential effect from a small numbers of devices will be lost in the natural variability of the system. Once larger arrays are in operation, field data will be needed to validate the models.

It is also important for MRE regulators to be able to examine and apply data and information gathered from other industries to MRE interactions, where appropriate. For example, information about reefing of fish around buoys and platforms placed in the ocean for a variety of purposes provides indications about the potential interaction of fish around wave energy devices, and the presence and emissions from telecom and inter-island subsea power cables provides information about potential EMF effects from MRE power export cables. It is also important to understand when information from other industries is not applicable to potential effects of MRE, such as the effects of conventional hydropower turbines on fish and commercial vessel propellers on marine mammals, both of which rotate at much higher speeds than tidal or river turbines, making them poor analogs for determining the potential effects of tidal or riverine turbines (Copping 2018).

As shown in Figure 1, the process of data transferability consists of five components:

1. Data Transferability Framework (Framework): brings together data sets in an organized fashion, compares the applicability of each data set for use in other locations, and guides the process of data transfer

2. Data Collection Consistency Table[4]: provides preferred measurement methods or processes, reporting units, and the most common methods of analysis or interpretation/use of data
3. Monitoring Data Sets Discoverability Matrix[5]: allows a practitioner to discover data sets based on the approach presented in the Framework
4. Best Management Practices (BMPs)[6]: five BMPs related to data transferability and collection consistency
5. Implementation Plan[7]: the approach for implementing the Framework and BMPs.

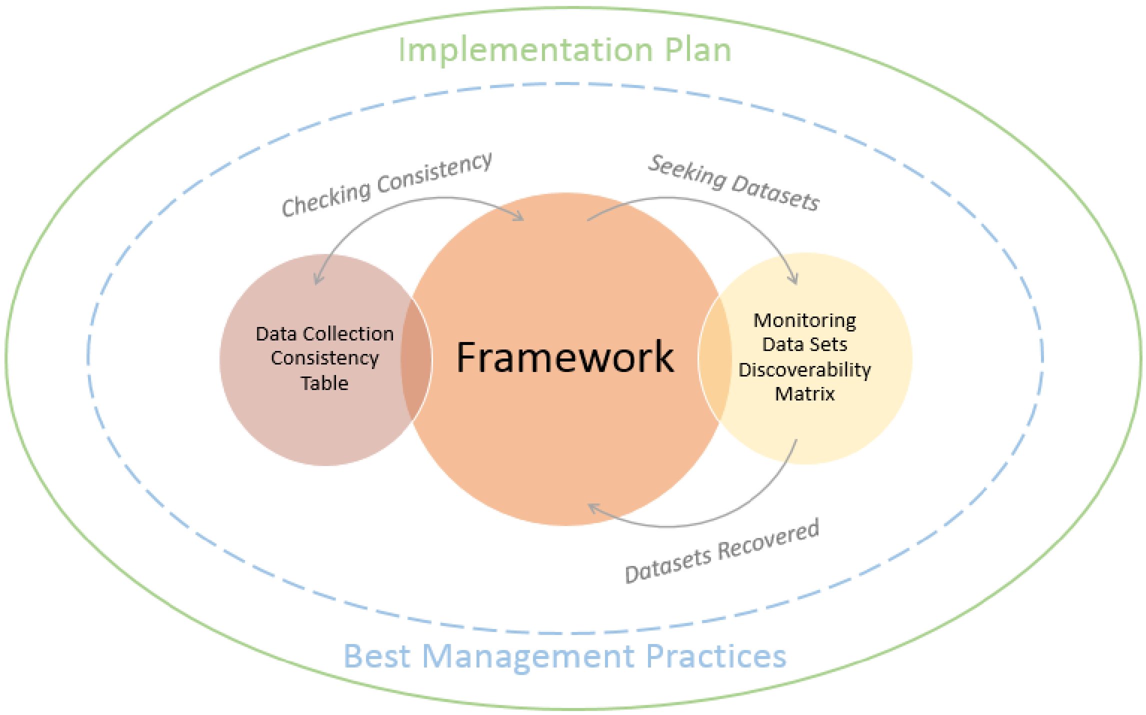

Figure 1. Data Transferability Process.

Data Transferability Framework

Under Annex IV, a *Data Transferability Framework* (Framework) has been developed that:

- brings together data sets from already permitted/consented projects in an organized fashion.
- compares the applicability of each data set for use in permitting/consenting future projects.

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[4] The Data Collection Consistency Table is a table within the Data Transferability Framework document.
[5] The Monitoring Data Sets Discoverability Matrix is currently under development and will be available on the Data Transferability and Collection Consistency *Tethys* webpage.
[6] The BMPs are a separate/stand-along document.
[7] The Implementation Plan is a separate/stand-along document.

- assures data collection consistency through preferred measurement methods or processes.
- guides the process for data transfer.

The Framework can be used to accomplish the following:

- Develop a common understanding of data types and parameters to determine and address potential effects.
- Engage regulators to test the Framework.
- Create a set of BMPs for data transferability and collection consistency.
- Set limits and considerations for how BMPs can be applied to assist with effective and efficient siting, permitting/consenting, post-installation monitoring, and mitigation.

MRE Project Archetypes

The viability of transferring data or learning from already permitted/consented projects to inform future projects was gleaned from literature in several fields. The most promising transferability methodology and framework that might be applied to MRE permitting/consenting follows that of Václavík et al. (2016), determined for research around sustainable land management. The authors' concept of defining a project "archetype" based on a variety of indicators can be applied to other place-based studies, including MRE studies. By adopting the concept of an "MRE project archetype" (MREPA), a combination of stressors, site conditions, MRE technologies, and receptors can be applied to help meet MRE regulatory needs. The comparability between archetypes at the location of origin of a data set (such as from already consented/permitted projects projects) and the location to which data will be transferred (future projects) can be evaluated, forming the basis of the Framework.

Each project MREPA is defined by four variables: stressor, site condition, MRE technology type, and receptor group. A series of tables has been developed for each of the six stressors that can be applied to an already permitted/consented project and proposed future projects. From each table, an MREPA can be identified for a particular project or set of data that might be useful for transfer. For example, the MREPA table for collision risk indicates 22 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 1). Defining the project MREPA is the first step in determining the ability to transfer data from already permitted/consented projects to future projects, as discussed in the following section. The tables for the six stressors are shown in the Appendix.

Table 1. Marine Renewable Energy Project Archetype (MREPA) Table for Collision Risk.

Site Condition [(a)]	Technology	Receptors
Shallow and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds

Site Condition [a]	Technology	Receptors
Shallow and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds

(a) Shallow channels are defined as having a depth less than 40 m. Deep channels are defined as having a depth greater than 40 m. Narrow channels are defined as having a width of less than 2 km. Wide channels are defined as having a width greater than 2 km.

Applying the Framework

The purpose of applying the Framework is to classify projects by archetype to enable discovery of existing data sets that are comparable in order to determine the potential risks of future projects. Once comparable data sets have been discovered and reviewed, here is a strong potential that trends and conclusions about specific stressors and risks from the existing data sets can inform future projects, resulting in a decrease in need for site-specific data collection and enabling more efficient permitting/consenting.

To apply the Framework, the following *Guidelines for Transferability* have been laid out as a hierarchy (Figure 2). The hierarchy of guidelines for transferring data and information from already permitted/consented projects to future projects includes five steps that range from critical, or necessary, to those that are desirable but perhaps not always necessary. The first step (same MREPA and data collected consistently) is necessary (and is the minimum requirement for transferability), while Steps 2 through 5 (same project size, same receptor species, similar technology, similar wave/tidal resource) range from important to desirable. Each step for applying the guidelines is described below.

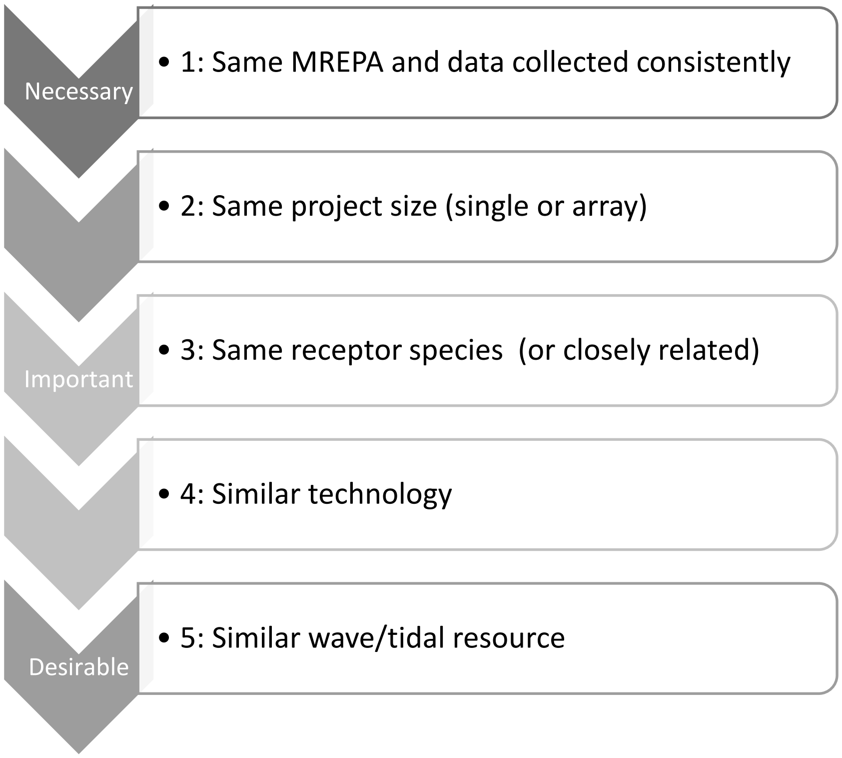

Figure 2. Guidelines for Transferability

Step 1 – Characterize the MREPA of the future project by examining the stressor, site condition, MRE technology type, and receptor. Figure 3**Error! Reference source not found.** provides an example of characterizing a project for collision risk for marine mammals. Compare the MREPA of the future project with those of already permitted/consented projects to determine the similarity of the MREPAs. The two projects must share the same MREPA, thereby ensuring that the two projects share the same stressor, site condition, MRE technology type, and receptor. Furthermore, the data must be collected consistently in order for the data to be transferred.

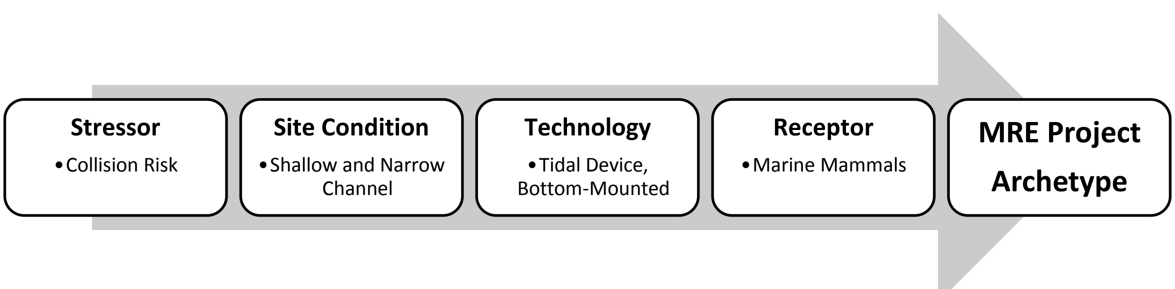

Figure 3. Example of an MREPA for an already permitted/consented project.

Step 2 – Compare the project size (single device or array). Data will best be transferred among projects with small numbers of devices, or among small arrays, or among large commercial arrays. However, because the MRE industry is fairly young and most deployments are single devices or small test arrays, there data on the environmental impacts of arrays is lacking. Until the industry can progress to a point at which enough data can be collected around small arrays and large commercial arrays, consideration should be given to transferring data from projects involving single MRE devices to inform projects involving arrays of MRE devices.

Step 3 – Compare the receptor species between the already permitted/consented project and the future project. This comparison will allow an evaluation of how comparable the data might be. As described for Step 1, the same receptor group is necessary between the two projects, but the species might differ. For example, when using marine mammals as the receptor group, transferring learning among seal species may be appropriate, but little may be learned about the effects on a seal species from data related to whale species.

Step 4 – Compare the particular type of tidal turbine or wave energy technology between the already permitted/consented project and the future project. For example, it would be best to compare point absorber data from an existing project to a future point absorber project, rather than comparing it to an oscillating water column device.

Step 5 – Compare outcomes from an already permitted/consented project to future project outcomes for areas with similar tidal or wave resources. For example, comparing high-velocity tidal currents (>3 m/s) among projects is preferable to comparing a high-velocity tidal current project (>3 m/s) to a lower-velocity current (<1.5 m/s) project.

Collection of Data in a Consistent Manner

Inherent in the effort to enable the transfer of monitoring data about MRE devices and their applications from already permitted/consented projects in one jurisdiction to future projects in another jurisdiction is the need to understand how similar the data might be. Ensuring that the data used from an already permitted/consented project are compatible with the needs of future projects, and that multiple data sets from one or more projects can be pooled or aggregated, requires an evaluation of the degree to which the data are consistent. To date, few efforts have prescribed or compared collection methods, instrumentation, or analyses. A key example of this is shown in data collected to evaluate acoustic output from wave devices to evaluate the potential deleterious effects that noise might have on marine animals (Table 2; Copping et al. 2016).

Table 2. Field measurements of acoustic data from Copping et al. (2016) to illustrate the variety of measurements used when collecting environmental effects data.

Project Location	Device Type	Developer, Project/ Device Name	Project Phase	Project Scope	Sound Levels and Pressure Spectral Densities	Organism Type	Results
Strangford Lough, Northern Ireland	Tidal; two 16 m open-bladed rotors, attached to a pile in the seabed in 26.2 m of water	MCT (Marine Current Turbines) SeaGen™	Ambient	Used hydrophones to measure ambient noise	Range of 115 to 125 dB re 1 µPa	NA	High frequencies (200 Hz – 70 kHz) attributed to sound of tidal flow.
			Construction	Measure noise levels of construction activities and marine mammal response to construction noise	• Driving pin-piles: 136 dB 1 µPa at 28 m; 110 dB 1 µPa at 2130 m • Drilling: 20-100 Hz. Equiv. to background noise at 464 m	Harbor porpoise	Temporary displacement of harbor porpoises during construction. Baseline abundances resumed following completion of construction.
			Construction	Calculate the perceived noise levels by marine animals during drilling	• Harbor seal: 59 dB_{ht} at 28 m and 30 dB_{ht} at 2130 m • Herring: 62 dB_{ht} at 28 m and 25 dB_{ht} at 2130 m	Harbor seals, harbor porpoise, herring, dab, trout	Perceived levels of sound from pin-pile driller were generally lower than ambient levels of sound in the narrows. Calculations of perceived noise suggest marine animals in Strangford Lough were unlikely to be disturbed at distances more than 115 m from drilling.
			Operation	Determine harbor seal behavior in area of operating device	Ambient plus device signature	Harbor seals	No significant displacement of seals or porpoises. Marine mammals swam freely in the Lough during operation. Noted evasion at channel center during turbine operation.
Cobscook Bay, Maine, USA	Tidal; a single, barge-mounted, cross-axis turbine generator unit in 26m of water	Ocean Renewable Power Company, Cobscook Bay Tidal Energy Project	Operation	Measure noise levels of the barge-mounted turbine	Less than 100 dB re $\mu Pa^2/Hz$ at 10m	NA	At 200 to 500 m from the turbine, sound was not detectable above ambient noise within the bay.
East River, New York, USA	Tidal; six three-bladed unducted turbines bottom-mounted in 10 m of water	Verdant Power, Roosevelt Island Tidal Energy Project	Operation	Measure noise levels around the array of tidal turbines	Up to 145 dB re 1µPa @ 1m from the array	14 fish species in the area	During the study, blades on one turbine were broken and another turbine was failing, resulting in more noise generation than would be expected. Conclude sound at damaged turbine array did not reach levels known to cause injury for 13 species of fish examined.
Puget Sound, Washington, USA	Wave; 1/7th-scale wave buoy	Columbia Power Technologies, SeaRay™	Ambient and Operation	Measure sound signature of the wave device and surrounding area	• Ambient: 116-132 dB re 1µPa in frequency of 20 Hz to 20 kHz when ships were nearby. • Device: 126 dB re 1µPa	NA	Ambient noise levels masked the wave device sound. Sound from the SeaRay was closely correlated to the wave period.

Assuring Data Consistency

MRE is an international industry, with permitting/consenting processes and research norms that differ from country to country, region to region, and among research and commercial data collection efforts. It would be extremely difficult to enforce the use of specific protocols or instruments to collect all data for pre- or post-installation monitoring. However, encouraging the use of consistent processes and units for the collection of monitoring data could increase confidence in the transfer of data or learning from already permitted/consented projects to future projects. For the six stressors previously discussed, a set of processes, reporting units, and general analysis or reporting methods are proposed in the *Data Collection Consistency Table* (Table 3). For each stressor, the preferred measurement methods or processes are reported, along with preferred reporting units and the most common methods of analysis or interpretation and use of the data.

Table 3. Data Collection Consistency Table.

Stressor	Process or Measurement Tool	Reporting Unit	Analysis or Interpretation
Collision Risk	Sensors include: • Active acoustic only • Active acoustic + video • Other	Number of visible targets in field of view, number of collisions	Number of collisions and/or close interactions of animals with turbines used to validate collision risk models
Underwater Noise	Fixed or floating hydrophones	- Amplitude dB re 1 µPa at 1 m - Frequency: broadband or specific frequencies	Sound outputs from MRE devices compared against regulatory action levels. Generally reported as broadband noise unless guidance exists for specific frequency ranges.
EMF	Source: • cable • other • shielded or unshielded	- AC or DC - voltage - amplitude	Measured EMF levels used to validate existing EMF models around cables and other energized sources.
Habitat Change	Underwater mapping with - sonar - video Habitat characterization from - mapping - existing maps	Area of habitat altered, specific for each habitat type	Compare potential changes in habitat to maps of rare and important habitats to determine if they are likely to be harmed.
Displacement/Barrier Effect	Population estimates by: - human observers - passive or active acoustic monitoring - video	Population estimates for species under special protection	Validation of population models, estimates of jeopardy, loss of species for vulnerable populations
Changes in Physical Systems	Numerical modeling, with or without field data validation	No units. Indication of data sets used for validation, if any.	Data collected around arrays should be used to validate models.

Quality Assurance

The process of transferring data or information from already permitted/consented projects to future projects relies on the use of existing data. There is a presumption that the data and the derived information that would be used for data transfer has undergone some degree of quality assurance. Regulators desiring to use existing data and information cannot be responsible for carrying out quality assurance procedures or checks on existing data; however, it is always prudent to inquire and examine documentation accompanying data sets and/or to search out the provenance of the information.

Guidelines for Evaluating Qualitative Data

Without strict adherence to common methods and instruments for collecting data, there will continue to be inherent differences among data sets that will require judgement calls on the part of the regulators. Combined with the format in which data are likely to be presented, these judgements can be informed by following guidance for evaluating qualitative data.

Data that are most likely to be presented to regulators as part of the permitting/consening process may be analyzed, synthesized, or presented as conclusions in reports. Collectively these data should be considered as qualitative rather than as quantitative data (Echambadi et al. 2006; White et al. 2012). There are approaches to the management and interpretation of qualitative data sets that can assist with determining how similar (and therefore how comparable data might be). Quality criteria used in *quantitative* research (e.g., internal validity, generalizability, reliability, and objectivity) are not suitable to judge the quality of *qualitative* research (Korstjens and Moser 2018). In qualitative research, key evaluation questions involve the trustworthiness of the data. Trustworthiness of data and criteria for judging that trustworthiness have been defined (Table 4), while strategies to ensure trustworthiness in qualitative research data are laid out (Table 5).

Table 4. Trustworthiness: definitions of quality criteria in qualitative research. Based on Lincoln and Guba (1985) (adapted from Korstjens and Moser 2018)

Quality Criteria	**Definition**
Credibility	The confidence that can be placed in the truth of the research findings. Credibility establishes whether the research findings represent plausible information drawn from the participants' original data and is a correct interpretation of the participants' original views.
Transferability	The degree to which the results of qualitative research can be transferred to other contexts or settings with other respondents. The researcher facilitates the transferability judgment by a potential user through thick description.
Dependability	The stability of findings over time. Dependability involves participants' evaluation of the findings, interpretation and recommendations of the study such that all are supported by the data as received from participants of the study.
Confirmability	The degree to which the findings of the research study could be confirmed by other researchers. Confirmability is concerned with establishing that data and interpretations of the findings are not figments of the inquirer's imagination, but clearly derived from the data.
Reflexivity	The process of critical self-reflection about oneself as researcher (own biases, preferences, preconceptions), and the research relationship (relationship to the respondent, and how the relationship affects participant's answers to questions).

Table 5. Definition of strategies to ensure trustoworthiness in qualitative research. Based on Lincoln and Guba (1985) and Sim and Sharp (1998) (adapted from Korstjens and Moser 2018)

Criterion	Strategy	Definition
Credibility	Prolonged engagement	Lasting presence during observation of long interviews or long-lasting engagement in the field with participants. Investing sufficient time to become familiar with the setting and context, to test for misinformation, to build trust, and to get to know the data to get rich data.
	Persistent observation	Identifying those characteristics and elements that are most relevant to the problem or issue under study, on which you will focus in detail.
	Triangulation	Using different data sources, investigators and methods of data collection. • Data triangulation refers to using multiple data sources in time (gathering data in different times of the day or at different times in a year), space (collecting data on the same phenomenon in multiples sites or test for cross-site consistency) and person (gathering data from different types or level of people e.g. individuals, their family members and clinicians). • Investigator triangulation is concerned with using two or more researchers to make coding, analysis and interpretation decisions. • Method triangulation means using multiple methods of data collection
	Member check	Feeding back data, analytical categories, interpretations and conclusions to members of those groups from whom the data were originally obtained. It strengthens the data, especially because researcher and respondents look at the data with different eyes.
Transferability	Thick description	Describing not just the behaviour and experiences, but their context as well, so that the behaviour and experiences become meaningful to an outsider.
Dependability and confirmability	Audit trail	Transparently describing the research steps taken from the start of a research project to the development and reporting of the findings. The records of the research path are kept throughout the study.
Reflexivity	Diary	Examining one’s own conceptual lens, explicit and implicit assumptions, preconceptions and values, and how these affect research decisions in all phases of qualitative studies.

Data Discovery

As a companion to the Framework, a Monitoring Data Sets Discoverability Matrix is being developed to classify monitoring data sets from already permitted/consented projects for the six stressors previously discussed. The matrix will be linked to key metadata features of each data set (i.e., data parameters, collection location, collection methods, contact, etc.). The matrix will allow regulators and/or developers to discover data sets based on the MREPA, and evaluate the consistency of information and therefore the ability to transfer data from an already permitted/consented project to future projects.

The Monitoring Data Sets Discoverability Matrix is in the initial stages of development and will be completed in fiscal year 2019. When completed, the matrix will be available as an interactive tool made available on the Data Transferability and Collection Consistency Tethys webpage. Updates to the matrix will be annual or as additional permitted/consented project data sets become available.

Use of the Framework

The Framework has been developed to provide a background against which discussions with regulators can proceed to enhance the understanding of the limits of transferability, based on the confidence individual regulators have to accept data and information collected for already permitted/consented projects for information analyses in support of applications for MRE developments in her/his jurisdiction. The Framework will also facilitate initial permitting/consenting discussions between developers and regulators to determine data collection and pre-installation monitoring efforts needed to permit/consent a project and to determine post-installation operational monitoring needs.

By implementing the Data Transferability Framework, the siting and permitting/consenting processes for installation of single MRE devices and MRE arrays may be shortened and scarce funding resources may be directed toward environmental interactions that remain most uncertain.

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Appendix

MRE Project Archetype Tables

The MRE project archetypes (MREPA) are shown for each stressor, which identify the potential site conditions, MRE technology types, and receptors that can be described for already permitted/consented MRE projects and for future projects. From each table, an MREPA can be identified for a particular project or set of data that might be useful for transfer. Defining the project MREPA is the first step in determining the transferability potential of data from existing projects to future projects.

Collision Risk

The potential for marine animals to collide with tidal or river turbine blades, resulting in injury or death is a primary concern for consenting turbines. There is a high degree of uncertainty around the probability and the consequence of collision, especially for populations afforded special protection (Copping et al. 2016). Projects related to collision risk have the potential to be classified as one of 22 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 1).

Table 1. Marine Renewable Energy Project Archetype (MREPA) Table for Collision Risk.

Site Condition [a]	Technology	Receptors
Shallow and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Shallow and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Diving Birds
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds
Deep and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
	Tidal Device in the Water Column	Marine Mammals
		Fish
		Diving Birds

(a) Shallow channels are defined as having a depth less than 40 m. Deep channels are defined as having a depth greater than 40 m. Narrow channels are defined as having a width of less than 2 km. Wide channels are defined as having a width greater than 2 km.

Underwater Noise

The potential for the acoustic output from operational wave or tidal devices to mask the ability of marine mammals and fish to communicate and navigate remains uncertain, as does the potential to cause physical harm or to alter animal behavior (Clark et at. 2009; DOE/EERE 2009; Götz et al. 2009; Wilson et al. 2007). Noise from installation, particularly pile driving, may cause short-term harm; the risks that this report focuses on are the longer term operational sound of devices. Projects related to underwater noise have the potential to be classified as one of 8 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 2).

Table 2. MREPA Table for Effects of Underwater Noise.

Site Condition	Technology [(a)]	Receptors
Isolated/Quiet Environment	Tidal Device	Marine Mammals
		Fish
	Wave Device	Marine Mammals
		Fish
Noisy Environment	Tidal Device	Marine Mammals
		Fish
	Wave Device	Marine Mammals
		Fish

(a) Sound levels generally caused by specific portions of each technology: tidal device sound from blade and rotor rotation, as well as power take offs; wave device sound from power take offs. In addition, some lower levels of sound may be generated by mooring systems and interactions between the device and the surface waters, but these sounds were considered to be of less amplitude and unlikely to be of concern for marine mammals (Copping et al. 2016). Isolated/Quite Environments are those with noise measuring less than 80 db. Noisy Environments are those with noise measuring greater than 80 db.

Electromagnetic Fields (EMF)

EMFs emitted from power export cables and energized portions of MRE devices are thought to potentially effect EMF-sensitive species by interrupting their orientation, navigation, and hunting. Cables have been deployed in the ocean for many decades, but uncertainty remains around the effects of cables associated with MRE devices (Copping et al. 2016). Projects related to EMF have the potential to be classified as one of 10 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 3).

Table 3. MREPA Table for Effects of EMFs.

Site Condition	Technology	Receptors
Buried Cables	Shielded Cables	Elasmobranchs
		Mobile /Sedentary Invertebrates
	Unshielded Cables	Elasmobranchs
		Mobile /Sedentary Invertebrates
Not Buried Cables	Seaflood Shielded Cables	Elasmobranchs
		Mobile/Sedentary Invertebrates
	Seaflood Shielded Cables	Elasmobranchs
		Mobile/Sedentary Invertebrates
	Draped Cables	Elasmobranchs
		Mobile/Sedentary Invertebrates

Habitat Changes

Placement of MRE devices in the marine environment may alter or eliminate surrounding habitat, which can reduce the extent of the habitat and affect the behavior of marine organisms. Habitat changes, including effects of fish and other organisms reefing around devices and buoys, are well-studied in the marine environment from other industries, and the small footprint of MRE devices are unlikely to affect animals or habitats differently than those from other industries, however regulators and stakeholders continue to express concern (Copping et al. 2016). Projects related to habitat changes have the potential to be classified as one of 9 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 4).

Table 4. MREPA Table for Nearshore Changes to Habitat and Reefing Patterns.

Site Condition	Technology	Receptors
Hard Bottom Habitat	Foundation/Anchors	Benthic Invertebrates
		Demersal Fish
		Shoaling Fish
Soft-Bottom Habitat	Foundation/Anchors	Benthic Invertebrates
		Demersal Fish
		Shoaling Fish
Water Column	Floats/Mooring Lines	Marine Mammals and Sea Turtles
		Demersal Fish
		Shoaling Fish

Displacement of Marine Animal Populations

While the placement of single MRE devices in the marine environment are unlikely to cause displacement of marine animal populations, as larger arrays are deployed, there are concerns that animals could be displaced from critical foraging, mating, rearing, or resting habitats (DOE/EERE 2009; Boehlert and Gill 2010; Dolman and Simmonds 2010). Large arrays might also cause a barrier effect, preventing animals from crossing a line of devices, navigating around an array, or crossing a cable to reach their preferred or essential habitats. Projects related to displacement of marine animal populations have the potential to be classified as one of 10 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 5).

Table 5. MREPA Table for Displacement of Marine Animal Populations.

<table>
<tr><th>Site Condition</th><th>Technology</th><th>Receptors</th></tr>
<tr><td rowspan="6">Encolsed Basin</td><td rowspan="3">Tidal Device</td><td>Marine Mammals</td></tr>
<tr><td>Fish</td></tr>
<tr><td>Diving Birds</td></tr>
<tr><td rowspan="3">Wave Device</td><td>Marine Mammals</td></tr>
<tr><td>Fish</td></tr>
<tr><td>Diving Birds</td></tr>
<tr><td rowspan="4">Open Coast</td><td rowspan="2">Tidal Device</td><td>Marine Mammals</td></tr>
<tr><td>Fish</td></tr>
<tr><td rowspan="2">Wave Device</td><td>Marine Mammals</td></tr>
<tr><td>Fish</td></tr>
</table>

Physical Systems Changes

MRE devices may alter natural water flows and remove energy from physical systems, which could result in changes in sediment transport, water quality, and other effects on farfield habitats (Polayge et al. 2011). While there is a lack of field data to validate models, modeling results indicate impacts from single devices are too small to be measured, but should be revisited once large arrays of MRE devices are deployed (Copping et al. 2016; DOE/EERE 2009). Projects related to physical systems changes have the potential to be classified as one of 4 possible MREPAs based on the project site conditions, MRE technology types, and receptors (Table 6).

Table 6. MREPA Table for Changes to Physical Systems and Farfield Habitat Changes.

Site Condition	Technology	Receptors
Enclosed Basin	Tidal Device	Sediment Transport
		Water Quality/Food Web
Open Coast	Wave Device	Sediment Transport
		Water Quality/Food Web

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Appendix E

Best Management Practices

Marine Renewable Energy: Best Management Practices for Data Transferability and Collection Consistency

Background

The term 'Best Management Practices', or BMPs, was coined in the US as a way to describe acceptable practices that could be implemented to protect water quality, as well as associated resources and habitats. The first published description of BMPs was released by the US Environmental Protection Agency (EPA) for developing guidance for National Pollutant Discharge Elimination System (NPDES) facilities to prevent the release of toxic and hazardous chemicals (EPA 1993). This guidance defined BMPs as practices or procedures that are qualitative and flexible. It further described BMPs as *general* (or baseline) practices and *specific* practices, with general/baseline practices widely applicable and practiced and easily implemented, while specific practices being applicable to a specific location or process and having practices that are often tailored to meet certain requirements.

The EPA guidance suggests that BMPs be separated into three phases: planning; development and implementation; and evaluation/re-evaluation. The planning phase includes demonstrating management support for the BMP plan and identifying and evaluating what areas, topics, or issues will be addressed by BMPs. The development phase consists of determining, developing, and implementing general and specific BMPs. The evaluation/re-evaluation phase consists of an assessment of the components of a BMP plan and re-evaluation of plan components periodically.

For purposes of creating BMPs for the transferability of data and information[1] from already permitted/consented marine renewable energy (MRE) projects to future projects, this document addresses the planning and development phases for BMPs. An *Implementation Plan for Data Transferability and Best Management Practices* has been developed that includes details on how the data transferability process (including BMPs) will be implemented; a brief section on the implementation of BMPs is presented at the end of this document.

Data Transferability Process

The purpose of examining the potential for data transferability and data collection consistency is to shorten regulatory timelines and provide greater standardization in baseline and post-installation data requested to support permitting/consenting of MRE projects across multiple jurisdictions, with the amount of data requested being proportional to the risk to the

[1] *Could be* raw or quality controlled data, but *more likely* analyzed data and information (includes synthesized data to reach some conclusion, information, learning, analyses, data sets, etc.)

environment. After the publication of the 2016 State of the Science Report (Copping et al. 2016) and as a result of extensive discussions with relevant stakeholders, six stressors[2] between MRE devices and the marine environment were identified as those most commonly associated with permitting/consenting processes that are challenging for both single MRE devices and arrays:

- Collision risk: The potential for marine animals to collide with tidal or river turbine blades, resulting in injury or death is a primary concern for permitting/consenting turbines. There is a high degree of uncertainty around the probability and the consequence of collision, especially for populations afforded special protection.
- Underwater noise: The potential for the acoustic output from operational wave or tidal devices to mask the ability of marine mammals and fish to communicate and navigate remains uncertain, as does the potential to cause physical harm or to alter animal behavior. Noise from installation, particularly pile driving, may cause short-term harm; the risks that this report focuses on are the longer-term operational sound of devices.
- Electromagnetic fields (EMF): EMFs emitted from power export cables and energized portions of MRE devices are thought to potentially affect EMF-sensitive species by interrupting their orientation, navigation, and hunting. Cables have been deployed in the ocean for many decades, but uncertainty remains around the effects of cables associated with MRE devices.
- Changes in habitat: Placement of MRE devices in the marine environment may alter or eliminate surrounding habitat, which can reduce the extent of the habitat and affect the behavior of marine organisms. Habitat changes, including the effects of fish and other organisms reefing around devices and buoys, are well-studied in the marine environment from other industries, and the small footprint of MRE devices are unlikely to affect animals or habitats differently than those from other industries, but regulators and stakeholders continue to express concern.
- Displacement of marine animal populations: While the placement of single MRE devices in the marine environment is unlikely to cause displacement of marine animal populations, as larger arrays are deployed, there are concerns that animals could be displaced from critical foraging, mating, rearing, or resting habitats (DOE/EERE 2009; Boehlert and Gill 2010; Dolman and Simmonds 2010). Large arrays might also cause a barrier effect, preventing animals from crossing a line of devices, navigating around an array, or crossing a cable to reach their preferred or essential habitats.
- Changes in physical systems: MRE devices may alter natural water flows and remove energy from physical systems, which could result in changes in sediment transport, water quality, and other effects on far field habitats. Numerical models provide the best estimates of potential effects; however, any potential effect from a small numbers of devices will be lost in the natural variability of the system. Once larger arrays are in operation, field data will be needed to validate the models.

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[2] Specifically, it is the interactions of these stressors with specific receptors that Annex IV is examining.

It is also important for MRE regulators to be able to examine and apply data and information gathered from other industries to MRE interactions, where appropriate. For example, information about reefing of fish around buoys and platforms placed in the ocean for a variety of purposes provides indications about the potential interaction of fish around wave energy devices, and the presence and emissions from telecom and inter-island subsea power cables provides information about potential EMF effects from MRE power export cables. It is also important to understand when information from other industries is not applicable to potential effects of MRE, such as the effects of conventional hydropower turbines on fish and commercial vessel propellers on marine mammals, both of which rotate at much higher speeds than tidal or river turbines, making them poor analogs for determining the potential effects of tidal or riverine turbines (Copping 2018).

As shown in Figure 1, the process of data transferability consists of five components:

1. Data Transferability Framework (Framework)[3]: brings together data sets in an organized fashion, compares the applicability of each data set for use in other locations, and guides the process of data transfer
2. Data Collection Consistency Table[4]: provides preferred measurement methods or processes, reporting units, and the most common methods of analysis or interpretation/use of data
3. Monitoring Data Sets Discoverability Matrix[5]: allows a practitioner to discover data sets based on the approach presented in the Framework
4. Best Management Practices (BMPs): five BMPs related to data transferability and collection consistency
5. Implementation Plan[6]: the approach for implementing the Framework and BMPs.

[3] The Data Transferability Framework is a separate/stand-alone document and should be consulted to gain further understanding of the Framework.
[4] The Data Collection Consistency Table is a table within the Data Transferability Framework document.
[5] The Monitoring Data Sets Discoverability Matrix is currently under development and will be available on the Data Transferability and Collection Consistency *Tethys* webpage.
[6] The Implementation Plan is a separate/stand-along document.

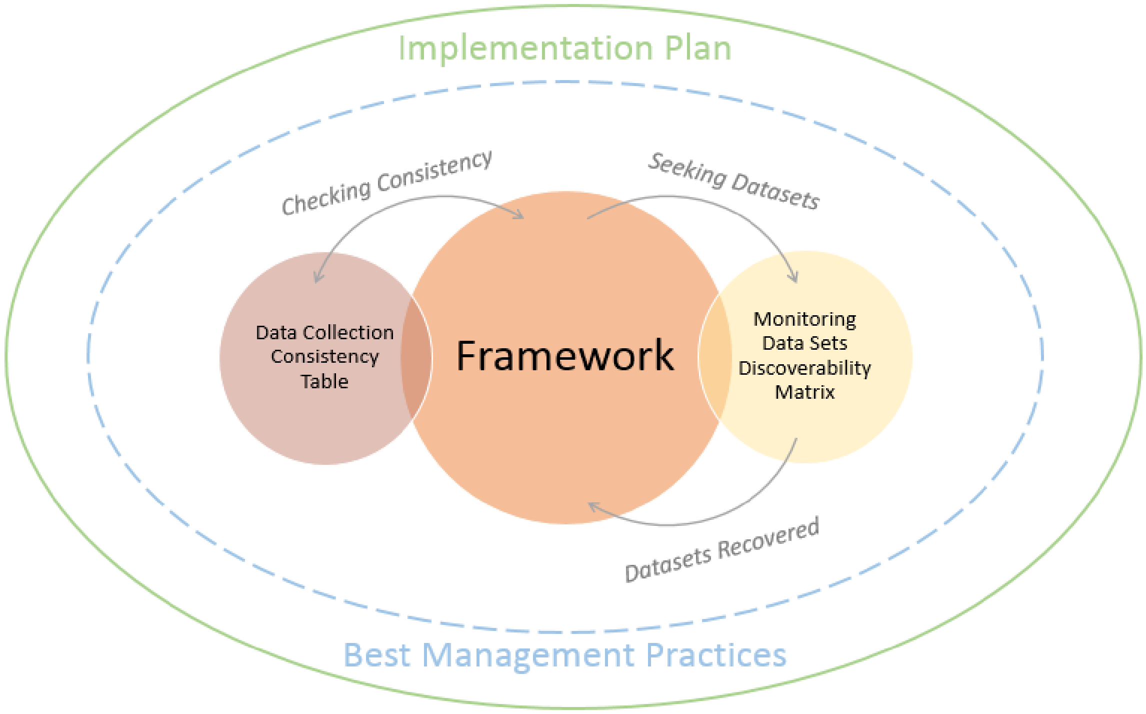

Figure 1. Data Transferability Process.

Definitions and Assumptions

For the purposes of the BMPs, data transferability is defined as data and/or information collected through research studies and/or monitoring from already permitted/consented projects that can be used to inform future projects. Collection consistency is defined as the similarity or consistency of monitoring data collected among data sets, with preference to an established set of methods or outcomes that will allow comparison among those data sets.

It is assumed that all data sets and information transferred from already permitted/consented projects to future projects must meet all national, regional, and local laws and regulations.

Process for Best Management Practices Development

Planning Phase for Best Management Practices

In developing BMPs for data transferability and collection consistency, the planning phase consisted of: 1) defining areas of potential environmental effects of MRE development, as documented in the Framework and 2) assessing the acceptability of transferring learning from already permitted/consented MRE projects to future MRE projects among regulators[7] through a series of workshops. It will be necessary to continue to iterate on these planning steps to ensure that BMPs meet the needs of regulators, to extend the interactions to regulators in

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[7] US regulators were the primary focus/target for initial engagement/outreach efforts on the data transferability process. Internationally, Annex IV analysts are currently engaging their country's respective regulators to ensure the data transferability process is socialized internationally and meets the needs of all relevant stakeholders.

other Annex IV nations, and to engage the development community in understanding what is needed for permitting/consenting of MRE devices.

Development Phase for Best Management Practices

The development phase included drafting BMPs, assessing their pertinence and completeness, and developing a process for implementation. The group of experts brought together at a workshop in conjunction with the International Conference on Ocean Energy (ICOE) held June 11th 2018 in Cherbourg, France provided review and input on the Framework and draft BMPs, as well as input to begin developing an implementation plan.

Best Management Practices for Data Transferability of Marine Renewable Energy Projects

BMPs designed to assist with data transferability and collection consistency must meet minimum requirements and conform to a set of defined steps. The BMPs will help to guide the data transferability process by applying practical steps to implementation.

Minimum Requirements for Transferring Data

The minimum requirements for data transferability from an already permitted/consented project to a future project using the Framework include the need for:

- The projects to share the same MREPA[8] (same stressor, same site conditions, same technology, same development size, same receptor). Within the Framework, the *Guidelines for Transferability* note that it is important or desirable that the projects also share several of the requirements in the next steps of the framework as well (same project size, same species, similar technology, and similar wave/tidal resources).
- The data to be collected in a consistent manner (*Data Collection Consistency Table* of the Framework).

Proposed Best Management Practices

BMPs proposed to meet the *Guidelines for Transferability* for the six key interactions (collision risk, underwater noise, EMF, changes in habitats, displacement of marine animals, changes in physical systems) were developed using the six stressors as the first organizing factor. Each BMP is accompanied by a purpose and set of process steps to clarify its use. In order for a data set or body of learning to be considered for transfer, the following practices should be followed:

[8] Marine Renewable Energy Project Archetype, as described in the Framework

BMP 1	**Meet the necessary requirements in the *Guidelines for Transferability* to be considered for data transfer from an already permitted/consented project to a future project.**		
	Purpose	**Process**	**Intended Party**
	This practice (coupled with BMP 2) will ensure that the minimum requirements in the *Guidelines for Transferability* (same MREPA and data collected consistently) are met for similarity and comparability between the data sets from already permitted/ consented projects to those of future projects. For this BMP, the MREPA of the new project, and that of the already permitted/ consented projects, will be determined.	Determine MREPA(s) for the future project site. Search for similar MREPAs in the *Monitoring Data Sets Discoverability Matrix*, and choose data sets from permitted/consented projects that match.	This practice is intended for those within the MRE community looking to transfer data from already permitted/consented projects to a future project (e.g., developers, consultants, regulators).

BMP 2	**Determine likely data sets that meet data consistency needs and quality assurance requirements.**		
	Purpose	**Process**	**Intended Party**
	This practice will help determine the validity of comparing data from an already permitted/ consented project and a future project as it ensures that the methods used to collect and analyze data from an already permitted/ consented project follows data consistency and compatibility needs of those required for future projects.	Use the *Data Collection Consistency Table*, and determine whether data collection methods and quality assurance requirements for existing data sets are sufficiently similar and adequate.	This practice is intended for those within the MRE community looking to transfer data from already permitted/consented projects to a future project (e.g., developers, consultants, regulators).

BMP 3	Use models in conjunction with and/or in place of data sets.		
	Purpose	**Process**	**Intended Party**
	This practice encourages the use of numerical models to simulate interactions when adequate monitoring data are not available. Using numerical models will help alleviate the need for extensive data collection for each interaction for every future project. Use of models will also allow regulators and other stakeholders to predict the potential effects of future projects.	Once sufficient data exist for an interaction, create models to describe the interaction, when applicable; these models will begin to take the place of larger field data collection efforts. In some cases (for example, to determine changes in physical systems) models may be used prior to collection of field data. For each model used, note the type of model, whether it has been validated with field data, and the associated major stated assumptions and limitations.	This practice is intended for those within the MRE community who develop and use numerical models (e.g., researchers, analysts).

BMP 4	Provide context and perspective for the data sets to be transferred.		
	Purpose	**Process**	**Intended Party**
	This practice encourages the use of available and pertinent data sets to enhance the interpretation of data and information. The use of ancillary data sets does not in any way imply that collection of the data is necessary for pre- or post-installation monitoring around MRE devices.	Where available, identify and assess ancillary data sets to provide context for the MRE interaction data. These data sets might include behavioral studies of animals, the hydrodynamics and wave climate of the site and surrounding area locations, habitat maps, etc.	This practice is intended for those within the MRE community looking for context and perspective for the data sets to be transferred (e.g., developers, consultants, regulators, and researchers).

Implementation of Best Management Practices

The process for implementing BMPs for data transferability and collection consistency will require the involvement of all parties that play a role in permitting/consenting MRE devices. It is desireable that all parties support and apply the BMPs in order to reach a level of acceptance and understanding such that:

- Regulators are willing to accept the premise of data transferability so that they apply the principles of data transferability and collection consistency to evaluate permitting/consenting applications;
- Device and project developers recognize the value of data transferability and commit to collecting and providing data that are consistent with the collection guidelines and that will best fit the Framework and guidelines for collection consistency, quality assurance, and trustworthiness; and
- Researchers and consultancies inform themselves of the data consistency requirements and potential use of data collected around MRE devices to ensure that research data are usable for transfer.

During the early trial period of applying the data transferability process, it would be helpful to convene a virtual group of international representatives from across the MRE community (regulators, developers, researchers, and consultants) to (1) share progress in understanding and permitting/consenting MRE projects; (2) provide technical assistance in using the data transferability process; and (3) gauge the success of the data transferability initiative.

An *Implementation Plan for Data Transferability and Best Management Practices* has been developed that includes additional details on how the BMPs will be implemented.

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Appendix F

Implementation Plan

Implementation Plan for Data Transferability Process and Best Management Practices

Introduction

As the marine renewable energy (MRE) industry advances around the world, the increasing demand for data and information about how MRE technologies (wave and tidal devices) may interact with the marine environment continues. Our understanding of the potential environmental effects of MRE development is slowly increasing, informed by monitoring data collected around devices in several nations and a growing body of research studies. However, information derived from monitoring and research is published in scientific journals and technical reports, which may not be readily accessible or available to regulators and other stakeholders.

Regulators in all jurisdictions must satisfy legal and regulatory mandates in order to grant permission to deploy and operate MRE devices. Inherent in these laws and regulations is a concept of balancing risk to the environment and human uses of public resources against economic development and human well-being. Research efforts related to the potential effects of MRE development are focused on this concept of risk; the interactions between devices and the environment most likely to cause harm, or those for which the greatest uncertainty exists, are garnering the most attention (Copping et al. 2016). The components of risk—probability of occurrence and consequence of occurrence—are fundamental to the process by which regulators evaluate project compliance with environmental statutes. The concept of risk also provides an excellent context for discussing research outcomes and assisting regulators in learning more about potential effects.

The MRE industry is struggling with the high costs of baseline assessments and post-installation monitoring, as well as long timelines for obtaining permits or licenses, all of which lead to uncertainty and risk related to project financing. Regulators require assessment and monitoring information to allow them to carry out the necessary analyses to describe, permit/consent, and manage the environmental risks associated with new MRE technologies and new uses of ocean space. One way to reduce risks to the industry and the environment and to allow for acceleration of this new form of low carbon energy could be the ability to transfer learning, analyses, and data sets from one country to another, among projects, and across jurisdictional boundaries.

As the MRE industry matures, the ability to readily transfer research and monitoring results, data, study designs, data collection methods, and best practices from project to project will lead to cost reductions for baseline environmental studies and post-installation monitoring. Regulators and stakeholders currently lack access to synthesized and contextualized data emerging from existing projects, and there are no mechanisms by which to apply data and information across geographically distinct projects. This leads to each individual project bearing the full burden of information requirements on a site-by-site basis. In addition, data are collected around early-stage MRE devices using many different methods, instruments, and measurement scales. If similar parameters and accessible methods of collection were used for baseline and post-installation monitoring around all early-stage devices, the results would be more readily comparable. This comparability would lead to a decrease in scientific uncertainty and support a common understanding of the risk of MRE devices to the marine environment. This in turn would facilitate more efficient and shorter permitting/consenting processes, which would decrease financial risk for MRE project development.

There continue to be high costs and long timelines for permitting/consenting MRE devices. The ability to learn from early projects to inform permitting/consenting processes can help to lower costs and requirements for extensive data collection and subsequently move deployment of wave and tidal devices forward more rapidly.

As a means to address the concept of transferring data and information[1] among projects and collecting data consistently, Annex IV has developed a data transferability process that has been socialized with relevant stakeholders[2]. The data transferability process is described in the following section.

The goal of this implementation plan is to present the approach for implementing the *Data Transferability Framework* and *Best Management Practices for Data Transferability and Collection Consistency for Marine Renewable Energy* documents. Specifically, this plan will outline a process that will support the transfer of data from already consented/permitted MRE projects to inform future MRE projects for consenting and other project phases in order to simplify and accelerate permitting/consenting processes. Through the successful execution of this plan and implementation of the above documents, Annex IV will:

1. Ensure that regulators have access to data sets and processes for transferring data from already permitted/consented projects to future projects (as per the process outlined in the Implementation Plan).
2. Assist regulators in understanding the applicability of these processes through an active outreach and engagement process.
3. Provide technical assistance to help regulators implement the data transferability process using Annex IV and *Tethys* to facilitate the exchange of relevant data and information.
4. Ensure developers and their consultants are active participants in Annex IV's outreach and engagement efforts to ensure their familiarity with and acceptance of the data transferability process

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[1] *Could be* raw or quality controlled data, but *more likely* analyzed data and information (includes synthesized data to reach some conclusion, information, learning, analyses, data sets, etc.)

[2] *Relevant stakeholders* include the Annex IV community, along with MRE regulators, MRE device and project developers, researchers, consultants, and other stakeholders.

5. Provide added value to the data transferability process through engagement activities and the consistent collection of data around MRE devices

Background

The purpose of examining the potential for data transferability and data collection consistency is to shorten regulatory timelines and provide greater standardization in baseline and post-installation data requested to support permitting/consenting of MRE projects across multiple jurisdictions, with the amount of data requested being proportional to the risk to the environment. After the publication of the 2016 State of the Science Report (Copping et al. 2016) and as a result of extensive discussions with relevant stakeholders, six stressors[3] between MRE devices and the marine environment were identified as those most commonly associated with permitting/consenting processes that are challenging for both single MRE devices and arrays:

- Collision risk: The potential for marine animals to collide with tidal or river turbine blades, resulting in injury or death is a primary concern for permitting/consenting turbines. There is a high degree of uncertainty around the probability and the consequence of collision, especially for populations afforded special protection.
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- Changes in habitat: Placement of MRE devices in the marine environment may alter or eliminate surrounding habitat, which can reduce the extent of the habitat and affect the behavior of marine organisms. Habitat changes, including the effects of fish and other organisms reefing around devices and buoys, are well-studied in the marine environment from other industries, and the small footprint of MRE devices are unlikely to affect animals or habitats differently than those from other industries, but regulators and stakeholders continue to express concern.
- Displacement of marine animal populations: While the placement of single MRE devices in the marine environment is unlikely to cause displacement of marine animal populations, as larger arrays are deployed, there are concerns that animals could be displaced from critical foraging, mating, rearing, or resting habitats (DOE/EERE 2009; Boehlert and Gill 2010; Dolman and Simmonds 2010). Large arrays might also cause a

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barrier effect, preventing animals from crossing a line of devices, navigating around an array, or crossing a cable to reach their preferred or essential habitats.

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5. Implementation Plan: the approach for implementing the Framework and BMPs.

[4] The Data Transferability Framework is a separate/stand-alone document and should be consulted to gain further understanding of the Framework.
[5] The Data Collection Consistency Table is a table within the Data Transferability Framework document.
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[7] The BMPs are a separate/stand-along document.

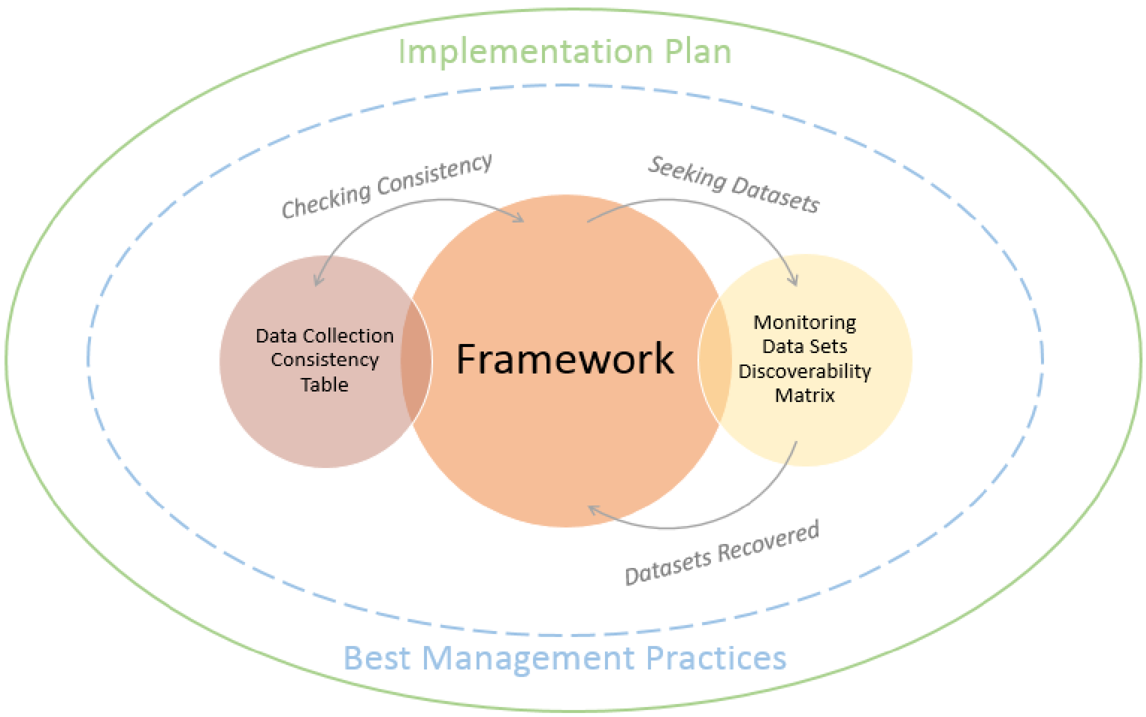

Figure 1. Data Transferability Process.

Implementation Plan

Solicitation of Feedback

Gathering input and feedback on the data transferability process will be an ongoing effort. Relevant stakeholders, with a specific focus on Annex IV analysts, will be engaged through focus groups and workshops to ensure the intent and approach of the data transferability process and associated components is articulated in a clear and transparent manner and is applicable for use by the MRE community. Relevant content will be made available on the *Data Transferability and Collection Consistency Tethys* webpage which is currently under development, and users will have the ability to provide feedback virtually, if desired.

Additionally, the Framework and BMPs will be presented at MRE-related conferences and workshops to targeted audiences to inform the MRE community of these efforts. Conferences also provide another venue to solicit feedback on the documents.

Tethys Web Interface and Associated Content

A *Data Transferability and Collection Consistency Tethys* webpage is currently under development that will provide information on the data transferability process. The *Data Transferability Framework* and *Best Management Practices for Data Transferability and Collection Consistency for Marine Renewable Energy* documents will be available on the webpage, along with access to the *Monitoring Data Sets Discoverability Matrix* described below. Notes and reports generated from focus groups and workshops will also be available on the webpage, along with outreach materials. Users will have the ability to provide feedback on the available material.

Updates to the *Data Transferability Framework* and *Best Management Practices for Data Transferability and Collection Consistency for Marine Renewable Energy* documents and *Monitoring Data Sets Discoverability Matrix* will not only be communicated on the *Data Transferability and Collection Consistency Tethys* webpage, but will be communicated in relevant in bi-weekly *Tethys* Blasts that are sent to users to provide updates on MRE news and information that is new to *Tethys*.

Monitoring Data Sets Discovery Matrix

As a companion to the Framework, a *Monitoring Data Sets Discoverability Matrix* is being developed to classify monitoring data sets from already permitted/consented projects for the six stressors previously discussed. The matrix will be linked to key metadata features of each data set (i.e., data parameters, collection location, collection methods, contact, etc.). The matrix will allow regulators and/or developers to discover data sets based on the MREPA, and evaluate the consistency of information and therefore the ability to transfer data from an already permitted/consented project to future projects.

The *Monitoring Data Sets Discoverability Matrix* is in the initial stages of development and will be completed in fiscal year 2019. When completed, the matrix will be available as an interactive tool made available on the Data Transferability and Collection Consistency *Tethys* webpage. Updates to the matrix will be annual or as additional permitted/consented project data sets become available. New data sets will be sought out through direct communication with Annex IV country analysts, international wave and project developers, and the MRE community, with assistance from Aquatera Limited. A formal process for identifying new data sets will be developed in fiscal year 2019.

Case Studies

A series of case studies will be compiled that include already permitted/consented MRE projects with relevant monitoring data available related to the most common concerns for permitting/consenting MRE devices (collision risk, underwater noise, electromagnetic fields, changes in habitat, displacement, and changes in physical systems). These case studies will be evaluated against the Framework and *Monitoring Data Sets Discoverability Matrix* to ensure the processes and approaches can be easily and appropriately applied. The results of this exercise may result in updates to the Framework and BMPs, which will be communicated to relevant stakeholders by means described in this plan.

An initial set of case studies will be analyzed to test and update the data transferability process and to provide examples for regulators and others to apply the data transferability process.

Short Science Summary

Annex IV develops Short Science Summaries to ensure new research and findings are made available in a timely manner and in a short, accessible format for regulators, policy-level agency staff, developers, and other stakeholders. Short Science Summaries have been developed for collision risk, underwater noise, marine spatial planning, and permitting/consenting case studies, to name a few.

A Short Science Summary will be developed for the data transferability process. The summary will be available on the *Data Transferability and Collection Consistency Tethys* webpage and will also be publicized through a *Tethys* Blast issue and other outreach methods.

Outreach Plan

The following sections outline the outreach approach to relevant stakeholders to ensure familiarity of these efforts and solicit feedback.

Materials Development

Guidance and training materials will be developed that articulate the value and intent of and approach to the data transferability process. Tools will be provided (including the *Monitoring Data Sets Discoverability Matrix*, brochures, pamphlets, videos, recorded webinars*)* for defining, discovering, and applying data sets from already permitted/consented projects to future projects. The case studies identified through the matrix will be used as examples and tools to demonstrate the applicability of the data transferability process. These materials can be shared with and used by all relevant stakeholders to ensure they are familiar with and accepting of the data transferability process (and all components) and provide overall guidance on their implementation. These materials will be available on the *Data Transferability and Collection Consistency Tethys* webpage.

Outreach and Engagement Processes

Relevant stakeholders will be engaged through focus groups, workshops, webinars, conferences, and other publications to ensure their familiarity of the data transferability process and to solicit further feedback. The *Data Transferability and Collection Consistency Tethys* webpage will house all of the relevant documents, guidance, training material, notes, and tools.

Goals and Objectives Evaluation

The goals and objectives of the data transferability process will be evaluated several ways. Relevant stakeholders will be asked to take a short survey related to their familiarity with the data transferability process (and all components) and *Data Transferability and Collection Consistency Tethys* webpage. Those surveyed will be asked about their preferred engagement approach (e.g., focus group, workshop, webinar, email blast) to inform future engagement efforts and activities. They will also be asked if they have implemented any aspects of the data transferability process and to provide feedback. Results of the survey will inform future outreach and engagement efforts as well as serve as an annual review of the data transferability process. Additionally, Google Analytics will be used to track the visits and use of the *Data Transferability and Collection Consistency Tethys* webpage and the *Monitoring Data Sets Discoverability Matrix.* Metrics reported will include, but will not be limited to total visits and total page views. Results of the Google Analytics reporting will also inform future outreach and engagement efforts using *Tethys* as a platform to disseminate methods and materials associated with the data transferability process and to gather input to the matrix.

Next Steps

Soliciting input and feedback on the data transferability process is an ongoing effort. The data transferability process will be extended internationally to Annex IV countries, with Annex IV analysts acting as outreach agents to their respective regulators to introduce the process and solicit feedback in their respective countries. Focus groups, workshops, and webinars are being planned to continue the dialog with relevant stakeholders and ensure their concerns are heard. Once the data transferability process is finalized, it will be presented to the MRE community at workshops and conferences and will be published in relevant journals, if applicable. The refinement of the *Monitoring Data Sets Discoverability Matrix* will also be an ongoing effort. A series of validation case studies will be compiled to test the data transferability process and for training purposes, and the MRE community will be continuously engaged to identify other relevant data and information available for already permitted/consented projects. Guidance and training material will be developed, along with a Short Science Summary on the topic.

A virtual collaborative group of international representatives across the MRE communities may be formed. The purpose of this group will be to (1) share progress in understanding and permitting/consenting MRE projects, (2) provide technical assistance in using the data transferability process, and (3) gauge the success of the data transferability initiative.

Conclusion

As a means of addressing the concept of transferring data and information among MRE projects and collecting data consistently, a data transferability process has been developed that consists of a data transferability framework, approaches and recommendations for data collection consistency and data discoverability, BMPs, and implementation efforts. The process provides a background against which discussions with regulators can proceed as we come to understand the limits of transferability, based on the confidence individual regulators have to accept data and information collected for already permitted/consented projects for information analyses in support of applications for MREs in her/his jurisdiction. The data transferability process will facilitate initial permitting/consenting discussions between developers and regulators to determine data collection and monitoring efforts needed to permit/consent a project and determine operational monitoring needs.

Through the successful development and implementation of the data transferability process, Annex IV will continue its efforts of continuous outreach and engagement with relevant stakeholders to further the knowledge and understanding of potential environmental effects of MRE devices, in order to accelerate the siting and permitting/consenting process for MRE developments.

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