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Assessment of entanglement risk to marine megafauna due to offshore renewable energy mooring systems

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ABSTRACT

This paper defines a methodology to compare different offshore renewable energy (ORE) mooring configurations in terms of the risk of entanglement they present to marine megafauna. Currently, the entanglement of large marine animals is not explicitly considered in environmental impact studies. Recommendations need to be developed, assessing the risk of entanglement of ORE mooring configurations at the beginning of their design process.

Physical parameters of the mooring system affecting the relative risk of entanglement have been identified as tension characteristics, swept volume ratio and mooring line curvature. These have been investigated further through six different mooring configurations: catenary with chains only, catenary with chains and nylon ropes, catenary with chains and polyester ropes, taut, catenary with accessory buoys, taut with accessory buoys.

Results indicate that the taut configuration has the lowest relative risk of entanglement, while the highest relative risk occurs with catenary moorings with chains and nylon ropes or with catenary moorings with accessory buoys. However, the absolute risk of entanglement is found to be low, regardless of the mooring configuration. This methodology can also be applied to other mooring configurations, arrays or power cables.

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1. Introduction

Floating offshore renewable energy (ORE) technologies, which include most wave and some tidal devices, are undergoing extensive development and testing but are yet to reach full commercialisation. The offshore wind industry is also moving towards the deployment of floating turbines to enable a move into deeper water. A number of individual full-scale devices have been successfully deployed and the number of floating offshore renewable energy projects, and the array sizes proposed, are growing. One of the many challenges facing developers wishing to test a single device or to deploy an array is the need to ensure that these devices do not adversely impact the marine environment, or, where this is unavoidable, that such impacts are minimised and mitigated against. Although requirements differ slightly between countries, most proposed deployments require environmental impact studies. Guidelines for the implementation of such environmental impact assessments for marine energy are detailed for example in the EquiMar protocols [1]. With so few devices having undergone testing at sea, it will only be possible to validate the predicted environmental effects once devices have been in place for a number of years.

This paper considers one aspect of environmental impact assessment: the potential for entanglement of marine megafauna (e.g. cetaceans, pinnipeds, sea turtles, large sharks, etc.), between mooring lines of floating offshore renewable energy devices. Entanglement can be defined as the inadvertent capture or restraint of marine animals by strong, flexible materials of anthropogenic origin. Bycatchs by lost or discarded fishing gears entangled in moorings are not considered in this study.

The consequences of entanglement are loss of animal life – possibly from endangered species- and negative public opinion. Entanglement has been observed (albeit infrequently) for large whales in stationary trap fisheries [2] and in aquaculture [3,4]. It could be noted that no entanglement has been reported in oil and gas moorings (which however does not mean it did not occur). Smaller animals are more likely to become entangled in fishing gears, for example pinnipeds (seals and sea lions) [5], or large sharks and rays [6,7]. It should be noted that entanglement is difficult to detect because it occurs offshore and underwater in remote locations with few, if any, observers.

At present, entanglement is not addressed as standard in environmental impact assessment (EIA) studies, and there are currently no records of such entanglement occurring at any offshore renewables site; however the risk of entanglement of marine mammals and turtles in moorings for wave energy devices has been raised [8]. An additional consequence of entanglement in the case of an ORE device would be a possible damage to an ORE device leading to a change in the performance of the mooring or the device.

In addition to requirements for environmental impact assessments, ORE moorings have their technical requirements, which have certain commonalities with conventional mooring systems, used, for example, for oil and gas platforms [9]. The key aspect is the need to keep the floating structure in position. In some cases, the restraint of the dynamic motion of the floating structure is additionally required, for example for floating wind or overtopping wave energy devices. In other cases, such as point absorber wave energy devices, the mooring system must leave the floating structure to move "freely" at the wave frequency in order to maximise energy production. In both cases, the slow and large horizontal motion of the floating structure should be restrained because (a) the power cable, exporting energy, should not become tensioned, and (b) in an array configuration, collisions must be avoided between devices.

This paper presents a methodology developed to evaluate the *relative* risk of marine megafauna entanglement with different mooring systems, focussing on the physical characteristics of mooring lines that will influence this risk. It is not intended to be a quantitative assessment of risk; this is unfeasible given the scarcity of data available. However, it provides a tool that will enable developers to assess whether their proposed mooring configurations will pose a higher or lower entanglement risk to marine life than alternative systems, and this can then be highlighted in the EIA with appropriate monitoring programmes proposed to mitigate any risk if required. The general methodology, using the hydrodynamic modelling software OrcaFlex, is described in Section 2, with the detailed physical parameters and their specific mode of assessment presented in Section 3. Results are presented for