Assessing the environmental impacts of wave energy converters: determining appropriate reference sites

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***Abstract*— The importance of the study design and the need for comparability of methods has been acknowledged in the context of the environmental impact assessment of the Marine Renewable Energy Sector. The standardization of the EIA process of Marine Renewable Infrastructures is still far to be sorted out and a good deal of variation exists in the considered parameters and receptors as in the methods adopted during the EIA process. Among the several statistical designs that have been proposed to assess the effects of environmental perturbations, the Before-and-After-Control-Impact or BACI design is the one commonly recommended over the others since it is believed to mitigate chances that unmeasured covariates are influencing observed effects. A clear guideline on how to identify the control status to be assumed in the BACI design studies is still lacking. This study demonstrates how reference scenarios could be identified and used as control status based on the correlations of the ecosystem components (i.e. the wind-wave climate conditions, benthic habitats and macrovertebrate populations) when defining the control sites in BACI studies.**

***Keywords*— Wave energy converters; Environmental impact assessment; Baseline data; BACI design; Reference scenarios, Marine environment; Ecosystem components.**

I. Introduction

Ocean renewable energy sources are increasingly attractive in the perspective of satisfying the worldwide demand of clean energy. Among the different ocean sources, wave energy is abundant, largely untapped and spatially more concentrated than other sources (e.g. wind and solar energy) [1]. The global wave power resource has been estimated to be at least 1 TW, with a potential annual energy production of about 2000 TWh [2-3]. Although over 1000 WECs are patented worldwide, classified within three basic types Oscillating Water Columns (OWC), Over Topping Devices (OTD) and Wave Activated Bodies (WAB) [4-5], WEC technology is still immature. Only few of these concepts have in fact moved on to ocean testing and are on the merge of commercialization [6-7]. The need to meet renewable energy targets [8] created the ground to explore the feasibility of the combined exploitation of wave and offshore wind energy [9-10] in the attempt to lower the system integration costs of renewables reducing the variability of the produced power. If research efforts are increasing on the side of the technological development, several non-technical barriers still need to be overcome for wave energy to become an established energy source. The most significant of these non-technical barriers is the necessity to comply with the EU Environmental Impact Assessment (EIA) Directive and associated national legislation, which requires the collection and collation of environmental data in order to enable regulatory authorities to make an informed decision on the proposed project and its potential environmental impacts at an early stage [11]. In this perspective developers are required to supply data concerning both the environmental baseline conditions and the possible environmental impacts of device installation. The potential effects of WECs on marine organisms have been comprehensively discussed and include effects on nearshore intertidal and benthic habitats, fish, fish habitats, large marine vertebrates (sea birds, marine mammals and large fish), oceanographic and coastal processes [12, 13]. Decreases in wave energy and changes in wave-driven processes have also been hypothesized as potential impacts of WECs on the coastal environment and morphological processes [14]. However, due to the novelty of wave and tidal energy device deployments, most of these discussed effects and

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