Reef effect of Floatgen floating offshore wind turbine (Le Croisic – Atlantique) and interactions with soft bottom benthic communities

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Abstract :

This PhD-thesis project aims to better understand the impact of floating offshore wind turbines - which are very specific artificial reefs - on the benthic compartment of coastal ecosystems. The objective is to study the biodiversity of the invertebrate communities (biofouling) that colonize the float and its influence on the underlying soft bottoms, in particular by caracterising the flow of organic matter between the biofouling (consisting mainly of filter feeders) and the natural bottoms. The thesis is part of a 4-year collaborative project (VELLELA – 2023-2026), funded by ADEME, which brings together academic partners (including several IFREMER teams) and companies specialized in offshore wind energy and offshore monitoring technologies.

FLOATGEN (BW Ideol), © Centrale Nantes

Hosting laboratories :

The thesis will be hosted within the ODE (Observation and Ecosystem Dynamics) department of IFREMER. The PhD student will have a double attachment: i- to the LEBCO laboratory (Laboratory of coastal benthic ecology ; https://dyneco.ifremer.fr/Nos-equipes/LEBCO) of the DYNECO unit (Dynamics of Coastal Ecosystems) located at the Ifremer center in Brest and ii- to the environment and resources laboratory of the North Brittany Coastal unit located in Dinard (https://littoral.ifremer.fr/Laboratoires-Environnement-Ressources/LER-Bretagne-Nord-Dinard).

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Scientific context :

The implementation of wind turbines in the coastal marine area started in Northern Europe more than 30 years ago, with the first wind turbine installed in Denmark in 1991. This human activity is now booming with nearly 6000 wind turbines installed in the North Sea, the Baltic Sea and the Irish Sea (Ramirez 2022), and the implementation of the first farms along the American (Hutchison et al. 2020) and Asian coasts. To limit CO_2 emissions and meet energy demand, the development of offshore wind energy is becoming a priority for several countries.

However, the exploitation of marine renewable energies must not be at the expense of the preservation of marine ecosystems. The issue of the ecological impact of offshore wind farms was therefore addressed very early on, with the first Danish environmental monitoring (Gill 2005; DONG Energy et al. 2006) and the knowledge base on this topic has been strongly consolidated thanks to the numerous studies carried out subsequently in the most advanced countries on this technology (Denmark, Germany, United Kingdom, Belgium, Netherlands; Boehlert 2010). However, in addition to the most significant and well-documented environmental issues, such as the risks of collision with seabirds and chiropterans or the impact of underwater noise on mammals (Galparsoro et al. 2022), many questions remain about the overall impact of offshore wind turbines on the functioning of coastal marine ecosystems. For this, it is necessary to improve the understanding of the response of key ecosystem compartments, including benthic habitats and species (Lindeboom et al. 2015; Dannheim et al. 2020).

In this area, knowledge has been advancing in Northern Europe on the dynamics of biological colonization and biodiversity present on the foundations of installed wind turbines as well as on changes in the benthic communities of the natural bottoms surrounding these turbines (Degraer et al. 2020; Coolen et al. 2022). Depending on the nature of the colonization by marine invertebrates, the presence of new offshore infrastructure is likely to modify to a greater or lesser extent the functioning of the ecosystem in the adjacent area. On the other hand, provided that certain precautions are respected, the presence of wind farms may allow the local preservation of certain habitats (Inger et al. 2009), for example by limiting the footprint of other highly impacting activities (such as fishing with towed gear). A direct illustration is, under the condition that anthropogenic activities are excluded from the area, the evidence of a "reserve" effect within highly disturbed ecosystems prior to wind farm implementation (Lindeboom et al. 2011).

In terms of offshore wind energy development, France is lagging behind Northern European countries: the very first wind farm (Saint-Nazaire; 80 wind turbines) has only been operational since November 2022. Until recently, the French scientific community working on environmental impacts has therefore relied heavily on feedback from other countries to analyze the dossiers under investigation. In response to the energy crisis, France recently announced an ambitious program to install 40 GW of offshore wind power (50 farms) by 2050, focusing in particular on floating technology, which allows the installation of wind turbines further offshore, where the winds are more favorable and the impact on the landscape is much less. The fifth call for tenders launched by the French government is currently underway and concerns floating wind power. It targets the coasts of Southern Brittany, off Belle-Île en mer.

This thesis project aims to anticipate the need for knowledge on the environmental impact of floating wind turbines, focusing on the only floating wind turbine currently installed in France (FloatGen[1]) on the SEM-REV[2] test site. This demonstrator was installed in 2018 on this test site located off the coast of Le Croisic, and has been producing electricity for several years. The float on which this wind turbine rests is a 36 m square concrete structure, with a draft of about 7 meters and held in position by six anchor lines (three bundles of two lines). This test site, as well as the

1 https://www.bw-ideol.com/fr/demonstrateur-floatgen

2 https://sem-rev.ec-nantes.fr/navigation/sem-rev/presentation-et-missions-du-sem-rev

monitoring of MRE technologies that are tested there, is managed by a team from the Ecole Centrale de Nantes.

The thesis is part of the multi-disciplinary VELLELA project, funded by ADEME, which brings together several French academic and private partners, including BW-Idéol, Ecole Centrale de Nantes and Ifremer. This initiative started at the end of 2022 for a duration of 4 years. The present proposal has therefore full funding for the salary of the PhD student, as well as for the realization of the main scientific tasks envisaged.

Scientific objectives of the thesis:

NB: The objectives of the PhD-thesis remain partially modifiable according to the ideas and desires of the doctoral student.

1. Biocolonization.

The first step will be to describe the benthic biodiversity (macro- and megafauna) present on the different sections of the floating foundation of the Floatgen wind turbine and along its anchor lines. This diversity being variable according to depth, exposure to light and hydrodynamics, or the type of material, it will have to be finely characterized in order to evaluate the differences of communities according to the specificities of the structure[3]. A 3-4 years temporal monitoring is planned, which will take into account the logistical constraints associated with interventions in the area. Data have already been acquired by SEM-REV prior to the launch of the VELELLA project. Thus, between 2018 (installation of Floatgen on site) and 2020, six observation campaigns have already been carried out to monitor the colonization of the float and five to monitor the anchor lines and the umbilical cable. These data will be analyzed (or re-analyzed) and will serve as a reference. Particular attention will be paid to the possible (but expected) presence of non-native species.

2. Fluxes of matter.

In order to evaluate the influence of the presence of the demonstrator on the benthic communities located under the wind turbine, the flow of particulate matter transiting from the floating structure to the bottom will be estimated and characterized, distinguishing between organic matter (feces ; dead or living organisms) likely to constitute a food supply for the benthic species located on the bottom, and the inert material (shell debris) likely to modify the granulometry of the sediment (increase in the heterogeneity of the sediment; supply of coarse elements favourable to certain species of hard substrate). To this end, particle traps will be deployed under the float and the input of material will be evaluated in two seasons (surveys at the end of winter and end of summer) and over two years. Indeed, the test site is located at the limit of the influence area of the Loire plume, which can constitute a significant material input. In addition, the dispersion of the float's inputs will be variable depending on the season.

3. Impact on the bottom.

Spatial changes in structural and functional diversity on the bottom will be characterized, in relation to inputs from the floating structure. Grab samples taken before the installation phase of the demonstrator will serve as a reference. Changes in the functional diversity of benthic communities can be addressed through the analysis of species traits and trophic markers (stable isotopes). The acquisition of sediment profiles along a transect going from the float to the open sea will make it possible to follow the evolution of the traces of biological activity and the sphere of influence of the inputs from the float.

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3 The walls of the float and the anchor lines have no anti-fouling coating

Scientific interests of the project :

Monitoring of biocolonization is important to understand the establishment processes of benthic communities on submerged substrates such as artificial structures associated with marine renewable energy technologies and in particular floating wind turbine foundations. These structures have the particularity of being large objects, not directly connected to the seabed (only by the anchoring lines) and located at significant distances from the coast. Such monitoring is also a tool to monitor the appearance of new species, including potential non-indigenous species.

On a more fundamental ecological level, it is necessary to better understand the benthic biodiversity present on these structures (including its non-indigenous component, likely to spread to other habitats), and to estimate the influence of this biological colonization on the underlying bottoms. The analysis at the scale of a single device, by direct in situ measurements, must be sufficiently fine to be able to distinguish the contributions of the floating structure from external contributions (such as the influence of the Loire plume). These data can then be used to feed material flow models and food web models on the scale of an industrial park of several dozen wind turbines, or on a larger scale integrating the closest continental inputs (Pezy et al. 2020).

From an operational point of view, operators of floating wind farms absolutely need to know the total biomass that a floating foundation and its anchors can host, and the temporal dynamics of colonization (for example to predict the sizing of anchor line elements or to estimate the frequency of maintenance of certain structures). In this respect, the deliverables of the VELLELA project will contribute to the validation of the design and engineering of offshore structures. In a more general way, these results will allow to consider a transposition of the results acquired for a unique wind turbine to the scale of a park, and will give place to technical recommendations for the monitoring of biofouling communities. These data will be the subject of scientific publications which should interest the offshore wind turbine industry, government services and environmental protection associations.

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