Disentangling risks and opportunities of offshore wind for marine ecosystems

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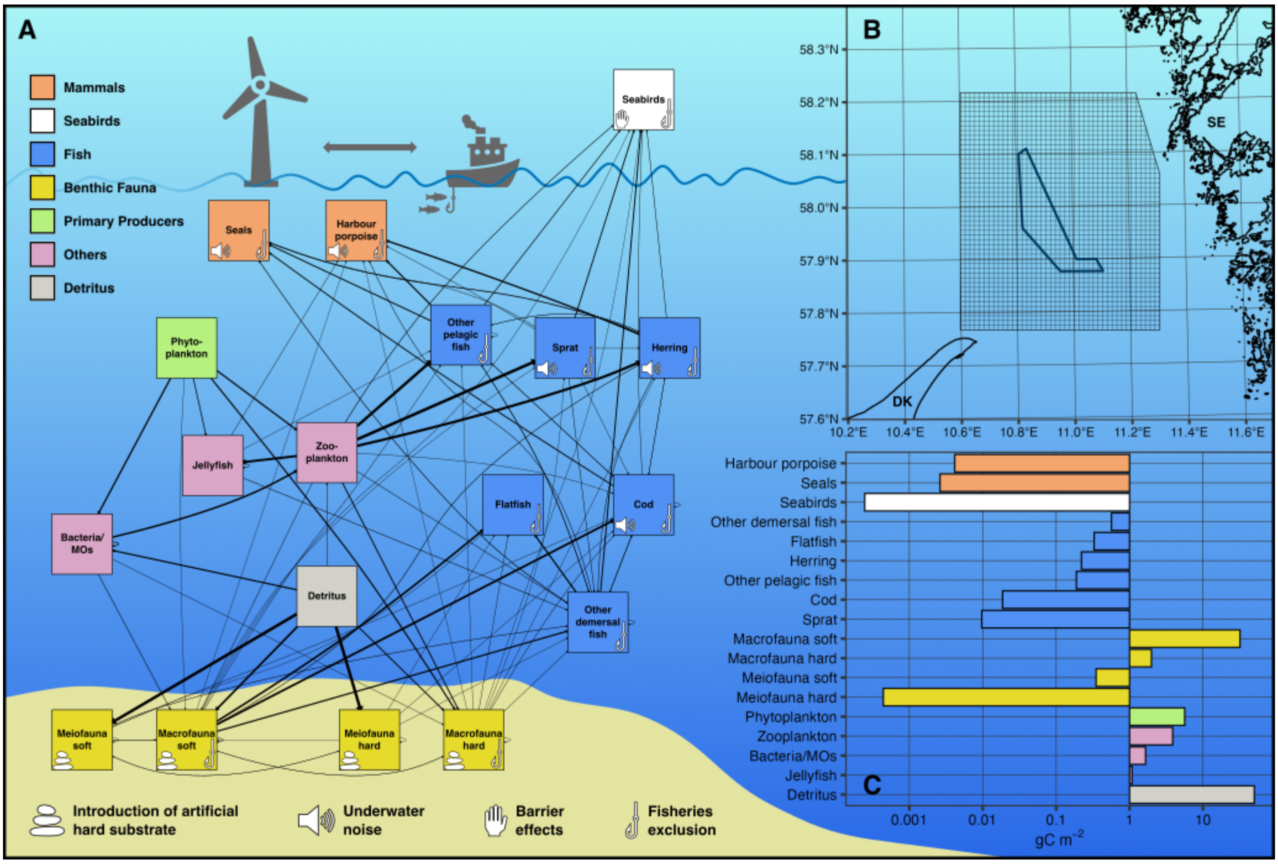

Figure 1A. The carbon flow food web model of the southern Skagerrak comprises 18 interconnected compartments, with link thicknesses proportional to the feeding preferences of the receiving group. Icons indicate where offshore wind-mediated effects are incorporated into the model. B. Model area (1x1 km grid) in the southern Skagerrak between Denmark and Sweden, centred around the planned Poseidon offshore wind farm (blue). C. Estimated carbon content of the model compartments in the year 2000.

Offshore wind brings new challenges alongside new opportunities for marine governance. Ecosystem models help to shed light on the complex interplay between humans and nature

When water stretches as far as the eye can see, the assumption lies near that the seas are infinite. However, what seems endless, is often already divided among stakeholders, each with their own interest in the resources and opportunities the oceans provide. In this crowded and much-competed space, the arrival of offshore renewable energy causes additional friction among established industries, such as shipping, fisheries, tourism or national defence, who each fear for their share of the "blue cake".

Achieving a fossil-free future is a necessity to combat and mitigate climate change. This is not possible without renewable energy, and increased use of offshore wind is key to reaching this goal. Considering the poor state of our oceans, a central challenge is, therefore, to facilitate the expansion of the energy sector, while at the same time mitigating conflicts with existing operations and protecting or even often restoring marine ecosystems, which form the basis of our well-being.

Conversation instead of isolation

The Swedish transdisciplinary program "Co-Creating Better Blue" (Mistra C2B2) involves academic and industry partners, as well as a number of competent authorities. To foster a governance model by which we can navigate around and diffuse conflicts, Mistra C2B2 engages stakeholders in a dialogue around mutually agreed-upon challenges, thus providing a platform ("LivingLabs") to transform and co-create the future use of the sea.

Efficient work on common visions and solutions requires a solid knowledge base, but when it comes to processes below the sea surface, there is a lot we don't know. One aim of the project is, therefore, to improve our understanding of how offshore wind parks impact the structure and functioning of marine ecosystems and biodiversity in the long term. To tackle this, we are applying a state-of-the-art, spatial ecosystem food web model of the offshore Skagerrak in the eastern part of the North Sea.

Make it complex – or not?

A golden rule in modelling is to keep a model as simple as possible. Nevertheless, to model wind parks in offshore ecosystems, a certain level of complexity is required to account for the numerous direct and indirect effects on the ecological system. For example, any negative (or positive) effect on seals or other predators are likely to cause trophic cascades through the food web by altering the predation pressure on prey species. Such effects would go under the radar when looking at seals in isolation.

In contrast, using a food web model has the potential to inform about where and how offshore wind is likely to impact the ecosystem during the operational phase (Fig. 1A). Focusing on a timeframe of 30 years (the approximate longevity of a park), we have identified the following main drivers of change for marine ecosystems:

- Barrier effects on seabirds, meaning increased mortality due to collision risks and a loss of foraging habitat.
- Underwater noise in the low-frequency range, continuously caused by physical movement of the rotor blades and impacting noise-sensitive species, especially marine mammals.
- Artificial reef effects are due to the introduction of artificial hard substrates, allowing for the settlement of hard-bottom-associated flora and fauna.

- Changes in fisheries patterns owing to the incompatibility of offshore wind and industrial fishing gears, first and foremost benthic trawling, resulting in strongly reduced fishing activity within a wind park and an allocation of fisheries to adjacent areas.

Other potential mechanisms often mentioned in the literature but not incorporated in the model are behavioural disturbances of certain species due to electromagnetic fields and changes in plankton dynamics due to aerodynamic phenomena in the wake of turbines.

Everything, everywhere, all at once

Accounting for the interconnectedness of marine species and a suite of direct and indirect impacts mediated by offshore wind in spatially explicit ecosystem simulations provides a more comprehensive picture of large-scale system changes beyond species-specific impacts. These simulations allow us to test a range of management scenarios, from differences in wind farm layouts and fisheries allocations to exploring the potential of multi-use solutions. The latter includes exploring and promoting synergies between offshore wind on one hand, and aquaculture, fisheries, shipping or additional renewable energy technologies (wave, solar, etc.), on the other.

This approach will provide a scientifically solid basis for balancing the opportunities and challenges posed by complex interactions among business sectors and contribute to the C2B2 aim of supporting ecosystem-based marine spatial planning, helping to transform degraded marine ecosystems into diverse, productive, and resilient systems for the benefit of future generations.

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