The contribution of the SafeWAVE EU project to the future development of ocean energy

Juan Bald, Ibon Galparsoro, Gotzon Mandiola, Iñaki de Santiago, Iratxe Menchaca, Maria C. Uyarra, Sarai Pouso, Ainhize Uriarte, Iñigo Muxika, Beatriz Sobradillo, Pedro Vinagre, Inês Machado, Luana Clementino, Paulo Chainho, Janete Correia, Thomas Soulard, Enored Le Bourhis, Ivan Felis, José Antonio García,Emma Verling, Anne Marie O´Hagan, Niall Dunphy, Aaron Luke Smith, Gregorio Iglesias, Breffni Lennon, Yago Torre Enciso, Laura Zubiate, José Chambel, Sofia Cardoso Bartolomeu, Hélio Santos, Quentin Geerinckx, Corentin Troussard, Florian Tanguy, Jean Luc Longeroche, Phillipe Magaldi

Abstract—**The development of marine renewable energies and wave energy (WE) in particular, are vital components of sustainable ocean governance and the transition towards a low-carbon economy. In a new industry like marine renewable energy (MRE), and Wave Energy (WE) in particular, time-consuming procedures linked to uncertainty about project environmental impacts, the need to consult with numerous stakeholders and potential conflicts with other marine users appear to be the main obstacles to consenting WE projects. These are considered as non-technological barriers that could hinder the future development of WE in EU. Through three different strategies (environmental demonstration strategy, consenting and planning strategy and education and public engagement strategy), the aim of the SafeWAVE project has been to contribute to overcome these barriers through the knowledge and tools developed during the project life.**

Keywords—**Marine renewable energies, wave energy, environmental impact, environmental consenting, maritime spatial planning, public engagement.**

Part of a special issue for EWTEC 2023. Original version published in EWTEC 2023 proceedings at https://doi.org/10.36688/ewtec-2023-303. Manuscript submitted 17 December 2024; Accepted 13 January 2025. Published 31 May 2025.

This work was part of the SafeWAVE Project co-funded by the European Climate, Infrastructure and Environment Executive Agency (CINEA), Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.

Juan Bald, Ibon Galparsoro, Gotzon Mandiola, Iñaki de Santiago, Iratxe Menchaca, Maria C. Uyarra, Sarai Pouso, Ainhize Uriarte, Iñigo Muxika, Beatriz Sobradillo are at AZTI, Herrera Kaia, Portualdea z/g, 20110 Pasaia (Gipuzkoa), Spain (email: jbald@azti.es).

Pedro Vinagre, Inês Machado, Luana Clementino, Paulo Chainho, Janete Correia are at WavEC/Offshore Renewables – Centro de Energia Offshore Associaciao (WavEC). Edifício Diogo Cão, Doca de Alcântara Norte, 1350-352 Lisbon, Portugal (email: pvinagre@wavec.org).

T. Soulard, E. Le Bourhis are at Fondation OPEN-C, 1 Rue de la Noe, 44321 Nantes Cedex 3, France (email: thomas.soulard@fondation-open-c.org).

Ivan Felis, José Antonio García are at Asociación Centro Tecnológico, Naval y del Mar de Cartagena (CTN). Ctra El Estrecho Lobosillo KM 2 Parque Tecnológico. Fuente Alamo, 30.320, Murcia. (email: ivanfelis@ctnaval.com).

Emma Verling, Anne Marie O´Hagan, Niall Dumphy, Aaron Luke Smith, Gregorio Iglesias, Breffni Lennon are at University College Cork – National University of Ireland, Cork (UCC). Western Road, T12 YN60, Cork (Ireland) (email: Emma.verling@ucc.ie).

Yago Torre Enciso, Laura Zubiate are at Biscay Marine Energy Platform (BiMEP). Atalaia Kalea, 2, 48620 Armintza, Bizkaia (Spain) (email: lzubiate@bimep.com).

José Chambel, Sofia Cardoso Bartolomeu, Hélio Santos are at HIDROMOD Modelacao em Engenharia LDA. Rua Rui Teles Palhinha piso 14. ,2740 278, Porto Salvo, (Portugal) (email: jcleitao@hidromod.com).

Quentin Geerinckx is at Corpower Ocean AB. Brinellvagen 23. 114 28 Stockholm (Sweden) (email: quentin.geerinckx@corpowerocean.com).

Corentin Troussard, Florian Tanguy are at RTsys. 25 rue Michel Marion. 56850 Caudan (France) (email: ctroussard@rtsys.fr).

Jean Luc Longeroche, Phillipe Magaldi are at GEPS TECHNO. 1 route de la croix moriau, 44350 Guerande (France) (email: jean-luc.longeroche@geps-techno.com).

Digital Object Identifier: https://doi.org/10.36688/imej.8.73-82

I. Introduction

The European Atlantic Ocean offers a high potential for marine renewable energy (MRE), which is targeted to be at least 32% of the EU's gross final consumption by 2030. The European Commission is supporting the development of the ocean energy sector through an array of activities and policies: the Green Deal, the Energy Union, the Strategic Energy Technology Plan (SET-Plan) and the Sustainable Blue Economy Strategy. The nascent status of the MRE sector and Wave Energy (WE) in particular, yields many unknowns about its potential environmental pressures and impacts. Wave Energy Converters' (WECs) operation in the marine environment is still perceived by regulators and stakeholders as a risky activity. The complexity of MRE licensing processes is also indicated as one of the main barriers to the development of the sector. The lack of clarity of procedures, the varied number of authorities to be consulted and the early stage of Marine Spatial

Planning (MSP) implementation are examples of the issues identified that may delay the permitting of the projects. Finally, there is also a need to provide more information on the sector to the general public. Only with an informed society would be possible to carry out fruitful public debates on MRE implementation at the local level. These non-technological barriers that could hinder the future development of WE in EU were addressed by the WESE project funded by EMFF in 2018 and ended in 2021 (https://wese-project.weebly.com/wese-project.html). The Streamlining the Assessment of environmental effects of Wave Energy (SafeWAVE) project (https://www.safewave-project.eu/), co-funded by European Climate, Infrastructure and Environment Executive Agency (CINEA) in 2020, builds on the results of the Wave Energy in the Southern Europe (WESE) project and aims to move forward through the following specific objectives until its end in December 2024 (Fig. 1): (1) Development of an **Environmental Research Demonstration Strategy** based on the collection, processing, modelling, analysis and sharing of environmental data collected in WE sites from different European countries where WECs are currently operating; (2) Development of a **Consenting and Planning Strategy** through providing guidance to ocean energy developers and to public authorities tasked with consenting and licensing of WE projects in France and Ireland; this strategy will build on country-specific licensing guidance and on the application of the MSP decision support tools (i.e. WEC-ERA, https://aztidata.es/wec-era/ and VAPEM https://aztidata.es/vapem/, tools) developed for Spain and Portugal in the framework of the WESE project; the results will complete guidance to ocean energy developers and public authorities for most of the EU countries in the Atlantic Arch; (3) Development of **a Public Education and Engagement Strategy** to work collaboratively with coastal communities in France, Ireland, Portugal and Spain, to co-develop and demonstrate a framework for education and public engagement (EPE) of MRE enhancing ocean literacy and improving the quality of public debates.

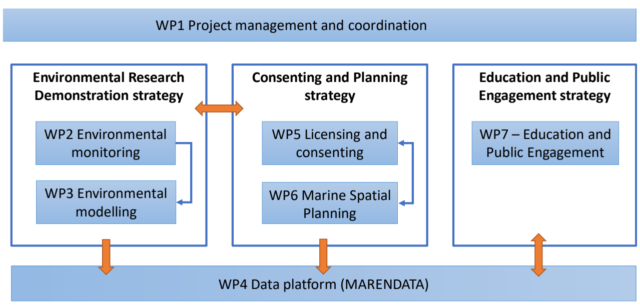

Fig.1. SafeWAVE project activities structure.

II. Environmental Research Demonstration Strategy

The SafeWAVE project aimed to collect, process, analyse and share environmental data collected in sites where WECs are operating in real sea conditions representing different types of technology, sites and, therefore, types of marine environment (onshore, nearshore and offshore) that can potentially be affected by wave energy projects. Data were collected for four of the priority areas of research identified in the "State of Science Report" on "environmental effects of marine renewable energy development around the world" [1, 2] through the corresponding monitoring plans [3, 4]:

- Electromagnetic fields (EMFs) occur naturally in the marine environment, while anthropogenic activities may create altered or additional sources of EMF, including those from wave devices export cables. Cables are commonly buried or lying on the seabed, while inter-device cables may be suspended in the water column.
- Underwater and aerial sound: the addition of anthropogenic noise sources from operational ocean energy devices may induce behavioural changes in those marine animals that use sound for communication, social interaction, orientation, predation, and evasion.
- Seafloor integrity effects: the installation of wave devices alters benthic (bottom) habitats by the addition of gravity foundations, piles, or anchors, as well as the sweep of mooring lines, cables, and mechanical moving parts. During the operation stage, dragging or rubbing of materials such as chains, wires, ropes or cables across the seabed could be expected.
- Reef-effect: generally speaking, any submerged structure located in the sea may cause an attraction effect on fish communities, especially if it is floating. The installation of MRE devices may also provide opportunities for creating and enhancing habitats increasing the number of fish in an area as they reef around the supporting structures of the devices (searching for protection, food availability and using the structures as reference points for spatial orientation), and create de facto marine protected areas as other human uses, such as trawling (which is one of the most severe threats to the marine environment including both benthic and fish assemblages), are avoided in the vicinity or inside the areas of MRE development.
- Energy removal: in marine environments, physical systems act as drivers for the sustainability and health of organisms. The installation of wave devices may affect the system by changing natural flow patterns around devices, which can alter sediment distribution and transport. A small number of wave devices will not create measurable changes, but large commercial arrays might alter the system over time.

A. *Collection, processing and analysis of environmental data around WECs currently operating at sea*

TABLE I. MONITORING WORKS UNDERTAKEN BY WESE AND SAFEWAVE PROJECT IN EACH TEST SITE, TECHNOLOGY AND ENVIRONMENTAL FACTOR.

Test site	BIMEP		Mutriku Wave Power Plant		SEM-REV	Peniche	Agoçadoura
Project	WESE	SafeWAVE	WESE	SafeWAVE	WESE	WESE	SafeWAVE
Technology	MARMOK-A-5 Offshore	WELLO Offshore	Mutriku Wave Power Plant Onshore		WAVEGEM Nearshore	WAVEROLLER Nearshore	WAVEGEM Offshore
Underwater sound	X	X	X	X	X	X	X
Aerial sound	X	X	X	X	X		
Seafloor integrity	X	X			X	X	X
EMF	X				X		X
Reef effec		X					X
Energy removal (modelling)	X	X			X	X	X

The SafeWAVE project acquired environmental data around full-scale devices installed in Portugal, Spain and France, namely the CorPower Ocean device, Hiwave 5 project, planned to start installation in 2023 at Aguacadoura (Portugal), the WAVEGEM device installed during the summer of 2019 at the SEMREV site (France), the Mutriku Wave Power Plant located in the Basque Country in Spain and the Penguin's (WELLO) device installed at BiMEP in 2021 also in the Basque Country, Spain. These devices are in addition to those already studied in the WESE project: (i) Idom-Oceantec MARMOK-A-5, installed in BiMEP; (ii) WaveRoller (AW-Energy), installed in Peniche (Portugal) and (iii) Mutriku Wave Power Plant again. Table I summarize the monitoring works undertaken in each test site, technology and environmental factor monitored.

1) *Electromagnetic Fields (EMF)*

Unfortunately, for different reasons (delays in the installation of HiWAve-5 device, unexpected removals of Penguin II due to maintenance and repair operations and the no connection of WAVEGEM device to the grid), it was not possible to monitor the EMF produced by WECs. Instead, a floating wind turbine prototype was monitored, FLOATGEN. The prototype was connected by a 5 MVA umbilical cable to a collection hub at the SEM-REV test site in France. The surveys show that even with significantly higher current values the magnetic field is in the order of the nT at a distance of 5 m from the cable. Similar results were found by [5] for the monitoring of the Marmok-A-5 WEC in the BiMEP test site, although the magnetic field values were quite below (maximum 0.15 nT) than the present ones (13 nT and 20 nT for the umbilical and export cables, respectively), mostly owed to low power production during calm sea state. effects of magnetic fields on animals, namely fish and invertebrates, were originated by exposure to magnetic levels considerably higher (three to six orders of magnitude) than those found in the present monitoring (13 nT and 20 nT for the umbilical and export cables, respectively). Therefore, it is most likely that the EMF, namely the magnetic fields, measured at the umbilical or export cables at SEM-REV have no significant impact, if any impact, on such animals.

2) *Underwater sound*

The guidelines of IEC 62600-40 have been followed in most of its aspects during the monitoring works of underwater sound, both regarding: (i) the conditions of instrumentation (Frequency range: sample rate 288 kHz VS. 10 Hz-100 kHz; sensitivity: -174 dB re 1 V/uPa + VS. between -165 to -145 dB re 1 V/uPa (16 bits system).This could be a point of deviation but, combining with dynamic range (96 dB) it has been observed that is sufficient to measure ambient sounds exceeding typical sea-state 1 conditions up to maximum levels received by the WEC without saturating; Self-noise: < 37 dB re 1 uPa^2/Hz VS. < 55 dB re 1 uPa^2/Hz; Directionality: ±3dB VS. < ±5dB and Calibration: from manufacturer VS. < 24 months); (ii) measurements (sound measurement system deployment: Level A; Temporal resolution: acquired over ranges of sea states at least 50% and Spatial resolution: 3 hydrophones, one on dominant wave directions, and two almost perpendicular); (iii) deployment platforms (fixed platforms have been used); (iv) contextual measurements (wind, wave and current have been measured) and (v) data analysis (Sections 6, 7, 8 of the guideline).

From all devices monitored during operation (PENGUIN II, Mutriku Power Plant, and WAVEGEM, located in BiMEP, Mutriku and Nantes, respectively), we can conclude that only in the case of PENGUIN II there is some kind of acoustic contribution to the background noise. However, this happens whether the device is operating or not (higher when operating though), and only when the comparison is made with respect to the baseline levels existing after is decommission, case in which sound levels increase more than 20 dB re 1 µPa in the lowest frequencies. The device is a floating asymmetric hull containing a rotating mass which drives a generator. When device was off (not generating or operating) the rotator was unlocked so it actually could rotate. What it did, it short circuited the generator so that movement was generating the current in coils which was generating magnetic field opposing the movement of mass rotator. There was also a pin locking device, but if that was operated, it needed to drive the mass rotator on certain location and then pin actuated. But that was only used on during deployment of the device. When device was off (not generating), there might have been also cooling fan and cooling circuitry making some noise. All these factors could explain why sound levels where similar whether the device was operating or not. In the other hand, there is another WEC-related element with a detectable acoustic signature, which is the system of moorings that can be found both in the BiMEP and SEM-REV test sites. When significant wave heights are above ~1 meter (and thus the moorings are displaced), a high frequency (between 3 and 5 kHz) component in the SPL spectrum is observable. Similar results were found by [6]. Regarding the MARMOK-A-5 device, the most significative contribution to its surrounding soundscape appears between 40 and 120 Hz, with increments of 14 dB re μPa (Hs<1 m), 13 dB re μPa (1 m≤Hs<2 m) and 6 dB re μPa (Hs>2 m), even though the variability is quite relevant. Another sources of noise, most relevant with high wave heights, are the mooring chains, which can be perceived at frequencies beyond 2500 Hz, with SPL values approximately ranging from 90 (for lower wave heights) to 105 (higher wave heights) dB re 1 μPa. It should be noted that this metrics have been calculated at a distance of 90 meters away from the converter. Regarding the Mutriku Power Plant, there is no clear indication of an increase in the sound pressure levels when the plant is operating, at least at a distance of 1000 meters away from the central.

3) Seafloor integrity

Although the impacts over the seafloor integrity could not be assessed at the Aguçadoura test site for the HiWave-5 device, from the information collected in BiMEP and SEM-REV (Penguin II and WAVEGEM devices, respectively) the impacts observed by video surveys and side scan sonar, can be summarized in:

- Artificial reef effect: the introduction of new substrates in the marine environment allows for many organisms (fauna and flora) to settle and grow and contribute to increase local biomass and biodiversity. These artificial reefs also attract fauna from higher trophic levels, such as fish. Furthermore, the added complexity of the biofouling assemblages and the artificial structures themselves provide refuge to some animals (e.g., lobsters) from predators. Although not monitored in the framework of the present project, this could lead to changes in the structure of communities and trophic webs, and could also favour the development of non-native species assemblages.
- Changes in the seafloor morphology (e.g., removal of natural ripples) due to dragging of the chains during the operational phase, and/or an effect of the local change on sedimentation and currents, caused by the presence of the mooring lines.

Due to the small area affected by the mooring lines, compared to the total area occupied by the installations (<1%), those impacts could be considered as non-significant over seafloor integrity. Similar results were found by [7] during WESE monitoring campaigns around Idom-Oceantec MARMOK-A-5, installed in BiMEP and WaveRoller (AW-Energy), installed in Peniche (Portugal).

4) Fish communities – reef effect

The removal of the Wello Penguin WEC-2 from the BiMEP in December 2021 area was initially a setback for the team. As a mitigation strategy, the project team decided to conduct monitoring around Tecnalia's HarshLab floating laboratory device. Although the floating lab is not a WEC, it is very similar in terms of dimensions and mooring systems employed, and can be used as a good model for the potential reef effect due to the presence of structures on the water surface. In general, the placement of any artifact in the sea can have an attracting effect on fish communities, especially if it is floating. The aim of the project was to monitor this possible effect thanks to the deployment of the ITSASDRONE surface drone device equipped with a Simrad EK80 programmable stand-alone split-beam acoustic echosounder.

As explained by [8], regarding the possible reef or fish aggregating effect, schools of unidentified small pelagic fish were observed distributed throughout the water column, predominantly near the bottom in the HarshLab area and more detached from the bottom in the deeper third berth position. The acoustic sensors showed a relatively high abundance in the BiMEP area, generally as high as in the Armintza harbor access route. Although the HarshLab could be considered as a good model for the possible reef or fish attraction effect due to its similar dimensions to the WECs, it is true that it doesn't have specific elements of the WECs that could intervene or affect this potential effect. These are the underwater noise generated by the moving parts of the harnessing machine inside the WEC and the electromagnetic fields of the exporting electric cables, which could generate an avoidance effect and compensate the attraction of the floating structures of the devices.

Consequently, these results are considered as basic information. Future studies and further trials with the ITSASDRONE device are needed to further investigate the relationship between WECs and fish aggregations.

B. Sharing of environmental data

To guarantee that SafeWAVE project must give access to their results to EU institutions, bodies, offices or agencies, for developing, implementing or monitoring EU policies or programmes, and also to authorities, stakeholders, researchers, developers and data providers, a Data Sharing Platform, named MARENDATA (https://marendata.eu/) was developed. This data platform will serve data providers, developers and regulators, including the partners of the project. The Data Platform is made of several Information and Communication Technology (ICT) services intending to disseminate data and knowledge on ocean energy: i) a single Web access point to relevant data based on Hidromod's AQUASAFE software; (ii) generation of requests to access data via command line (advanced users); (iii) a dedicated cloud server to store frequently used data or data that may not fit in existing Data Portals and (iv) synchronised collected data and modelled environmental parameters in order to feed EIA methodologies. In order to increase the impact and maintain the legacy of MARENDATA, this platform has been integrated in the Portal and Repository for Information on Marine Renewable Energy (PRIMRE, https://openei.org/wiki/PRIMRE) developed by the Pacific Northwest National Laboratory, National Renewable Energy Laboratory, and Sandia National Laboratories on behalf of the U.S. Department of Energy Water Power Technologies Office. PRIMRE provides centralized access to a variety of marine renewable energy data and information, ranging from power performance data and environmental monitoring reports to device testing guidance and software code.

C. *Modelling future cumulative pressures and impacts associated to larger arrays of WECs*

The aim of the modelling tasks of the project was to develop strategic research to address gaps in knowledge to improve modelling of potential cumulative pressures and environmental impacts of future wave energy deployments at larger scale coming from: (i) EMF emitted by subsea power cables; (ii) underwater acoustic fields radiated by the WECs and (iii) energy absorption and impact on marine dynamics.

1) *Electromagnetic Fields (EMF)*

Several software packages are available to model magnetic and electric fields. Based on the authors previous experience with different tools, the software package - Finite Element Method Magnetics (FEMM) [9] was viewed as the most suitable option. The magnetic fields modelled considering either the devices maximum power production (maximum 10 µT at 10 cm from the export cable) or the export cables maximum current capacity/ampacity (maximum 152 µT at 10 cm from the export cable) are quite below the values generally reported as having detrimental effects to marine animals [10-12]. Nonetheless, some authors have reported behavioural [13] or physiological [14] effects on animals exposed to magnetic fields in that range. Regarding electric fields, it might be possible that electric fields in the range of those modelled for a device at its maximum power production (18 µV/m at 3 m and 342 µV/m at 10 cm from the export cable) and for an export cable at its maximum current capacity (174 µV/m at 3 m and 5,501 µV/m at 10 cm from the export cable) overlap the fields precepted by predators, preys, or both, with potential effects at the individual level that might lead to consequences at the population level. As highlighted by other authors [13, 15], future research needs to involve not only research from the ”stressor” perspective, i.e. artificial EMF measurement and modelling e.g. in relation with the cables characteristics, environment, and distance to cables, but also from the "receptor” perspective, i.e. considering the different effects at different life stages, for different species or focusing on particular species of interest, and the consequences at the population level. Further work should be dedicated to increase understanding on the effects caused in marine animals by EMF both at different intensity levels and at different frequency levels.

2) *Underwater sound*

At the time of writing of the present paper, the underwater noise propagation modelling work of the SafeWAVE project was still ongoing and unfinished. The aim is similar to the work undertaken in the WESE project, that is, to modelize the propagation of the underwater noise generated by a larger array of WECs in each of the test sites of the SafeWAVE project. For the calculation of acoustic transmission losses fields, a Nx2D approach was used. The chosen model was the Monterey-Miami Parabolic Equation (MMPE) model, which is a parabolic equation model able to take into account range dependency on sound speed profile, bathymetry, and seabed geo-acoustic properties [16]. Result obtained by [17] in WESE around MARMOK-A-5 device showed a sound emission most energetic in the 62.5 Hz band, although worse acoustic propagation conditions existed for this case in BiMEP, as the shallow water environment inhibits efficient sound transmission. When considering the depth in which greater overall values of SPL were found, the area of disturbance obtained is 0.9 km^2 for such frequency and wave heights between 0 and 1 m, which is equivalent to a 0.28 km radius circle around the device. This can be viewed as an upper bound to the distance of disturbance around the device. When considering a swarm of 80 identic devices, differences up to a maximum of 50 dB re 1 µPa were found between this and the single device scenario (placed in the centre of the swarm), for the incoherent case. The radial distances (from the centre of the swarm) at which the sound pressure level fields are indistinguishable from the background noise levels are now much greater though, with maximum values for low wave heights (where there is less background noise) and frequencies around 3.4 km.

3) *Marine dynamics*

In the present study the impact of WEC farms in nearshore morphodynamics was evaluated in two distinct case studies, BiMEP and Agoçadoura. In the first case the validation of the Hybrid Statistical Downscaling methodology followed in [18] within the WESE project was carried out. In the second case, the hydrodynamics and beach shoreline evolution were studied by means of a probabilistic approach and morphodynamic evolution was analysed using a dynamic downscaling methodology. For the Aguçadoura test site in Portugal, the simulation of one WEC unit demonstrates how the SNL-SWAN model interacts with the WEC device and what energy extraction is expected. In this case, there is a 68% reduction in energy to the lee of the equipment over a 15-day period. The simulation results of the WEC farm reveals that the most considerable energy reduction takes place right to the lee of the site, with a reduction exceeding 10% and a maximum extension of 250.0 m. The shadowing effect gradually diminishes towards the shore, with the reduction nearshore being less than 2%. The results achieved with these simulations indicate that a WEC farm located at the Aguçadoura site would not influence the sediment transport at the shore or any other processes.

Similar results were obtained in the framework of the WESE project by [18] in two distinct case studies, BiMEP and Peniche. In the first case, the WEC farm studied is composed by 80 WECs deployed at 80m water depth at 4km from the coast in the BiMEP area. The period (P) and significant wave height (Hs) reduction produced by the WEC farm is limited and with little effect at the coastline. This is attributed to the long distance at which the WEC farm is located from the coastal zone, which is far enough to significantly reduce the wave shadowing effect that occurs in the vicinity of the WEC farm. The morphodynamic impact is quantified in the only beach of the study site where the hydrodynamic impact is limited. Both accretion and erosion magnitudes are considerably low, consequently it could be considered that the WEC farm does not provide any protective effect for the beach. In the second case study, the impact of an array of 17 bottom-mount Waveroller devices was analysed in terms of energy removed from the system by the devices and its impact on the nearshore morphological evolution. Results show that the WEC array not only removes energy from the system but can also change the shape of the transmitted wave spectrum. Results also indicate that the WEC array offers little protection to extreme wave conditions due to the frequency operation limits of the Waveroller. No significant sediment exchange between long shore areas have been observed.

III. Consenting and Planning Strategy

As mentioned in the Introduction time consuming procedures linked to uncertainty about project impacts, the need to consult with numerous stakeholders before reaching a permitting decision, the lack of general and detailed guidance on consenting procedures, authorities involved and to be consulted with and the lack or early stage application of marine spatial planning regulations appear to be the main obstacles to consenting of ocean energy projects, delaying project implementation and risking general project feasibility.

A. *Consenting*

The aim of SafeWAVE is to provide guidance to ocean energy developers and to public authorities tasked with consenting and licensing of WECs in France and Ireland. It should be noted that the tasks proposed have already been carried out within the framework of the WESE project for Spain and Portugal [19-22]. Thus, by building on the previous work carried out in the WESE, this task aims to contribute to a complete set of guidelines for ocean energy developers and public authorities in the EU countries located in the Atlantic Arch.

In the case of WESE project, the first task consisted on the development of a database of key stakeholders such as project developers and promoters (license applicants and specialist consultants), policy makers and regulators, consenting and surveying service providers (including technology providers, Environment Impact assessment practitioners, consenting and surveying consultants), energy companies, academic experts (both in science and policy) and representatives of appropriate lobby and pressure groups. A total number of 310 stakeholders were identified belonging to 7 groups, 6 roles and 16 sectors for Spain and Portugal [19].

The second task was the review of national consenting processes in France and Ireland [23]. Both countries have made and continue to make changes to their legal systems in order to streamline consenting systems for the realisation of offshore renewable energy projects. This is already in place in France but under development in Ireland, so it is difficult to determine the effectiveness of the changes at this time. What is also evident from analysing the policy drivers at EU and national levels, is that whilst the potential contribution of ocean energy is clearly expressed at EU, it is more difficult to see this in national level policies which may have implications for development. The implementation of Maritime Spatial Planning is likely to have an impact on offshore energy development planning in future. At this time, the first plans are just being published and starting to be implemented so their relative impact on the MRE sector is largely unknown.

The third task was the study of the legal feasibility for the implementation of a risk-based approach (RBA) and adaptive management (AM). An RBA to consenting is one aspect of AM, interpreted as a structured process that enables learning by doing and adapting management interventions based on those lessons. This is one way to manage uncertainty whilst also enabling development to progress. Adaptive management is a legal requirement under the EU's Marine Strategy Framework Directive but there is no agreed definition of this at EU level and somewhat limited experience, at Member State level, in applying it to marine contexts. This task will assess how a risk-based approach within an over-arching adaptive management framework can be implemented during the consenting process and also during subsequent environmental monitoring programmes at site level i.e. a WE project. [24] identified five RBAs that have been developed for practical use in the implementation of different policies globally: The ISO Standards, The Survey Deploy Monitor approach, the Environmental Risk Evaluation System, the Risk Retirement approach and the Ecological Risk Assessment approach. Once examined, a "simple stepwise approach" was created which reduced

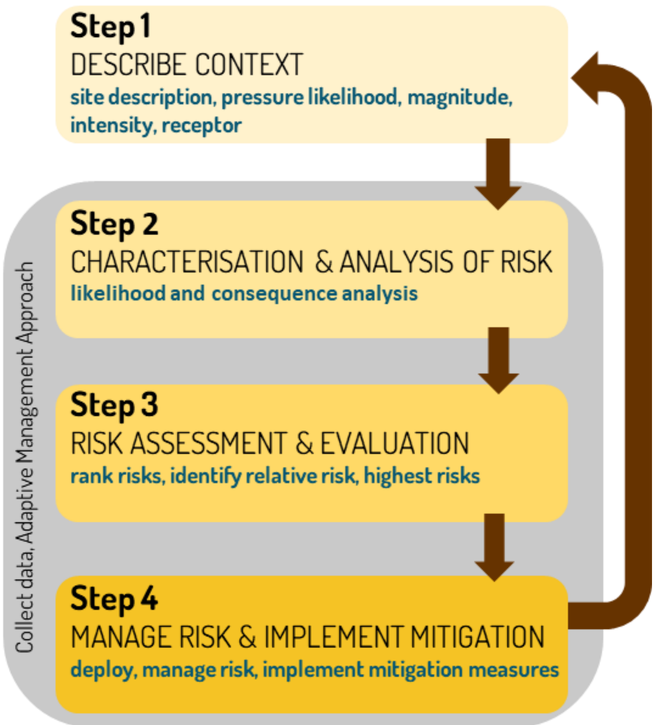

Fig. 2. Diagram showing the stepwise Risk-Based Approach process and steps.

the complexity of the RBA but ensured that all the detailed scientific work was considered [25] (Fig.1).

Involving a range of stakeholders in the development of an RBA to ocean energy consenting is necessary to ensure that any proposed changes to consenting are acceptable to other sectors working in the marine environment. This may include representatives from fisheries, aquaculture, shipping and navigation and conservation. Working meetings with representative stakeholders from different groups (developers, regulators, consultancies, sectoral representative organisations) in France and Ireland will be held similar to those undertaken in Spain and Portugal in the framework of the WESE project [21].

Finally and similarly to guidelines developed for Spain and Portugal [22], based on the results of the previous tasks, guidance will be developed for France and Ireland aimed at describing the various steps of the licensing process for MRE projects to be located on the coast. At the time of writing the present paper, this task together with the working meetings with stakeholders was still ongoing and unfinished.

B. *Maritime Spatial Planning*

Building on the development undertaken in the WESE project for Portugal and Spain [26-28], the MSP Decision Support Tool (DST) for site selection of ocean energy projects in France and Ireland are being implemented for a more efficient planning of future deployments in these countries. As the objective of SafeWAVE is equivalent to that of the WESE project, the same approach was adopted, but modifications, adaptations and improvements were applied to fit with the objectives of SafeWAVE. In addition, the adaptation and improvement of the model was enriched by the consultation and discussion with WEC industrial developers and scientists. The objective of the workshop was to share and discuss the approach and assumptions made during the development and operationalisation of the site suitability model. The main focus was put on the structure and technical factors considered within the model. There was a general agreement on that the main factors were already considered but additional feedback was obtained in relation to information sources and the way such factors could be integrated into the model. In particular, regarding the wave energy resource and the estimation of the production capacity, the oceanographic conditions for construction and maintenance of the devices, the calculation of the levelized cost of energy (LCOE), as well as the other aspects related to the deployment of the farms such as depth, slope, seafloor type, distance to substation and distance to port.

The conceptual model was then operationalized in a Bayesian Network and implemented into a web-based decision support tool called VAPEM (https://aztidata.es/vapem/) [29]. The spatial data to feed the model were obtained from different publicly available datasets [30]. The geographical scope of the model is the European Atlantic region which covers the EEZs of Ireland, the UK, France, Spain and Portugal. Accounting for a total area of 3,676,970 km^2.

The final objective is to produce suitability maps for WE deployment by developed DSTs. At the time of writing the present paper, this task was still ongoing and unfinished. The results obtained by [28] for Spain and Portugal showed that 17% of the total area was identified as suitable for the development of wave energy projects, while the highly suitable areas account for just 0.2% of the area. Almost half of the region is not suitable due to technical restrictions (45.9%). The areas limited by environmental risks are representing 5.3% of the study area, while the areas that would be excluded for the development of wave energy projects due to the presence of excluding human activities or underwater infrastructures are just 0.9% of the study area. The approach implemented also allows the identification of areas that are presenting combined restrictions for the development of wave energy projects. In that sense, the combination of environmental and technical restrictions is present in 18.1% of the area, uses and technical restrictions in 7.5%, and uses and environmental restrictions in 0.3% of the area. All types of restrictions are identified for 4.7% of the study area.

IV. Public Education and Engagement Strategy

The deployment of ocean renewable energy technologies, such as WE, has the potential to evoke opposition within intended host communities. In many cases this leads to a social mobilisation objecting to specific deployments, and associated collective actions obstructing their realisation. The aim of the SafeWAVE project is to work collaboratively with coastal communities in France, Ireland, Portugal and Spain, to co-develop and demonstrate a framework for education and public engagement (EPE), specifically aimed at ocean literacy. This EPE framework will aim to go beyond social acceptance, which is often equated to acquiescence to a fait accompli, and be designed to contribute to development of projects which exhibit inherent social acceptability. This work will be informed by five core dimensions of acceptability (personal and interpersonal; structural; political; market; local and community) adapted from social acceptance models of [31] and [32].

First of all, a literature research was conducted [33] to identify: (i) the obstacles and reasons that lead to opposition to marine renewable energies; (ii) the main actors that normally present opposition, and when possible; (iii) the solutions given to overcome such problems. [33] reveals that the opposition that wave energy projects raise is rather limited. Very few documents provide evidence of opposition to wave energy projects. Yet, and since the wave energy activity is expected to expand in the near future, such opposition, even if limited, needs to be considered in advance, so projects can be adapted, and measures can be developed and implemented as means to prevent or mitigate any negative impact that could generate opposition.

In a second step, a critical review of education and public engagement (EPE) programmes was done [34]. In summary, improved mechanisms of consultation and engagement of stakeholders can be important to dispel any myths generated about the project and develop the trust required for societal and other stakeholders to hold a positive attitude towards the new renewable energy technology from the outset. However, even though advice given by regulatory authorities and experienced developers advocate for "early and often" stakeholder engagement, in practice, stakeholders are often consulted only when the lease has been awarded which can be a stage where it can be difficult to present alternative proposals to the project has been leased [35]. Any MRE project must begin by winning the support of the key stakeholders within the community, which gives the entire project more credibility. Otherwise, as the old political adage goes 'when you're explaining, you're losing' – the potential goodwill of those stakeholders to the project. Therefore, according to [34] it is good practice to first hold informal consultation processes to agree on the most appropriate site for the proposal, followed by a more formal consultation where observations and comments are formally received from all stakeholders.

Following to this review, an initial characterisation of the societal stakeholder context within the five focal communities that are host to the marine renewable energy installations and test sites in France, Ireland, Portugal and Spain was done [36]. For each case, information was gathered about the test site, the host community, political context, public administration, societal and community stakeholders, the community of water-users, and thought-leaders. This new knowledge will inform the planned engagement with the communities and directly feed into the EPE programme developed by [37]. [37] begins by establishing a general framework applicable to any EPE program drawn from a broad integrative literature review of relevant research in the fields of sociology, political science, psychology, public administration, education, and science-technology-society studies. After establishing how the components of the general framework relate to each other, [37] then applies the general framework to the task of creating a documented methodological approach for the development of tailored ocean literacy programmes about ocean energy projects with a focus on wave energy. The participatory co-design process of this latter stage revealed the importance of taking an intersectional approach to the design and implementation of the EPE program, an approach which facilitates consideration of the socio-demographic specificities of the intended public to be engaged (including for example gender, economic privilege, educational attainment, and life stage).

Based on the framework developed by [37], an approach for creating education and public engagement (EPE) programmes that are tailored to the specific circumstances in each of the communities of the project's four member countries – France, Ireland, Portugal, and Spain was developed. These programmes aim to: (i) raise awareness of wave energy, energy transition and climate action through outreach, education, and training initiatives and (ii) provide an inclusive mechanism for community and wider society stakeholders to input into the planning and realisation of ocean energy projects.

V. Conclusion

As stated in the Introduction, the SafeWAVE project builds on the findings of the precedent WESE project ended in 2021 and at the time of writing the present paper, the work of the SafeWAVE project was still ongoing and unfinished. Consequently it´s still too early to obtain robust and significative conclusions of the project until it is finalised. However, following the structure of the project and the link between the different strategies that have been implemented (Fig.1), some considerations may be mentioned.

Regarding the Environmental Research Demonstration Strategy of the project, the environmental data acquired around different types of technology, sites and, therefore, types of marine environment (onshore, nearshore and offshore) together with the study of the impacts of larger arrays has contributed to a better understanding of the expected impacts of MRE and WE associated to EMF, underwater sound, seafloor integrity alteration and reef effect over fish communicates. At the same time, all the acquired data has contributed to the feeding the MARENDATA platform allowing the free access to these data to a variety on end users (academia, developers and regulators) that could use them to improve further environmental impact assessment studies or MRE.

All these results are contributing to the Consenting and Planning Strategy of the project. In some cases, the acquired knowledge will contribute to de-risk some of the expected impacts contributing to streamline the licensing and consenting procedures and the implementation of the suggested risk-based approach (RBA) and adaptive management (AM). At the same time, this better knowledge will contribute to improve the DST for MSP developed through the improvement of the risk assessments relationships between stressors and environmental factors that constitute the basis of the models under which these DST are based.

Ultimately, the Public and Education and Engagement Strategy rely on the knowledge base developed in the previous strategies. The education and public engagement (EPE) programmes to be implemented in the different in each of the communities of the project's four member countries – France, Ireland, Portugal, and Spain will feed in the knowledge generated to develop the best materials for the public education and engagement.

Once completed, the aim of the SafeWAVE project is to contribute with the knowledge and tools generated to overcome of the non-technological barriers that could hinder the future development of the MRE and WE in particular in the EU.

REFERENCES

[1] A. Copping *et al.*, "Annex IV 2016 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World.," Pacific Northwest National Laboratory on behalf of the U.S. Department of Energy (the Annex IV Operating Agent), 2016. [Online]. Available: http://tethys.pnnl.gov/publications/state-of-the-science-2016. [Online]. Available: http://tethys.pnnl.gov/publications/state-of-the-science-2016.

[2] A. Copping, L. G. Hemery, and editors, "OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World," in "Report for Ocean Energy Systems (OES)," Pacific Northwest National Laboratory on behalf of the U.S. Department of Energy (the Annex IV Operating Agent), 2020. [Online]. Available: https://tethys.pnnl.gov/sites/default/files/publications/OES-Environmental-2020-State-of-the-Science-Report_final.pdf. doi: doi:10.2172/1632878.

[3] P. A. Vinagre *et al.*, "Deliverable 2.1 Monitoring plans for Noise, Electromagnetic Fields and Seabed Integrity. Corporate deliverable of the Wave Energy in the Southern Europe (WESE) Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640," 2019. doi: http://dx.doi.org/10.13140/RG.2.2.17431.70562

[4] P. A. Vinagre *et al.*, "Deliverable 2.1 Development of Environmental monitoring plans. Corporate deliverable of the SafeWAVE Project co-funded by the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.19708.41600/1.

[5] P. Chainho and J. Bald, "Deliverable 2.2 (Monitoring of Electromagnetic fields). Corporate deliverable of the WESE Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640," 2020. doi: http://dx.doi.org/10.13140/RG.2.2.27498.03526.

[6] I. Felis, E. Madrid, R. Álvarez-Castellanos, J. Bald, A. Uriarte, and E. Cruz, "Deliverable 2.3 Acoustic Monitoring (v3). Corporate deliverable of the WESE Projectfunded by the European Commission. Agreement numberEASME/EMFF/2017/1.2.1.1/02/SI2.787640.," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.10406.24649.

[7] I. Muxika, P. Vinagre, and J. Bald, "Deliverable 2.4 (Monitoring of seafloor integrity). Corporate deliverable of the WESE Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640.," 2020. doi: http://dx.doi.org/10.13140/RG.2.2.15753.98404.

[8] A. Uriarte *et al.*, "Deliverable 2.5 Monitoring fish communities. Corporate deliverable of the SafeWAVE Project co-funded by the European Climate, Infrastructure and Environment Executive Agency (CINEA), Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.," 2022. doi: http://dx.doi.org/10.13140/RG.2.2.33682.12489.

[9] D. C. Meeker. "Finite Element Method Magnetics, Version 4.2 (21April 2019 Build)." https://www.femm.info/wiki/HomePage (accessed 2023).

[10] C. Fisher and C. Slater, "Electromagnetic Field Study – Effects of electromagnetic fields on marine species: a literature review. Report 0905-00-001 prepared on behalf of Oregon Wave Energy Trust.," 2010.

[11] L. Albert, F. Deschamps, A. Jolivet, F. Olivier, L. Chauvaud, and S. Chauvaud, "A current synthesis on the effects of electric and magnetic fields emitted by submarine power cables on invertebrates.," *Marine Environmental Research*, vol. 159, no. 104958, 2020.

[12] P. Harsanyi *et al.*, "The Effects of Anthropogenic Electromagnetic Fields (EMF) on the Early Development of Two Commercially Important Crustaceans, European Lobster, Homarus gammarus (L.) and Edible Crab, Cancer pagurus (L.)." *Journal of Marine Science and engineering*, vol. 10, no. 564, 2022.

[13] Z. L. Hutchison, A. B. Gill, P. Sigray, H. He, and J. W. King, "Anthropogenic electromagnetic fields (EMF) influence the behaviour of bottom-dwelling marine species," *Scientific Reports*, vol. 4219, no. 10, 2020.

[14] T. Nishi, G. Kawamura, and K. Matsumoto, "Magnetic sense in the Japanese Eel, Anguilla japonica, as determined by conditioning and electrocardiography.," *The Journal of Experimental Biology*, vol. 207, pp. 2965-2970, 2004.

[15] Z. L. Hutchison, A. B. Gill, P. Sigray, H. He, and J. W. King, "A modelling evaluation of electromagnetic fields emitted by buried subsea power cables and encountered by marine animals: Considerations for marine renewable energy development.," *Renewable Energy* no. 177, pp. 72-81, 2021.

[16] K. B. Smith, "Convergence, stability, and variability of shallow water acoustic predictions using a split-step Fourier Parabolic Equation Model," *Journal of Computational Acoustics*, vol. 9, no. 1, pp. 243-285, 2001.

[17] I. Felis, E. Madrid, and J. Bald, "Deliverable 3.2 Acoustic Modelling. Corporate deliverable of the WESE Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640. ," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.11559.68001.

[18] I. De Santiago, T. Moura, J. Chambel, P. Liria, and J. Bald, "Deliverable 3.3 Marine dynamics modelling. Deliverable of the WESE Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640. ," 2020. doi: http://dx.doi.org/10.13140/RG.2.2.24981.45283.

[19] I. Galparsoro *et al.*, " Deliverable 4.1 Stakeholder database. Deliverable of the Wave Energy in Southern Europe (WESE) Project funded by the European Commission. Agreement

number EASME/EMFF/2017/1.2.1.1/02/SI2.787640. ," 2019. doi: http://dx.doi.org/10.13140/RG.2.2.18270.56647.

[20] J. Bald and M. Apolonia, "Deliverable 4.2 Review of consenting processes for wave energy in Spain and Portugal focusing on risk-based approach and Adaptive Management. Deliverable of the WESE Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640. ," 2020. doi: http://dx.doi.org/10.13140/RG.2.2.16209.61281.

[21] M. Apolonia, E. Cruz, T. Simas, I. Menchaca, M. C. Uyarra, and J. Bald, "Deliverable 4.3 Feasibility for the implementation of wave energy licensing based on a risk-based approach and adaptive management in Spain and Portugal. Corporate deliverable of the WESE Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640.," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.14915.12328.

[22] I. Machado, M. Apolonia, I. Menchaca, and J. Bald, "Deliverable 4.4. Guidance for a risk based and adaptive management consenting of wave energy projects in Spain and Portugal. Corporate deliverable of the WESE Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640.," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.22920.49927

[23] A. M. O'Hagan, E. Le Bourhis, and T. Soulard, "Deliverable 5.1 Legal and institutional review of national consenting processes. Deliverable of the SafeWAVE Project co-funded by the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.," 2021.

[24] E. Verling and A. M. O´Hagan, "Deliverable 5.2 RISK-BASED APPROACHES AND ADAPTIVE MANAGEMENT. Corporate deliverable of the SafeWAVE Project co-funded by the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices. ," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.17467.08481.

[25] E. Verling, I. Menchaca, I. Galparsoro, I. Machado, A. M. O'Hagan, and J. Bald, "Deliverable 5.3 Refinement of a Risk-based Adaptive Management Approach with industry, regulatory and societal stakeholders. SAVEWave Corporate deliverable of the SafeWAVE Project co-funded by the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.," 2023. doi: http://dx.doi.org/10.13140/RG.2.2.17188.35201

[26] I. Galparsoro, A. D. Maldonado, A. Borja, and J. Bald, "Deliverable 5.2 Development and implementation of a decision support tool for wave energy development in the context of maritime spatial planning. Corporate deliverable of the Wave Energy in Southern Europe (WESE) Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640. ," 2020. doi: http://dx.doi.org/10.13140/RG.2.2.23618.30409

[27] I. Galparsoro *et al.*, "A new framework and tool for ecological risk assessment of wave energy converters projects. ," *Renewable and Sustainable Energy Reviews,* vol. 151, no. 111539., 2021, doi: https://doi.org/10.1016/j.rser.2021.111539.

[28] I. Galparsoro *et al.*, "Deliverable 5.3. Creation of suitability maps for wave energy projects in the context of Maritime Spatial Planning. Corporate deliverable of the Wave Energy in Southern Europe (WESE) Project funded by the European Commission. Agreement number EASME/EMFF/2017/1.2.1.1/02/SI2.787640. ," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.26210.40641.

[29] I. Galparsoro *et al.*, "Development of a model for the identification of suitable areas for the development of wave energy projects in the European Atlantic region in the context of maritime spatial planning and its implementation into a Decision Support Tool. The corporate deliverable of the SafeWAVE Project co-funded by the European Climate, Infrastructure and Environment Executive Agency (CINEA), Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices. ," 2022. doi: http://dx.doi.org/10.13140/RG.2.2.29874.07360.

[30] I. Galparsoro, G. Mandiola, S. Pouso, I. de Santiago, R. Garnier, and J. Bald, "Deliverable 6.1 Gathering, editing and management of relevant information for identifying suitable areas for the development of wave energy projects. Corporate deliverable of the SafeWAVE Project co-funded by the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices. ," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.10179.48169.

[31] R. Wüstenhagen, M. Wolsink, and M. Burer, "Social acceptance of renewable energy innovation: An introduction to the concept. ," *Energy Policy*, vol. 35, pp. 2683–269., 2007.

[32] P. Devine-Wright, "Reconsidering public acceptance of renewable energy technologies: a critical review,," in *Delivering a Low-Carbon Electricity System: Technologies, Economics and Policy*, T. Jamasb, M. Grubb, and M. Pollitt Eds. Cambridge: Cambridge University Press, 2007.

[33] M. C. Uyarra *et al.*, "Deliverable 7.1 Societal response to marine renewable energy. Corporate deliverable of the SafeWAVE Project co-funded by European Climate, Infrastructure and Environment Executive Agency (CINEA), Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices. ," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.30469.42729.

[34] N. P. Dunphy, P. Velasco-Herrejon, and B. Lennon, "Deliverable 7.1 Review of education and public engagement programmes. Corporate deliverable of the SafeWAVE Project co-funded by the European Maritime and Fisheries Fund (EMFF) program of the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.," 2021. doi: http://dx.doi.org/10.13140/RG.2.2.15002.93123/2.

[35] T. Simas *et al.*, "Review of consenting processes for ocean energy in selected European Union Member States," *International Journal of Marine Energy*, vol. 9, no. 0, pp. 41-59, 2015, doi: http://dx.doi.org/10.1016/j.ijome.2014.12.001.

[36] N. P. Dunphy, P. Velasco-Herrejon, B. Lennon, J. Gonçalves, E. Le Bourhis, and D. Marina, "Deliverable 7.3 Societal stakeholder characterisation. Corporate deliverable of the SafeWAVE Project co-funded by the European Maritime and Fisheries Fund (EMFF) program of the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.," 2021.

[37] A. L. Smith, L. Quinlivan, and N. P. Dunphy, "Deliverable 7.4 Education and Public Engagement Framework for Ocean Literacy. Corporate deliverable of the SafeWAVE Project co-funded by the European Maritime and Fisheries Fund (EMFF) program of the European Union, Call for Proposals EMFF-2019-1.2.1.1 - Environmental monitoring of ocean energy devices.," 2021.