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Data Transferability and Collection Consistency in Marine Renewable Energy

An Update to the 2018 Report

May 2020

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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 consenting/permitting (hereafter "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 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 licenses, 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, 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 consenting process could be to transfer research, analyses, and datasets from one country to another, among projects, and across jurisdictional boundaries. However, data are collected and analyzed around early-stage MRE devices using many different measures, instruments, and methods. 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 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 datasets) among projects and collecting data consistently, OES-Environmental (formerly Annex IV) has developed a data transferability process that has been socialized with the MRE community including regulators, industry, developers, consultants, and researchers. The data transferability process consists of four components:

1. The *data transferability framework* brings together datasets in an organized fashion, compares the applicability of each dataset for use on other projects, and guides the process of data transfer.

2. The *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. The *monitoring datasets discoverability matrix* allows a practitioner to discover datasets based on the approach presented in the framework.

4. The *best management practices* (BMPs) include four BMPs related to data transferability and collection consistency.

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 datasets and processes for transferring data from already consented projects to future projects.
- 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 OES-Environmental and *Tethys* to facilitate the exchange of relevant data and information.
- Ensure developers and their consultants are active participants in OES-Environmental'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.
- Support the risk retirement process through the application and transfer of datasets, research, learning, and analyses.

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Preface

OES-Environmental (formerly Annex IV) was established by the International Energy Agency Ocean Energy Systems (OES) in January 2010 to examine environmental effects of marine renewable energy (MRE) development. The United States leads the OES-Environmental effort, with Pacific Northwest National Laboratory (PNNL) serving as the Operating Agent and partnered with the U.S. Department of Energy (DOE), the U.S. Bureau of Ocean Energy Management (BOEM), and the U.S. National Oceanic and Atmospheric Administration (NOAA). PNNL implements OES-Environmental, using *Tethys* as the platform on which OES-Environmental 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 15 partner nations for the OES-Environmental effort: Australia, Canada, China, Denmark, France, India, Ireland, Japan, Norway, Portugal, South Africa, Spain, Sweden, United Kingdom, and United States. Each country has an OES-Environmental country analyst who commits 20 hours per quarter to OES-Environmental. Some of the responsibilities include an online OES-Environmental country analyst meeting every 2 to 3 months, OES-Environmental 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. OES-Environmental is mobilizing information and practitioners from OES nations to coordinate research that can progress the industry in an environmentally responsible manner.

OES-Environmental is currently in Phase 3 (2016–2020), which includes a strong emphasis on working with regulators to facilitate consenting processes. In addition, OES-Environmental is focusing attention on collection of data and information about socio-economic 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
dB	decibel
DC	direct current
DOE	U.S. Department of Energy
EMF	electromagnetic field
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
ICOE	International Conference on Ocean Energy
MRE	marine renewable energy
NOAA	National Oceanic and Atmospheric Administration
OES	Ocean Energy Systems
PNNL	Pacific Northwest National Laboratory
WPTO	Water Power Technologies Office

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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 (mainly wave and tidal devices) may interact with the marine environment continues. Our understanding of the potential environmental effects of MRE development is 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 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, consent/permit (hereafter "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, research, analyses, and datasets from one country to another, among projects, and across jurisdictional boundaries.

1.1 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 consenting of MRE projects across multiple jurisdictions. 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 between MRE devices and the marine environment were identified as those most commonly associated with 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 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 from the longer-term operational sound of devices.

- Electromagnetic field (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.
- 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.
- 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.

1.2 Background

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 and analyzed around early-stage MRE devices using many different measures, instruments, and methods. 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 consenting processes, which would decrease financial risk for MRE project development.

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 of telecom and inter-island subsea power cables provide 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 knowledge on environmental effects from MRE has increased through research and MRE deployments, there are strong indications that effects from single or small numbers of devices are unlikely to be significant. The ability to “retire” potential risks from MRE that may not pose harm to marine animals or the environment can aid the MRE industry and help facilitate consenting as each potential risk may not need to be fully investigated for each new project. OES-Environmental has developed a risk retirement pathway (Figure 1) to detail the process of determining if a risk can be considered retired[1]. As PNNL developed the risk retirement process, the role of data transferability within that process became clear. Data transferability plays a key role in understanding potential risk (or absence of risk) by examining and applying existing learning, data, information, and analysis to determine if a risk can be retired (Figure 1 – stage 2 of the pathway). Additional information on risk retirement can be found in Copping et al. (2020a, 2020b).

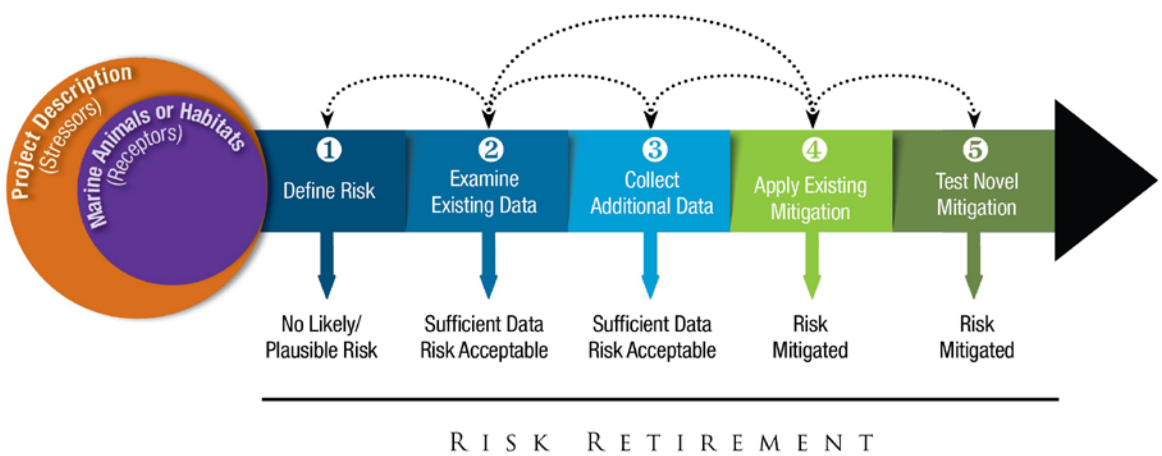

Figure 1. Risk retirement pathway. Data transferability is a key aspect of the risk retirement process, especially at stage 2 where exisiting data is examined.

As a means of addressing the concept of transferring data and information among projects and collecting data consistently, OES-Environmental has engaged with relevant stakeholders through surveys, focus groups, and workshops. A discussion of these engagement and

[1] The concept of risk retirement aims to “retire” risks that are unlikely to have significant effects on marine animals or the environment for single or small numbers or devices. While a risk may be considered retired, if more information comes to light from larger deployments of arrays there may be a need to reconsider the risk and make new decisions about the potential for risk.

outreach efforts and their contribution to the development of the data transferability process is described in Section 2.0. The data transferability process and associated components are detailed in Section 3.0. Future work and next steps are discussed in Section 4.0 and conclusions are summarized in Section 5.0. Additional information on data transferability can be found on *Tethys*.[2]

[2] Find more information on the *Tethys* data transferability page: https://tethys.pnnl.gov/data-transferability

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 is a perception that regulators in many jurisdictions are not eager to rely on datasets, information, and outcomes generated from already consented projects to make consenting decisions for other projects 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 consenting risk, and their appetite to engage in a data transferability process (Section 2.1).

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' willingness to use such data from another project to consent a project in their jurisdiction (Section 2.3). The international research and development community was then brought together at several in-person and online workshops to gather additional feedback on the data transferability process, its individual components, and its implementation (Section 2.4). Finally, the regulatory communities in other OES-Environmental countries were surveyed to determine the level of understanding of MRE technologies, priorities for consenting risk, and their appetite to engage in a data transferability process (Section 2.5). The following sections discuss these outreach and engagement activities.

2.1 U.S. Regulator Surveys

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 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, consenting, or consulting on MRE licenses. 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 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 they had recommendations for others to add to the outreach list. The regulator mailing list has continued to be updated as new U.S. regulators engage in the process.

Following the *Environmental Effects of Permitting MRE Developments* webinar 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 consenting MRE developments. An invitation to participate in the survey was sent to the U.S. regulators 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, key challenges, and thoughts on best approaches for MRE development and data transferability. The survey results and next steps based on the findings were shared with regulators during a second webinar, *Environmental Effects of Permitting MRE Developments: Regulator Survey Results and Next Steps*, held in November 2017. Results of the regulatory survey helped confirm the selection of the six stressors previously discussed and revealed that regulators were open to using data from already consented projects to inform future projects, especially with increased knowledge of the MRE technologies, types of data collected, and methods of data collection. More information can be found in the *MRE Regulator Survey Report*.

2.2 Data Transferability White Paper

A white paper entitled *Marine Renewable Energy: Data Transferability and Collection Consistency* 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 consented projects for a future project.
- Outline a process for creating best practices for transferring data from an already 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 included 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 *Marine Renewable Energy: Data Transferability and Collection Consistency*.

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 stressors (described previously) that are commonly associated with the consenting challenges 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 this concept, an interaction defined by the combination of four variables (stressor, site conditions, MRE technology, and receptor) can be applied to help meet MRE regulatory needs.

The concepts behind the data transferability white paper were presented to U.S. regulators through a series of focus groups, 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 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 *Data Transferability and Collection Consistency workshop* in June 2018, discussed in Section 2.4. Suggestions and feedback received from these outreach and engagement activities were used to further refine the data transferability process, as presented in Section 3.0.

2.3 U.S. 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 datasets, 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 datasets on relevant environmental stressors to increase their understanding of potential environmental effects and obtain their feedback on perceived limitations for accepting data generated for already consented project for their own regulatory analyses.
- Present the data transferability framework, including *Guidelines for Transferability* (Section 3.1.2, Figure 3), to receive feedback on the usefulness of the framework and understand how the framework might be improved.

- Integrate lessons learned from the variety of federal and state regulators who are constrained by different legal and regulatory regimes for 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. 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 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.

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 preferred 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; many stated that they needed a method for dataset discoverability to find comparable datasets with which to inform their consenting decisions.

2.4 Workshops

2.4.1 2018 Data Transferability and Collection Consistency Workshop

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* on June

11th held in concert with the International Conference on Ocean Energy (ICOE) 2018 in France. There was a total of 17 participants at the workshop, which included OES-Environmental Analysts, consultants, developers, researchers, and government representatives from 7 countries (Canada, France, Ireland, Japan, Portugal, Scotland, and the U.S.). 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* (Section 3.2) and associated draft BMPs (Section 3.4);
- Discussions of improving and/or accepting the framework, data collection consistency, and the BMPs;
- A brainstorming session to begin developing implementation strategies for the data transferability process.

Overall, the participants thought the data transferability framework would help regulators and developers throughout consenting processes and that the BMPs were well developed and applicable. They noted that it is necessary to have regulators and developers buy in to the data transferability process, and in order to do so the process would have to be practical for developers to carry out and attractive for regulators to use (or require of developers) for consenting processes. Additionally, participants argued that 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 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 implementation. 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.

2.4.2 2018 Data Transferability Online Webinars

Two online webinars were held in August and September 2018 to present the data transferability process, especially the BMPs, and show some sample data on the key stressors from the focus groups. The August 2018 webinar was geared towards regulators that had yet to engage, while the September 2018 webinar was a public *Tethys* webinar geared towards the broader MRE community. A total of 13 regulators attended the August webinar, including federal representatives from DOE, Federal Energy Regulatory Commission (FERC), Fish and Wildlife Service, National Oceanic and Atmospheric Administration (NOAA), and several state agency representatives from California, Oregon, Rhode Island, and Virginia. A total of 34 members of the MRE community attended the September webinar.

Feedback from the workshop was recorded and summarized by the project team. Feedback on the data transferability process and BMPs were positive. Participants mentioned that it would be useful to know to what extent transferability has been used with existing consent applications and success of initial attempts to use transferred data.

2.4.3 2019 Data Transferability Online Workshop

An online workshop was held in April 2019 to engage a broader audience of U.S. regulators, specifically including regulators who had consented U.S. test centers, and update any regulators on the latest progress related to data transferability. The workshop walked through data and information for each of the six stressors and presented the data transferability process. The April workshop was held on both April 9th and April 16th. A total of 18 attendees participated in the online workshops, including federal representatives from the Army Corps of Engineers, BOEM, FERC, NOAA, and several state agency representatives from California, Hawaii, Maine, New York, and Oregon. The recording of the workshop was posted to *Tethys* for further engagement and has been viewed 11 times.

Feedback from the workshop was recorded and summarized by the project team. Participants reacted positively to the quality of data and visualizations available, especially for collision risk, and found the information presented helpful to gain a better understanding of MRE. Overall there was strong support for the concept and application of data transferability for the key MRE-environment interactions. There was a concern about the application of data transferability and that projects either may not be similar enough to enable accurate transfer of data or that projects would still need to collect some site-specific data (especially for habitat change). Some participants recommended that low-frequency sounds and potential masking effects be studied further. Some participants noted that changes to physical systems require accurate and detailed models to collect appropriate data. One regulator suggested that further studies be done to refine transferability of mitigation options.

2.4.4 2019 Risk Retirement Online Workshop

A workshop was held in May 2019 to introduce the concept of the *monitoring datasets discoverability* matrix, showcase data transferability case studies, and present the risk retirement pathway (see Figure 1). U.S. regulators were invited to the workshop, which was presented separately on two days (May 28th and May 30th). A total of 10 attendees participated in the online workshops including federal representatives from BOEM, DOE, and NOAA, and several state agency representatives from Hawaii, New York, and Oregon. The recording of the workshop has been posted to *Tethys* for further engagement.

Feedback from the workshop was recorded and summarized by the project team. Participants liked the idea of risk retirement and continued to express support for data transferability. While there was limited feedback, some key points included the need to include monitoring as part of applying mitigation strategies to see if mitigation is successful and the continued need for baseline data especially as the industry progresses. One participant expressed that the pathway depends on having a significant project in the water to assess risk and effects. Another participant noted that effects can only be minimized so much, and since mitigation will be used to offset those effects it would be helpful to include data to show if such efforts have been successful. One participant also noted that as risk retirement moves forward it is important for data collected on environmental effects to inform regulatory analyses and to also be defensible in court to prove levels of risk, especially in Endangered Species Act situations. Another participant explained that it is important to define the risk retirement process as a guidance framework, rather than a one-size-fits-all scenario and that risk retirement may take away some leverage of collecting future data by regulators as part of consenting requirements.

2.4.5 2020 Data Transferability and Monitoring Datasets Discoverability Matrix Online Workshops

Two workshops were held in February 2020 to showcase the online *monitoring datasets discoverability matrix* (matrix) on *Tethys* and receive feedback on the matrix from regulators before making it publicly available. The first workshop was held with UK regulators from the ORJIP Steering Committee on February 25th. UK regulators were included in this engagement effort as they have experience consenting MRE projects and would be able to provide useful feedback on the applicability and use of the matrix. The second workshop was held with U.S. regulators on February 27th. A total of 16 attendees (7 UK regulators and 9 U.S. regulators – including representatives from BOEM, FERC, Bureau of Safety and Environmental Enforcement, NOAA, California, Oregon, and Washington) participated in the online workshops. The recording of the workshop has been posted to *Tethys* for further engagement.

Feedback from the workshop was recorded and summarized by the project team. Overall the regulators thought the matrix was well developed and would be useful. They especially thought it is valuable for making data available in one location since it can be difficult to find monitoring studies or data/information. One regulator who has been involved in OES-Environmental’s engagement efforts since 2017 confirmed that the matrix was something asked for by the regulators to help consolidate and easily access information. While regulators understood that there is still a need for data, there was agreement that the matrix would be increasingly useful as more data is collected and available. It was stated that it would be helpful to have some case studies of the data transferability process and document transferability to increase the acceptability of transferring data from one project to another. In the future, regulators thought it would be useful to increase the specificity of the matrix (for example, classified by species or functional groups) as more data is available.

2.5 International Regulator Surveys

Surveys have been conducted with regulators in other OES-Environmental countries, analogous to those in the U.S. These surveys were sent to regulators identified by each country’s OES-Environmental Analyst. The original U.S. regulator survey was used as a template and was reviewed and revised by each country’s OES-Environmental Analyst to be relevant and appropriate for their country, and where necessary, was translated by the Analyst. To date, survey results have been analyzed and a report of the results developed for the following countries:

- *Canada*: Eight regulators participated. The Canadian regulators that participated in this survey have experience consenting MRE and are much more familiar with tidal devices than wave devices. The agencies they represent primarily focus on the effects of MRE devices on seabed, habitat, and marine animals. Their main concern in consenting MRE developments, for both single devices and arrays, is collision risk. In general, regulators are open to transferring data to consent projects, but are concerned about the applicability of local or site-specific data to different locations, especially unique habitats. One regulator indicated that data transferability would never be possible for the Bay of Fundy ecosystem. The majority of participants favor a phased approach to develop the MRE industry, where single devices are deployed first before slowly ramping up to array scale after potential risks are better understood and managed. About half of the regulators surveyed have been using *Tethys* for over a year and have found it moderately to very useful. The remaining regulators were not aware of the *Tethys* platform or the work of OES-Environmental. Promotion of OES-Environmental and *Tethys* among Canadian regulators is recommended to increase the success of additional outreach for webinars and trainings, to improve general knowledge about environmental effects of MRE, and move the industry forward.

- *France*: Twelve regulators participated. Most of the French regulators that participated in this survey have participated in the consenting of an MRE project, though most indicated that they are not very familiar with any types of tidal or wave devices. All regulators indicated that they are at least somewhat familiar with floating and fixed offshore wind turbines. The agencies they represent primarily focus on environmental protection and management. Their main concerns are collision risk and the effects of underwater noise for single devices, which is similar for arrays with the added concern of water quality degradation. All but one regulator indicated that they are open to transferring data to consent projects, with the caveat that data must be relevant for the location and scrutinized to determine comparability. The preferred approach to development of the MRE industry varies widely among the French regulators, with an even split for adaptive management and survey, deploy, and monitor as the top approaches. Most participants were not aware of *Tethys*, and those that are aware have found it somewhat to very useful but have been using it in limited ways. Going forward, the use of *Tethys* as a platform for additional engagement, including data transferability and risk retirement, will require increased promotion of *Tethys* and demonstration of its features and capabilities in order to reach regulators in France.
- *Ireland*: Four regulators participated. Half of the Irish regulators have participated in consenting of an MRE project. None of the regulators surveyed consider themselves very familiar with any wave or tidal technologies, though they were slightly more familiar with wave energy technologies than tidal, with mixed experience based on type of device. The agencies they represent focus on foreshore leasing/licensing, with less emphasis on environmental factors for consenting. Their main concerns are benthic/habitat disturbance and underwater noise for single devices, and benthic/habitat disturbance and collision risk for arrays of devices. Most regulators are open to the possibility of transferring data for consenting projects. The preferred approach to development of the MRE industry is split between mitigation hierarchy and a phased approach. Most regulators were not familiar with *Tethys*, though the regulator that used it for environmental effects information found it moderately useful. Going forward, the use of *Tethys* as a platform for additional engagement, including data transferability and risk retirement, will require increased promotion of *Tethys* and demonstration of its features in order to reach regulators in Ireland.
- *United Kingdom (UK)*: Seven regulators participated. The UK regulators that participated in this survey have experience consenting MRE and are most familiar with tidal devices. The agencies and advisors they represent focus more on the effects of MRE devices on marine mammals, fish, seabirds, and ecology than they focus on economic or social effects. Their main concern in consenting MRE developments, for both single devices and arrays, is collision risk. In general, regulators are open to transferring data to consent projects, but note that it depends on the applicability of the data to the specific site of the project to be consented. Most of the participants prefer an adaptive management approach for both tidal and wave projects as a means to move the MRE industry forward from a consenting

perspective. Most regulators have been using *Tethys* for over a year to gather information about environmental effects and have found it moderately to very useful. Going forward, the use of *Tethys* as a platform for additional webinars and trainings seems useful and likely to be successful for regulators in the UK.

- *Spain:* Two regulators participated. The Spanish regulators who participated have differing levels of experience consenting MRE and are not familiar with MRE devices. The government agencies they represent focus on the effects on marine mammals, fish, seabirds, and other animals rather than on energy production. Their main concerns in consenting MRE developments, for both single devices and arrays, is energy removal from the environment and changes to flow patterns. In general, regulators are open to transferring data to consent projects, but note that it depends on the applicability of the data to the specific site of the project to be consented. Regarding *Tethys* use, one regulator has been using *Tethys* for over six months to gather information about environmental effects and has found it very useful. Going forward, the use of *Tethys* as a platform for additional webinars and trainings seems useful but will require increased promotion for awareness in Spain. While the two regulators who participated are the main regulators dealing with consenting of environmental effects of MRE at the Spanish national level, additional feedback from a larger number of regulators at different levels of government, especially the regional level, is recommended to provide a more representative view of Spanish regulator opinions. PNNL is currently working with the Spanish OES-Environmental Analyst to survey regional regulators. If additional regulators respond, the results and associated report will be updated.

- *Sweden:* One regulator participated and had no experience consenting MRE and is not familiar with MRE devices. The federal agency represented focuses on energy production. The lack of responses to questions makes it difficult to identify concerns in consenting MRE developments for single devices or arrays. Since the participant did not respond to any of the questions regarding *Tethys*, no information is available on regulator awareness, uses, or perceived usefulness of *Tethys* as a platform for communicating the environmental effects of MRE. Increased promotion of *Tethys* as a tool may be helpful in increasing regulator awareness and engagement. The low response rate on this survey for Sweden indicates that a more strategic approach is needed to increase participation. It appears that this survey is not the best option at this time to engage regulators. Without sufficient responses from regulators it is difficult to know how to move forward. At the time, the Sweden OES-Environmental Analyst noted that there has been a decrease in interest and funding for MRE in Sweden. It should also be noted that during this time, the Sweden OES-Environmental Analyst lost funding from the Swedish government. If a new Sweden OES-Environmental Analyst is appointed and there is a renewed interest in MRE, it may be fruitful to repeat the survey with additional engagement approaches such as personal emails to regulators to increase participation.

Other countries that are planning surveys are listed with their current status below:

- *Australia*: PNNL is working with the Australia OES-Environmental Analyst to revise the survey to fit the Australian regulatory context and to compile a list of regulators.

- *China*: The Chinese regulator survey is finalized with a list of regulators to contact, but there has been a change in participation among the Analysts. When China reengages, there is reason to move forward with the survey.

- *Japan*: Some survey responses have been received on paper during an even the Japanese OES-Environmental Analyst attended. In the future, the goal is to increase additional participation from Japanese regulators through an online version of the survey.

- *Portugal*: The Portuguese OES-Environmental Analyst is interested in distributing the survey but indicated that they do not have time at the moment.

3.0 Data Transferability Process

Feedback and input solicited from the regulator surveys, regulator focus groups, and workshops (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 2, the process of data transferability consists of four components:

1. The *data transferability framework* brings together datasets in an organized fashion, compares the applicability of each dataset for use on other projects, and guides the process of data transfer (Section 3.1)
2. The *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 (Section 3.2)
3. The *monitoring datasets discoverability matrix* allows a practitioner to discover datasets based on the approach presented in the framework (Section 3.3)
4. The *best management practices* (BMPs) include four BMPs related to data transferability and collection consistency (Section 3.4)

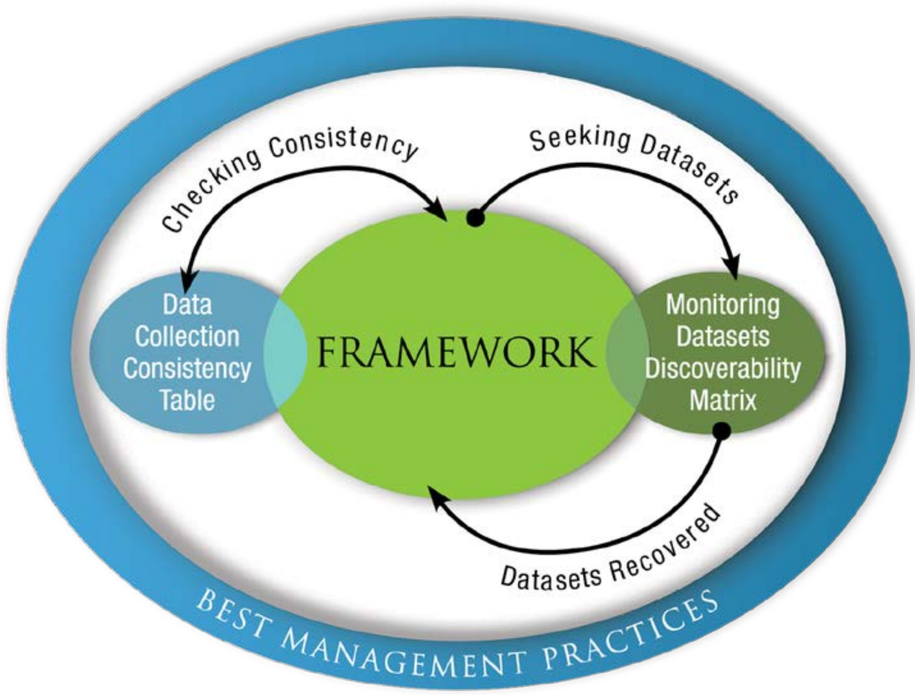

Figure 2. Data Transferability Process.

3.1 Data Transferability Framework

Under OES-Environmental, a d*ata transferability framework* ("framework") has been developed that:

- Brings together datasets from already consented projects in an organized fashion
- Compares the applicability of each dataset for use in 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, consenting, post-installation monitoring, and mitigation

3.1.1 Defining Interactions

The viability of transferring data or learning from already 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 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 this concept, an interaction defined by the combination of four variables (stressor, site conditions, MRE technology, and receptor) can be applied to help meet MRE regulatory needs.

A series of tables has been developed for each of the six stressors that can be applied to an already consented project and proposed future projects. From each table, an interaction can be identified for a particular project or dataset that might be useful for transfer. For example, the interaction table for collision risk indicates 22 possible interactions based on the project site conditions, MRE technology types, and receptors (Table 1). Defining the interaction is the first step in determining the ability to transfer data from already consented projects to future projects, as discussed in the following section. The tables for the six stressors are shown in the Appendix.

Table 1. Interaction 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.

3.1.2 Applying the Framework

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

To apply the framework, the following *guidelines for transferability* have been laid out as a hierarchy (Figure 3). The hierarchy of guidelines for transferring data and information from already 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 (interaction defined by same four variables 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.

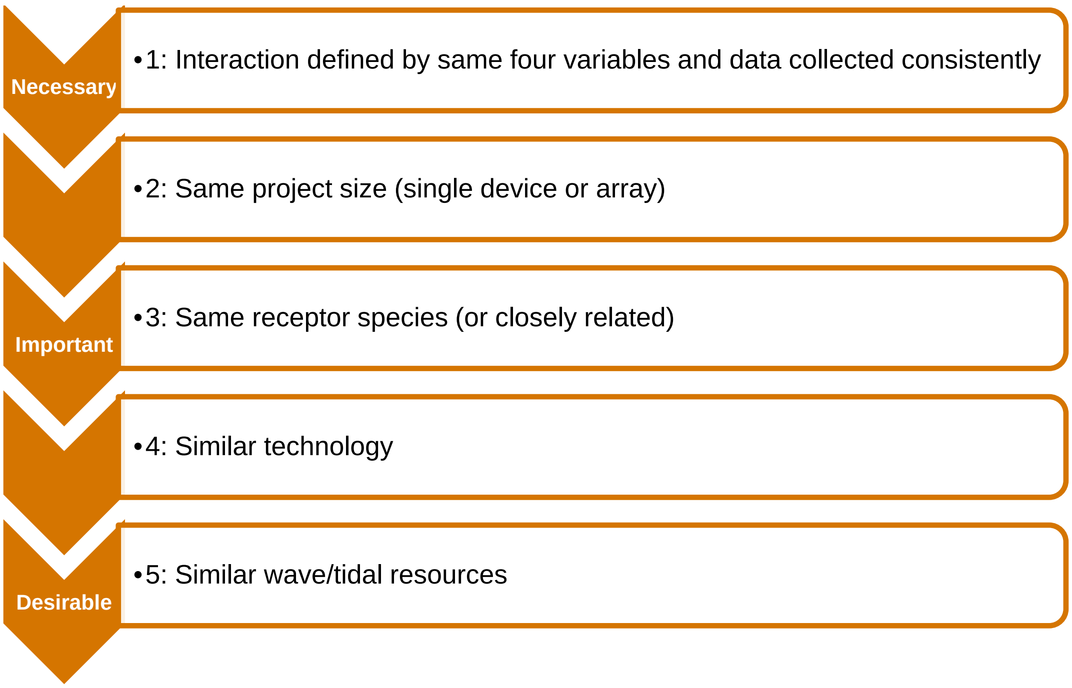

Figure 3. Guidelines for Transferability.

Step 1: Characterize the interaction of the future project by examining the stressor, site conditions, MRE technology type, and receptor. Figure 4 provides an example of characterizing a project for collision risk for marine mammals. Compare the interaction of the future project with those of already consented projects to determine the similarity of the interactions. The two projects must share the same interaction, thereby ensuring that the two projects share the same stressor, site conditions, MRE technology type, and receptor. Furthermore, the data must be collected consistently in order for the data to be transferred.

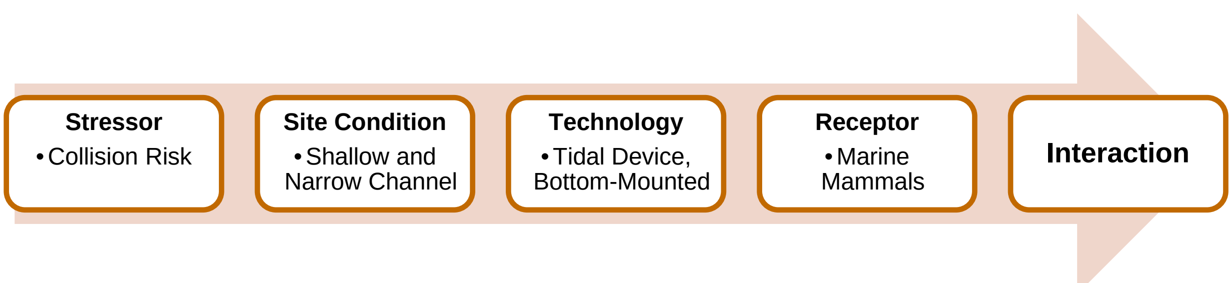

Figure 4. Example of an interaction for an already consented project.

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, 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 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 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 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 consented projects for information analyses in support of applications for MRE developments in her/his jurisdiction. The framework will also facilitate initial consenting discussions between developers and regulators to determine data collection and pre-installation monitoring efforts needed to consent a project and to determine post-installation operational monitoring needs.

By implementing the framework, the siting and 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 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 consented project are compatible with the needs of future projects, and that multiple datasets 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.

3.2.1 Assuring Data Consistency

MRE is an international industry, with 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 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. The information presented in the *data collection consistency table* was compiled by PNNL and Aquatera subject matter experts. The information has been presented to U.S. regulators, the larger MRE community, and the OES-Environmental Analysts for further review and assessment.

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 ● video only ● observations from vessel or shore	• Number of visible targets in the field of view • Number of collisions	• Number of collisions and/or close interactions of animals with turbines over time, used to validate collision risk models. • Avoidance/evasion • Density of animals that may raise risk (based on subsea observations) vs predicted densities from models or surface counts to refine collision risk models.
Underwater noise	Fixed or drifting hydrophones	Sound spectrum (amplitude as function of frequency) with units: Amplitude: dB re 1 µPa at 1 m Frequency (Hz/kHz): frequencies within marine animal hearing range	Sound outputs from MRE devices compared to 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 in Tesla units (µT or mT)	Measured EMF levels used to validate existing EMF models around cables and other energized sources.
Habitat change	Underwater mapping with ● sonar ● video Habitat/species distribution characterized from ● mapping	Area of habitat/species distribution altered, specific for each habitat type/species.	Compare potential changes in habitat and/or species distributions to maps of rare and important habitats/species to assure that these vulnerable species and habitats are not likely to be harmed by the location of the proposed project.

	• existing maps • grabs and other benthic sampling gear		
Displacement/ Barrier effect	Population estimates on or near a project site by: • human observers • passive or active acoustic monitoring • video	Population estimates for species under special protection. Importance of high-energy areas for key activities/transit.	• Validation of population models • Estimates of jeopardy • Loss of species for vulnerable populations, locally or globally
Changes in oceanographic systems	Numerical modeling, with field data validation for currents, turbulence, wave height, wave period, etc.	No units. Indication of datasets used for validation, if any.	Data collected around arrays should be used to validate models.

3.2.2 Quality Assurance

The process of transferring data or information from already 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 datasets and/or to search out the provenance of the information.

3.2.3 Guidelines for Evaluating Qualitative Data

Without strict adherence to common methods and instruments for collecting data, there will continue to be inherent differences among datasets 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 consenting 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 datasets 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 3), while strategies to ensure trustworthiness in qualitative research data are laid out in Table 4.

Table 3. 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 4. Definition of strategies to ensure trustworthiness 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 behavior and experiences, but their context as well, so that the behavior 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.

3.3 Monitoring Datasets Discoverability Matrix

In FY20, PNNL completed the development of the *monitoring datasets discoverability matrix* (matrix), an interactive tool available on *Tethys* that classifies monitoring datasets from already consented projects for the six stressors previously discussed. The matrix allows regulators and/or developers to discover datasets and evaluate the consistency of information and therefore the ability to transfer data from an already consented project to future projects.

PNNL has collected and categorized relevant datasets for inclusion in the matrix. The datasets could be in the form of raw or quality-controlled data but could also include information in the form of analyzed, synthesized data to reach a conclusion, reports, and other material that has been presented to regulators as part of a consenting process. Each entry in the matrix is tagged for easy retrieval, allowing the user to identify useful datasets by environmental parameters, type of MRE technology, stressors evaluated, and receptor animal groups and habitats. That data and information included in the matrix are automatically filtered and included based on information curated and available on *Tethys* and includes:

1. OES-Environmental project site metadata forms: The main source of monitoring datasets for the matrix are OES-Environmental metadata from MRE project sites or test sites. OES-Environmental has designed metadata forms (or questionnaires) that solicit information from developers and researchers that are involved in environmental monitoring around MRE project sites or test sites. These metadata forms capture many of the activities around the world that are exploring potential environmental impacts of MRE devices. For ongoing projects, each metadata form is aimed to be updated on an annual basis. Currently there are 108 project site metadata forms on *Tethys*. In FY20, OES-Environmental went through a process to update all project site metadata forms to include the key characteristics that are described in the matrix (i.e., depth, support structures, etc.). This allows the matrix to automatically pull and sort information from the 108 project site metadata forms as the matrix output, allowing users to easily find relevant monitoring data and information from project sites. Each project site includes a baseline assessment and a post-installation monitoring table that summarizes environmental monitoring completed around the MRE project or test site. Each entry has linkages to the metadata form for the project or test site located on *Tethys*, with details on the datasets available and/or a contact person for the project. All project site metadata can be found here.

2. OES-Environmental research study metadata forms: OES-Environmental also collects metadata forms from developers and researchers that are involved in environmental studies related to MRE. For ongoing research, each metadata form is aimed to be updated on an annual basis. Currently there are 72 research study metadata forms on

Tethys. Similar to the journal articles, research studies are included in the matrix results, but are sorted only by stressor and receptor and they don't have the same level of detail as the project site metadata forms. All research study metadata can be found here.

3. Key journal articles: As OES-Environmental has developed the risk retirement process, evidence bases have been compiled for the understanding and retirement of stressors. To date, four of the six stressors (underwater noise, EMF, habitat changes, and changes in physical systems) have been completed and key journal articles for each of the four have been documented. These key journal articles are included as a matrix result but sorted only by stressor and receptor (rather than the other characterizes, such as technology type, structure, etc.).

A workshop with U.S. and UK regulators was held in February 2020 to receive feedback on the matrix and its usefulness (Section 2.4.5). The matrix was also presented to the OES-Environmental Analysts at a quarterly meeting to receive feedback. Feedback from the regulators and the Analysts have been incorporated into the matrix. The matrix will be finalized shortly and a *Tethys* public webinar announcing and demonstrating use of the matrix will be held for the broader MRE community. The matrix will continue to be updated in the future through the addition of new metadata forms for projects and research studies that have relevant datasets for transfer, curated by the *Tethys* team.

3.4 Best Management Practices

The term 'best management practices', or BMPs, was coined in the U.S. 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 U.S. Environmental Protection Agency (EPA) for developing guidance for National Pollutant Discharge Elimination System 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.

3.4.1 Development of 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 consented MRE projects to future MRE projects among regulators 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 other OES-

Environmental nations, and to engage the development community in understanding what is needed for consenting of MRE devices.

The development phase included drafting BMPs, assessing their pertinence and completeness, and developing a process for implementation. The group of experts brought together at the 2018 workshop held in conjunction with ICOE provided review and input on the framework and draft BMPs (Section 2.4.1).

3.4.2 Best Management Practices

BMPs proposed to meet the *guidelines for transferability* (Figure 3) were developed using the six stressors (collision risk, underwater noise, EMF, changes in habitats, displacement of marine animals, changes in physical systems) 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 dataset 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 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 interaction and data collected consistently) are met for similarity and comparability between the datasets from already consented projects to those of future projects. For this BMP, the interaction of the new project, and that of the already consented projects, will be determined.	Determine interaction(s) for the future project site. Search for similar interaction(s) in the *monitoring datasets discoverability matrix* and choose data sets from consented projects that match.	This practice is intended for those within the MRE community looking to transfer data from already 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 consented project and a future project as it ensures that the methods used to collect and analyze data from an already 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 datasets are sufficiently similar and adequate.	This practice is intended for those within the MRE community looking to transfer data from already consented projects to a future project (e.g., developers, consultants, regulators).

BMP 3	**Use models in conjunction with and/or in place of datasets.**	
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 (e.g., 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 datasets to be transferred.**	
Purpose	**Process**	**Intended Party**
This practice encourages the use of available and pertinent datasets to enhance the interpretation of data and information. The use of ancillary datasets 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 datasets to provide context for the MRE interaction data. These datasets 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 datasets to be transferred (e.g., developers, consultants, regulators, and researchers).

3.4.3 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 consenting MRE devices. It is desirable that all parties support and apply the BMPs so 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 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.

4.0 Future Work

The development of the data transferability process is complete, though open to revision over time. The focus going forward will be on risk retirement and further engagement with regulators. As PNNL focuses on the larger risk retirement process, data transferability will continue to be an important aspect of OES-Environmental work moving forward.

4.1 OES-Environmental Phase 4 Proposal

Through the first three phases of Annex IV/OES-Environmental (2009-2012; 2013-2016; 2016-2020), OES-Environmental has been successful in accomplishing the initial goals set out in 2008: to facilitate efficient government oversight of the development of ocean energy systems by compiling and disseminating information on the potential environmental effects of these technologies and identifying methods used to monitor for effects.

Analysts from the 15 nations participating in Phase 3 of OES-Environmental believe that there is an important continuing role for OES-Environmental to play in understanding environmental effects, making consenting processes more efficient, and furthering the MRE. As such, OES-Environmental nations have proposed that the initiative be continued for a fourth phase, lasting four years (2020-2024).

The proposed objectives of Phase 4 of OES-Environmental are to:

- Continue to curate and expand the knowledge base hosted on *Tethys* to ensure that all relevant publications are represented and accessible;
- Continue to update and collect metadata on all MRE projects for which environmental effects information has been collected;
- Engage members of the MRE community and their organizations around key questions of environmental interactions that are of importance for devices and arrays;
- Provide information that is useful and accessible for regulators to reduce uncertainty around environmental effects, and continue to make strides with risk retirement and data transferability;
- Identify and disseminate information on environmental effects uncertainties that continue to slow and complicate the development of the MRE industry through active outreach and engagement to device and project developers, researchers, and regulators;
- Support the acceleration of scientific findings into management and policy products to help reduce uncertainty for sustainable MRE development;
- Ensure that OES member nations are kept apprised of important findings in environmental effects research and monitoring; and
- Ensure that the new name OES-Environmental is recognized and accepted as the same effort as the previous Annex IV.

DOE and their U.S. partners will continue to coordinate tasks among the task participants for all aspects of the work. The activities will be implemented by PNNL, on behalf of DOE, with significant input and specific work products led and carried out by the analysts from the OES-Environmental participating nations.

4.2 Next Steps

During FY19 the focus of OES-Environmental work shifted from data transferability to risk retirement. The focus will continue to be on risk retirement for certain interactions of MRE devices and the marine environment. During FY20, the high-level goals for the project include a draft framework for guidance on risk retirement, including the methodology and criteria for developing guidance documents for four major stressor-receptor interactions (EMF, underwater noise, habitat changes, and changes in physical systems). Specific tasks for the FY20 that are relevant to data transferability are described in the subsections below.

4.2.1 Monitoring Datasets Discoverability Matrix

During FY20, PNNL will continue to collect and categorize relevant datasets for inclusion in the *monitoring datasets discoverability matrix*. A public webinar announcing and demonstrating use of the matrix will be conducted when the matrix is finalized. The matrix will continue to be updated in the future through the addition of new metadata forms for projects that are relevant for data transferability, curated by the *Tethys* team.

4.2.2 Triton Coordination

The Triton Field Trials (T-Fit)[3] project was born from the necessity to further investigate the need for data collection consistency for monitoring around MRE devices. Data collection consistency is a necessary element of the data transferability and risk retirement processes in order to reduce requirements necessary for each MRE consenting application. As T-Fit carries out field tests and identifies a suite of methods and instruments that are preferred for measuring key stressor-receptor interactions, OES-Environmental will assess those outputs and integrate them into the matrix, if applicable, and into the draft guidance framework for risk retirement.

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[3] The PNNL Triton initiative, Triton Field Trials (TFiT), has built on OES-Environmental's efforts with the data collection consistently table and are reviewing commonly used methods and measures for environmental monitoring to produce best practices and conduct field trials in the Pacific Northwest. To read more about the Triton initiative, visit their website https://triton.pnnl.gov/.

5.0 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 consented projects for information analyses in support of applications for MREs in their jurisdictions. The data transferability process will facilitate initial consenting discussions between developers and regulators to determine data collection and monitoring efforts needed to consent a project and determine operational monitoring needs.

Through the successful development and implementation of the data transferability process, OES-Environmental 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 consenting process for MRE developments.

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Appendix

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 48 possible interactions based on the project site conditions, marine renewable energy (MRE) technology types, and receptors (Table 1).

Table 1. Interaction Table for Collision Risk.

Site Condition[a]	Technology	Receptors
Shallow and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Subsurface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Surface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
Shallow and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Subsurface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Surface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
Deep and Narrow Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Subsurface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Surface)	Marine Mammals
		Fish
		Birds

		Sea Turtles
Deep and Wide Channels	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Subsurface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Surface)	Marine Mammals
		Fish
		Birds
		Sea Turtles

(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

Underwater noise emitted from wave and tidal devices may affect marine mammals and fish by causing changes in behavior such as avoidance or attraction to the device and/or by masking communication (Copping et al. 2016). However, MRE devices may not be detectable above ambient noise levels and other anthropogenic sources and there is little evidence that the effects of underwater noise from a single device create a substantial disturbance or cause injury to marine animals (Copping et al. 2020a, 2020b).

Projects related to underwater noise have the potential to be classified as one of 8 possible interactions based on the project site conditions, MRE technology types, and receptors (Table 2).

Table 2. Interaction Table for Underwater Noise.

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

Electromagnetic fields (EMFs) emitted from MRE devices, power cables, underwater substations, or transformers may affect marine animals by causing changes in behavior such as avoidance or attraction to the power source, changes in hunting or feeding patterns, and/or changes in physiology or development in certain species (Copping et al. 2016). However, due to the level of power carried in MRE cables, EMFs are not likely to be a risk for small numbers of MRE devices (Copping et al. 2020a, 2020b).

Projects related to EMF have the potential to be classified as one of 9 possible interactions based on the power export cables and receptors (Table 3).

Table 3. Interaction Table for Electromagnetic Fields.

Power Export Cables	Receptors
Buried Seafloor Cables	Fish
	Invertebrates
	Sea Turtles
Unburied Seafloor Cables	Fish
	Invertebrates
	Sea Turtles
Cables in the Water Column	Fish
	Invertebrates
	Sea Turtles

Habitat Change

Physical changes in benthic and pelagic habitats due to the installation of MRE devices may alter species occurrence or abundance at a localized scale, lead to some level of habitat loss, and/or cause changes in animal behavior. Habitat changes, including effects of fish and other animals 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). Habitat changes are divided into water column and benthic habitat changes due to the difference in effects based on where the MRE device and its associate parts are located.

Projects related to habitat changes in the water column have the potential to be classified as one of 15 possible interactions based on the MRE technology types, support structures, and receptors (Table 4).

Table 4. Interaction Table for Habitat Change (Water Column).

Technology	Support Structure	Receptors
Bottom-Mounted	Monopile	Marine Mammals
		Fish
		Birds

		Invertebrates
		Sea Turtles
	Gravity Base	Marine Mammals
		Fish
		Birds
		Invertebrates
		Sea Turtles
Floating	Mooring Lines	Marine Mammals
		Fish
		Birds
		Invertebrates
		Sea Turtles

Projects related to benthic habitat changes have the potential to be classified as one of 33 possible interactions based on the MRE technology types, support structures, and receptors (Table 5).

Table 5. Interaction Table for Habitat Change (Benthic).

Site Condition	Support Structure	Receptors
Soft-Bottom Habitat	Monopile	Fish
		Invertebrates
		Sea Turtles
	Gravity Base	Fish
		Invertebrates
		Sea Turtles
	Rock Anchor	Fish
		Invertebrates
		Sea Turtles
	Gravity/Deadweight Anchor	Fish
		Invertebrates
		Sea Turtles
	Drag Embedment Anchor	Fish
		Invertebrates
		Sea Turtles
	Suction Bucket Anchor	Fish
		Invertebrates

		Sea Turtles
Hard-Bottom Habitat	Monopile	Fish
		Invertebrates
		Sea Turtles
	Gravity Base	Fish
		Invertebrates
		Sea Turtles
	Rock Anchor	Fish
		Invertebrates
		Sea Turtles
	Gravity/Deadweight Anchor	Fish
		Invertebrates
		Sea Turtles
	Drag Embedment Anchor	Fish
		Invertebrates
		Sea Turtles

Displacement

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 2009, Boehlert and Gill 2010, Dolman and Simmonds 2010). Large arrays may 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 45 possible interactions based on the project site conditions, MRE technology types, and receptors (Table 6).

Table 6. Interaction Table for Displacement.

Site Condition	Technology	Receptors
Open Coast	Wave Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Wave Device, Floating (Subsurface)	Marine Mammals
		Fish
		Birds

		Sea Turtles
	Wave Device, Floating (Surface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
Enclosed Basin	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Subsurface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Surface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
Constricted Channel	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Subsurface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
	Tidal Device, Floating (Surface)	Marine Mammals
		Fish
		Birds
		Sea Turtles
River	Tidal Device, Bottom-Mounted	Marine Mammals
		Fish
		Birds
	Tidal Device, Floating (Subsurface)	Marine Mammals
		Fish

		Birds
	Tidal Device, Floating (Surface)	Marine Mammals
		Fish
		Birds

Changes in Physical Systems

Harnessing energy with MRE devices may affect important physical processes in the ocean such as tidal circulation and wave action, temperature and salinity gradients, and sediment transport by removing energy from the system, changing natural flow patterns around devices, and/or decreasing wave heights (Copping et al. 2016). While changes in physical systems caused by single MRE devices or small arrays are likely to be small compared to natural variability (Robins et al. 2014), potential impacts should be revisited once large arrays of MRE devices are deployed (Copping et al. 2016, DOE 2009).

Projects related to physical systems changes have the potential to be classified as one of 8 possible interactions based on the project site conditions, MRE technology types, and receptors (Table 7).

Table 7. Interaction Table for Changes in Physical Systems.

Site Condition	Technology	Receptors
Open Coast	Wave Device	Ecosystem Processes
		Physical Environment
Enclosed Basin	Tidal Device	Ecosystem Processes
		Physical Environment
Constricted Channel	Tidal Device	Ecosystem Processes
		Physical Environment
River	Tidal Device	Ecosystem Processes
		Physical Environment

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