

Tidal Range in Wales: Critical Environmental Evidence Gaps and How to Address Them

ORJIP OE Workshop

Marine Energy Wales Conference, Llandudno, Wales

23 March 2022, 9:00 – 12:00

**Report to: The Crown Estate, Crown Estate Scotland,
Welsh Government, NatureScot and Natural Resources
Wales**



EXECUTIVE SUMMARY

There is substantial interest in tidal lagoons in Wales, and in 2021 the Welsh government launched a prior information notice (PIN) exercise to determine the level of interest in a potential competition or procurement for a future tidal lagoon project with possible support from the Welsh government. In late 2021, a new tidal lagoon project was put forward for the Swansea area: the Blue Eden Project¹. The project includes a proposal for a 320 MW lagoon, alongside battery technology, a floating solar energy array, a data centre, and other new infrastructure.

In response, ORJIP Ocean Energy hosted a workshop at the Marine Energy Wales Conference in Llandudno, Wales, on 23 March, 2022. Workshop attendees were from predominantly Welsh organisations. The aim of this workshop was to review and update the critical evidence gaps in relation to environmental impacts and consenting risks of tidal range energy in Wales. This was a follow-on to a previous workshop held by ORJIP Ocean Energy on the same topic in 2017.

Participants discussed four key themes, commenting on the key consenting issues and risks set out in 2017:

- Physical processes and benthic ecology
- Biological receptors
- Mitigation and compensation
- Human environment, policy and regulation

The key consenting issues and risks were updated to reflect the current state of the science and policy, and priorities for research and monitoring at the first tidal range development were discussed and complemented by a series of recommendations to progress the industry in Wales.

PRIORITY ACTIONS

The first tidal lagoon development is an opportunity to validate predictions made in the EIA, for example for fish impacts, coastal processes, marine mammals, and electricity generation. These validations should be revisited throughout the lifetime of the project – over 5 years, 10 years, 20 years, and beyond. Additionally, such monitoring over time could reveal that some impacts are not as severe as predicted, enabling some impacts to be retired or ‘scoped out’.

Priority actions should work to address the eight key questions identified by workshop participants, listed in the table below.

¹ <https://www.swansea.gov.uk/article/11538/1.7-billion-Blue-Eden-project-announced-for-Swansea>



Priority question to address at the first tidal range development
How can site selection for tidal lagoons be improved, building on information from the first site?
How does the extent of the development zone of influence compare with the zone of influence predicted in the EIA?
What are near-field effects of the development on coastal processes?
How do fish and marine mammals behave around the lagoon?
What, if any, are the impacts on fish and marine mammal populations?
What are the effects (positive and negative) on habitats within the lagoon?
How effective are mitigation measures over time?
How has construction of the structure affected the prevalence of invasive non-native species (INNS)?

A number of key recommendations for tidal range development in Wales also emerged from the workshop. These are set out in the table below.

Recommendations
To advance understanding of fish behaviour, distribution, and population structure, collaborative projects are needed between developers, academics, and government and environmental organisations.
Anticipated operational regimes for tidal lagoon developments should be incorporated into coastal process modelling to improve accuracy of impact assessments.
Data, information and knowledge from the first project(s) should be stored centrally and made widely accessible to inform future studies. This could be within an existing database, or in a newly developed one.
There is some responsibility for the UK Government or government bodies to fund monitoring of pathway projects, to help to deliver an evidence base that can inform future decision making. More specifically, where specific types of monitoring are set out in conditions of the marine license, then the developer should take lead responsibility. However strategic studies should be government funded.

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1 BACKGROUND

1.1 TIDAL RANGE ENERGY IN WALES: TIDAL LAGOONS

Tidal lagoons are the most advanced tidal range technology in development in Wales. Tidal lagoons are constructed to impound a body of water in a location with substantial tidal action, using the difference in the rise and fall of tides to drive turbines, thereby generating electricity. Tidal lagoons may generate power via:

- One way generation at ebb tide, as water flows out of the tidal lagoon;
- One way generation at flood tide, as water flows in to the tidal lagoon; and,
- Two way generation, in both directions of water flow.

In the UK, there have been numerous proposals for tidal barrage or tidal lagoon developments, many of which were sited in the Severn Estuary. Other project sites include the Solway Firth, Liverpool Bay, and North Wales. The most recent project of note, Tidal Lagoon Swansea Bay, received development consent in 2015.

The 2017 Hendry Review concluded that tidal lagoons would help to deliver security of energy supply, contribute to the UK's net zero commitments, and provide opportunities for the UK supply chain². The review also concluded that tidal lagoon projects could play an important role as part of the UK's energy mix alongside other renewable energy technologies. However, the 320 MW Swansea Tidal Lagoon project did not receive financial support from the UK Government in 2018, and in 2020 its consents lapsed.

Substantial interest in tidal lagoons remains in Wales. In 2021 the Welsh government launched a prior information notice (PIN) exercise to determine the level of interest in a potential competition or procurement for a future tidal lagoon project with possible support from the Welsh government. The exercise received written responses from 27 organisations.

In late 2021, a new tidal lagoon project was put forward for the Swansea area: the Blue Eden Project³. The project includes a proposal for a 320 MW lagoon, alongside battery technology, a floating solar energy array, a data centre, and other new infrastructure.

The workshop described in this report was hosted by ORJIP Ocean Energy at the Marine Energy Wales Conference in Llandudno, Wales, on 23 March, 2022. Workshop attendees were from predominantly Welsh organisations. While Wales is at the forefront of tidal lagoon development in the UK, the themes and issues discussed in this report will have a wider application within the UK and internationally.

1.2 ABOUT ORJIP OCEAN ENERGY

The Offshore Renewables Joint Industry Programme Ocean Energy (ORJIP OE)⁴ is a UK-wide collaborative programme of environmental research with the aim of reducing consenting risks for wave, tidal stream and tidal range projects. The programme brings together industry, regulatory and advisory bodies, academia, and other key stakeholders to identify and address critical evidence gaps for the principal Environmental Impact Assessment (EIA) and Habitats Regulations

² <https://www.gov.uk/government/news/independent-review-into-the-strategic-role-of-tidal-lagoons-in-the-uk-published>

³ <https://www.swansea.gov.uk/article/11538/1.7-billion-Blue-Eden-project-announced-for-Swansea>

⁴ <http://www.orjip.org.uk/oceanenergy/about>

Assessment (HRA) consenting risks for the wave and tidal sectors. Two important outputs of ORJIP OE are the Forward Look and the Critical Evidence Needs.

The Forward Look provides a list of outline project plans for research projects to address key EIA/HRA issues based around a series of prioritised consenting issues for the wave and tidal stream sectors. These consenting issues were identified and agreed in a gap analysis process carried out by industry, regulators, and other key stakeholders. The latest version of the Forward Look was published in 2017, and was updated to include EIA/HRA issues for tidal lagoon developments.

The **Critical Evidence Needs** complements and builds on the Forward Look and the growing body of evidence, knowledge and experience of wave and tidal stream consenting both in the UK and globally. It sets out the critical outstanding evidence needs for wave and tidal stream energy in the UK, grouped into ten strategic topics. This document currently applies to wave and tidal stream energy only.

2 ABOUT THE WORKSHOP: TIDAL RANGE ENERGY

In 2017, ORJIP Ocean Energy held a workshop investigating the key consenting risks for tidal lagoons. During the workshop evidence gaps and consenting risks for tidal range developments were identified and prioritized. This is presented in the Forward Look, 2017⁵. The aim of the workshop held in March 2022 was to review and update the critical evidence gaps in relation to environmental impacts and consenting risks of tidal range energy in Wales. The objectives of this workshop were to:

- Revisit and review the tidal lagoon elements of the 2017 Forward Look
- Share information on Strategic Resource Areas in Wales
- Discuss and prioritise the consenting risks for tidal range in Wales
- Review and update the key consenting issues and proposed priority research projects to be presented in an updated report.

2.1 AGENDA

An agenda for the workshop that took place on 23 March, 2022 can be found in Table 1.

Table 1: Agenda for ORJIP OE Marine Energy Wales Workshop on tidal range energy

Time	Item	Lead
0830 - 0900	Registration and coffee	ORJIP OE Team
0900 - 0915	Welcome and introductions	Raeanne Miller, Aquatera Ltd.
0915 - 0935	Scene setting- current status of Tidal Range including environmental risks	Kat Route-Stevens, MarineSpace
0935 - 0950	Strategic Resource Areas- Marine Planning for Tidal Range in Wales	Natalie Frost, ABPMer
0950 - 1010	Swansea Bay Tidal Lagoon- lessons learnt in consenting	Tim Carter, JBA Consulting
1010 - 1025	Coffee break	
1025 - 1030	Brief on the breakout sessions	ORJIP OE Team

⁵ <http://www.orjip.org.uk/documents>

Time	Item	Lead
1030 - 1100	Break out session 1	ORJIP OE Team
1100 - 1105	Report out from session 1	All
1100 - 1130	Break out session 2	ORJIP OE Team
1130 - 1145	Report out from breakout sessions	All
1145 - 1200	Next steps & conclusions	ORJIP OE Team
1200	Close	

2.2 BREAKOUT SESSIONS

2.2.1 Session 1 – Review of the consenting risks (30 minutes)

The list of consenting risks (issues) outlined in the Forward Look, 2017, was divided into four themes: physical processes, biological receptors, mitigation and compensation, and human environment, policy and regulation (Table 2).

Table 2: Summary of consenting risks for tidal lagoon energy outlined in the 2017 Forward Look.

No	Theme	Subtheme	Number of issues	Number classified as <i>key strategic issues</i> in 2017
1	Physical Processes	Physical Processes	9	6
2	Biological Receptors	Benthic ecology	3	0
2	Biological Receptors	Fish	13	11
2	Biological Receptors	Marine Mammals	5	3
2	Biological Receptors	Ornithology	3	3
3	Mitigation and Compensation	Nature Conservation	9	4
4	Human environment, policy, and regulation	Other users	1	0
4	Human environment, policy, and regulation	Policy and legislation	3	1
4	Human environment, policy, and regulation	General	3	1
4	Human environment, policy, and regulation	Environment Act 2021 and legacy Water Framework Directive targets	5	3
4	Human environment, policy, and regulation	Decommissioning	2	0
	Total		56	32

Workshop attendees selected the Forward Look theme that they most wished to discuss in the first breakout session and were divided into groups according to theme. Each group was provided with a list of tidal lagoon consenting issues set out in the 2017 Forward Look and associated with their chosen theme. For each set of consenting issues, groups were asked to:

- Identify any gaps or new consenting issues that may have emerged since 2017
- Identify any consenting issues that were no longer relevant

- Evaluate whether issues classified as 'key strategic consenting issues' in 2017 were still key issues in 2022, and whether other issues should be newly classified in this way.
- Evaluate whether any details needed updating

2.2.2 Session 2 – Scaling Up (30 minutes)

In this breakout session workshop attendees remained in the same groups as for Breakout Session 1. Groups were provided with blank paper, and several colours of marker. This session was divided into three parts:

1. Groups were asked to identify 3-5 key environmental questions that will be important to address at the first tidal lagoon project in Wales. Questions should be SMART (specific, measurable, achievable, relevant, and time-bound). After 10 minutes, groups were asked to rotate to the next table.
2. At the next table, groups reviewed the questions set out by the previous group (Part 1), and then identified monitoring strategies or approaches that could be used to address the questions. After 10 minutes, groups were asked to rotate to the next table.
3. At the next table, groups were asked to review the questions and monitoring strategies set out by the previous two groups in parts 1 and 2. They were then asked to consider when the activities in 1 and 2 should take place (baseline, post installation, etc), over what duration, and who should lead and fund these activities. After 10 minutes, groups were asked to move back to their original table.

Once back at their original table, groups were given the opportunity to review the environmental questions they posed in part 1, and the subsequent additions from other groups in parts 2 and 3. A short discussion of the session ensued.

3 WORKSHOP OUTCOMES

3.1 BREAKOUT SESSION 1 OUTCOMES

3.1.1 Physical processes

Attendees in this group were in broad agreement with the key consenting issues identified in the 2017 Forward Look. The group noted that for Wales, Natural Resources Wales has produced new guidance on marine and coastal physical processes baseline survey and monitoring (Brooks et al. 2018), and that this has been published on their website⁶. For Wales, this suggests that the need for, level, scope, and quality of physical baseline data and characterisation is much better understood than it was in 2017.

Modelling approaches are often used to determine development effects on physical processes, but it was noted that most current modelling efforts are based on spring/neap cycles. It was suggested that it would be more appropriate to model real scenarios where possible, although the patterns of operation for the lagoon would need to be identified, depending on the supply and demand for energy, which is currently uncertain. Future modelling efforts should reflect the operational regime of the installation in question. It was also suggested that:

- The questions being asked of models should be clearly defined.
- The ability of models to predict small-scale changes in physical processes amidst a wider background of natural variability and larger-scale changes such as sea level rise should be questioned.

⁶<https://cdn.naturalresources.wales/media/689057/guidance-on-best-practice-for-marine-and-coastal-physical-processes-baseline-survey-and-monitoring-requirements-to-inform-eia-of-major-developement-projects.pdf>

- Although they continue to improve, models will always be dependent on the data available and on expert geomorphological assessment.
- There may be a need to focus on sensitivity testing of physical models.

This group also noted that understanding saltmarsh erosion will be important as saltmarshes, as carbon sinks, make up an important part of carbon footprinting the development.

3.1.2 Biological receptors

Of the key consenting issues and risks to biological receptors identified in the 2017 Forward Look, the issues associated with fish were highlighted as the most important. The group identified that sea trout were missing from the 2017 Forward Look, and should be included in future documents, while in Wales, eel were not considered to be an issue.

This breakout group suggested that the greatest priority issue was improving understanding of fish avoidance rates, as this would provide information about what proportion of fish closely encounter a turbine. For example, if 95% of fish avoid the tidal lagoon development, then encounters and/or collisions with turbines are unlikely to be an issue for that development. Improved understanding of fish avoidance rates would also enable the development of lagoon-specific encounter rate models.

A further important gap for fish was understanding the distribution and population dynamics of marine anadromous fish. This breakout group noted that technologies for gathering relevant data on fish populations are now well established and have been demonstrated in several contexts. These technologies now need to be implemented to gather sufficient data to develop good population models, and it was suggested that joined up projects would be important in order to make fish monitoring programmes, and especially tagging programmes, more efficient. The impacts of physical barriers (i.e. a tidal lagoon) on fish species using estuaries was considered to be something that should be monitored post-construction.

Marine mammals were considered to be at low risk of impact from tidal lagoon developments. It was expected that the response of marine mammals to tidal lagoons would be to avoid turbines, as has been evidenced for tidal stream turbines. The 2017 Forward Look included the need to identify acceptable limits for marine mammal mortality from tidal lagoons, but breakout group participants acknowledged that an acceptable limit had now been determined for harbour porpoise.

The group did not consider the 2017 Forward Look issues related to ornithology.

3.1.3 Mitigation and compensation

This breakout group noted that mitigation and compensation schemes should be incorporated into project design at the earliest stages, in order to design out impacts and ensure that monitoring of such schemes is an intrinsic part of the project.

The breakout group suggested that the key issues highlighted in the 2017 Forward Look were in some ways too specific, and that mitigation and compensation should be considered from a wider perspective across the entire potential zone of influence of the project, including broader-scale impacts on coastal processes, species, and habitats. However, the group considered that it will remain challenging to identify appropriate areas for large scale compensation schemes. The following key issues and knowledge gaps were identified:

- Identifying appropriate locations for compensation schemes.
- Monitoring the success of compensation schemes.

- Guidance or methods for incorporating mitigation into design at an early stage.
- Understanding the appropriateness and effectiveness of measures for ecological enhancement.

The need to consider IROPI (imperative reasons of overriding public interest) in the context of tidal lagoons was also discussed in the context of mitigation and compensation. In the UK, if there are no feasible alternative solutions to a development and there are IROPI, then compensatory measures must be taken to offset any damage that will or could be caused to a protected site⁷. These must be technically feasible, effective, and financially viable.

3.1.4 Human environment, policy, and regulation

This breakout group considered that at present there is a lack of resources available to address the topics highlighted in the human environment and policy and regulation categories of the 2017 Forward Look. However, the group noted that some issues were now better understood, for example there is now an improved understanding of how developments will interact with other users of maritime space, which has been enabled through improvements to marine planning, the availability of data in the Welsh marine planning portal⁸, and experience from other EIA approval processes. Although there have been some improvements at a Welsh level, the group noted that there is still a need to align and streamline consents for tidal lagoon projects, particularly for areas such as terrestrial planning.

The group agreed that the following issues were of particular importance:

- The need to develop guidance and policy around Adaptive Environmental Management Plans
- The need to agree standard approaches to fish impact assessments

3.2 BREAKOUT SESSION 2 OUTCOMES

3.2.1 Questions to address at the first tidal lagoon development

Overall, the first tidal lagoon development is an opportunity to validate predictions made in the EIA, for example for fish impacts, coastal processes, marine mammals, and electricity generation. These validations should be revisited throughout the lifetime of the project – over 5 years, 10 years, 20 years, and beyond. Additionally, such monitoring over time could reveal that some impacts are not as severe as predicted, enabling some impacts to be retired or 'scoped out'.

Eight questions were identified to address at the first tidal lagoon development:

- How can site selection for tidal lagoons be improved, building on information from the first site?
- How does the extent of the development zone of influence compare with the zone of influence predicted in the EIA?
- What are near-field effects of the development on coastal processes?
- How do fish and marine mammals behave around the lagoon?
- What, if any, are the impacts on fish and marine mammal populations?
- What are the effects (positive and negative) on habitats within the lagoon?
- How effective are mitigation measures over time?
- How has construction of the structure affected the prevalence of invasive non-native species (INNS)?

⁷ <https://www.gov.uk/guidance/habitats-regulations-assessments-protecting-a-european-site#derogation>

⁸ <http://lle.gov.wales/apps/marineportal/>

3.2.2 Monitoring strategies and approaches for the first lagoon

It was agreed that monitoring of the first tidal lagoon development must be appropriate and proportionate. The approaches employed should be relevant to the project, risk-based, specific to the topic or impact in question, and should have clearly defined geographical scales. It was also agreed that developers should not be expected to monitor everything. Instead, the project developer should be expected to monitor those specific aspects of habitats and animals within the consent conditions, while more strategic studies should be undertaken through collaborative approaches.

Two topics for monitoring were discussed in detail: effects on coastal processes and effects on fish.

Monitoring strategies for effects on coastal processes

Understanding and verifying the zone of impact of the first tidal lagoon development will be important. This might include effects on scour, or the need for maintenance dredging over time. Key monitoring aims might include:

- Monitoring and understanding sedimentation of lagoon;
- Understanding how the lagoon's specific design affects coastal processes; and,
- Verifying and iteratively improving coastal process modelling.

Tidal gauges and sea level topography were suggested as methods for monitoring changes in hydrography. Satellite data and UAVs could also be considered, and data collected post-construction of the tidal lagoon could be compared with historical mapping studies of the coastline.

The evaluation of a tidal lagoon's effects on coastal process should also be addressed within and outwith the perimeter of the lagoon via bathymetric surveys and monitoring of suspended sediment concentrations.

Monitoring strategies for effects on fish

The monitoring aims for understanding tidal lagoon effects on fish should focus on:

- The proportion of the population that approach the lagoon;
- Of those that approach the lagoon, the proportion enter and exit the lagoon; and
- The survival rates of animals entering and exiting the lagoon.

Tagging studies were suggested as an effective method for monitoring fish behaviour and could also provide insight for turbine avoidance studies. Cameras, acoustic devices, and citizen science approaches were also suggested.

To monitor population level impacts of fish, it will be important to assess any changes against a good population baseline. Data collected using the methods described above should be used iteratively to update and re-run population models. Long-term population modelling should also be considered.

Monitoring marine mammals was also briefly considered by some breakout groups. It was suggested that if an effect on marine mammals is observed, it will be important to determine the ultimate impact of that effect on populations.

3.2.3 Responsibility, leadership, and funding of monitoring

Participants suggested that responsibility for monitoring of the first tidal lagoon development will depend on the licensing conditions that apply to the development. Where specific types of monitoring are set out in license conditions, then it is

necessarily the responsibility of the developer to lead on monitoring in these areas. However, the group agreed that there should be some responsibility for government bodies in supporting and/or funding monitoring of pathway projects and of larger-scale strategic studies. For example, it was suggested that collaboration between project developers and government bodies would be necessary to answer questions about the scale of the zone of influence of a development.

It was agreed that the monitoring of near-field coastal processes such as dredging and scour should be developer-led and funded, while wider coastal changes should continue to be monitored in partnership with local authorities. The verification of coastal process modelling from EIA should also be developer led. However, it was noted that there would be substantial opportunities for collaboration across the sector (including the Crown Estate and government bodies) to inform future tidal lagoon developments.

Studies of fish behaviour, on the other hand, would for the most part require collaboration between developers, government bodies, academia, environmental organisations, and nature conservation bodies. However, some groups suggested that turbine avoidance studies could be developer led, and that these studies should be objectively risk-based. Statutory nature conservation bodies and environmental agencies should be strongly involved in the leadership of larger-scale studies on fish populations, and should ensure that any population level impacts are empirically measured, rather than just modelled.

For all types of monitoring carried out at the first tidal lagoon, data collected should be stored in a central database and made available to inform future studies and decisions pertaining to current and future projects. There is also an anticipated need to understand the potential for data transferability between tidal lagoon development sites.

4 DISCUSSION

With a very few exceptions, the key consenting issues identified in the 2017 Forward Look remain important today. Workshop participants noted that some new guidance has emerged, and that some progress has been made on several issues, particularly site characterisation, modelling turbine wakes, and understanding the migratory routes of diadromous fish.

Physical process modelling was an important area for continuous improvement. It will be key that up-to-date data, information, and understanding continue to be fed into modelling approaches. This should also include project-specific information such as operational cycling. Once a development has been constructed, models should be updated with monitoring data and re-run to verify pre-construction predictions.

Fish continue to be the most important biological receptor for impact from tidal lagoon developments. It is still unclear to what level tidal lagoon developments pose a risk to fish populations. The rate at which fish avoid the development will be a key element for monitoring at the first tidal lagoon development.

More broadly, improving understanding of fish distributions and population dynamics is important. While much previous focus for fish was spent on techniques and technologies for fish monitoring, this group stated that technologies and techniques for monitoring fish populations were well established, but that more extensive data collection needed to be undertaken. A joined-up and collaborative approach will be particularly important for fish monitoring programmes, as many different types of stakeholders have common interests in fish populations around Wales (for example tidal stream technology developers, environmental organisations, academics, etc). It should be highlighted that marine mammals were thought to be at low risk of impact from an operational tidal lagoon development, and that ornithology receptors were not discussed.

Workshop attendees were in broad agreement with key issues for mitigation and compensation identified in the 2017 Forward Look, although it was highlighted that mitigation and compensation for impacts on species and on human activities in addition to habitats should potentially be considered.

Some advancements have been made on the human environment, policy, and regulation issues highlighted in the 2017 Forward Look. For example, advances in marine planning, improved data availability, and more experience in EIA approval processes have progressed understanding of how tidal lagoon developments may interact with other uses of marine space. The most important issues to address include developing guidance and policy for adaptive environmental management plans and agreeing standard approaches to developing and undertaking fish impact assessments for tidal lagoons.

Many of the key consenting issues discussed in the first breakout session were brought forward as questions to be addressed at the first tidal lagoon development, although participants did not identify any new policy or regulation-related questions. This is perhaps because the session was framed to identify questions that could be addressed through active monitoring of the first development site. However, it is likely that a great deal will be learned through the approvals and consenting process of the first tidal lagoon, which could be applied to improving policy and regulatory approaches as the tidal lagoon energy industry evolves.

Overall, participants emphasised that monitoring programmes should be proportionate, and balanced between what the developer is responsible for and wider strategic monitoring. While it was expected that developers would be responsible for site-specific monitoring in association with consent conditions, strategic monitoring should also be led by government and statutory nature conservation bodies. As suggested in the Hendry Review, it was noted that government should provide support for monitoring of pathfinder projects.

5 RECOMMENDATIONS AND NEXT STEPS

The first tidal lagoon project represents a substantial opportunity to gather data and develop the knowledge base for this technology, in order to inform future developments both in Wales, the UK, and internationally. Attendees at the Marine Energy Wales Tidal Lagoon Workshop identified the following recommendations that could support or enhance these opportunities:

- To advance understanding of fish behaviour, distribution, and population structure, collaborative projects are needed between developers, academics, and government and environmental organisations.
- Anticipated operational regimes for tidal lagoon developments should be incorporated into coastal process modelling to improve accuracy of impact assessments.
- Data, information and knowledge from the first project(s) should be stored centrally and made widely accessible to inform future studies. This could be within an existing database, or in a newly developed one.
- There is some responsibility for the UK Government or government bodies to fund monitoring of pathway projects, to help to deliver an evidence base that can inform future decision making. More specifically, where specific types of monitoring are set out in conditions of the marine license, then the developer should take lead responsibility. However strategic studies should be government funded.

APPENDIX A WORKSHOP ATTENDEES

Attendees included*:

Arne Kollandsrud	Tidetec
Baudewijn Morgan	Welsh Government (WEFO)
Ceri Morris	Natural Resources Wales
Dave Clarke	Swansea University
David Christie	Bangor University
Ellis Humphreys	Port of Mostyn
Emmer Lit	Natural Resources Wales
Ian Fairley	Swansea University
James Moon	Natural Resources Wales
Jessica Campbell	The Crown Estate
Jose Horrillo	Swansea University
Karen Perrow	Natural Resources Wales
Kath Wellard	Atkins
Matt Lewis	Bangor University
Morgan Johnson	Welsh Government
Natalie Frost	ABPMer
Paul Evans	Intertek
Sarah-Joy Lewis	Local Partnerships
Sharon Davies	Welsh Government
Simon Cheeseman	ORE Catapult
Tim Carter	JBA Consulting
Vicky Marti	Bangor University

*Note that not all attendees to the workshop signed in, and that additional individuals and organisations were in attendance, but were not recorded.

APPENDIX B KEY CONSENTING ISSUES AND RISKS AND WORKSHOP PARTICIPANT COMMENTARY

B.1 THEME 1. TIDAL RANGE – KEY CONSENTING ISSUES AND RISKS – THEME 1. PHYSICAL PROCESSES & BENTHIC ECOLOGY

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
THEME 1: Physical Processes & Benthic Ecology				
1. Physical Processes (EIA Characterisation Data)	1.1 Understanding the need for, level, scope and quality of physical baseline data and characterisation deemed appropriate to inform EIA/HRA/WFD assessment requirements and predictive models (including sediment budgets and pathways).	Yes, relevant to all tidal lagoon projects	No	NRW has now produced guidance on this topic, which can be found on their website.
1. Physical Processes (Impact Assessment)	1.2 The need to (a) collate and evaluate the efficacy of available modelling tools and other assessment techniques to predict near and far-field and medium to long-term morphological changes arising from single or multiple tidal range developments and (b) innovate and develop existing models as well as improve capabilities with regards to application of such modelling tools.	Yes, relevant to all tidal lagoon projects	Yes	
1. Physical Processes (Impact Assessment)	1.3 Understanding and predicting changes to physical processes (hydrodynamics including tidal and wave characteristics, sediment dynamics, geomorphology) in an estuary/system, as a result of schemes, both near and far field (plus associated indirect loss and changes to habitats and species). Need to agree procedures to define study boundaries and appropriate grid resolution for single or multiple tidal range developments.	Yes, relevant to all tidal lagoon projects	Yes	There is a specific gap within this issue on fine sediment processes. Models should be based on the operational regime of the development (related to energy supply/demand) rather than solely on spring/neap cycles.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
1. Physical Processes (Impact Assessment)	1.4 Understanding and predicting impact of single and multiple lagoon projects on water quality (turbidity and pathogens) – WFD and fisheries implications.	Yes, relevant to all tidal lagoon projects	Yes	
1. Physical Processes (Impact Assessment)	1.5 Agreed procedures are needed for assessing and modelling effects of decommissioning scenarios of single or multiple tidal range developments on the future baseline environment (evaluation of existing methods and models).	Yes, relevant to all tidal lagoon projects	Yes	
1. Physical Processes (Impact Assessment)	1.6 Agreed approach or suitable model for cumulative impact assessment of structures on physical processes.	Yes, relevant to all tidal lagoon projects	Yes	
1. Physical Processes (Impact Assessment)	1.7 Validation of computational models to predict wakes from turbines within lagoon structures.	Yes, relevant to all tidal lagoon projects	No	Work on this topic has been started and is ongoing
1. Physical Processes (Flood Risk)	1.8 Understanding the potential for changes to existing areas of flood risk (as a result of tidal range developments) and how a project might affect the integrity and standard of coastal defences.	Yes, relevant to all tidal lagoon projects	No	
1. Physical Processes (Sea Level Rise)	1.9 Need to ensure that discussion undertaken and consensus reached between industry and regulators on the key assumptions that should be used to inform existing models used to better understand the compounding effect of projected Sea Level Rise (SLR) on other pressures and impacts. In particular changing tidal levels, shifting habitats (in response to extreme events) in-combination with the impacts of project-level developments themselves.	Yes, relevant to all tidal lagoon projects	Yes	
2. Benthic Ecology (Impact Assessment)	2.1 Understanding the likely impacts of tidal range developments on planktonic communities within impoundments and corresponding uncertainty with respect to how to calculate impacts to algal communities and/or on primary production.	Yes, relevant to all tidal lagoon projects	No	

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
2. Benthic Ecology (Impact Assessment)	2.2 Understanding how tidal range developments (including associated artificial hard substrates and shipping associated with the sourcing of aggregate materials for construction) might affect the introduction, rate and spread of Marine Invasive Non-Native species (MINNS)	Yes, relevant to all tidal lagoon projects	No	
2. Benthic Ecology (Coastal Ecology)	2.3 Understanding the potential effects of impoundment on saltmarsh habitat (not possible to fully investigate until actual lagoon built).	Yes, relevant to all tidal lagoon projects	No	

B.2 THEME 2. TIDAL RANGE – KEY CONSENTING ISSUES AND RISKS – THEME 2. BIOLOGICAL RECEPTORS

In addition to the key consenting issues and risks listed in the table below, one additional key consenting issue was suggested to be strategically relevant and essential for consideration for tidal lagoon projects:

Fish avoidance rates for tidal lagoon developments (avoidance of the structures) and turbine intakes.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
THEME 2: Biological Receptors				
3. Fish (EIA Characterisation Data)	3.1 Need for increased understanding for all stages of the life cycle of key diadromous and marine fish species (each species would have the opportunity to interact with a tidal lagoon at least twice, as a juvenile and an adult).	Yes, relevant to all tidal lagoon projects	no	Understanding the marine distribution of key diadromous and marine fish species is more important than understanding the life cycle.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
3. Fish (EIA Characterisation Data)	3.2 Need for increased understanding and data on the migratory routes of diadromous fish (particularly eel, lamprey, shad and salmon) and on habitat utilisation of these species within or adjacent to proposed lagoon developments. Need to develop methods to gather such information. These data needed to inform fish modelling work and to verify parameters used in Individual Based Modelling (IBM).	Yes, relevant to all tidal lagoon projects	Yes	This should remain a high priority. Some work has now been taken forward on this topic. Sea trout should be included in this topic, as there is a lack of understanding of how many sea trout travel to and from particular areas. Eel was noted to be a European species and so not an issue for Wales.
3. Fish (EIA Characterisation Data)	3.3 Review and recommendations for appropriate and proportionate objectives and methodologies for fish characterisation surveys to inform EIA / HRA /WFD (study should also list all existing programmes and data (e.g. Instituut voor Natuur- en Bosonderzoek – INBO) and investigate scope for data sharing networks to be established.	Yes, relevant to all tidal lagoon projects	Yes	Any tagging approached implemented should be more joined-up in order to make them more efficient and cost effective.
3. Fish (EIA Characterisation Data)	3.4 Development of agreed methodology to identify and quantify fish population modelling parameters and key data requirements for species of concern (links with 3.1, 3.2 and 3.3).	Yes, relevant to all tidal lagoon projects	Yes	This is considered to be a key issue.
3. Fish (EIA Characterisation Data)	3.5 Development of existing or new tools and approaches for stock assessment and population level impact assessment for key marine and diadromous fish species. Impact thresholds must be realistic, i.e. can actually be detected via available monitoring techniques.	Yes, relevant to all tidal lagoon projects	Yes	There is an important need to understand fish population dynamics.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
3. Fish (EIA Characterisation Data)	3.6 Development of tools / agreed approaches for assessing the economic value of river/estuarine/coastal fisheries (commercial/recreational/heritage).	Yes, relevant to all tidal lagoon projects	Yes	
3. Fish (EIA Characterisation Data)	3.7 Development of fish tagging/tracking technology (and correct methods of obtaining and handling sufficient numbers of fish) to provide suitable data to inform modelling and EIA work needed for lagoon projects. To include technology suitable for use on juvenile fish.	Yes, relevant to all tidal lagoon projects	Yes	<p>This is no longer a key issues as it is felt that the technologies and methods for gathering data are well understood. Instead, the priority should be placed on data collection.</p> <p>Any tagging approached implemented should be more joined-up in order to make them more efficient and cost effective.</p>
3. Fish (Water Quality Impacts)	3.8 Understanding the potential synergistic and/or cumulative effects of (construction) contaminants on fish and prey species.	Yes, relevant to all tidal lagoon projects	No	
3. Fish (Underwater noise)	3.9 Understanding the effects of construction / operational turbine noise on hearing ranges for key fish species (and risk of barrier effect) and whether this results in avoidance.	Yes, relevant to all tidal lagoon projects	Yes	Avoidance is perhaps the most important context for this issue. For example, if 95% of fish avoid structures/turbines, then this is unlikely to be an issue.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
3. Fish (Collision Risk)	3.10 Development of a lagoon-specific fish encounter modelling approach that is accepted across industry and regulators.	Yes, relevant to all tidal lagoon projects	Yes	
3. Fish (Entrainment)	3.11 Understanding the risk of (i) multiple turbine passes and risk of re-entrainment and (ii) sub-lethal damage and development of appropriate or novel modelling and assessment tools.	Yes, relevant to all tidal lagoon projects	Yes	
3. Fish (Impact Assessment)	3.12 Need to increase understanding of the responses of fish to changes in migratory cues as a result of tidal range developments.	Yes, relevant to all tidal lagoon projects	No	
3. Fish (Impact Assessment)	3.13 Need to increase understanding of the impact of physical barriers and constrained tidal flow on diadromous fish species utilising estuaries within impounded area, i.e. is migration upstream and downstream hindered by change in tidal flows/delays in passage.	Yes, relevant to all tidal lagoon projects	Yes	This is something that would need to be monitored when the development is built.
4. Marine Mammals (EIA Characterisation)	4.1 Understanding the temporal and geographical distribution of marine mammals at proposed sites and wider region.	Yes, relevant to all tidal lagoon projects	No	
4. Marine Mammals (Impact Assessment/Loss of Habitat)	4.2 Understanding impacts on near and far field hydrodynamics and corresponding consequences for marine mammal feeding and foraging areas via development / innovation to deliver marine mammal encounter models specific to renewable technology such as Tidal Lagoons.	Yes, relevant to all tidal lagoon projects	Yes	Interactions with marine mammals are considered to be low risk given recent results on avoidance of tidal stream turbines and developments.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
4. Marine Mammals (Impact Assessment)	4.3 Need to establish and agree the most appropriate approach for determining the limit/threshold of acceptable mortality for a number of marine mammal species	Yes, relevant to all tidal lagoon projects	Yes	Interactions with marine mammals are considered to be low risk given recent results on avoidance of tidal stream turbines and developments. A limit for acceptable mortality for harbour porpoise has already been identified for Wales.
4. Marine Mammals (Underwater Noise)	4.4 Understanding the possible effects of underwater noise from the construction and operation of tidal range developments on marine mammals and e.g. impacts such as injury, disturbance, masking of vocalisations.	Yes, relevant to all tidal lagoon projects	Yes	Interactions with marine mammals are considered to be low risk given recent results on avoidance of tidal stream turbines and developments.
4. Marine Mammals (Impact Assessment / Entrapment)	4.5 Understanding potential risks and consequences of entrapment for marine mammals	Yes, relevant to all tidal lagoon projects	No	Interactions with marine mammals are considered to be low risk given recent results on avoidance of tidal stream turbines and developments.
5. Ornithology (EIA Characterisation)	5.1 Appropriate and proportionate objectives and methodologies which apply/integrate use of novel technologies for site characterisation surveys to inform EIA / HRA is required.	Yes, relevant to all tidal lagoon projects	Yes	

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop commentary
5. Ornithology (Impact Assessment)	5.2 Understanding impacts of intertidal and subtidal habitat distribution and composition and consequences for food availability and foraging behaviour of birds (and consequent impacts on relevant bird populations) via development of reliable IBM and Habitat Association Modelling tools.	Yes, relevant to all tidal lagoon projects	Yes	
5. Ornithology (Impact Assessment)	5.3 Need to establish and agree the most appropriate approach for determining the limit/threshold of acceptable mortality for a number of bird species.	Yes, relevant to all tidal lagoon projects	Yes	

B.3 THEME 3. TIDAL RANGE – KEY CONSENTING ISSUES AND RISKS – THEME 3. MITIGATION AND COMPENSATION

In this theme, in addition to the key consenting issues and risks highlighted in the table below, workshop participants considered that there is a need to consider compensation for broader scale impacts on coastal processes for tidal lagoons across the full extent of the zone of influence.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop Commentary
THEME 3: Mitigation and Compensation				
6. Nature Conservation (Mitigation/Compensation)	6.1 Development of innovative approaches and models for improving capability to predict environmental responses to compensatory measures over varying timescales.	Yes, relevant to all tidal lagoon projects	No	
6. Nature Conservation (Mitigation/Compensation)	6.2 Understanding / addressing conflicts between need for compensation habitat creation and other statutory obligations (e.g. designated sites). Offset should not contradict or compete directly with other offset requirements (e.g. shoreline management plan compensation).	Yes, relevant to all tidal lagoon projects	No	
6. Nature Conservation (Mitigation/Compensation)	6.3 Develop agreed set of options and principles for creation of compensation habitat, particularly for features that cannot easily be created.	Yes, relevant to all tidal lagoon projects	Yes	'Species' should also be included in this issue, in addition to habitats.
6. Nature Conservation (Mitigation/Compensation)	6.4 Agree standard set of " success criteria " for compensation habitat measures.	Yes, relevant to all tidal lagoon projects	No	'Species' should also be included in this issue, in addition to habitats.

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop Commentary
6. Nature Conservation (Physical Processes Mitigation and Monitoring)	6.5 Development of novel / emerging technologies tools and methods for monitoring long-term changes in mudflat levels /morphological changes, i.e. X-Band Radar, Satellite imagery, drone imagery, and demonstration needs for routine applications.	Yes, relevant to all tidal lagoon projects	Yes	
6. Nature Conservation (Benthic Ecology Mitigation)	6.6 Understanding the feasibility, likely effectiveness of habitat translocation / re-creation and development of innovative approaches as mitigation/compensation measures.	Yes, relevant to all tidal lagoon projects	Yes	
6. Nature Conservation (Benthic Ecology Mitigation)	6.7 Understand / demonstrate the potential for integrated aquaculture ecosystems inside tidal impoundments to promote restoration of local marine species, generate and maintain high levels of biodiversity and provide multiple ecosystem services.	Yes, relevant to all tidal lagoon projects	No	
6. Nature Conservation (Fish Ecology Mitigation)	6.8 Need to increase understanding of options for mitigation and monitoring strategies for marine/estuarine and freshwater diadromous fish (including noise/light deterrents)	Yes, relevant to all tidal lagoon projects	Yes	
6. Nature Conservation (Marine Mammal Mitigation)	6.9 Understanding mitigation options for impacts to marine mammals , including the use of different types of pingers.	Yes, relevant to all tidal lagoon projects	No	Suggested inclusion of other receptors, including coastal processes, fish, and birds. There is also a need to consider detection of animals in order to avoid indiscriminate use of deterrents.



B.4 THEME 4. TIDAL RANGE – KEY CONSENTING ISSUES AND RISKS – THEME 4. HUMAN ENVIRONMENT, POLICY AND REGULATION

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop Commentary
Theme 4: Human Environment				
7. Other users	7.1 Understanding interactions with other users : navigation, recreational boating, commercial fishing, etc.	Yes, relevant to all tidal lagoon projects	No	This issue is better understood now, thanks to data provided by the marine planning portal (Wales), and knowledge from previous EIAs.
Theme 4: Policy and Regulation				
8. Policy and Legislation	8.1 Lack of overarching National Policy Statement and lack of a strategic approach for Tidal Range Technology	Yes, relevant to all tidal lagoon projects	Yes	There is policy support for tidal lagoon projects in Wales, but national policy continues to be important.
8. Policy and Legislation	8.2 Lack of integration/streamlining across different Directives e.g. projects that are likely to invoke Imperative Reasons of Overriding Public Interest (IROPI) under the requirements of the Habitats Directive and Article 4.7 under the Water Framework Directive	Not at current scale of sectors	No	

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop Commentary
8. Policy and Legislation	8.3 Further consideration is needed with respect to how schemes of the scale and nature of tidal range developments align with the principles of sustainable development . Specifically, there is a requirement to ensure that socio-economic assessments undertaken as part of EIA's consider an agreed set of factors and use consistent methods of assessment. This will enable the development of a quantitative assessment approach to determining water costs (ecosystem services) vs. sustainable development vs combating climate change.	Not at current scale of sectors	No	This is not considered to be an issue or a gap.
9. General	9.1 Development of guidance and policy around Adaptive Environmental Management Plans . To include review of; <ul style="list-style-type: none"> - use of lead (not lag) criteria - use of advisory panels including key stakeholders - setting clear objectives - disclosure of data - cost and liabilities 	Yes, relevant to all tidal lagoon projects	Yes	This is still a relevant issue.
9. General	9.2 Possible need for whole system R&D to underpin the development pathway to sustainable tidal lagoon development, long term ecosystem health and well-being of populations.	Yes, relevant to all tidal lagoon projects	No	
9. General	9.3 Potential for using Regional Environmental Assessment (REA) approach for areas defined supporting multiple lagoon developments with individual EIAs using the regional-scale data (as done for marine aggregate industry)	Yes, relevant to all tidal lagoon projects	No	This is probably not a relevant issue.
10. WFD	10.1 Development of tools and methodologies to determine thresholds for acceptable change , particularly for WFD biological elements and agreement on the use of these tools with Regulatory Authorities.	Yes, relevant to all tidal lagoon projects	Yes	
10. WFD	10.2 Guidance needed on the information requirements to inform the 'Significantly Better Environmental Options' WFD 4.7 Derogation test	Yes, relevant to all tidal lagoon projects	Yes	

Topic	EIA/HRA issue	Strategically relevant?	Key strategic consenting issue?	MEW 2022 Workshop Commentary
10. WFD	10.3 Development of a Cost/Benefit Analysis tool to assign a quantitative/monetary approach to the cost of deterioration in the context of a WFD water body and 4.7 derogation tests.	Yes, relevant to all tidal lagoon projects	No	
10. WFD	10.4 Agreed procedures are needed for the physical process assessment approach(es) to inform EIA/HRA/WFD assessment requirements.	Yes, relevant to all tidal lagoon projects	No	
10. WFD	10.5 Need to agree standard approach to fish impact assessments i.e. approach to assessing against WFD, eels regs etc.	Yes, relevant to all tidal lagoon projects	Yes	This issue is extremely important.
11. Decommissioning	11.1 Development of guidance on information requirements for decommissioning at project application stage.	Yes, relevant to all tidal lagoon projects	No	
11. Decommissioning	11.2 Models or approaches for predicting future status of the environment and effects over the very long term.	Yes, relevant to all tidal lagoon projects	No	