ORJIP Ocean Energy

Information Note: Collision Risk

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1 INTRODUCTION

This series of technical, topic specific Information Notes has been co-produced by the Welsh Consenting Strategic Advisory Group's Science and Evidence subgroup (SEAGP) in order to support the consenting of wave and tidal stream energy projects. The Information Notes have been developed to establish the current position of key stakeholders in Wales on the evidence available on interactions of wave and tidal energy technologies with the marine environment. They are designed to set out a starting point for applicants by providing an understanding of where consenting challenges might lie. The aim of the Information Notes is to support marine licence applications that are robust, proportionate, and focused on assessing the key potential significant impacts and possible interactions between marine renewable energy (MRE) devices and the marine environment.

These Information Notes will support careful consideration of how, for a particular development, potential impacts that are considered low risk could be safely retired from further detailed consideration within Environmental Impact Assessments (EIA), where available evidence supports this approach. Ocean Energy Systems-Environmental (OES-Environmental) has set out a general process for risk retirement[1,2] but for developments in Welsh waters, risk retirement should always be discussed between developers and Natural Resources Wales (NRW) at the pre-application stage. In the context of these Information Notes, risk retirement implies that all potential impacts are included for consideration at the project scoping stage, and that following a review of the evidence some impacts may be 'scoped out' of any further detailed assessment to focus EIA on key significant impacts[3]. In all cases, potential impacts should be acknowledged in EIAs, with evidence-based justifications describing why particular impacts could be 'scoped out' of further detailed assessment.

Further information about this series of Information Notes, who these documents are for, how they were produced, and how they should be used can be found in the accompanying document *Information Notes: Background*

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[1] https://tethys.pnnl.gov/events/oes-environmental-webinar-risk-retirement
[2] https://tethys.pnnl.gov/publications/state-of-the-science-2020-chapter-13-risk-retirement
[3] It should be noted that The Wildlife Trusts expressed concerns about the use of the phrase 'risk retirement' being applied in this context, particularly considering the uncertainties in impact assessment that are likely to arise with increasing scale of MRE developments.

Information. The *Information Notes: Background Information* documentation also contains information about the terminology used in this document.

1.1 COLLISION RISK – GENERAL

Collision risk can be defined as the potential for receptors (marine mammals, fish and seabirds) to encounter and collide with the moving parts of MRE devices. At present the greatest concern is associated with collisions between tidal turbines and marine mammals, seabirds, and fish (Sparling et al. 2020). Wave energy devices have fewer submerged moving parts and are generally considered to be more benign with respect to collision risk (Greaves et al. 2016). This Information Note therefore only considers collision risk in relation to marine mammals, seabirds and fish with tidal turbines.

Many species are protected in Welsh waters under the Wildlife and Countryside Act 1981, the Conservation of Habitats and Species Regulations 2017, and the Conservation of Offshore Marine Habitats and Species Regulations 2017. These regulations establish a network of areas designated to protect a range of habitats and species of importance and make it illegal to deliberately disturb, injure, or kill marine protected species, including: wild birds at sea and their eggs and nests, dolphins, porpoises, whales, otters, basking sharks, migratory fish, and marine turtles. In Welsh waters there is a statutory requirement to consider and manage potential impacts on marine biodiversity, particularly within Marine Protected Areas (MPA)[4] and to protect and enhance marine biodiversity of conservation importance under the Environment (Wales) Act 2016.

Collisions between tidal turbines and marine mammals, seabirds or fish are likely to be rare. However, monitoring data is limited and although some evidence is emerging regarding near field behaviour of animals around tidal turbines (e.g. avoidance of moving and static rotors by marine mammals and fish aggregation around devices), much less information is available about the likelihood of collisions. Uncertainty about how receptors interact with operating tidal turbines and a lack of empirical data mean that the perceived and actual risks may differ (Copping and Hemery, 2020; Clarke et al. 2021).

The uncertainty associated with collision risk increases as MRE developments increase in scale due to a lack of available evidence. The implementation of a phased approach to development combined with adaptive management could

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[4] Designated Marine Protected Areas can be viewed on the Welsh Marine Planning Portal: http://lle.gov.wales/apps/marineportal/#lat=52.5145&lon=-3.9111&z=8&tgt=false

help to address this uncertainty. NRW provide guidance on applying for a marine licence in Wales for projects using adaptive management[5].

1.2 EVIDENCE SOURCES CONSIDERED BY SEAGP

SEAGP members were asked to apply their expertise and were encouraged to read the OES-Environmental Short Science Summary document[6] on collision risk in advance of providing a response to a Collision Risk Information Note questionnaire. Respondents were also encouraged to consult the full chapter on collision risk within the OES-Environmental 2020 State of the Science Report[7]. SEAGP members also highlighted the recent Welsh Government commissioned review on the current status of monitoring technologies and methodologies suitable for use in Welsh waters (Clarke et al. 2021). Additional key references are listed at the end of this document.

2 VIEWS OF NATURAL RESOURCES WALES ON COLLISION RISK

The information presented in this section was gathered in consultation with NRW marine mammals, ornithology and fish specialists. As stated in Section 1.1, this Information Note considers collision risk between tidal turbines and marine mammals, seabirds, and fish. These receptors are discussed in detail in Sections 2.2-2.4.

2.1 GENERAL PERSPECTIVES ON COLLISION RISK

The areas with advantageous resources for marine energy in Wales tend to coincide with areas of rich biodiversity. As such, collision risk is a high priority area for NRW.

NRW perceives the level of risk associated with collision to be high (for single devices) and very high (for small and large arrays, Table 1). The level of risk increases with the scale of development because of the lack of available evidence from single device deployments, small, and large arrays.

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[5] https://naturalresources.wales/permits-and-permissions/marine-licensing/applying-for-a-marine-licence-for-projects-using-adaptive-management-or-project-phasing/?lang=en
[6] https://tethys.pnnl.gov/summaries/short-science-summary-collision-risk-2020
[7] https://tethys.pnnl.gov/publications/state-of-the-science-2020-chapter-3-collision

Table 1: NRW perspectives on the general level of environmental risk associated with collision risk for generic development scenarios.

Deployment scale	Very low	Low	Intermediate	High	Very high
Single device				✓	
Small array					✓
Large array					✓

**Note that risks are, by their nature very site specific. This table should be treated as a general indication of risk.*

2.1.1 Factors influencing collision risk

The location of a development will influence the level of risk associated with collision, and this will depend on the proximity of the development to an MPA, the receptor groups present at a development site and their specific behaviours at that site (e.g. foraging, resting, or transiting). The level of risk will also be dependent on the type of device installed. Devices with few moving parts are considered to be lower risk while characteristics such as the depth of operation (in relation to the behaviour of species present) and swept area will influence collision risk.

Taken together, the importance of collision risk relative to other potential environmental effects from a development is high for all scales of development. It is very likely that applicants will be expected to assess collision risk in detail for all developments at all scales, unless the project design and evidence indicate there to be no or negligible risk, for example a device with no moving parts, or that mitigation strategies are clearly effective.

2.1.2 Status of the evidence base and requirements for data collection

The evidence base on collision risk is perceived to be insufficient and should remain a high priority for research and monitoring. Key evidence gaps include understanding collision frequency, the physiological and behavioural impacts of collision on receptors, and the potential population and ecosystem level impacts. For example, how the location of a turbine encounter within a large array influences the risk of collision is poorly understood (i.e. at the centre of a large array or on the periphery).

NRW recommends that applicants implement an adaptive management approach to manage the uncertainties around collision risk. This approach would include starting with smaller or low-risk deployments before scaling up to larger arrays. NRW also recommends that these preliminary deployments have minimal or no deterrents, to learn about animal movements around devices, before implementing full deterrent systems (if necessary).

Across all receptor groups, monitoring of collisions and fine-scale 3-dimensional behaviour in the vicinity of devices could help to manage collision risk. In-situ/real-time detection systems such as active sonar linked to pingers and/or passive acoustic monitoring are recommended to detect and mitigate any impacts early in the project. Monitoring systems become more difficult to design for large arrays, as multiple systems would be required. In the case of large arrays, it may be that representative devices are sampled and results are generalised to the array scale.

2.2 FISH

NRW considers the importance of collision risk for fish to be very high at all development scales (Table 2). At the large array scale, other impact pathways could become more important, including barrier effects and displacement but at present the importance of these impact pathways for large-scale developments is uncertain.

Table 2: NRW perspective on the importance of collision as an effect on fish and on the status of the current evidence base

Deployment scale	Importance*	Available evidence base**
Single device	Very high	Poor
Small array	Very high	Very Poor
Large array	Very high	Very Poor

**the scale for importance is 'negligible, very low, low, intermediate, high, very high'*
***the scale for evidence base is 'very poor, poor, adequate, good, very good'*

2.2.1 Factors influencing effects on fish

NRW considers that collision risk will increase should the development in question cross migratory routes for diadromous fish or if it is situated in proximity to important spawning/nursery/feeding grounds. Increasing the array size will also increase the perceived risk associated with collision.

2.2.2 Status of the evidence base and requirements for data collection

There are limited scientific studies that address collision risk associated with fish in comparison with other receptor groups such as marine mammals, and as such the available evidence base for decision-making is poor for single devices and very poor for small and large arrays. The existing evidence base relates primarily to single-turbine and small array deployments and no observations of collision between tidal turbines and fish have been recorded in the marine environment. In a freshwater environment, a 2017 study confirmed a single collision between a fish and a static video camera mounted on a horizontal axis helical turbine device operating in a river (Matzner et al. 2017). However, in a study of a tidal turbine array at Bluemull Sound in Shetland, saithe, the most abundant species observed in a review of 4,049 hours of video footage, were generally observed to drop to the seabed as current speeds increased, and no physical contact with the turbine was observed (Smith, 2021). Given that evidence for fish interactions with turbines is so limited it is important to recognise the constraints of existing studies when applying the observations to turbine developments in Welsh waters.

Collision risk would very likely be 'scoped in' for detailed assessment in an EIA. NRW would expect that project-specific data and information on collision risk would be provided for projects at all scales of development. The project-specific data required will be dependent on the type of device in question, but could include device characteristics (e.g. turbine tip speed, cut-in speeds), information on the density and movement patterns of fish species of concern in proximity to the development, and consideration of potential collision risk with a level of detail appropriate to the project. NRW did not identify best practice guidance for collecting project-specific information on collision risk associated with fish.

2.2.3 Mitigation strategies

Some appropriate strategies have been suggested to mitigate collision impacts. For example, the location and positioning of devices in the water column should, where possible, consider the water column use of fish present. Effects could also be mitigated through design by minimising moving parts and/or the number of turbine blades, slower rotation speeds, and blunt edges on the structure. Slow start procedures for turbines would be recommended for use at all development scales. Behavioural deterrents such as acoustic fish deterrents could also potentially deter fish from devices.

Coating to aid visual detection of blades is included in the Tethys Management Measures Tool[8] as a potential mitigation measure, however, NRW suggest that there is a high level of uncertainty associated with the effectiveness of this form of mitigation. This uncertainty is related to the possibility that coating or painting blades to aid visual detection could attract fish to the structure, especially at higher rotational speeds, where a 'flicker' effect could mimic shoaling fish. Until more evidence is available NRW would not recommend this as suitable mitigation.

2.3 SEABIRDS

The importance of collision as an impact pathway for seabirds increases with development scale (Table 3), although this effect is highly dependent on the location of the development, the species present at the development site, and their associated behaviour.

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[8] https://tethys.pnnl.gov/management-measures

Table 3: NRW perspective on the importance of collision as an effect on seabirds and on the status of the current evidence base

Deployment scale	Importance*	Available evidence base**
Single device	Intermediate	Poor
Small array	High – depending on location & species present	Poor
Large array	High – depending on location & species present	Poor

**the scale for importance is 'negligible, very low, low, intermediate, high, very high'*
***the scale for evidence base is 'very poor, poor, adequate, good, very good'*

2.3.1 Factors influencing effects on seabirds

NRW suggest that as the size of a development increases, the associated level of risk may also increase depending on the development's proximity to MPAs or other established seabird foraging areas, and the species of birds using those areas.

The importance of collision risk will also change with device type, depending on the species of seabird present and how they use the water in which the devices are placed. For example, risk scenarios for diving birds would change depending on the type of moving parts on a device, the radius of those moving parts, the speed of blade rotation, and whether diving birds are attracted to the device (e.g. through lighting).

2.3.2 Status of the evidence base and requirements for data collection

The current level of information and research outcomes available to support decision-making on collision risk for seabirds is not considered to be sufficient. NRW suggest that the current evidence base at all scales is 'poor' for seabirds. Scaling up to arrays is a significant evidence gap from an ornithological perspective. Whilst there are multiple research projects in the water currently gathering evidence from single turbines, there is not yet evidence or convincing modelling of the potential impacts of multiple devices, or the cumulative effects for multiple arrays.

It is very likely that collision risk to seabirds would be 'scoped in' for detailed assessment in an EIA for developments at all scales. For collision risk to be 'scoped out' of further detailed consideration in an assessment, the evidence and validation of that evidence that collision risk will not have a likely significant effect on designated populations will be required. At present there are no recommended best practice strategies for collecting project-specific information on collision-risk, although examples can be found in previous project documentation (Appendix A).

2.3.3 Mitigation strategies

Some appropriate mitigation strategies have been suggested. The location and position of devices in the water column should, where possible, consider the water column use of seabird species present. Effects could also be mitigated through the design of MRE devices, for example, minimising moving parts and/or the number of turbine blades, slower rotation speeds, and blunt edges on the structure. Slow start procedures for turbines would be recommended for use at all development scales. Mitigation options will differ according to the type of device and proximity to MPAs and significant regional populations of seabirds.

2.4 MARINE MAMMALS

It is difficult to rule out a risk to marine mammals for tidal energy projects situated anywhere in Wales because of the wide-ranging nature of these animals. The impact pathway is a key consideration and remains one of the most important issues for developments at all locations in Wales. Locations with fewer sightings of marine mammals may be considered to be lower risk, however, populations of highly mobile marine mammals (e.g. dolphins, porpoises, whales and seals) occur at broad scales so low risk locations would not discount the need for assessment, and consequences of mortality from collision would still need to be considered at the appropriate scale (i.e. Marine Mammal Management Unit[9]). In locations known to be associated with high densities of marine mammals, NRW would apply greater scrutiny to projects to satisfy the need to rule out a likely significant effect on the population.

2.4.1 Factors influencing effects on marine mammals

Collision risk becomes a more important issue as the development size increases (Table 4). NRW consider that the importance of collision risk as an impact pathway for small arrays is intermediate between single devices and large arrays.

Table 4: NRW perspective on the importance of collision as an effect on marine mammals and on the status of the current evidence base

Deployment scale	Importance*	Available evidence base**
Single device	High	Poor » Adequate
Small array	High	Poor
Large array	Very high	Very poor

**the scale for importance is 'negligible, very low, low, intermediate, high, very high'*
***the scale for evidence base is 'very poor, poor, adequate, good, very good'*

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[9] https://hub.jncc.gov.uk/assets/f07fe770-e9a3-418d-af2c-44002a3f2872

Collision risk is likely to be highest for large arrays, although depending on the design and other characteristics of the array, marine mammals may choose to avoid the area entirely. This would reduce collision risk but could also introduce additional barrier effects by preventing a marine mammal population from accessing important locations such as feeding grounds. Overall, there remain uncertainties about how risk increases with increasing development size (e.g. linearly, exponentially, etc).

The design of proposed devices is important, with reference to the depth of deployment and design features of moving parts such as the blade swept area.

2.4.2 Status of the evidence base and requirements for data collection

Historically, the quality of information available on collision risk between tidal turbines and marine mammals has been poor. However, in recent years more information and high-quality studies have been published (e.g. Gillespie et al. 2021; Joy et al. 2018; Malinka et al. 2018; Onoufriou et al. 2021) and are now helping to inform decision-making, particularly in respect of deployments of single turbines. There remains, however, a lack of available information to inform decision-making for small and large arrays.

NRW would expect to see collision risk to marine mammals 'scoped in' for detailed assessment in EIAs, unless the project design and evidence indicated that there was no or negligible risk to marine mammals, for example a device with no moving parts, or that proposed mitigation strategies are supported by evidence demonstrating their effectiveness.

There is not currently any best practice for collecting project-specific information on collision risk to marine mammals, however, there are many sources and cases outlining what data was collected for consented projects (Appendix A). Scoping advice from NRW would also make suggestions on what data might be best to collect as part of pre-application monitoring (baseline) or consent condition monitoring (e.g. in situ measurement of avoidance or evasion activity).

When required, monitoring systems should be adapted to the location and scale of each development. Different system configurations may be required for different device types, for example seabed mounted sonar systems are unlikely to be appropriate for tidal kites. In such cases, other monitoring methods will be required, such as a network of sound recorders or a machine mounted system (although this has not yet been demonstrated). It is important to note that active sonar and other detection systems are considered to be monitoring methodologies, not mitigation measures.

2.4.3 Mitigation strategies

Mitigation measures may be required for developments. Existing mitigation strategies include timing of operations, shutdown mechanisms (although this may not be preferable for developers) and deterrent technologies such as acoustic deterrent devices. NRW currently recommends a detect and deter system to avoid indiscriminate or long-term disturbance in important locations for marine mammals.

Monitoring and mitigation systems are not mutually exclusive and can be used in combination to provide an adaptive management framework to manage risk and consequences.

2.4.4 Priorities for research and monitoring

Variations in the behaviour of marine mammals and other environmental characteristics are expected between different development locations, which makes it difficult to apply data or learning gained at one development to another. This is a key challenge in addressing collision risk. To address this challenge, it is increasingly important to gather in-situ observations of avoidance and/or evasion for different species, development locations, and device or array designs. Research and monitoring of collision risk effects associated with tidal energy developments should be given very high priority.

3 PERSPECTIVES OF ENVIRONENTAL ORGANISATIONS

The information in this section was gathered in consultation with the Royal Society for the Protection of Birds (RSPB) and The Wildlife Trusts (TWT) as members of SEAGP.

Collision risk is a high priority area for RSPB and TWT, and the evidence base for this effect is not yet considered to be sufficient. Collision risk should remain a high priority for research and monitoring. RSPB noted that the evidence base is 'very poor' for seabirds and collision risk. Meanwhile, TWT identified several important evidence gaps including understanding collision frequency, the physiological and behavioural impacts of collision on receptors, and the potential population and ecosystem level impacts.

3.1 FACTORS INFLUENCING COLLISION RISK

Both organisations commented that risk of collisions would likely increase depending on the scale of development. The level of risk is also associated with the location of a development, and TWT emphasises the importance of the mitigation hierarchy to avoid and minimise impacts on the environment when choosing a location for development. This might include avoiding areas of high or sensitive biodiversity.

Similarly, RSPB consider that the location of tidal energy developments and the behaviour of receptor groups associated with that location are key to understanding whether impacts will occur to nearby MPAs (even if the development is not located within the MPA). For example, if a nearby MPA is designated for a seabird species that forages by diving (where it could be in proximity of tidal turbines), the importance of collision risk for seabirds at the development site is likely to be greater than if a nearby MPA is designated for a seabird species that forages by surface skimming. These characteristics influence the mortality risk to seabirds, which in-turn affects population viability calculations, and therefore collision risk modelling. This would apply to breeding, overwintering, and migratory seabird species.

3.2 STATUS OF THE EVIDENCE BASE AND REQUIREMENT FOR DATA COLLECTION

TWT consider that it is important to gather evidence and learning from smaller-scale projects to understand and assess risks before developments are permitted to scale up. A well-regulated and structured process for scaling up developments that includes clearly defined requirements for data gathering and sharing could better facilitate evidence-based decision making. Publicly available data and evidence would also enable an independent assessment of the predicted risks of a small development. TWT suggest that this could also provide more confidence to developers in reducing environmental risks and understanding the future environmental footprint of any planned build-out.

RSPB expects that project-specific data should be provided with regards to collision for all scales of development. RSPB also indicated that for seabirds the key impact pathway for tidal energy developments is collision, in part because there is substantial uncertainty around our understanding of the risks. As RSPB's perspective is based on modelling outputs that vary in direct proportion to the size of a development, until better evidence is provided to underpin collision risk models, RSPB's concerns about collision would increase with the size of any proposed development.

3.3 PRIORITIES FOR RESEARCH AND MONITORING

At a strategic level, TWT suggested that NRW could set out a standard for data collection to support collision risk assessment, so that assessments can be analysed and compared. Identifying and agreeing the priority questions, specific to Wales, that need addressing increase certainty around collision risk would provide clarity as to what data should be collected by developers at project sites, and what data needs collection at larger scales. For example, the behaviour of wide-ranging receptors within a development site could be monitored by the developer, but large-scale population monitoring to identify impacts (such as displacement) must occur at a larger geographical scale, necessitating strategic monitoring. Coordinated strategic monitoring should begin immediately to develop a baseline against which future monitoring results could be compared.

4 PERSPECTIVES FROM INDUSTRY

Industry members perceive that for collision risk, a lack of knowledge and uncertainty in outcomes continue to drive precautionary approaches to development, although tidal energy deployments to date have not provided any evidence of substantial environmental impact. It is important that knowledge and information from previous operational deployments elsewhere be used for project-specific decision-making that will support further deployments and collection of additional monitoring data to verify predictions of collision risk. Some useful data is now emerging from existing commercial arrays, suggesting that at the current scale of development, decisions in favour of projects could be made.

4.1 FACTORS INFLUENCING COLLISION RISK

Industry members identify that the importance of collision risk for receptors would increase with the scale of development. The evidence base for collision around single devices is perceived to be 'good', and so the importance of collision risk is perceived to be 'very low' for single devices. Small arrays would imply greater caution than single devices, because of the limited data available from small arrays, though a limited number of small arrays have been deployed and the data emerging is useful to validate predictive collision risk models and to provide greater confidence for decision-making. The importance of collision risk for small arrays is perceived to be 'low'. Like NRW, RSPB, and TWT, industry members expect to take a precautionary approach to the development of large arrays, owing to the lack of field-acquired data for this type of development. Industry members perceive that the importance of collision risk would increase to 'intermediate' for large arrays.

Industry members identify that different types of devices will result in different levels of concern, for example floating tidal platforms may be of less concern than fixed platforms, while a device's tip speed ratio (the relative speed of the blade tip compared to the tidal stream) will influence the speed at which the receptor encounters the device. Similarly, the water column location of moving parts in relation to the water column use of the receptors in question will also influence the perceived risk associated with collision, however, without data on different types of devices, these effects remain speculative.

When considering the risks associated with different deployment locations, this group suggested that movements and activities of receptors at a selected location would have bearing on the perceived level of risk. However, it was also noted that regardless of location, the overall population effect of collision could still be low.

4.2 STATUS OF THE EVIDENCE BASE AND REQUIREMENTS FOR DATA COLLECTION

It is expected that detailed assessments of collision risk in EIAs will likely be required for all tidal energy developments unless the risk of collision is demonstrated to be negligible. The level of caution and concern about specific receptor groups would drive the quantity of evidence required to provide regulators adequate confidence for decision-making. Industry members suggest that the evidence base is sufficient to support decision-making for single devices, and potentially small arrays, but is not yet sufficient for large arrays.

Likewise, the available evidence base is perceived to be best for marine mammals, and less good for seabirds and fish. Decision-makers' views on the acceptability of existing information and confidence in the evidence base will affect their ability to make an informed decision based on expert judgement, and therefore the level of evidence required will increase with the size of array. Addressing in-combination and cumulative effects remains challenging.

4.3 MITIGATION STRATEGIES

Given the perceived level of risk associated with different sizes of developments, it was suggested that there was no great need for mitigation of collision for single devices and perhaps for small array deployments. Practical measures to mitigate risk would be needed for large arrays, although measures that reduce device performance and energy output (e.g. soft cut-in speeds or shut-downs) may not be feasible for commercial projects that are operating on small profit margins and may also be unfavourable to grid operators who expect a highly predictable electricity supply. Mitigation measures that do not affect device performance would be more viable from a commercial standpoint.

4.4 PRIORITIES FOR RESEARCH AND MONITORING

To industry, the greatest challenge is associated with the lack of knowledge and evidence about collision risk and the assumption that these deployments must have an impact. To grow the evidence base around collision risk, it is imperative that opportunities for research and monitoring are enabled through carefully managed deployments accompanied by targeted, strategic research efforts.

5 SUMMARY AND RECOMMENDATIONS

Areas of high tidal energy resource in Welsh waters are also areas rich in biodiversity, particularly for marine mammals, but also for other species of concern including seabirds and fish receptor groups. For this reason, collision risk is a high priority topic of concern for SEAGP members.

Detailed assessments with case-specific data and information are likely to be required for all tidal energy developments, although the level of detail required will be determined by the scale and type of the development. This will also depend on the development location in relation to MPAs and sensitive receptor groups.

Applicants are encouraged to work with NRW to develop adaptive management frameworks for proposed projects. These might include phased developments, starting with a small number of deployments and monitoring systems to learn about interactions between fish, seabirds, and marine mammals and single devices or small arrays, before scaling up to larger arrays.

Overall, the evidence base for collision risk remains generally 'poor'. However, some evidence is now emerging around the behaviour of these receptor groups (particularly marine mammals) around single turbines and small commercial arrays, although evidence for large arrays is 'very poor'. To date no rotating blade strikes to marine animals have been detected in the marine environment (Sparling et al. 2020). As collisions are likely to be rare based on the evidence to date, detecting a collision between a tidal turbine and a marine animal remains a monitoring challenge.

All SEAGP members note that monitoring and researching collision risk should be a high priority around tidal energy developments, although it was acknowledged that the costs of addressing collision risk and monitoring devices are prohibitively expensive. Development of cost-effective monitoring systems for small and large arrays remains difficult. Important evidence gaps that must be addressed include:

- collision frequency,
- the physiological and behavioural impacts of collision on wildlife, and
- potential population and ecosystem level impacts.

SEAGP is of the view that these gaps in the evidence base should be addressed as part of a strategic programme of research, with appropriate levels of funding from both public and private sources to improve our understanding around collision risk and inform future decision-making.

5.1 RECOMMENDATIONS

- For all proposed developments, applicants should work closely with NRW to develop proportionate strategies for assessment and monitoring of collision risk. Where appropriate, applicants should also work with NRW to develop adaptive management frameworks for phased projects.
- Knowledge and information from previous operational deployments elsewhere should be used to inform decision-making and monitoring requirements for new projects.
- Data emerging from the first tidal energy projects in Wales should be used to validate collision risk model outcomes and refine future collision risk models, in order that more accurate assessments of collision risk with reduced uncertainty can be made for future developments.
- Development of cost-effective monitoring systems for small and large arrays should be pursued to enable high quality data gathering at larger development scales.
- Gaps in the evidence base for collision risk should be incorporated into a collaborative, strategic environmental programme for MRE development in Wales and across the UK that is resourced with appropriate levels of public and private funding.

6 REFERENCES

NOTE THAT ADDITIONAL REFERENCES ARE INCLUDED THAT ARE NOT CITED IN THIS INFORMATION NOTE

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APPENDIX A ADDRESSING COLLISION RISK IN PREVIOUS MARINE ENERGY PROJECTS: LICENSING DOCUMENTS AND CONSENT CONDITIONS

Project Name	Location	Technology	Consenting Status	How Collision Risk is addressed	EIA/ HRA/ Other	Consent Conditions
MeyGen	Scotland	Tidal Stream Array	Constructed	Granting the development in a staged manner, where the development can only expand when previous stages have been completed to the satisfaction of the Licensing Authority (MS-LOT)	S36 Consent condition (Condition 3)	Condition 3 of the Section 36 consent
MeyGen	Scotland	Tidal Stream Array	Constructed	In the Post-consent PEMP	Project Environmental Monitoring Programme (PEMP)	Condition 12 of the Section 36 consent
MeyGen	Scotland	Tidal Stream Array	Constructed	Consideration of Atlantic Salmon Collision Modelling	Post consent (Phase 1)	
Morlais	Wales	Tidal Stream Demo Zone	Consented	Marine Mammals CRM	EIA	
Morlais	Wales	Tidal Stream Demo Zone	Consented	Marine Ornithology Collision Risk Modelling	EIA	

Project Name	Location	Technology	Consenting Status	How Collision Risk is addressed	EIA/ HRA/ Other	Consent Conditions
Dounreay Tri	Scotland	Floating Offshore Wind	Consented	Collision risk modelling (CRM) included within HRA	HRA	Condition 16 of the Section 36 consent
Hywind Scotland	Scotland	Floating Offshore Wind	Consented	CRM: Northern Gannet, Black-legged Kittiwake and European Herring Gull.	HRA	
Kincardine	Scotland	Floating Offshore Wind	Consented	CRM (Ornithology) included within HRA	HRA	

Project Name	Location	Technology	Consenting Status	How Collision Risk is addressed	EIA/ HRA/ Other	Consent Conditions
META	Wales	Wave and Tidal Demo Zone	Consented	Collision Risk Modelling not undertaken		Scoping Opinion: Collision risk – Although a review of available evidence, and swept area of operational tidal turbines will allow a broad assessment of the likely risk of the project, it will not be possible to conduct a detailed collision risk assessment without data on local densities of marine mammals. However, given the small scale, and inshore location resulting in likely low level of risk from the project, we are satisfied that this level of detail is unlikely to be necessary.
Nova Innovation Blue Mull Sound	Scotland	Tidal Stream Array	Consented	Appropriate assessment (undertaken by NatureScot)	HRA	
Seagreen	Scotland	Offshore Wind	Consented	Collision risk modelling (CRM): Northern Gannet, Black-legged Kittiwake and European Herring Gull.	EIA	

Project Name	Location	Technology	Consenting Status	How Collision Risk is addressed	EIA/ HRA/ Other	Consent Conditions
Beatrice	Scotland	Offshore Wind	Consented	CRM (Ornithology)	EIA	Condition 5 of the Section 36 consent (great black-backed gull CRM)
Moray Offshore Renewables (Moray East)	Scotland	Offshore Wind	Consented	CRM (Ornithology)	EIA	
Moray Offshore Renewables (Moray West)	Scotland	Offshore Wind	Consented	CRM (Ornithology)	EIA	
EMEC	Scotland	Wave and Tidal Demo Zone	Consented	Detailed Collision Risk Assessment: Marine mammals, Basking Shark, and Diving Birds	EIA	
West Islay Tidal Energy Park	Scotland	Tidal Stream Array	Consented	Collision risk calculations undertaken by Marine Scotland Science for harbour porpoise, harbour seals or grey seals	During consultation of the EIA	

Project Name	Location	Technology	Consenting Status	How Collision Risk is addressed	EIA/ HRA/ Other	Consent Conditions
European Offshore Wind Deployment Centre	Scotland	Offshore Wind	Consented	Collision risk modelling (Ornithology)	EIA (and addednum to the EIA)	

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