Impact of Offshore Renewable Energy on fisheries and marine ecosystems

Context

With members from the EU, the UK and Norway, the NFA represents fishers across the North Sea and coordinates through dedicated working groups, including one focused on northern cod and another on spatial maritime considerations (such as spatial squeeze, ORE and MPAs). Throughout the year, the NFA presents consolidated positions to fisheries managers, particularly ahead of negotiations.

The NFA spatial working group met in London in early 2026 to agree on a unified stance regarding ORE development. This document sets out that joint position.

Introduction

Offshore renewable energy (ORE), especially offshore wind farms (OWFs), is expanding at an unprecedented pace in response to rising global energy demands and the need to mitigate climate change. In the North Sea, installed offshore wind capacity has surged over the past decade and is projected to grow even further as European countries accelerate the transition toward low-carbon energy systems.

At the Third North Sea Summit in January 2026 in Hamburg, Belgium, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Norway, and the United Kingdom reaffirmed their shared vision of transforming the **North Seas into the world's largest clean energy hub, aiming for 300 GW of offshore wind capacity by 2050**. Building on this ambition, governments, industry actors, and transmission system operators adopted **the Joint Offshore Wind Investment Pact** for the North Seas, committing to strengthen regional cooperation, mobilise large-scale investment, and coordinate infrastructure development to enable the rapid deployment of offshore wind energy. The pact outlines a pathway toward an integrated and resilient energy system, including cross-border cooperation projects, **expanded grid and hydrogen infrastructure, and an annual installation capacity of up to 15 GW between 2031 and 2040.**

While this expansion represents a step toward decarbonization, it also brings profound challenges. **OWFs do not exist in isolation**: **they interact with complex marine ecosystems and deeply impact the livelihoods of fishers who have worked these waters for generations and will be displaced by OWF developments**. Understanding these interactions is not just a scientific necessity but also a societal imperative, if we are to ensure that renewable energy growth respects both the ocean and the communities that depend on it. OWFs can influence currents, habitats, and species distributions, all which ripple through marine ecosystems and fisheries.

As a preamble, it is also important to underline that the fishing industry is not opposed to the development of OWFs. Fishers recognize the importance of decarbonization and the role that OWFs must play in addressing climate change. However, there is growing concern about how trade-offs between energy development, marine ecosystems, and fisheries are currently being managed. In particular, the sector is concerned that the costs and spatial pressures associated with this transition are disproportionately borne by fisheries, without sufficient consideration of long-term ecological balance, socio-economic impacts, or fair and inclusive decision-making processes.

Ecological impacts

Physical, chemical, and biological changes

Literature shows that OWFs can influence the physical, chemical, and biological characteristics of the marine environment. Turbine foundations and arrays may contribute to changes in local and regional hydrodynamics, modifying currents and wind patterns, which can, in turn, interact with broader ecosystem processes. **In the North Sea, models suggest that large-scale wind farm deployment may reduce current velocities by up to 20% and disrupt tidal energy distribution** (Christiansen et al. 2026). Turbine wakes may enhance vertical mixing in the water column, with possible effects on nutrient transport, surface heat fluxes, and the timing of phytoplankton blooms which are the foundation of marine food webs (Van Duren et al., 2021). **Even subtle delays in spring blooms can ripple upward** (Van Duren et al., 2021)**, affecting commercially important fish species and the livelihoods of those who exploit them.**

Artificial reefs and biodiversity

Beyond currents and nutrients, wind turbines introduce significant hard substrate into largely soft-sediment seascapes. Foundations and scour protection structures often become artificial reefs, colonized by mussels, barnacles, and other organisms. These new habitats can enrich biodiversity and create feeding opportunities for some species, but they can also displace others, disrupt traditional trophic interactions, and alter nutrient cycling. **The ecological story is complex and deeply site-specific: in some areas, productivity may flourish, while in others, increased turbidity can reduce light availability and limit phytoplankton growth** (Van Duren et al., 2021)**.** OWFs can also favour the spread of non-native species, often invasive, acting as steppingstones to colonise areas normally not accessible (Przeslawski et al., 2025). Risks are largest for gravity and floating foundations, as they are generally towed to the site from port (Horwath et al., 2022).

Floating wind structures focus

Upcoming wind farm projects are now turning toward floating wind structures, which allow installation at greater depths. However, **given their dynamic structure they are likely to span the thermocline, reducing and delaying seasonal stratification which in turn can alter the productivity in the surrounding area** (Harris et al., 2025). Floating structures also introduce other concerns such as entanglement risks and seabed abrasion with mooring lines (and anchors) as well as potential barriers for migrating species (Przeslawski et al., 2025).

Spawning and nursery habitats disruption

Both fixed and floating offshore wind developments can disrupt fish and shellfish spawning and nursery habitats, particularly during foundation installation, anchoring and piling, inter-array cable installation, and export cable works. These activities resuspend sediments and may adversely affect sensitive early life stages of marine species.

Lifecycle and cumulative impacts

The ecological impacts of OWFs extend throughout the lifecycle of these installations, from construction to operation and decommissioning. Each stage reshapes habitats, circulation patterns, and nutrient flows, with consequences for primary productivity and fish distributions. In the coming years, government will face decision of repowering, decommissioning, installing new turbines, or a combination of all options (García et al., 2024). Although repowering may be perceived as "space-efficient," it can result in an increased functional spatial footprint due to larger turbines, wider spacing, and regulatory constraints (Unnewehr et al., 2021, Horwath et al., 2022). With regard to the decommissioning process, the question of whether to remove or preserve artificial reefs will arise, as their conservation may limit site redesign, while their removal may disrupt locally adapted ecosystems, **shifting local biodiversity once more**. This highlights the need for **integrated spatial planning that accounts for both ecological dynamics and cumulative space use**.

Even localized environmental effects such as corrosion-related chemical release, plastics, or marine debris contribute to the broader ecological footprint. **While smaller in scale, these impacts still require careful monitoring.**

The effects of OWFs are not confined to individual projects: they accumulate, interacting with climate change, nutrient loading, and other human activities. Habitat alteration, species redistribution, vessel traffic, and fishing displacement can collectively reshape marine ecosystems over vast areas. Consequences of large scale OWFs on phytoplankton and primary production are still uncertain, and both physical and biogeochemical impacts of OWFs on regional scales remain uncertain (Renner, 2025).

Most current environmental assessments focus narrowly on single projects, **leaving uncertainty about ecosystem-scale consequences. Meeting all national offshore wind targets could place over 19,000 turbines across 11% of the North Sea** (cf. figure 1 below), **dramatically increasing spatial pressure on fisheries** (Waldman et al, 2026). New research, which takes the atmosphere's energy budget into account, indicates that a scale-up of OWFs in the North Sea, in the order of a few hundred GW, will reduce area efficiency and lead to power densities near or below 1 Wm^{-2} (Nøst, 2025). This implies that the total need for space for planned OWFs, and hence the ecological effects, may be even greater than expected.

To conclude on a regional example, the Saint-Brieuc OWF in the Bay of Saint-Brieuc, illustrates the tension between energy development and conservation**. This construction required derogations for 59 protected species** (European court of auditors, 2023), underscoring the difficulty of balancing renewable energy ambitions with the protection of fragile ecological habitats. This situation also illustrates an **emerging governance challenge,** as activities such as **fisheries are subject to increasingly complex and stringent environmental regulations, while large-scale renewable energy projects may benefit from regulatory exemptions** or special authorizations in the context of energy transition goals.

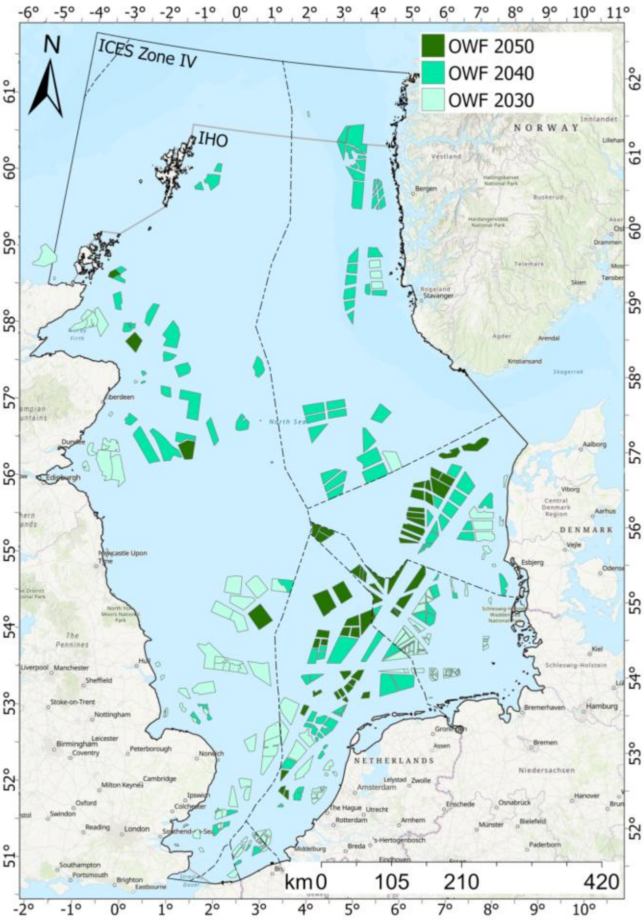

Figure 1: Map showing a plausible arrangement of OWFs in the North Sea in 2050 (Waldman et al., 2025)

Impacts on fisheries and seafood production

Fisheries: what's at stake?

Before addressing the impacts of OWFs on fisheries, **it is essential to recognize what is at stake.** Fisheries are not simply one of many maritime activities competing for space, they are a cornerstone of food security, economic resilience, and cultural heritage across Europe's coastal regions.

The fishing sector provides a source of sustainable, high-quality protein, contributing to food sovereignty at a time of increasing geopolitical uncertainty and pressure on global food systems. Seafood is increasingly recognised as one of the most environmentally efficient sources of animal protein available. Recent scientific research has highlighted that replacing protein from capture fisheries with terrestrial animal production would require substantial additional agricultural land and could significantly increase biodiversity impacts (Leadbitter et al, 2025). Well-managed fisheries can provide nutritious food with a comparatively low carbon footprint while avoiding many of the land-use pressures associated with other animal protein sources. In this context, maintaining access to productive fishing grounds should not only be viewed as an economic concern but also as a contribution to food security, biodiversity conservation, and climate objectives.

Beyond food provision, fisheries sustain coastal economies, supporting thousands of jobs both at sea and on land, across processing, logistics, and local markets. In many regions, fishing activity underpins entire communities, where alternative economic opportunities are limited.

Fisheries are also deeply embedded in cultural identity. Generations of fishers have developed knowledge of marine ecosystems, seasonal patterns, and sustainable practices: this intangible heritage cannot be relocated or replaced.

The loss or displacement of fisheries is therefore not only an economic issue; it represents a broader societal loss. Recognizing this value is essential to ensure that the energy transition does not come at the expense of food production, coastal livelihoods, and cultural continuity.

For fishers, the development of OWFs raises **significant concerns about the sustainability of marine ecosystems and their livelihoods, both of which are critical to ensure food sovereignty**

Restricted access and operational challenges

The creation of wind farms introduces exclusion zones, preventing fishing in areas that have been the backbone of coastal communities for decades. Fishers that are already working in heavily regulated waters are forced to travel further, spending more time at sea and facing longer transit time that contributes **to fatigue, higher operational costs and carbon footprint, as well as competing in crowded fishing grounds.** In some cases, traveling farther is not even an option due to safety concerns and vessel size limitations (ICES, 2025).

Even in cases where regulations technically allow fishing near turbines, **access is restricted by perceived risks, practical operational challenges, particularly for mobile gears and insurance limitations,** thereby amplifying the stress and economic pressure on those whose work is intimately tied to the sea. With the development of floating OWFs, concerns about accident risks associated with mooring lines are being raised, which will most probably result in the systematic avoidance of these areas for safety reasons.

Beyond the footprint of turbine arrays, export cables, inter-array cables, and associated infrastructure can create equally significant, and in some cases greater, impacts on fisheries. Cable routes may restrict access to traditional fishing grounds and contribute to cumulative spatial squeeze, particularly where multiple projects overlap. In floating wind developments, additional wet storage areas located outside the main array (such as those proposed in projects like Moray Firth or Moray FLOW Park) can further exacerbate displacement pressures by introducing additional exclusion zones over active fishing grounds.

Ecological shifts and adaptation

Changes in habitat add also another layer of complexity **requiring fishers to adapt to evolving fishing ground ecosystem.** Artificial reefs can provide shelter and feeding grounds, sometimes increasing local fish abundance, but they also favor hard-substrate species over soft-bottom ones, reshaping the composition of marine life. Altered nutrient dynamics further influence fish distribution and availability. **The combined ecological and operational impacts can therefore have complex, sometimes contradictory effects on fisheries,** benefiting some species and areas while creating challenges in others.

Compensatory measures and double costs

The development of wind farm projects can also lead, in parallel to the implementation of compensatory environmentally measures designed to safeguard biodiversity. However, a major concern arises when the industry responsible for the impact is not the one bearing the costs created but instead the fishing sector, already affected by the loss of fishing grounds, is the one financially impacted. In practice, this means that fishers must undergo compensatory measures, such as MPAs or no-take zones, to offset environmental impacts they did not create.

As an example of compensatory measures on seabirds, the Natural England commissioned report (McGregor et al., 2022) notes that "The closure of sandeel and sprat fisheries in UK waters was a recommended method for compensation for black-legged kittiwake, guillemot, razorbill, Atlantic puffin and Sandwich tern." and that "Fisheries bycatch mitigation was a recommended compensation measure for northern gannets."

More concerning, the report encourages at a wider level the development of such measures in future projects, indicating that [these measures] have "the potential to be a strategic level compensation measure for the offshore wind industry, at least in the North Sea".

Compensatory measures add a further burden on fishers, who must face (alone) the established requirements alongside the ongoing loss of fishing opportunities. **Fishers experience a 'double cost': direct exclusion from turbines and indirect constraints from protected areas and other measures**, which can mean longer trips, higher fuel use, and intensified competition in remaining fishing zones. Meaningful marine spatial planning must integrate the voices of fishers alongside ecological goals, **recognizing that human communities are inseparable from the ecosystems they rely on.**

Conclusion

ORE, particularly wind farms, is a key component for North Sea governments to reach their low-carbon objective. **Yet it comes with profound responsibilities and impacts**. Changes in currents, nutrient flows, and habitats affect biodiversity and fisheries, while artificial reefs and spatial restrictions **reshape both marine life and the livelihoods of fishers**.

The rapid expansion of offshore wind infrastructure, in the North Sea and beyond, **demands holistic, ecosystem-based management strategies that account for cumulative impacts, socio-economic realities, and the long-term sustainability of fisheries.** Fishers' voices, ecological understanding, and rigorous monitoring must guide this transition to ensure that the promise of clean energy does not come at the expense of ocean life, highly important seafood production, and the communities who depend on it.

Recommendations

With this paper, NFA calls for a more balanced and inclusive approach to offshore renewable energy development, grounded in the following key principles:

1. **Genuine partnership in marine spatial planning**

Fisheries must be recognized as equal stakeholders in decision-making processes. This requires early and continuous involvement of fishers in planning, siting, and management of offshore developments, rather than consultation at late stages.

2. **Protection of essential fishing grounds**

Marine spatial planning must safeguard areas that are critical for fisheries, including spawning grounds, nursery areas, and historically important fishing zones. The progressive loss of space through cumulative developments must be addressed through a "no net loss" approach.

The preservation of productive fishing grounds is not only important for coastal communities and seafood supply chains, but also for maintaining a low-carbon source of animal protein and avoiding the biodiversity impacts that may result from shifting food production onto land.

3. **Comprehensive assessment of cumulative impacts**

Environmental and socio-economic assessments must move beyond project-level evaluations to consider ecosystem-wide and basin-scale impacts, including interactions with climate change and other maritime activities.

4. **Fair compensation based on the polluter pays principle**

The costs associated with offshore wind development should be borne by the industries generating the impacts. Fishers should not be subject to additional restrictions or financial burdens as compensation for environmental effects they did not cause. Compensation mechanisms must be transparent, adequate, and long-term.

5. **Precautionary approach to emerging technologies**

The deployment of floating offshore wind structures should be guided by precaution, given the current uncertainties regarding their ecological and operational impacts.

6. **Coherent and equitable governance frameworks**

Regulatory frameworks must ensure consistency across sectors. Activities such as fisheries should not face stricter environmental obligations than large-scale energy developments benefiting from derogations or exemptions.

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