Impact of Offshore Wind Farms on marine food web structure, functioning, and carbon dynamics : A 13-Year study in a Belgian Offshore Wind Farm

Reynés-Cardona Abril[1], Braeckman Ulrike[1], Vanaverbeke Jan[2], De Borger Emil[1] and Buyse Jolien[3]

[1] Marine Biology Research Group, Ghent University, Krijgslaan 281, 9000 Gent
E-mail: abril.reynescardona@ugent.be
[2] Marine Ecology and Management (MARECO), Institute of Natural Sciences, RBINS, Rue Vautier 29, 1000 Bruxelles
[3] ILVO, Jacobsenstraat 1, 8400 Oostende

The installation of Offshore Wind Farms (OWFs) introduces artificial hard substrates into areas where they naturally do not occur. These artificial structures are rapidly colonized by marine organisms, particularly suspension feeders, which attract fish and other top predators. However, this colonization process is dynamic, evolving over time through successional steps that involve shifts in community composition, abundances and dominance. As OWFs expand globally, there is a growing need to understand these successional dynamics from the perspective of ecosystem structure and functioning. Marine food web analysis offers an integrated approach to study functional changes in marine ecosystems focusing on changing species interactions. By constructing food web models, the energy flow between compartments can be estimated and a variety of indices that inform on ecosystem maturity, stability, and complexity can be derived.
The present study investigates the effects of OWF development on food web structure, functioning, and carbon flows in the C-Power OWF over 13 years (2009-2022). Using Linear Inverse Modelling (LIM) and topological network analysis, the study reveals that OWF development significantly increases carbon flows directed towards the fauna on the turbine foundation, enhancing secondary production of these fouling organisms and increasing overall ecosystem activity. The temporal changes in community composition (increased biomass and dominance of specific species) lead to an increasing mean and variance of interaction strength, reflecting an uneven distribution of energy flows. This indicates a less stable local ecosystem as the OWF food web develops. Additionally, the food web structure exhibits reduced omnivory, which has implications for food web stability, as higher levels of omnivory provide trophic flexibility to the network. Alternatively, mean trophic level also decreases with time, highlighting the increasing role of the established suspension feeding communities. Overall, our findings suggest that the observed succession patterns and community changes in developing OWF communities associate with a decreased stability of the local OWF ecosystem.

Keywords
Offshore Wind Farms; Food Webs; Succession Dynamics; Ecosystem Functioning; Ecosystem Stability; Network Analysis