Proceedings of the 13th European Wave and Tidal Energy Conference 1-6 Sept 2019, Naples, Italy

Retiring Environmental Risks: Facilitating Marine Renewable Energy Development through Accelerated Consenting

Andrea E. Copping, Mikaela C. Freeman, Alicia M. Gorton

Abstract—**Concerns about the potential effects of marine renewable energy (MRE) devices on marine animals, habitats, and the environment continue to slow siting and consenting of devices worldwide. Such concerns are often fueled by scientific uncertainty around these environmental interactions, which leads to heightened perceptions of risk. By increasing our understanding of these risks, the MRE industry can begin to move forward and certain risks may be "retired." Under the Ocean Energy Systems (OES) Environmental task, a process for retiring risk has been developed that helps determine which interactions of MRE devices and the marine environment are low risk and may be "retired", and which may need further data collection or mitigation applied to reduce the risks to an acceptable level. Sufficient data are needed to retire risk; transferring data and information from early consented projects can assist regulators in their determinations. If data from baseline assessments and post-installation monitoring programs are collected consistently, the results can be evaluated and applied to increase understanding of the environmental effects, supporting more efficient consenting processes and reducing scientific uncertainty. OES-Environmental has developed a data transferability process that can provide a robust assessment of monitoring data and make those data readily accessible to assist regulators and others in these determinations.**

Keywords—**consenting and licensing processes, data transferability, environmental effects, marine renewable energy, risk retirement**

I. INTRODUCTION

CONCERNS about the potential effects of marine renewable energy (MRE) devices on marine animals, habitats, and the environment continue to slow siting and permitting/consenting of devices worldwide [1]. Regulators and other stakeholders may view the operation of MRE devices as causing risk to the marine environment, which translates into increased scrutiny over consenting applications, and in turn, slows consenting processes and increases costs to the emerging MRE industry. These perceptions of risk are often associated with scientific uncertainty around interactions of MRE devices and marine animals or habitats, but also often result from lack of familiarity and access to existing scientific information around these interactions.

Through a systematic process of examining and cataloguing datasets from wave and tidal projects that have been consented, ensuring that the datasets are accessible and understandable to regulators, and developing criteria to remove or "retire" those risks that are not likely to cause harm to the marine environment, there is a pathway towards lowering barriers to consenting and licensing MRE projects for wide spread and rapid development. This paper describes a risk retirement process that links results of environmental monitoring around MRE devices in several nations, provides a process for applying data from consented projects to new MRE development applications, and reports on progress in working with regulators to understand and potentially accept these pathways for accelerated consenting.

Ocean Energy Systems has tasked the nations under the OES-Environmental task (formerly known as Annex IV) to understand and help accelerate the consenting processes for MRE devices. This work is carried out as part of that process.

A. *Current state of knowledge*

The most recent comprehensive review of existing information, the Annex IV 2016 State of the Science report [2], summarized the key risk areas that continue to slow siting and consenting of MRE devices and arrays. The approach taken here follows the concept of stressors (portions of MRE systems that may cause harm) and receptors (animals, habitats, or ecosystem processes that might be harmed) [3]. The greatest concerns expressed by regulators and stakeholders are associated with:

- Potential collision of marine animals with tidal turbine blades;

Paper ID number: 1270 - Environmental impact and appraisal

This research is possible due to the generous support of the US Department of Energy EERE-Water Power Technologies Office to PNNL under Contract DE-AC05-76RL01830, and the support of Ocean Energy Systems.

A.C. and M.F. are with the Pacific Northwest National Laboratory, 1100 Dexter Avenue North, Seattle, WA, 98109 U.S.A (emails: andrea.copping@pnnl.gov, mikaela.freeman@pnnl.gov).

A.G. is with the Pacific Northwest National Laboratory, 902 Battelle Boulevard, Richland, WA, 99354 U.S.A (email: alicia.gorton@pnnl.gov).

- Effects of underwater noise from MRE installations and operation on marine animal behaviour and health;
- Potential effects of electromagnetic fields (EMF) from cables and energized devices on sensitive marine species;
- Changes in benthic and water column habitats from MRE anchors, foundations, and mooring lines;
- Displacement or barrier effect on migratory animal populations from arrays of MRE devices; and
- Changes in circulation and sediment transport from operational MRE devices.

To date there have been no observations of marine mammals or seabirds colliding with tidal turbines, while fish interactions have not been shown to be harmful. The amplitude and frequency of sound from wave energy converters (WECs) and tidal turbines does not appear to be sufficient to significantly disturb marine mammals or fish, although animal behaviour studies in response to these sounds are virtually non-existent. Effects of EMF on sensitive species do not appear to prevent crabs and other invertebrates from reaching their preferred habitats or affect their distribution patterns based on observational studies. Similarly, field studies of eel as well as resident and migratory fish do not indicate that cables will prevent these animals from reaching their preferred habitats. Changes in marine habitats from MRE do not differ from those from other industries. Numerical models best inform changes in circulation and sediment transport for small numbers of MRE devices. Studies and data that define displacement and barrier effects will not become available until large arrays are operational [2].

Based on interactions with the MRE industry, researchers, and other stakeholders, it is clear that certain possible interactions with portions of MRE systems and operational strategies place little to no risk to the marine environment. For example, the risk of chemical leaching from system components, including oil, is widely considered to be negligible as few such products are used on MRE devices [2]. Similarly, other stressor/receptor interactions can be informed by established industries, such as reefing of fish and invertebrates around floats and anchor lines, which has no demonstrable mechanism for harming the marine environment [1][2]. These risks might be considered to be "retired", or no longer in need of active investigation for all MRE projects.

B. *Previous support for consenting*

The OES-Environmental process for understanding and progressing towards efficient consenting developed and administered a survey to regulators to understand their information needs and to effectively design a process to accelerate consenting [4]. A series of meetings with a wide range of US federal and regional (state) regulators was used to provide information on data collected and information determined from consented projects internationally, and to get initial feedback on acceptability of risk retirement and data transferability processes to aid in consenting [4][5].

II. A Process for Retiring Risk

Based on feedback from international regulator surveys and interactions with US regulators, the risk retirement process was developed. A portion of that process involves the concepts of data transferability and data collection consistency [4]. Similar engagement is pending with the other OES-Environmental nations and will be followed by a series of meetings with regulators in each nation.

Under OES-Environmental, the process to retiring risk was developed to indicate a methodology that can be used to move from the determination of the level of risk from MRE devices and systems, towards a set of solutions that will allow regulators to consent and license devices more readily than is available currently (Fig. 1). The risk retirement process is applicable to any set of stressor/receptor interactions.

At the start of the risk evaluation it is important to include information on the size of the proposed development as single devices are less likely to have significant effects than arrays. The risk to the marine receptor must be defined for the specific project (outer ring of Fig. 1) and the animals or habitats that may be affected (next ring) in order to define the likely risk. At that point the risk enters into a series of stage gates, each with an "off ramp" to allow the risk to be considered "retired". If at any step there is not sufficient data to determine that the risk might be retired (via an off ramp, implied by the downward facing arrow), the risk must be moved into the next step to the right. A particular risk can only be considered to be retired if available data are sufficient for an informed decision to be made.

The steps in the risk retirement process are: 1) determining if significant risk exists for a particular project (if not, that risk can be retired); 2) determining whether sufficient data exists to demonstrate the significance of the risk; 3) following the design and collection of targeted data around the project, determining whether the risk is significant; 4) determining whether there are proved mitigation measures that can mitigate the risk (if so, the risk can be retired); and 5) following development and testing of mitigation measures, determining whether the risk can be mitigated (if so, the risk can be retired). If none of the steps can determine the risk to be insignificant, the project will need to be redesigned or perhaps abandoned.

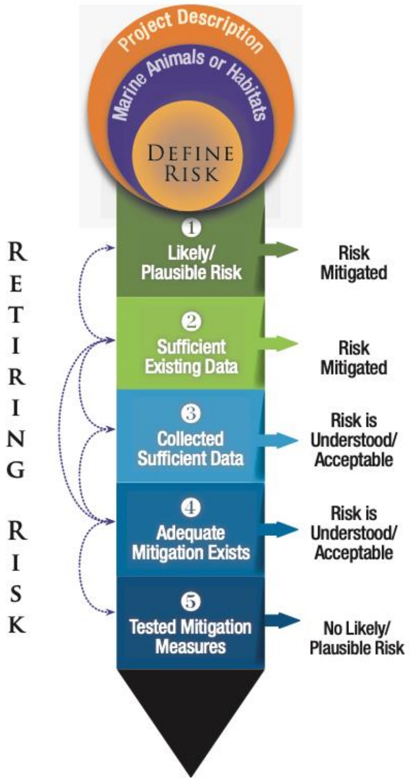

Fig.1. Risk Retirement Process.

Between and among the steps in the risk retirement process there is a need to examine available data and mitigation measures in order to provide feedback among steps, as signified by the dotted arrows on the top of the diagram (Fig. 1).

Currently there are no plans to set quantitative criteria or thresholds for change due to effects of MRE devices as each project site, species assemblage, and interactions with devices is likely to be unique. As the risk retirement process is implemented, it may be possible to develop semi-quantitative envelopes for acceptable risk for specific stressor/receptor interactions.

While the use of the risk retirement process must be tested and proved through consenting and licensing processes to determine its efficacy, it is envisioned that the process will be helpful if applied at multiple steps leading to deployment and operation of MRE devices. Details for implementing the risk retirement process will require discussion among regulators and developers (or their designated consultants); the process is likely to unfold as follows:

The first steps - determining whether this is a likely risk (step 1); determining whether sufficient data exist (step 2); and collecting sufficient data if needed (step 3) – would feed into the environmental assessment needed for consenting (Environmental Impacts Assessments in Europe, National Environmetnal Policy Act assessments in the US). Once a project has been consented and sited, further discussions among regulators and the project proponents will also focus on steps 4 and 5, to determine needed mitigation.

The risk retirement process is likely to be initially applied in some detail to each proposed project. However, as additional datasets from consented projects become available and specific risks are better understood, it is assumed that risk evaluation and resolution will become more routine, allowing consenting processes to proceed more expeditiously.

III. Data Transferability and Data Collection Consistency

A key aspect of using the risk retirement process is ensuring that datasets from consented MRE projects are readily available and catalogued so that the two projects (an already consented project, and a project subject to consenting and licensing permission) can be compared in terms of the stressor/receptor interactions, the size and technologies involved in the projects, and the methodologies used to collect data. This process, termed Data Transferability, becomes a vital part of evaluating data in stage gate 2 (Fig. 1). In addition, assessment of datasets and feedback among the steps in the risk retirement process (Fig. 1) will be necessary and are symbolized by the dotted lines and arrows at the top of the figure.

The Data Transferability Process (Fig. 2) consists of:

- Data Transferability Framework which classifies stressor/receptor relationships for different project types;
- Monitoring Datasets Discoverability Matrix that catalogues datasets from consented projects;
- Best Management Practices for Data Transferability that suggest practices to achieve transfer of data; and
- Data Collection Consistency Table that outlines the parameters for comparison of monitoring data between projects.

While the process has been termed "data" transferability, the intent is the transfer and application of a range of data and information. This might include raw data, but more commonly regulators and other stakeholders (with the exception of many researchers) are in need of compiled and analysed data, reports, lessons learned, and other media. For the purposes of the Data Transferability Process, all these components are referred to as "data".

C. Data transferability framework

Drawing from studies of data transferability from other industries including economics [6], transportation [7], ecology [8], and land system science [9], a set of archetypes, or example descriptions of projects, were developed. The archetypes allow for the classification of MRE projects based on the stressor of interest, overall site conditions, the specific type of wave or tidal technology, and the vulnerable receptors at the project site. For example, for collision risk, the site conditions might include the width and depth of the channel through which animals must navigate a turbine, the technology might be a bottom-mounted tidal turbine, and the receptor might be a harbour porpoise; for underwater sound, the site characteristics might include whether the sea area has other sources of significant noise, the technology might be a point attenuator wave device, and the receptor might be a large whale. More detail on the archetypes and their application can be found in [3] and [10].

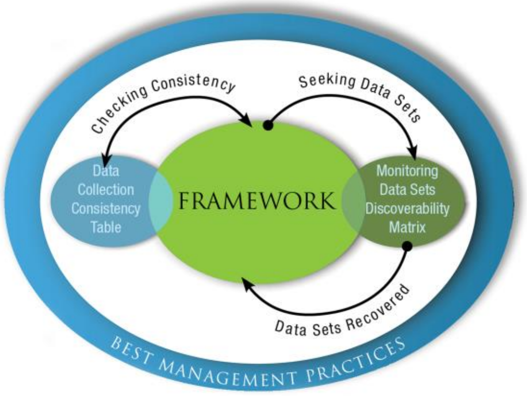

Fig. 2. Data Transferability Process.

D. *Monitoring datasets discoverability matrix*

Based on feedback from US regulators [4], a Monitoring Datasets Discoverability Matrix provides easy sorting and access to monitoring datasets from existing consented projects. The matrix is searchable by the archetypes, as well as by other key features of each dataset (for example, specific data parameters, collection location, collection methods, contact for accessing the data, etc.). By providing this access, the process of data transferability becomes more tangible and provides regulators and developers a basis for discussion at the start of a consenting process.

The initial build of the Monitoring Datasets Discoverability Matrix has been completed and datasets associated with consented projects in the UK, Canada, and the US have been added; the matrix is available on Tethys (https://tethys.pnnl.gov/riskretirement). The matrix will be updated as additional consented project datasets become available. As new data become available, the matrix will be further developed, allowing for greater access to information that will inform new projects.

E. *Best Management Practices*

Best Management Practices (BMPs) were developed to help guide the Data Transferability Process. The BMPs are based on practical steps for implementation of the Data Transferability Process and address the use of archetypes, datasets from consented projects, the use of numerical models to delineate stressor/receptor interactions as MRE development progresses, and the use of additional datasets that are available in the area of an MRE project (Table I).

TABLE I
BEST MANAGEMENT PRACTICES FOR DATA TRANSFERABILITY, INCLUDING THE PURPOSE OF EACH BMP AND THE INTERESTED PARTIES WHO WOULD BENEFIT FROM THEIR USE.

BMP 1: Meet the necessary minimum requirements to be considered for data transfer from an already permitted/consented project to a future project. Purpose: Ensure minimum thresholds including using the same archetypes, are met for transferring data. Interested Parties: Regulators, as well as MRE device developers and consultants.
BMP 2: Determine likely datasets that meet data consistency needs and quality assurance requirements. Purpose: Ensure methods used to collect/analyse data are compatible and will help to determine the validity of comparing the datasets. Interested Parties: Regulators, as well as MRE device developers and consultants.
BMP 3: Use models in conjunction with and/or in place of datasets. Purpose: Encourages the use of numerical models to simulate interactions. Interested Parties: Researchers, consultants, and regulators.
BMP 4: Provide context and perspective for datasets to be transferred. Purpose: Encourages the use of available and pertinent datasets to enhance the interpretation of data and information. Interested Parties: Device developers, consultants, and regulators, researchers.

F. *Data collection consistency*

Comparing datasets from one location and one consented project to another project requires that there be a consistency between the methods and instrumentation used to collect the underlying data. The distributed nature of MRE development among many nations responsible to many different regulatory and scientific bodies makes it unlikely that specific protocols and identical instruments will be used among different projects; OES-Environmental strives to bring a level of consistency for documenting methods, instruments, and calibration records for key stressor/receptor interactions (Table II). In the future additional effort is needed to understand and evaluate methods and instrumentation for detecting potential effects. OES-Environmental and related projects will be pursuing these efforts.

IV. APPLICATION OF RISK RETIREMENT PROCESS

Application and testing of the risk retirement process requires that regulators and others begin to use the process. In order to encourage the use of the process, several steps remain:

Examples from among the datasets in the Monitoring Dataset Discoverability Matrix have been chosen to span the range of stressor/receptor interactions that regulators and developers have worked through to license real world consented projects. In particular, the datasets chosen have all been used to inform regulatory processes beyond the project for which they were collected, or to demonstrate the potential for such application. Each chosen dataset is being developed into a story to demonstrate the accessibility and usability of the Data Transferability Process.

TABLE II

DATA COLLECTION CONSISTENCY TABLE, LISTING METHODS FOR DATA COLLECTION, REPORTING UNITS, AND ANALYSIS.

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

OES-Environmental is actively working to retire additional risks from MRE development. While challenging, there are two risks that appear to be ripe for retirement: potential effects from underwater noise on marine mammals and fish and potential effects from EMF. The evidence base for each risk, as well as designs of appropriate monitoring and modelling studies that could further support that evidence base are under development.

The concept of "retiring risk" is not universally embraced by regulators in several nations. Assurances are needed that any risk that is deemed "retired" may be re-examined as new information comes to light, particularly as larger commercial arrays of tidal turbines and WECs are deployed. For example, there is no opportunity to separate changes in circulation or sediment transport from the MRE device operation from natural variability; however, once large numbers of devices are operational, this risk might be revisited. Until then, reliance on numerical models will suffice. Similarly, there will be no discernible displacement or barrier effect on migratory animals until large numbers of turbines or WECs are in place.

OES-Environmental is committed to engaging with regulators and other stakeholders, encouraging these groups to test and add to the risk retirement process. This appears to be an effective way to bring together all the interested parties, ensure that the broadest possible knowledge is entrained, and provide a sense of stewardship for MRE devices in a healthy marine environment.

V. CONCLUSION

A major challenge to establishing the MRE industry as a viable contributor to low carbon energy either at the national grid scale or to serve a number of smaller end users in the emerging Blue Economy, is the need to accelerate the consenting, licensing, and deployment of many more MRE devices than has been seen to date anywhere in the world. At the same time, any development of MRE farms must be protective of the rich and diverse sea life that provides ecosystem services and essential transportation corridors for humans and animals alike. Understanding the potential risks from MRE devices, concentrating monitoring and analysis resources on high priority risks, and avoiding or mitigating those risks is essential to gaining regulatory and social license to deploy and operate in the oceans. This work is driven by the international cooperation of many nations committed to fostering MRE development. With the risk retirement process laid out here, combined with strong engagement among regulators, developers, researchers, and others, there is good reason to believe we can accelerate this process.

ACKNOWLEDGEMENT

We would like to thank the representatives of the other 14 OES-Environmental nations and the US Department of Energy EERE-Water Power Technologies Office for their guidance and insight, as well as regulators and other members of the MRE community who helped us visualize, challenge, and refine our approach.

REFERENCES

[1] A.E. Copping. “The State of Knowledge for Environmental Effects: Driving Consenting/Permitting for the Marine Renewable Energy Industry,” Ocean Energy Systems. 2018. [Online]. Available: https://tethys.pnnl.gov/publications/state-knowledge-environmental-effects-driving-consentingpermitting-marine-renewable

[2] A.E. Copping, N. Sather, L. Hanna, J. Whiting, G. Zydlewski, G. Staines, A. Gill, I. Hutchison, A. O'Hagan, T. Simas, J. Bald, C. Sparling, J. Wood, and E. Masden. “Annex IV 2016 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World,” Ocean Energy Systems. 2016. [Online]. Available: https://tethys.pnnl.gov/publications/state-of-the-science-2016

[3] G. Boehlert and A. Gill, “Environmental and Ecological Effects of Ocean Renewable Energy Development: A Current Synthesis,” *Oceanography*, vol. 23, no. 2, pp. 68-81, 2010.

[4] M.C. Freeman, A.E. Copping, A.M. Gorton, and S. Dreyer, “Managing Environmental Effects of Marine Renewable Energy Development through Regulator Engagement, Data Transferability,” presented at the *Marine Energy Technology Symposium*, 2018.

[5] A.E. Copping, M.C. Freeman, A.M Gorton, and S. Dreyer, “Managing Environmental Effects to Facilitate Marine Renewable Energy Development,” presented at the *Asian Wave and Tidal Energy Conference*, 2018.

[6] M. Drummond, M. Barbieri, J. Cook, H.A. Glick, J. Lis, F. Malik, S.D. Reed, F. Rutten, M. Sculpher, and J. Severens, “Transferability of Economic Evaluations Across Jurisdictions: ISPOR Good Practices Task Force Report,” *Value in Health*, vol. 12, no. 4, pp. 409-418, 2009.

[7] Volpe National Transportation Systems Center. “Summary Report for the Peer Exchange on Data Transferability: Held December 16, 2004,” U.S. Department of Transportation. 2005.

[8] S.J. Wenger and J.D. Olden, “Assessing transferability of ecological models: an underappreciated aspect of statistical validation,” *Methods in Ecology and Evolution*, vol. 3, pp. 260-267, 2012.

[9] T. Václavík, F. Langerwisch, M. Cotter, J. Fick, I. Häuser, S. Hotes, J. Kamp, J. Settele, J.H. Spangenberg, and R. Seppelt, “Investigating potential transferability of place-based research in land system science,” *Environmental Research Letters*, vol. 11, pp. 1-16, 2016.

[10] A.E. Copping, A.M. Gorton, and M.C. Freeman. “Data Transferability and Collection Consistency in Marine Renewable Energy,” Pacific Northwest National Laboratory. Richland, Washington, USA. PNNL-27995, 2018.