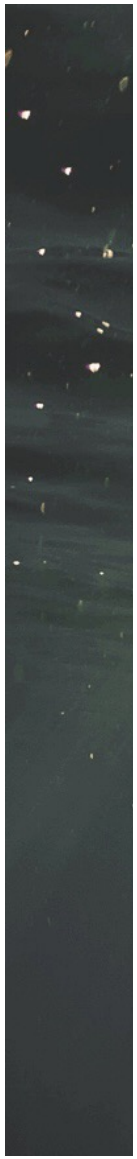


Pacific Northwest NATIONAL LABORATORY

OES ENVIRONMENTAL

THE CROWN ESTATE

SAFE WAVE — STREAMLINING THE ASSESSMENT OF ENVIRONMENTAL EFFECTS OF WAVE ENERGY

Supporting Consenting Processes for Marine Renewable Energy: International Perspectives

Lysel Garavelli, Debbie Rose, Sarah Wren, Juan Bald, Anne Marie O'Hagan

October 2, 2025

U.S. DEPARTMENT of ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

Today's Webinar

- All participants will be **muted** during the webinar and question period.
- After all the presentations, we will answer questions. Use the **Q&A box** to add your questions at any time.
- The **chat** can be used to contact organizers if you need help with Zoom, and we will use it to share links to resources throughout.
- The webinar will be **recorded**. The recording will be available on Tethys after the event, and the link will be sent to all registrants.
- We will share a **feedback survey** at the end.

Agenda

- **OES-Environmental updates and resources**

  Lysel Garavelli and Debbie Rose,

  Pacific Northwest National Laboratory, USA

- **Tidal Stream Data Transferability Matrix**

  Sarah Wren, The Crown Estate, UK

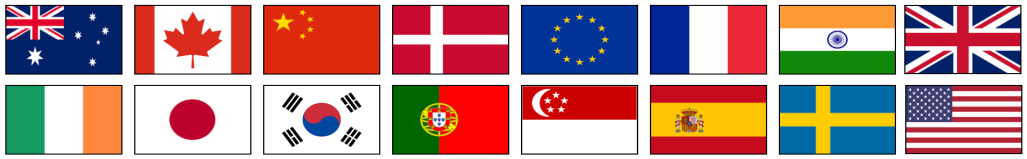
- **SAFEWAVE Overview**

  Juan Bald, AZTI, Spain, and Anne Marie O'Hagan, University College Cork, Ireland

- **Q&A**

OES-Environmental

- Established by the International Energy Agency-Ocean Energy Systems in 2010
- Examines environmental effects of marine renewable energy (MRE) development to advance the industry in a responsible manner
- Led by the U.S. Department of Energy Water Power Technologies Office and implemented by Pacific Northwest National Laboratory
- Phase 5 (2024-2028): 15 countries + European Commission



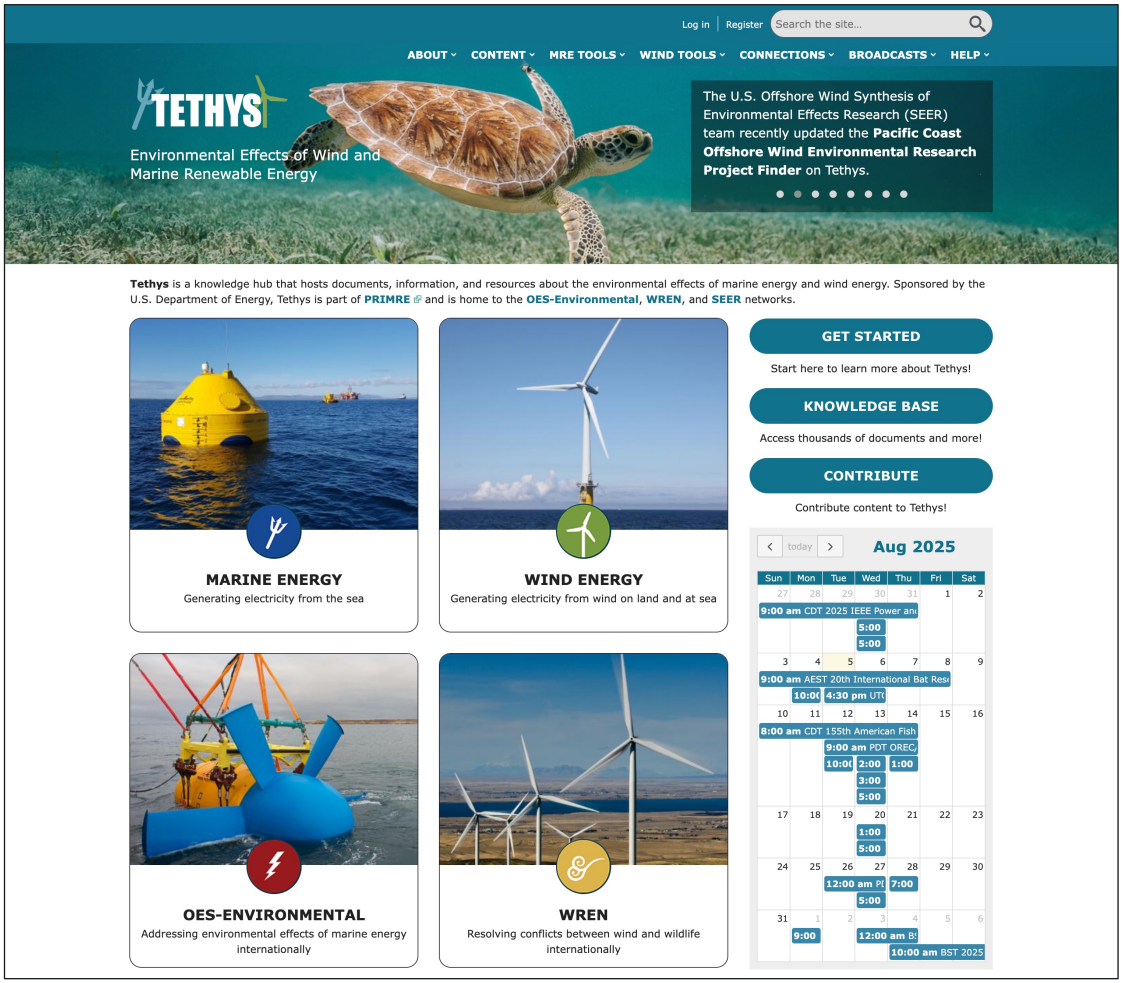
U.S. DEPARTMENT of ENERGY

Pacific Northwest NATIONAL LABORATORY

OES ENVIRONMENTAL

https://tethys.pnnl.gov/

- Publicly available knowledge management system
- All OES-Environmental activities are documented on Tethys
- Over 4,400 documents on the environmental effects of MRE
- Additional features:
  - Tethys Blast Emails
  - Events Calendar
  - Archived Webinars
  - Summaries & Fact Sheets

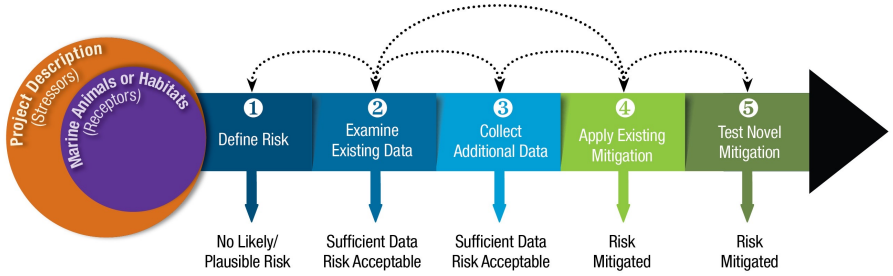


Approaches to Aid Consenting

- For certain stressor-receptor interactions, potential risks need not be fully investigated for every project (**risk retirement**)
- Consenting new MRE projects informed by what is already known (**data transferability**)
- For use during consenting processes by regulators, advisors, developers, consultants

Caveats:

- Does not replace/contradict regulatory processes
- Site-specific data may be needed for new projects



https://tethys.pnnl.gov/risk-retirement

STRESSOR-RECEPTOR INTERACTION	READINESS FOR RISK RETIREMENT
Collision risk	Need more information.
Underwater noise	Retired for small numbers of devices. May need to revisit as the industry moves to larger-scale arrays.
Electromagnetic fields	Retired for small numbers of devices. May need to revisit as the industry moves to larger-scale arrays.
Changes in habitat	Retired for small numbers of devices. May need to revisit as the industry moves to larger-scale arrays.
Oceanographic systems	Retired for small numbers of devices. May need to revisit as the industry moves to larger-scale arrays.
Entanglement	Need more information as the industry moves to larger-scale arrays.
Displacement	Need more information as the industry moves to larger-scale arrays.

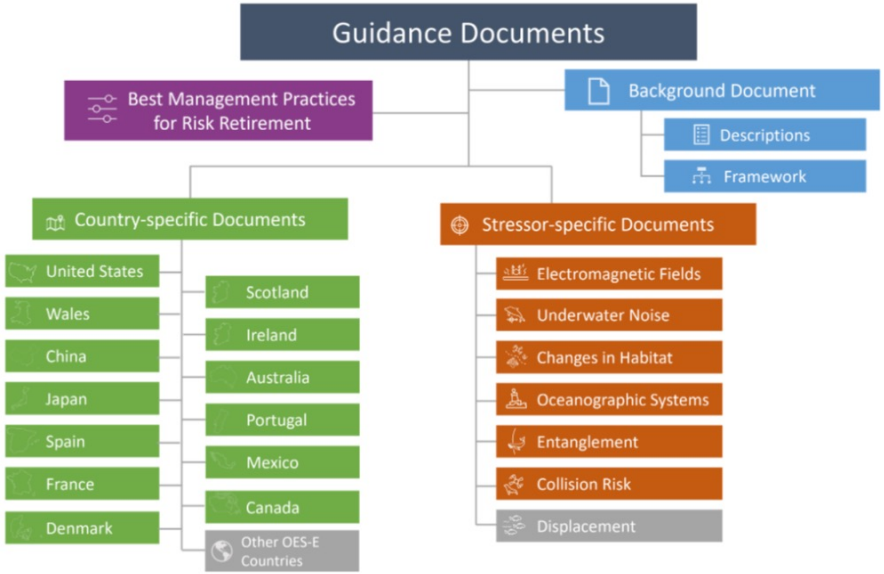
Resources to Aid Consenting

Evidence bases:

- Key research papers and monitoring reports that inform risk retirement for each stressor-receptor interaction
  - All evidence bases updated and Displacement evidence base created in 2025

Guidance documents:

- Documents tailored to regulators and advisors to bridge scientific evidence to regulatory use
  - Stressor-specific guidance documents updated in 2025

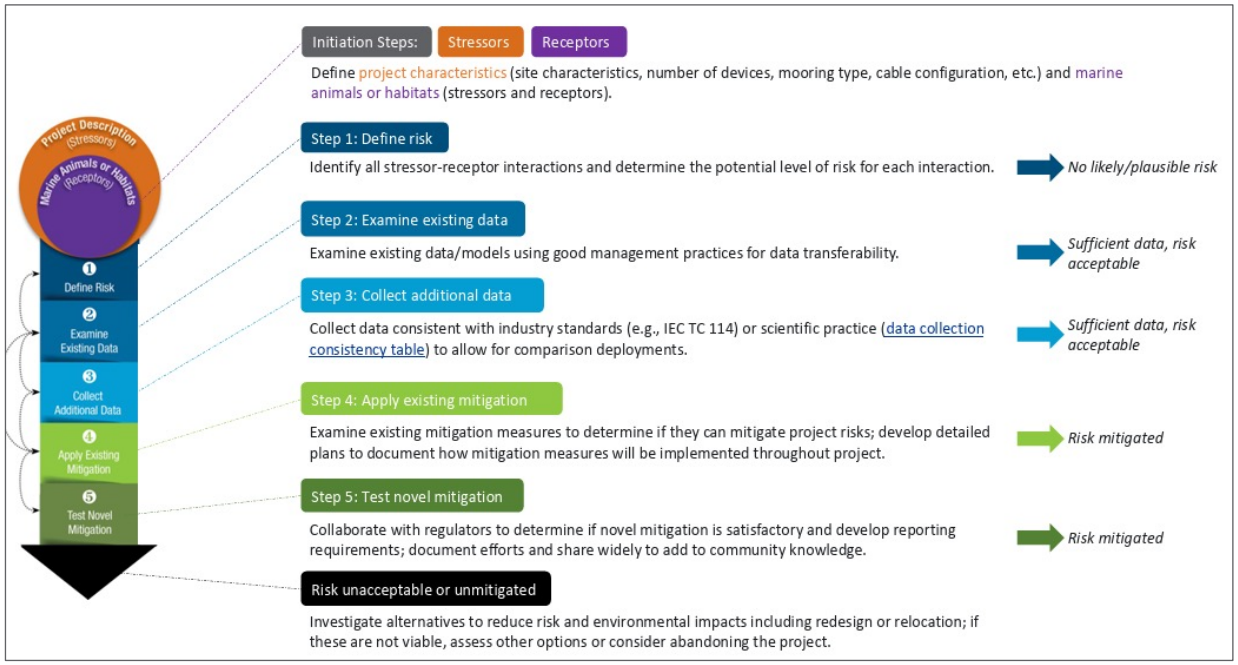


https://tethys.pnnl.gov/risk-retirement

Resources to Aid Consenting

Best Management Practices for Risk Retirement:

- Provide actionable steps for implementing the risk retirement process
- Support consenting dialogues with regulators
- Written in a manner that is accessible and actionable
- Reviewed by MRE developers in online expert forum in 2025



https://tethys.pnnl.gov/publications/best-management-practices-risk-retirement

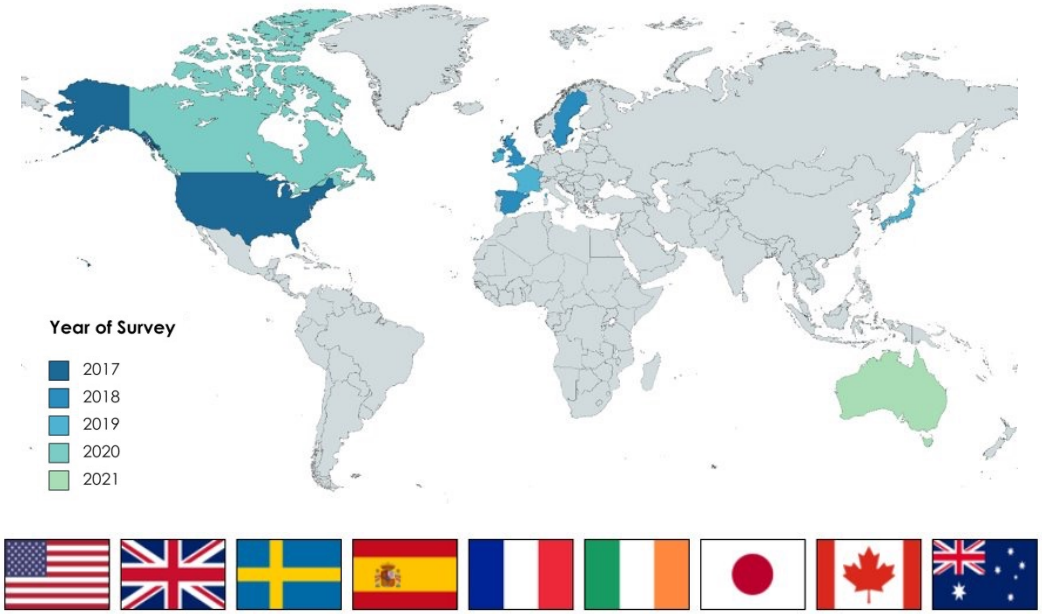
Outreach & Engagement

Regulator Engagement

- Engage regulators and advisors to share knowledge, understand needs, and provide resources for decision-making
- Outreach began in 2017, and has included webinars, workshops, iterative feedback

- Regulator survey
  - 2017 - 2021
    - ✓ Conducted first regulator surveys in 9 countries
    - ✓ Developed data transferability (and later risk retirement) based on survey results
  - 2025 – ongoing:
    - ✓ Updated regulator survey to understand changing information needs and challenges
    - ✓ Sharing in OES-Environmental countries throughout 2025-2026

2017-2021 Regulator Survey



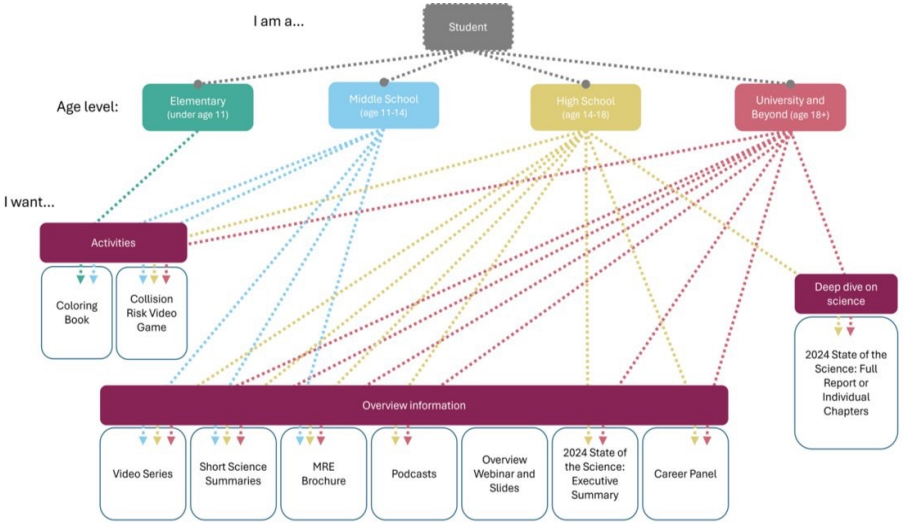
https://tethys.pnnl.gov/regulator-surveys

Outreach & Engagement

Educational Resources Guide:

- Interactive flowchart to help teachers and students find resources for various age groups

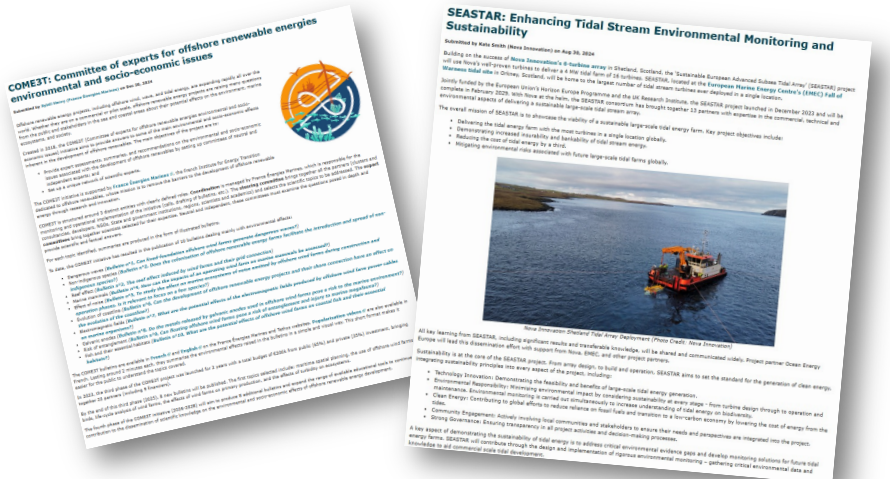
https://tethys.pnnl.gov/mre-educational-resources-guide



Tethys Stories:

- Feature news, events, research, and projects that are relevant marine renewable energy development activities around the world

https://tethys.pnnl.gov/tethys-stories

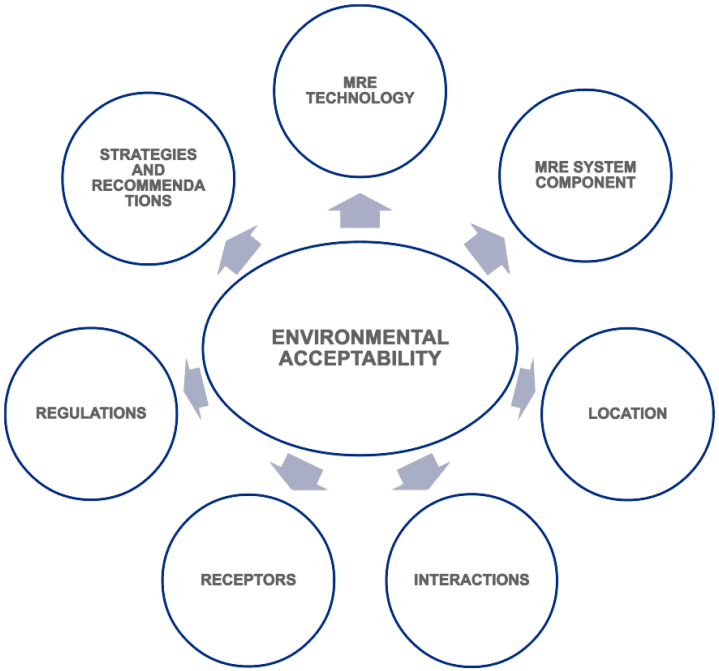


New Areas of Research (2024-2028)

❖ Environmental Acceptability

Proactive guidance that will allow for harnessing MRE resources efficiently while limiting the risks to the environment (marine animals, habitats, ecosystems), assuring compliance with environmental regulations, and promoting benefits.

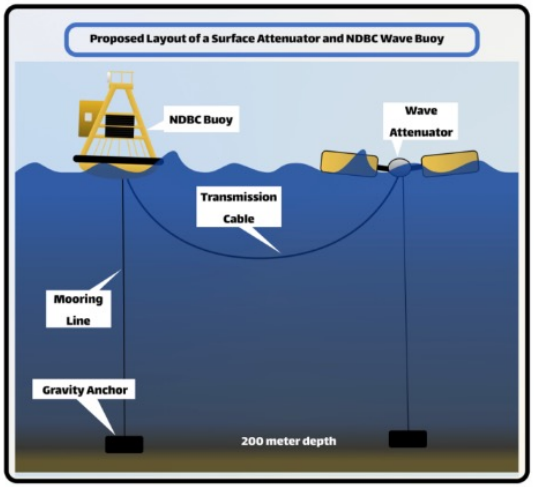
- Examine wave and tidal device types to understand specific environmental risks associated with each component
- Develop guidance for the environmental acceptability of MRE devices
- Assess potential induced benefits

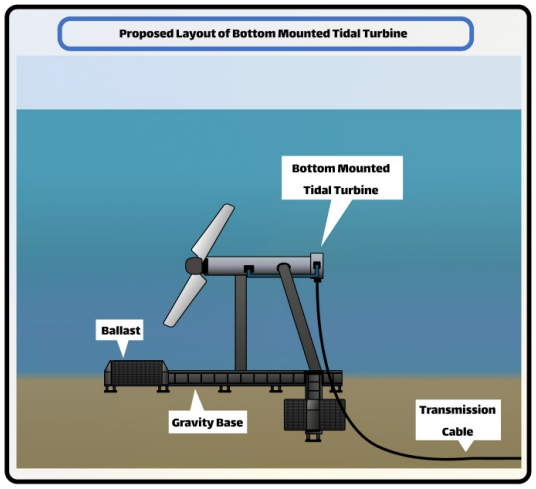


New Areas of Research (2024-2028)

❖ **Environmental Effects of Off-grid Applications**

- Develop use cases for off-grid MRE applications (i.e., power at sea, remote communities)
- Understand how environmental effects may differ from grid-scale applications
- Develop guidance on specific environmental monitoring needs, mitigation measures, and/or consenting





New Areas of Research (2024-2028)

❖ **System-wide Effects**

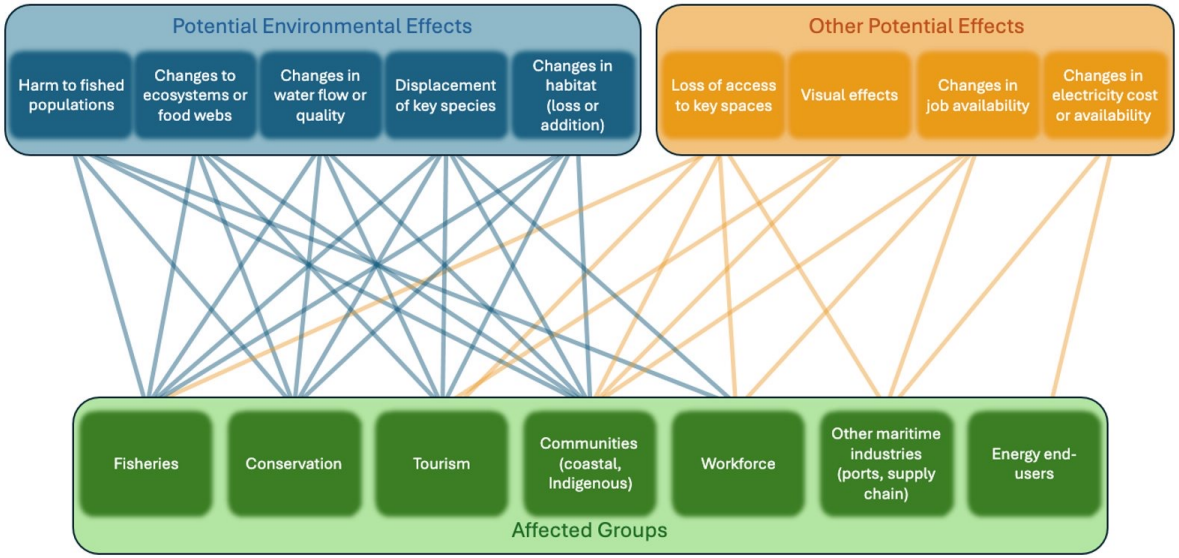
- Understand how knowledge of potential environmental effects of MRE might differ as arrays and larger projects develop in the coming year

  - Topics:
    - Scaling up to arrays (Hasselman et al. 2023)
    - Ecosystem approach (Le Marchand et al. under review)
    - Cumulative effects
    - Tropical regions

New Areas of Research (2024-2028)

❖ Social and Economic Effects

- Coordinate an international working group to investigate the relationships between the environmental and socioeconomic effects of MRE



Progressing the MRE Industry

- Stay informed:
  - Get familiar with risk retirement, data transferability
  - Tethys Blast https://tethys.pnnl.gov/subscribe-tethys
- Give access to your data/information collected around devices
- Collaborate with OES-Environmental on new and emerging issues
- Collaboration between all parties:
  - Device and project developers
  - Researchers
  - Regulators and advisors
  - Students
  - Communities

Tidal stream data Transferability Matrix and Framework

The Crown Estate

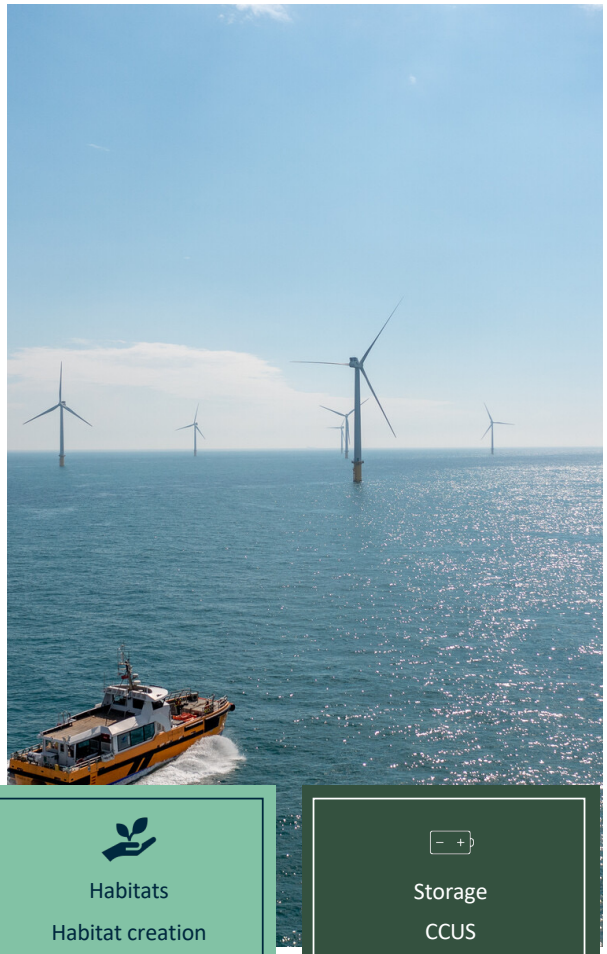
Sarah Wren, Marine Evidence Manager

2nd October 2025

THE CROWN ESTATE

Agenda

- Introduction to The Crown Estate
- Importance of funding evidence
- Introduction to Data Transferability
- Previous work
- Deliverables
- Future look



Energy
Offshore wind
Energy conversion
Marine energy

Infrastructure
Export/Interconnectors
Pipelines
Telecoms

Habitats
Habitat creation
Biodiversity
Nature recovery

Storage
CCUS
Hydrogen
Natural gas

Minerals
Reclamation
Aggregate dredging
Marine mining

Coastal
Ports and harbours
Aquaculture
Leisure

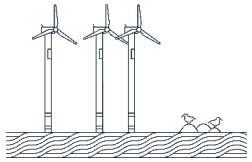
Data and evidence role in supporting sustainable decision making and unlocking value from the seabed

orjip working to accelerate offshore consenting

Offshore Wind Evidence + Change Programme

Marine Data Exchange

OWEKH Offshore Wind Evidence + Knowledge Hub



Plan-level Habitats Regulations Assessment and Strategic Compensation

Commission and support research into restoration techniques (e.g. ReMeMaRe)

Pressure reduction activities (e.g. reducing marine litter, pollution, invasive species, etc)

Market development (e.g. Investible products, blended finance mechanisms)

Evolved leasing approach (e.g. nature inclusive design, environmental leases)

Continue our world-leading work to understand and share data and evidence on the value of the seabed and coast and activities of the sectors we manage, and continuously improve our leasing processes to minimise harm to nature

Build partnerships to protect, restore, enhance and create coastal and marine habitats at scale and take strategic seabed use decisions, through collaboration with policy-makers and investment in science, technology and business models.

The Shared Challenge: Consenting Risks and the Tidal Sector

Why Tidal Matters

Tidal stream energy offers clean, predictable, renewable energy which also benefits the grid. There is also social impact as jobs relating to tidal developments can occur in coastal communities.

Morlais: A Strategic Asset

Morlais is the world's largest consented tidal stream test site with grid connection. The grid connection currently supports 18MW of capacity and is progressing toward 180MW. It has 38MW of CfD-backed sub-leases already secured.

TCE's Role in Enabling Deployment

TCE has invested £2.6M in the Marine Characterisation Research Project (MCRP) to enable safe, phased turbine deployment at Morlais and unlock broader sector growth.

Driving Sector Ambition

TCE also co-funds the Marine Energy Taskforce, which is developing a roadmap to deliver 1GW of tidal stream capacity by 2035.

© MCRP

Tidal Stream Data Transferability Project

- Provide a data and evidence summary of tidal stream research to date
- Provide a structured way to assess where environmental data can be reused across different projects
- Develop a framework and matrix that allows for a nuanced, evidenced based assessment of data
- Streamline the consenting process and accelerate deployment

Key Aspects of the Project:

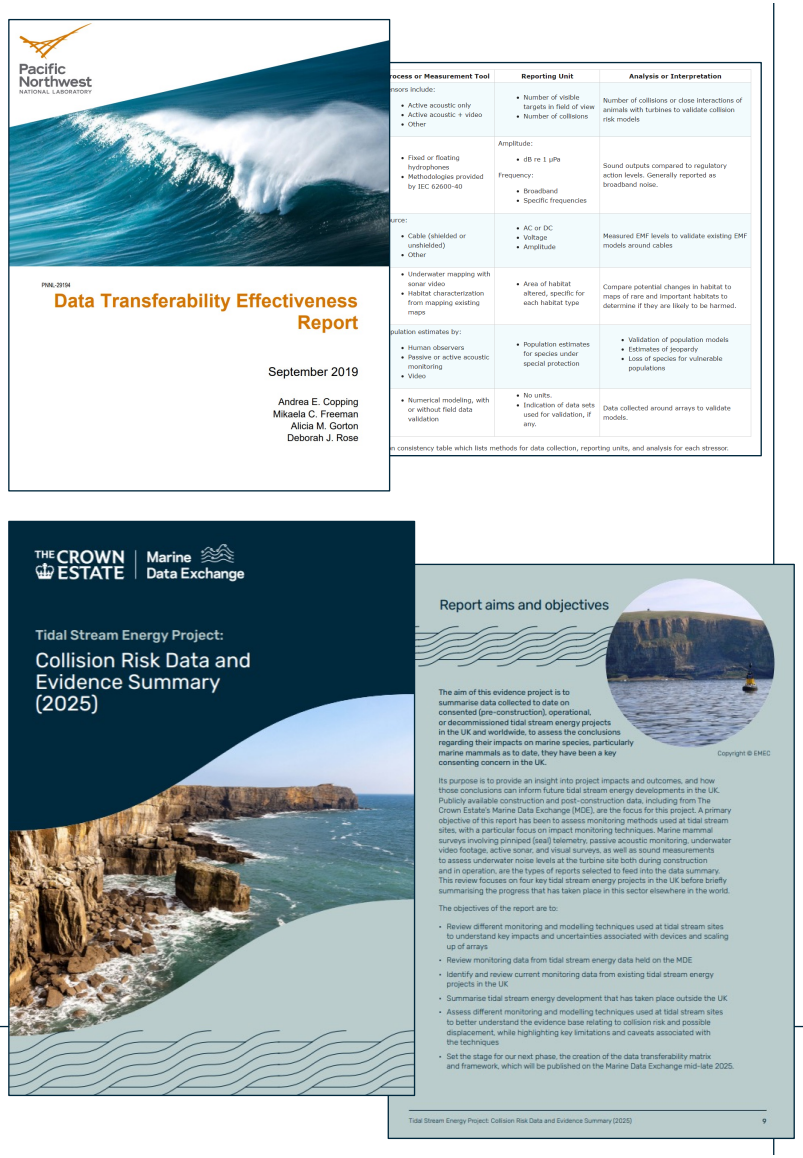
- Reduce costs and increase efficiency
- Improve informed decision making
- Streamline decision making
- Focus on key evidence gaps
- Support industry growth
- Enhance data management
- Highlight importance of collaboration and best practice

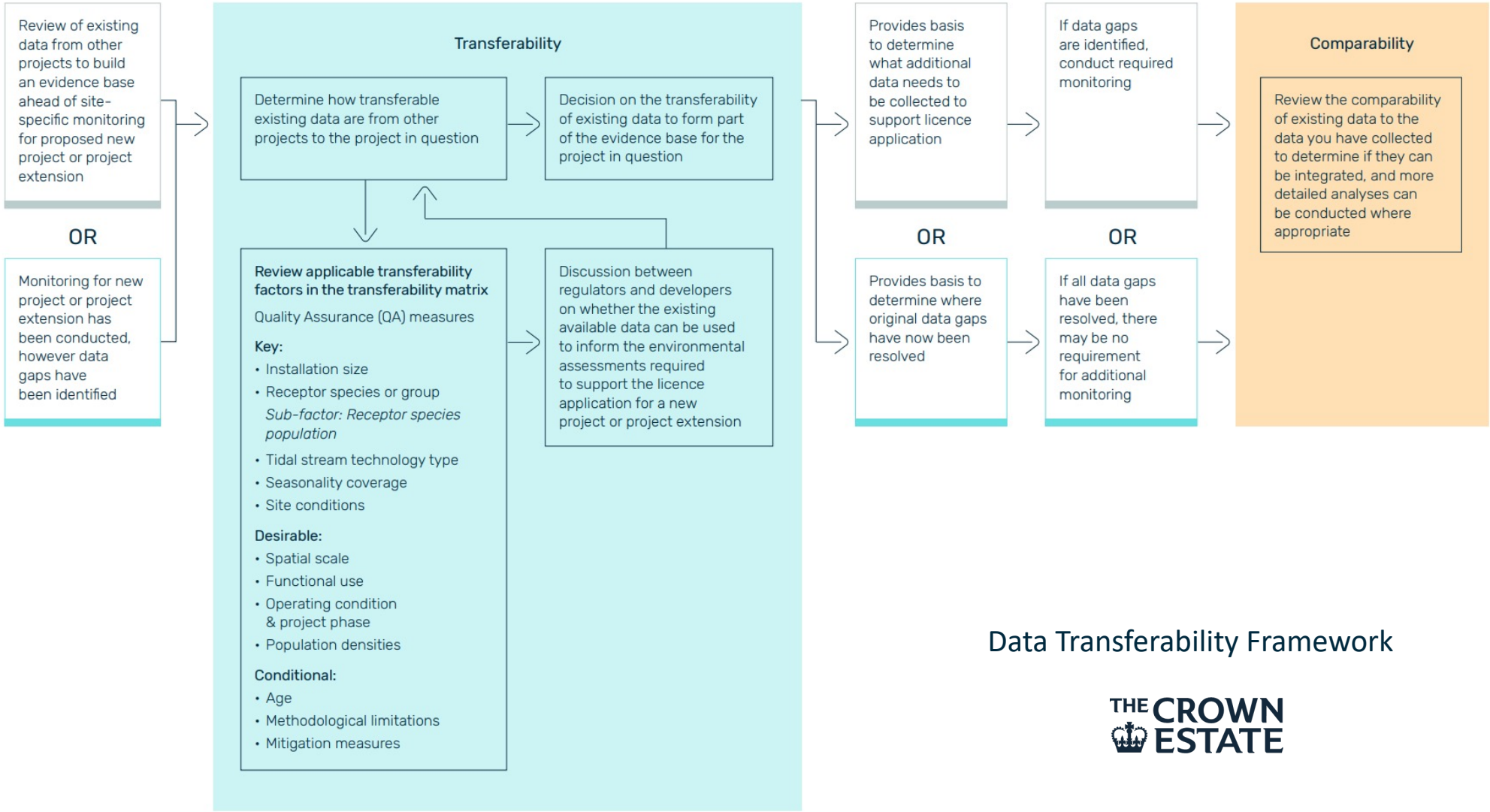
How we got here…

- Reviewed data evidence collected at Tidal Stream sites to produce a Data Summary Report
- Reviewed previous work in data transferability for offshore renewables
- Ensured no duplication of effort to create something useful for regulators and developers
- Developed a framework and matrix to help inform guidance or matrix principals

Monitoring Methods/Techniques:

- Reviewed data collection methodologies
- Highlighted existing standards for [sound] methods, or do we need to produce one
- What's worked/ has not
  - E.g. X surveying, Y standard needs to be made.





Data Transferability Framework

THE CROWN ESTATE

Data Transferability Matrix: Evaluating the transferability of marine mammal impact data from tidal stream energy projects

Transferability Factors		Applicable to Post-installation Data	Applicable to Baseline Data	Factor description	Level of Transferability		
					H	M	L
Quality Assurance (QA) Measures		Y	Y	Data that is more consistent and has undergone quality checking will have a greater transferability and will be more useful for applying to future projects. If data has not undergone QA, the data may have the potential to be relevant, however QA would need to be undertaken to enable its consideration. This factor is needed for successful transfer of data between projects to take place.	Data is consistent with QA measures stated		Data is inconsistent, and QA not conducted or QA information unavailable
Key	Installation size	Y		Data for the same or similar installation size class will have a greater transferability. Size classes are a single device, a small array (2 to 6 devices), a medium array (7 to 9 devices) and an larger array (10 to 30 devices).	Installation size is the same e.g. both projects small arrays	Installation size is one size class different e.g. a small array and a medium array	Installation size is more than two size classes apart e.g. a single device and a large array
	Receptor species or group	Y	Y	Data for the same receptor species or group will have a greater transferability. The three marine mammal groups considered within the transferability matrix are seals, toothed cetaceans, and baleen cetaceans. The same receptor group is important when comparing data between the two projects, but the species might differ. Examples of different species include harbour seal and grey seal. Examples of different groups include baleen cetaceans and seals.	Receptor species is the same	Receptor group is the same	Both receptor species and group are not the same
	Sub-factor: Receptor species population	Y	Y	*It is important to consider the specific population when comparing the same species, as they could be a resident population which occupy a given geographic area over a long period of time, or a population that use the area while in transit.*	*Species is the same population*	*Species is a different population*	
	Tidal stream technology type	Y		Data for a device with same or similar technological specifications will have a greater transferability.	Device specification is the same	Same group of tidal stream generators	Different group of tidal stream generators
	Seasonality coverage	Y	Y	Data fully covering seasonality will have a greater transferability. Seasonal species may need longer monitoring timeframes to collect sufficient data for assessment.	Data covers all seasonal cycles	Data has partial seasonal coverage	Data covers only one seasonal/ behavioural period
	Site conditions	Y	Y	Data that is from sites with similar geography, hydrodynamics, and oceanographic conditions will have a greater transferability. Considerations include seabed type, seabed depth (bathymetry), and current speeds. Channels between islands and more open areas of water may be used differently by marine animals. It should also be considered that evidence from similar geographic regional areas are likely to be more transferable than evidence from distinctly different regions.	Site conditions are the same	Site conditions are similar	Site conditions are dissimilar
Desirable	Spatial scale	Y		Data that covers all three spatial scales will have a greater transferability than data that only covers one spatial scale. Near field monitoring around the tidal device will provide data on device interactions whereas larger scale data collection can provide wider disturbance or barrier effects. Levels of spatial coverage for monitoring can be defined as macro, meso, and micro.	Data covers all three spatial levels (macro, meso, micro)	Data covers two spatial levels	Data covers one spatial level
	Functional use	Y	Y	Data is likely to be more transferable between areas with more similar functional use by the receptor species rather than one area being a low use area and the other of important functional value. This factor should be assessed for each receptor species considered.	Functional use of the habitat is the similar (e.g. both sites are functionally important areas)		Functional use of the habitat is dissimilar (e.g. low use area vs functionally important area)
	Operating condition & project phase	Y		Data that have been collected across all possible operating conditions and throughout different phases of a project's lifecycle will provide a more comprehensive and valuable dataset and are therefore considered to have a higher transferability. If turbines are not operational at particular times, such as no nighttime operation, this limits the usefulness of data collected.	Data covers all operating conditions	Data covers some operating conditions	Data covers one operating condition
	Population densities	Y	Y	Data from sites with similar species population densities will have a greater transferability. Marine mammals can be found in high abundances in some sites, and low in others.	Population density is similar		Population density is dissimilar
Conditional	Age	Y	Y	Data that is more recently collected will have a greater transferability, when considering data at the same project site. Age of data may be more or less relevant based on the amount of data available at the site. Data transfer between projects would be suitable for 3 to 5 years as species diversity and ecology at a project area are unlikely to change in the short term. However, it is recognised that this may not always be possible, and should be assessed on a case-by-case basis.	Data is < 5 years old	Data is 5 to 10 years old	Data is > 10 years old
	Mitigation measures	Y		Data collected where less mitigation measures are in place will have a greater transferability. For example, if the turbine is switched off when marine animals are detected, data on collision risk is less valuable. It is important to note that data that includes knowledge and/or clarity around any mitigation employed and how that impacts the findings will be more useful. The impact of this factor on transferability is dependent on the spatial scale of data (e.g. micro scale collision risk data is most impacted by the shutdown procedure).	No mitigation measures are employed to deter animals from the turbine	Mitigation measures are employed to deter animals during construction/ operation of turbine	Mitigation measure of switching the turbine off when marine animals are detected
	Methodological limitations	Y	Y	Data that has fewer methodological limitations associated with its collection will have a greater transferability. Techniques to reduce limitations of the data collection method could make the data more transferable (e.g. measures to reduce biofouling).	A limited number of methodological limitations	Some methodological limitations	A lot of methodological limitations

TRANSFERABILITY FACTOR TYPES

- **Key:** These factors are key in the transferability process, and should be considered of high importance when applying the matrix.
- **Desirable:** These factors are important and should be considered, however may be of less importance depending on the project location and/or receptor species.
- **Conditional:** These factors only need to be considered if applicable to the project and/or data in question.

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Road to Success…

Continue data sharing

Continue sharing lessons from projects globally

Continue collaborative discussions between both developer and regulator

Test, adapt and use the framework and matrix

Next Steps…

Call to Action:

- Explore the framework
- Consider local adaptation
- Engage with the data
- Join the conversation

The Crown Estates Next Steps:

- The Marine Energy Taskforce will provide recommendations moving forward
- Further engagement in other forums
- Convening experts on collision risk models

Thanks for listening

The Crown Estate are grateful for **Ceri Seaton, Ceri Morris, Tom Stringell, Holly Dunn, Jasmine Sharp** and **Leonie Richardson** from Natural Resources Wales for their valuable input and feedback throughout the project. The Crown Estate would also like to thank those at the Pacific Northwest National Laboratory, United State Department of Energy, for sharing their knowledge and feedback throughout the project's delivery period, in particular **Lenaïg Hemery, Mikaela Freeman,** and **Lysel Garavelli**.

We would also like to thank all the industry specialists and regulators who took the time to provide input, to carefully review information and/or to meet with The Crown Estate to discuss the projects outputs.

Contact: Sarah Wren, Marine Evidence Manager
sarah.wren@thecrownestate.co.uk

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SAFE WAVE
STREAMLINING THE ASSESSMENT OF ENVIRONMENTAL EFFECTS OF WAVE ENERGY

Supporting Consenting Processes for Marine Renewable Energy: International Perspectives

Risk Based Approach

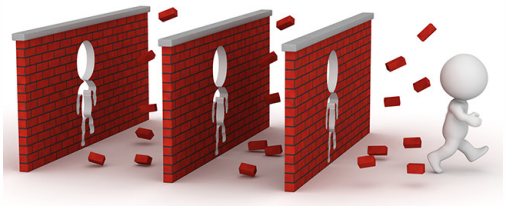
Juan Bald (AZTI, jbald@azti.es)
Anne Marie O´Hagan (UCC, a.ohagan@ucc.ie)

OES OCEAN ENERGY SYSTEMS

October 02, 2025

This Project is co-funded by the European Climate, Infrastructure and Environment Executive Agency (CINEA)

SafeWAVE project was co-funded by the European Climate, Infrastructure and Environment Executive Agency (CINEA)



While the technological development of devices is growing, there are some **non-technological barriers** that could hinder the future development of WE in EU:

1. The environmental **risk and uncertainty about the potential environmental impacts** of WE developments.

2. The need of a **MSP approach** to overcome the potential competition and conflicts between WE and other marine users.

3. The complex and long **consenting processes**.

4. The opposition among **host communities** of future WE deployments.

The MAIN OBJECTIVE of the SafeWAVE project is to **overcome these non-technological barriers through 3 strategies**

1. **Environmental Research Demonstration Strategy**
2. **Consenting and Planning Strategy**
3. **Public Education and Engagement Strategy**

ENVIRONMENTAL RESEARCH DEMONSTRATION STRATEGY based on the **collection, processing, modelling, analysis and sharing of environmental data** collected in WE sites from different European countries where WECs are currently operating (Mutriku power plant and BIMEP in Spain, Aguçadoura in Portugal and SEMREV in France).




Monitoring:

(i) Underwater noise

(ii) Seafloor Integrity

(iii) EMF

Modelization:

(i) Underwater noise

(ii) Marine dynamics

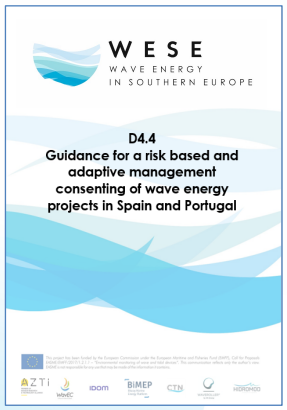
(iii) EMF

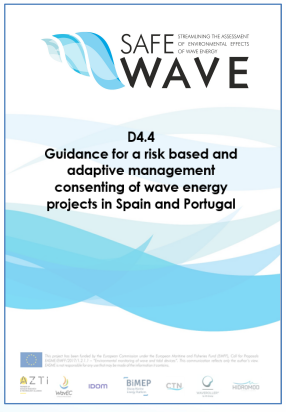
Sharing data:

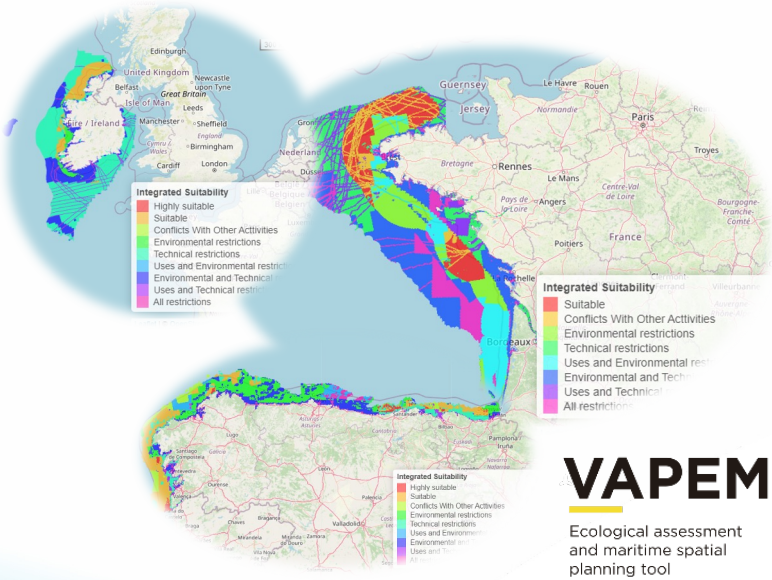
MARENDATA

PUBLIC EDUCATION AND ENGAGEMENT STRATEGY to work collaboratively with coastal communities in France, Ireland, Portugal and Spain, to co-develop and demonstrate a framework for education and public engagement (EPE) of MRE.

CONSENTING AND PLANNING STRATEGY through providing **guidance** to ocean energy developers and to public authorities tasked with consenting and licensing of WE projects in France and Ireland and the application of the **MSP decision support tool** developed for Spain and Portugal in the framework of the WESE project.

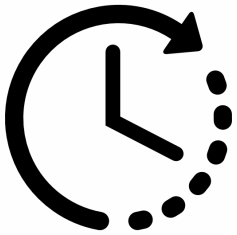






VAPEM
Ecological assessment and maritime spatial planning tool

Risk Based Approaches and Wave Energy



Consenting procedures for Wave Energy Converters are often long, **time-consuming processes**, demanding a lot of **time and data**. This is **delaying** the testing and deployment of novel WECs

Due to uncertainty around environmental impacts, an **Adaptive Management** approach (learning by doing) is needed that allows **progress** to be made faster but in a robust way that **protects the environment**

Much research exists into Risk-based Approaches, but these are **complex**, **multiple approaches** have been developed and are often embedded in scientific literature. This means they **aren't accessible** to non-scientific communities

Embedding a Risk Based Approach in Marine Renewable Energy Consenting Processes

WHY use a Risk-based Approach?


Can **speed up** decision making


Can work in **data-poor** situations

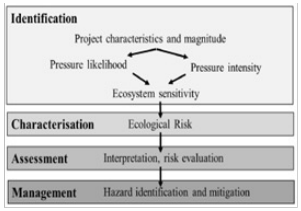

Suitable for different situations – part of an **Adaptive Management** process


Provides a **clear process** to follow and track

Consenting processes represent a NON-TECHNOLOGICAL BARRIER to progress in Wave Energy development

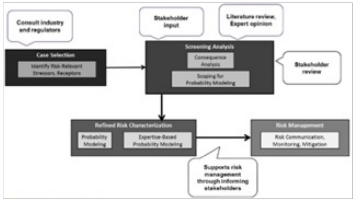
Analysing existing Risk-based Approaches

Finding **commonalities** and **differences** between the existing Risk-based approach (alluvial diagram)



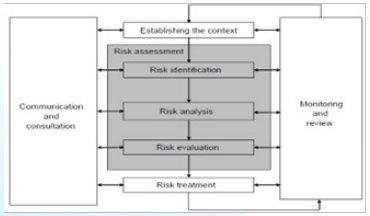
ERA Framework

Galparsoro et al., 2021



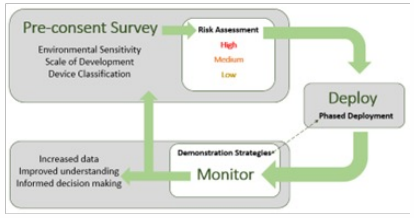
ERES Framework

Copping et al., 2015



ISO Standards

ISO, 2009

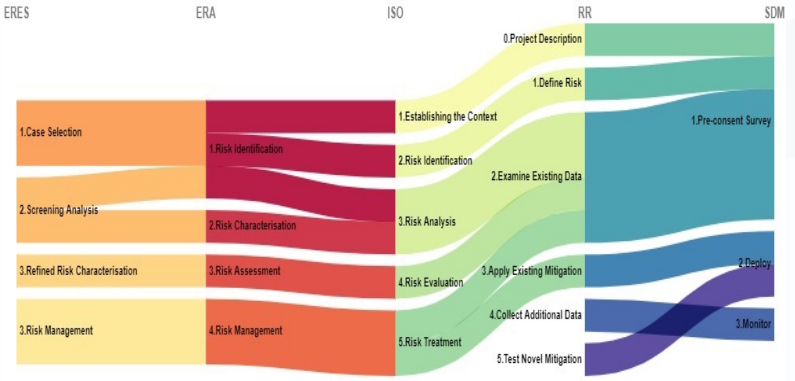


Survey-Deploy-Monitor

Marine Scotland, 2016

Risk Retirement

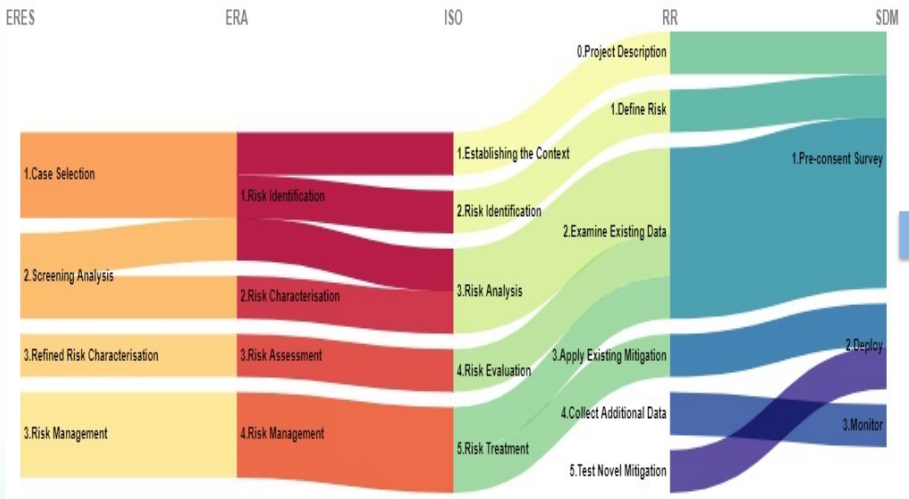
Copping et al., 2020

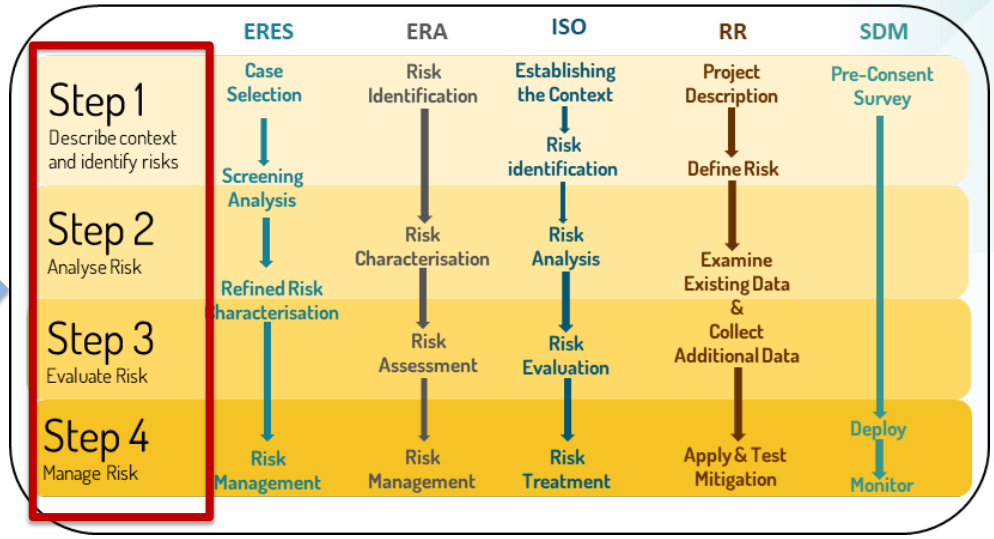


See SafeWAVE Deliverable 5.2

Existing Risk-based Approaches

Creating one graphic to show the **relationship** between all the different approaches



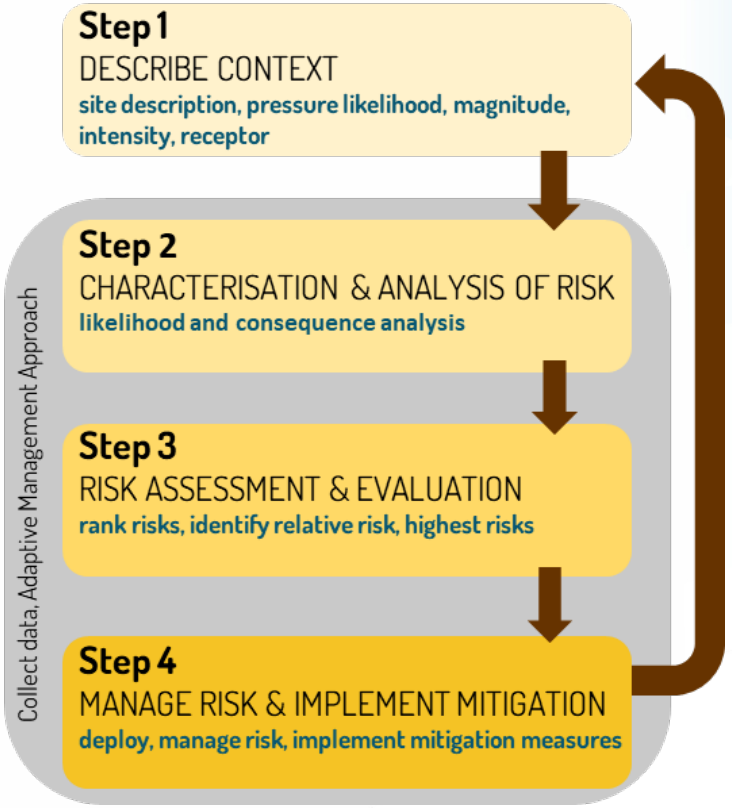


See SafeWAVE Deliverable 5.2

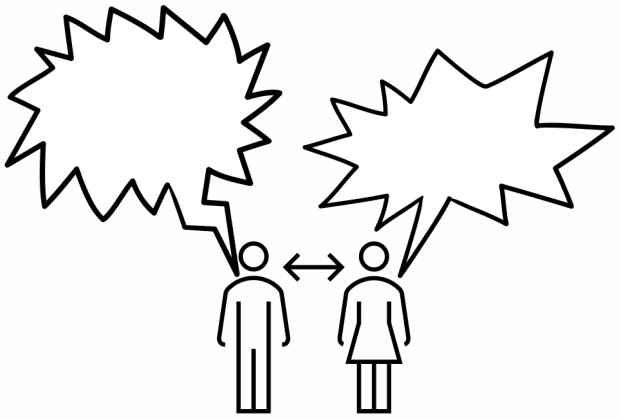
Existing Risk-based Approaches

Creating a simple step-wise approach that is USER-FRIENDLY for wider use

See SafeWAVE Deliverable 5.3



FEASABILITY OF RISK-BASED APPROACHES?



Meetings and Workshops with **regulators** to determine **operational feasibility** of RBA

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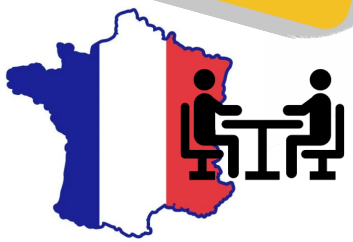
Step 1
DESCRIBE CONTEXT
site description, pressure likelihood, magnitude, intensity, receptor

Step 2
CHARACTERISATION & ANALYSIS OF RISK
likelihood and consequence analysis

Step 3
RISK ASSESSMENT & EVALUATION
rank risks, identify relative risk, highest risks

Step 4
MANAGE RISK & IMPLEMENT MITIGATION
deploy, manage risk, implement mitigation measures

Collect data, Adaptive Management Approach



FEASABILITY OF RISK-BASED APPROACHES?

SAFE WAVE

Questions

1. Have you encountered risk-based approaches in your work?

2. Have you used (RBAs) in any Offshore Renewable Energy projects to date or do you plan to?

3. Which RBAs have you used, why? What worked and what did not?

4. Would you use RBAs again or would you like to see wider uptake?

5. Which environmental inputs would you consider to be most ‘uncertain’?

6. If the use of RBAs was successfully streamlined and embedded in the processes of other countries, would this increase the likelihood of their use in your country?

7. Would a worked example of this process make it more understandable and assist in its future use?

Conclusions and future work

1. None of the regulators or developers asked felt that they were using a formalised RBA in their work at present, but felt that they were **using risk concepts in an informal way**

2. Any incorporation of RBAs **must** take note of existing processes so as not to increase workload and complexity

3. There was a feeling that **direct evidence** of RBAs in action would be welcome (e.g. from RBAs in action in other countries or through worked examples) before regulators, developers and consultants feel confident that they can fully engage and understand the benefits and improvements RBA might offer.

4. Seeing RBAs working **effectively** in another jurisdiction would be an incentive to consider using the approach

5. **Cumulative effects** were seen as presenting significant difficulty in general to consenting processes and anything that could help with this would be welcome

SAFE WAVE
STREAMLINING THE ASSESSMENT OF ENVIRONMENTAL EFFECTS OF WAVE ENERGY

¡¡MANY THANKS FOR YOUR ATTENTION!!

Juan Bald (AZTI, jbald@azti.es)
Anne Marie O´Hagan (UCC, a.ohagan@ucc.ie)

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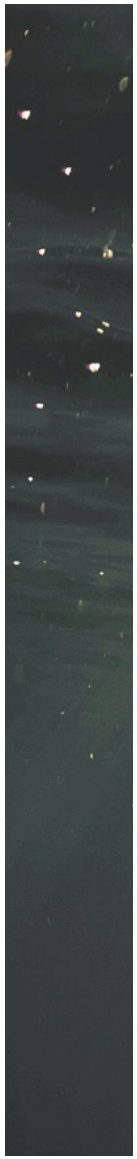

Thank you

Lysel Garavelli
lysel.garavelli@pnnl.gov

Debbie Rose
deborah.rose@pnnl.gov

Mikaela Freeman, Andrea Copping,
Lenaïg Hemery, Hayley Farr, Kristin Jones,
Jacob McGrath, Jonathan Whiting

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