Is Biofouling a Critical Issue for Wave Energy Converters?

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ABSTRACT

We quantify through simple population-dynamics models the biological growth on wave energy converters (WECs). We also evaluate the effects of the inherently unsteady flow induced by waves and currents on the settlement of various species. Finally, we discuss the impact of the biological growth on the flow pattern around such devices (and consequently on their efficiency) and investigate the influence WEC farms might exert on the marine environment (in particular possible enhancements in kelp vegetation). Our results indicate that biofouling is an issue that should be considered carefully in the design and site selection processes of wave power devices.

1. INTRODUCTION

Although the outstanding energy resource contained in the oceans, and in particular in ocean waves, has been recognized for some time now, the extraction of wave power is still in developmental stages with many different technologies being currently tested. At the same time, there is an increased interest in sustainable energy resources, which could prompt a significant expansion of large-scale renewable energy installations worldwide in the near future.

In this context, the potential impact of wave energy converters installations on the marine environment is an issue of growing concern. This impact is very likely multifaceted: acoustic and electromagnetic pollution, changes in habitats and hydrological conditions, etc. – see for instance Witt et al. (2012) and Langhamer et al. (2010). Indeed, wave energy converters will be integrated in the ecosystem as artificial reefs suitable for algal growth and colonization by many other species but also within larger structures such as kelp forests.

Conversely, biofouling on the device would likely impede on the efficiency of power extraction and even the normal functioning of the device. Biofouling is generally defined as the “undesirable” accumulation of fixing organisms (bacteria, plants, algae, or animals) on any structure in contact with water. The biofouling process starts as soon as the object comes into contact with the sea water. At the beginning, a biofilm develops through the adhesion of bacteria to the surface. This initial process, known as micro-fouling, facilitates the recruitment of other cells by providing both an initial matrix which gives structural integrity to the attached layer and also nutrients. This biofilm enables the initiation of the macro-fouling process which consists of soft and hard larger species colonizing the submerged surface. Soft foulers are flexible organisms that lack a rigid external skeleton, and include seaweeds, anemones, tunicates and hydroids. Hard fouling organisms possess a hard external skeleton and include molluscs, tubeworms, barnacles and the bryozoans.

Marine biofouling is a major cause of concern for the naval industry; high levels of fouling increase drag, reducing the overall hydrodynamic performance and increasing the fuel consumption (Railkin 2004). It affects however any offshore structure: e.g. oil “rigs”, submarine pipes, marine buoys. Clearly biofouling will also impact offshore energy installations such as wave energy converters.

The speed of the biofouling depends on the local marine environment: the type and density of the species present in the area surrounding the installation. A good indicator of biological diversity and abundance is the plankton density. The temperate areas around the globe have high dissolved-oxygen content, luminosity and nutrients and thus the plankton levels are very high. These levels are further enhanced by the homogeneous repartition of oxygen and nutrients induced by waves and currents through mixing. Thus, perhaps not surprisingly, there is a direct correlation between wave activity and plankton distribution (Figure 1). In fact, the most favorable sites for wave energy extraction are at the same time the areas with the highest levels of plankton and consequently high biological activity. This suggests that biofoul-