Optimising offshore wind at the ecosystem scale

Minimising the impacts to wildlife by looking beyond national boundaries

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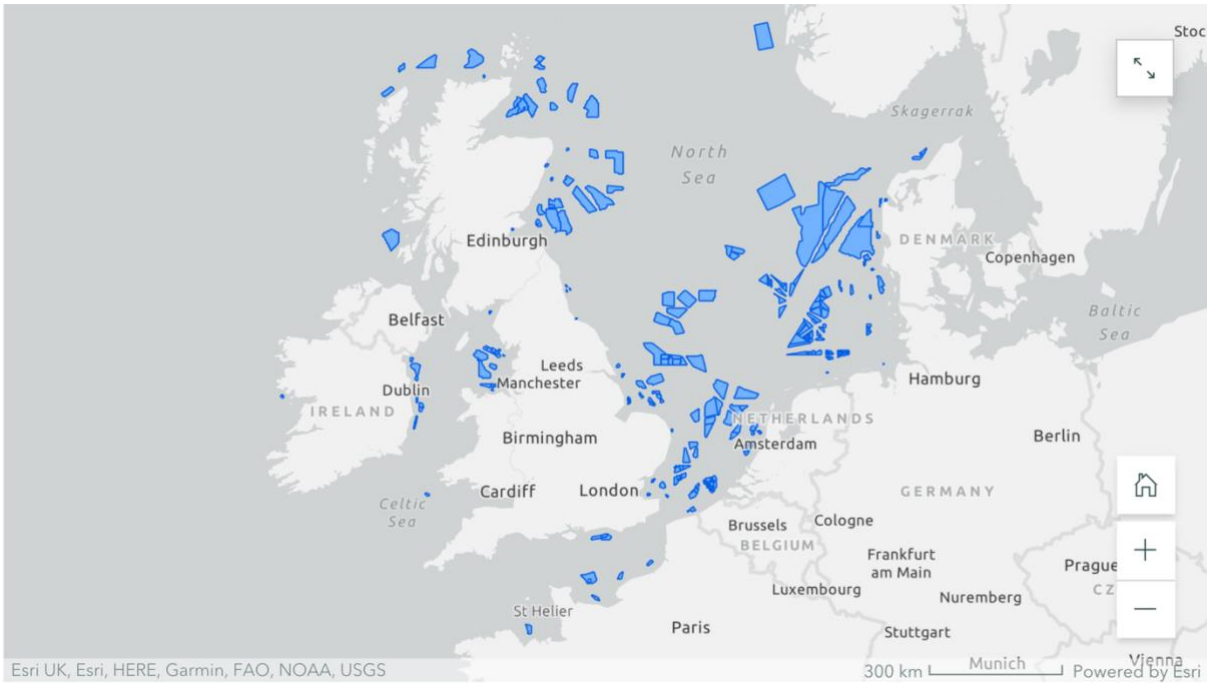
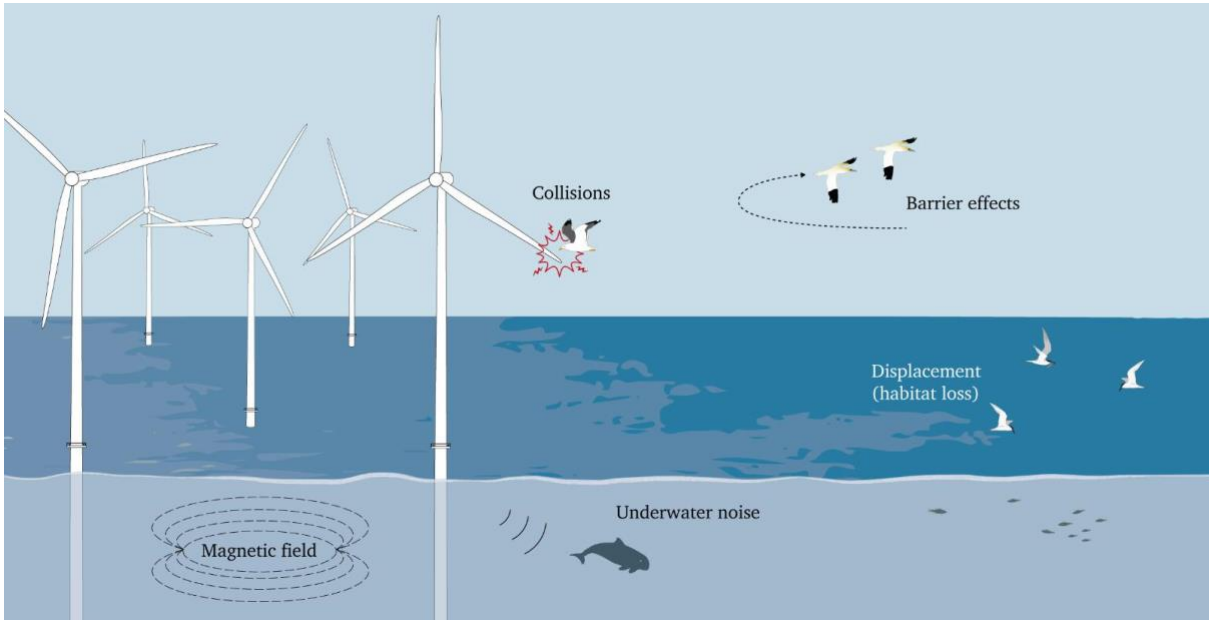
Introduction

Europe is the global leader in the development of offshore wind energy. As a result of policies to reduce reliance on fossil fuels and to mitigate the effects of climate change, international agreements were set to reduce CO_2 emissions, also by increasing renewable energy production. In the Paris Agreement in 2015, a goal was set to reduce CO_2 emissions by 49% in 2030 in comparison to 1990. The European Commission estimates between 240 and 450 GW of offshore wind power is needed by 2050 to keep temperature rises below 1.5°C, up to twenty times current capacity. Electricity will represent at least 50% of the total energy mix in 2050 and 30% of the future electricity demand will be supplied by offshore wind.



Potential wind farm developments in 2030

Wind farm effects



Seabirds

Flying birds are at risk of **collisions**. Mortality may occur due to collision with the rotor blades, the hub of a wind turbine, or from the air flow around moving rotors. Collision risk is thought to be highest during periods with bad visibility, such as during the night or in misty weather.
Birds are forced to adjust their flight paths due to **barrier effects**. Wind turbines may form a barrier to flight routes, resulting in longer flights and increased energetic costs or even loss of habitat where these costs outweigh the gains.

Displacement results in effective **habitat loss**. An area may become less attractive to birds due to disturbance from wind turbines or increased human activity, such as boat transfers or construction noise. As disturbance is highest during the construction and decommissioning phases, its effects on birds can be temporary. Nevertheless, the effects of disturbance also occur when the wind farm is operational and can therefore be considered as long-term effects. Birds may avoid the entire wind farm and even large areas around the wind farm due to rotating rotor blades and/or the presence of large objects within their habitat. As a result, a certain proportion of their usable habitat gets lost.

Indirect effects on birds include changes to prey species and ecological conditions (from large-scale changes in currents to local habitats). In an offshore environment, these indirect effects mainly consist of bottom-up processes, such as altering the presence and abundance of potential prey for birds.

Marine mammals

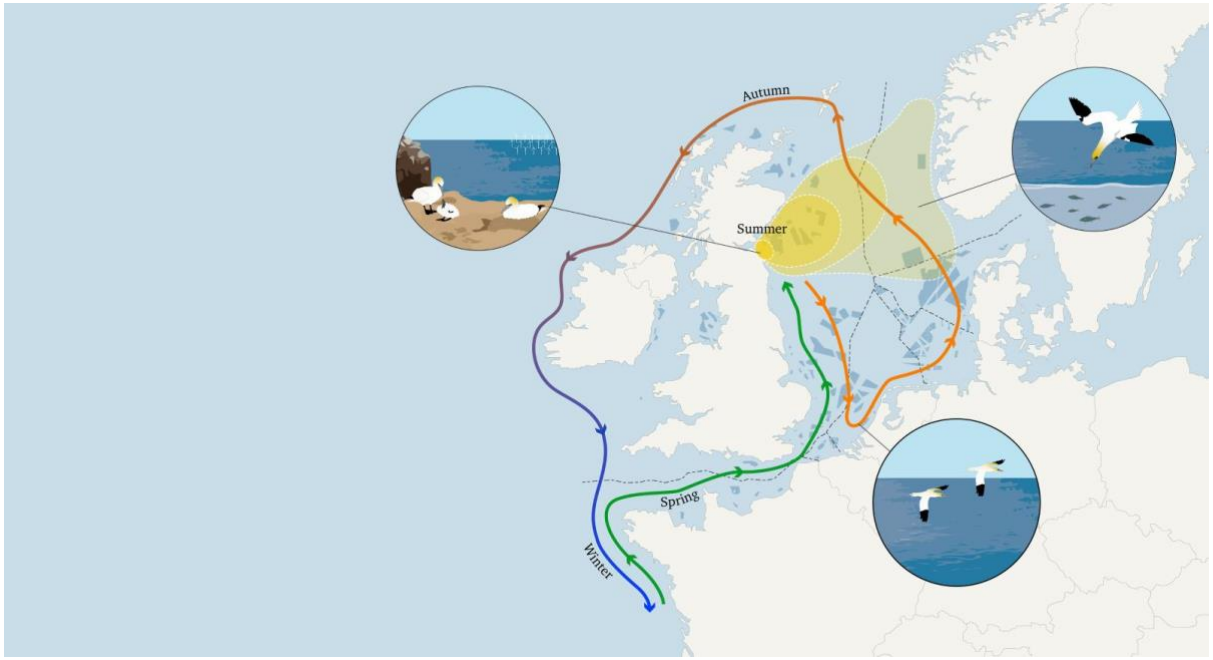
Underwater noise primarily affects marine mammals during construction because of pile-driving activities. Furthermore, marine mammals are affected by sounds from vessel activity and operational wind turbines. Underwater noise may lead to temporal disturbance and displacement, or even hearing damage.

Collision risk for marine mammals involves the risk of colliding with vessels associated with the construction and maintenance of an offshore wind farm, resulting in severe injuries or death. These risks may be exacerbated by other factors like underwater noise and electromagnetic fields.

The **electromagnetic fields** created by underwater cables associated with offshore wind farms may affect the navigational ability of marine mammals and prey distributions, which could lead to increased energetic costs or even strandings.

Like birds, **indirect effects** on marine mammals may occur through to the effects of the construction and exploitation of a wind farm on the prey and ecological conditions, both locally and at the large-scale. These effects can result in changes in the presence and abundance of potential prey and may affect marine mammals either negatively or positively.

The Northeast Atlantic as one habitat

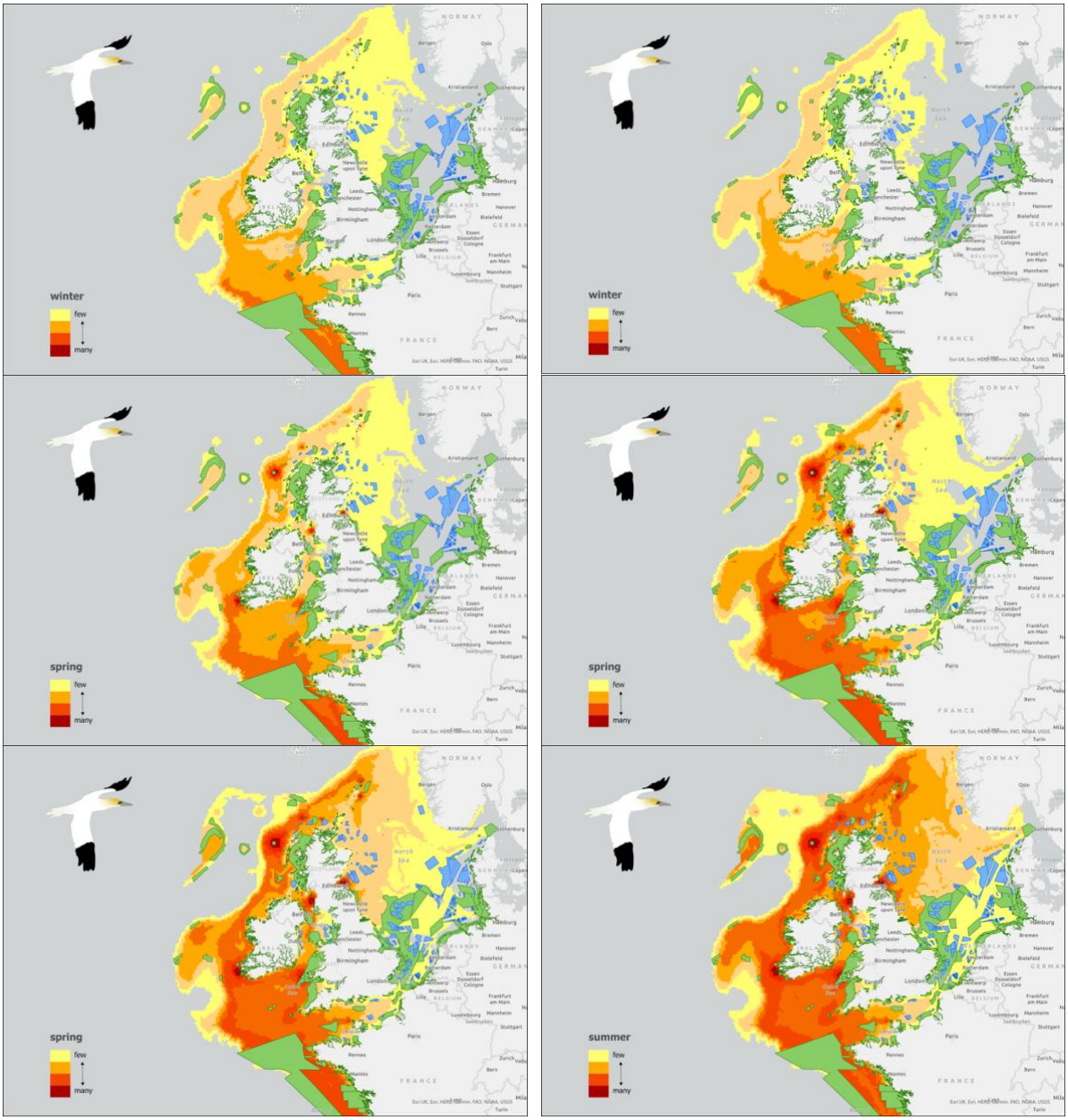


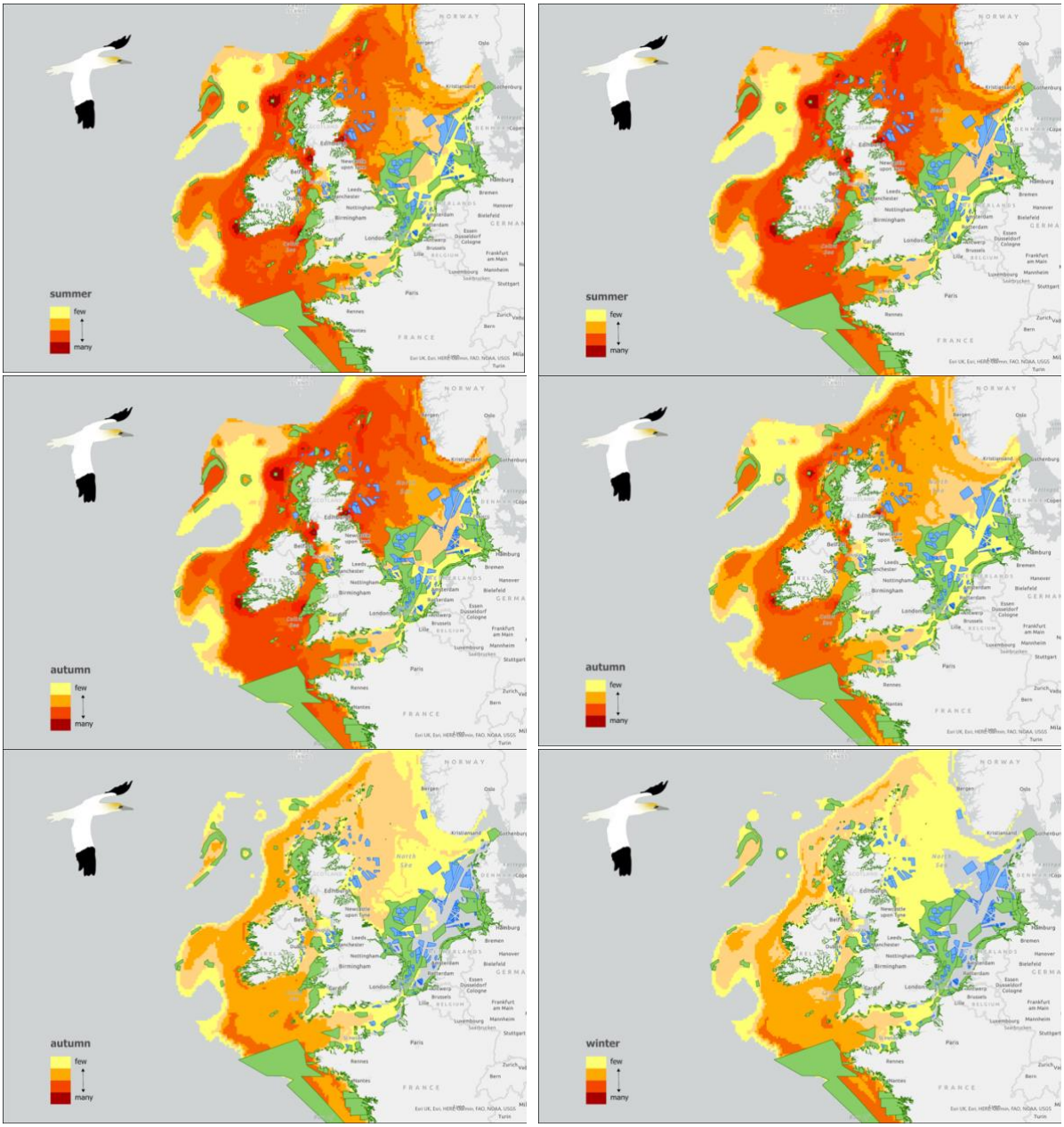
A key step in the evaluation of the potential interactions between marine animals with proposed wind energy developments is understanding the scale at which effects may occur. Seabirds and marine mammals are highly mobile organisms and cover large distances during foraging trips. Tens to hundreds of kilometers are not unusual, especially outside the breeding season when animals are not bound to a certain breeding site. We provide examples of three seabird and a marine mammal species, showing how they use the Northeast Atlantic region as one habitat throughout their annual cycle, without recognising national borders. The **black-legged kittiwake** is a widespread but declining species, vulnerable to collisions with offshore wind turbines. The **northern gannet** is a widespread species that travels long distances, but is vulnerable to collisions as well as habitat loss. The **Sandwich tern** is predominantly a coastal species with limited foraging ranges, but highly variable in its breeding site selection, travelling large distances between breeding sites. Sandwich terns breeding around the southern North Sea readily switch between colonies in the UK and the Netherlands, even within breeding seasons. The **harbour porpoise** is the most widespread cetacean in the Northern Hemisphere, and hence commonly part of evaluation processes of offshore wind farms.

Life without borders

Annual life-cycle

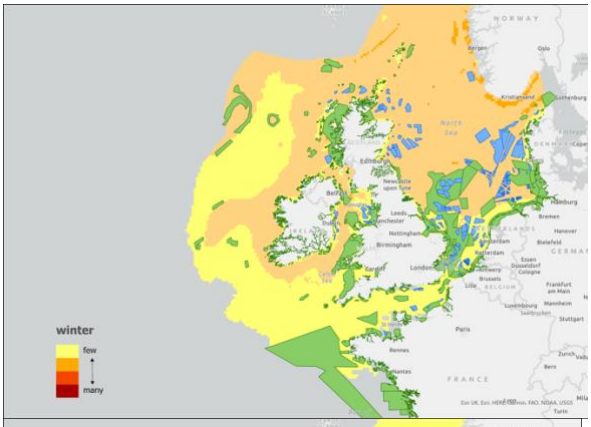
Breeding seabirds can cover large distances during foraging trips and can readily cross international waters. **Northern gannets** can forage over 500 km from their colony. After breeding birds can circumnavigate the North Sea before heading south via the west of Scotland and Ireland or through the English Channel.
(data from Waggitt et al. 2019)





Northern Gannet: January – December (right to left, top to bottom).

Breeding **black-legged kittiwakes** can forage up to 200 km from their colony. After breeding, birds spread throughout the marine environment. Birds present in the North Sea can include birds that have bred as far north as Svalbard. *(data from Waggitt et al. 2019)*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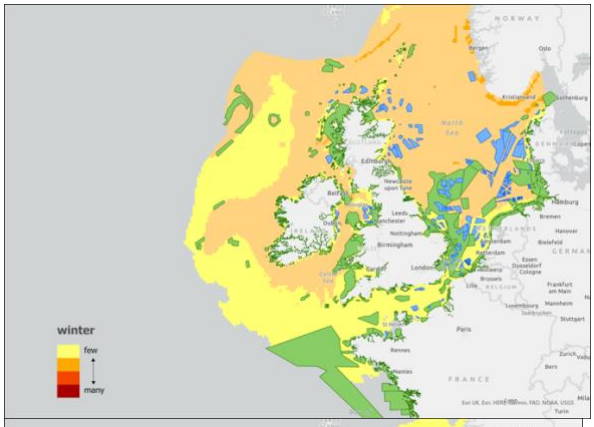
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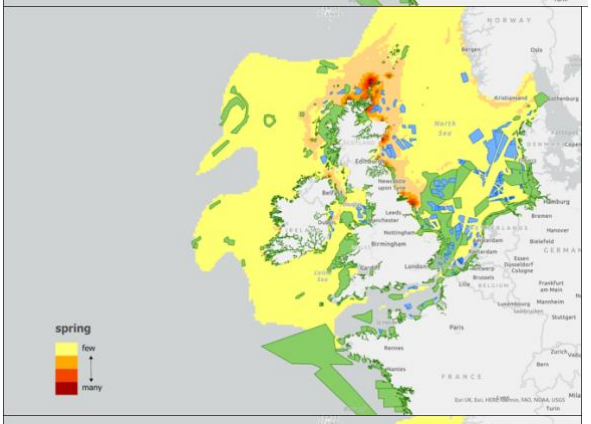
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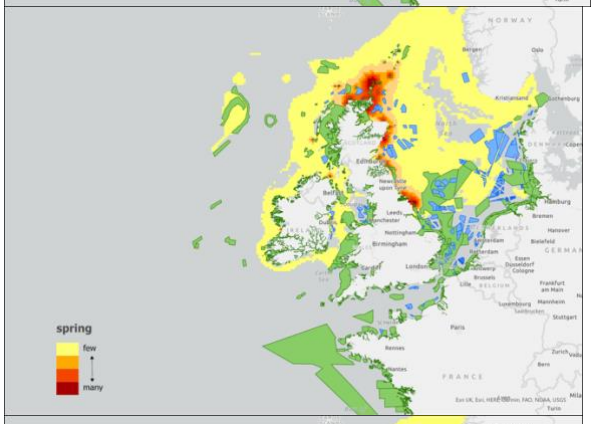
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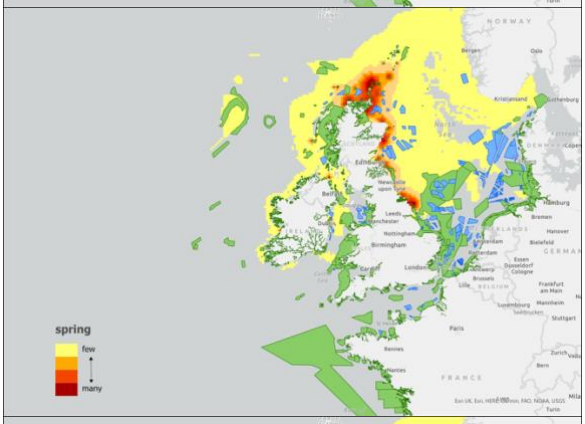
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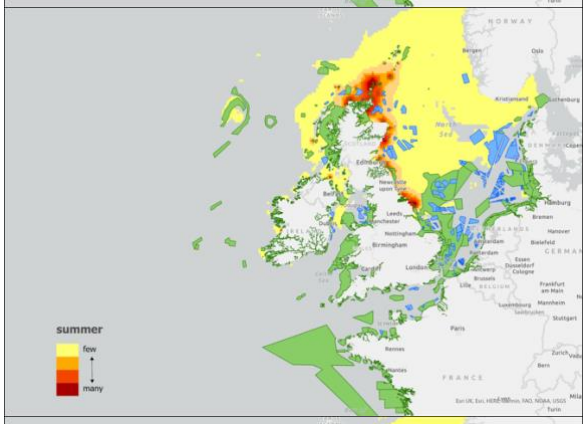
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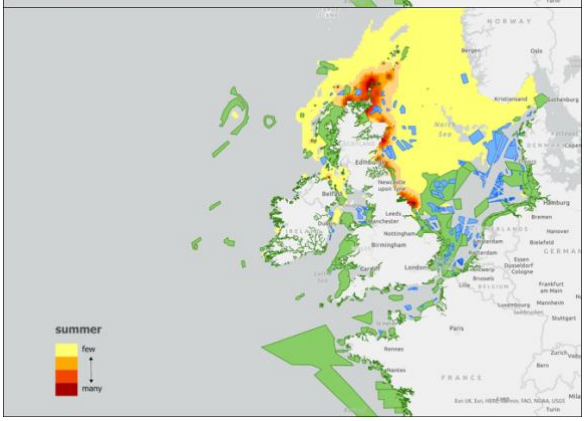
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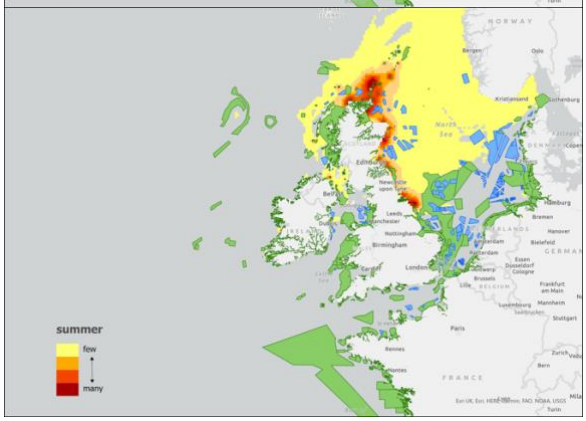
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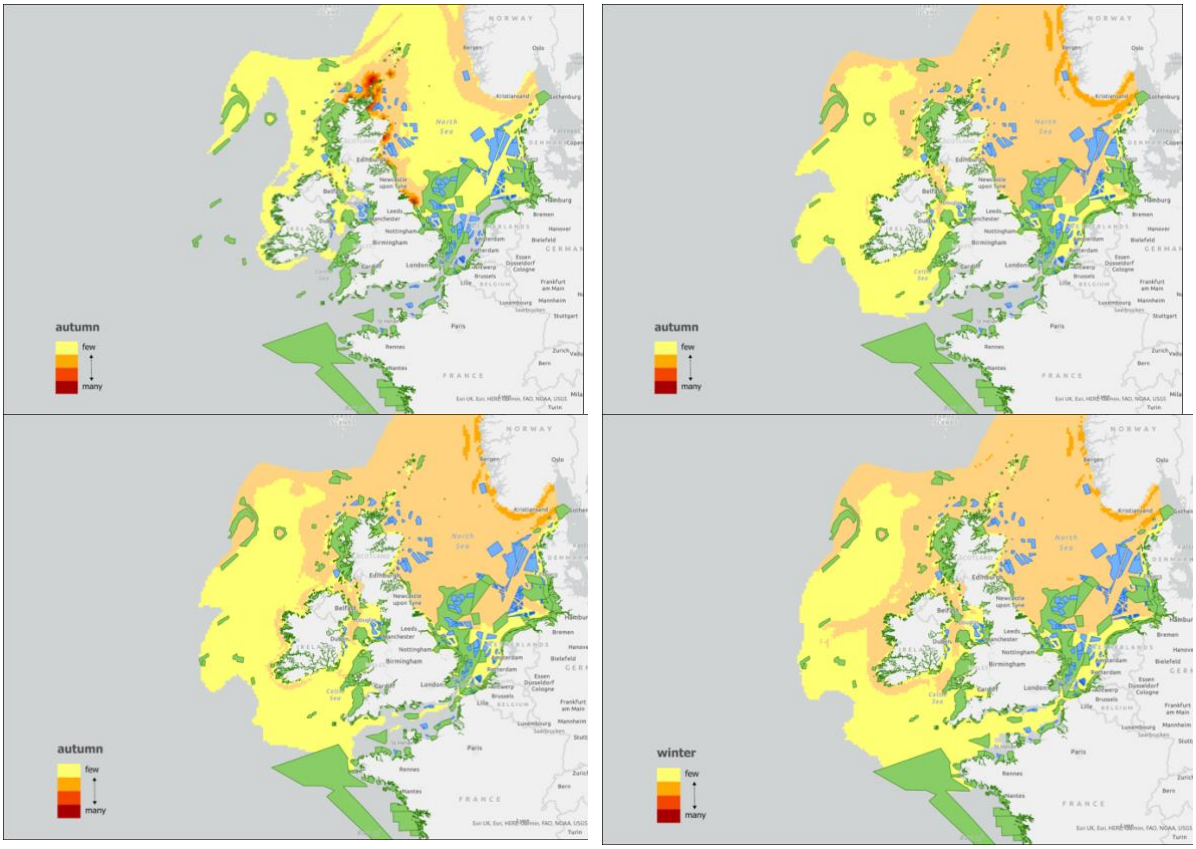
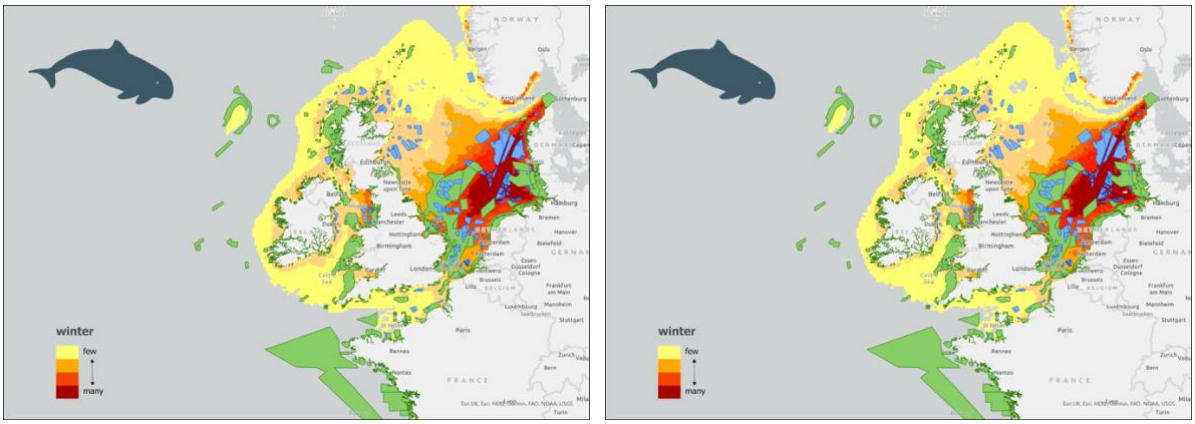
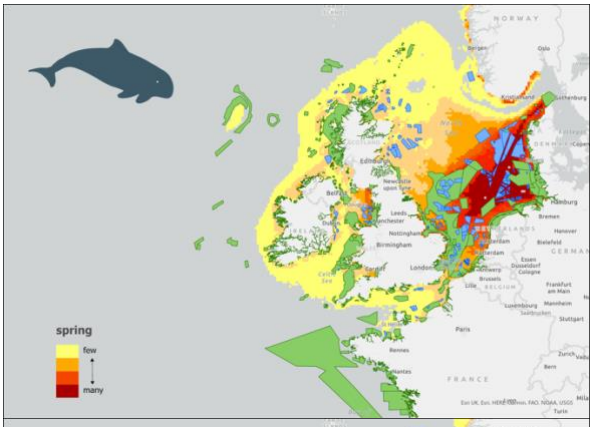


Black-legged Kittiwake: January – December (right to left, top to bottom).

Harbour porpoises occur throughout the Northeast Atlantic but favour shallower waters. Concentrations can occur off the coasts of the UK and in German waters during summer as animals calf.
(data from Waggitt et al. 2019)

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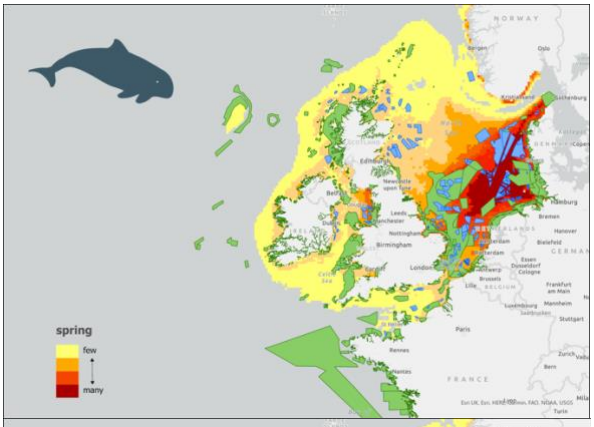
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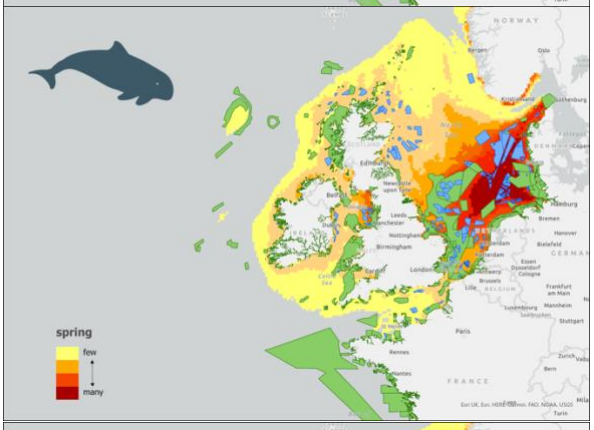
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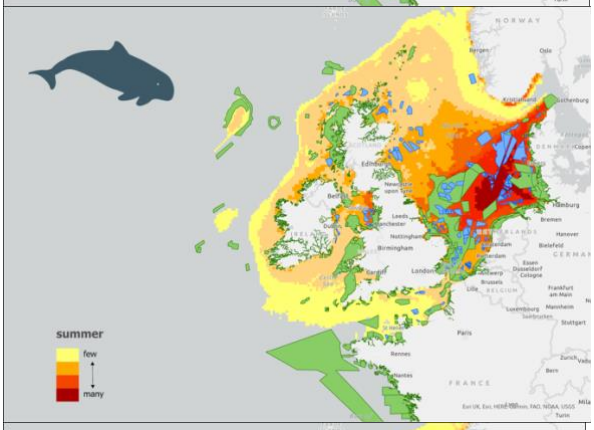
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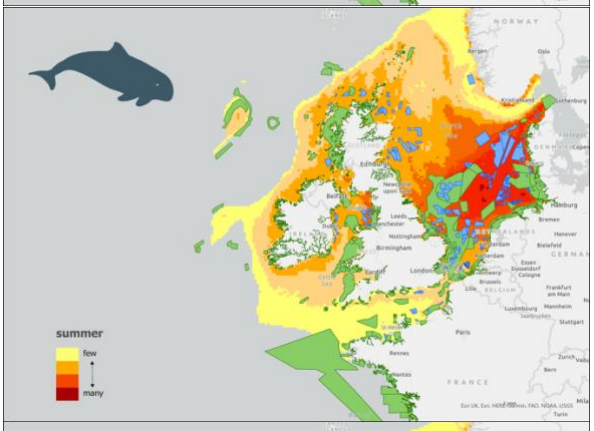
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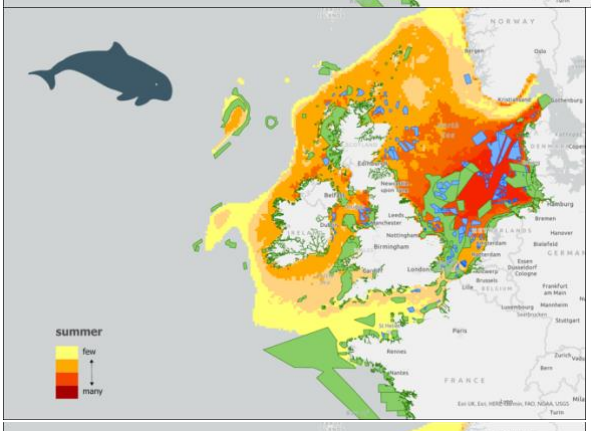
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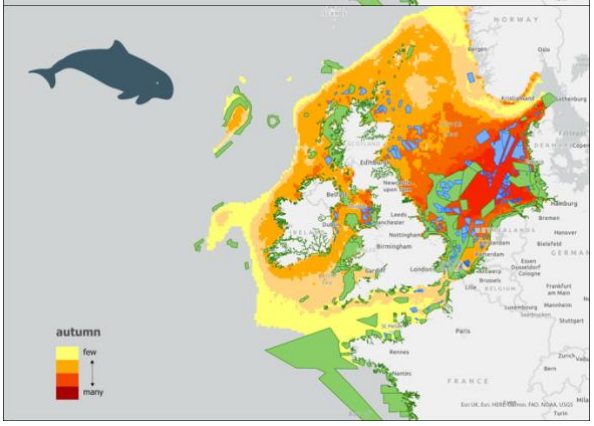
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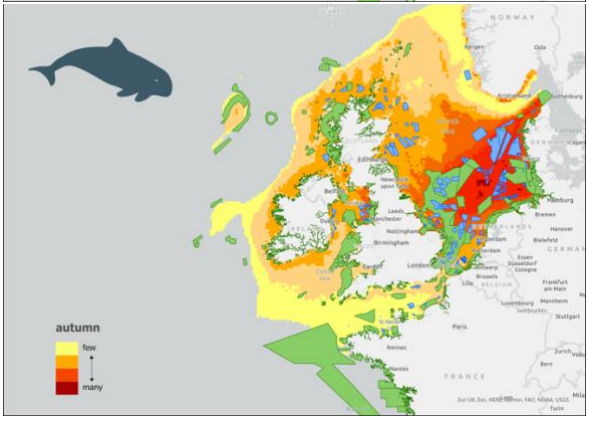
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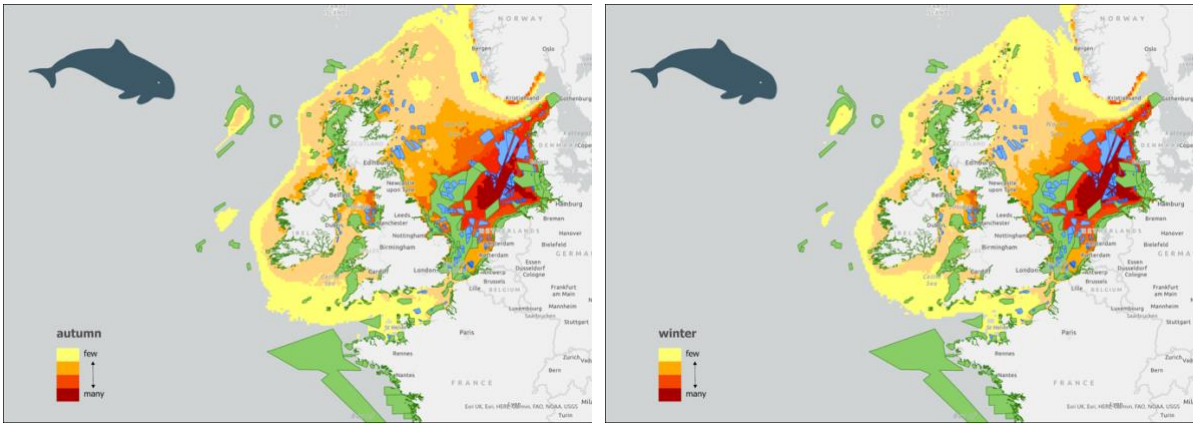


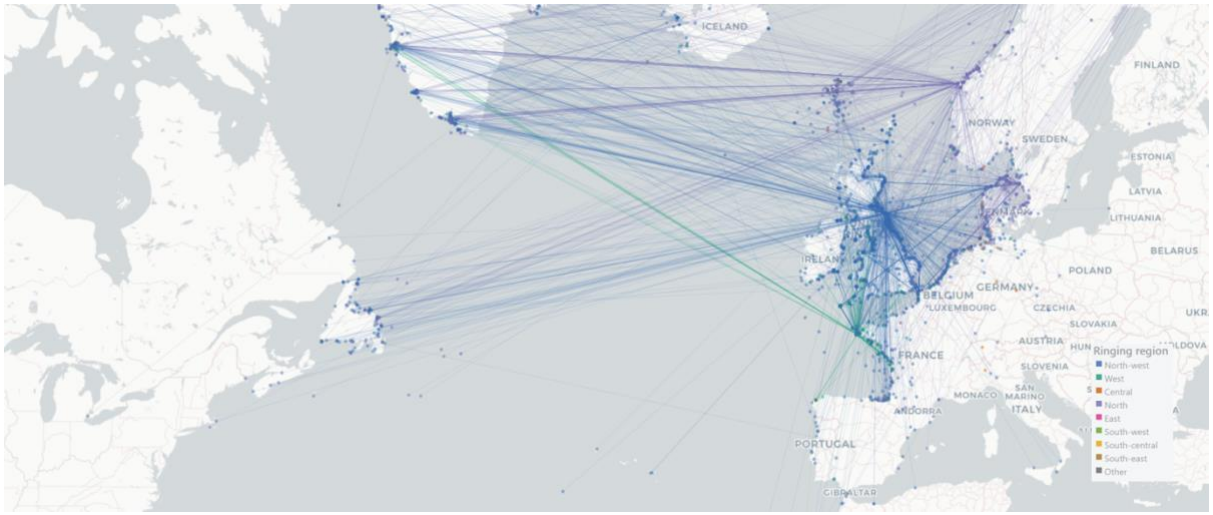
Harbour Porpoise: January – December (right to left, top to bottom).

International travel

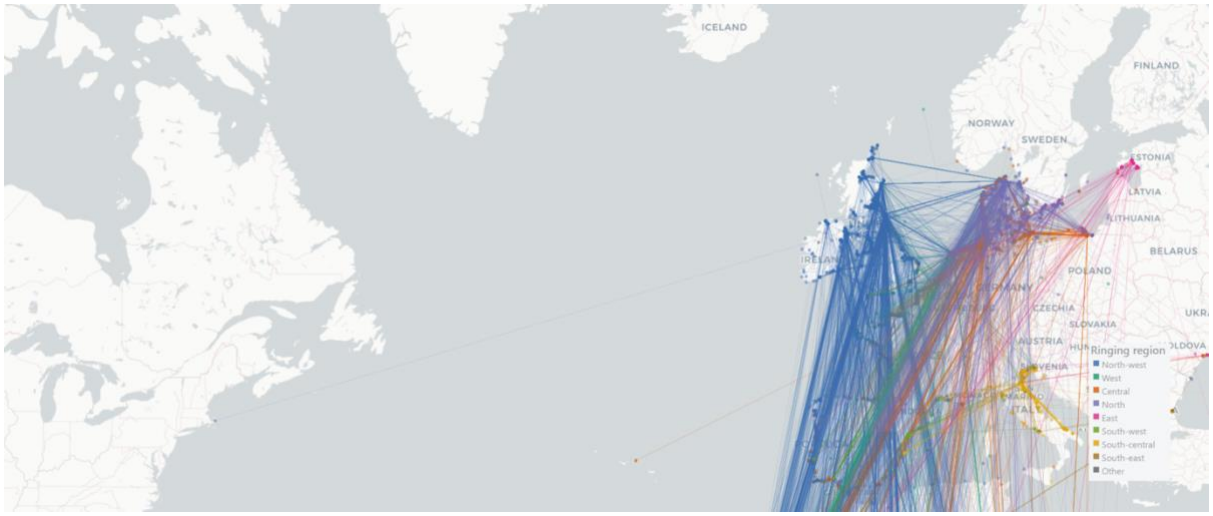
Many seabird species are accustomed to travelling, at times covering huge distances during migration between their breeding and wintering areas. **Northern gannets**, for example, leaving their colonies in Northern Europe often migrate along the Atlantic coast of France and Spain and off West-Africa. **Black-legged kittiwakes** can use the whole of the Northern Atlantic during the winter. **Sandwich terns** breeding in Northern Europe migrate mostly along the Atlantic coast as far south as Southern Africa, but can even continue their journey to the Indian Ocean.

Ringing studies reveal the extent of movements for **northern gannets** between the coasts of Northern Europe to Southern Europe and beyond. These movements connect countries in their importance for the species. Protection measures need to reflect the fact that birds do not stop at national borders.

(adapted from migrationatlas.org)



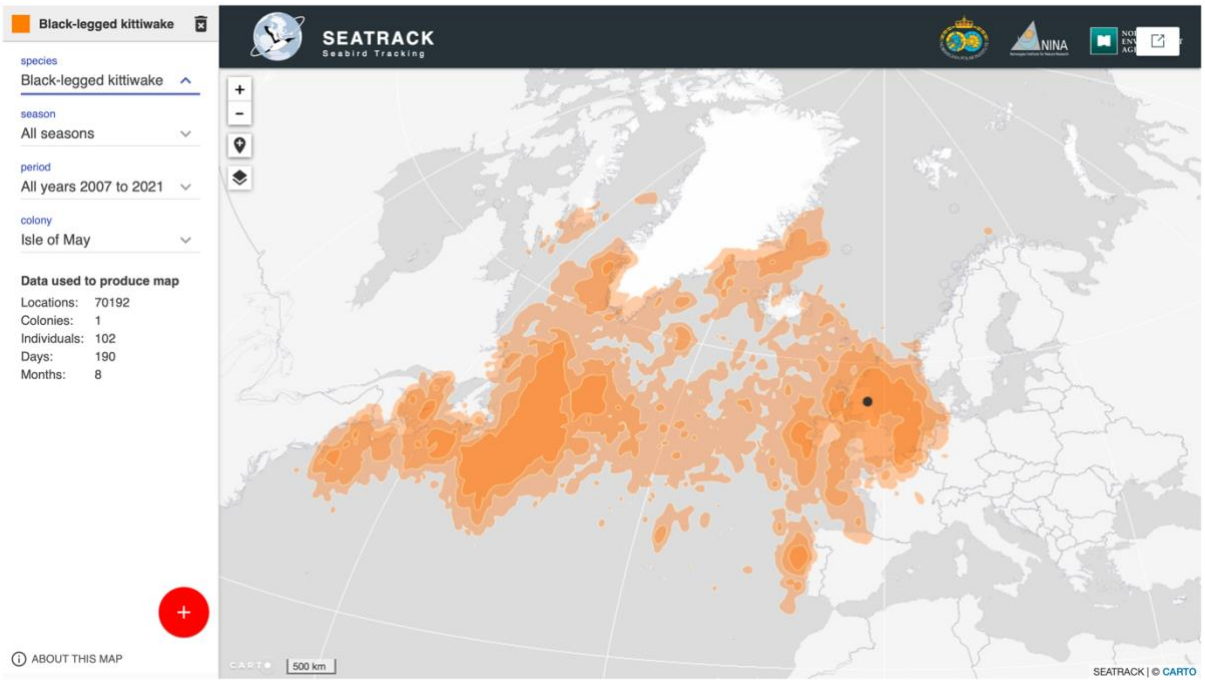
Ringing studies show **black-legged kittiwakes** disperse widely from their European breeding grounds towards Greenland and North America. During winter, the species occurs in the open sea, across the North Atlantic.
(adapted from migrationatlas.org)



Sandwich tern movements are highly seasonal. Breeding through northwest Europe, summering further north and wintering off the coasts of Africa and the Mediterranean. During their post-breeding migration, birds can occur along coasts from Sweden to Senegal and Ireland to Ivory Coast. Afterwards, they move to their wintering grounds in West Africa and Southern Africa.
(adapted from migrationatlas.org)

At home on the seas

Many species' migrate across unfavourable habitats. Seabirds are at home in the marine environment and do not always necessarily migrate to a specific site. **Black-legged kittiwakes**, for example, is a mainly pelagic species that has a large dispersal range without strictly defined migratory routes. Birds disperse widely over the whole North Atlantic. As is common in long-lived seabirds, immature birds roam the open sea for many years before eventually returning to land to look for a breeding colony.

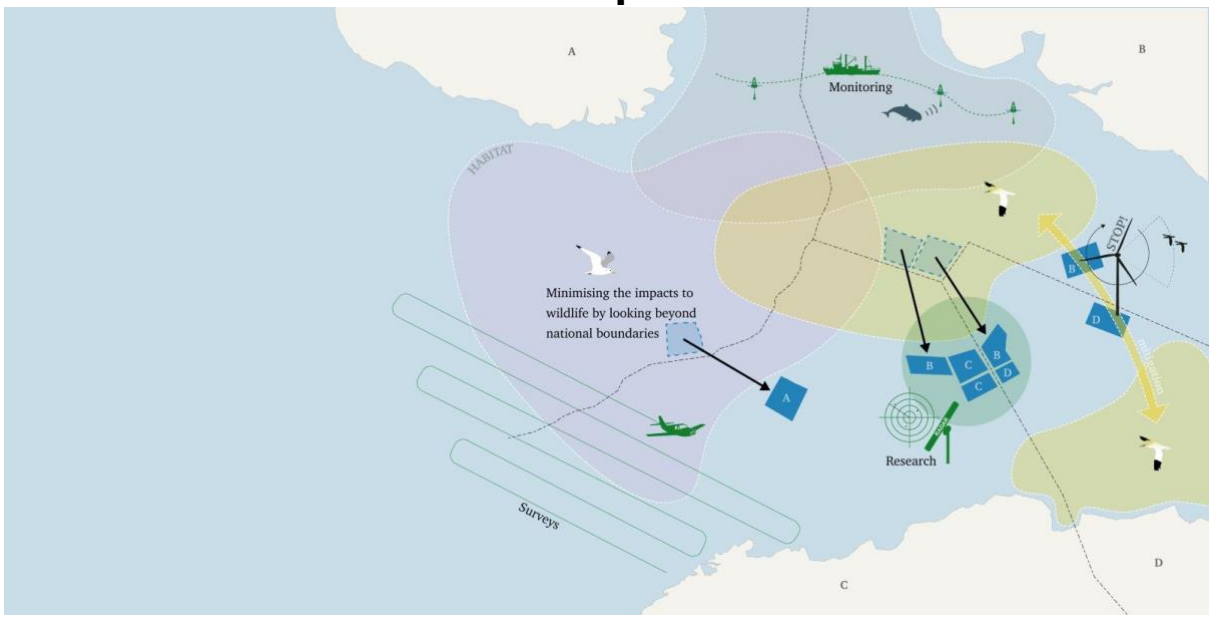


Visit: https://seapop.no/en/seatrack

Redefining the map

Seabirds are highly mobile organisms that inhabitant a very specific habitat. This marine habitat, being away from human settlements, is the very place we have drawn many international borders. Considering this marine environment as a single habitat where birds live out their lives, find food, a partner and rest, gives another view on where the ecological boundaries can be found. Looking beyond the national scale is essential when assessing the importance of specific areas for marine animals and for successful mitigation measures for offshore wind developments.

Need for international cooperation



The whole picture

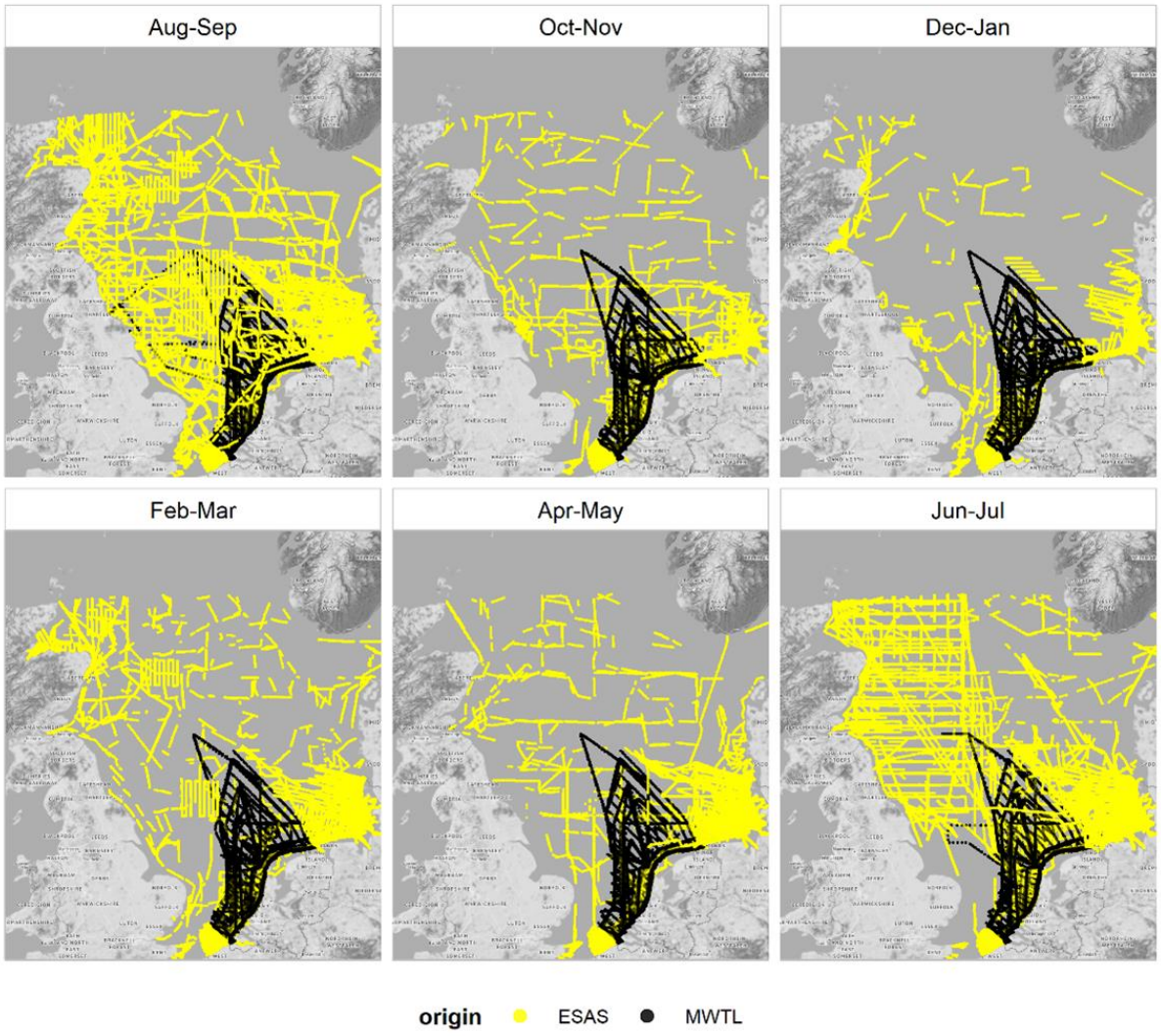
Seabirds and marine mammals are dependent on large parts of the marine habitat and form part of this distinct ecosystem. Populations span large areas and rely on different areas throughout the year, each essential for the survival of individuals and for the health of the population. Small-scale measures can help prevent conflict locally or during part of the life-cycle, but broad cooperation is fundamental to mitigating the effects of offshore developments.

Planning

The optimisation of offshore wind developments at the ecosystem scale can alleviate pressures on populations by reducing the effects of offshore wind in hotspot areas and at vulnerable life-stages. Considering factors such as wind farm effects and ecological importance will be essential in preventing conflicts between wildlife and offshore wind developments.

Monitoring

Varying monitoring effort can lead to difficulties in interpreting the abundance and distribution of seabirds, both locally and internationally. Population monitoring must look beyond individual colonies and protected areas to account for annual shifts and long-term changes, particularly in relation to offshore wind developments. Breeding success in one country may be being driven by factors in another. Monitoring data often forms the basis for assessments on numbers, distributions and population changes. Ensuring monitoring protocols and data exchange can help in identifying important areas at the international level.



Seabird counts from 1991 onwards until July 2020 for Dutch national MWTL surveys (black) and December 2019 for ESAS surveys (yellow)

Assessments

Assessments for offshore wind developments often rely on monitoring data. Local changes may be driven by changes elsewhere. Similarly, impacts from developments may not be immediately apparent, sometimes affecting birds over a larger scale or longer period than can be assessed at the local level. This is likely to become more apparent with the increase in developments around the North Sea. Linking breeding success and survival to all stages of the life-cycle can give insights into the processes at work beyond individual wind farms. Agreeing similar approaches when assessing the effects of offshore wind is crucial for minimising impacts on animal populations.

Mitigation

Mitigation measures such as avoiding ecological hotspots, bubble curtains and stop-on-demand can have local effects. Nonetheless, coordination of mitigation measures is essential as populations can be heavily influenced by local factors.

The strength of collaboration

Only through an international approach in realising offshore renewables can we safeguard the future integrity of the marine ecosystem in the Northeast Atlantic and further afield while simultaneously addressing the energy demands of constituent countries and the region as a whole. Looking beyond national boundaries provides opportunities and solutions for realizing our offshore energy requirements.

Minimising the impacts to wildlife by looking beyond national boundaries.

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Waardenburg Ecology