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How should the use of offshore wind farms by birds be approached and should it be encouraged?

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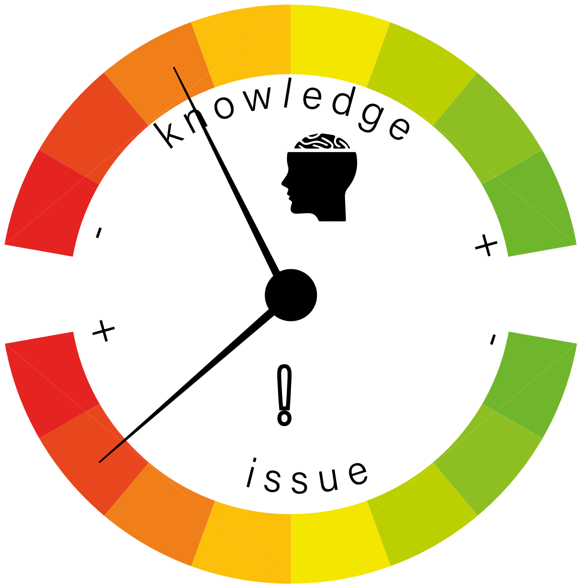

Question deemed by the experts to be "a major issue given the risks of interactions between seabirds and offshore wind farms; knowledge of these interactions needs to be improved, in particular in order to gain a better understanding of birds' behaviour within offshore wind farms"

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Introduction

The development of offshore wind farms off the French coast is set to increase the risk of interactions with birds that live in and use the marine environment for feeding, breeding, migrating, etc. The fact that birds are regularly observed on artificial structures at sea (lighthouses, beacons, boats, etc.) raises the question of how they will use offshore wind farms and whether this should be encouraged.

To begin with, this bulletin will outline how artificial structures at sea, and in particular wind farms, may attract seabirds. It will also address the main risks to which birds are exposed within a wind farm and the consequences of their presence for operators. The question of whether (or not) the use of these artificial structures by seabirds should be encouraged is then explored in light of the possible interactions between these structures and bird species. In the final section, a set of measures aimed at facilitating the coexistence of seabirds and offshore wind farms is put forward with a view to reconciling: (i) the projected large-scale development of wind farms off the French coast (45 GW of installed capacity expected by 2050, compared with around 1.4 GW of capacity already installed in 2024) and (ii) the need to protect and preserve these species.

In short

Artificial structures at sea constitute **a stimulus in the marine environment** for **birds**. According to the **nature** of these structures (floating or bottom-fixed), the **distance/visibility** from the coast, the **architecture** of the structures and the possibility of **co-location with other activities**, offshore wind farms can provide sites for **resting** (opportunistic, for birds coming to rest between two foraging trips, or regular, for birds coming to sleep), **nesting** (for species capable of nesting in an artificial environment) and **feeding** (for birds feeding directly from the structures, using the structures to hunt and/or benefiting from the reef effect as a new food source). By exploring the **risks for birds** and the implications for **offshore operators**, this bulletin puts forward two visions of the possible use of offshore wind farms by birds.

Definitions

Seabirds

Seabirds are birds which depend on marine resources for their subsistence [9]. They are closely associated with the marine environment for all or a large part of their life cycle and use the marine environment for feeding and reproduction [3]. Seabirds include gulls, cormorants, terns, gannets, etc.

Colony

A group of individuals within a territory containing no resources other than nests [9].

Demography

Studying the demography of a species involves analysing spatial and temporal variations in population structure and dynamics (increase, decrease, stability), based on fertility, mortality and migration characteristics (demographic factors) [9].

Reef effect

Increase in the environment's capacity to host hard substrate or sedentary organisms (i.e. species present most of the time, on an annual or at least seasonal basis) as a result of the introduction of a hard substrate of anthropogenic origin (e.g. a wind turbine foundation). The reef effect applies at the scale of the artificial structure and its immediate surroundings and has consequences for the marine ecosystem at different scales [5].

Guano

Accumulated excrement of seabirds [9].

Migration

The seasonal journey of "migratory" birds to breeding grounds (known as prenuptial migration) or to wintering grounds (post-nuptial migration) [10].

Nesting

Period during which a bird species will nest, i.e. build their nest, lay eggs and raise their chicks [10].

Phenology

All observations relating to the effects of environmental conditions (temperature, weather conditions, etc.) on the date of emergence of certain periodic biological phenomena (migration, flowering, etc.) [15].

Plasticity

Ability of a species to adapt to different environmental conditions [1].

Sanderlings in flight

Population

Group of individuals with a greater probability of interbreeding with one another than with other individuals of the same species [9].

Resting place

A place used by birds to rest or sleep. Depending on their distance from the coast, resting places will host varying numbers of birds [15].

Functional area

A spatially defined area with ecological functions (feeding, resting, reproduction, etc.) defined due to its physical environment and which performs specific functions [15].

In what respects are artificial structures at sea an asset for seabirds?

Artificial structures at sea (lighthouses, beacons, oil platforms, wind farms, etc.) represent "stimuli" in oceanic habitats equating to an "artificial archipelago" of structures [16]. For many bird species, the presence of an artificial structure offers opportunities for resting, nesting and feeding [1] (**Fig. 1**, in pale orange). Although artificial structures at sea are used by birds all year round, the presence of certain species is dependent on (i) the breeding phenology, (ii) the distance from the coast and (iii) the phenology of migratory birds. The closer the artificial structure is to the coast, the more likely it is to be used by birds [1].

Resting

At sea, an artificial structure can serve as a resting or roosting place, where many bird species will sleep or rest. Depending on the species and their needs, the use of such a structure may be:

- Occasional, using the structure for a short resting period. In this case, use is opportunistic and irregular. This may be the case for a Northern Gannet (*Morus bassanus*) resting between foraging trips [1] or a migrating bird using an artificial structure as a stop-off while it regains strength, for example [9, 16].
- Regular use of the structure as a roosting place. This is the case of the Great Black-Backed Gull (*Larus marinus*), for example, which can be seen to gather in groups of several dozen (or more) individuals on artificial structures at sea [1].

Nesting

Certain species of seabirds are known to build their nests on artificial structures [1]. One example of this is the Black-Legged Kittiwake (*Rissa tridactyla*) whose colonies can be found on buildings, bridges or oil platforms, as seen in the North Sea [4]. In France, like the European Shag (*Phalacrocorax aristotelis*), it is one of the species capable of nesting on isolated artificial structures at sea. In fact, the Black-Legged Kittiwake is the most likely species to be found nesting in offshore wind farms, as they are able to use artificial structures up to 200 km from the coast [4]. This is thanks to their high plasticity in relation to habitat selection and nesting. For some colonial nesting species, the presence of a few individuals on an artificial structure can make these structures more attractive to other individuals of the same species.

Feeding

Any artificial structure deployed at sea will quickly be colonised by a variety of plant and animal species. These species may colonise the underwater part of the structure, which is regularly emergent, as well as its crevices (micro-organisms, larvae, algae, crustaceans, molluscs, etc.). This is referred to as the reef effect [1]. Insects (flies, butterflies, etc.) may gather around the aerial part of these structures [1, 8]. The presence of these artificial structures provides a new food source for seabird species which could also be of interest to certain species of waders (e.g. Ruddy Turnstones – *Arenaria interpres* – which come to feed on the platforms) or migrating passerines which feed on insects or crustaceans [1].

More generally, the presence of these artificial structures at sea can also trigger changes in the ecosystem from which birds can indirectly benefit thanks to enhanced access to food resources through various effects: the temporary aggregation effect, the perch effect and the opportunity effect (**Fig. 1**, in dark orange).

• Temporary aggregation effect

The reef effect generally leads to temporary aggregation (temporary and localised increase) around the artificial structure of mobile fauna using a large marine surface area (mainly fish, but also crustaceans, etc.). These mobile species, generally passing predators, are attracted by the new food source generated by the reef effect [5]. This aggregation phenomenon may arouse the interest of certain seabirds, attracted by the availability of food. This is the case for instance at the Saint-Nazaire wind farm, which attracts large numbers of seagulls within the immediate vicinity of the monopiles [1].

• Perch effect

Some birds of prey, such as the Peregrine Falcon (*Falco peregrinus*), can use large artificial structures as vantage points to hunt other birds. Peregrine Falcons have been spotted on the rotor of the Floatgen wind turbine when it is not operating [1], as well as on some American oil platforms in the Gulf of Mexico [11].

• Opportunity effect

Through an opportunity effect, the presence of an artificial structure at sea can spur certain bird species to explore and then use areas that are remote from the areas they usually use for feeding, breeding, roosting, referred to as "functional areas". Structures may therefore serve as “stepping stones” between two functional areas of interest [16].

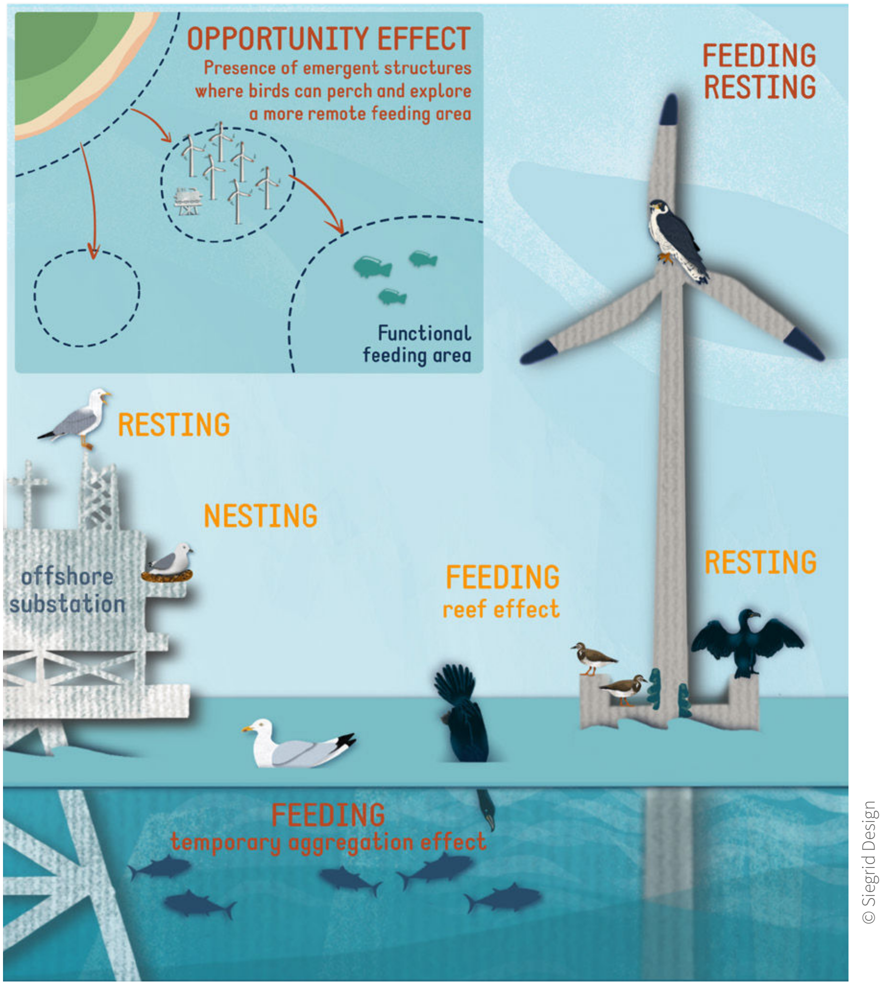

Fig. 1 *Overview of the main sources of interest of an artificial structure at sea (here a wind farm) for birds. In pale orange, interests directly linked to the presence of an artificial structure at sea; in dark orange, indirect interests. The opportunity effect can be explained by the presence of emergent structures where birds can perch and from which they can explore a more remote feeding area that would be inaccessible without this stop-off point.*

What makes offshore wind farms attractive?

Whatever the system deployed, the installation of any artificial structure at sea will result in interactions with birds and trigger an attraction or avoidance phenomenon depending on the species [7]. The plasticity of certain species means that they are sometimes able to adapt and integrate artificial structures into their life cycle (e.g. for nesting).

The development of wind farms off the French coast will lead to an increase in the number of artificial structures at sea and may arouse the interest of certain bird species. The extent of this interest will depend on several factors **(Fig. 2)**:

- **Structure size** (Fig. 2, in yellow): Given the intended dimensions of the wind turbine floats (36 x 55 metre Damping Pool® floating foundation for the Floatgen floating wind turbine at the Ecole Centrale de Nantes test site; 45 x 45 metres for the three floating wind turbines at the EOLMed pilot farm), they are likely to be more attractive to birds than bottom-fixed wind farms, which have more limited emergent surfaces that can be used by birds for resting or nesting;
- **Distance and visibility from the coast** (Fig. 2, in orange): Wind farms located close to the coast are more attractive to certain seabirds and coastal species (birds of prey, bats, etc.), which may use the sites for a large part of the year. These wind farms constitute potential areas of interest for feeding, resting and exploring new functional areas. Wind farms located beyond the visibility range and far from the coast are of less interest to coastal birds (with the exception of migratory birds or birds disoriented by harsh weather conditions) and will be used primarily by seabirds;
- **Number of secondary steel structures and foundation/float architecture** (Fig. 2, in blue): All elements attached to the wind farm structures, such as work platforms, railings, handrails, reinforcements, ladders, steps, are likely to be attractive to birds, which will use them as perches and/or vantage points, or even for building nests;
- **Co-location** (Fig. 2, in green): Offshore wind farms can represent an opportunity for certain sectors of activity, such as aquaculture, which could benefit from these surfaces in the marine environment to rear species of commercial interest. For example, mussel farming projects are being studied at the Belwind and C-Power wind farms in Belgium (Edulis project) and at the Saint-Brieuc wind farm in France (AMTI project).

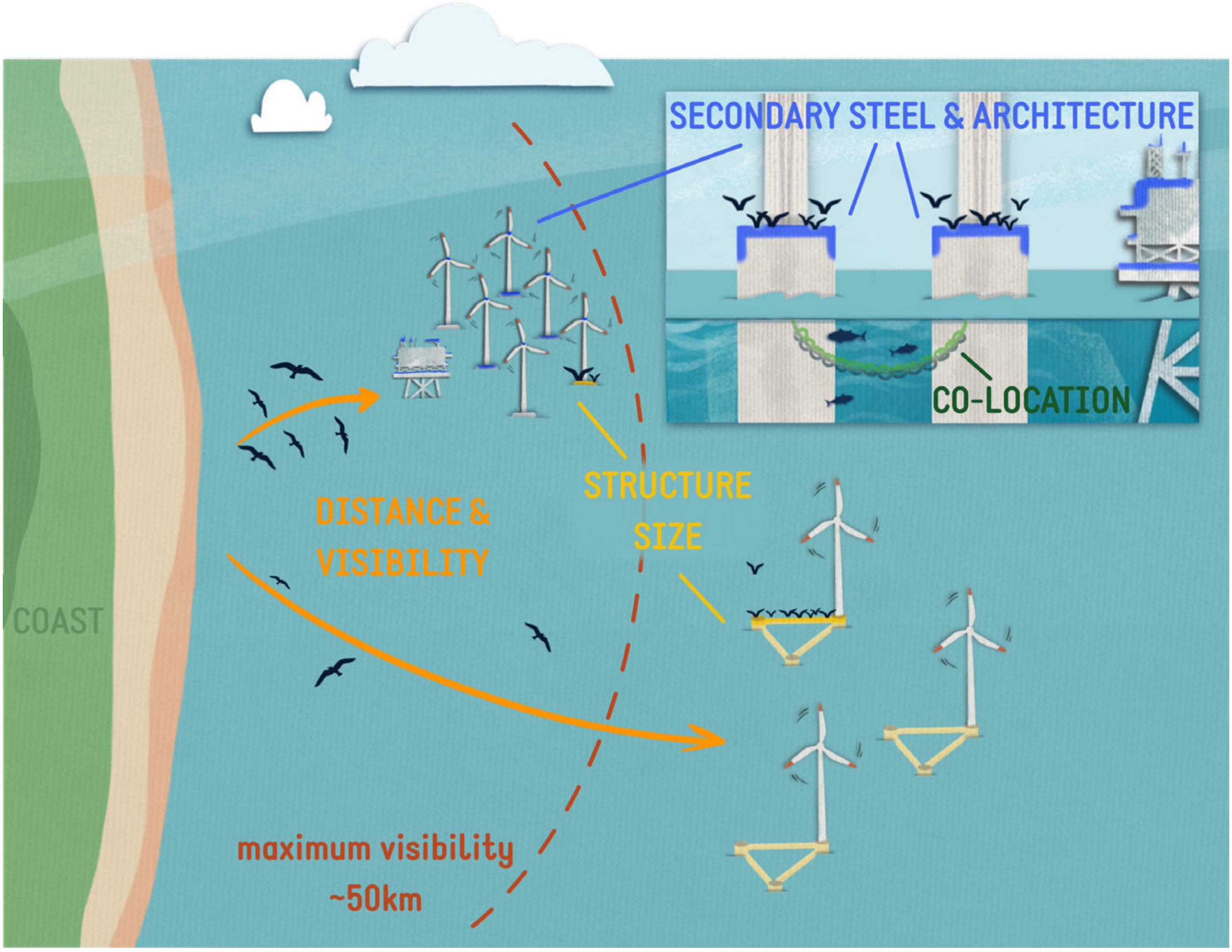

Fig. 2 *Overview of the main factors liable to influence the degree of attractiveness of wind farms for birds*

What risks are entailed for...

European Shags

... birds

The main effects of wind farms for birds are: **collision**, **attraction**, **avoidance**, **habitat loss** and the **barrier effect** [1]. The barrier effect results in birds avoiding the wind farm completely, as it forms a physical obstacle to their movements. Its main consequences are increased flight durations (and the associated risks in terms of energy expenditure by individuals and populations) and habitat loss [1]. The wind farm avoidance rate for seabirds varies from species to species and is generally not 100%. The species with the highest avoidance rates are Northern Gannets, loons, Great Crested Grebes (*Podiceps cristatus*) and Northern Fulmars (*Fulmarus glacialis*), with avoidance rates greater than or equal to 99.5% [6, 7, 8 , 12, 13, 14].

For some species, avoidance rates can be high but vary according to the season and the position and characteristics of the wind farm (e.g. turbine density) [7]. In the case of certain migratory birds that encounter several wind farms on their migration routes, the successive barrier effects contribute to an increase in cumulative effects.

On the other hand, for birds that are not sensitive to the barrier effect (e.g. Laridae), the use of wind farms could expose birds to an increase in:

- **risks specific to offshore wind farms**: collision, change of habitat (reef effect and increase in water temperature due to the discharge of substation cooling water and the resulting changes in the ecosystem), light pollution, exposure to noise emissions, electromagnetic fields and chemical pollution inherent to the presence of cathodic protection systems and the industrial nature of the site (presence of oil, grease, etc.).
- **risks of interactions** due to:
    - **maintenance operations** (work on the structures and vessel movements within the wind farm), which can be a source of disturbance for birds that use the wind farm structures for resting, breeding or feeding.
    - **the multiple activities** within a defined area, which may increase the level of disturbance, with consequences for the birds' physical condition (particularly if the wind farm is located in a functional area). In France, in addition to maintenance operations, professional fisheries and pleasure boating are regulated but authorised within wind farms. Industrial tourism activities (boat tours of wind farms) are developing and should also be taken into consideration.
- **risks of dispersal of natural colonies** for certain birds capable of nesting on artificial structures located close to the coast (< 20 km). Over and above the entailed risks of destabilising natural colonies, a number of questions remain:
    - Are the colonies established on these structures capable of persisting over time and achieving breeding success comparable to that of colonies established on the coast (ecological sustainability)?
    - Is the presence of colonies on these structures compatible with the expected energy outputs of these farms and do the colonies cause excessive disturbance (economic sustainability)?

For some species, such as the Black-Legged Kittiwake, these different cumulative risks apply. As this species is able to nest on artificial structures, it is exposed to risks of both collision and dispersal of natural colonies, especially when onshore colonies are in poor condition (predation, disturbance, habitat loss, etc.).

… wind farm structures and personnel?

Whatever the type of structure the birds colonise, their presence can lead to a deterioration in the condition of the occupied structures and in the working conditions for maintenance staff: presence of regurgitated remains (shells, fish bones, etc.), droppings/guano, nesting materials/debris (natural materials, pieces of plastic and netting, eggshells, remains of dead chicks, etc.), remains of dead birds in the case of an epidemic (avian flu), nest defence by breeding birds, etc.

The impact of the presence of birds for wind farm structures and maintenance personnel can be divided into three categories [18]:

- **Employee welfare** : Contamination of work clothing and tools;
- **Health and safety**: In dry weather, possible inhalation of dried guano and in wet weather, increased risk of slips and falls;
- **Structure deterioration**: Corrosion and abrasion of coatings by guano, as bird droppings are acidic and corrosive.

To reduce the risks, why not scare birds away?

Definitely not! Although it is advisable to keep birds away from the blades of wind turbines to reduce collision risks (painted patterns on blades, combined detection approach – radar + cameras – for curtailment, i.e. shutting down of wind farms during peak migration), introducing systems to directly deter birds from entering an offshore wind farm could prove counter-productive!

Firstly, because certain bird species, such as those in the Laridae family (gulls, etc.), are particularly difficult to scare away. Bird scaring devices can sometimes trigger a strong reaction (startle, flight, etc.), generating a sudden change in trajectory and increasing the risk of collision with the blades. These devices can also be a source of stress (occasional or chronic, depending on the device installed) and will cause non-negligible additional disturbance (emission of sound, light, laser signals, etc.) in a marine environment that is increasingly exposed to anthropogenic pressures.

Furthermore, such devices often prove ineffective because birds adapt quickly and learn to bypass the scaring devices [1]. The deterrents installed at Burbo Bank offshore wind farm in the UK to deter Great Cormorants proved ineffective and were quickly ripped off, destroyed or bypassed by the birds [11].

A study carried out at Burbo Bank offshore wind farm in Liverpool Bay (UK) examined the interactions between maintenance personnel and a resident population of Great Cormorants (*Phalacrocorax carbo*). Scoping interviews with on-site staff highlighted the recurrent presence of guano and dead/regurgitated fish on the structures. The structures most affected are the wind turbines around the edges of the wind farm. The risk for personnel is non-negligible, with the investigation revealing 12 cases of slips, trips and falls over a one-year period during maintenance operations due to the presence of guano in locations used by on-site operators (railings, ladders, etc.) [11].

Should the use of offshore wind farms by birds be encouraged?

View of the Floatgen floating wind turbine in the foreground and the Saint-Nazaire offshore wind farm in the background

This question is particularly complex as it raises a philosophical issue: to what extent should humans interfere with the management of nature?

Understanding the factors that cause a species to prefer one site over another is complicated. Seabirds are long-lived species, i.e. they have a long lifespan and a long reproductive cycle. Adults reach sexual maturity late and the fecundity rate is low (1 to 3 young per brood per year), but adults invest considerable time and effort into caring for their young. Any pressure exerted on adults therefore has a significant impact on the demographic dynamics of the population. This is very different from certain species with a short reproductive cycle (high fertility and rapid growth of young), thus compensating for higher adult mortality (the case of passerines for instance).

Furthermore, the introduction of measures to promote the use of offshore wind farms by birds will be specific to certain species. For example, measures intended for species capable of nesting on artificial structures will not be effective for other seabird species or migratory species.

Two hypotheses emerge on the consequences of encouraging the use of offshore wind farms by seabirds:

1. It will help to improve the survival or maintenance of populations of certain species (despite the loss of individuals due to interactions with wind turbines).

2. It is counter-productive because (i) the effects of wind farms (risks of collisions, disturbance, etc.) are too high to allow viable population development and (ii) specific systems introduced in wind farms to facilitate coexistence with seabirds are potentially ineffective.

In response to these two hypotheses, two proposed visions provide some answers to the initial question.

The first vision involves an approach that promotes research and innovation in order to facilitate the coexistence of birds and offshore wind farms. In view of the projected large-scale development of offshore wind farms in France, it is proposed that this coexistence be facilitated through technical innovations (designing foundations conducive to breeding birds, installation of specific structures for birds on the edges of wind farms, etc.), with monitoring of the effects on the seabird populations concerned as a critical requirement. This proposal is built on the assumption that an increase in exposure to the risks of seabird interactions with wind farms, and therefore in individual mortality, is acceptable as long as the effects on the population as a whole are beneficial.

This proposal does not meet with unanimous approval because, in the immediate vicinity of the coast and therefore of onshore nesting sites, the risk of desertion of onshore colonies in favour of artificial offshore colonies is too high, given the uncertainty over the long-term viability of populations in an artificial environment. Encouraging the use of offshore wind farms could go against measures currently in place to reduce collision risks and could overexpose birds to risks of impacts due to interactions with offshore wind farms (see above).

The second vision therefore proposes to apply the precautionary principle and focuses on the known risks related to the impacts of bird interactions with wind turbines (see above). Encouraging the use of offshore wind farms by birds could lead to an increase in exposure to these risks. We note that, in the specific case of nesting, nests may be disturbed by regular structure maintenance operations.

Whatever the point of view expressed, it is difficult for the experts to take a stance due to the lack of knowledge on bird's behaviour and use of offshore wind farms, as well as the uncertainty over habituation by different bird species. While observations made in offshore wind farms in Europe, and in particular in the North Sea, may provide some insights, observations made at a given site cannot be extrapolated to all offshore wind farms. Numerous aspects, such as the wind farm configuration, environmental conditions, species present in the area, state of bird populations, distance from the coast, must all be studied on a case-by-case basis.

Gulls resting on a wind turbine foundation at the Saint-Nazaire offshore wind farm

How can the coexistence of seabirds and offshore wind farms be facilitated?

The first measure to be implemented with a view to seabird conservation would be to avoid coexistence by not installing offshore wind farms in areas that are known to be of interest for birds. This first step in the **"avoid, reduce, compensate" sequence (ERC)** should be applied to all areas identified as of importance for birds (breeding, feeding, moulting or wintering areas) under the Birds Directive, also known as "Special Protection Areas" or SPAs. This first **avoidance** measure should be applied as a priority during the definition of potential areas for offshore wind development by the State.

Secondly, **reduction measures**, implemented once the offshore wind farms have been installed, aim to reduce all the pressures exerted by each wind farm, in particular:

Phototaxis	*Limit the impact of light pollution generated by lighting requirements (marine and air navigation safety), particularly for migratory species.*
Disturbance	*Organise training and awareness-raising for operators in charge of construction and maintenance work at wind farms* *Define access corridors to the farm to promote habituation and limit disturbance* *Optimise maintenance conditions to minimise interactions with birds, particularly breeding birds (where present)* *Take into account the biological rhythms of the species and define a suitable maintenance schedule so that major interventions take place outside breeding periods.* *Limit chemical pollution and the use of detergents for cleaning structures (for instance by opting for high-pressure washing with seawater)* *Regulate co-location of leisure craft and industrial tourism vessels with offshore wind farms*
Farm architecture	*Position the offshore substation (a significant source of attraction for certain breeding species such as the Black-Legged Kittiwake) outside the wind farm* *Optimise the platform and foundation architecture to limit the stagnation of droppings for instance and facilitate coexistence with birds when present*

As a last resort, **compensation measures** can be proposed to preserve bird populations. Such measures could consist, for instance, in preserving natural nesting sites to dissuade birds from moving to artificial structures, managing natural and introduced predators at nearby natural breeding sites, and/or creating platforms on the edges of wind farms to host certain birds whose onshore breeding conditions have considerably deteriorated.

However, such compensatory measures should only be implemented as a last resort and should not be encouraged to the detriment of prior "avoid" and "reduce" measures. Generally speaking, these compensatory measures are only beneficial for a few target species. They do not apply to all the bird species that could potentially be affected by an offshore wind farm. Introducing compensation measures in the marine environment is a complex task with no guarantee of success [1].

In addition to these "avoid, reduce, compensate" measures, **monitoring and support measures** can be introduced. Monitoring programmes should help to improve knowledge of (i) the ecology and (ii) the health status of seabird and migratory bird populations at sea (colony monitoring, breeding success, population dynamics, species distribution at sea, trajectories and behaviour of migratory birds, etc.) and (iii) the interactions between these birds and offshore wind farms (behaviour of birds within wind farms, consequences of the barrier effect on the energy balance of species sensitive to this effect, etc.).

In practice, the experts suggest:

- Not installing bird scaring devices;
- Optimising on-site monitoring by taking qualified ornithologists on board service vessels during offshore wind farm maintenance operations to identify the species present and define appropriate monitoring protocols;
- Monitoring any breeding success of birds on site and comparing breeding success rates at artificial sites (offshore wind farms) with natural sites;
- Monitoring the occupation of offshore wind farms and surrounding areas, and monitoring the use of different structures using a range of complementary monitoring tools.

Finally, encouraging **research & development projects** devoted to the introduction of innovative systems could help to reduce the effects of wind farms and improve coexistence with birds when unavoidable. On-site studies and monitoring programmes could help to assess the relevance of all the avoidance and compensation measures implemented, as well as to enhance knowledge of existing interactions between birds and offshore wind farms.

What is "avoid, reduce and compensate" sequence?

Introduced in France by the nature protection law of 10 July 1976, the main aim of the "avoid, reduce, compensate" sequence is "to avoid damage to the environment, to reduce unavoidable damage and, if possible, to compensate for significant effects that can be neither avoided nor sufficiently reduced". This sequence must be applied to any project, plan or programme whose implementation could have an impact on the environment. Avoidance should be given first priority, as it is the only method that guarantees no damage to the environment, whereas compensation should only be used as a last resort, if it has not been possible to avoid or reduce the impacts.

Conclusion

While some substantiated knowledge is available on the behaviour of certain emblematic species (such as the Black-Legged Kittiwake and the Great Black-Backed Gull) in offshore wind farms, there are still many unknowns on the potential interactions between offshore wind farms and seabirds and migrating land birds. In France, the offshore wind farms currently in operation or under construction are coastal wind farms, sometimes located close to colonies of certain species capable of extending their natural breeding area to colonise artificial structures (case of the Black-Legged Kittiwake, for example). Nesting within wind farms is therefore a possibility. Before encouraging this practice, it is important to consider the risks of interactions (for birds and workers) and to introduce appropriate monitoring programmes. Knowledge of the actual use of offshore wind farms by birds remains very scarce and there are still knowledge gaps on the effects of the various pressures exerted by wind farms on birds (change of habitat, collisions, etc.) and their ecology (population sizes, demography, migratory routes, seasonal patterns, etc.).

The complexity of these interactions, together with the notion of cumulative effects on populations, makes it difficult to assess the potential effects of offshore wind farms on birds, especially against a backdrop of climate change.

Some uncertainties, such as the frequency of use of offshore wind farms and/or the ability of certain species to nest and maintain a viable population within the farms, could be addressed by carrying out targeted research and development projects and fostering technical innovation. To better understand the behaviour of birds in offshore wind farms, ambitious monitoring programmes must be implemented using the most appropriate methodological tools. In this way, it will be possible to assess whether the various innovations and measures implemented are successfully ensuring the viability of the populations they are designed to support.

Sandwich terns

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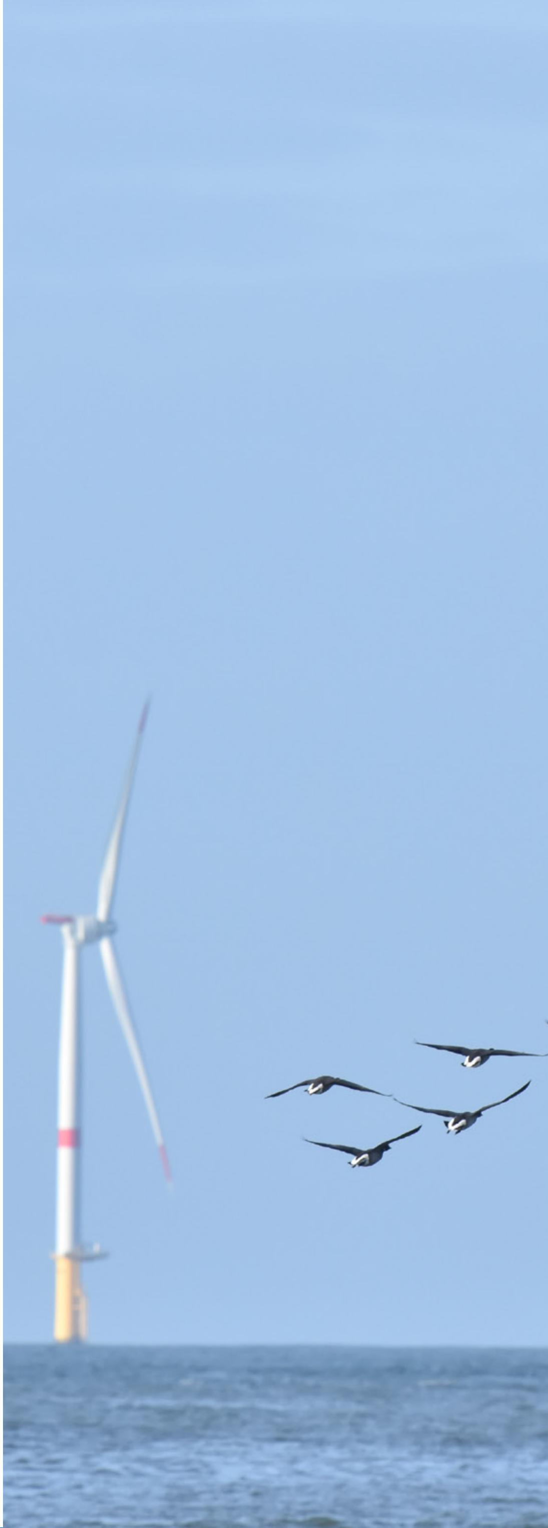
COME3T is an initiative that brings together a panel of national and regional stakeholders (universities, industrial firms, consultants, regions, State services, etc.) within a steering committee that puts forward questions, based on public concerns and key environmental and socio-economic issues identified by the stakeholders, to committees of neutral, independent experts. For each topic, a committee of experts is established following a call for applications and provides information, summaries and recommendations on the environmental and socio-economic issues associated with offshore renewable energy.

https://www.france-energies-marines.org/projets/come3t/

An initiative coordinated by France Energies Marines.

France Energies Marines is a research and innovation centre devoted to offshore wind energy with a recognised industrial, economic and societal impact in France and internationally. Its mission is to overcome the barriers facing the offshore wind sector. Supported by the French State, the Institute, driven by a 90-strong multi-disciplinary team and a network of international experts, underpinned by one-of-a-kind infrastructures, conducts excellence-oriented multi-partner research projects. The results of these projects are transferred to the sector in the form of research and expertise services, operating licences, know-how transfer and participation in expert committees and networks. One of its four key research programmes is devoted to the environmental and social integration of offshore wind farms.



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