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# Marine Bird Habitat Quality

## Pilot Assessment

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OSPAR's Quality Status Report 2023

# Pilot Assessment of Marine Bird Habitat Quality




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## Contents

## Key Message

The human maritime activities shipping and offshore wind farming negatively affect marine birds wintering at sea in the south of the Greater North Sea (OSPAR Region II), whereas no negative effect of bottom-trawling fishery was found in the species examined. This pilot assessment helps to identify causes for decline in marine birds and to direct conservation measures appropriately.

## Message clé

Les activités maritimes humaines, le transport maritime et l'éolien offshore ont un impact négatif sur les oiseaux marins qui hivernent en mer dans le sud de la Mer du Nord au sens large (Région II OSPAR), alors qu'aucun effet négatif de la pêche au chalut de fond n'a été constaté sur les espèces examinées. Cette évaluation pilote permet d'identifier les causes du déclin des oiseaux marins et à orienter les mesures de conservation de manière appropriée.

## Background (brief)

According to the Strategic Objective S5.O4 in the Strategy of the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic 2030, OSPAR will at the latest by 2025 *take appropriate actions to prevent or reduce pressures to enable the recovery of marine species and benthic and pelagic habitats in order to reach and maintain good environmental status as reflected in relevant OSPAR status assessments, with action by 2023 to halt the decline of marine birds*.

Among the pressures acting on marine birds in the OSPAR Maritime Area, visual disturbance is often emanating from human activities at sea, because the distribution of marine birds often overlaps with activities such as shipping, fishing, extraction of gravel and sand, offshore wind farming, drilling for oil and gas - to mention just a few. Depending on species, birds react to such visual disturbance by taking flight, by diving or by avoiding the area of concern. These reactions can lead to higher energy expenditure of the birds and / or their displacement from preferred foraging areas.

The candidate indicator *Marine bird habitat quality* is concerned with quantifying the relationship between maritime human activities and bird distribution at sea. By comparing the observed quantitative distribution (i.e. the spatio-temporal abundance), which is influenced by human activities, with a scenario without such disturbance, the indicator shows where and to which degree a marine bird species is affected by the activities. This information allows the application of appropriate conservation measures in terms of space and disturbing activity.

The indicator is generally of relevance for all species, including those in the *OSPAR List of Threatened and/or Declining Species and Habitats*.

## Background (extended)

There is much evidence about how marine birds are disturbed by human activities. Escape flights and escape diving have been measured in relation to the distance of approaching ships, with considerable differences between the species. Mean escape distance ranged from 80 m in great black-backed gull to 1 600 m in common scoter (Fliessbach et al. 2019). Further, it has been shown that areas with intense ship traffic tend to be avoided by species sensitive to visual disturbance (Kube & Skov 1996, Schwemmer et al. 2011).

Likewise, visual disturbance by wind turbines in offshore wind farms causes very different species-specific reactions in marine birds. Whereas some species such as gulls and cormorants are commonly observed inside wind farm footprints, others are avoiding such offshore wind farms to various degrees, with effects observed up to distances of more than 10 km (Dierschke et al. 2016, Vanermen et al. 2019, Mendel et al. 2019).

Other activities have indirect effects. For example, aggregate extraction, and bottom trawling fishing disturb or even destroy the seabed habitats, with consequences for marine birds feeding on benthic prey or demersal fish species. Fisheries, on the other hand, can have positive effects for some bird species, because some birds use discarded fish as a food resource (Camphuysen et al. 1995).

This indicator can be applied to all marine bird species, including those in the *OSPAR List of Threatened and/or Declining Species and Habitats* (OSPAR Agreement 2008-6), during the periods in the annual cycle when they inhabit the open sea. In this pilot assessment, only one species listed as threatened and / or declining, the black-legged kittiwake (*Rissa tridactyla*) could be addressed, because the other species do not occur in the assessment area, the Southern North Sea.

The indicator was designed to fit the requirements of the Marine Strategy Framework Directive (2008/56/EC, MSFD) and The Commission Decision 2017/848, which for Article 8 assessments of marine birds includes the criterion D1C5: *The habitat for the species has the necessary extent and condition to support the different stages in the life history of the species*. This indicator addresses the condition of the habitat in terms of disturbance by human activities.

## Assessment Method

### Overview

This candidate indicator pilot assessment builds on the same data and the first steps of analysis as the pilot assessment for the offshore extension of the Common Indicator B1 (*Marine Bird Abundance*). It covers the same seven species also addressed in that pilot assessment and the same area, i.e. the North Sea sections of Belgium, the Netherlands and Germany species in the OSPAR sub-division IId (Southern North Sea, see **Figure 1**).

The indicator:

i. produces models for the observed spatio-temporal abundance of species,
ii. identifies covariates (including human activities) explaining the current patterns of occurrence, and (based on these correlations) predicts spatio-temporal abundance for scenarios without human activities.
iii. The comparison of both scenarios is used to sum up negative effects of activities on seabirds, reflected in the metric $D_{global}$.

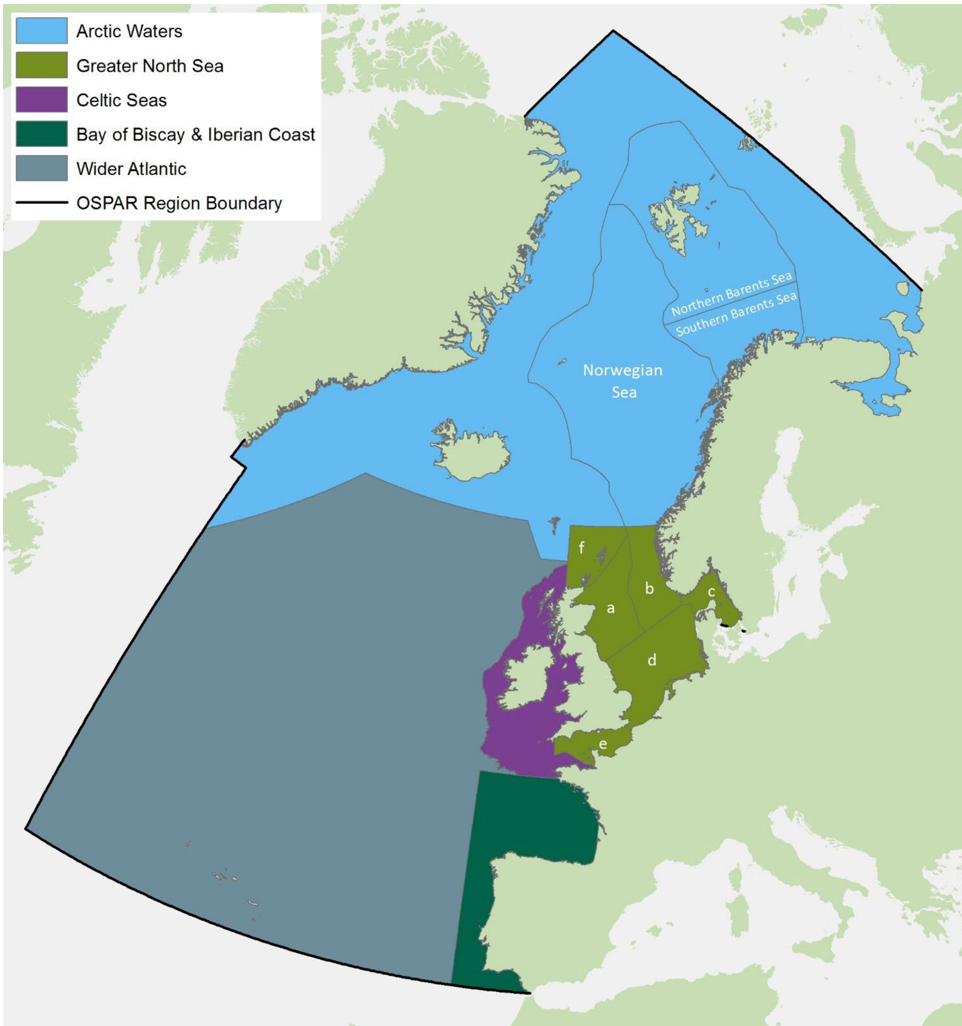


*Figure 1. Marine bird assessment units.*
*Greater North Sea sub-divisions: a) Northeast coast of Britain, b) West coast of Norway, c) Skagerrak and Kattegat, d) Southern North Sea, e) English Channel, f) North coast of Scotland and the Northern Isles*

**Species-Specific Indicators of Relative Abundance**

*Data Acquisition*

In 2021, data from offshore marine bird surveys were requested from the European Seabirds at Sea (ESAS) database for the wintering period (December to February) of the years 1991-2020.

*Data used in this Assessment*

This pilot assessment is based on bird data from aerial and ship-based bird surveys which use standardised methods described by Camphuysen et al. (2004) and which were conducted in the North Sea sections of Belgium, the Netherlands and Germany (OSPAR subdivision IId) in the years 2006-2020 in winter. Data were restricted to counts within the standardized transects. For each method separately, data have been corrected for distance-dependent visibility bias (Mercker et al. 2021a).
Data referring to human activities, namely the footprints of offshore wind farms, the density of ships and the swept area ratio as a proxy for the intensity of bottom-trawl fishing were derived from various publicly accessible internet sources. The same applies to environmental data (**Table 1**), which include physical parameters (distance to coast, water depth) as well as parameters used as proxies for productivity and therefore food supply (Chlorophyll A concentration, sea surface temperature, both from preceding summer). In the case of sea surface temperature, three variants are used: the absolute values measured, their local

deviation from the multiannual mean and the occurrence of small-scale spatial gradients (indicating the presence of hydrographic fronts).

**Table 1: Human activity and environmental data used for potential variables in the analyses.**

| Variable | Unit | Temporal resolution | Source |
|---|---|---|---|
| Bottom-trawling | swept area ratio (subsurface) | 2006-2019 | OSPAR ODIMS and NGR National Georegister |
| Ships | hours per km² per month | 2012-2017 | EMODnet and GeoSeaPortal (BSH) |
| Offshore wind farms | nearest distance (meters) | 2006-2020 | OSPAR ODIMS and NGR National Georegister |
| Water depth | meters | NA | GEBCO |
| Distance to coast | nearest distance to mainland (meters) | NA | NCEAS |
| Chlorophyll A | mg per m³ | 2006-2020 | OceanColor WEB (NASA) |
| Sea surface temperature | °C | 2006-2020 | MODIS (NASA) |
| Sea surface temperature: deviation from multiannual mean | °C | 2006-2020 | MODIS (NASA) |
| Sea surface temperature: spatial gradient | °C | 2006-2020 | MODIS (NASA) |

*Regression analysis*

Data were analysed based on the integrative regression techniques (namely species-distribution generalized additive models, sdGAMs) as presented in Mercker et al. 2021a, 2021b). These models were extended such that further environmental covariates (such as variables reflecting prey availability) were integrated, in addition to human pressure-related variables. The latter concern distance to offshore windfarms, ship densities, as well as bottom-trawling intensities. These sdGAMs were used for two analytical purposes: to detect correlations between the different variables and bird densities and to predict the current bird distribution, as well as the hypothetical distribution without human pressures. More technical details are given in Mercker et al. (2021b).

*Parameter / Metric*

The metric of this indicator is the integration of all negative effects from human activities across the entire assessment area and is called $D_{global}$. This value indicates what proportion of the birds in the assessment area are disturbed in their habitat. The term disturbance includes visual disturbance as the most prominent pressure from offshore wind farms and shipping, but also physical disturbance to the seabed from bottom-trawling.

At first, for each grid cell of 1x1 km in the assessment area the effect of activities is calculated as

$$D_{local} = XY$$

with $X$ representing the local (undisturbed) abundance (ranging between 0 and approximately 1) and $Y$ being the strength of human pressure-related decline ($Y = 1$ equals 100% decline, $Y = 0.5$ equals 50% decline, $Y = 0$ equals 0% decline, and $Y < 0$ equals an increase due to human activities). In a second step, the metric $D_{global}$ sums up all negative effects as

$$D_{global} = \frac{\sum_{i \in A}(X_i \times \max(0, Y_i))}{\sum_{i \in A} X_i}$$

where $D_{global}$ is weighted by the local abundance, i.e., grid cells with high local abundance influence this measure more strongly than areas with low abundance. In particular, $i$ is an index referring to all 1 x 1 km grid cells throughout the study area $A$. Importantly, the above formula means that grid cells with zero abundance (in a situation without disturbance) are not considered, because when $X = 0$, the product also becomes 0. Grid cells with low abundances thus only have a minor influence on $D_{global}$. Notably, this metric (in contrast to $D_{local}$) only considers negative effects (i.e. avoidance and not attraction) of human activities. We account for this by considering $max(0, Yi)$ instead of $Yi$, such that in the event of negative $Yi$-values (i.e. local abundance increase due to human activities), 0 is used instead. An overview of the overall approach is given in **Figure 2**.

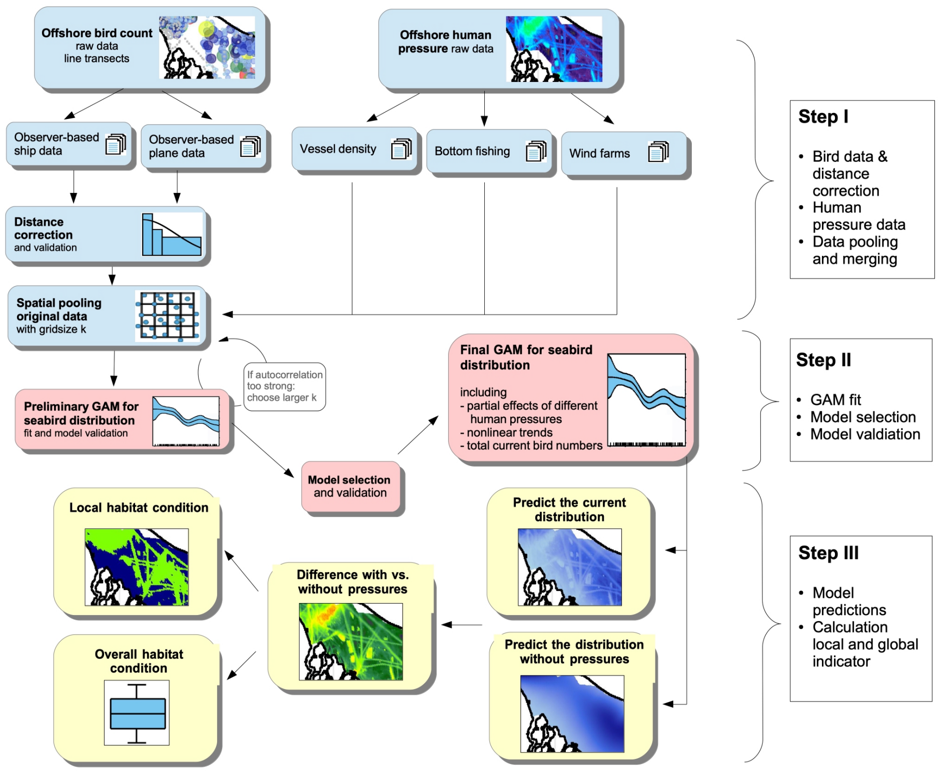


*Figure 2: Sketch of the analyses from raw offshore bird survey data and human pressure data via regression models to local and global metrics of marine-bird habitat disturbance.*

*Baselines*

The baseline of this indicator is the predicted spatio-temporal abundance with the elimination of the effects of human activities. Modelling this undisturbed scenario is part of the analysis described under *Regression analysis* above.

The reference value of this indicator is that marine birds are not disturbed by human activities.

*Species Selection and Aggregation (Functional Groups)*

Although there would have been sufficient data to assess all species wintering at sea in the Southern North Sea, the pilot assessment was restricted to selected species. The selection included species from different species groups, with different distribution patterns and with different reactions to disturbance activities known from earlier studies. At sea, three functional groups of marine birds occur (**Table 2**); the pilot assessment includes three surface feeders (great black-backed gull, herring gull, black-legged kittiwake), three water column feeders (red-throated diver, northern gannet, common guillemot) and one benthic feeder (common scoter). This selection further includes species wintering along the coastal strip (red-throated diver, common scoter) and / or at the open sea (northern gannet, herring gull, black-legged kittiwake, common guillemot). In the current approach of this indicator, grazing and wading feeders cannot be assessed because they do not live at the open sea in any season.

**Table 2: Marine bird functional groups relevant for species wintering at sea.**

| **Functional group** | **Typical feeding behaviour** | **Typical food types** | **Additional guidance** |
|---|---|---|---|
| Surface feeders | Feed within the surface layer (within 1–2 m of the surface) | Small fish, zooplankton and other invertebrates | 'Surface layer' defined in relation to normal diving depth of plunge-divers (except gannets) |
| Water column feeders | Feed at a broad depth range in the water column | Pelagic and demersal fish and invertebrates (e.g. squid, zooplankton) | Include only species that usually dive by actively swimming underwater; but including gannets. Includes species feeding on benthic fish (e.g. flatfish) |
| Benthic feeders | Feed on the seafloor | Invertebrates (e.g. molluscs, echinoderms) | |

**Assessments**

*Species-Specific threshold Values*

For this candidate indicator, no threshold value has been defined so far.

*Integration of Species-Specific Assessments*

An integration of species assessments on the level of species groups is not intended in this pilot assessment, because only selected species are assessed.

## Results (brief)

The assessment explores the influences of i) environmental variables and ii) of disturbance – visual disturbance by offshore wind farms and shipping, physical disturbance to the seabed by bottom-trawling – on the spatio-temporal abundance of seven marine bird species in the Southern North Sea in winter. It was found that both the environmental variables Chlorophyll A concentration and sea surface temperature as well as variables related to human activities explained the spatio-temporal abundance of the seven marine bird species examined.

Regarding disturbance by human activities, the analysis worked well for six out of seven species, but it failed in the common scoter due to its relatively restricted distribution with few variations in the variables used (that species no longer treated from here on, see *Knowledge Gaps* below for more details). Among the other six species, different degrees of disturbance by human activities were found (**Table 3**). One species (herring gull) did not show any negative effect from activities, while two others (black-legged kittiwake, great-black-backed gull) were only slightly affected, with a completely undisturbed situation. Common guillemot and northern gannet took an intermediate position, with 20% and 10% of the individuals disturbed, respectively. The highest degree of disturbance was found in the red-throated diver, in which 41% of the birds in the Southern North Sea were affected by human activities.

While bottom-trawling fishery ratio - expressed as the swept area - did not negatively affect the spatio-temporal winter abundance pattern in any species, highly significant negative effects were observed in three out of the seven species examined (red-throated diver, common guillemot, black-legged kittiwake) with respect to offshore wind farms. Also, four species responded negatively to the presence of ships (red-throated diver, northern gannet, common guillemot, great black-backed gull).

There is **moderate** / **low** confidence in the methodology used and **high** confidence in the data coverage.

**Table 3: Habitat quality in terms of disturbance from human activities for six marine bird species.** *The value $D_{global}$ represents the proportion of birds of a species disturbed by human activities. Positive (+) and negative (-) effects of the three activities are shown (significant cases printed bold), in empty cells the respective covariate was not selected during model selection and thus not included in the model. Colour of species name indicates belonging to the functional groups water column feeders (amber) and surface feeders (blue).*

| Species | $D_{global}$ [C.I.] | Offshore wind farms | Shipping | Bottom-trawling fishery |
|---|---|---|---|---|
| **red-throated diver** | 41% [22%, 59%] | **- (p=0,000)** | **- (p=0,000)** | **+ (p=0,007)** |
| **northern gannet** | 20% [ 1%, 53%] | + (p=0,152) | **- (p=0,000)** | **+ (p=0,004)** |
| **common guillemot** | 10% [ 2%, 27%] | **- (p=0,005)** | **- (p=0,019)** | - (p=0,059) |
| **black-legged kittiwake** | 1% [ 0%, 8%] | **- (p=0,000)** | | **+ (p=0,000)** |
| **great black-backed gull** | 5% [ 0%, 26%] | | **- (p=0,000)** | **+ (p=0,000)** |
| **herring gull** | 0% [ 0%, 0%] | + (p=0,362) | | **+ (p=0,000)** |

## Results (extended)

*Species-specific Assessments*

As additional information beyond the overall degree of disturbance from activities ($D_{global}$ values), maps showing the $D_{local}$ values across the entire assessment area indicate where much disturbance and high bird numbers co-occur (**Figures 3-8**). This information is helpful if *"appropriate actions to prevent or reduce pressures to enable the recovery of marine species"* as required by NEAES 2030 shall be taken in appropriate areas.

The maps of those species with strongest reaction on disturbance as expressed by relatively high $D_{global}$ values (red-throated diver, northern gannet, common guillemot) show where this disturbance is acting negatively. While in the red-throated diver, which is distributed along the coastline in winter, the disturbance is most prominent in the coastal strip from the Netherlands to Belgium (**Figure 3**), the more widely distributed species are most affected in the southwestern part of the assessment area (northern gannet, **Figure 4**) or in an even larger area in the western half of the assessment area (common guillemot, **Figure 5**). The avoidance of offshore wind farms is most obvious in the black-legged kittiwake (**Figure 6**). In contrast, the map for the herring gull (**Figure 8**) shows almost no disturbance.

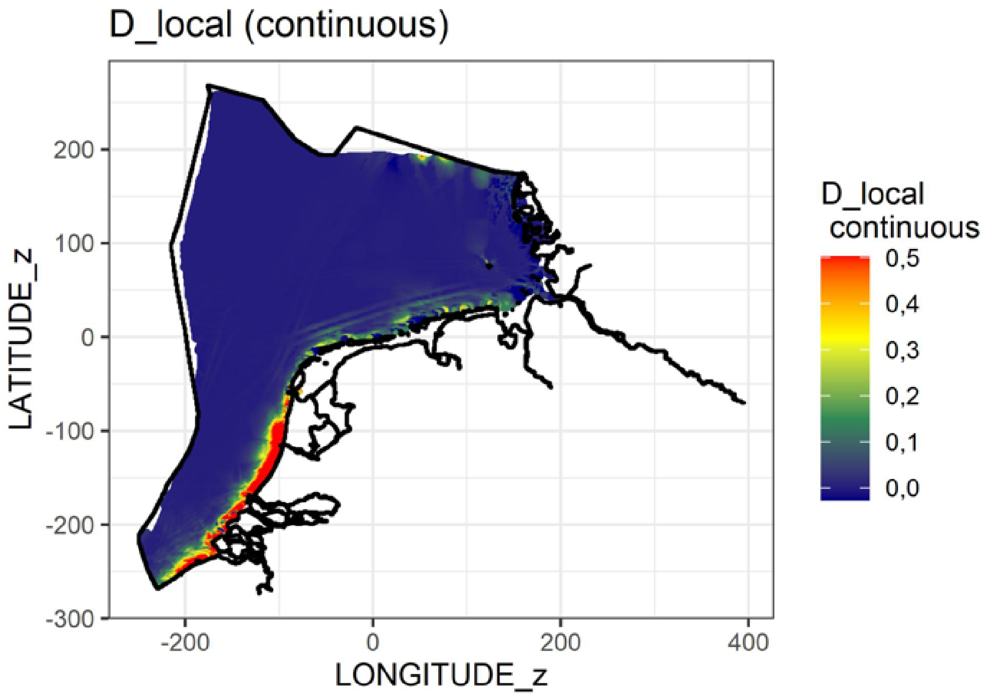


*Figure 3: Distribution of $D_{local}$ values expressing the degree of disturbance of red-throated divers by human activities across the North Sea sections of Belgium, the Netherlands and Germany (falling into subdivision IId of the Greater North Sea). The higher the $D_{local}$ value is, the stronger is the displacement compared to an undisturbed scenario. Negative values (not occurring in this figure) indicate attraction caused by human activities. Significant negative effects were detected from shipping and offshore wind farms (**Table 1**). Note that scaling is not the same in Figures 3-8.*

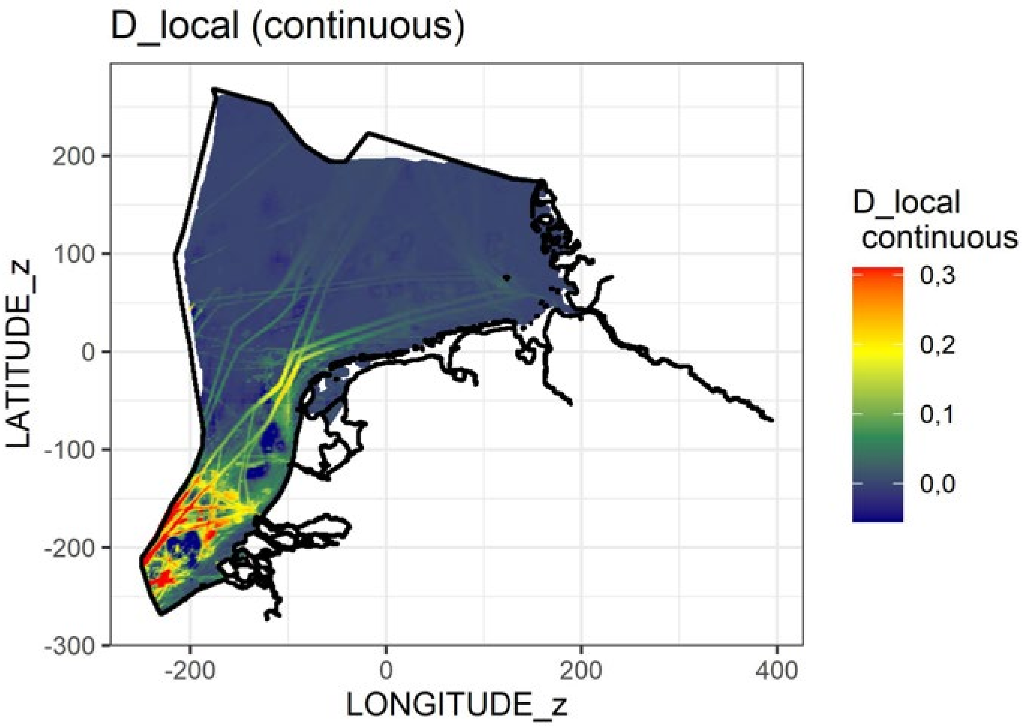


*Figure 4: Northern gannet (for details see caption to Figure 3). Significant negative effects were detected from shipping (**Table 1**).*

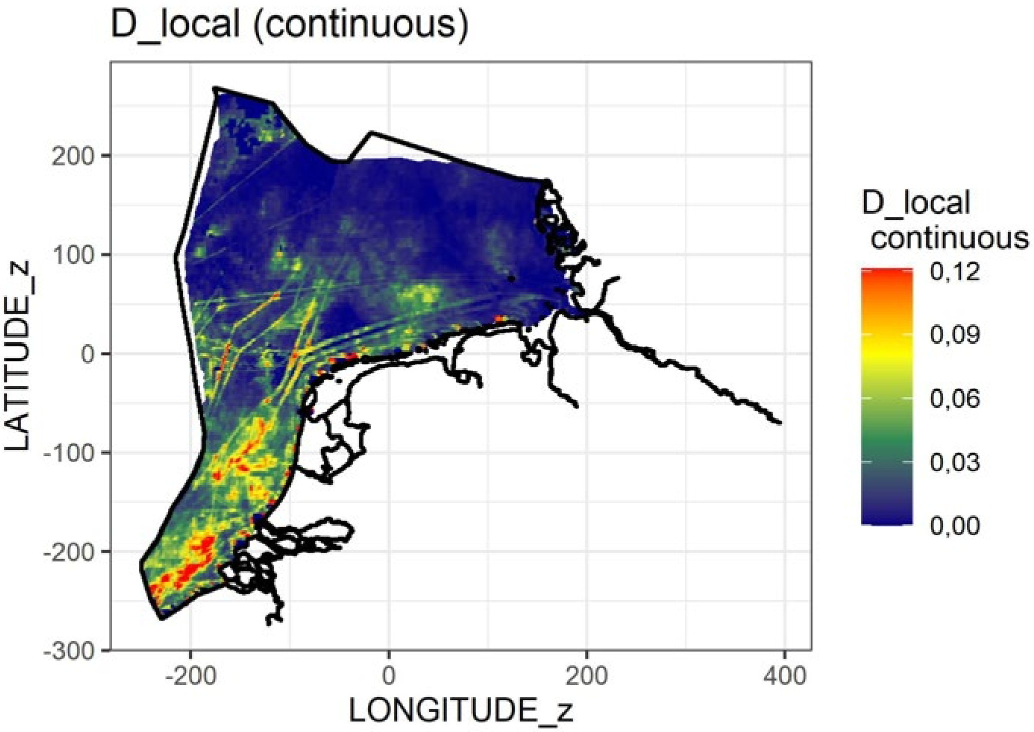


*Figure 5: Common guillemot (for details see caption to Figure 3). Significant negative effects were detected from shipping and offshore wind farms (**Table 1**).*

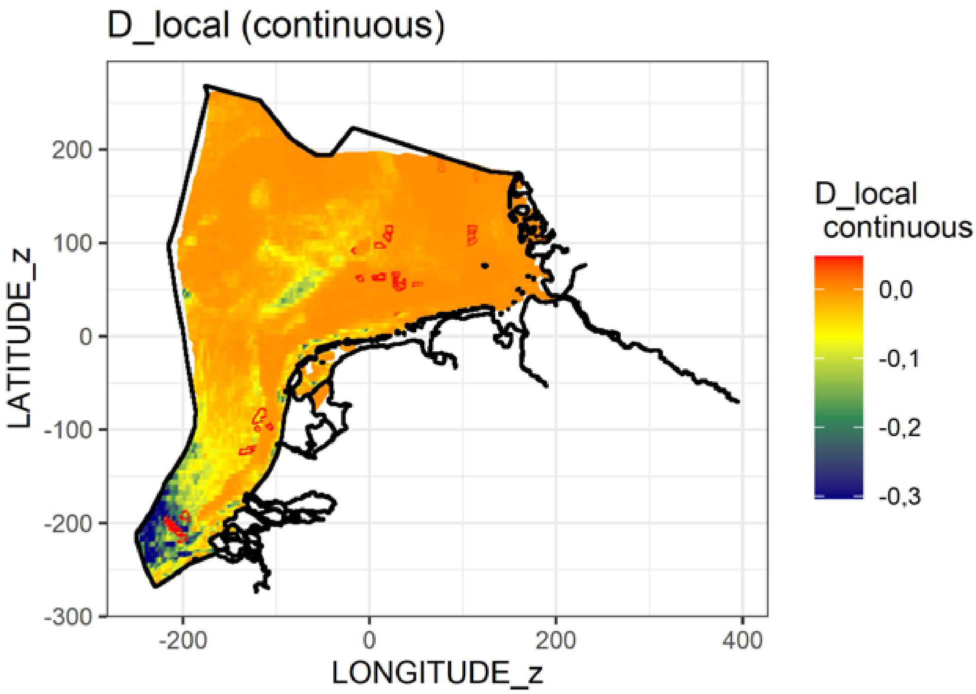


*Figure 6: Black-legged kittiwake (for details see caption to Figure 3). Significant negative effects were detected from offshore wind farms (**Table 1**).*

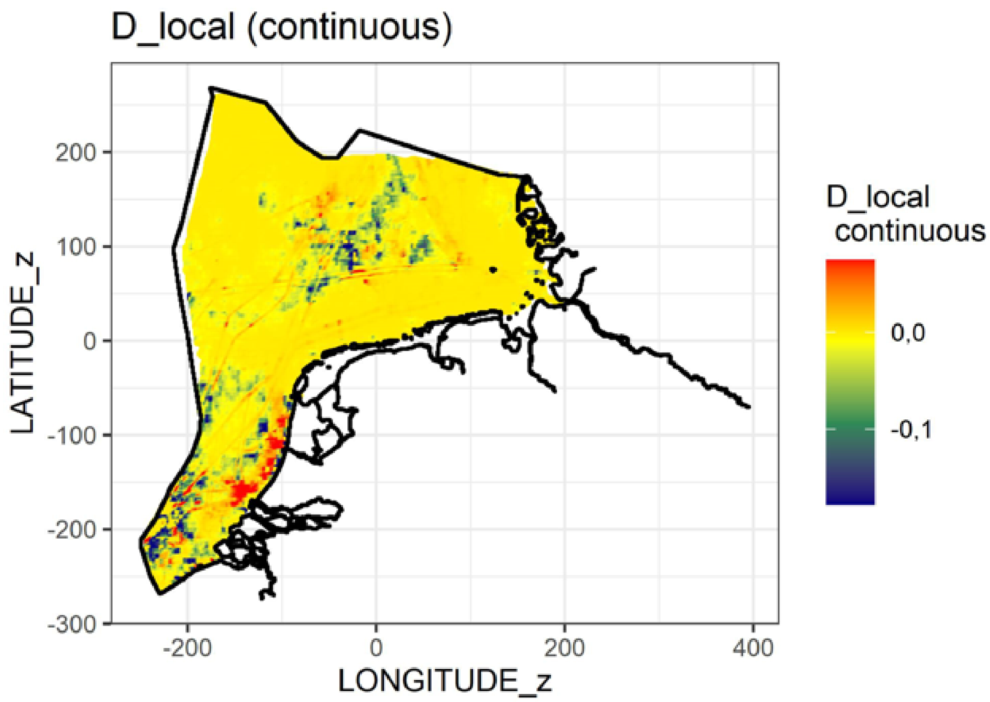


*Figure 7: Great black-backed gull (for details see caption to Figure 3). Significant negative effects were detected from shipping (Table 1).*

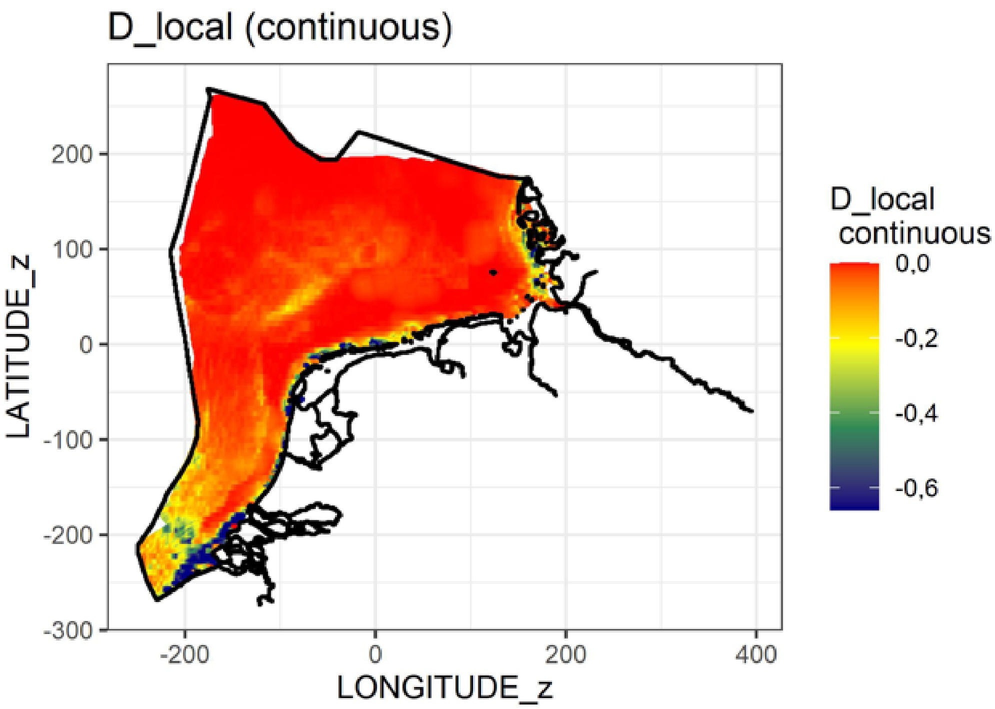


*Figure 8: Herring gull (for details see caption to Figure 3).*

The environmental variables Chlorophyll A concentration and sea surface temperature (absolute values, deviations from multiannual means and spatial gradients) do not exactly reflect the abundance and availability of food for marine birds, but they are used here as proxies for productivity in the marine environment and thus may indicate the quality of feeding conditions. The spatio-temporal abundance of all species was partly explained by Chlorophyll A concentration or variables related to sea surface temperature (**Table 4**), whereas distance to coast and water depth were not included in the best fitting models of each species. Due to the fact that i) interaction terms are present, and ii) several food-related variables are considered in parallel, a straightforward interpretation of the corresponding regression terms is not possible.

However, the significant relationships indicate that these variables play an important role in describing spatio-temporal bird abundance.

**Table 4: Effects of the environmental variables Chlorophyll A concentration (ChlA), sea surface temperature (SST), its deviation from the multiannual mean (SST dev) and spatial gradients in SST (SST grad) and the interaction of these variables with distance to coast (dist) on the spatio-temporal abundance of six marine bird species in the southern North Sea in winter** *(p values indicating significance, printed bold for significant cases). In empty cells the respective covariate was not selected during model selection and thus not included in the model. If the logarithmic values of the variables were selected for the model, the p values are printed in italics. Colour of species name indicates belonging to the functional groups water column feeders (amber) and surface feeders (blue).*

| Species | ChlA | SST | SST dev | SST grad | interactions |
|---|---|---|---|---|---|
| **red-throated diver** | **0,003** | **0,000** | **0,000** | **0,035** | **0,000**<br>**dist x SST dev** |
| **northern gannet** | | **0,000** | **0,000** | | **0,000**<br>**dist x SST dev** |
| **common guillemot** | **0,000** | ***0,000*** | ***0,000*** | ***0,000*** | ***0,000***<br>***dist x SST dev*** |
| **black-legged kittiwake** | ***0,000*** | ***0,000*** | **0,000** | ***0,000*** | ***0,000***<br>***dist x ChlA*** |
| **great black-backed gull** | ***0,001*** | **0,027** | ***0,002*** | ***0,003*** | **0,000**<br>**dist x SST grad** |
| **herring gull** | ***0,000*** | **0,000** | ***0,000*** | | ***0,000***<br>***dist x ChlA*** |

*Confidence assessment*

The methodology used has been developed specifically for this assessment, but a first version of this assessment was published in a peer-reviewed journal. Therefore, the confidence in the methodology is **moderate / low**. The assessment is undertaken using data with sufficient spatial coverage for the area assessed. Therefore, the confidence in data coverage is **high**.

## Conclusion (brief)

The candidate indicator *Marine bird habitat quality* shows which species are disturbed by human activities in the Belgian-Dutch-German North Sea and where this effects relatively high numbers of individuals. This information supports directing measures appropriately in order to *prevent or reduce pressures to enable the recovery of marine species*, as called for by NEAES 2030.

Further, the results of the pilot assessment show that the indicator can contribute to the assessment of species status under MSFD Article 8 by informing the criterion D1C5, because it shows to which degree the condition of a species' habitat is affected.

## Knowledge Gaps (brief)

The effects of specific human activities on marine bird species found in this pilot assessment are largely in line with evidence from independent dedicated studies examining the relationship between these activities and marine birds. However, in a few cases the outcomes of the analyses are not straightforward to explain. Therefore, the results of this indicator need to be carefully analysed. Where necessary, the method must be adapted and refined.

## Knowledge Gaps (extended)

The method applied in this pilot assessment was not successful in the common scoter, of which the distribution is restricted to shallow waters along the coast. On the one hand, both common scoters use the same shallow waters, because the benthic-feeding scoters cannot use deeper waters due to diving depth constraints and the shallow waters are the favourite areas for bottom-trawlers targeting shellfish and shrimps. On the other hand, there are almost no wind farms in the high-density scoter areas. Thus, there are simply no areas where common scoters are left undisturbed by the bottom-trawling fishery or are disturbed by wind farms, because of which the model cannot estimate a difference between disturbed and undisturbed.

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## Assessment Metadata

| Field | Data Type | |
|---|---|---|
| **Assessment type** | List | Pilot Assessment |
| **SDG Indicator** | List | 14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans |
| **Thematic Activity** | List | Biological Diversity and Ecosystems |
| **Date of publication** | Date | 2022-06-30 |
| **Conditions applying to access and use** | URL | https://oap.ospar.org/en/data-policy/ |

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**Our vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, which is productive, used sustainably and resilient to climate change and ocean acidification.**

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