Marine Pollution Bulletin 220 (2025) 118368

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Perspective paper - Marine Pollution Bulletin

Offshore wind farms and marine protected areas in European waters: Better apart than together

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ARTICLE INFO

Keywords:
Co-location
Marine protected areas
Offshore wind farms
Maritime spatial planning
Fisheries
Marine biodiversity
Conflicts
NIMPA

ABSTRACT

This article addresses the ongoing debate on the desirability of locating offshore wind farms (OWFs) within, or near marine protected areas (MPAs), bearing in mind the trade-off between the need to meet renewable energy targets and the equally important need to meet biodiversity conservation targets. In essence, this article contends that OWFs should not, as a general rule, be considered to be a biodiversity conservation tool, nor a "*de facto* MPA" and any such claim should be demonstrated case by case. Indeed, as a first principle, OWFs should not be allowed to be developed within or near Natura 2000 sites –nor other type of area devoted to biodiversity conservation or the management and recovery of fish stocks. A new concept is proposed for the spatial planning of OWFs: "Not in marine protected areas" (NIMPA). This strategy entails searching for alternative sites that prioritize already degraded sea bottoms and industrialized areas.

1. Introduction

In the spatial planning of offshore wind energy that is taking place in Europe, there is currently a discussion on whether offshore wind farms (OWFs) should, or should not, be located within marine protected areas (MPAs). This article aims to contribute to this debate, which focuses on the trade-off between two pressing needs. First, there is the need to increase the area of European oceans and seas under protection to meet the European Union's (EU) Biodiversity Strategy and the Kunming-Montreal Global Biodiversity Framework (CBD, 2022), the goal being a 10 % increase in strictly protected areas (as part of an overall 30 % increase in protected areas) by 2030. MPAs not only contribute to the preservation of marine biodiversity and the maintenance of essential ecosystem services but also have the natural potential to remove carbon from the atmosphere and to strengthen the adaptability and resilience of the ocean, and can therefore act as a *Nature Based Solution* to mitigate the effects of climate change (Roberts et al., 2017; IUCN, 2019a). Second, there is the need to increase the area devoted to offshore wind energy generation to reduce greenhouse gas emissions in line with renewable energy targets, such as the EU target of more than 300 GW of offshore wind capacity, which would require a 15-fold increase in the marine space currently allocated to wind energy (European Parliament, 2019). To meet both these targets, new locations for offshore energy production are increasingly likely to coincide with existing and planned MPAs.

So far, the potential effects of offshore wind power plants and MPA's co-location have been extrapolated from known environmental impacts identified for fixed turbines outside MPAs in northern European Seas, where most of the published studies on OWF impacts on marine biodiversity and ecosystem services have been conducted (e.g., Gill, 2005; Boehlert and Gill, 2010; Benjamins et al., 2014; Degraer et al., 2020; Copping et al., 2020; Farr et al., 2021; Bennun et al., 2021; Watson et al., 2025). There are also a handful of case studies within MPAs (Sanders et al., 2017; Ashley et al., 2018; Defingou et al., 2019; Allen et al., 2020; Lloret et al., 2022, Lloret et al., 2023; Degraer et al., 2023; Wawrzynkowski et al., 2025) and reviews (Thurstan et al., 2018, WWF-France, 2019, Stephenson, 2023). These publications have described different types of environmental impacts resulting from the deployment of OWFs, depending on the context, including the characteristics of the sea basin, the habitats, the design and type of technology used, the associated infrastructure, and the development stage of the particular OWF (pre-construction, construction, operation and decommissioning). OWF infrastructure can impinge on species and habitats through different stressors including noise and vibrations, chemical pollution, electromagnetic fields, loss or modification of habitats, introduction of invasive alien species, increase of opportunistic species, collisions and entanglement risk, sediment resuspension and barrier effects. Many of these impacts are expected to be higher within MPAs because of the more pristine status of their environment (Sanders et al., 2017; Stephenson, 2023).

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https://doi.org/10.1016/j.marpolbul.2025.118368
Received 13 May 2025; Received in revised form 24 June 2025; Accepted 25 June 2025
Available online 8 July 2025

In addition, it has been found that, in certain circumstances, the deployment of OWFs can actually increase local biodiversity, for two main reasons. First, offshore wind infrastructure can act as artificial reefs or fish aggregation devices, introducing new hard substrate habitat on soft-bottoms (e.g., Inger et al., 2009; Wilson and Elliott, 2009; Ashley et al., 2014; Degraer et al., 2020, 2023). Second, OWFs preclude other human activities and therefore can effectively act as a fishing area closure leading to an increased abundance of benthic fauna, including fish and other commercially exploited species (e.g., Bergström et al., 2013; Hammar et al., 2016, Kafas, 2017; Methratta and Dardick, 2019). These positive effects on biodiversity are particularly noticeable when *Nature-Inclusive Designs* (NIDs) are used (The Rich North Sea, 2023; Wageningen University and Research, 2023).

However, the net positive or negative impacts of offshore wind infrastructure on marine biodiversity often remains unclear (Willsteed et al., 2018), with many of the pressures and impacts on marine ecosystems still poorly understood, including cumulative and large-scale impacts derived from OWFs (Farr et al., 2021) and impacts on ecosystem services (Watson et al., 2025). These gaps in our knowledge are particularly important with regard to floating turbines and areas outside the northern European Seas (Lloret et al., 2023). In this context, a number of controversies have emerged in recent years related to the co-location of OWFs with MPAs in Europe, and these can be grouped into two main nature conservation dilemmas, which are presented and discussed in the following sections.

2. First dilemma: Should OWFs be allowed within Natura 2000 sites and other areas defined for biodiversity and nature conservation?

Some countries allow wind farms in Natura 2000 sites and other MPAs, while others prohibit them (Stephenson, 2023). Nevertheless, EU policies (European Commission, 2020) allow wind farms to be installed in Natura 2000 sites, provided that a special permit, following what is known as an Appropriate Assessment (AA), has been granted. Having taken into consideration (i) the results of the various scientific studies on the impacts of OWFs on MPAs described in the "Introduction"; (ii) the many gaps in our knowledge regarding the impacts and benefits of co-location (especially in the case of floating wind farms); and (iii) the Precautionary Principle, adopted by the CBD (2007) and enshrined in EU policy in the Habitats Directive, the EU Marine Strategy Framework, and the EU Maritime Spatial Planning Framework, it is reasonable to assert that, as a general first principle, OWFs should not be allowed to be built within any Natura 2000 site nor within a surrounding "buffer zone", the size of which should be defined for each individual MPA according to the ecological and biological characteristics of the site and the technical characteristics of the proposed wind farm. Pre-commercial experimental and pilot projects should also be excluded from Natura 2000 sites and their buffer zones because such projects are mainly set up to test certain technical issues (Cruz and Atcheson, 2016) that could easily be carried out on already degraded sea beds.

The exclusion of OWFs should also be considered beyond Natura 2000 sites to other areas defined for biodiversity and nature conservation, such as *Key Biodiversity Areas* (KBA), *Important Marine Mammal Areas* (IMMA), *Important Shark and Ray Areas* (ISRA) and *Important Bird Areas* (IBA), as well as areas recognized as important for the management and recovery of commercial fish stocks, such as seasonal or permanent *Fisheries Restricted Areas* (FRA), which also include fisheries habitat management areas (Gaines et al., 2010; Lloret, et al., 2023). Keeping OWFs out of these areas would ensure the creation of interconnected networks of ecologically-representative areas, and conserve areas of particular importance for biodiversity and ecosystem functions and services (CBD, 2022). Furthermore, given the requirement to protect cultural heritage (European Commission, 2021), OWFs should also be excluded from sites where natural values coexist with important cultural values. In other words, both natural and cultural dimensions must be fully integrated into biodiversity policies and decisions so that marine spatial planning can take both into account (Seardo, 2015; Roe and Stead, 2022). This will contribute to the implementation of an ecosystem-based approach in maritime spatial planning that is needed to achieve sustainability (CBD, 2007; European Commission, 2021).

It would be advisable that the rigorous and independent AA is carried out for all OWFs that could potentially affect these areas defined for biodiversity and nature conservation (at present, only OWFs that may affect Natura 2000 sites are legally required to carry out this assessment). The AA, which can currently be conducted by OWF developers themselves, should be carried out by the competent authorities with the assistance of external, independent experts from different fields (Lloret et al., 2023). The AA should never be carried out by the offshore wind developers as part of the Environmental Impact Assessment (EIA) they prepare for their projects. Treating the AA as merely a component of the EIA for an individual project risks undermining its integrity and could lead to flawed or insufficient evaluations. And, in addition to assessing the possible impacts that an OWF may produce throughout its lifetime, the AA should also consider the impacts of major elements such as cables for the export of electricity, offshore or onshore electric substations, new port infrastructure or port expansion to accommodate wind farm service vessels, which may further impact the marine environment, and any future industry developments associated with the wind farm, for example, hydrogen plants (Taormina et al., 2018; Lloret et al., 2022). In particular, subsea cables can have diverse impacts on marine biota during their installation -for example, through sediment resuspension and habitat loss or modification- and during their operation, primarily through the emission of electromagnetic fields. These effects may be amplified by the spatial extent of the cable footprint (Szostek et al., 2025).

NIDs and mitigation measures should always be considered by developers during the design of an OWF, in order to restore overexploited species or degraded habitats, and to minimise the impacts of an OWF on marine biodiversity (The Rich North Sea, 2023; Wageningen University and Research, 2023; Nordic Energy Research, 2023). However, they should not be regarded simply as an offsetting measure that will ameliorate the impact of an OWF being built within or near a MPA. NIDs can have unexpected negative effects on the marine environment (Cale and Churn, 2021) that make their generalized use unadvisable in MPAs.

Pressing ahead with OWF development in areas of exceptional ecological value, without a proper understanding of the subsequent impacts on biodiversity and ecosystem services in such areas – which are also vital for the welfare of local communities – can easily lead to conflicts between the offshore wind industry and other marine industries, such as fishing and tourism (Ladenburg, 2009; Gee, 2010; Rudolph, 2014; Voltaire et al., 2017; Lloret et al., 2022). Furthermore, considering that fisheries, aquaculture, tourism, shipping and other activities currently are taking place in many MPAs, the potential combined and cumulative impacts of all these activities (including offshore energy) need to be studied. Finally, the challenges associated with OWF development in non-protected areas must be evaluated in light of the limited spatial availability for multiple competing uses outside MPAs. The rapid expansion of offshore wind energy is generating significant spatial conflicts in many regions, with both the energy and fishing sectors competing for access to increasingly constrained marine space. These spatial constraints are further exacerbated by the presence of other maritime activities, including commercial shipping, recreational activities and aquaculture (EUROPEAN MSP PLATFORM, 2018; Szostek et al., 2025). Therefore, any deployment of offshore wind power outside MPAs needs to be carried out in coordination with other maritime activities to reduce conflict and ensure the sustainable co-use of the sea space.

3. Second dilemma: Can an OWF serve as a MPA?

Some studies have shown that bottom fixed turbines can contribute

to the protection and/or restoration of particular species and habitats in two ways: (i) by increasing the available substrate for attachment for sessile species (Degraer et al., 2020, 2021) and (ii) by prohibiting damaging activities such as bottom trawling during the construction (and even during the operational phase, in some countries) because, in the absence of fishing, the abundance of benthopelagic and benthic species using wind farms for shelter and as feeding grounds may increase, with potential spillover effects (Vaissière et al., 2014; Hammar et al., 2016; Kafas, 2017; Gill et al., 2020; Mavraki et al., 2021, Schupp et al., 2021). Thus, some have argued that an OWF can provide marine conservation benefits by becoming a "*de facto* MPA" (Inger et al., 2009; Christie et al., 2014).

Nevertheless, the costs, benefits and limitations of co-locating OWFs and MPAs to achieve dual conservation objectives are, in many cases, not well known and therefore it should not be taken for granted that all offshore wind developments can be beneficial for the preservation and restoration of marine biodiversity and its associated ecosystem services. The most important factor is the particular background of each particular area of the sea. In chronically disturbed and dynamic environments, such as certain Belgian and Dutch parts of the North Sea (Lindeboom, 1995; Degraer et al., 2023), the benefits caused through the reef effect of an OWF may outweigh any of its overall negative effects. However, OWFs are more likely to cause significant negative impacts to areas with more diverse, undisturbed and threatened habitats, as is the case, for example, in the northern Catalan Sea in the Mediterranean (Lloret et al., 2022), or other areas of the Belgian part of the North Sea with undisturbed gravel beds and sandbanks (Degraer et al., 2023). OWFs can also threaten protected species such as birds and marine mammals (Hammar et al., 2016; Wawrzynkowski et al., 2025), so they are unlikely to help conservation of these species.

Furthermore, OWFs do not embody many of the core characteristics that define MPAs). MPAs are clearly delineated geographic spaces designated and managed to achieve the long-term conservation of marine biodiversity, ecosystem services, or cultural heritage (NOAA, 2025). Their establishment and management are often guided by the International Union for Conservation of Nature's (IUCN) Global Conservation Standards (IUCN, 2019b), which emphasize ecological integrity, governance, and sustainability. In contrast, OWFs are primarily developed for energy production and are not inherently designed to meet conservation objectives. More importantly, OWFs may generate environmental stress, as outlined in the previous section. Additionally, OWFs are generally temporary installations with operational lifespans of around 25 to 30 years unless repowered. Consequently, any potential ecological benefits associated with their presence are likely to cease upon decommissioning, effectively eliminating any 'reserve effect' that might have been attributed to the OWFs.

The most beneficial location for an OWF would be in an already degraded area where the underwater structures could help restore the damaged ecosystem and increase biodiversity, and only then could it be regarded as an '*Other Effective Area-based Conservation Measure*' (Lloret et al., 2022).

4. Conclusion

This article argues that OWFs should not, as a general rule, be considered to be a biodiversity conservation tool, nor a "*de facto* marine MPA" and any such claim should be demonstrated case by case. Instead, this paper advocates that OWFs should not be allowed to be developed near (i.e, within a buffer zone) or inside Natura 2000 sites, or any other area defined for biodiversity and nature conservation, or the management and recovery of fish stocks, regardless of any proposed measures intended to reduce impacts (such as NIDs) on such areas. In this sense, a new concept is here proposed for European policy makers and maritime spatial planners dealing with offshore wind energy planning: "Not in Marine Protected Areas" (NIMPA). European authorities should continue to enlarge the network of MPAs as the principal strategy for meeting national and international biodiversity targets and improving management and recovery of fish stocks. Nevertheless, OWFs have an important role to play in meeting renewable energy goals, and their exclusion from MPAs and their vicinities necessarily entails searching for alternative sites, preferably in already degraded sea bottoms and industrialized areas, where the expansion of OWFs can be effectively reconciled with marine biodiversity restoration goals.

CRediT authorship contribution statement

Josep Lloret: Writing – review & editing, Writing – original draft, Conceptualization.

Ethical standards

This work abided by the Marine Pollution Bulletin guidelines on ethical standards.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Josep Lloret reports financial support was provided by European Union - NextGenerationEU. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was carried out in the frame of the BIOPAIS project (https://oceanshealth.icm.csic.es/es/biopais.html), which has the support of the Fundación Biodiversidad of the Spanish Ministry for the Ecological Transition and the Demographic Challenge (MITECO) within the framework of the Recovery, Transformation, and Resilience Plan (PRTR), financed by the European Union-NextGenerationEU. The author thanks the two referees whose insightful comments greatly improved the quality of this paper.

Data availability

Not applicable.

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