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The location of offshore wave power devices structures epifaunal assemblages

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ABSTRACT

With large-scale development of offshore wave power conversion, artificial structures become more common in the open sea. To examine how wave power devices may be colonized by epifaunal organisms, 21 concrete foundations used for anchoring wave power generators were studied during two years, 2007 and 2008. The foundations were placed in two different clusters, located north and south within the Lysekil test site at the Swedish west coast. The degree to which early recruits covered the foundations and the succession of epibenthic communities were documented during two years. A succession in colonization over time was observed, with a higher degree of cover in the northern location. Furthermore, the northern location showed an increase in number of individuals, number of species and in Shannon-Wiener diversity in 2008. Dominant organisms on the foundations were the serpulid tubeworms (*Pomatoceros triqueter*) and barnacles (*Balanus* sp.). This comprehensive large-scale study about succession and colonization patterns on wave power foundations suggests that the location of wave energy devices affects colonization patterns. This gives indications on settlement patterns on already operating and planned offshore wave power parks further off the coasts.

1. Introduction

The worldwide interest in a lower carbon economy and demand for renewable energy is driving increases in the marine renewable energy sector. Ocean wave power conversion is a renewable energy source with high potential for harnessing significant amounts of energy [1]. Although there might be several positive ecological effects, major concerns for the marine environment that is exposed to offshore energy installations include noise, electromagnetic fields, and changed hydrological conditions [2–5]. The alteration of natural habitats is another potential impact of this exploitation [6–9]. Still, the possible environmental impact from wave power parks has not yet been studied thoroughly, and in order to increase the potential positive impacts, environmentally adapted offshore constructions need to be developed. The wave power park with its devices will make it impossible to trawl in the area, turning it into a no-take zone [10,11]. The deployment of offshore installations can contribute to an increase in fish and invertebrate diversity by serving as fish aggregation devices floating on the surface or as artificial reefs [6,8,11,12]. In case of offshore wave power the devices do not have a primary function as reefs; instead it is often a secondary effect. However, this effect can improve the environmental conditions of devices by e.g. an attraction of reef-aggregating organisms [12,13]. Targeted eco-engineering for multi-use purposes of wave power devices or other marine renewable energy installations can already from an early stage maximize the positive environmental and socio-economic benefits [14].

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Artificial reefs have been used in a variety of ways for hundreds of years to increase the carrying capacity of an environment. They are used worldwide for enhancement of commercial fisheries [15], protect natural stocks of fish and crabs, provide refuge and spawning areas [16], and hence contribute to the biological and socio-economic development of the region [17,18]. In Europe the first artificial reefs for nature conservation issues were constructed in the late 60s and increased significantly since then [16]. Artificial structures offer a perfect basis for sessile assemblages to colonize but concerns are raised since these organisms never resemble those on natural hard substrates [7,19–21].

Benthic macrofaunal assemblages colonizing artificial reefs have been studied for decades, and factors that influence that colonization include material, surface characteristics, complexity, height, size and inclination [22–24]. These different factors influence the composition of species and trophic groups by favouring particular taxa and their settlement, reproduction, growth and biomass [25]. The abundance of different epibenthic species is mostly dependent on food availability and shelter from predators [26]. Thus environmental factors of the area where the artificial structures are deployed are important since these will, to a major extent, regulate the species that are likely to be found associated with an artificial reef. Exposure to wave action seems to be an important factor in determining the epibenthic assemblages, constraining communities differently depending on degree of exposure [27]. Water motion has been shown to affect all aspects of the life history of a marine organism, such as the rate of fertilization of gametes, settlement of larvae onto hard substrata [28], growth [29], and mortality [30].

In 2005 the Lysekil project, a test park for wave energy conversion, has been established at the Swedish west coast. A wave power device consists of a point absorber buoy floating on the surface, connected by a wire to a translator in a linear generator [31,32]. The generator is positioned on a concrete foundation on the seabed that generally comprises soft sediment, and the wave power device adds hard substrata to the area [33]. Only a few studies have been conducted on artificial reefs in cold temperate waters [23], and even fewer experimental studies have been carried out at depths below 15 m at higher latitudes [but see [9,12,13,34]].

The present study has been conducted on 21 wave power devices in the Lysekil test site to examine for a large scale effect on epibenthic assemblages developing on wave power foundations over two years of submergence. In addition, I wanted to investigate whether different locations will have an impact on colonization processes and species assemblages at this depth (25 m) in cold temperate waters.

2. Material and methods

2.1. Study site

The Lysekil test site is situated at the Swedish west coast in an archipelago about 100 km north of Gothenburg, and about 2 km offshore, between a northern marker (58° 11′850″N, 11° 22′460″E) and a southern marker (58°11′630″N, 11°22′460″E) in an area of about 0,5 km^2. The first devices were deployed in March 2005 on an otherwise featureless soft bottom. They consisted of five "ecological" wave power devices (without generators). The purpose of these devices was to study environmental impacts and interactions with marine organisms, ranging from small bottom dwelling organisms living in the seabed, organisms involved in biofouling (and therefore of interest to mechanical wear and maintenance) to vertebrates, including fish, seabirds and marine mammals [10,35]. In spring 2006, the first wave energy converter (WEC) was deployed in the research area. The purpose of the WEC was to measure the maximum line force from a cylindrical buoy with a diameter of 3 m and a weight of 1 t, simulating a wave generator that is disconnected from a grid [31]. In April 2007, an additional 21 ecological devices were deployed in the research site.

The research site has an average depth of 25 m ± 0.5 m with a flat soft bottom and is exposed to heavy winds and waves, mostly from the northwest. The entire Skagerrak region is a productive zone connecting the cold and highly saline North Sea with the lower salinity region of Kattegat. The salinity is around 24‰ at the surface and around 33‰ at 30 m depth. The temperature of the surface water is in the range of 15–20 °C in the summer and 0–2 °C in the winter, and ice covers the shores on average every fourth year [36]. The shoreline of the area is characterised by rocky slopes covered by algae, with sandy and muddy bottoms below the rocky outcrops [33]. The closest natural hard substrate, where macrofauna may recruit from is approximately 2 km south of the Lysekil test site; north of the site is the open ocean.

2.2. Experimental design

The 21 ecological devices were placed in two locations: north and south. The locations were about 250 m apart from each other. Foundations were constructed of large round concrete blocks (3 m in diameter, 1 m high) weighting 10 t each, within a distance of 15–20 m. The dimensions of the wave power foundations were adapted for extreme wave conditions and lifting capacities of wave power buoys [31]. I sampled each of the 21 wave power foundations once in July – August 2007 and again in June – July 2008 by SCUBA-diving [37]. I took 10 photographs per foundation from the same vertical position in both years. Each photo had a size of 7.0 × 10.6 cm and I took all photos evenly distributed on the foundations at 25 m depth (Fig. 1a, b).

I estimated the coverage degree of epibiota on the foundations using Image Tool 3™ and identified invertebrate taxa to the lowest practical taxonomic level. All epibenthic organisms were indentified using a number of references [38–41]. Epifauna