frontiers | Frontiers in Marine Science

TYPE Perspective
PUBLISHED 04 January 2023
DOI 10.3389/fmars.2022.952593

OPEN ACCESS

EDITED BY
José Guerreiro,
University of Lisbon, Portugal

REVIEWED BY
Rafael Sarda,
Spanish National Research Council (CSIC), Spain

*CORRESPONDENCE
Catherine Boemare
catherine.boemare@ehess.fr

SPECIALTY SECTION
This article was submitted to Marine Affairs and Policy, a section of the journal Frontiers in Marine Science

RECEIVED 25 May 2022
ACCEPTED 08 December 2022
PUBLISHED 04 January 2023

CITATION
Boemare C (2023) Challenging the new blue deal by embedding interactions with the non-humans in the offshore renewable energy development.
Front. Mar. Sci. 9:952593.
doi: 10.3389/fmars.2022.952593

Challenging the new blue deal by embedding interactions with the non-humans in the offshore renewable energy development

Catherine Boemare*

École des Hautes Études en Sciences Sociales, Centre International de Recherche sur l'Environnement et le Développement (CIRED), UMR 8568 CNRS-EHESS-Ecole des Ponts ParisTech-CIRAD-AgroParisTech, Jardin d'Agronomie Tropicale de la Ville de Paris, Cedex, France

This paper is challenging the new blue deal outlining the need for a change in the expectative. Offshore wind farms (OWFs) are not only a climate-friendly way of producing electricity but also a shifting paradigm unique opportunity, acknowledging the increasing presence of anthropogenic infrastructure in the marine environment and seeing them as the place for recreating relations with non-humans and work with them. We give some ideas that could ground a research program pairing both positive and negative aspects of OWF and study the conditions of realization of mutual beneficial relationship coming from the "mosaic of open-ended assemblages of entangled ways of life."

KEYWORDS

OWF, MPA (marine protected area), reef effect, entangled mesh, world-making, interconnectedness, hybridity, assemblages

Introduction

Offshore wind farm (OWF) development is increasingly seen as a climate-friendly way for energy supply by contributing decarbonizing and reducing greenhouse gas emissions and achieving the United Nations Sustainable Development Goal 7 "Affordable and Clean Energy" (IEA, 2019; Galparsoro et al., 2022). In addition, technological advances and increasing demand for renewable energy (Glarou et al., 2020) added to the European goal of climate neutrality by 2050 and lead to the integration of this technology option into the future energy mix. Hence, the European Union (EU) forecasts that offshore wind must provide 30% of Member States' electricity demand by 2050, increasing from the current 12 Gigawatts (GW) capacity to 300 GW, hence multiplying by 15 the marine space allocated to wind energy (Lloret et al., 2022). The US Department of Energy (DOE) as well has set a goal of 54 GW installed by 2030 and is planning for 86 GW to be installed by 2050 (Goodale and Milman, 2019). This ocean sprawl (Duarte et al., 2013; Firth et al., 2016) will at least modify the occupation of the marine space and consequently the status of marine ecosystems. One can imagine that introducing a deep technological artifact will alter the living conditions of the inhabitants and hence disturb the environment or users of this environment. This new potential source of alteration of marine spaces must be added to the list of disturbances and pressures already existing in the marine space and recorded through the 11 descriptors of good environmental status of the Marine Strategy Framework Directive (MSFD) adopted in 2008. What does this perspective imply for marine life and the present ocean users? Will the development of wind power be an additional pressure on ecosystems when we are struggling to reduce those that are actually harming the marine environment? What if this large-scale deployment initiates a new era of our development model looking for a symbiosis between energy production for human use and proliferation of marine life? How does this challenge open up new perspectives for approaches to conservation and economic development? To clarify these issues, we first review the literature identifying socio-ecological impacts of OWF development. Then, we explore the contemporary thoughts that pave the way for imagining a symbiotic relation between energy production and marine life. Then, we conclude by identifying grounds for future research.

OWF, a threat for marine life and users of the ocean but also an asset

OWFs are and will be increasingly established in marine areas to meet the rising global demand for renewable energy, hence experiencing the ocean sprawl. For Europe, however, this development must be consistent with the commitments to marine biodiversity protection and strategic planning. Those latter are contained respectively in the MSFD (Directive 2008/56/EC), which came into force in 2008 as the environmental pillar of European maritime policy, and the Maritime Spatial Planning Directive (MSPD; Directive 2014/89/EU). While the former aims to maintain or restore the functioning of marine ecosystems, the latter aims to promote the sustainable growth of maritime economies, the sustainable development of maritime spaces, and the sustainable use of marine resources. To achieve this, Member States must take into account economic, social, and environmental aspects by applying an ecosystem-based approach and promote the coexistence of relevant activities and uses. In this context, OWF as one pillar of the blue economy provides obvious benefits while producing renewable energy but may induce several ecological disruptions in marine environment and socioeconomic upheavals, known as negative externalities. They can provide some positive impacts as well. With few exceptions like Galparsoro et al. (2022), the scientific literature reviews separately negative and positive impacts. Hernandez et al. (2021) stress the importance of understanding the relationship between the activities associated with an OWF and their impacts, distinguishing effects from impacts (Taormina et al., 2018; Hernandez et al., 2021). They can be classified considering the ecological levels and the spatial and temporal scales (Hernandez et al., 2021). Whereas effects consider modifications of environmental parameters, such as the substrate type, hydrodynamics, water temperature, noise, or electromagnetic fields, the impacts are the changes observed at the receptor level, that is, the ecosystemic compartments (biotopes, biocenocis), ecological levels (populations or community), and some ecological processes within marine ecosystems (trophic interactions) (Hernandez et al., 2021). OWF effects and impacts might be present at the three stages of OWF development (installation, operation and maintenance, decommissioning) regardless of technologies used (Furness et al., 2013; Bailey et al., 2014; Bergström et al., 2014; Schuster et al., 2015).

Among the negative impacts are collision risks with avian and bat collision above the water and entanglement of marine vertebrates or marine mammals with underwater structures (Inger et al., 2009; Peschko et al., 2020; Peschko et al., 2021), underwater noise could generate stress (Wahlberg and Westerberg, 2005; Madsen et al., 2006; Cook et al., 2018; Glarou et al., 2020; Mooney et al., 2020; Tougaard et al., 2020; ; Maxwell et al., 2022), generation of electromagnetic fields that could be a concern for some fish species that are magneto-sensitive or that use geomagnetic field information for orientation purposes (Peters et al., 2007; Normandeau et al., 2011; Gill et al., 2014; Maxwell et al., 2022), and loss of soft bottom habitats with the introduction of hard bottom substrata (Glarou et al., 2020). Maxwell et al. (2022), acknowledging the abundance of literature about fixed offshore wind turbines, do it as well, focusing on floating wind turbines. They all mainly identify ecosystem degradation; habitat loss for marine mammals, fish, benthic communities (at the installation and operation stages); habitat disturbance for birds and bats (at the operation stage); changes on habitat at the seabed level for benthic communities (at the installation and decommissioning stage); and physical damage for marine mammals, birds, and bats (at the installation, operation stage). However, there are still gaps in scientific knowledge about the ecological impact of wind turbines (Dannheim et al., 2020; WWF, 2014); especially, uncertainties remain regarding the assessment of cumulative impacts (Galparsoro et al., 2022). Nevertheless, Gartman et al. (2016a); Gartman et al. 2016b) identify how to design turbines and operate their installation and operation to minimize impacts on marine species and habitats and reduce risks on marine life.

However, this discussion is site-specific. It depends greatly on location. The magnitude and the matter of concern are determined case by case for each specific OWF project. The initial state and resilience of the area can vary and impact differently some ecosystem elements (Causon and Gill, 2018; Gill, 2005; Cook et al., 2018; Galparsoro et al., 2022). Lloret et al. (2022) demonstrate that importing the northern European sea OWF model development to the Mediterranean Sea is not straightforward. That is why each project, as a response to a call for tenders, is supposed to carry out an impact analysis showing in each specific case what the issues are. Indeed, OWF projects must be consistent with biodiversity protection and conservation objectives like Sustainable Development Goal (SDG) 14 or Convention on Biological Diversity at the international level or Marine Strategy Framework Directive (MSFD) at the European level.

Moreover, as this implementation occurs in a crowded ocean, not only marine life but also some human uses and activities could be disrupted as well (Inger et al., 2009; Glarou et al., 2020). Conflicting marine activities and competing uses of the littoral zone are likely to arise, as well as different societies' inherent values regarding legacy and "patrimonialization" in coastal regions (Bell et al., 2013; Bidwell, 2017; Lloret et al., 2022). Although OWF can be seen as visually appealing, representing a shift toward clean energy in the future, it could compete spatially with some other uses, mainly fishing, but also shipping, extraction of resources, tourism (Virtanen et al., 2022) that are responsible for current pressures and cumulated impacts on marine environments and their degradation while OWFs are not yet implemented. OWFs could also face societal opposition and disapproval especially from close by communities (Kermagoret et al., 2016; Virtanen et al., 2022). Therefore, the OWF is developed as part of marine spatial planning, especially in Europe, since the EU set a target in May 2020 to protect 30% of the EU's seas by 2030 when launching the EU Biodiversity Strategy 2030.

But wind farm implementation could also have positive effects by increasing the abundance and biodiversity of hard bottom species due to reef effects (provision of food, spawning, nursery, shelter opportunity) (Punt et al., 2009; Wilson and Elliott, 2009; Langhamer, 2012; Reubens et al., 2013; Ashley et al., 2014; Bray et al., 2016; van Hal et al., 2017; Glarou et al., 2020; Coolen et al., 2020; Degraer et al., 2020). Indirect impacts, such as the increase in prey species that results from the creation of a no-fishing zone for safety reasons in the OWF, may in some cases have positive impacts. The increase in prey species will increase the availability of food for higher trophic levels (Galparsoro et al., 2022) and outlines the need for an ecosystem-based approach when considering the suitability of wind farm implementation. Creating a no-take zone within the OWF can also favor possible spillover effects to neighboring areas (Ashley et al., 2014; Coates et al., 2016; Halaouani et al., 2020). As an example, Langhamer (2012) outlines how the artificial reef effect is important when constructing scour protections; it can generate an enhanced habitat, creating heterogeneity in the area that is important for species diversity and density. OWFs could also behave as marine protected areas (MPAs) by being exclusion zones to destructive fishing activities like trawling (Ashley et al., 2014; Halouani et al., 2020). Indeed, prohibiting trawling near OWFs eliminates fishing pressure and decreases disturbance of fish benthos and benthic habitats (Teilmann and Carstensen J 2012, Galparsoro et al., 2022). Here again, location matters and can differ among organisms (Langhamer, 2012). Benefits will only be realized with consideration of the layout, design of OWF arrays, location, and access rules. Illustrative evidence of the reef aspect and spillover effect is the discussion around the "rigs to reef" in the context of decommissioned offshore man-made installations that pave the way of "renewables to reefs" (Smyth et al., 2015). Fowler et al. (2018) conducted a global survey of environmental experts to guide the best decommissioning practices in the North Sea. Whereas partial removal options were considered to deliver better environmental outcomes than complete removal platforms, they were equally supported for wind turbines. The key elements under discussion here are biodiversity enhancement, provision of reef habitat, and protection from bottom trawling (Fowler et al., 2018). This reef effect is confirmed by Coolen et al. (2020); by conducting a multivariate analysis, they compared data from old oil and gas platforms with data of a young wind farm and a natural reef. They showed an overlap in communities on steel and rock and between the wind farm and platforms (Coolen et al., 2020). Callahan and Jackson (2014) explored the future of California's offshore oil and gas platforms and assessed the economic and ecological efficiency of a "rig-to-reef" program through a cost–benefit analysis and concluded that such a program would result in direct and indirect benefits that far exceed the costs. When displacement of fisheries occurs and is of particular concern, the artificial reef effects could be an argument for exploring the coexistence of OWF and fisheries (Hooper et al., 2015). Indeed, the co-location already exists off the coast of Louisiana in the Gulf of Mexico where oil and gas platforms are used by recreational fishermen and scuba divers (Stanley and Wilson, 1989; Gordon, 1993).

A discussion that remains within the minimizing risks perspective: The need for a change of paradigm seeking for hybridity

The literature review allows to consider OWF development projects' pros and cons and how much they are site-dependent. Major studies discuss separately wind farms' positive and negative effects related to the different projects' locations focusing on one side on disruptions and on the other side—however to a lesser extent—on reef and MPA benefiting effects. Literature neglects assessing systematically both sides jointly. At the very best, discussions about wind farm developments and their locations try to be the least invasive concerning other existing activities and try to minimize the associated risks. From one specific project point of view, this approach allows to consider the necessary trade-offs to be made. But it remains within the paradigm of impact minimization and cost–benefit analysis. This approach is in line with the thinking that considers economic development on one hand and environmental preservation on the other. The very few studying both negative impacts and benefits conclude asking policymakers "whether installations should be designed to either minimize negative environmental impacts or as facilitators of ecosystem restoration" (in Inger et al., 2009). Is this enough for overcoming issues at stake that face climate change upheavals and loss of biodiversity in an ocean sprawl? In Europe, the existing institutional and political frameworks with the MSFD (Directive 2008/56/EC) and the MSPD (Directive 2014/89/EU) together with the blue growth challenge and the EU Biodiversity Strategy 2030 shape a context that calls for a new conception of marine space. This new conception could be based on recent philosophical proposals. Recent proposals allow us to consider the relationships between humans, their actions, and their non-human environment in a more integrated way and with a different ambition than that of minimizing impacts. In this perspective, what if the ocean sprawl becomes the opportunity of establishing a mutually beneficial relationship between biota, users of the sea, and man-made infrastructure (Glarou et al., 2020)? The OWF would not be considered only as disruptive or benefiting projects but rather as a disturbance occasioning fluctuating assemblages between humans and non-humans alike. Those assemblages would be multispecies "world-making projects" in line with a renewal ecology (Bowman et al., 2017), a symbiotic economy that would showcase a shifting development pathway groundbreaking with business-as-usual trends.

OWF as a disturbance occasioning fluctuating assemblages between humans and non-humans alike

OWFs could challenge the traditional dichotomy between conservation and exploitation because they could initiate new ways of inhabiting the world. Michel Serres and Philippe Descola put an end to the great division between nature and culture (Boemare, 2021). The former by calling for a natural contract to be negotiated between Earth and its inhabitants and granting nature the status of a legal subject (Serres, 1990). The latter by stressing on the existing different conceptions of relating human and non-human and shaping new ontology about nature–culture relations (Descola, 2005, 2013 for the English version). Hence, the idea of inhabiting the Earth within an interspecific co-habitation with non-human has emerged far away from the "modern" vision of the 17th century inherited from Descartes for whom the project was to become master and possessor of nature. This approach is enlarged to things and objects by Morton (2012); Haraway (2016), and Coccia (2019); Coccia (2020); Coccia (2022).

The landscape and the territory as a life artifact

We follow on the analysis proposed by Boemare (2021). The first step is to explore what life is, awakening awareness of the oneness of life that runs through all living things, leading to an understanding of culture and nature (Coccia, 2019). Coccia (2019) proposes in the sower a useful interpretation of the painting Sower at Sunset of Vincent Van Gogh. The starting idea, well known to biologists, is that at the base of life is the process of capturing light and solar energy and transforming it into organic matter. Growing up is a process of accumulating light in the body; it is still metabolized light that both and identically animals and humans seek to capture in the tissues of their prey. Van Gogh's painting shows the sower and a tree on the same foreground outlining no difference between sowing whether it will be a human's or vegetable's act. Hence, the landscape and therefore the territory are resulting from the various strategies of human, animal, or vegetable seeding, of each of the live beings that compose it. There is no more artificiality in the act of the sower than in the act of the plant, "every species cultivates and constructs the world differently"; they are both developers of space, the territory is co-constructed by the species that animate it. The landscape is thus a "random accumulation of disparate living individuals … each species is the agro-ecological territory of the other: each being is the gardener of other species but also the garden of other species, and what we call 'world' is finally only a relationship of reciprocal culture." His conclusion enlightens the notion of wild nature, "in this sense there is no wild space, because everything is cultivated and because being in the world means gardening other species, and at the same time and with the same gesture being the object of the seeding of others … Each landscape is thus an ephemeral, artificial installation provisionally constructed by the sowing of its inhabitants," which is the essence of living. Enlarging the analysis, he sees the earth as a non-natural space but a "life artefact, no less artificial than a chair or a smartphone" (Coccia, 2022).

A life artifact composed of living and non-living beings in an entangled mesh

The second step takes root in Morton (2012). Morton (2012) is opposed to the idea of a face-to-face confrontation between man and nature. He pleads for a participative ecology that experiences the interweaving and coexistence of things and beings (Morton, 2012). He argues that all forms of life as well as all dead forms, just like the environment composed of living and non-living beings, are connected in a vast entangling mesh. But what are those things interconnected? The mesh is vast in Tim Morton's work and confronts us with encountering "strange strangers." Those are the ones, beings and things of all kinds, with which the things we look at are likely to enter into relation, to coexist. Hence, this interconnectedness penetrates all dimensions of the natural and the artificial: no being, construct, or object.

Less is more, the necessity of cooperation and symbiosis to inhabiting disorder

It allows him to account for the idea that thinking the mesh means that "less is more" like two married people pay less taxes than two single people because in a sense they are less than two (Morton, 2012). Because each one needs the other to exist, there are no two single parts interconnected but interdependent like bacteria in the human stomach. In Morton's theory, it leads to the very interesting necessity of cooperation and symbiosis to exist. In this, he joins and relies on Margulis (1981) for whom symbiosis is the driving force of evolution. He is not very far away from Haraway (2016) arguing for sympoiesis, the "making-with" idea that nothing is self-organizing. Since all things depend on each other, we have a good reason to pay attention to things. The destruction or creation of some things will affect others, since we cannot exist independently. Meeting with strange strangers, we have to accept "inhabiting disorder" (Haraway, 2016), which means "to risk getting back to earth, to follow the tangled threads of everything that makes up the complicated fabric of the world, the wefts that attach to each other, not only humans, the earth, other species, biological elements, but also artifacts, technologies, and objects mixed together…" (Caeymaex et al., 2019).

Renewing relationships: Assemblages as multispecies "world-making projects"

The detour we made through the analysis of the sower's chart, the entangling mesh, and inhabiting the disorder is useful because it renders obsolete the arbitrations between artificiality and naturalness, domestic and wildlife and allows for a shift that considers the actions of the species that inhabit a territory, and therefore their impacts, as powers to act. These powers of action are inscribed in time and space. As such, the landscape is an ephemeral and contextual temporal construction. For those who wish to intervene on the territory, the objective of prioritizing an ecological composition rather than another in reference to a known ideal state of the past is no longer necessarily appropriate and allows thinking about the territory, its composition, and the exploration of its possible futures with other criteria that can be debated by "ruminating" as proposed by Isabelle Stengers (Boemare, 2021).

The project of acting becomes that of defining "new and more attentive ways" of relating to other beings in order to make the world with them (Despret, 2019; Stengers, 2019; Morizot, 2020). The erosion of biodiversity and environmental upheavals can then be understood as a "crisis of relations" between live beings, things. The project becomes one of building, rebuilding, and renewing these relationships and "reviving the world" (Latour, 2021). For research, remedying the erosion of biodiversity and the living requires conducting a program that places the powers of action as the meshes of a web of entangled relationships to be constructed. We also need tools for its operationalization.

Discussion

How far this analysis helps us thinking to OWF development? What if one grabs this moment, seizes this window of opportunity of OWF development to change our way of being in the world operating a true metamorphosis challenging the new blue deal? The institutional and political context is favorable. Wind energy development projects are part of national energy transition strategies aligned with ambitious international climate and biodiversity protection objectives. They are also integrated for European states in a regulatory framework formed by a national planning imposed by the European directive on strategic planning establishing a framework for maritime spatial planning. The governance of the ocean is being reshaped (Guerreiro, 2021). A wind turbine is an artifact, it is also a portion of territory engaging economic activities and marine life on the ground and throughout the height of the water column on the whole territory of the farm but also on land. A contemporary and fruitful avenue for research would be to put at the core of research the idea of interconnectedness and to seek around offshore wind turbines the creation of interspecific assemblages that maximize the benefits for both humankind and biodiversity. This would allow us to take advantage of the advances in science and philosophy while being careful not to fall into unbridled optimism and remaining conscious of our cultural hubris. Indeed, we face here a moment of "wild renaissance" (Logé,

2019) where cross-cutting knowledge between ecology, economy, biosemiotics (Emmeche and Kull, 2011), and anthropology but also the opening to a new sensibility can lead to a metamorphosis of our way of being in the world (Coccia, 2020; Latour, 2021). Paradoxically, this new perspective should emerge thanks to an "enlarged anthropocentrism" allowing us to make a common world (Bimbenet, 2017) and operate the necessary decentering and multiplication of worlds (Viveiros de Castro, 2009). We first need rethinking habitats and worlds as environments in an Uexküll sense. In an operational way, it consists of translating and taking into account the "world" produced by each living being in its specific way of inhabiting it, that is, by considering that each living being accesses its surroundings through its physiological senses (Uexküll, 1934). This is a subjective "world view." These being different from one species to another, living beings of multiple species can at the same time inhabit a different and similar environment. The mesh obtained will represent the juxtaposition of "environments-worlds." These "environments-worlds" are made of more or less broad series of elements, "carriers of significance," and "marks" that are the only things that interest the animal. These new elements could be integrated in an ecosystemic framework and related to the OWF pros and cons reviewed. The MSFD and MSPD directives would shape their development and ensure consistency with the new governance of the ocean. We would then be up to locate, design, and define OWF access rules at each specific site in a way that fosters mutual beneficial relationships coming from the "mosaic of open-ended assemblages of entangled ways of life" (Morton, 2018).

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

Funding

This work was supported by grants from Fondation de France. This work was supported by the Institute of Human and Social Sciences of the CNRS within the framework of the program "Support to international mobility 2021".

Acknowledgments

The author thanks the researchers in EmLab at the Bren School of Environmental Science and Management at University of California Santa Barbara for fruitful discussions during her stay as visiting scholar.

Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Ashley, M. C., Mangi, S. C., and Rodwell, L. D. (2014). The potential of offshore windfarms to act as marine protected areas–a systematic review of current evidence. *Mar. policy. 45*, 301–309. doi: 10.1016/j.marpol.2013.09.002

Bailey, H., Brookes, K. L., and Thompson, P. M. (2014). Assessing environmental impacts of offshore wind farms: lessons learned and recommendations for the future. *Aquat. Biosyst.* 10, 8. doi: 10.1186/2046-9063-10-8

Bell, D., Gray, T., Haggett, C., and Swaffield, J. (2013). Re-visiting the'social gap': public opinion and relations of power in the local politics of wind energy. *Environ. Polit.* 22 (1), 115–135. doi: 10.1080/09644016.2013.755793

Bergström, L., Kautsky, L., Malm, T., Rosenberg, R., Wahlberg, M., Astrand Capetillo, N., et al. (2014). Effects of offshore wind farms on marine wildlife–a generalized impact assessment. *Environ. Res. Lett.* 9. doi: 10.1088/1748-9326/9/3/034012

Bidwell, D. (2017). Ocean beliefs and support for an offshore wind energy project. *Ocean Coast. Manage.* 146, 99–108. doi: 10.1016/j.ocecoaman.2017.06.012

Bimbenet, E. (2017). *Le complexe des trois singes* (Paris: Seuil).

Boemare, C. (2021). "Le sauvage dans les aires marines protégées, expérimenter une métamorphose de notre rapport au vivant," in *Le livret vert*. Ed. Le Pommier (Paris: Publisher Editions Le Pommier), 33–40.

Bowman, D. M. J. S., Garnett, S. T., Barlow, S., Bekessy, S. A., Bellairs, S. M., Bishop, M. J., et al. (2017). Renewal ecology: conservation for the anthropocene. *Restor. Ecol.* 25, 674–680. doi: 10.1111/rec.12560

Bray, L., S., Reizopoulou, Voukouvalas, E., Soukissian, T., Alomar, C., Vazquez-Luis, M., et al. (2016). Expected effects of offshore wind farms on Mediterranean Marine Life. *J. Marine Sci. Eng.* 4(1), 18. doi: 10.3390/jmse4010018

Caeymaex, F., Despret, V., and Pieron, J. (2019). *Habiter le trouble avec Donna* (Haraway, Paris: Editions Dehors). Éditions Dehors.

Callahan, E., and Jackson, A. (2014). "Rigs to reef: exploring the future of california's offshore oil and gas platforms," (UC San Diego: Capstone papers), p19.

Causon, P. D., and Gill, A. B. (2018). Linking ecosystem services with epibenthic biodiversity change following installation of offshore wind farms. *Environ. Sci. Policy* 89, 340–347. doi: 10.1016/j.envsci.2018.08.013

Coates, D. A., Kapasakali, D.-A., Vincx, M., and Vanaverbeke, J. (2016). Short-term effects of fishery exclusion in offshore wind farms on macrofaunal communities in the Belgian part of the north Sea. *Fish Res.* 179, 131–138. doi: 10.1016/j.fishres.2016.02.019

Coccia, E. (2019). *Le semeur – de la nature contemporaine* (Arles: Fondation Vincent van Gogh).

Coccia, E. (2020). *Métamorphoses* (Paris: Éditions Payot & Rivages).

Coccia, E. (2022). Une vie à la frontière. interview. *Philosophie magazine Hors-série* n°53, 96–99.

Cook, A. S. C. P., Humphreys, E. M., Bennet, F., Masden, E. A., and Burton, N. H. K. (2018). Quantifying avian avoidance of offshore wind turbines: Current evidence and key knowledge gaps. *Mar. Environ. Res.* 140, 278–288. doi: 10.1016/j.marenvres.2018.06.017

Coolen, J. W. P., van der Weide, B., Cuperus, J., Blomberg, M., Van Moorsel, G. W. N. M., Faasse, M. A., et al. (2020). Benthic biodiversity on old platforms, young wind farms, and rocky reefs. *ICES J. Mar. Sci.* 77, 3, 1250–1265. doi: 10.1093/icesjms/fsy092

Dannheim, J., L., Bergström, S. N. R., Birchenough, R., Brzana, A. R., Boon, J. W. P., Coolen, et al. (2020). Benthic effects of offshore renewables: identification of knowledge gaps and urgently needed research. *ICES J. Mar. Sci.* 77, 1092–1108. doi: 10.1093/icesjms/fsz018

Degraer, S., D. A., Carey, J. W. P, Coolen, Z. L., Hutchison,, F., Kerckhof, B., Rumes, et al. (2020). Offshore wind farm artificial reefs affect ecosystem structure and functioning: A synthesis. *Oceanography* 33, 48–57. doi: 10.5670/oceanog.2020.405

Descola, P. (2005). *Par-delà nature et culture* (Gallimard, Paris. Trad in English, 2013. Beyond Nature and Culture. Chicago: University of Chicago Press).

Despret, V. (2019). *Habiter en oiseau, coll* (Actes Sud, Arles: Mondes Sauvages), p224.

Duarte, C. M., Pitt, K. A., Lucas, C. H., et al. (2020). Is global ocean sprawl a cause of jellyfish blooms? *Front. Ecol. Environ.* 11.2, 91–97. doi: 10.1890/110246

Emmeche, C., and Kull, K. (2011). *Towards a semiotic biology, life is the action of signs* (London: Imperial College Press).

Firth, L. B., Knights, A. M., Bridger, D., Evans, A., Mieszkowska, N., Moore, P. J., et al. (2016). Ocean sprawl: Challenges and opportunities for biodiversity management in a changing world. *Oceanogr. Mar. Biology: Annu. Review.* 54, 189–262. doi: 10.1201/9781315368597-5

Fowler, A. M., Jørgensen, A. M., Svendsen, J. C., Macreadie, P. I., Jones, D. O., Boon, A. R., et al. (2018). Environmental benefits of leaving offshore infrastructure in the ocean. *Front. Ecol. Environ.* 16 (10), 571–578. doi: 10.1002/fee.1827

Furness, R. W., Wade, H. M., and Masden, E. A. (2013). Assessing vulnerability of marine bird populations to offshore wind farms. *J. Environ. Manage. Apr* 15. 119, 56–66. doi: 10.1016/j.jenvman.2013.01.025

Gartman, V., Bulling, L., Dahmen, M., Geißler, G., and Köppel, J. (2016a). Mitigation measures for wildlife in wind energy development, consolidating the state of knowledge — part 1: planning and siting, construction. *J. Env. Assmt. Pol. Mgmt.* 18, 1650013. doi: 10.1142/S1464333216500137

Gartman, V., Bulling, L., Dahmen, M., Geißler, G., and Köppel, J. (2016b). Mitigation measures for wildlife in wind energy development, consolidating the state of knowledge — part 2: operation, decommissioning. *J. Env. Assmt. Pol. Mgmt.* 18, 1650014. doi: 10.1142/S1464333216500149

Gill, A. B. (2005). Offshore renewable energy: ecological implications of generating electricity in the coastal zone. *J. Appl. Ecol.* 42, 605–615. doi: 10.1111/j.1365-2664.2005.01060.x

Gill, A. B., Gloyne-Philips, I., Kimber, J., and Sigray, P. (2014). "Marine renewable energy, electromagnetic (EM) fields and EM-sensitive animals," in *Marine renewable energy technology and environmental interactions, humanity and the Sea*. Eds. M. A. Shields and A. I. L. Payne (Dordrecht: Springer Netherlands), p61–p79. doi: 10.1007/978-94-017-8002-5_6

Galparsoro, I., Menchaca, I., Garmendia, J. M., Borja, A., Maldonado, A. D., Iglesias, G., et al. (2022). Reviewing the ecological impacts of offshore wind farms. *NPJ Ocean Sustainability* 1, 1. doi: 10.1038/s44183-022-00003-5

Glarou, M., Zrust, M., and Svendsen, J. C. (2020). Using artificial-reef knowledge to enhance the ecological function of offshore wind turbine foundations: Implications for fish abundance and diversity. *J. Mar. Sci. Eng.* 8, 332. doi: 10.3390/jmse8050332

Goodale, M. W., and Milman, A. (2019). Assessing the cumulative exposure of wildlife to offshore wind energy development. *J. Environ. Manage.* 235, 77–83. doi: 10.1016/j.jenvman.2019.01.022

Gordon, W. R. (1993). Travel characteristics of marine anglers using oil and gas platforms in the central gulf of Mexico. *Mar. Fish. Rev.* 55 (1), 25–31.

Guerreiro, J. (2021). The blue growth challenge to maritime governance. *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.681546

Halouani, G., Villanueva, C. M., Raoux, A., Dauvin, J. C., Ben Rais Lasram, F., Foucher, E., et al. (2020). A spatial food web model to investigate potential spillover effects of a fishery closure in an offshore wind farm. *J. Mar. Syst.* 12, 103434. doi: 10.1016/j.jmarsys.2020.103434

Haraway, D. (2016). *Staying with the trouble: Making kin in the chthulucene* (Durham: Duke University Press).

Hernández, O., Shadman, M., Amiri, M., Silva, C., Estefen, S., and La Rovere, E. (2021). Environmental impacts of offshore wind installation, operation and maintenance, and decommissioning activities: A case study of Brazil. *Renewable Sustain. Energy Rev.* 144, 18. doi: 10.1016/j.rser.2021.110994

Hooper, T., Ashley, M., and Austen, M. (2015). Perceptions of fishers and developers on the co-location of offshore wind farms and decapod fisheries in the UK. *Mar Pol.* 61, 16–22. doi: 10.1016/j.marpol.2015.06.031

Inger, R., Attrill, M. J., Bearhop, S., Broderick, A. C., James Grecian, W., Hodgson, D. J., et al. (2009). Marine renewable energy: potential benefits to biodiversity? an urgent call for research. *J. Appl. Ecol.* 46, 1145–1153. doi: 10.1111/j.1365-2664.2009.01697.x

International Energy Agency (2019)Offshore wind outlook 2019. Available at: https://iea.blob.core.windows.net/assets/495ab264-4ddf-4b68-b9c0514295ff40a7/Offshore_Wind_Outlook_2019.pdf.

Kermagoret, C., Levrel, H., Carlier, A., and Ponsero, A. (2016). Stakeholder perceptions of offshore wind power: a fuzzy cognitive mapping approach. *Soc. Nat. Resour.* 29 (8), 916–931. doi: 10.1080/08941920.2015.1122134

Langhamer, O. (2012). Artificial reef effect in relation to offshore renewable energy conversion: State of the art. *Sci. World J.* 2012, 386713. doi: 10.1100/2012/386713

Latour, B. (2021). *Où suis-je ? Les empêcheurs de tourner en rond, Éditions la découverte* (Paris: Publisher Editions La Découverte). p186.

Lloret, J., Turiel, A., Solé, J., Berdalet, E., Sabatés, A., Olivares, A., et al. (2022). Unravelling the ecological impacts of large-scale offshore wind farms in the Mediterranean Sea. *Sci. Total Environ.* 824, 153803. doi: 10.1016/j.scitotenv.2022.153803

Logé, G. (2019). *Renaissance sauvage, l'art de l'anthropocène* (Paris: P.U.F).

Madsen, P., Wahlberg, M., Tougaard, J., Lucke, K., and Tyack, P. (2006). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Mar. Ecol. Prog. Ser.* 309, 279–295. doi: 10.3354/meps309279

Margulis, L. (1981). *Symbiosis in cell evolution, freeman* (New York: W. H. Freeman).

Maxwell, S., Kershaw, F., Locke, C. C., Conners, M. G., Dawson, C., Aylesworth, S., et al. (2022). Potential impacts of floating wind turbine technology for marine species and habitats. *J Environ. Management*, 307. doi: 10.1016/j.jenvman.2022.114577

Mooney, A., Andersson, M., and Stanley, J. (2020). Acoustic impacts of offshore wind energy on fishery resources: an evolving source and varied effects across a wind farm's lifetime. *Oceanography* 33, 82–95. doi: 10.5670/oceanog.2020.408

Morizot, B. (2020). *Manières d'être vivant* (Arles: Actes Sud).

Morton, T. (2012). *The ecological thought* (Cambridge: Harvard University Press).

Morton, T. (2018). *Being ecological, pelican* (UK: Pelican Books). doi: 10.7551/mitpress/11638.001.0001

Normandeau, E., Tricas, T., and Gill, A. (2011). Effects of EMFs from undersea power cables on elasmobranchs and other marine species. *(No. OCS Study BOEMRE 2011-09). U. S. Dept. Interior Bureau Ocean Energy Manage. Regulation Enforcement Pacific OCS Region*. Camarillo, CA.

Peschko, V., Mendel, B., Mercker, M., Dierschke, J., and Garthe, S. (2021). Northern gannets (Morus bassanus) are strongly affected by operating offshore wind farms during the breeding season. *J. Environ. Manage.* 279, 111509. doi: 10.1016/j.jenvman.2020.111509

Peschko, V., Mercker, M., and Garthe, S. (2020). Telemetry reveals strong effects of offshore wind farms on behaviour and habitat use of common guillemots (Uria aalge) during the breeding season. *Mar. Biol.* 167, 118. doi: 10.1007/s00227-020-03735-5

Peters, R. C., Eeuwes, L. B. M., and Bretschneider, F. (2007). On the electrodetection threshold of aquatic vertebrates with ampullary or mucous gland electroreceptor organs. *Biol. Rev.* 82, 361–373. doi: 10.1111/j.1469-185X.2007.00015.x

Punt, M. J., Groeneveld, R. A., van Ierland, E. C., and Stel, J. H. (2009). Spatial planning of offshore wind farms: A windfall to marine environmental protection? *Ecol. Econ.* 69, 93–103. doi: 10.1016/j.ecolecon.2009.07.013

Reubens, J., Braeckman, U., Vanaverbeke, J., Van Colen, C., Degraer, S., and Vincx, M. (2013). Aggregation at windmill artificial reefs: CPUE of Atlantic cod (Gadus morhua) and pouting (Trisopterus luscus) at different habitats in the Belgian part of the north Sea. *Fish Res.* 139, 28–34. doi: 10.1016/j.fishres.2012.10.011

Schuster, E., Bulling, L., and Köppel, J. (2015). Consolidating the state of knowledge: A synoptical review of wind energy's wildlife effects. *Environ. Manage.* 56, 300–331. doi: 10.1007/s00267-015-0501-5

Serres, M. (1990). *The natural contract, Ann arbor* (Ann Arbor: The University of Michigan Press).

Smyth, K., Christie, N., Burdon, D., Atkins, J. P., Barnes, R., and Elliott, M. (2015). Renewables-to-reefs? - decommissioning options for the offshore wind power industry. *Mar. pollut. Bull.* 90 (1-2), 247–258. doi: 10.1016/j.marpolbul.2014.10.045

Stanley, D. R., and Wilson, C. A. (1989). Utilization of offshore platforms by recreational fisher- men and scuba divers off the Louisiana coast. *Bull. Mar. Sci.* 44 (2), 767–776.

Stengers, I. (2019). *Résister au désastre* (Wildproject / Dialogues: Editions Wildproject), p87.

Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N., et al. (2018). A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renewable Sustain. Energy Rev.* 96, 380–391. doi: 10.1016/j.rser.2018.07.026

Teilmann, J., and Carstensen, J. (2012). Negative long-term effects on harbour porpoises from a large-scale offshore wind farm in the Baltic - evidence of slow recovery. *Environ. Res. Lett.* 7, 045101. doi: 10.1088/1748-9326/7/4/045101

Tougaard, J., Hermannsen, L., and Madsen, P. T. (2020). How loud is the underwater noise from operating offshore wind turbines? *J. Acoust. Soc Am.* 148, 2885–2893. doi: 10.1121/10.0002453

Uexküll von, J. (1934). *Milieu animal et milieu humain* (Paris, Rivages: Editions Rivages) 2010.

van Hal, R., Griffioen, A., and Van Keeken, O. (2017). Changes in fish communities on a small spatial scale, an effect of increased habitat complexity by an offshore wind farm. *Mar. Environ. Res.* 126, 26–36. doi: 10.1016/j.marenvres.2017.01.009

Virtanen, E. A., Lappalainen, J., Nurmi, M., Viitasalo, M., Tikanmäki, M., Heinonen, J., et al. (2022). Balancing profitability of energy production, societal impacts and biodiversity in offshore wind farm design. *Renewable Sustain. Energy Rev.* 158, 112087. doi: 10.1016/j.rser.2022.112087

Viveiros de Castro, E. (2009). *Métaphysiques cannibales* (Paris: P.U.F).

Wahlberg, M., and Westerberg, H. (2005). Hearing in fish and their reactions to sounds from offshore wind farms. *Mar. Ecol. Prog. Ser.* 288, 295–309. doi: 10.3354/meps288295

Wilson, J., and Elliott, M. (2009). The habitat-creation potential of offshore wind farms. *Wind Energy*. 12, 2, 203–212. doi: 10.1002/we.324

WWF (2014). Environmental impacts of offshore wind power production in the north Sea. *A Literature Overview*. https://tethys.pnnl.gov/sites/default/files/publications/WWF-OSW-Environmental-Impacts.pdf.