SEA Wave: Strategic Environmental Assessment of Wave energy technologies

Deliverable Report D2.3

Environmental Demonstration Strategy

This project has been co-funded by the European Maritime and Fisheries Fund EMFF) of the European Union. The contents of this document reflect only the (author's view. EASME is not responsible for any use that may be made of the information it contains.

This project has been co-funded by the European Maritime and Fisheries Fund (EMFF) of the European Union

SEA Wave

Revision

Revision	Date	Description	Originated by	Reviewed by	Approved by
1.0	13/09/2019	First draft for internal review	Jennifer Fox (AQT)	Ian Hutchison & Kate Smith (AQT)	
2.0	26/09/2019	First draft for Project Team review	Jennifer Fox (AQT)	Ian Hutchison & Kate Smith (AQT)	Ian Hutchison (AQT)
3.0	15/10/2019	Revised version incorporating feedback from project team	Kate Smith (AQT)	Ian Hutchison (AQT) and Project partners	Caitlin Long (EMEC)
4.0	31/10/2019	Proof read	Jennifer Fox (AQT)	Erica Mathers (EMEC)	Caitlin Long (EMEC)

Project Information

Project title	Strategic Environmental Assessment of Wave energy technologies
Project acronym	SEA Wave
Grant agreement number	EASME/EMFF/2017/1.2.1.1/01/SI2.787660
Project start date	01/11/2018
Project duration	36 months
Project lead	The European Marine Energy Centre (EMEC) Ltd
Project website	www.seawave-emff.eu

Contents

1 Introduction

1.1 Background

Wave energy is an emerging sector, within the pre-commercial stage of development, whereby deployments generally consist of single devices or small arrays. As such, key evidence gaps and uncertainty about the potential environmental effects of wave energy devices can lead to a precautionary approach to impact assessment and project consenting. This can place resourcing and financial pressures on wave technology development companies to carry out extensive environmental monitoring, to provide reassurance to regulators and their advisors within Member States by addressing uncertainty around the potential environmental effects of devices. When added to the other complex areas in which wave technology developers face challenges and pressures (engineering, securing private investment and revenue support), this additional burden can have a significant effect on technology and even company viability.

The SEA Wave project aims to address long-term environmental uncertainty around the development of the wave energy sector and develop cost effective but statistically robust approaches to monitoring and data gathering. It will develop good practice in data gathering methodologies and take a strategic approach to investigate the possible environmental effects of wave energy devices, with the aim of reducing uncertainty about key potential effects to de-risk and streamline consenting. This will be achieved by carrying out coordinated, strategic monitoring, based around identified key evidence gaps for wave energy technologies. This Environmental Demonstration Strategy (EDS) sets out this proposed strategic monitoring activity, including the rationale for its focus (i.e. the key evidence gaps on which it will focus), the strategic objectives of the monitoring activity, the methodologies to be utilized and details of how the findings will be reported and disseminated.

SEA Wave has four wave energy partners with different technology types to ensure that the project outcomes will be representative of the sector. The environmental demonstration strategy currently involves four pan-European wave energy developers[1], as follows:

- Wello
- Laminaria
- CorPower Ocean
- Ocean Energy

It is recognised that the potential environmental impacts of wave energy are likely to be both site- and technology-specific. Technology-specific impacts may vary depending on, for example, mooring method, installation procedure and Power Take-Off (PTO) system. By encompassing a range of wave energy technology types, the SEA Wave project will identify synergies and commonalities across technologies. The ability to monitor four different technology types at different deployment sites, utilising different PTO systems, mooring methods, installation procedures, etc., will enable a number of these technology-specific environmental issues to potentially be addressed within this project. In addition, the design and deliver of an integrated monitoring programme across four wave technologies at different deployment sites provides a valuable opportunity to improve the statistical power of the

[1]Any changes to project schedules that could alter the delivery of the SEA Wave monitoring programme will be highlighted to the Project Partners and discussed with the Project Steering Group. Appropriate contingency measures will be introduced, which might include the identification of new technology developer partners, or monitoring of deployments at other locations.

resulting data to determine any site-specific effects, which can otherwise be challenging to address for single deployments. This will help to build an understanding for those potential environmental effects that will have an element of site-specificity.

The development of models within the SEA Wave project, validated by environmental monitoring and field measurements will enable consideration of how device specific environmental effects and responses might upscale from single devices to arrays.

Wave energy devices and their associated infrastructure have the potential to positively affect the environment and enrich the ecosystem, for example through the creation of additional habitat and fishery exclusion zones. These possible benefits of wave energy devices will be investigated as part of the SEA Wave project EDS.

The SEA Wave project will carry out coordinated environmental monitoring campaigns around technology deployments planned within the timeline of the project. Monitoring will be delivered by project partners University of Exeter, University of Plymouth and EMEC with guidance from Aquatera and EMEC, the lead partner. The team will work closely with the four developers to carry out the strategic environmental monitoring campaigns set out in this EDS.

In addition to the strategic monitoring activity detailed in this EDS, an individual environmental monitoring strategy will be produced for each technology to be deployed within the SEA Wave project timeline. These environmental monitoring strategies will be aligned with and draw on, this overarching EDS to ensure a cohesive, strategic approach which meets the needs of the technology developers (e.g. discharge of licence conditions by contributing to Project Environmental Monitoring Plans) as well as the strategic objectives of the SEA Wave project. The environmental monitoring strategies will sit beneath the EDS, as supplementary Annexes that will be developed in partnership with the technology developers, as project schedules and licensing requirements are confirmed. The environmental monitoring strategies will be reviewed by project partners and (where resources allow) the independent Steering Group to ensure that they meet technology or site-specific monitoring requirements (including discharge of consent conditions), and the needs of the SEA Wave project.

This EDS report provides an overview of the key environmental evidence gaps on the potential effects of wave energy deployments on which the SEA Wave project will focus. It describes how the project will reduce uncertainty in these areas to help streamline consenting.

1.2 Structure and purpose

The EDS for the SEA Wave project provides a framework for activities to address long term environmental concerns around the development of the wave energy sector. This includes trialling data gathering methodologies and investigating the potential environmental effects of wave energy devices, with the aim of reducing uncertainty about potential effects and developing cost effective approaches to monitoring and data gathering. Ultimately the intention is that this will help streamline consenting for wave energy technologies and projects across member states.

The EDS is structured as follows:

- Key resources (Section 2);
- Key evidence gaps for the wave energy sector (Section 3);
- Approach to addressing evidence gaps (Section 4);

- Environmental monitoring (Section 5); and,
- Conclusions (Section 6).

1.3 Relationship with SEA Wave strategic recommendations

Work package 5 of the SEA Wave project (Strategic Recommendations), will develop guidance, recommendations and best practice for key issues of relevance to the wave energy sector. The monitoring activity delivered through the EDS will inform the development of these strategic recommendations in a number of ways, including:

- Increasing the evidence base on key environmental effects of wave technologies;
- Providing a valuable opportunity to carry out monitoring across a range of technologies and sites to refine understanding for site- and technology specific effects;
- Overcoming the challenges of designing monitoring programmes to achieve statistical significance in any monitoring studies conducted;
- Development of good practice in monitoring methodologies and design of monitoring strategies for wave technologies;
- Development of approaches to nesting technology specific monitoring programmes within an overarching strategic monitoring framework; and,
- Improving understanding for good practice approaches to monitoring to de-risk future consenting processes.

The development of these will be informed by stakeholder consultation, through the Offshore Renewables Joint Industry Programme (ORJIP) Ocean Energy (OE) Network which includes a wide range of marine energy stakeholders including regulators, statutory nature conservation bodies, researchers, policy makers and technology developers. The key issues presented under 'Regulatory Processes' within the ORJIP OE Forward Look will be used as a guide for these deliverables, which will include;

- Guidance on impact assessment from site selection (and site characterisation) to decommissioning;
- Best practice guidance on effective environmental monitoring (including achieving statistical significance in any monitoring studies conducted) and mitigation methodologies;
- Recommendations on co-locating marine renewable energy developments with other industries in the context of marine spatial planning;
- Guidance on the translation of demonstrated best practice case studies into policy in an EU context; and
- Analysis of the challenges and regulatory requirements within array feasibility studies.

2 Key resources

The environmental demonstration strategy presented in this report has been informed by several key resources including;

- ORJIP Ocean Energy's Forward Look (2017);
- OES Environmental (previously known as Annex IV) State of the Science report (2016);
- SEA Wave Deliverable 2.1: Knowledge gaps and consenting risks for wave and tidal energy (2019);
- SEA Wave Deliverable 2.2: Critical analysis of environmental mitigation and monitoring strategies
- Ocean Energy Forum's Ocean Energy Strategic Roadmap; building ocean energy for Europe (2016).

The SEA Wave Deliverable 2.1. Knowledge gaps and consenting risks for wave and tidal energy (2019) provides a summary of key knowledge gaps relating to the potential environmental effects of wave and tidal energy technologies and an overview of consenting risks. This deliverable built on ORJIP OE and OES Environmental to present an up to date summary of key knowledge gaps for the marine renewable energy sector. The outputs of this deliverable have directly informed the focus of the EDS and associated monitoring activity identified.

3 Key evidence gaps for the wave energy sector

SEA Wave Deliverable 2.1: Knowledge gaps and consenting risks for wave and tidal energy, identified a series of high priority consenting issues and risks, to provide a focus for the SEA Wave project, detailed in Table 1.

Theme	Detail of key issue / evidence gaps
Ecological environment	
Underwater noise	Lack of available acoustic data from operational devices and arrays
Underwater noise	Knowledge regarding the possible effects of underwater noise from the construction and operation of arrays on marine mammals is incomplete
Electromagnetic fields (EMF)	Further data and information regarding the possible effects of EMF from transmission cables on fish would improve confidence in EIA and HRA
General	Further strategic baseline data (distribution, abundance, seasonality, etc.) for marine mammals and basking sharks is required to better understand use of potential development areas
General	Further strategic baseline data (distribution, abundance, seasonality, etc.) for birds is required to better understand use of potential development areas
General	Further strategic baseline data (distribution, abundance, seasonality, etc.) for migratory fish is required to better understand use of potential development areas
General	An agreed approach to undertaking site characterisation and baseline surveys for marine mammals and birds to inform EIA and HRA is required

General	Further data of mobile species populations (particularly qualifying species of Natura sites and EPS) for use in population modelling would improve confidence in EIA/HRA
General	Better understanding of population level impacts and methods to assess the significance of population level impacts would improve confidence in EIA/HRA
Human environment	
Impacts on commercial fisheries	There is a lack of standardised approach to assessing the availability of alternative fishing grounds (outside development areas) and their ability to sustain existing /displaced commercial fishing levels
Regulatory processes	
Regulatory processes	Methods/processes are required to help manage perceived and identified environmental risks that may arise from wave and tidal developments to ensure that project level requirements are proportionate
Regulatory processes	Methods/processes are required to predict and measure potential cumulative impacts around clusters of lease areas
Regulatory processes	Agreement is required on the approach to applying a design envelope approach to consenting wave and tidal arrays
Regulatory processes	Agreement is required on the approach to developing Project Environmental Monitoring Plans and incorporating adaptive management strategies, for commercial scale wave and tidal arrays
Regulatory processes	Further guidance is required as to how best to consider decommissioning in the consenting process.

Table 1 | Key strategic evidence gaps relevant to demonstration-scale wave energy projects, as identified through SEA Wave Deliverable 2.1

The SEA Wave project presents a unique opportunity to take a coordinated and strategic approach to gathering information to reduce uncertainty around the themes set out in Table 1 across multiple technologies. This strategic approach is a key recommendation in the Ocean Energy Europe Strategic Roadmap.

4 Approach to addressing evidence gaps

The overall aim of the SEA Wave EDS is to take a strategic and coordinated approach to investigate and reduce uncertainty around the four themes identified in the previous section. A core element of this approach will be to develop cost-effective monitoring plans for the planned deployments of the four wave energy technologies.

The implementation of the EDS and corresponding monitoring activity, including technology specific monitoring plans, will be directed by principles of robust experimental design to avoid data-rich, but information-poor outcomes. It will be overseen by an independent Steering Group, which includes representatives from Marine Scotland Science and Scottish Natural Heritage. Input from the Steering Group will help ensure monitoring has clearly defined aims and objectives, with the overall aim of reducing uncertainty about environmental effects for the wider sector. This includes considering how the EDS and outputs of any associated monitoring might be used in licensing processes, and the delivery and discharge of licensing conditions for the four deployments and the sector more widely.

Monitoring will be delivered through the following work packages (WP) within the SEA Wave project:

- WP 3: Data collection and analysis, led by University of Plymouth
- WP 4: Modelling and validation, led by University of Exeter

In collaboration with the Wave Energy in Southern Europe (WESE) project, led by WavEC (with common partner Hidromod), the SEA Wave project will develop a web accessible data platform. This data platform will provide a single access point to make relevant data from the SEA Wave and WESE projects publicly available. Metadata containing the spatial and temporal extent, and information on data types will be available. Refined Data Products (user-friendly summaries) will be available once post-processing and analysis have been completed. Further data will be available on request.

Data from previous projects, such as SOWFIA (IEE/09/809/SI2.558291), will also be accessible via the Data Platform. This will ensure data compatibility of SEA Wave project outputs with EU data platforms such as EMODNet, SeaDataNet and Copernicus Marine Services, to optimise dissemination and opportunities for learning transfer.

5 Environmental monitoring

5.1 Introduction and objectives

The overarching aims of environmental monitoring activities within the SEA Wave project are to gather evidence and data to:

1. Reduce uncertainty around key identified evidence gaps for wave energy devices.
2. Develop and inform outputs and tools to streamline consenting for wave energy devices (including models).
3. Upscale understanding for environmental responses from single devices to arrays.

Under each of the key evidence gap themes identified in Section 3 and through SEA Wave Deliverable 2.1, a series of objectives have been defined for environmental monitoring, to deliver these high-level aims, as set out below.

High-level monitoring objective Theme 1: Underwater noise	Rationale
Gather acoustic data from operational devices and arrays.	Fill key evidence gap Develop best practice methodologies
Gather data to inform understanding for the possible effects of underwater noise on the marine ecosystem.	Fill key evidence gap Develop best practice approaches for EIA and HRA
Theme 2: Electromagnetic fields (EMF)	
Gather data on the possible effects of EMF from transmission cables on fish and the marine ecosystem.	Fill key evidence gap[2].
Theme 3: General	
Gather data to inform the development of best practice, standardized approaches to gathering cost effective, baseline data for assessing the impacts of wave energy devices on the marine ecosystem.	Develop best practice approaches for EIA and HRA
Gather data to improve understanding for the effects of the presence of a wave energy device on seabed species structure, diversity and abundance.	Develop best practice approaches for data collection methodologies
Gather data to develop approaches to understanding the consequences of upscaling from single devices to arrays.	Develop best practice tools and approaches for EIA and HRA
Commercial fisheries	
Gather data to enable a standardized approach to assess the availability of alternative fishing grounds (outside developments area) and their ability to sustain existing/displaced commercial fishing levels.	Develop best practice approaches for EIA[3]

Wave energy technologies also have the potential to positively affect the environment and enrich the ecosystem, for example through the provision of artificial 'reef' habitat for sessile and mobile species. The SEA Wave project will therefore also consider the potential positive ecological effects of wave energy technologies.

[2] Electromagnetic fields (EMF) has been noted in Deliverable 2.1 Knowledge gaps and consenting risks for wave & tidal energy. It is the only key consenting issue identified for wave energy that has not been built into the SEA Wave project from the proposal stage. As a result, plans are in place to explore the opportunity to collect data to reduce the uncertainty around the variability in EMF from the cables of WECs. However, it may not be possible in the scale or timeframe of this project to carry out statistically robust monitoring to address this issue. Opportunities to collaborate with a leading expert in EMF in the UK to collect data that will be useful in reducing uncertainty around EMF variability through cables will be explored.

[3] Gathering data specifically to address this issue is beyond the scope of the SEA Wave project. However, data from the monitoring campaigns may inform the development of approaches recommendations for further work to progress good practice in this area of EIA.

To address the key objectives set out above, the monitoring activity delivered under this EDS will take a strategic and coordinated approach to data gathering and fieldwork, based around the following activities:

- Underwater noise measurements
- Assessments of seabed biodiversity and integrity
- Baited and unbaited camera surveillance
- Assessments of fisheries biomass

The SEA Wave project presents a unique opportunity to take a coordinated and strategic approach to gathering the information outlined above across multiple technologies and over multiple years. This scale of investigation should enable the development of models on environmental and ecosystem responses to large wave energy arrays. This in turn, will provide robust evidence to enable a proportionate approach to consenting future marine energy developments.

5.2 Monitoring timeline and project team

Baseline data collection at the EMEC wave energy test site (Billia Croo) and at reference sites nearby is continuing under the Clean Energy from Ocean Wales (CEFOW) project (see box below). The final season of baseline data collection was 2019. Data collection around the deployed technologies, as set out in this EDS and in individual technology monitoring plans will take place in 2019, 2020 and the first half of 2021.

Monitoring will be carried out primarily by partners University of Plymouth and University of Exeter with support from EMEC and technology developers as necessary.

CEFOW project

The SEA Wave project builds on the work of the H2020 Clean Energy from Ocean Waves (CEFOW) project. CEFOW partners were Wello, EMEC, University of Plymouth and University of Exeter and focused on the deployment of an array of two Wello Penguin wave energy converters (WEC) at the EMEC grid-connected wave energy test site.

The aim of CEFOW was to deploy advanced multiple WECs with improved power generation capability and demonstrate their ability to survive challenging sea conditions over a period of several years.

WP 6 in the CEFOW project was designed to conduct device-specific research to investigate responses of seals, seabirds, fish and seabed organisms to the deployment of single and multiple Penguin wave energy converters at EMEC. The aim was to aid industry and regulators regarding wider-scale deployments of renewable energy technology and potential environmental responses.

Monitoring data was collected around a deployed WED in 2017, 2018 and 2019. Additionally, baseline data was collected at the EMEC wave energy test site (Billia Croo) and at reference sites nearby. This presents an opportunity for the SEA Wave project to use similar methodologies in data collection to allow for this baseline dataset to be used to compare the data before and after deployment of WECs at Billia Croo and also to compare this with the data collected at nearby reference sites. This baseline data will be used to

CEFOW project

differentiate the effects of wave energy devices from the natural spatial and temporal variation of the environment at the site. This will be incorporated into the environmental monitoring strategy of the SEA Wave project in order to maximise the effectiveness of this data collection.

The data collected will be published as part of the SEA Wave outputs and hence will make further strategic baseline data publicly available. The baseline dataset will have been collected over a three-year time series, using consistent methodology. This baseline dataset will be evaluated against the post installation monitoring data in order to draw conclusions on changes in habitat or distribution and abundance of animals. In this way, this work will build towards an agreed approach to site characterisation and baseline surveys.

5.3 Monitoring activity

5.3.1 General approach

Where possible, monitoring equipment will be mounted on the wave energy devices deployed. It is envisaged that this will include at least cameras to support wildlife observations to supplement the monitoring outlined in the specific tasks below. Where required, this instrumentation will be hard wired through the wave energy device's IT systems so that data can be transmitted real-time through EMEC's Supervisory Control and Data Acquisition (SCADA) system.

5.3.2 Underwater noise measurements

Underwater operational noise has been identified as a key consenting issue for wave energy technologies. The influence of this issue on consenting is likely to grow as the scale of array deployments increases. There is a high degree of uncertainty around the level and type of noise emitted by operating wave energy technologies and on the likely consequences of any noise for marine species. Comparatively few datasets are available on the noise signature of wave energy technologies, in part due to the commercial sensitivity of these data.

The input of noise to the environment from wave energy technologies is of particular relevance to the Marine Strategy Framework Directive (MSFD) Descriptor 11 on human energy inputs to marine ecosystems including noise. As a result of this, there is a requirement for Member States to understand the effect of introduced noise on the marine environment.

A historic ambient data set is available for the site commissioned by EMEC some years ago. The SEA Wave project will build on this by collecting data on the ambient noise sound field at each of the device deployment sites. Additionally, the acoustic signature of each of the four wave energy technologies will be characterised and then analysed in relation to the baseline and ambient noise sound field data.

Static moored hydrophones will provide long-term information on ambient noise variability prior to and during deployment of the WECs.

Technology will be used to record higher-frequency background sounds and will be co-deployed with broad-band sound recorders to gather information on the presence of echolocating organisms. Baseline data gathered prior to deployments of the wave energy technologies will be compared with the post installation data to establish any changes in the presence of echolocating animals, where possible.

This task and the data collected will contribute to an understanding of seasonal and inter-annual variation in ambient soundscapes. This may enable predictions about the potential effects of noise generated by wave energy technologies at these sites, based on the known sensitivities of species present. These data will also be used to determine the degree to which ambient noise in dynamic energetic environments might mask introduced noise from operational wave energy devices.

As stated above, noise signature data of the operational wave energy devices will be collected as part of the SEA Wave project. These will be incorporated into the analysis and presented as part of the project results.

Data collection for the characterisation of noise signatures of operational WECs (including baseline and operational device surveys) will be carried out in as close adherence to IEC TS 62600-40:2019 as is practically possible. This newly published technical specification aims to standardise the methods used to characterise MEC noise, and any successful and/or unsuccessful attempts to follow the methods it prescribes will provide useful feedback for the development and improvement of this document.

While there will be no direct studies of the effect of underwater operational noise on marine mammals, static hydrophones will be used to gather data on the ambient soundscape of the environment and hence record any changes in presence, abundance or diversity of vocalising animals in the area of the deployed devices when compared with the reference sites.

5.3.3 Assessments of seabed biodiversity and integrity (towed video)

WP 3 and 4 of the SEA Wave project includes two tasks related to seabed biodiversity and integrity. WP3 will collect data using rapid towed video transects of the seabed. This is a non-destructive, cost and time effective method to capture information on seabed biodiversity and integrity. WP4 will enumerate the ecosystem response to the deployment of the four wave energy technologies by converting species-specific data into functional groups, diversity indices and key indicators.

Seabed data will be collected using high definition video cameras on a flying towed array. This method will collect data on species assemblage composition, abundance, diversity and distribution and can be used to cover wide areas. It is therefore suitable for the coverage of the wave energy technology deployment site and reference sites.

The reference sites are a vital part of the SEA Wave project monitoring strategy, to enable a robust assessment of the effects of the wave energy technologies on seabed biodiversity and integrity. Their inclusion will help distinguish between any effects of the devices from natural variation or other anthropogenic influences, including climate change or the exclusion of fishing activity from the test site.

The data collected will be analysed using a statistical framework specifically designed to deal with patchy, unbalanced data sets which are likely to be encountered in this environment. This design will build on the baseline data collection and wave technology monitoring within the CEFOW project. The null hypothesis to be tested is that there is no statistically significant difference between deployment sites and reference sites.

This task and the data collected will improve understanding for the effects of the presence of a wave energy device on seabed species structure, diversity and abundance. It will also improve consistency and development of best practice in data collection methodologies, since to date, collection of this type of data for multiple wave energy technologies across multiple years has not yet been attempted.

5.3.4 Baited and un-baited camera surveillance (BRUV)

Baited and un-baited video camera technology is a non-destructive method for collecting data in a time- and cost-efficient, non-invasive manner. This task will complement the towed video data collection described above, but will target more detailed information on larger mobile species such as larger fish and elasmobranchs (common skate, cod and cat shark).

In addition to the baited video camera deployments, infra-red illuminated, stereoscopic camera systems will be deployed to capture animals that are not attracted by bait, or that may not approach the baited system due to the light. These systems will allow morphometric measurements to be made of animals from the video.

Analysis of these data will be carried out in a similar way to the towed video data. Mobile species will be converted into functional groups and diversity indices (richness and abundance), with an additional focus on species of economic importance for recreational or commercial fisheries such as common skate, brown crab and cod. Gathered data from across the different technologies will also be analysed to gain an understanding of device dependent responses. Statistical models to aid analysis or predictions of effects will be developed. Analysis will also take care to account for any possible bias in the data (for example, attraction due to bait or lighting).

Opportunities will be explored to use the data collected through this task to improve understanding for developing a standardised approach to assessing the availability of alternative fishing grounds (outside development areas) and their ability to sustain existing /displaced commercial fishing levels.

As with the towed video, this task and the data collected will improve understanding for the effects of the presence of a wave energy device on species structure, diversity and abundance. It will also improve consistency and development of best practice in data collection methodologies, since to date, collection of this type of data for multiple wave energy technologies across multiple years has not yet been attempted.

5.3.5 Assessments of fisheries biomass

Scientific echosounders (Simrad EK80) will be used to record data on fish biomass throughout the water column. This method can be used to quantify animal presence near wave energy devices. This method can also be used to categorise fish present into broad fish groups eg. Gadoids, pelagics etc.. The data will directly interface with the baited and un-baited camera surveys to and provide insight into the changing spatial distribution of fish biomass in relation to development sites and number of devices deployed.

It is likely that wave energy devices will act as fish aggregation devices (FAD) and hence create a corresponding effect at the deployment site. This could attract larger predatory species including seals, seabirds and sharks to the area. The consequences of any FAD effect could include the provision of feeding opportunities for larger organisms or protective, sheltered habitat for juvenile species. However, the longer-term responses of host ecosystems are unknown.

This methodology has not been used in this way previously and therefore this task will further the knowledge in data collection to understand mobile species populations at marine energy sites. Additionally, this monitoring theme corresponds to the broader aim of the SEA Wave project to analyse the potential ecosystem enhancement effects of wave energy.

5.3.6 Information on device activity

A key component of the environmental monitoring strategy for the four wave energy technologies will be gathering information on device and operational activity throughout the monitoring campaigns. Information on device and site activity will be fed directly from the engineers and site managers in each of the wave energy technology developers (Wello, CorPower Ocean, Ocean Energy and Laminaria) to the Universities and EMEC who will support the interpretation and analysis. Confidential information on device performance and operation will be sanitised where appropriate.

5.4 Comparison of environmental monitoring equipment and techniques

The learning and outputs from the environmental monitoring activity carried out through the SEA Wave project will inform an assessment of the efficacy of the monitoring equipment and techniques. There have been relatively few opportunities to carry out environmental monitoring of deployed full-scale wave energy technologies to date. As a result, there remains uncertainty about best practice for data collection including equipment and techniques. The SEA Wave project will, under the guidance of the project's independent Steering Group, carry out a critique of monitoring equipment and techniques, to determine if they are fit-for-purpose and efficient in terms of data, statistical power, logistics and cost. This will be reported in Deliverable 5.1 of the SEAWave project; Best Practice Guidance on Effective Environmental Monitoring and Mitigation Methodologies

6 Conclusion

The SEA Wave project aims to address long-term environmental concerns around the development of the wave energy sector and develop cost effective approaches to monitoring and data gathering. It will trial data gathering methodologies and take a strategic approach to investigating the possible environmental effects of wave energy devices, with the aim of reducing uncertainty about key potential effects to help streamline consenting. This will be achieved by carrying out coordinated, strategic monitoring, based around identified key evidence gaps, as outlined in this Environmental Demonstration Strategy (EDS).

The environmental monitoring campaigns for the individual wave energy technologies will be aligned with the objectives and approaches set out in this EDS and detailed within supplementary Annexes to this document. The SEA Wave project presents a unique opportunity to take a coordinated and strategic approach to gathering information across multiple technologies, sites and years. It also presents the opportunity to take a proactive approach to gathering evidence on issues which may not be considered by regulators to be significant for small scale, pre-commercial deployments, but for which evidence gaps and uncertainty could present a problem for larger arrays. It also allows for research to investigate the possible positive effects of wave energy devices on the marine ecosystem which would otherwise be beyond the resources of individual developers.

The monitoring activity delivered through the EDS will inform the development of strategic recommendations from the SEA Wave project by:

- Increasing the evidence base on key environmental effects of wave technologies;
- Providing a valuable opportunity to carry out monitoring across a range of technologies and sites to refine understanding for site- and technology specific effects;
- Overcoming the challenges of designing monitoring programmes to achieve statistical significance in any monitoring studies conducted;
- Development of good practice in monitoring methodologies and design of monitoring strategies for wave technologies;
- Development of approaches to nesting technology specific monitoring programmes within an overarching strategic monitoring framework; and,
- Improving understanding for good practice approaches to monitoring to de-risk future consenting processes.

The partners of the SEA Wave project, in collaboration with ORJIP Ocean Energy would like to actively encourage feedback on the information presented in this report.

SEA Wave WP2 Leader & ORJIP OE Secretariat: Jennifer Fox, Aquatera Ltd (Jennifer.fox@aquatera.co.uk)

SEA Wave Project Manager: Caitlin Long, EMEC (Caitlin.long@emec.org)

7 Bibliography

Copping, A., Sather, N., Hanna, L., Whiting, J., Zydlewski, G., Staines, G., . . . Masden, E. (2016). *State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World.* Retrieved from https://tethys.pnnl.gov/publications/state-of-the-science-2016

Ocean Energy Forum. (2016). *Ocean Energy Strategic Roadmap; building ocean energy for Europe.* https://webgate.ec.europa.eu/maritimeforum/sites/maritimeforum/files/OceanEnergyForum_Roadmap_Online_Version_08Nov2016.pdf.

ORJIP Ocean Energy. (2017). *Forward Look.* ORJIP Ocean Energy. Retrieved from http://www.orjip.org.uk/documents

SEA Wave. (2019). *Knowledge gaps and consenting risks for wave and tidal energy.* Jennifer Fox.

This project has been co-funded by the European Maritime and Fisheries Fund EMFF) of the European Union. The contents of this document reflect only the (author's view. EASME is not responsible for any use that may be made of the information it contains.

www.seawave-emff.eu