Best Management Practices for Risk Retirement

August 2025

Background

Risk retirement[1] is a term used loosely by the marine renewable energy (MRE) community to describe a means of simplifying consenting processes for single or small numbers of devices (one to six) by focusing on key environmental effects of concern. Risks that are unlikely to cause harm to marine animals or habitats can be "retired" so that extensive investigations at every new MRE project are not required. Rather, MRE regulators, advisors, developers, and consultants may rely on data and information from consented projects, related research studies, or analogous offshore industries.

Once a risk is considered "retired", it is not completely eliminated. Issues that arise, such as key data gaps and uncertainties, will always need to be dealt with through a project's consenting/licensing process, environmental impact assessment, and other relevant regulatory processes. Risk retirement does not take the place of existing regulatory processes but rather allows for managing key uncertainties and data gaps in parallel with standard environmental impact assessment processes, which are used to identify, consider, mitigate, and manage potential environmental effects. Engagement between developers, consultants, regulators, and advisors at every step will improve the process. If necessary, retired risks can and should be reexamined if new information comes to light or as larger-scale arrays are deployed.

Risk retirement is an iterative process, as shown in Figure 1. In this figure, the black dotted lines with arrows on the far left represent entry points for applying data and feedback loops throughout the risk retirement pathway. Findings throughout the life of an MRE project should continue to inform the design, configuration, siting, operation, and monitoring/mitigation/management of a project. Regulatory decision-making should allow for flexibility and learning through the application of adaptive management when possible. More information on the risk retirement process can be found on Tethys[1], and the steps have been outlined in Copping et al. (2020a).

Best Management Practices (BMPs) for risk retirement have been developed to assist with implementing the risk retirement process and support consenting dialogues with regulators. BMPs are used in multiple industries, most commonly in water quality or resource management settings in the United States to support the regulatory process and proactively set approaches to minimize negative environmental impacts. The BMPs for risk retirement consist of a series of succinct statements that describe the optimal application of the risk retirement methods, written in a manner that is accessible and actionable for the MRE industry, regulators and advisors, and other stakeholders. The BMPs build off the information within Freeman et al. (2024) and Copping et al. (2020b) that provide details of the risk retirement process. They have been reviewed and iteratively improved by the OES-Environmental country analysts and MRE developers who participated in an expert forum[2]. The BMPs are intended to

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

[2] The expert forum was held in June 2025. Presentation slides and a summary of the event are available on Tethys: https://tethys.pnnl.gov/events/expert-forum-risk-retirement-environmental-effects

be used by MRE device or project developers with environmental expertise or by a third-party consultant or subject matter expert whose role is to evaluate environmental risks.

Figure 1 provides an overview of the risk retirement pathway aligned with the BMPs for each step.

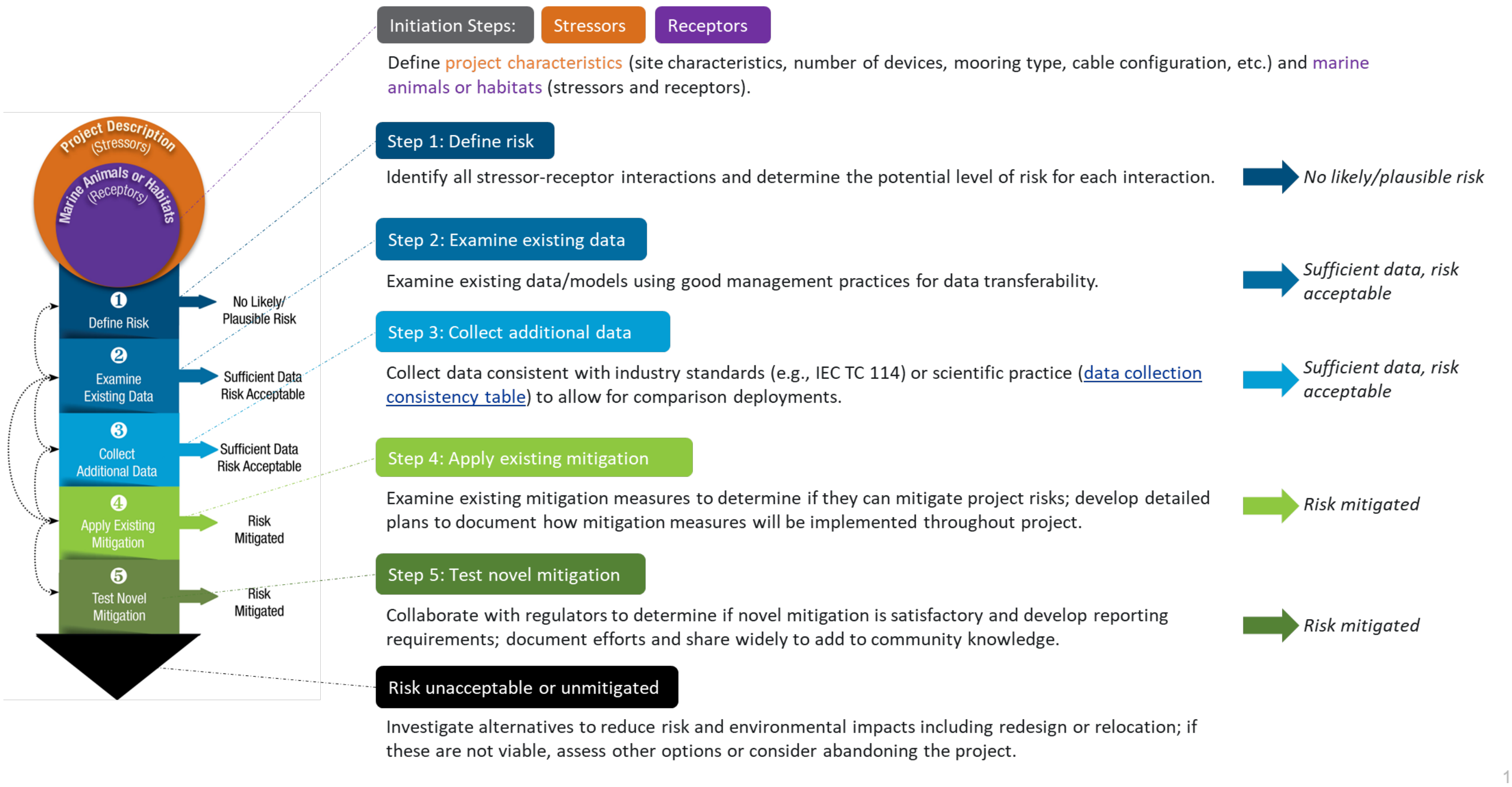

Figure 1. Risk retirement pathway (left) and best management practices defined under each step to guide risk retirement for marine renewable energy developments.

Applying BMPs for Risk Retirement

BMPs have been developed for each step in the risk retirement pathway. The sections below include a description of each step in the pathway, the BMP, "off ramps" or ways in which to exit the risk retirement pathway and retire risk, definitions of terms for each step, and links to relevant resources. Descriptions of the resources noted in each step are available in the Relevant Resources section. Additional examples of how risk retirement and data transferability have been applied are available in the Examples section.

Initiation Step: Stressors

To begin the risk retirement process, comprehensively define the project characteristics to identify relevant environmental stressors. The type of MRE device will determine which environmental stressors are most likely. Additional characteristics can include aspects such as the number and size of device(s), mooring type, cable configuration, power take-off, end user, and site characteristics. Key stressors to focus on are those that are of concern in the regulatory context (country, region, etc.) of the project.

Initiation Step: Receptors

In addition to stressors, comprehensively define the marine animals, habitats, or ecosystem processes (receptors) that may be affected by the different stressors. These may include marine mammals, fish and invertebrates, seabirds, benthic or pelagic habitats, sediment transport, nutrient cycling, and ecosystem processes. Key receptors to focus on include those that have legal protections; cultural, community or economic importance; or are of concern to regulators in the area of interest.

Step 1: Define risk

Identify stressor-receptor interactions that define potential risks to the marine environment from the MRE project. Together, the stressors and receptors identified in the Initiation Steps inform the potential stressor-receptor interactions that may occur around an MRE project. The key stressor-receptor interactions as identified by OES-Environmental are collision risk from turbines, effects from underwater noise, effects from electromagnetic fields (EMF), changes in habitat, changes in oceanographic systems, entanglement, and displacement.

- **BMP** – identify all stressor-receptor interactions and determine the potential level of risk for each interaction.
- Off ramp – once the level of risk has been determined for each stressor-receptor interaction, if no plausible or likely risk exists for a particular interaction, the interaction can be removed from further consideration.
- Definitions for this step – risk: the combination of the likelihood of an impact and the severity of that impact occurring (Copping et al. 2015).

- Relevant resources – 2024 State of the Science report, 2020 State of the Science report, guidance documents framework to define stressors and receptors, stressor-specific guidance documents to find scientific information on stressor-receptor interactions, and country-specific guidance documents to determine stressors and receptors of regulatory concern.

Step 2: Examine existing data

Locate and examine existing data and information to determine if sufficient data are available to understand the level of risk and uncertainty for each stressor-receptor interaction.

- **BMP** – examine existing data and information using best management practices for data transferability.
- Off ramp – if existing data from previous MRE projects and analogous industries/activities are available and can determine that the risk is acceptable, then the risk can be retired.
- Definitions for this step – sufficient data: data and information may be deemed sufficient when a regulator/advisor can be confident that the risk is clearly identified; data transferability: using learning, research, analyses, and datasets from one location or jurisdiction to another, between MRE projects, or from an analogous project/activity to a MRE project to inform understanding of environmental effects and potential risk.
- Relevant resources – data transferability Tethys page (guidelines for transferability and best management practices), monitoring dataset discoverability matrix, evidence bases, guidance documents

Step 3: Collect additional data

Collect additional data and information for the project for remaining interactions of concern, based on identified level of risk and uncertainty.

- **BMP** – collect data consistent with industry standards (e.g., IEC TC 114) or scientific practice (e.g., data collection consistency table, Crown Estate Transferability Framework) where possible to allow for comparison with other MRE deployments.
- Off ramp – if additional data determine that the risk is acceptable, the risk can be retired.
- Relevant resources – data transferability Tethys page (data collection consistency table and BMPs), Triton Field Trials Special Issue (habitat, collision risk, EMF, noise), IEC TC 114 guidance, Crown Estate Transferability Framework

Step 4: Apply existing mitigation

Apply existing mitigation to reduce or minimize potential impacts.

- **BMP** – examine existing applicable mitigation measures from MRE or analogous industries to determine if they are proven to mitigate remaining project risks; develop detailed plans to document how mitigation measures will be implemented during project design, installation, operation, and decommissioning.

- Off ramp – if existing mitigation measures can be applied to reduce, minimize, or mitigate the risk to an acceptable level, the risk can be retired.
- Definitions for this step – mitigation hierarchy: organized method of assigning appropriate actions which may include avoiding impacts when possible, minimizing remaining impacts, mitigating to diminish impacts, and/or providing compensation for unavoidable impacts of concern (Le Lièvre, 2020); categories of management measures: actions taken to reduce risk may fall within one of the following categories – compliance, design feature, mitigation, or monitoring.
- Relevant resources – management measures tool

Step 5: Test novel mitigation

Develop and test novel mitigation measures to determine if risk can be mitigated, this could include both new mitigation measures or those used in analogous industries and applied to MRE for the first time.

- **BMP** – collaborate with regulators and researchers to determine if novel mitigation is satisfactory and develop reporting requirements; document efforts and share widely to add to community knowledge.
- Off ramp – if novel measures can be applied to reduce, minimize, or mitigate the risk, the risk can be retired.
- Relevant resources – management measures tool

Risk unacceptable or unmitigated

If a risk proceeds through the entire pathway and cannot be retired, the project may require significant changes or longer-term research and monitoring, resulting in alterations to the project description and starting the risk retirement process again.

- **BMP** – investigate other avenues to reduce project risk and environmental effects including redesigning the technology or relocating the project; if neither redesign nor relocation are viable, assess any remaining options or consider abandoning the project.

Relevant Resources

The relevant resources mentioned under each BMP are compiled and described here.

OES-Environmental Resources:

- The guidance documents help make scientific information accessible and compile tools and information for easy access during consenting processes. All information is tailored for regulators, advisors, developers, and consultants to simplify the search for information with which to address consenting requirements and concerns from MRE.
    - The country-specific guidance documents provide the MRE regulatory context for each of the OES-Environmental countries.
    - The stressor-specific guidance documents provide an overview of the scientific information that is known for each stressor-receptor interaction and the status of risk retirement for each.
- The data transferability Tethys page hosts all developed materials about the data transferability process, including the following key pieces:
    - The guidelines for data transferability describe an approach for applying the data transferability framework to environmental interactions in a hierarchy, ranging from critical, or necessary, to desirable but perhaps not necessary. The guidelines help regulators and advisors understand the limits of data transferability and facilitate discussions between developers and regulators/advisors to determine data collection and monitoring efforts needed to consent a project.
    - The best management practices for data transferability provide regulators, advisors, developers, and consultants with practical steps for addressing use of data from previous projects for consenting new MRE projects.
    - The data collection consistency table helps support collection of pre- and post-installation environmental monitoring data for MRE projects to help ensure consistency and the ability to compare data across countries, regions, and research and commercial efforts. The table provides suggested measurement methods or processes, reporting units, and the most common methods of analysis or interpretation/use of data.
- The monitoring dataset discoverability matrix categorizes datasets from consented projects by six key stressor-receptor interactions (collision, underwater noise, electromagnetic fields, changes in change, displacement, changes in oceanographic systems) to make them easily accessible. It is tailored for regulators, advisors, developers, and consultants and helps to simplify consenting processes by facilitating data transfer and reducing the need for new monitoring when existing information is applicable.
- The risk retirement evidence bases compile key scientific data and information into curated reference lists, making resources easily accessible to evaluate stressor-receptor interactions and address environmental concerns for MRE projects.
- The *OES-Environmental 2024 State of the Science* report builds on the foundation of the *2020 State of the Science* report, offering updated research on the environmental effects of MRE. Together, the 2020 and 2024 reports serve as complementary resources, drawing on global

contributions to provide the most current insights into MRE technologies, environmental interactions, and lessons learned from other offshore industries.

Other Resources Mentioned:

- The Triton Initiative, supported by the U.S. Department of Energy, advances environmental monitoring technologies and methods to reduce barriers to testing and consenting for MRE. Through its Triton Field Trials (TFiT), the initiative evaluated the technologies and methods used by 118 international MRE projects to assess key environmental stressor-receptor interactions including changes in habitat, collision risk, electromagnetic fields, and underwater noise. This effort culminated in 10 peer-reviewed papers which provide recommendations to support consistent, transferable, and cost-effective monitoring data collection for MRE, which were published in a Special Issue.
- IEC TC 114 is an International Electrical Commission sub-committee that prepares consensus-based standards for wave, tidal, and other MRE devices. As referenced in Step 3, they have developed a standard methodology for characterizing operational noise generation from MRE devices.
- The Crown Estate Transferability Framework is a resource that organizes collected data on tidal stream energy projects to facilitate transferability, particularly for marine mammals and collision risk.

Examples of Risk Retirement and Data Transferability

Several examples of risk retirement exist and have been documented in [Chapter 6 of the *2024 State of the Science*] report. Figure 2 illustrates the steps in the pathway where the potential risk was considered retired for several MRE projects.

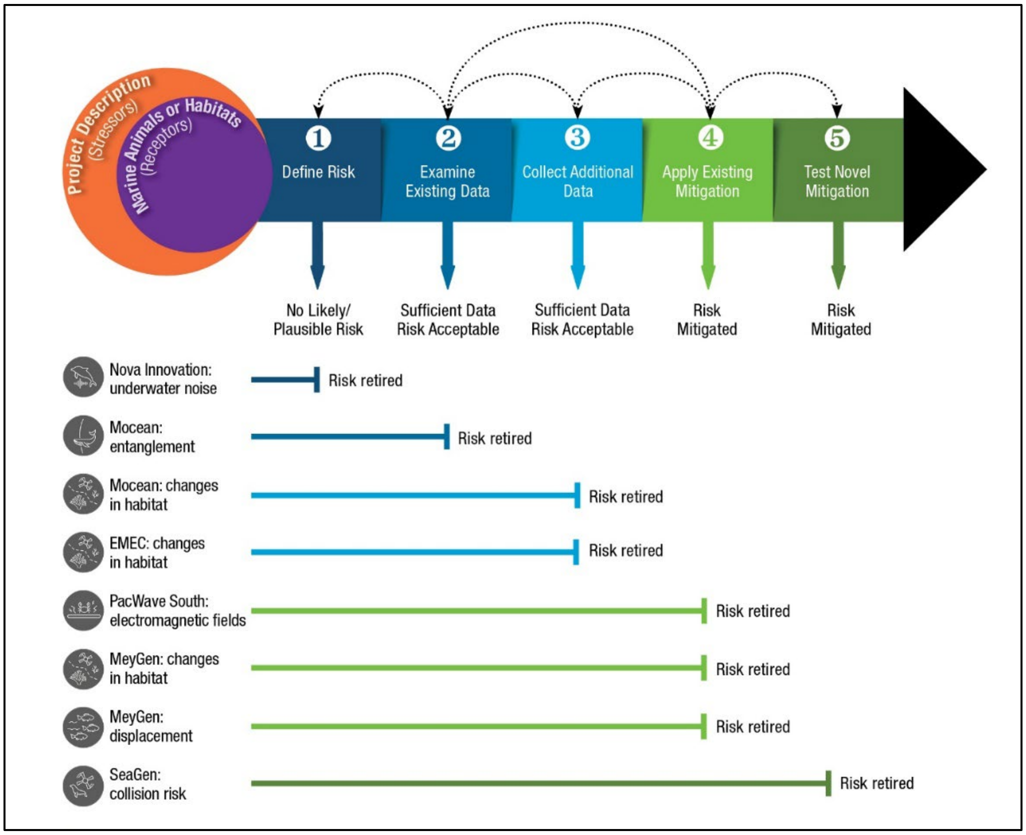

Figure 2. Examples of risk retirement from eight case studies, with colored lines denoting the step in the pathway where risk retirement was achieved for each marine renewable energy development. EMEC = European Marine Energy Centre. Figure from Freeman (2024).

Many examples of data transferability exist and several have been described in [Chapter 13 of the *2020 State of the Science* report]. Two are summarized below.

	[SME Plat-O #1]: underwater noise	Data was transferred from Yarmouth, England, acoustic monitoring to the European Marine Energy Centre Fall of Warness test. No additional acoustic monitoring was required during installation.
	[Voith Hytide and Brims Tidal Array]: changes in habitat	Underwater video data collected at EMEC under the Voith Hydro HyTide project determined baseline conditions and effects of operation on benthic habitat. The regulator for the Brims Tidal Array determined the previous report provided sufficient information to eliminate the need for additional studies on benthic footprint and drilling impacts as part of the environmental impact assessment for a deployment near Orkney, Scotland.

References

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