From Science to Consenting: Environmental Effects of Marine Renewable Energy

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I. Introduction

The marine renewable energy (MRE) industry has seen an increase in deployments over the past 10 years, particularly in Europe. However, other areas of the globe are still in the beginning stages of MRE development including the Americas. A small number of devices have been deployed in Canada and the United States, while South and Central America have seen very few if any devices in the water [1]–[4]. Without deployments and associated environmental monitoring, uncertainty around MRE remains, particularly regarding environmental effects. Potential environmental effects from tidal and wave devices are of concern to regulators, advisors, and other stakeholders in many nations. Monitoring results from early deployments and the first commercial arrays, coupled with targeted research studies, are providing a growing base of knowledge of how components of tidal turbines and wave energy converters might interact with marine animals and habitats. Efforts are underway to organize and direct these findings towards facilitating consenting that allays concerns and allows the MRE industry to move forward. Evidence to date shows that some of these potential risks are expected to be minimal or non-existent, especially for small numbers of operational devices [1], [5]. Understanding these risks can aid environmental consenting of MRE devices.

The OES-Environmental international initiative[1] aims to address uncertainty around environmental effects of MRE and aid the development of the MRE industry in a responsible manner. Despite a growing knowledge base and extensive ongoing environmental monitoring and data collection, barriers to consenting and deploying projects remain [6]. In addition, data collected by scientists may not be presented in a way that is accessible to regulators, advisors, and developers and the datasets are not always publicly available. Making this information accessible so that it is relevant across MRE projects, as well as easy to interpret, is key for industry-wide progress. OES-Environmental has worked to forge these connections and develop regulatory guidance documents to move the industry forward in an environmentally responsible manner.

To do so, OES-Environmental developed a risk retirement process to synthesize available information on key stressor-receptor interactions [1], [7] and identify which risks may be ripe for retirement. In addition, scientific evidence bases have been compiled for several key environmental interactions from MRE devices, organized around stressors (portions of MRE systems that may cause injury or stress to the marine ecosystem), and receptors (the animals, habitats, and ecosystem processes that may be affected).

II. Risk Retirement

Critical to this work are the concepts of risk retirement and data transferability. Risk retirement is the process of identifying which interactions of MRE devices and the environment are better understood and can be considered low risk, and therefore do not need to be fully investigated for every project (Fig. 1) [6]. Application of the risk retirement pathway has been more fully described by Copping et al. [8] in a general sense and for key stressors [6], [9]. To assess the ability to retire a risk, existing data and information from consented projects and research from comparable offshore industries or experimental studies should be used (Step 2 in Fig. 1). Applying these existing datasets, analyses, and learning appropriately is a key consideration of the data transferability process [8], [10]. Combining the principles of data transferability with the risk retirement process for key stressors could help satisfy regulatory requirements, reduce costs to the MRE industry, and allow efforts to be focused on topics with the greatest level of risk and remaining uncertainty [8].

[1] https://tethys.pnnl.gov/about-oes-environmental

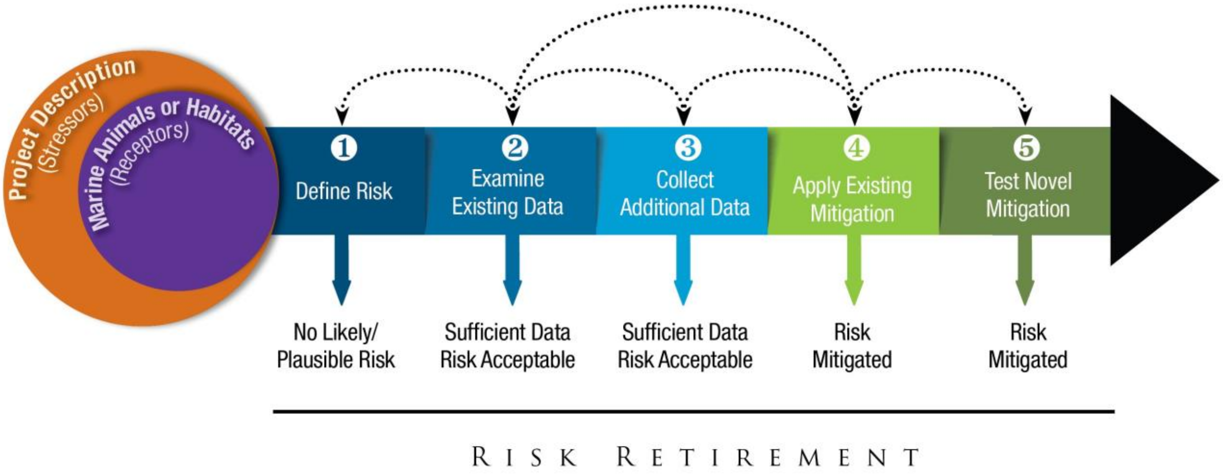

Fig. 1. The risk retirement pathway. A series of steps is shown that provide points at which to evaluate if there is a likely risk or if data or mitigation measures are sufficient to determine that a risk can be retired for a specific marine renewable energy project. If none of the steps can determine the risk to be insignificant, the project may need to be redesigned or perhaps abandoned.

A. *Evidence bases and assessment of risk*

Evidence bases were compiled for key stressor-receptor interactions: underwater noise, electromagnetic fields (EMFs), habitat change, changes in oceanographic systems, collision risk, and entanglement[1]. The evidence bases are comprised of key documents, including peer reviewed papers, reports, and research studies, that are central to understanding potential impacts for each stressor.

An extensive literature review on each interaction was carried out, followed by review, evaluation, and input from selected experts across industry, government, and academia at several international conferences and online workshops. Based on the data and information presented, selected experts provided feedback on the ability to retire risk for small numbers of devices (one to three), identified information gaps to be addressed, and put forth recommendations for additional research and data collection. Based on the evidence bases and associated reviews, there is substantial evidence indicating that the risks related to underwater noise, EMF, habitat change, and changes in oceanographic systems may be low for small numbers of devices [8]. Regarding entanglement, the risk is expected to be minimal, though more information may be required before it can be considered retired for small numbers of devices. For collision risk around tidal turbines, more information is needed to inform the potential risk. The evidence bases are updated and reviewed annually by the OES-Environmental team.

B. *Guidance documents*

Moving from scientific knowledge to application in consenting processes, the guidance documents aim to provide a broad guide that can be used internationally to look at stressor-receptor interactions of interest within a regulatory context. The guidance documents contain the information and recommendations to apply the concept of risk retirement to regulatory processes all along the path from scoping through consenting and licensing, by creating links between scientific information on environmental effects and the relevant legislation or regulations. The documents contain several components (Fig. 2), all of which are tailored for regulators, advisors, and developers to simplify their search for data with which to assess potential effects and will aid in the process of consenting. The guidance documents were developed in collaboration with OES-Environmental's international partners and are available online on *Tethys*.[2]

The guidance documents consist of (Fig. 2):

1) A background document that includes:

- Descriptions of four regulatory categories relevant for MRE consenting and licensing that occur in some form in virtually every nation: species and populations at risk; habitat loss or alteration; effects on water quality; and effects on social and economic systems.
- A framework that describes the application of risk retirement to consenting processes.

2) Stressor-specific documents on EMF, underwater noise, habitat change, changes in oceanographic systems, collision risk, entanglement, and displacement.

3) Country-specific guidance documents for OES-Environmental countries including United States, Wales, China, Japan, Spain, and France.

[1] https://tethys.pnnl.gov/risk-retirement-evidence-bases

[2] https://tethys.pnnl.gov/guidance-documents

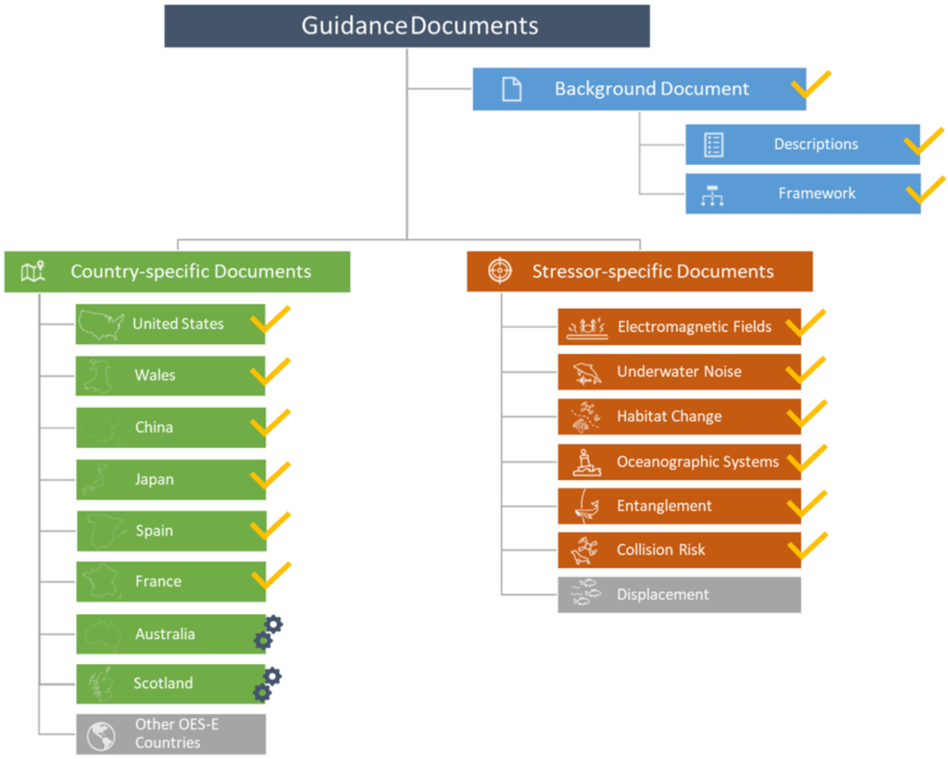

Fig. 2. Overview of the guidance documents. Coloured boxes indicate guidance documents that have been completed (yellow check marks) or drafted (blue gears). Boxes in grey are yet to be drafted and indicate the next steps to be taken in the development of the guidance documents.

The guidance documents can be used to organize and evaluate the potential impacts of MRE within a regulatory context. While in no way prescriptive, the guidance documents are intended to be a helpful tool in simplifying and streamlining consenting processes to advance the industry and ensure protection of the environment. These guidance documents should be helpful at the project level to complement and provide tools for regulators to leverage and interpret data and information on environmental effects, to assess risk retirement, or to analyze appropriate levels of mitigation or monitoring requirements.

C. *Management measures tool*

In addition to risk retirement and the evidence bases and guidance documents, OES-Environmental developed tools to identify and apply information and approaches used by other MRE projects for new context. Before risks are retired and uncertainties about environmental effects remain, management measures were developed and applied that help the industry move forward in the face of such uncertainty. OES-Environmental developed an online tool, the management measures tool, that documents management measures and mitigation alternatives used in past and present MRE deployments. This tool has been created for developers and their consultants to inform future MRE developments and to inform regulators and advisors during consenting processes. The tool, which was recently updated in 2022, is available online on *Tethys*.[4]

III. Conclusion

Bringing together the evidence bases, risk retirement for key stressors, and country-specific regulations provides a process and resource for regulators, advisors, and developers to use when consenting MRE projects. OES-Environmental continues to develop the remaining guidance documents, outlined in Figure 2., in collaboration with international partners and experts. Socializing these documents with regulators and advisors along with providing additional training resources on environmental effects of MRE is also a key focus for OES-Environmental moving forward. This large-scale cooperation, coupled with the commitment to environmentally, socially, and economically sustainable development, will enable success for the MRE industry. As the industry achieves success in deploying small numbers of devices, and transitions toward deployments of arrays, these guidance documents should provide a foundation for assessing risks and prioritizing knowledge gaps.

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