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Final Report

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Executive Summary

The aim of this task is to provide technical assistance to OSPAR in further developing an approach and tool(s) for cumulative environmental impact assessment, including carrying out different pilot assessments on birds in the OSPAR maritime area as proof of concept. To that end, a Cumulative Impact Assessment (CIA) framework, i.e. SCAIRM (Spatial Cumulative Assessment of Impact Risk for Management) was adopted and further developed such that it can evaluate scenarios of offshore wind and other human activities on birds. SCAIRM was initially developed for the Greater North Sea where it assesses effects of human activities and their pressures on ecosystem components, in the form of habitats and species groups. For this contract, however, the focus is on the effects of offshore wind on birds, partly in combination with other activities and the possibility to apply SCAIRM in the wider OSPAR area. Therefore, SCAIRM is applied in three pilots covering (part of) three OSPAR regions, i.e. North Sea (OSPAR Region II), Celtic Seas (OSPAR Region III) and Bay of Biscay and Iberian Coast (OSPAR Region IV), as a proof of concept. The pilots differ in terms of information available and level of development of the assessment and hence their level of development and operational readiness. The North Sea pilot is the most advanced, covering the entire Greater North Sea according to the MSFD and all relevant activities and their pressures are included. Depending on information availability multi-sector scenarios were evaluated covering all relevant human activities including offshore wind farms (OWF). The Celtic Sea local pilot covers only part of the OSPAR Celtic Seas region, i.e. South Coast Designated Maritime Area Plan (DMAP), but is assumed to be representative for that region. This pilot is also intended to be comprehensive in its coverage of activities and their pressures but is limited to a relatively small area in which licence locations related to potential offshore renewable energy were identified. The OSPAR region IV pilot follows the OSPAR geographical boundaries but is limited to only including offshore wind and all its pressures. All pilots cover a wide range of bird species selected in liaison with OSPAR, most of which are common in all three pilot regions. State-of-the-art information was applied in the CIA depending on availability, and planning scenarios of at least offshore wind in each of the pilots will be evaluated to the extent possible. Based on the findings in these pilots, a way forward is proposed to further improve the knowledge base for CIA specifically in view of the aims of ICG-ORED and ICG-EcoC, including the application of SCAIRM to provide options for policy and actions by OSPAR to minimize the impacts of offshore wind in the context of the other human activities occurring in each of the OSPAR regions.

Because the analyses include 12 to 16 bird species depending on the pilot, it was deemed necessary to avoid a multitude of maps hampering the readability of the report. Therefore, to illustrate how the spatial information from the different pilots may complement each other and provide an overall picture of much of the OSPAR area, the report provides all spatial information for a single species occurring in all pilots, i.e. Northern gannet. The same spatial information for all other bird species is given in the Annex. The final graphical and textual results provided in the report, however, are for all bird species in each pilot. These results show that the same main threats apply across the bird species, but that the relative contribution of these threats to the estimated Impact Risk vary per bird species and between pilots. In the North Sea, shipping appears the potentially biggest threat, affecting the birds through visual disturbance, while in the Celtic Sea contaminants and litter from land-based industries form the potentially biggest threat. This difference follows from the fact that the DMAP area, representing the Celtic Sea, is relatively inshore compared to the Greater North Sea but may also be caused by how the available information on shipping was used to calculate Impact Risk. Both pilots identified bycatch caused by various types of fishing as another main threat.

OWF is one of the minor threats for all bird species, but is expected to increase resulting in a bigger contribution to the cumulative impact of the already existing activities and their pressures. Without any additional mitigation, the status of certain bird populations is likely to be compromised, certainly in the more distant future (i.e. 2050 in this study) as is the sustainability of the combined human activities. The assessments of OWF together with all other activities show that whether or not the threat to the bird populations increases and by how much, largely depends on their spatial distribution during breeding, migration, and wintering periods in relation to the spatial distribution of the pressures of those activities and

their variations over time according to the planning scenarios. If a strict OWF single-sector perspective is applied (a *de facto* Environmental Impact Assessment, EIA) then all three pilots show a general trend that the OWF development causes an increase in Impact Risk, which continues to increase as the OWF extent expands with (further) future developments.

Widespread species occurring in all three pilots such as the black-legged kittiwake, northern gannet and lesser black-backed gull, exhibit relatively higher collision risks due to their flight-based foraging behaviors and frequent presence within turbine rotor-swept zones. While diving species are less prone to collisions, diving species like common guillemot and razorbill are more susceptible to displacement effects, leading to habitat loss and increased foraging effort. During the breeding season in all three areas, seabird species are restricted to foraging areas near their colonies, making them particularly vulnerable to OWF-induced habitat changes, such as avoidance of nearby relatively inshore OWFs, resulting in increased foraging distances and energy expenditure. Moreover, both attraction and avoidance behaviors near OWFs have implications for collision and displacement risks.

In the Greater North Sea, extensive OWF development overlaps with critical seabird habitats, mostly during the breeding season but also during the wintering period. The Celtic Sea, while currently experiencing less OWF development than the North Sea, is identified for future expansion of OWF areas. Seabird species such as the Manx shearwater and northern gannet utilize this area for breeding and migration. The introduction of OWFs may impact the species involved, necessitating careful spatial planning to mitigate impacts. The Bay of Biscay is a crucial area for some relatively rare and threatened species such as the Balearic shearwater which traverses this region, potentially exposed to OWFs. Notably, in all pilot areas, strictly coastal seabird species such as terns, cormorants, divers and seaducks are generally less affected by OWF development due to their limited range offshore and preference for nearshore or intertidal zones. However, these shallow coastal waters are often subject to a range of other human activities, including vessel movements related to commercial fisheries, recreational boating, and coastal construction, causing disturbance and habitat displacement. Additional indirect ecosystem impacts may play a role but these are not considered in the assessment. Because of the bird species' annual cycles, both OWF phases considered in this study, i.e. construction and operation, were found to be relevant as their contribution to the estimated Impact Risk differs markedly. Similarly, the different timings of the OWF developments in the different pilots affect the estimated Impact Risk for each of the future scenarios. Not surprisingly, a relatively long operational phase can be expected to cause considerably more risk for bird species over the OWF lifetime than a shorter construction phase.

If scenarios of OWF development over time are assessed together with those of all other relevant human activities as was done in the North Sea and Celtic Sea pilots, it was found that Impact Risk in the North Sea increased up to 30% (for Northern Fulmar) and with several species above 20% (i.e. Great skua, Herring gull, Lesser black-backed gull, Great black-backed gull and Black-legged kittiwake). In the Celtic Sea pilot this was up to 14% (Herring gull) and with another two other species above 10% (i.e. European shag and Atlantic puffin). For several species the increased threat from OWF developments may be (partly) offset by a reduction in fisheries-induced Impact Risk as a result of, at least, the concomitant decline in fishing effort. For the North Sea this even resulted in a net decrease in Impact Risk for Common scoter (-4%) and Sandwich tern (-1%). In the Celtic Sea pilot a net decrease was found for seven bird species of which Northern gannet and Common guillemot showed a net decrease of more than 10%. While this decrease strongly depends on the assumed future scenarios, which are very uncertain, it confirms the importance of conducting Cumulative Impact Assessments in which all activities are included with realistic future scenarios.

A CIA, and in this case SCAIRM, appears to be an appropriate framework for these type of assessments. The outcome of these assessments in terms of Impact Risk is determined by the availability and accuracy of information and assumptions on how this could best be used to estimate of the two main aspects of risk, i.e. Exposure and Effect Potential. The Exposure estimation is heavily dependent on data availability and quality, which may depend on resolution and accuracy of the metric, of both the activities and their pressures as well as the bird species. The applied species distributions could genuinely reflect the species' area preferences, but they may also be affected by limitations in monitoring coverage and/or the modelling with which the distributions were generated. Another issue is that these distributions may be affected by (past and present) human activities or future changes in habitat suitability as a consequence of, for example, climate change. The

actual impact on the species is determined by the extent of the pressure which may differ from that of the activity due to dispersal, for example in case of contaminants, noise, visual disturbance, and litter. A higher dispersal results in higher Impact Risk estimates. While known to be relevant it was not addressed in this study and remains an area for further improvement. For estimation of the Effect Potential species-specific parametrisation was only applied for OWF in relation to the pressures of collision and disturbance during the operational phase (i.e., not considering the construction, nor the decommissioning phases) and for shipping in relation to the pressure disturbance (visual) of species (North Sea pilot only). While this confirms that species-specific parametrisation of Effect Potential is possible and can be done for other activity-pressure combinations as well if data are available, currently the effect potential estimation is still based on expert-judgement for most impact chains. As the use of available information may also come with uncertainties in how best to interpret and use this information to estimate Effect Potential, it is an adequate default option.

The main outcome of this task is that a CIA can be done for each of the OSPAR regions independent of data availability. The SCAIRM framework was found to be fit for purpose as it can incorporate all the available data-based information while having the fall-back option to apply expert-judgement if this is missing. However, despite extensive guidance on the SCAIRM method the transfer to other regions turned out to be challenging. While this exercise has contributed to improve the guidance document, i.e. the so-called "SCAIRM cookbook", further improvements are still required. The current use of proprietary software, i.e. FME, for notably the spatial analyses limits accessibility and transparency and hampers the application by other parties without access to that software. Ultimately a repository of open access code (preferably R) should become available. Furthermore, the output of the CIA is determined by data availability as spatial assessments require spatial information of both the stressors (activities and their pressures) and receptors (here bird species) and further data-driven parametrisation should improve accuracy. The main bottleneck turned out to be the availability of quantitative information of adequate quality rather than the methodology. Spatial distributions were available for most of the selected bird species. As the spatial resolution was fairly coarse, this may have hampered the accuracy of the output. Higher resolution spatial maps were available for a smaller subset of the selected bird species, but, in case of the North Sea, did not cover the whole assessment area. Spatial distributions of OWF were available for each of the pilots. However, these came with issues such as (1) search areas versus the actual implementation areas; (2) increased uncertainty for more distant futures, etc. Moreover, these are the types of research questions that come with the highest demands in terms of spatial information as they require spatial information at different points in time. For this study, the available actual, i.e. baseline, spatial information was applied for as many activities and their pressures as possible. In addition, we applied assumed changes over time for some activities but OWF was the only activity for which the combination, i.e. spatial distributions over time, was actually available. This exemplifies the types of issues that may need to be resolved in selecting the best spatio-temporal data. Perfect data does not exist and balances such as between resolution and coverage need to be struck and inferences need to be made to combine spatial information with future scenarios. Certainly, when it comes to spatial information to estimate the Exposure aspect of risk, the fallback option of applying expert-judgement is not appropriate to address these types of research questions. The estimation of the Effect Potential aspect of risk is not prevented if quantitative information is lacking but is likely to be severely hampered as the few pressures that could be parametrized with quantitative information have proven. And even with quantitative information available, the application required a solid theoretical basis and understanding of what the data represent. As opposed to many other CIA methods, SCAIRM appears to provide this theoretical basis thereby allowing a (further) piecemeal parametrization of the Effect Potential of more pressures than the few OWF-based pressures parametrized for these analyses. This process, however, will require substantial research effort which should be coordinated across the OSPAR area and beyond. CIA and notably methods such as SCAIRM can be applied to guide such research effort focussing on the activities and their pressures that contribute most to the threats and parameters that mainly determine the uncertainty in the outcome of the assessment.

1 Introduction and background

1.1 Background

The OSPAR Convention is the mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic. As part of this mechanism, OSPAR assesses the impact of human activities on the environment.

The overall aim of the work on offshore renewables is to support the implementation of the OSPAR North-East Atlantic Strategy (NEAES) 2030 in developing guidance on how to promote and facilitate sustainable development and scaling up of offshore renewable energy in a way that cumulative environmental impacts are minimised. To this end, an Intersessional Correspondence Group on Offshore Renewable Energy Development (ICG-ORED) was established in March 2021.

As part of the initial scope of work, ICG-ORED is prioritising the impacts of offshore renewable energy developments on birds, to progress simultaneously on Operational Objective S5.04 of the NEAES 2030: "By 2025 at the latest, OSPAR will 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."

In the face of the planned large-scale development of offshore wind energy in the North-East Atlantic and the aims and scope of ICG-ORED, the group initiated the development of a framework for assessing the cumulative impacts of offshore wind energy on marine ecosystems on a regional sea scale. In line with NEAES Operational Objectives S12.04 and S5.04, this cumulative impact assessment (CIA) framework will be developed and first applied to assess the impacts of offshore wind energy on birds. These two elements constitute the focus of this request for proposals.

1.2 Objectives

The aim of this study is to provide technical assistance to OSPAR ICG-ORED in further developing an approach and tool(s) for cumulative impact assessment, including carrying out different pilot assessments on birds in the OSPAR maritime area as proof of concept. These pilot assessments are intended to cover regions that differ in terms of bird species, the availability of information, the advancement of the implementation of offshore wind and the types of other activities and their pressures to ensure that these are sufficiently representative of the whole OSPAR area.

This study has several aims:

- To adopt, apply and further develop a Cumulative Impact Assessment (CIA) framework that can evaluate scenarios of offshore wind and other activities on birds but with the possibility to expand this to include other ecosystem components as well.
- The assessments should cover the North Sea, Celtic Sea and Bay of Biscay
- To show how available information can be applied within this framework. For these first pilot assessments, the CIA will be limited to birds only and include all pressures from a variety of human activities that may potentially impact birds but with a focus on offshore wind energy development and operations.
- In each of the pilot assessments the CIA will be applied to evaluate some multi-sector scenarios.

1.3 Description of the pilots and delimitations

This study consists of three bird pilot assessments covering several of the OSPAR areas, i.e. the North Sea, Celtic Sea and Bay of Biscay (**Figure 1**). The different pilots are intended to cover regional differences in terms of bird species, the availability of information, the advancement of the implementation of offshore wind and the types of other activities and their pressures to ensure that these are sufficiently representative of the whole OSPAR area. While the pilots are aligned in their application of the same CIA method, i.e. SCAIRM, and similar typologies of the linkage framework, they come with regional specificities. This will also translate into the scenarios they can evaluate.

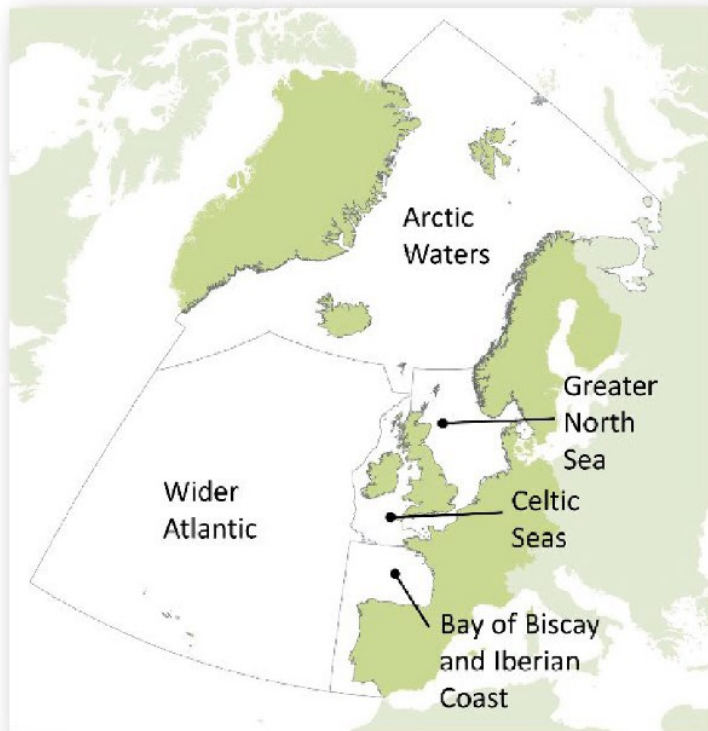


Figure 1.1 OSPAR areas in 2024.

1.3.1 North Sea pilot assessment

The North Sea pilot area is according to the Greater North Sea as in the MSFD. However, it should be noted that a limited spatial coverage is available for some of the selected bird species which are the species for which no map is presented by Waggitt et al. (2020) (see Table 2.1) as well as some human activities in the northern part of the Greater North Sea.

1.3.2 Celtic Sea local pilot assessment

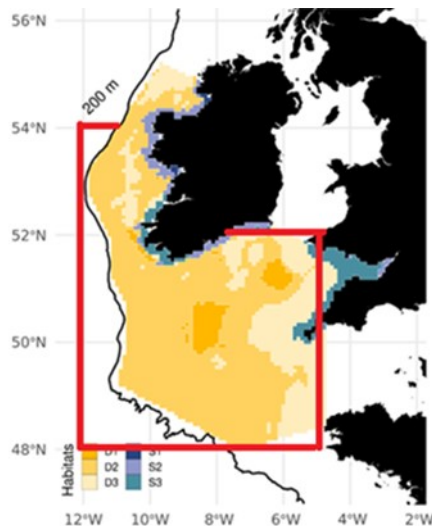


Figure 1.2 GES4SEAS Celtic Sea study area, outlined in red.

In the HorizonEurope GES4SEAS project (<https://www.ges4seas.eu/>), the Celtic Sea Learning Site area takes in the Celtic Sea (south of Ireland) and the west of Ireland Atlantic shelf (*Figure 1.2*). It is an open sea environment, supporting multiple conflicting activities. It has huge potential for Blue Economy activities and contains the current focal areas for offshore wind development. To this date, 17 sectors, 20 pressures and 26 ecological components and their interactions have been identified and assessed for risk (see Section 3.2). Additionally, recurrent stakeholder engagement has been carried out, including identifying issues and questions relevant to the stakeholders. The questions have centred around the interactions between offshore renewable energy, fisheries, and marine protected areas. As such, the project work gives us a strong baseline to build upon for carrying out the current assessment focused on sea birds. This baseline allows us to investigate the pressures arising from OWF directly, but to also include the range of pressures arising from other sectors in the region.

In this work, the Celtic Sea pilot assessment will use the information from the GES4SEAS assessment to inform on the top sectors and pressures relevant to seabirds, which are treated as a single component in that wider assessment. These top sectors and pressures will be further refined to focus specifically on the South Coast Designated Maritime Area Plan (DMAP) Proposal published in July 2023. The DMAP puts forward an initial 'proposed' geographical area within which future offshore renewable energy development may take place. It is important to note that this area does not currently have any operational wind farms, as such, all of the presented scenarios are hypothetical. Within the DMAP area, four smaller scale maritime areas (labelled A-D) have been designated as potential development sites (*Figure 1.3*). A development within Maritime Area A aims to be operational by 2030 or as soon as feasible thereafter, subject to all necessary project level assessments and consents being completed (Government of Ireland 2025).

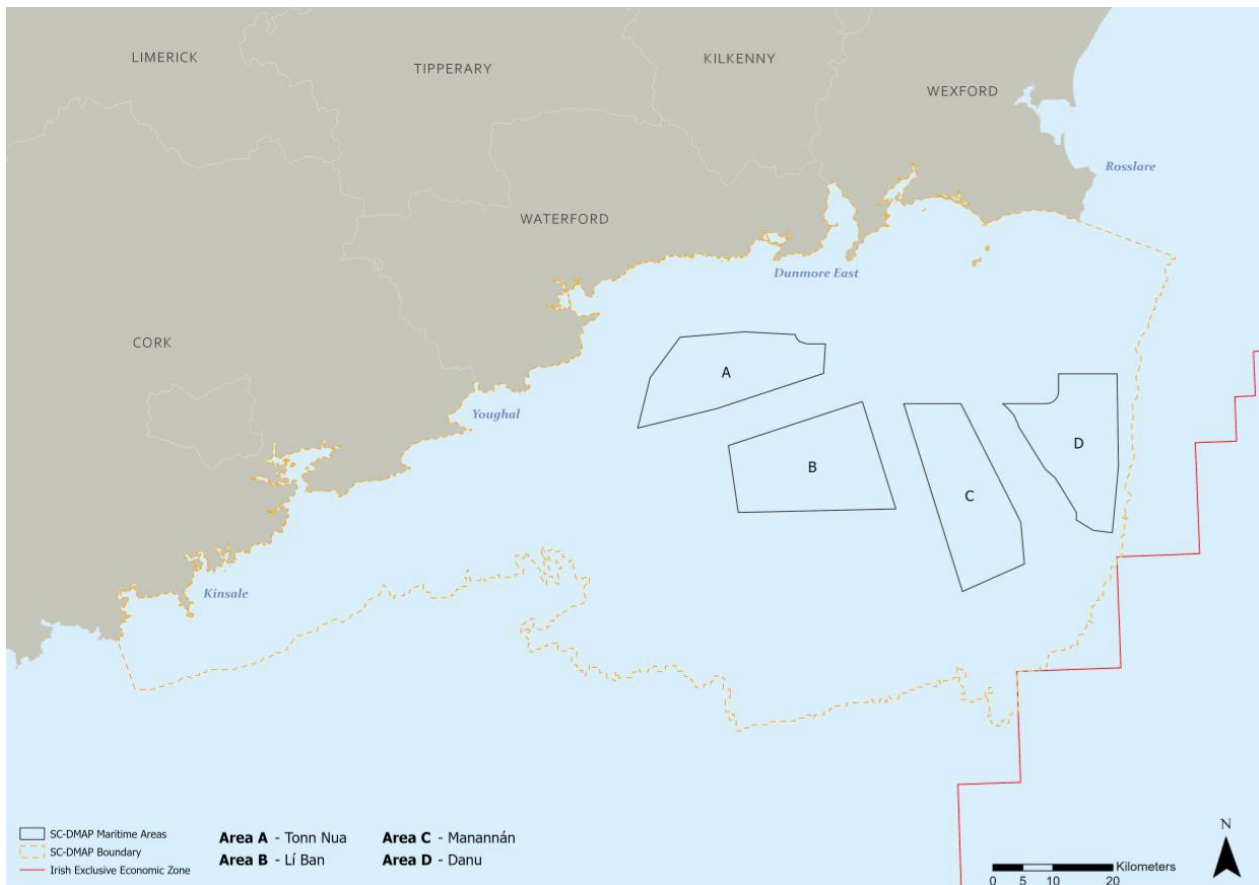


Figure 1.3 The four Maritime Areas identified by the South Coast Designated Maritime Area Plan (SC-DMAP) for proposed future deployments of both grid-connected and non-grid-connected offshore wind developments.

Carrying analyses out at this scale allows us to assess impacts at the scale of the actual site of activity.

1.3.3 Bay of Biscay and Iberian Coast pilot assessment

The OSPAR Region IV “Bay of Biscay and Iberian Coast” area extends from 48°N to 36°N and from 11°W to the coasts of France, Portugal, and Spain. Located in temperate latitudes, this region is significantly influenced by the inflow of Atlantic Ocean water and large-scale westerly air circulation, which brings frequent large storms, especially in winter (OSPAR, 2025). The area boasts a variety of habitats, ranging from continental shelves to deep abyssal plains. The coastline is equally diverse, featuring estuaries, rias, and wetlands that support highly productive ecosystems. The study area is delimited by the geographical boundaries defined by OSPAR region IV and Marine Strategy Framework Directive (MSFD) regions (Figure 1.4).

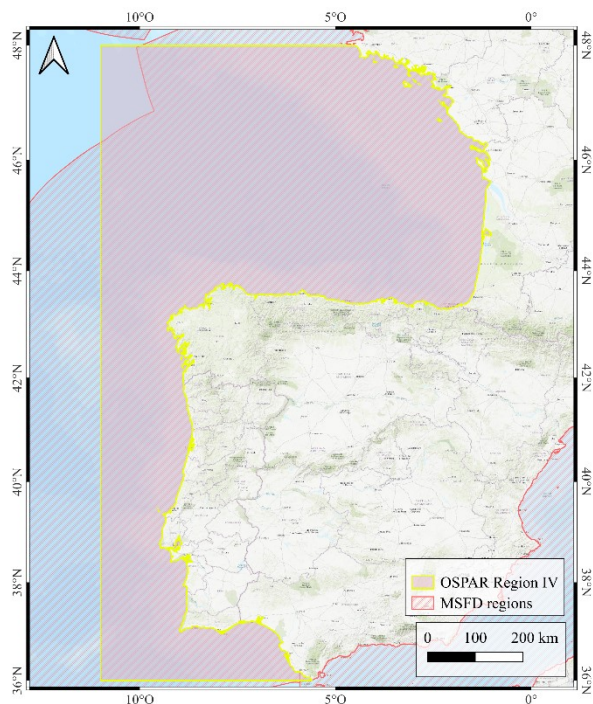


Figure 1.4 The OSPAR Region IV "Bay of Biscay and Iberian Coast" area.

The seabird community in OSPAR Region IV is particularly distinctive during migration and winter, owing to the region's strategic location along major migratory flyways (OSPAR, 2025). While the breeding seabird population is relatively sparse compared to other areas of the European Atlantic, the number of individuals increases markedly during migratory and wintering periods. Most of these species breed along the western coasts of northern and central Europe—such as Scandinavia, the British Isles, and the North Sea—and migrate southward to their wintering grounds beginning in late summer (post-nuptial migration), returning north in spring (pre-nuptial migration). Some of these northern breeders also reproduce in low numbers in the northern sector of OSPAR Region IV, particularly in the Bay of Biscay and along the Iberian Peninsula, where they breed at the southern edge of their distribution range. In these cases, the majority of individuals present in the region are likely migratory. As a result, several dozen seabird species can be observed in the coastal and offshore waters of the Bay of Biscay. This area also serves as an important wintering ground for many of these species (Pettex et al., 2017), which benefit from the high biomass of small to medium-sized pelagic fish available during this period.

France, Spain, and Portugal are making significant strides in the expansion of offshore energy, particularly in offshore wind energy. In the OSPAR Region IV, these three countries have installed wind turbines for both research and development (R&D) purposes and commercial production. The actual locations for offshore renewable energy development in OSPAR Region IV are shown in Figure 1.5. In Portugal, there are currently three wind turbines installed in the testing site of Viana do Castelo area as part of the WindFloat Atlantic project, with a total installed capacity of 25 MW. Additionally, the coasts of Aguçadora and Peniche host R&D testing sites zones focused on marine renewables, currently without installed offshore wind turbines. In Spain, in the R&D testing site of BiMEP (Armintza) is the DemoSATH project, which has an installed capacity of 2 MW. In France, there is one fixed wind farms installed in Saint-Nazaire with a capacity of 480 MW. Also, the Yeu-Noirmoutier wind farm with a capacity of 496 MW is currently under construction. Furthermore, the area of Sud-Bretagne (floating, 250 MW) is already allocated, with an extension (floating, 500 MW) currently out to tender, as well as the area of Sud-Atlantique (fixed, 1200 MW) and its extension (fixed or floating, 1200 MW), both out of tender.

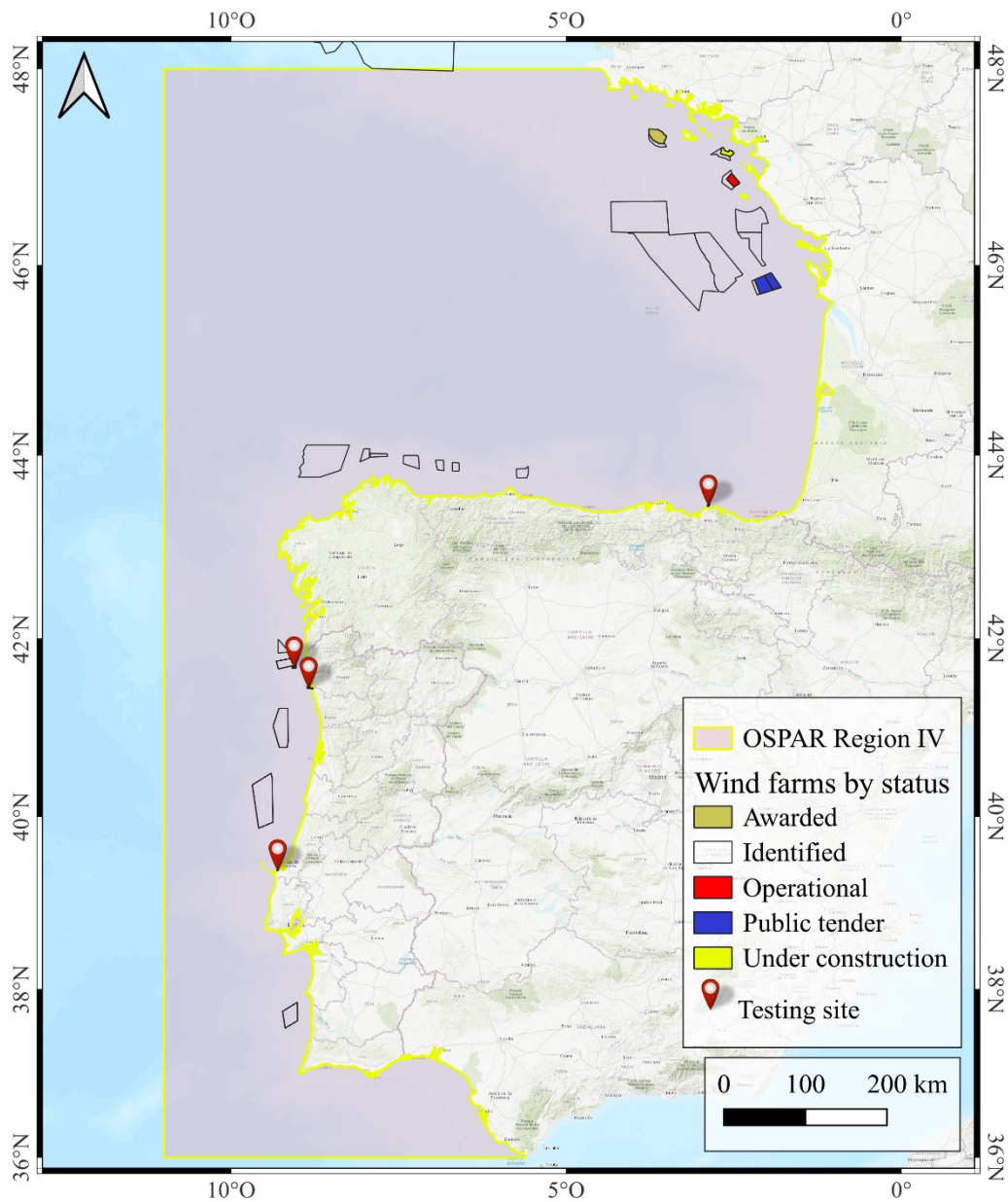


Figure 1.5 Designated locations for offshore renewable energy in OSPAR Region IV, including areas for research and development, operational offshore wind farms (OWFs) for testing or commercial use, and zones allocated or under tender for future OWF development.

2 Approach

2.1 Description of the Cumulative Impact Assessment method

The development of the CIA method selected for these assessments was inspired by the first global assessment by (Halpern et al., 2008) and commenced as part of the EU-funded ODEMM (Option for Delivering Ecosystem-based Marine Management, <https://www.liverpool.ac.uk/odemmm/>) project and further elaborated the EU-funded Aquacross (Knowledge, Assessment, and Management for AQUatic Biodiversity and Ecosystem Services aCROSS EU policies, <https://www.aquacross.eu>) which resulted in the following key peer-reviewed publications: Knights et al., 2015; Borgwardt et al., 2019; Piet et al., 2021a, 2023. The database of Borgwardt et al. (2019) contains 7771 impact chains for the greater North Sea, all of which have been estimated semi-quantitatively using scientific knowledge from literature supplemented with expert judgment by a large team of international experts. This CIA method has been further developed and applied (including Piet et al., 2021a, 2021b; 2023) and is now referred to as SCAIRM (Spatial Cumulative Assessment of Impact Risk for Management). SCAIRM is now also endorsed by the ICES WGCEAM (Working Group on the Cumulative Effects Assessments for Management) as it is specifically designed to guide an ecosystem-based approach to management, including marine or maritime spatial planning (EB-MSP). Further development of the method occurs in the H2020 project GES4SEAS (achieving GES for maintaining ecosystem SERVICES by ASsessing integrated impacts of cumulative pressures, <https://www.ges4seas.eu/>) where it will be applied in at least two of the selected pilot areas, i.e. North Sea and Celtic Sea. Applications of the method in the context of EB-MSP will occur in the H2020 project MarinePlan (Improved transdisciplinary science for effective ecosystem-based maritime spatial planning and conservation in European Seas, <https://www.marineplan.eu/>). These ongoing projects should ascertain the continued improvement and application of the method in other EU marine waters than the pilots selected for this study.

2.1.1 Description of the SCAIRM method

Risk-based approaches have often been at the basis of CIAs for marine management (Stelzenmuller et al., 2018). Such approaches apply either a likelihood-consequence approach for estimating the risk of a rare or unpredictable event (i.e., calamities; Williams et al., 2011), or an exposure-effect approach which is considered more suitable when assessing existing and (more or less) continuous or frequently occurring pressures (Smith et al., 2007 and Knights et al., 2015). The calculation of Exposure and Effect Potential in SCAIRM includes many known concepts often used in the context of environmental risk assessments (see figure 2.1). The Exposure in space and time was defined as the likelihood that the receptor (i.e. ecosystem component) is co-occurring with the stressor (i.e. pressure caused by an activity) and hence potentially affected by it (Piet et al., 2021a). The Effect Potential can be assumed conceptually identical to sensitivity (Laffoley et al., 2000), and is a function of its ability to avoid interaction, tolerate or resist change (*Resistance*), and/or recover from impact (*Resilience*) (Tillin et al., 2010). According to Weißhuhn et al. (2018) sensitivity is the susceptibility to hazard. In SCAIRM this was reconciled by estimating resistance as a function of hazard (according to ISO 31000, 2018), magnitude and frequency of the stressor together with the responsiveness of the receptor to that stressor.

The model uses Impact Risk (IR) as the key concept that allows cumulation assessment of risk across pressures. There is a wealth of categorical risk-based approaches that have estimated Impact Risk in various guises (Knights et al., 2015; Borgwardt et al., 2019; Galparsoro et al., 2021, Galparsoro et al., 2022). Piet et al. (2021a) recently provided a roadmap towards a fully quantitative calculation of IR, defined as the change in an equilibrium state (i.e. biomass or abundance compared to undisturbed) of the receptor caused by a stressor. Albeit covering only a few stressor-receptor causal chains, this provided a major advancement from the previous estimates of Impact Risk as it now becomes tangible and can be readily understood and interpreted by any recipient of the assessment outcome. In this way, the output allows an interpretation of the assessment outcome, e.g. in relation to IUCN criteria (IUCN, 2012). Impact Risk here is expressed as a percentage of change.

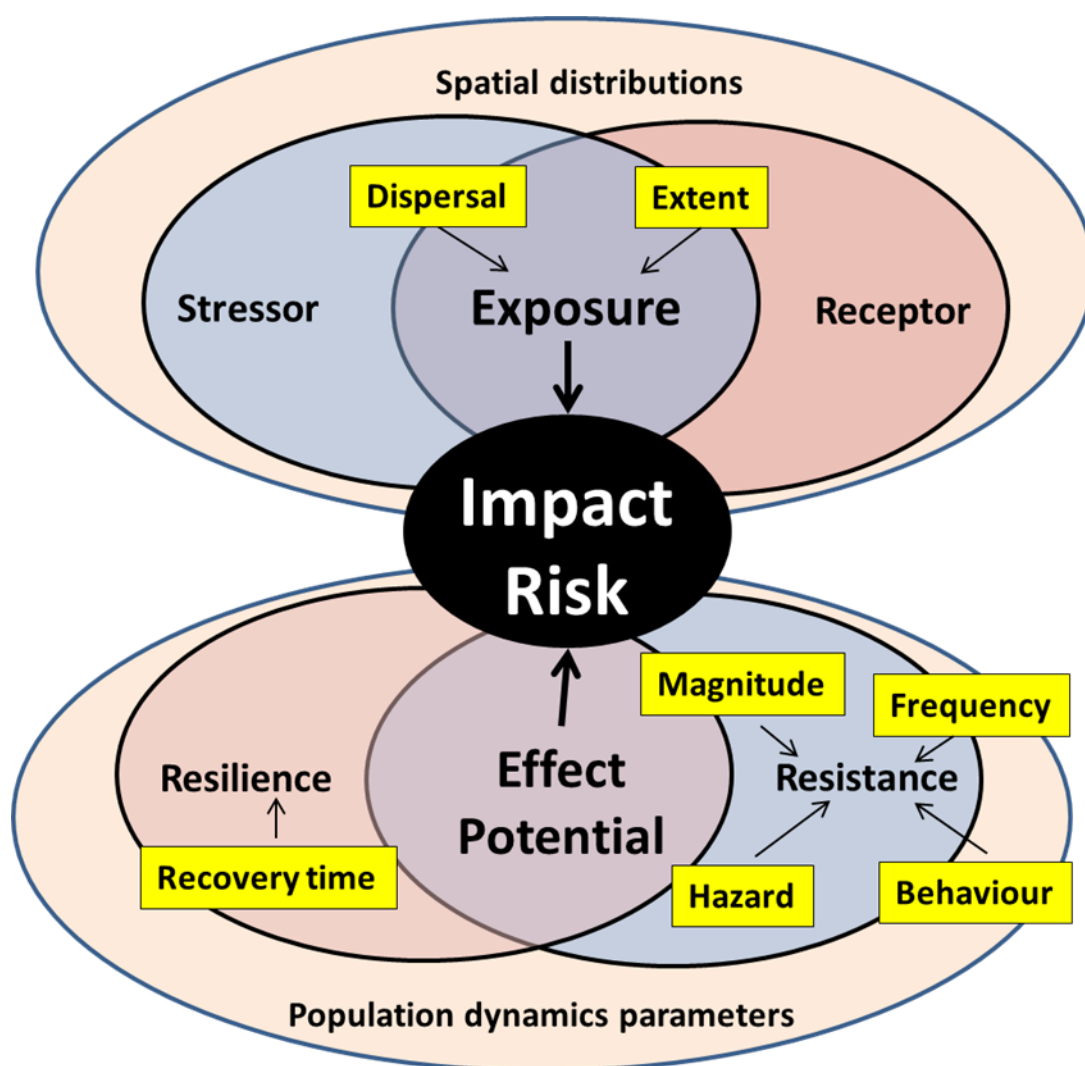


Figure 2.1 Calculation of Impact Risk as the key concept that allows cumulation across pressures from Exposure and Effect Potential. These, in turn, can be estimated from respectively the spatial distributions of the stressor (i.e. activity-pressure combinations) and receptor (i.e. ecosystem components) and population dynamics parameters resilience and resistance if quantitative information is available. If lacking, these can be estimated from the boxed terms using categorical scores based on expert judgment.

The SCAIRM method is essentially a risk-based approach designed for application in data-poor and data-rich marine ecosystems as it can be based on respectively categorical expert-judgement scores (Piet et al., 2023) which are semi-quantitative at best but can also be based on fully quantitative information (Piet et al., 2021a) if available. An advantage is that this allows the continued application of the method for assessments while there is an ongoing process of piecemeal improvements when better and often quantitative information becomes available.

Linkage framework and typologies

The basis of any assessment is a so-called linkage framework (or conceptual model) consisting of impact chains that connect sectoral human activities and their pressures with the ecosystem components (i.e. species groups consisting of a selection of species) they can potentially impact. The categorisation of these human activities, pressures and ecosystem components is reflected in the typologies given in Annex 1. The pilot assessments were set up such that the same typologies were applied but whether or not a specific sector, pressure or bird species was included in the assessment is determined in the definition of the pilots (see Chapter 3).

A CIA should be comprehensive in that it includes all manageable human activities and their pressures as well as all the relevant ecosystem components that together make up the marine biodiversity of that pilot area.

The chosen typologies at the highest level of aggregation are aligned as much as possible with the relevant policy frameworks, e.g. MSFD, BHD.

Risk-based approach

The SCAIRM method is essentially a risk-based approach where the key term, Impact Risk (IR), is calculated from estimates of Exposure and Effect Potential (Figure 2.1). The method is supposed to capture the 'best of both worlds' in terms of how it handles data availability: it builds on the comprehensive categorical risk-based approaches (Knights et al., 2015; Borgwardt et al., 2019; Piet et al., 2021a, 2023), but altered them where needed so as to obtain an Impact Risk that is conceptually identical to the Impact Risk from the quantitative approach so that both can now be harmonized into a single method that has the advantage of (1) being comprehensive and flexible in terms of its application in other ecosystems as the categorical approach allows every impact chain to be easily weighted using the expert-judgement scores, while it allows (2) a gradual transition towards an increasingly more quantitative assessment. The two aspects of risk that together determine Impact Risk are further elaborated below.

Exposure

Exposure usually only reflects the spatial overlap which implies that a default 100% temporal overlap is assumed and hence no seasonal patterns of the stressor or receptor apply. Three options apply for the estimation of Exposure depending on the availability of information:

- If no quantitative information is available then the qualitative Exposure score is based on Extent and Dispersal categories such as in (Borgwardt, 2019), where the extent score reflects the overlap between the activity and the ecosystem component which is then combined with a pressure-specific dispersal. For further details see Annex 2.
- If there is information on the spatial distribution of the ecosystem component and quantitative information on the spatial distribution of the activity, i.e. spatial maps, but not of the (dispersal of) the pressure the activity extent is used but complemented with a pressure-specific dispersal based on the buffer according to (Lonsdale et al., 2020) or else the existing dispersal scores.
- Ideally, there is quantitative information available on the spatial distribution of both the pressure and the ecosystem component. In that case, Piet et al. (2021a) applies who distinguishes increasingly more accurate Exposure metrics depending on data availability, i.e. spatiotemporal information on pressure magnitude and ecosystem component density. It should be noticed that this exposure option is a minority.

Effect Potential

Given the exposure of a receptor to a stressor in a specific unit of space and time, the Effect Potential (EP) describes the degree to which this receptor is likely to be affected by that stressor (i.e. activity and its pressure) as a change in biomass or abundance relative to an undisturbed situation. The estimation of EP is essentially a function of Resistance and Resilience which, in turn, can be estimated using quantitative information or, if lacking, categorical scores from literature or expert judgement. *Resilience* is the time after impact until full recovery (to the receptor's original undisturbed state) which can be estimated using the receptor-specific expert judgement scores from Knights et al. (2015) (Annex 2). For *Resistance* a more elaborate approach was developed which better captures the intricacies that determine resistance hence providing a more realistic score (see Annex 2). In this approach, resistance contains a behavioural component that, in case of co-occurrence (i.e. in a specific grid cell based on spatial distributions in the specific assessment period as also applied for Exposure), determines whether an interaction event actually occurs. Depending on the nature of the interaction, the (essentially within-grid cell) likelihood of an interaction is determined by (1) the behaviour of the receptor in relation to the stressor, i.e. within the spatial unit(s) used to estimate Exposure, and (2) the frequency of occurrence of the stressor (i.e. within the temporal unit of Exposure, usually year). Two conceptually different mechanisms can be distinguished that determines, in the case of exposure, the nature of the interaction and thus resistance:

- 1) **Intermittent interactions** where EP is determined by the likelihood of interaction and its consequence. The likelihood of interaction is determined by the frequency of occurrence of the stressor and the behavioural response of the ecosystem component to that pressure, i.e. its capacity to avoid interaction. Note this interaction occurs at spatiotemporal scales much smaller than those at which Exposure was estimated. The consequence of an interaction event is subsequently determined by the characteristics of the ecosystem component specific to that pressure (captured by the Hazard) and the Magnitude of that pressure. The EP estimation is based on four parameters, i.e. *Frequency* and *Magnitude* of the stressor,

its *Hazard* in relation to the ecosystem component and the *Behaviour* of the receptor (ecosystem component) in relation to the stressor.

- 2) **Continuous interactions** where EP estimation only requires two parameters, i.e. *Hazard* of the stressor in relation to the ecosystem component and *Magnitude* of the stressor.

Each of these resistance parameters and how they were scored are further elaborated in Annex 2 and Piet et al. (2023). This then allows the interpretation of these concepts in a population dynamics context (Pitcher et al., 2017), where a population's resistance is reflected in the depletion rate and the resilience in the population growth rate. For further details and equations see the supplementary material in Piet et al. (2023).

2.2 Exposure selected bird species

2.2.1 North Sea

Based on a “long list” of bird species that was drawn up in the ICG-ORED expert meeting (January 2023) and sent to us by Rijkswaterstaat (RWS), it was agreed to select 16 bird species for the assessment of the North Sea. The bird species are shown in the Table 2.1, together with an indication of the availability of density maps.

Table 2.1 List of bird species for the assessment of the North Sea and the availability of spatial information.

Common name	Scientific name	Selected for North Sea	North Sea source: ESAS+MWTL data	NE Atlantic source: Waggitt et al. (2020)
Red-throated diver	<i>Gavia stellata</i>	x	x	
Black-legged kittiwake	<i>Rissa tridactyla</i>	x	x	x
Northern gannet	<i>Morus bassanus</i>	x	x	x
Atlantic puffin	<i>Fratercula arctica</i>	x	x	x
Razorbill	<i>Alca torda</i>	x	x	x
Great black-backed gull	<i>Larus marinus</i>	x	x	
European storm petrel	<i>Hydrobates pelagicus</i>			x
Leach's storm petrel	<i>Hydrobates leucorhous</i>			
Manx shearwater	<i>Puffinus puffinus</i>			x
Balearic shearwater	<i>Puffinus mauretanicus</i>			
Sooty shearwater	<i>Ardenna grisea</i>			
Great shearwater	<i>Ardenna gravis</i>			
Northern fulmar	<i>Fulmarus glacialis</i>	x	x	x
Common scoter	<i>Melanitta nigra</i>	x	x	
Herring gull	<i>Larus argentatus</i>	x	x	x
Little gull	<i>Hydrocoloeus minutus</i>	x	x	
Lesser black-backed gull	<i>Larus fuscus</i>	x	x	x
Common guillemot	<i>Uria aalge</i>	x	x	x
Cory's shearwater	<i>Calonectris borealis</i>			
European shag	<i>Gulosus aristotelis</i>		x	x
Sandwich tern	<i>Thalasseus sandvicensis</i>	x	x	
Roseate tern	<i>Sterna dougallii</i>			
Yellow-legged gull	<i>Larus michahellis</i>			
Great cormorant	<i>Phalacrocorax carbo</i>	x	x	
Great skua	<i>Stercorarius skua</i>	x	x	x
Black-throated diver	<i>Gavia arctica</i>	x	x	

The annual maximum density maps applied in the model are presented for each of the selected bird species in additional material. An example of such density maps is presented for the Northern gannet in Figure 2.2. The average density of birds in the North Sea is given in Figure 2.3.

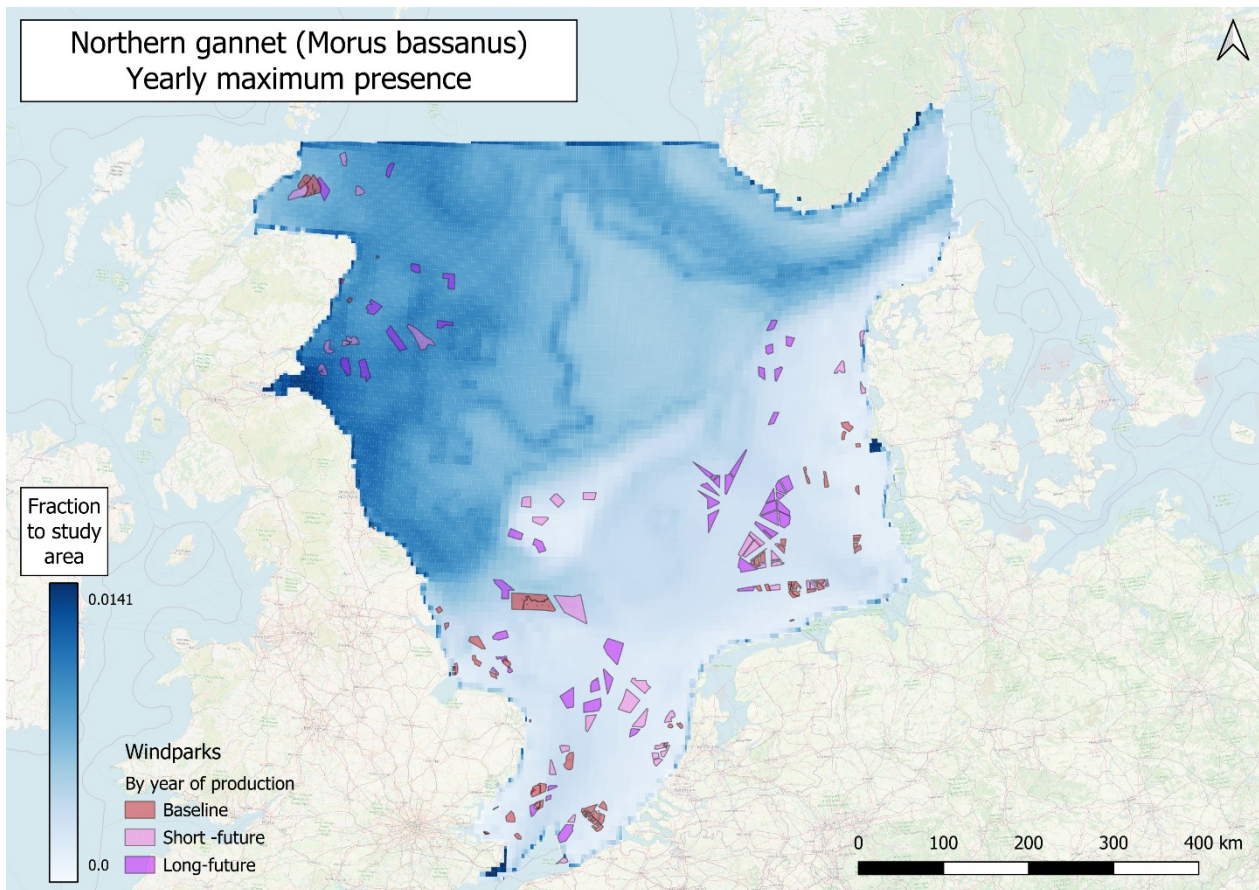


Figure 2.2 Northern gannet density in the North Sea. Species density values of grid cells (0.5 C-squares) are normalised over the population size in the North Sea pilot area.

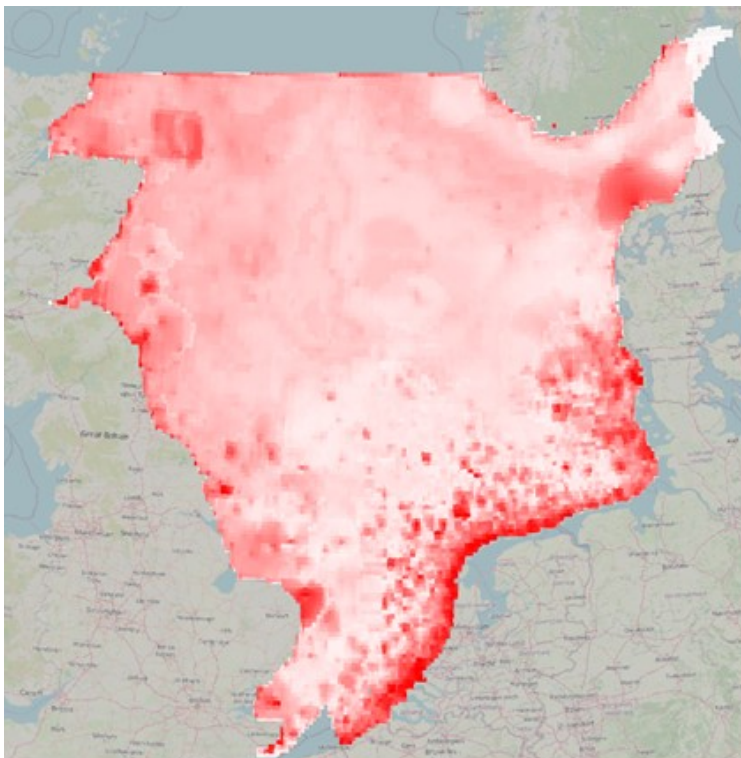


Figure 2.3 Average of the fraction of the predicted density over all selected bird species for the North Sea. For each bird species density values are normalized over the population size in the North Sea pilot area. Subsequently, the averages are calculated.

2.2.2 Celtic Sea

A selection of 12 bird species for the Celtic Sea was agreed. These species all have distribution data available from Waggitt et al. (2020) and additional data from seabird observers and the North East Atlantic predictive seabird atlas as indicated in Table 2.2. Figure 2.4 shows a map with density of northern gannet in the Celtic Sea and the borders of the DMAP area and the designated future wind farm areas.

Table 2.1 List of bird species for the assessment of the Celtic Sea, x in the third column indicates that it is proposed for the Celtic Sea pilot assessment.

Common name	Scientific name	Selected for Celtic Sea	Source: seabird Observer Survey Data	Source: NEA Predictive Seabird Atlas	Source: Waggitt et al. (2020)
Red-throated diver	<i>Gavia stellata</i>		no sightings		
Black-legged kittiwake	<i>Rissa tridactyla</i>	x	x	x	x
Northern gannet	<i>Morus bassanus</i>	x	x	x	x
Atlantic puffin	<i>Fratercula arctica</i>	x	x	x	x
Razorbill	<i>Alca torda</i>	x	x	x	x
Great black-backed gull	<i>Larus marinus</i>		x - south coast and north west	x	
European storm petrel	<i>Hydrobates pelagicus</i>	x	x	west coast only	x
Leach's storm petrel	<i>Oceanodroma leucorhoa</i>				
Manx shearwater	<i>Puffinus puffinus</i>		x	x	x
Balearic shearwater	<i>Puffinus mauretanicus</i>		no information		
Sooty shearwater	<i>Ardenna grisea</i>				
Great shearwater	<i>Ardenna gravis</i>				
Northern fulmar	<i>Fulmarus glacialis</i>	x	x		x
Common scoter	<i>Melanitta nigra</i>		No information		
Herring gull	<i>Larus argentatus</i>	x	south coast	x	x
Little gull	<i>Hydrocoloeus minutus</i>		very rare		
Lesser black-backed gull	<i>Larus fuscus</i>	x	x	x	x
Common guillemot	<i>Uria aalge</i>	x	x	x	x
Cory's shearwater	<i>Calonectris borealis</i>				
European shag	<i>Gulosus aristotelis</i>	x	very rare	limited (coastal)	x
Sandwich tern	<i>Thalasseus sandvicensis</i>		very rare	limited, sites	
Roseate tern	<i>Sterna dougallii</i>				
Yellow-legged gull	<i>Larus michahellis</i>				
Great cormorant	<i>Phalacrocorax carbo</i>			limited (coastal)	
Great skua	<i>Stercorarius skua</i>	x	x		x
Black-throated diver	<i>Gavia arctica</i>				

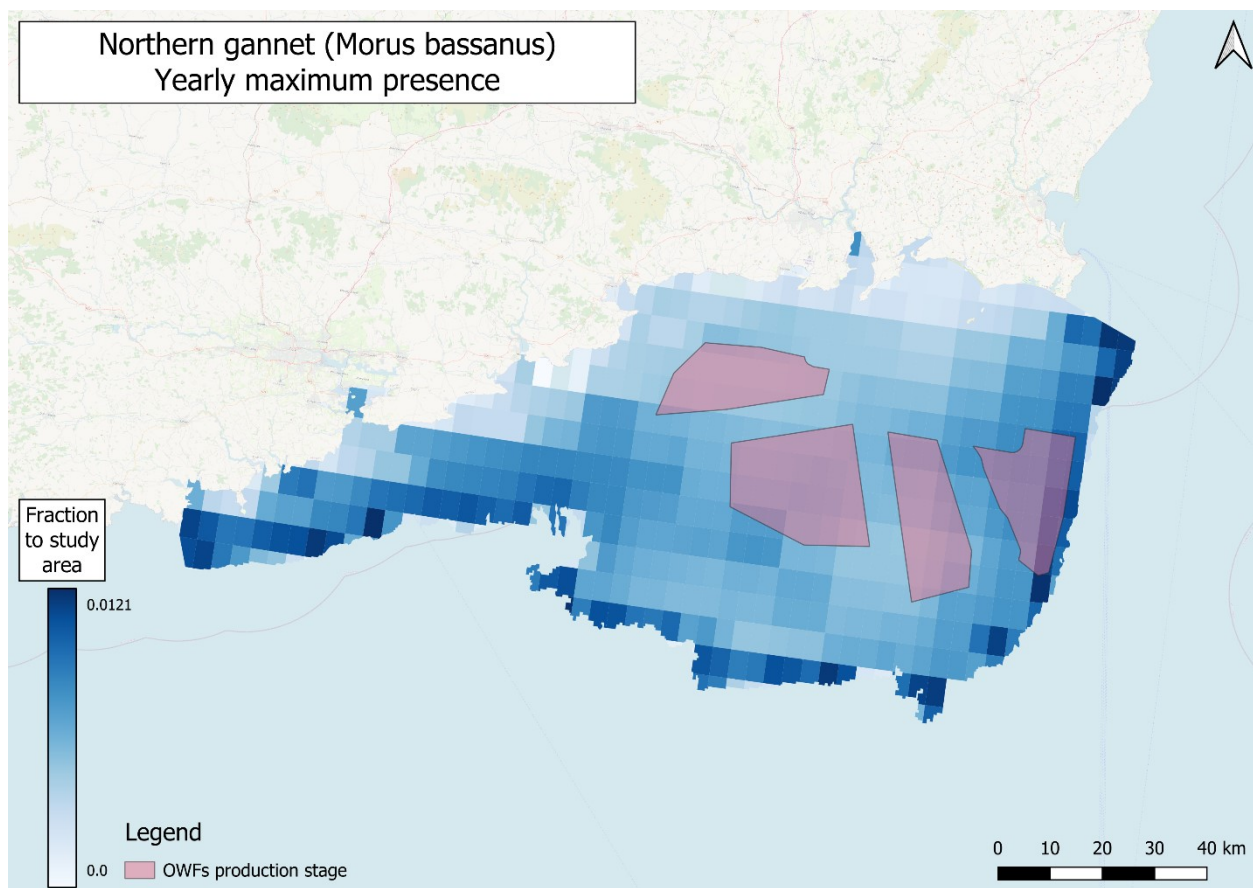


Figure 2.4 Northern gannet density in the Celtic Sea pilot. Species density values of grid cells (0.5 C-squares) are normalised over the population size in the Celtic Sea pilot area.

2.2.3 Bay of Biscay and Iberian Coast

Based on the OSPAR ORED list of bird species, 16 seabird species were agreed for the pilot assessment of the Bay of Biscay and Iberian Coast (see Table 2.3), along with information on the availability of corresponding density maps. To guide the analysis, three biogeographical categories were established according to each species' distribution and breeding range: (1) species that breed widely across OSPAR Region IV, (2) species that breed only in the northern part of the region, representing the southern edge of their breeding distribution, and (3) migratory species that either pass through the area or spend the non-breeding season within the region. Distribution density maps and breeding distribution maps for these species are provided in the Annex. Abundance maps were sourced from Evans *et al.* (2021), while breeding distribution maps were derived from datasets illustrating the breeding populations of seabird species in OSPAR Region IV, based on data from the European Breeding Bird Atlas (EBCC, 2022).

In OSPAR Region IV, seabird species exhibit three main biogeographical breeding patterns. Approximately 44% are widespread breeders, nesting throughout the region. This group includes species such as the Great Black-backed Gull, European Storm Petrel, Herring Gull, Lesser Black-backed Gull, Cory's Shearwater, European Shag, and Yellow-legged Gull (see Section 3 of the Annex for distribution maps). Another 44% are primarily confined to the northern part of the region for breeding, particularly around the Bay of Biscay, which marks the southernmost extent of their nesting range, as their core breeding grounds lie further north in Europe. Species in this group include the Black-legged Kittiwake, Northern Gannet, Atlantic Puffin, Razorbill, Manx Shearwater, Common Guillemot, and Northern Fulmar. The remaining 12%—such as the Balearic Shearwater and Great Skua—do not breed in the region but are present as migratory visitors, either passing through or overwintering in the area.

Table 2.2 Bird species selected for the assessment of the environmental risk of offshore wind farms in the Bay of Biscay and Iberian Coast pilot. NE Atlantic: the density map encompasses the whole Northeast Atlantic area; Bay of Biscay: the density map only encompasses the Bay of Biscay area; Celtic Sea: the density map only encompasses the Celtic Sea area. And data sources used for the assessment.

Common name	Scientific name	Selected for Bay of Biscay and Iberian Coast	Source: Waggitt et al. (2020)	Source: Evans et al. (2021)
Red-throated diver	<i>Gavia stellata</i>			
Black-legged kittiwake	<i>Rissa tridactyla</i>	x	x	
Northern gannet	<i>Morus bassanus</i>	x	x	
Atlantic puffin	<i>Fratercula arctica</i>	x	x	
Razorbill	<i>Alca torda</i>	x	x	
Great black-backed gull	<i>Larus marinus</i>	x		x
European storm petrel	<i>Hydrobates pelagicus</i>	x	x	
Leach's storm petrel	<i>Hydrobates leucorhoa</i>			
Manx shearwater	<i>Puffinus puffinus</i>	x	x	
Balearic shearwater	<i>Puffinus mauretanicus</i>	x		x
Sooty shearwater	<i>Ardenna grisea</i>			
Great shearwater	<i>Ardenna gravis</i>			
Northern fulmar	<i>Fulmarus glacialis</i>	x	x	
Common scoter	<i>Melanitta nigra</i>			
Herring gull	<i>Larus argentatus</i>	x	x	
Little gull	<i>Hydrocoloeus minutus</i>			
Lesser black-backed gull	<i>Larus fuscus</i>	x	x	
Common guillemot	<i>Uria aalge</i>	x	x	
Cory's shearwater	<i>Calonectris borealis</i>	x		x
European shag	<i>Gulosus aristotelis</i>	x	x	
Sandwich tern	<i>Thalasseus sandvicensis</i>			
Roseate tern	<i>Sterna dougallii</i>			
Yellow-legged gull	<i>Larus michahellis</i>	x		x
Great cormorant	<i>Phalacrocorax carbo</i>			
Great skua	<i>Stercorarius skua</i>	x	x	
Black-throated diver	<i>Gavia arctica</i>			

The overall assessment is focused on the cumulative pressures produced by wind turbines affecting seabirds in the region. The assessment was performed at the species level and based on the SCAIRM approach. The assessment firstly relies on available data (e.g. spatial maps) where such information is available, literature and/or expert opinion is used. As part of the analysis, maximum density maps used in the model are presented alongside areas of high seabird density, identified using the 95th percentile threshold of species-specific density distributions, following the methodology of Astarloa et al. (2021). These maps are presented for the Northern gannet in section 2.5 and each of the selected bird species in the additional material if wanted.

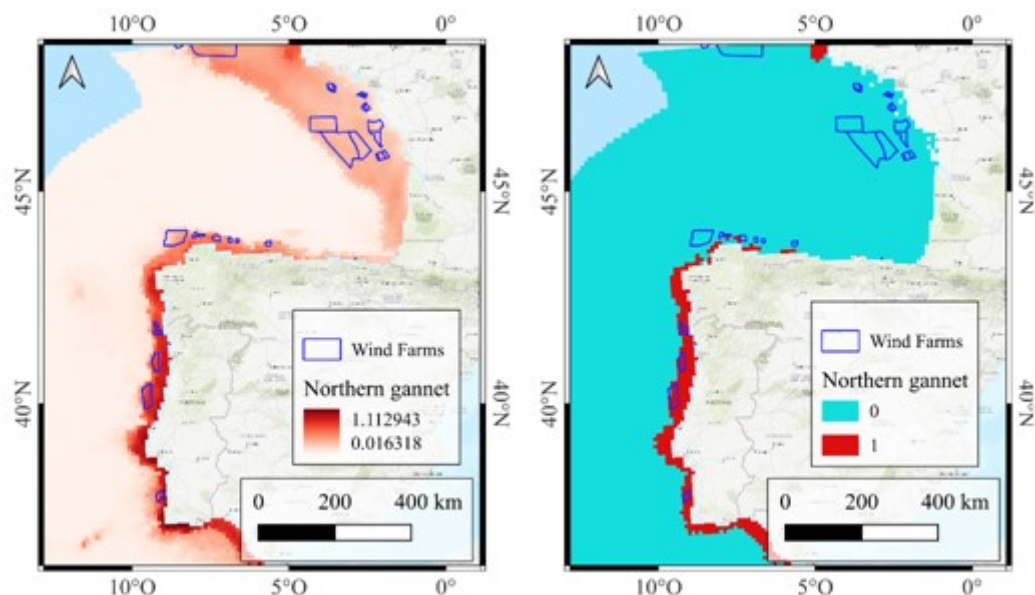


Figure 2.5 Left: northern gannet density (individuals per km²); right: northern gannet high-density zones (based on percentile 95th), in the OSPAR Region IV.

2.3 Effect Potential selected bird species

2.3.1 Parametrization of effect from OWF pressures

To parametrize collision and displacement due to OWF for each selected bird species (Effect Potential, see paragraph 2.1.1), species-specific information was used from literature (Maclean et al., 2009; Leopold et al., 2014; Cook et al., 2018; Skov et al., 2018; Potiek et al., 2022; Soudijn et al., 2022), (Table 2.4). Collision, was parametrized based on avoidance rates (the proportion of birds taking action to avoid collision). These rates were used to calculate the collision risk, i.e. the percentage of birds overlapping with a wind farm area that do not succeed in avoiding collision are assumed to die. To account for the effects of displacement which is caused by the pressure “disturbance (visual) of species”, relative displacement risk scores (RDRS) were used that reflect the additional mortality (i.e. fraction of exposed birds) caused by displacement from their preferred habitat. RDRS were derived by Leopold et al. (2014) and were also used by Soudijn et al. (2022). Some RDRS were adjusted here, based on expert judgement.

Table 2.4 Parametrization of effects from the main OWF pressures, i.e. collision and visual disturbance causing displacement.

Common name	Scientific name	Collision rate	Relative displacement
Red-throated diver	<i>Gavia stellata</i>	1.00% #	8% **
Black-throated diver	<i>Gavia arctica</i>	1.00% #	8% **
Northern fulmar	<i>Fulmarus glacialis</i>	0.10% #	1% (**)
Manx shearwater	<i>Puffinus puffinus</i>	0.10% #	1% (**)
Cory's shearwater	<i>Calonectris borealis</i>	0.10% #	1% (**)
Balearic shearwater	<i>Puffinus mauretanicus</i>	0.10% #	1% (**)
European storm petrel	<i>Hydrobates pelagicus</i>	1.00% @	1% (**)
Northern gannet	<i>Morus bassanus</i>	1.10% *\$	2% (**)
Great cormorant	<i>Phalacrocorax carbo</i>	1.00% #	1% **
European shag	<i>Gulosus aristotelis</i>	1.00% #	4% **

Common scoter	<i>Melanitta nigra</i>	1.00% #	8% **
Great skua	<i>Stercorarius skua</i>	0.50% *	2% (**)
Little gull	<i>Hydrocoloeus minutus</i>	0.50% *	2% (**)
Herring gull	<i>Larus argentatus</i>	0.50% *\$	0% (**)
Lesser black-backed gull	<i>Larus fuscus</i>	0.20% *\$	0% (**)
Great black-backed gull	<i>Larus marinus</i>	0.50% *\$	2% **
Black-legged kittiwake	<i>Rissa tridactyla</i>	0.80% *\$	2% **
Sandwich tern	<i>Thalasseus sandvicensis</i>	1.00% *	5% (**)
Common guillemot	<i>Uria aalge</i>	0.50% #	6% (**)
Razorbill	<i>Alca torda</i>	0.50% #	5% (**)
Atlantic puffin	<i>Fratercula arctica</i>	1.00% #	5% (**)

Precautionary avoidance rates reported by Maclean et al. (2009): 99% for terns, divers, cormorants, ducks, geese, grebes and puffins; 99.5% for auks, gulls and gannet; 99.9% for fulmar and shearwater.

@ Expert judgement based on Furness et al. (2013) and Potiek et al. (2022)

* Potiek et al. (2022)

\$ Cook et al. (2018)

** Leopold et al. (2014); Soudijn et al. (2022)

(**) Expert judgement adjustment of values reported by Leopold et al. (2014) and Soudijn et al. (2022)

The original SCAIRM linkage framework contained parameterization only for a single birds ecosystem component. This is now markedly improved with species-specific parametrisation. First, relevant impact chains were selected. For this study, the impact chains Windfarms – operational (A) – Death or injury by Collision (P) – Birds (EC) and Windfarms – operational (A) – Disturbance (visual) of species (P) – Birds (EC) were used. The original value of Hazard*Behaviour*Magnitude was replaced with a single parameter representing the proportion of species that die from a single interaction with the Activity-Pressure event. Yellow-legged gull was initially not included when setting up these species-specific parametrization. Therefore, in the OSPAR region IV assessment, where the yellow-legged gull was also included, the parameters of the herring gull were used, being the most similar species in behaviour and life history.

2.3.2 Parametrization of effect from shipping

A similar approach to acquire sensitivity scores for shipping was applied. The impact chain Shipping – steaming (A) – Disturbance (visual) of species (P) – Birds (EC) was selected to be used for species-specific parametrization. Scores were obtained from Fliessbach et al. (2019). Sensitivity scores from the paper were scaled to a value between 0 and 1, to be compatible to replace the Behaviour*Hazard*Magnitude value. Because of a lack of information on bird deaths after disturbance from a vessel, the most sensitive species, the red-throated diver, was set to a maximum sensitivity of 1, with the other species scaled to this setting. The numbers were then multiplied with 0,1, according to the approach for OWF. The parametrization of the bird species is shown in the Table 2.5 below.

Table 2.5 Parametrization of effects from shipping (representing all marine traffic). Derived from Fließbach et al. (2019).

Common name	Scientific name	Disturbance
Red-throated diver	<i>Gavia stellata</i>	10.00%
Black-throated diver	<i>Gavia arctica</i>	9.00%
Northern fulmar	<i>Fulmarus glacialis</i>	1.00%
Manx shearwater	<i>Puffinus puffinus</i>	-
Cory's shearwater	<i>Calonectris borealis</i>	-
Balearic shearwater	<i>Puffinus mauretanicus</i>	-
European storm petrel	<i>Hydrobates pelagicus</i>	-
Northern gannet	<i>Morus bassanus</i>	2.00%
Great cormorant	<i>Phalacrocorax carbo</i>	3.93%
European shag	<i>Gulosus aristotelis</i>	-
Common scoter	<i>Melanitta nigra</i>	9.29%
Great skua	<i>Stercorarius skua</i>	1.29%
Little gull	<i>Hydrocoloeus minutus</i>	1.74%
Herring gull	<i>Larus argentatus</i>	1.14%
Lesser black-backed gull	<i>Larus fuscus</i>	1.29%
Great black-backed gull	<i>Larus marinus</i>	1.29%
Black-legged kittiwake	<i>Rissa tridactyla</i>	1.29%
Sandwich tern	<i>Thalasseus sandvicensis</i>	0.86%
Common guillemot	<i>Uria aalge</i>	2.79%
Razorbill	<i>Alca torda</i>	6.00%
Atlantic puffin	<i>Fratercula arctica</i>	6.00%

The paper of Fliesbach et al. (2019) did not give sensitivity values for Atlantic puffin, great skua, European shag, European storm petrel, Cory's shearwater, Manx shearwater and Balearic shearwater. The sensitivity score of razorbill was given to Atlantic puffin and the sensitivity score of great black-backed gull to great skua, for those species are assumed to have the most similar life history. The remaining species were left out, for this shipping scenario was only applied in the North Sea pilots, where they do not occur.

2.4 Applied scenarios

In order to define the scenarios for the current activities and the expected future activities in the regional seas, the relevant activities were selected and information was collated. In this chapter, it is described for each of the three pilot assessment areas with an indication of the information sources. Ready to use future scenarios for OWF up to 2030 (short term) and after 2030 (long term) are often not available. Therefore, these future scenarios were constructed in the project by identifying, collecting and combining relevant input information in a way that is comparable for each of the pilot areas.

Moments in time (e.g. 2030, 2040, 2050) chosen for the short-term and/or long-term scenarios was done by the regional partner. This can be because of available/limiting data or other reasons. Everywhere it is assumed that the long-term scenario has no construction phase.

2.4.1 Required information to design scenarios for OWF

In order to formulate future scenarios for OWF in each of the pilot areas several types of information were collated from publications and data sources or requested to authorities. An overview of these characteristics is given in Table 2.6. The importance differs among these characteristics. Assumptions were made when necessary but increased the uncertainty of the designed scenarios. One important aspect to consider is that in case plans for future spatial areas for OWF are published these often are so-called search areas for OWF being much larger than the area that is necessary to contain the wind farms in order to generate the intended energy capacity. So, it is important to assess the expected conversion from search areas to realistic surface areas for OWF in the future. This conversion can be expressed in a so-called scaling factor specific for each of the future OWF surface areas. Scale factors to realistic OWF surface areas can be based on information on wind turbine parameters e.g. inter turbine distances and centralisation for the placing of wind farms within a search area. An example is recently carried out for OWF in the North Sea (Source: memo KEC 5.0 Technische Aannames windparkscenario, 8 April 2024 with additional shapefiles and Excel data file).

It should be realized that the design of scenarios for OWF will require much exchange of information and ideas of the project team with marine spatial planning authorities and OSPAR. Important data gaps may be encountered and can be expected especially for the Celtic Sea and Bay of Biscay, where OWF are not developed as far as for the North Sea.

In the North Sea pilot, utilization factors were applied to OWF search areas, by reducing the area with the utilization factor towards the centroid of the OWFs polygon. Therefore, it is assumed that all developed OWFs are built in the middle of the search areas.

Table 2.6 Required information to design scenarios for OWF. X implies required for SCAIRM, * only required in case other (preferred) information is not available and # nice to know but not necessary for our impact assessment with SCAIRM.

Nr	Characteristics of OWF	Required for SCAIRM	Comment
1	Area (km ²) of wind farms	X	Preferably published or provided information, but in case this is lacking it can be derived from installed/required capacity and density of capacity per area for an OWF
2	Capacity (GW) of wind farms	*	Is required in case OWF area is not provided
3	Capacity per wind turbine (MW)	*	Is required in case OWF area is not provided
4	Density of energy capacity per OWF area (MW/km ²)	*	Is required in case OWF area is not provided. What assumption to make in case of missing information? e.g. 10 MW/km ² ?
5	Development phase of wind farm		#
6	Construction or operational phase for each OWF	X	
7	Spatial location of wind farm (search area) (GIS data)	X	To link OWF area with the density of seabirds (to derive exposure)
8	Utilisation factor (scaling factor) of wind farm search area (ration realistic area/search area) per wind farm	X	Derived by the project team
9	Location of realistic OWF area with search area (choice to make e.g. centralise)	X	
10	Scenario year or period to consider for our impact assessment	X	Which time scale for short-term and longer-term views relevant to OSPAR. Or propose 2030 and either 2040 or 2050?
11	Distances between wind turbines		#
12	Design of wind farm (localisation pattern of wind turbine with wind farm)		#
13	Height of wind turbines / rotor dimensions		#
14	Type of wind turbines (seafloor attached or floating)	X	
15	Stop-start procedures to mitigate collision risk when intense migration occurs at rotor height		Could be of importance in future SCAIRM analyses

2.4.2 North Sea

Activities

There are many human activities taking place in the North Sea or its surroundings (e.g. land-based activities) that may be impacting the North Sea. The SCAIRM typology distinguishes 36 activities (see Annex 1). This includes activities that can be considered major threats to the bird species whereas others are expected to be negligible. Therefore, we distinguish between:

- All activities (36) in SCAIRM where Exposure was estimated based on expert judgement.
- Assessed activities where overlap with species is calculated from spatial GIS-based information (mostly obtained from EMODnet) and scenarios involving spatial information can be evaluated. This comprises 24 activity - phase combinations involving 17 activities:
 - Aquaculture: fin-fish - Operational

- Aquaculture: macro-algae - Set-up
- Aquaculture: macro-algae -Operational
- Boating/Yachting - Steaming
- Dredging - Spoil/waste disposal
- Dredging - Extraction of substrate
- Fisheries -- Steaming
- Fishing: benthic trawls - Operational
- Fishing: pelagic trawls - Operational
- Fishing: static gear - Operational
- Marinas and dock/port facilities - Operational
- Military - Steaming
- Military - Operational
- Military - Marine dumped munitions
- Mining (sand/gravel aggregates) - Extraction of substrate
- Oil & Gas - Operational
- Oil & Gas - Construction
- Shipping - Steaming
- Suction/hydraulic dredges - Operational
- Telecoms and Electricity: Cables - Operational
- Waste management - Operational
- Water sports without engine - Steaming
- Wind farms - Operational
- Wind farms - Construction

Information sources

The main human activities (and their different phases) were included in this pilot assessment using the scenario values presented in Jongbloed et al. (2023). The values represent the extent of the activity, expressed as the percentage of the North Sea study area. The baseline and future scenario values for aquaculture, fishing, oil and gas, sand/gravel mining, shipping and telecoms and electricity scenarios were previously derived by Piet et al. (2021b). The future scenario values were applied as Frequency values (see section 2.1) in the SCAIRM methodology.

For wind farms, baseline and future scenarios were updated by Wageningen Marine Research (WMR) in April 2023 using data provided by RWS (see Annex for more information on the wind farm scenarios and underlying data). Using this recent RWS data, a map of offshore wind farm areas in different stages of development was developed. Two main phases can be distinguished:

1. Development zones, which are areas designated for wind energy development;
2. Wind farm areas, which indicate the sites where wind farms are being developed in stages ranging from early planning to fully commissioned

For the other 27 human activities (see list above) there were no scenarios available. These were therefore assumed not to change in future scenarios, i.e. the baseline as used in Piet et al. (2023) was used for the future scenarios.

Scenarios used for the impact assessment

Preferably, spatial future scenarios for the North Sea are used in impact assessments, but these are only available for OWF. For other human activities future scenarios are only known for the North Sea as a whole area with a factor of change of intensity or frequency without information on the change in spatial allocation and are therefore considered as “non-spatial future scenarios”.

Spatial future scenarios for offshore wind

Figure 2.6 gives an overview of the spatial scenarios to calculate Impact Risk from (partially) construction and production of OWFs. For reading purposes, the pictures are given in a comprised format below. Higher resolution pictures are given in Annex II. The future OWF scenarios are derived from Rijkswaterstaat (2024).

All maps are created and adapted with QGIS, where also the utilization factor was applied. In the Baseline and Short-term scenario, a differentiation is made between the construction and operation phases, where the selected year determines the situation. The Baseline scenario occurs in 2023 and the Short-term scenario in 2030. In the selected years, all wind farms that have been built in year-1 are classified as the activity Wind farms – operational. The wind farms that are being constructed in the given year are classified as the activity Wind farms – construction. In the long-term scenario, which occurs in 2035, it is assumed that all wind farms are completed and are therefore all classified as the activity Wind farms – operational. For the spatial Impact Risk assessment of OWF no displacement zones are applied for birds around the wind farms. Displacement is only considered within the outer borders of a wind farm. This is a simplification of the reality. It is known that displacement zones occur and these vary among bird species (e.g. a 19.5 km displacement zone for common guillemots found by (Garthe et al. 2023)). This simplification was applied because displacement distances are not known for each of the selected bird species. Therefore, displacement is only considered within wind farm areas. However, due to working with grid cells of 0.5 C-squares this also involves grid cells that are occupied partly by OWF and therefore an extra distance of 6.5 km at maximum outside the border of a wind farm may be included in some cases.

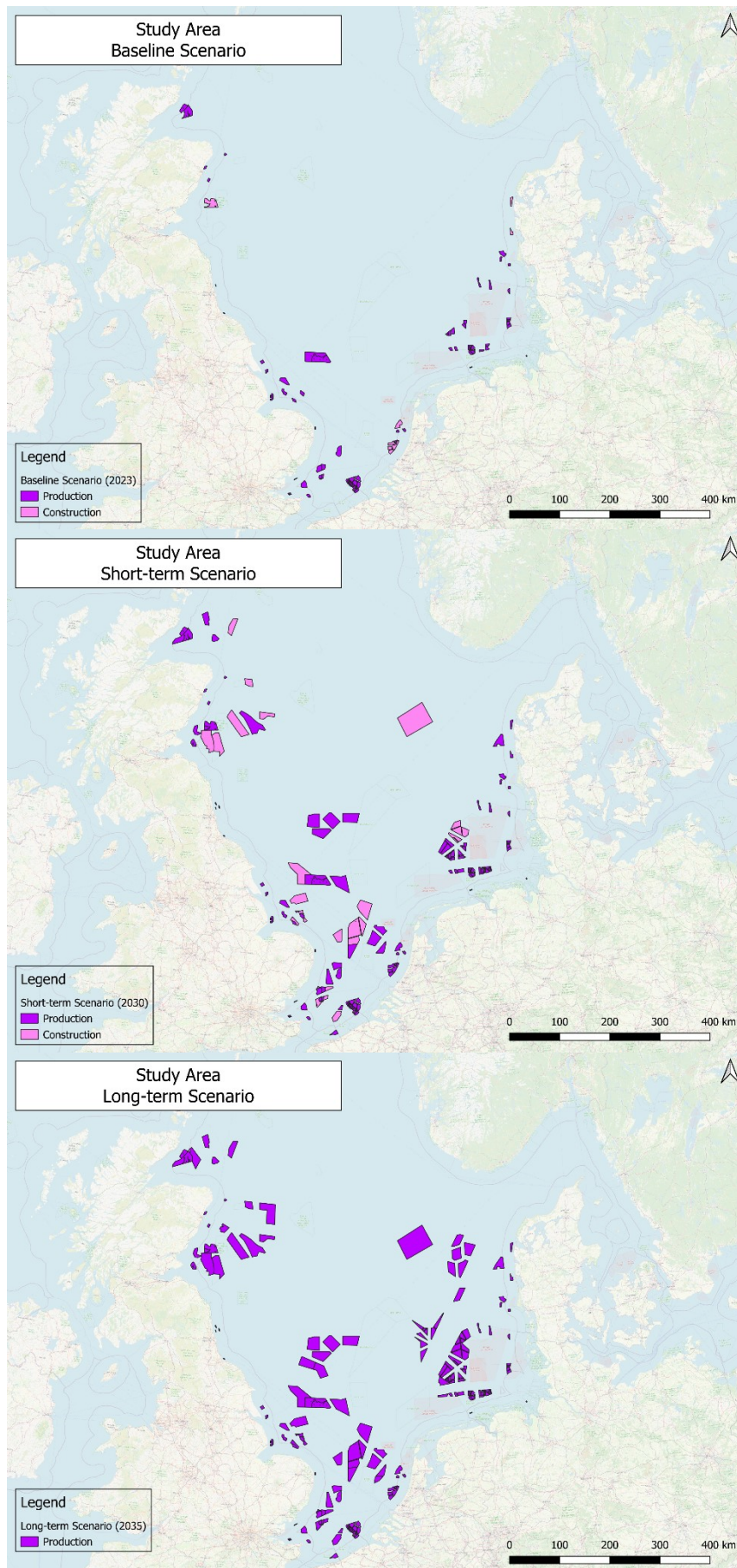


Figure 2.6 Spatial future scenarios for offshore wind farms in the North Sea study pilot for baseline (2023) (top panel), short-term future (2030) (middle panel) and long-term future (ca. 2035) (bottom panel).

Non-spatial future scenarios for activities other than offshore wind

In this study, the goal was to derive future scenario values for all human activities (in fact activity-phase combinations, e.g. construction versus operations) for which spatial information (GIS) was available and that concerns 24 activity-phase combinations (section 0). However, future scenarios were only available for 14 activity-phase combinations. Except for offshore wind farms, these future scenarios are not spatially known but only as a single value for the North Sea study area as a whole area. The future scenario values are expressed as factors for the change in the future in relation to the baseline situation and presented in Table 2.7. The future scenario values for aquaculture, fishing, oil and gas, sand/gravel mining, shipping, telecoms and electricity were taken from Piet et al. (2021b). For 10 of the activity-phase combinations, insufficient information was available to derive future scenario values. Therefore, the assumption was made that these activity-phase combinations will not change in the short-term and long-term future and the scenario factor values are set at 1 and marked in red.

Table 2.7 Short-term and long-term future scenario values for the main human activities in the North Sea study area derived in the current study. These future scenarios are expressed as factors relative to baseline and taken from (Piet et al., 2021b).

Activity	Phase of activity	Scenario factor for short-term future	Scenario factor for long-term future
Aquaculture: fin-fish	Operational	1.76	30.42
Aquaculture: macro-algae	Set-up	1.75	30.42
Aquaculture: macro-algae	Operational	1.75	30.42
Boating/Yachting	Steaming	1	1
Dredging	Spoil/waste disposal	1	1
Dredging	Extraction of substrate	1	1
Fisheries	Steaming	0.94	0.94
Fishing: benthic trawls	Operational	0.94	0.88
Fishing: pelagic trawls	Operational	0.94	0.88
Fishing: static gear	Operational	0.94	0.88
Marinas and dock/port facilities	Operational	1	1
Military	Steaming	1	1
Military	Operational	1	1
Military	Marine dumped munitions	1	1
Mining (sand/gravel)	Extraction of substrate	1.32	1.60
Oil & Gas	Operational	1	0.02
Oil & Gas	Construction	1	0
Shipping	Steaming	1	1.39
Suction/hydraulic dredges	Operational	1	1
Telecoms/Electricity cables	Operational	1.34	1.86
Waste management	Operational	1	1
Water sports without engine	Steaming	1	1
Wind farms	Operational	Realistic area: 2.70 Search area: 4.92	Realistic area: 3.39 Search area: 6,27
Wind farms	Construction	1,49	0,00

For the calculations of the Impact Risk of the activities in future scenarios, it is assumed that the intensity of the activities will change according to the scenario factors whereas the spatial extent and allocation will not change with respect to the baseline scenario.

2.4.3 Celtic Sea

Activities

There are many human activities taking place in the Celtic Sea or its surroundings (e.g. land-based activities) that may be impacting the Celtic Sea. Prior to this pilot study, 17 sectors, 20 pressures and 26 ecological components and their interactions have been identified and assessed for risk, with Fishing, Land-based Industry, Waste Water, Shipping, Tourism and Recreation accounts for 92% of the observed risk to the system (Figure 2.7) (Pedreschi et al., 2023). Within this study seabirds were treated as a single group, for which 11 pressures arising from 16 sectors were found to be relevant, with particular risks arising from litter and contaminants.

Shelf Pelagic —

Figure 2.7 Sankey diagram of pathways between sectors (left), the pressures these exert (middle) and the ecosystem components these impact (right) in the Celtic Sea. The width of lines (colour-coded according to pressures) represents the Impact Risk score (product of overlap, frequency and degree of impact). The thickness of the grey bars indicates the summed Impact Risk score for that component.

The current work was built on a previous CIA that did not distinguish bird species and was still based on an adapted ODEMM assessment (Pedreschi et al. 2023). For the OSPAR bird pilot, the previous assessment was used as a starting point to identify potentially relevant sectors and pressures that affect seabirds in the region to be included in the species-level SCAIRM analyses. The assessment has been informed by data (e.g. spatial maps) where such information is available, and by literature and/or expert opinion where it is not, similarly to the North Sea approach. In this updated assessment, 21 activities and 24 pressures were considered, of which 19 activities, 14 pressures and 12 bird species were identified as relevant and further assessed for risk. Work was also carried out to align the categories and terminology used across the various pilots for the purposes of this work.

The 21 Activities assessed for the Celtic Sea pilot area are:

- Mining, extraction of materials: including organic, maerl, rock/minerals, sand/gravel, salt
- Agriculture (crops and livestock)
- In-situ Aquaculture
- Beam Trawling
- Benthic Trawling
- Coastal Infrastructure
- Dredge Fishing
- Harvesting/Collecting
- Land-based Industry
- Military
- Navigational Dredging
- Net Fishing
- Oil and Gas
- Pelagic Trawling
- Potting
- Research
- Shipping
- Telecoms and Electricity
- Tourism/Recreation
- Waste management – operational disposal of waste or other material and/or sewage treatment and storm overflows
- Wind Farms

For the spatial cumulative analysis, activities that were available on EMODnet and occur in the study area were used. There are currently no operational OWF sites within the Celtic Sea. The pilot assessment has investigated realistic potential scenarios of ORE expansion within the region, and their potential impacts (see Section 3.2.1).

In the Celtic Sea spatial assessment, one scenario (Baseline) was applied, where all OWFs are assumed to be operational. The following activities were applied spatially:

- Aquaculture: macro-algae - Set-up
- Dredging - Spoil/waste disposal
- Dredging - Extraction of substrate
- Fishing: benthic trawls - Operational
- Fishing: pelagic trawls - Operational
- Fishing: static gear - Operational
- Military - Operational
- Military - Marine dumped munitions
- Suction/hydraulic dredges - Operational
- Telecoms and Electricity: Cables - Operational
- Waste management - Operational
- Wind farms - Operational

Scenarios will be based on currently proposed and planned ORE activity within the Celtic Sea, with a focus on the DMAP region, and may include (based on feedback from OSPAR);

- A. Scenarios of varying spatial extent developed based on current regional spatial plans, e.g. short-term vs. longer-term views at a time scale relevant to OSPAR (feedback required). In these cases, other sectors will be assumed not to change between scenarios to assess the impacts specifically associated with ORE.
- B. Investigating trade-offs between pressures/sectoral level impacts due to the interactions of activities at the site level, e.g. reduction of pressures from fishing due to the exclusion of fishing ORE sites.

Information sources

Bird distribution data from Waggitt et al. (2020), national survey data, and the North East Atlantic Predictive Seabird [Atlas](#). Initial scoring will be informed by the previous Celtic Sea risk assessment (Pedreschi et al. 2023) and the North Sea analyses. Sensitivity information will be informed by the previous North Sea analyses and project partners. Sectoral spatial data will be informed via national and EU data, such as from [Ireland's Marine Atlas](#) and EMODnet/ [European Atlas of the Sea](#). For fisheries, Irish national fisheries data (logbooks, VMS, surveys) will be used. Licensing and site use will be informed by Ireland's Marine Spatial Planning Authority, with spatial maps available at MarinePlan.ie, and informed by [National Marine Planning Framework](#) (NMPF). For the spatial assessment, OWF species-specific parametrisations were used where possible.

Table 2.8 Short term (2030) and long term (2050) future scenario values for the main human activities in the Celtic Sea study area and the baseline values (km² or % of study area) derived in the current study. These future scenarios are expressed as factors with respect to baseline values.

Activity	Phase of activity	Baseline Surface area (km ² or %)	Scenario factor for short term future (2030)	Scenario factor for long term future (2050)
Fishing: benthic (bottom trawls)	Operational		No change	0.9
Fishing: beam trawls	Operational		No change	0.7
Fishing: dredges	Operational		No change	0.6
Fishing: pelagic trawls	Operational		No change	0.8
Fishing: nets	Operational			0.8
Fishing: pots	Operational		No change	No change, displaced within DMAP area
Shipping	Steaming		No change	No change- displaced but still within study area
Tourism/Recreation			No Change	No Change
Wind farms	Operational		See provided maps – Area A by 2030,	All areas (A-D) by 2050
Wind farms	Construction		Area A pre 2030,	Areas B-D between 2030-2050. Construction complete by 2050

Non spatial future scenarios (for main activities)

The following non-spatial qualitative scenarios were produced for the Celtic Sea DMAP area:

1. S1: Current baseline assessment with no offshore wind farms present
2. S2: A pre-2030 assessment with windfarm related "Construction Only" impacts added proportional to a single development area (DMAP area A Figure 4)
3. S3: A 2030 assessment with both operational and construction activities present. The first development area, area A is expected to be developed and operational by 2030, with additional areas B-D expected to be operational by 2050. This scenario assumes that area A is operational and while construction has ceased in area A, construction and development has initiated in one other DMAP sub-area.
4. S4: A 2050 assessment when construction activities and pressures have ceased, but all four proposed development areas are complete and operational.
5. S5: A 2050 assessment with hypothetical impacts on fishing activity resulting from decreases and/or displacement of certain types of fishing within DMAP area. The following assumptions are made:
 - a. Dredge fishing is substantially reduced due to overlap with DMAP area. This results in downgrading of spatial extent by one category for each pressure. Frequency unaffected.
 - b. Some decreases in net fishing spatial extent and frequency due to overlap with DMAP area.
 - c. Pelagic trawling: existing activity within DMAP is relatively low. Existing offshore activity is displaced to areas outside of ORE development areas, whereas coastal activity remains. Overall spatial footprint reduced to Site (>5%) across all pressures. Frequency unaffected.
 - d. Beam trawling fishing decreases in spatial extent (all WP reduced to L) and frequency (some reductions from VF) due to overlap with DMAP area. Removal rather than displacement is assumed as this type of trawling is more habitat associated.

- e. Benthic trawling (bottom otter trawling) spatial extent reduced from WP to L where relevant. Frequency not affected. Displacement rather than removal expected, resulting in more concentrated activity.
- f. No change to potting activity; assume access allowed, or activity is displaced within DMAP area due to spatial limitation of smaller vessels.

2.4.4 Bay of Biscay and Iberian Coast

Activities

The study of Bay of Biscay and Iberian Coast looks for the potential effects of different phases of wind farm development in the OSPAR IV region's bird species. In consequence, the spatial information of human activities applied was the distribution of offshore wind farms. This activity was considered for the construction and operational phases. As the considered activity is one, no spatial information of other activities was used and thus, only cumulative risk produced by wind farms was assessed.

Information sources

Predicted seabirds' spatial and temporal distribution was obtained from the predicted density distribution maps produced by Waggitt et al. (2020) and Evans et al. (2021). Sensitivity information was adopted from literature review and expert judgement (see Section 2.3.1). The spatial data and information on offshore wind farms were obtained from the national legislation or planning documents from France, Spain and Portugal. In the case of France, the spatial distribution of areas for offshore wind farm development was allocated in CEREMA repository. The technical characteristics and temporal information regarding the wind farms were obtained from DGITM (2025). For Spain, the spatial information about the areas for offshore wind farm development established in the national maritime plans by Royal Decree 363/2017 and approved by Royal Decree 150/2023, were obtained from the National Spatial Data Infrastructure (<https://infomar.miteco.es/visor.html>). For Portugal, the information regarding the offshore wind farms approved by the Council of Ministers Resolution no. 19/2025, of 7th February is available in the repository of the Directorate General for Natural Resources, Security and Maritime Services¹.

Scenarios used for the impact assessment

Portugal approved the marine renewable energy allocation plan in Council of Ministers Resolution No. 19/2025 of 7 February, published in the Official Bulletin of the Union No. 27/2025, Series I of 7 February 2025. According to the resolution, offshore wind farms are expected to start construction by 2030. The aim is to create the necessary conditions for the allocation and installation of 2 GW of capacity through auctioning by 2030. The National Energy and Climate Plan (PNEC, 2030) aims to increase the share of renewable energy in gross final energy consumption to 51% and move towards climate neutrality by 2045. The PAER (Plano de Afetação para as Energias Renováveis Offshore) identifies specific areas for the installation of offshore wind farms with a total capacity of up to 9.4 GW. For that, 11 selection criteria were adopted to identify potential areas for offshore energy extraction: Horizontal wind speed (m/s); Number of operating hours equivalent to nominal power (NEPS) (h/year); Incident wind power flux (W/m²); Wave energy resource (kW/m); Bathymetry (m); Slope (°); Distance to the coast (nm); Seabed; Tectonic rifts; Servitudes, administrative restrictions and conditioned areas; Private uses of the national maritime space. Applying established criteria, five potential areas with different extensions and potential capacities have been proposed to consider in the National Maritime Spatial Plan for commercial renewable energy extraction: Viana do Castelo (229 km² and 0.8 GW), Leixões (722 km² and 2.5 GW), Figueira da Foz (1325 km² and 4.6 GW), Sines (430 km² and 1.5 GW), and Aguçadora (5.6 km², non-applicable due to research objectives). Moreover, in 2019 Portugal approved the National Maritime Spatial Planning Situation Plan for the Mainland, Madeira and Extended Continental Shelf subdivisions, according to the Council of Ministers Resolution no. 203-A/2019, of 30 December, published in the Official Bulletin no. 250/2019, 1st Supplement, Series I of 2019-12-30, pages 72-(2) to 72-(391), where three areas were identified for offshore renewable energy, in Aguçadora, Viana do Castelo, and Peniche. Currently, the operating turbines

¹ <https://webgis.dgrm.mm.gov.pt/portal/apps/webappviewer/index.html?id=15c32cf0500c43148f97270db0c1f584>

are present in Viana do Castelo, occupying an area of 10 km² approximately. All potential areas, except for Peniche and Aguçadoura, are destined for the implementation of commercial renewable energy farms.

The roadmap for the development of offshore wind and marine energy in Spain published by the MITECO (Ministry for Ecological Transition and the Demographic Challenge), sets a target of 1 to 3 GW of installed offshore wind capacity by 2030. In this context, Spain establishes a framework for maritime spatial planning through Royal Decree 363/2017, of 8 April, and approves five plans (once per national maritime districts) by the Royal Decree 150/2023. These plans identify areas of high potential for offshore wind energy development where offshore wind deployment is technically most suitable and where certain criteria for environmental protection and compatibility with other uses of the sea are met. The definition of the areas to facilitate the commercial development of offshore wind, while trying to respect the needs of each sector was done in four phases. The first phase consisted of identifying those areas where the wind resource, from a strictly theoretical and technical point of view, could be exploited: a maximum depth of 1,000 m; an average annual wind speed above 7.5 m/s; and proximity to an onshore electrical substation for energy evacuation and transformation. The second phase consisted of discarding areas of high ecological value and those for other reasons incompatible with the development of wind farms. The third phase consisted of analyzing interactions with other maritime uses and activities, where the criteria provided by the different administrations consulted were considered. In the fourth and last phase, a public consultation was conducted to obtain information to correct, modify and expand the content of the plans. With the information provided, the necessary corrections were made, and the final polygons were designated. Although the Spanish offshore wind capacity targets are defined, the exact placement of wind farms and the division between the Atlantic and the Mediterranean Sea is not yet decided. Therefore, it was not possible to estimate the exact magnitude in OSPAR Region IV.

France published the priority zones for offshore wind energy development, aiming to install a total of 18 GW by 2035, and 45 GW by 2050. As these areas are in three different zones (Atlantic, English Channel, and Mediterranean), the wind farms that affect OSPAR Region IV are only those in the Atlantic zone. In this area, between 3.6 and 4.4 GW of floating wind energy has been identified for allocation by 2035. By 2050, the priority areas will be further specified or revised, however, about 20 GW should be identified to reach the 2050 target, and are expected to be exclusively floating and located mainly in the Atlantic seaboard. Currently, on the Bay of Biscay coast, a wind farm is installed in Saint-Nazaire (480 MW), and another one is under construction: Yeu-Noirmoutier (496 MW). For the period 2030-2040, the following are planned to be installed: Sud-Bretagne (250 MW), Sud-Atlantique (1200 MW), Extension of Sud-Bretagne (500 MW), Extension of Sud-Atlantique (1200 MW), Bretagne Nord-Ouest (1.2 - 2 GW), Golfe de Gascogne Sud (1.2 GW), Golfe de Gascogne Nord (1.2 GW), Bretagne Nord-Est (2 GW). For 2050, only the zones for 1.1 GW are identified in Bretagne Grand Large (only a part of it overlaps OSPAR region IV), Centre Atlantique Grand Large, and Golfe de Gascogne Ouest. It is expected that further research into the feasibility of eventually installing wind farms beyond the canyons could open up new opportunities.

2.4.5 Notes on calculations

All data from activities and ecosystem components was projected in Csquares (Rees, 2002).

SCAIRM consist of a linkage framework comprised from a multiple of studies on CIAs (see section 2.1). This linkage framework for the North Sea consists of 7771+ impact chains, each with different parameterization. Before this pilot, the ecosystem component hierarchy only applied to species groups, e.g. birds. In this pilot, however, species-specific parameterization is applied to the model. The parameters that are altered are given in section 2.3 Species sensitivity. This more accurate and species-specific parameterization allows for a more distinctive analysis in the assessment of the sensitivity of each species for impact of OWFs and shipping (see section 2.3.1 and 2.3.2) as well as cumulative impact. However, the remaining impact chains' values are still the same for each species, since they fall under the same hierarchical ecosystem component in SCAIRM (i.e. Birds). Differences in Impact Risk of each species for the remaining impact chains will therefore only be determined by species distribution.

Distribution maps of bird species were obtained from Waggitt et al. (2020), Evans et al. (2021) and ESAS/MWTL (as used in KEC4.0, Soudijn et al., 2022) data (see section 2.2). Waggitt et al. (2020) maps are expressed in the chance of encounter per month, whereas the ESAS/MWTL maps are expressed in seabird density per every

two months. As most of the species partake in some seasonal migration, choices had to be made to alter distribution to not miss any Impact Risk. Taking only a moment in time, for example, April, when most of the breeding takes place and calculation Impact Risk on the population, would underestimate Impact Risk on areas that are used throughout the year, such as wintering or foraging habitats. Therefore, the maximum chance of encounter or density is taken at every c-squares grid. This will inevitably lead to an overestimation of Impact Risk on the sea birds' population, but will reduce the chance of missing vital living areas of the sea birds' yearly lifecycle.

3 Results

3.1 North Sea

The results of the assessment of the Impact Risk of human activities on bird populations in the North Sea according to 6 scenarios are shown in this section. The scenarios comprise three scenarios (baseline, short-term future, long-term future) for offshore wind farms and three scenarios for all human activities considered. The scenarios are described in the section 2.4. First spatial maps with the distribution of Impact Risks are shown for each of the selected bird species (section 3.1.1) and subsequently, these spatial results are presented in an aggregated, quantitative way for the North Sea by means of summarising tables and bar graphs allowing comparison among activities, pressures, bird species and scenarios in order to gain an “overall view” (section 3.1.2).

3.1.1 Spatial maps

The maps with the calculated Impact Risk of OWF and cumulative Impact Risk for each of the selected bird species for the North Sea pilot in each of the scenarios are presented in this section for the northern gannet (figure 3.1) and for each of the selected species in Annex X. 6 maps are shown for each bird species, starting from top to bottom with: ‘baseline’, ‘short term scenario’ and ‘long term scenarios’, on the left shows Impact Risk caused by OWF only, on the right shows all activities. It should be noted that these maps show the Impact Risk only and not the distribution of the birds, thus only representing a potential change in state relative to an undisturbed situation (Piet et al., 2023). Figure 3.2 then shows the difference in Impact Risk between baseline and the two future scenarios, i.e. short term or long term for the northern gannet.

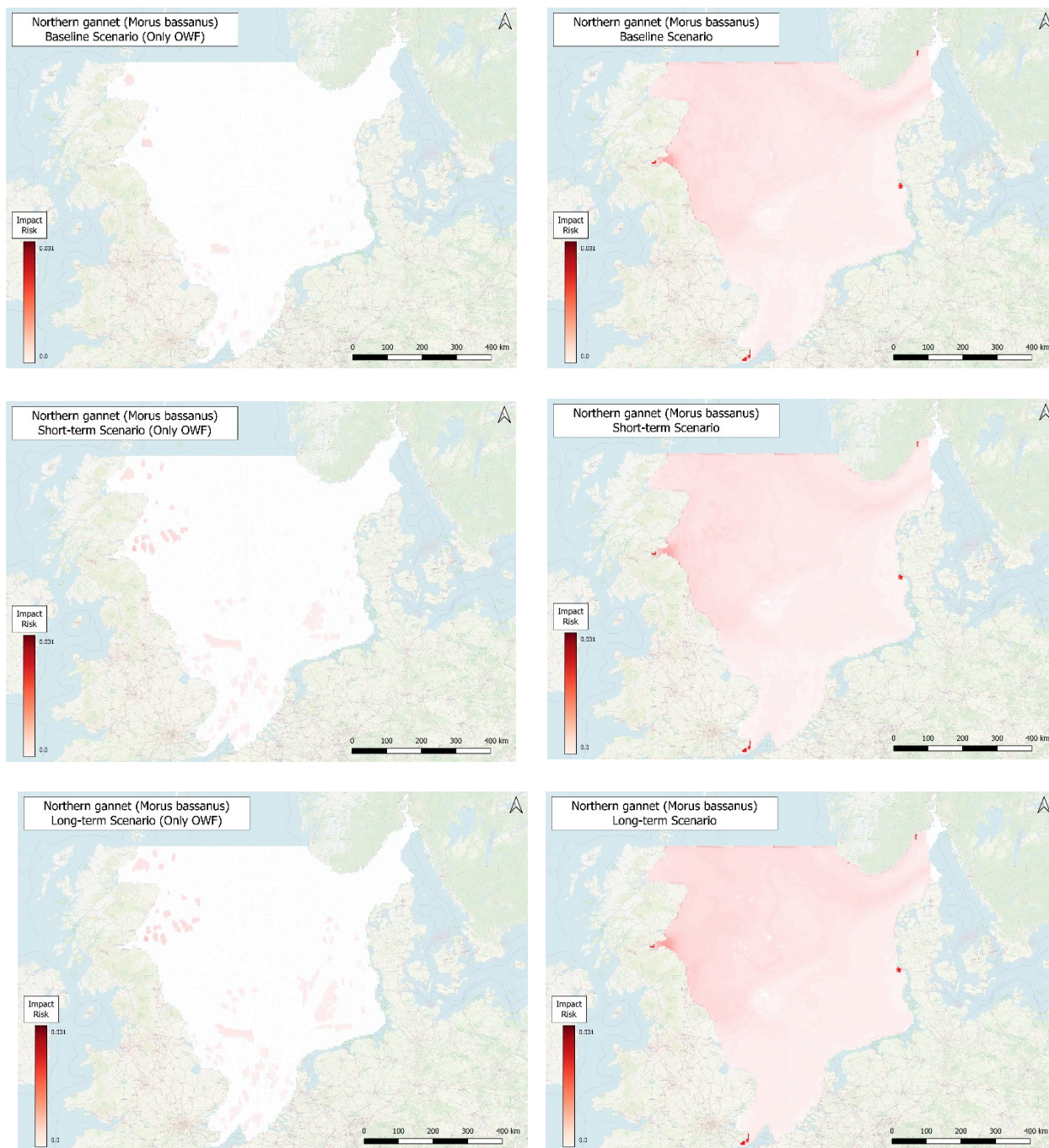


Figure 3.1 Impact Risk for northern gannet caused by OWF (left panels) or multiple activities (right panels) in the North Sea in different scenarios: baseline (upper panels), short-term future (middle panels), long-term future (lower panels).

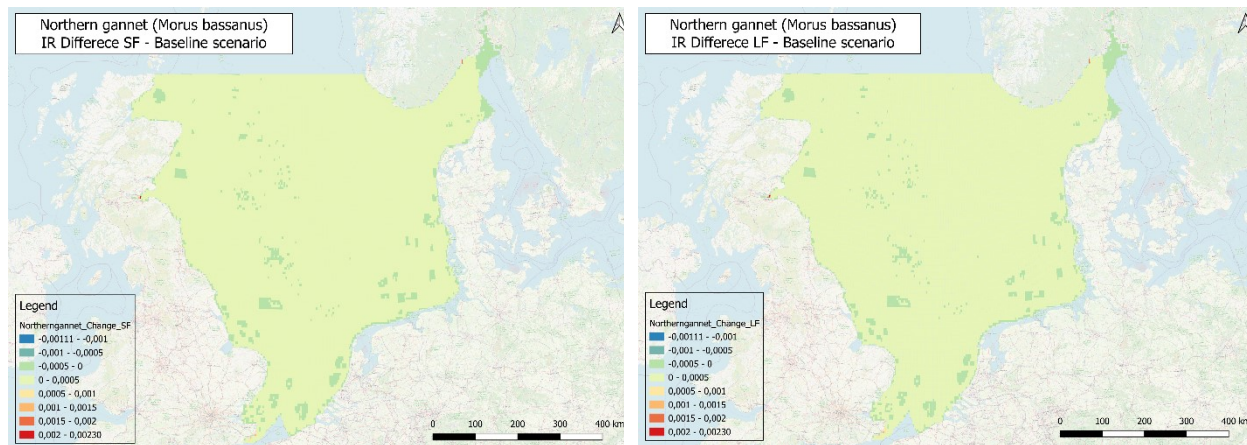


Figure 3.2 Change in Impact Risk for northern gannet caused by multiple activities in the short-term future (left panel) and the long-term future (right panel) as compared to the baseline.

Northern gannets (*Morus bassanus*)

Northern gannets occur year-round in the study area, where they are widespread, but most birds migrate to southern wintering areas along the West African coast and the Mediterranean Sea. Cliffs and rocky islands are used for breeding (BirdLife International, 2018). Impact Risk on northern gannets seems to be present in the entire study area and increases with increasing OWF presence. Impact Risk is also high in certain coastal regions, including the English Channel, Danish, Norwegian, and UK shores. In most of the area of the North Sea the Impact Risk for northern gannet caused by multiple activities is expected to increase in the short-term future as well as the long-term future will increase as compared to the baseline (light green in figure 3.2). Dark green spots indicate a reduction of Impact Risk. This reduction is mostly in the areas where the baseline OWFs are placed. Because spatial data of activities, e.g. from EMODnet still runs through these windfarm sites, and is decreased in the model, the Impact Risk decreases there. It should however stay the same, since other activities are usually excluded from OWFs. Therefore, these areas should have zero change in Impact Risk until decommissioning.

Divers (Gaviidae)

Red-throated diver (*Gavia stellata*) and black-throated diver (*Gavia arctica*) are taken together in the ESAS/MWTL distribution maps, with the Red-throated diver being by far the most abundant species. The two species are given the same collision and displacement values in the earlier analysis (see section 2.3.5). Both species use coastal areas or shallow waters to forage. They occur in pairs or small groups (Birdlife international, 2018). The Impact Risk is highest, especially in the eastern shallow waters of the German Bight, where new OWFs increasingly overlap with the high concentration areas of divers' presence, especially during late winter/spring (Garthe et al. 2023).

Northern fulmar (*Fulmaris glacialis*)

Impact Risk on the northern fulmar looks to be on a relatively basic low level. The species occurs quite spread-out in the northern part of the study area, visible only in the maps on the right. The increase of OWF presence in future Scenarios can be noticed but not substantially. In the study area they breed all around the North Sea coasts except for the eastern shorelines, due to lack of rocky cliffs (BirdLife International, 2018).

Great cormorant (*Phalacrocorax carbo*)

The OWF maps of Impact Risk on the great cormorant show relatively many interactions, despite small/minimal overlap with the distribution pattern of this coastal species. The overlap increases with the increasing scenarios, with some places with high Impact Risk and others that are low, depending on the density of the seabird in a given grid cell. Overall, Impact Risk is present in much of the coastal waters, aside from a part of UK's and Denmark's shorelines. The highest level of Impact is near the Dutch coastal zone. Great cormorants are not specific marine birds, but a substantial part has colonized the marine environment and have extended their marine distribution out of the coastal zone due to the presence of OWFs. They typically breed in colonies. Sea-going cormorants mainly fish in the coastal zone where they forage alone, in social groups as well as feed on discards behind fishing vessels (BirdLife International, 2018). Great cormorants can benefit from the presence of OWFs, due to increased opportunity to rest and dry their feathers, therefore expanding their foraging range and profiting from new areas with food availability.

Common scoter (*Melanitta nigra*)

Common scoters use the coastal areas in a zone of a few kilometres up to approx. 10 kilometres as foraging and resting habitats outside of the breeding period. Therefore, the Impact Risk of OWF developments is low for this specific coastal species due to the lack of overlap. The presence along the coast is restricted by the diving depth up to 20 m. They are a migrating species who aggregate in large groups of thousands of birds during wintering and the moulting period when they cannot fly (BirdLife International, 2018). The Impact Risk of multiple activities is already high in the baseline scenario due to the already high rates of human activities within the shallow coastal zones, the change to the future scenarios is therefore hardly noticeable.

Great skua (*Stercorarius skua*)

The great skua population is very limited and breed on only a couple of islands in the north of Scotland, along the coast of Iceland and Norway outside of the study area. Islands that are not inhabited by humans are preferred. If not breeding, great skuas remain at sea. Besides it's kleptoparasite behaviour, prey is found in discards of fisheries (BirdLife international, 2018). Impact Risk in the Baseline Scenario is distributed mostly northwest close the breeding locations, where the highest densities occur, but during migration it is also present in the southern North Sea. The Impact Risk increase in proportion to the expanding size of the OWF areas, as can be seen in the maps.

Little gull (*Hydrocoloeus minutus*)

Little gulls are distributed mostly in the southern North Sea, where the Impact Risk is highest nearshore related to the distribution patterns of highest abundance. The Impact Risk (IR) is only slightly increasing with the increasing OWFs, for being relatively high already. Only in some areas with less presence, the Impact Risk is low, not changing by scenarios. Little gulls breed inshore far outside the study area and migrate south along the coastal waters (BirdLife, 2018). The lower Impact Risk offshore is due to the decreasing distribution and decreasing human activities.

Herring gull (*Larus argentatus*)

Herring gull are opportunistic foragers. They are not necessarily bound to the marine area (Birdlife International, 2021). Impact Risk is relatively low and distributed almost homogeneously, although the OWFs effect is noticed. Herring gull is to most extent a coastal species and like the great cormorant, it profits from OWFs, working as facilitators for resting places. Despite being opportunists with various nests sites and a variable prey choice, they can make wide foraging trips up to 100 km from their breeding locations. And despite seeming to be common and resilient, the population of European herring gulls is declining (Birdlife International, 2021).

Lesser black-backed gull (*Larus fuscus*)

Lesser black-backed gulls are mostly migratory birds, with the Northern European population travelling south. Breeding can take place in mixed-species colonies (with e.g. herring gulls). Like the herring gull, the species is opportunistic but much more sea-bound (BirdLife International, 2018). Impact Risk appears mostly in the southern North Sea in relation to the highest abundance and colonies, with a slight increase with the OWF Scenarios. Lesser black-backed gulls also profit from OWF as they facilitate resting places, thus the Impact Risk primarily reflects the risk of collision.

Great black-backed gull (*Larus marinus*)

With the increasing OWFs, the Impact Risk changes, but relatively less compared to other species, possibly due to the Impact Risk that is already in place. Great black-backed gulls have different migration ranges, with northern populations joining southern populations that do not migrate far (Birdlife, 2018). Despite their wide distribution, the largest numbers of the species mainly winter near the coast. Breeding takes place in coastal areas. Although distributed near the coast, the Impact Risk is distributed across the study area, possibly indicating that migrators are affected equally on their passages. Impact Risk by multiple activities on great black-backed gulls is already relatively high in the Baseline Scenario. Impact Risk is also partly homogeneously spread with some congregations where it is higher.

Black-legged kittiwake (*Rissa tridactyla*)

Impact Risk on black-legged kittiwakes appears to be relatively homogeneously distributed, with no major outliers with dark red colour. With increasing OWF areas, which are distributed almost everywhere in the study area, the Impact Risk increases. Black-legged kittiwakes breed around the coastal areas of the study area,

except for the southeastern coasts without cliffs. When not breeding, they disperse at sea in large numbers (BirdLife International, 2018). This wide distribution account for the wide distribution of the Impact Risk.

Sandwich tern (*Thalasseus sandvicensis*)

Sandwich terns are coastal bound birds, that migrate south up to South Africa for wintering. Sandwich terns breed (in mixed or single species colonies) on islands or sandy beaches where vegetation is poor and predation is low. The species forages from the shore but come return to the coast to rest at their colonies or roosting sites (BirdLife International, 2019). Impact Risk is already high from the Baseline Scenario, and is not noticeable increasing when looking at the Long-term Scenario of cumulative impacts. The OWF maps do show increasing overlap with the increasing scenarios, but not much.

Common guillemot (*Uria aalge*)

The Impact Risk on common guillemots also seem distributed homogeneously, without many red outliers. Although the Impact Risk seems to increase substantially with the increasing OWFs. Common guillemots are residents as well as seasonal visitors to the study area. Foraging ranges can differ substantially per population, and breeding populations can consist of large colonies (BirdLife international, 2018). These large regional gatherings are not reflected in the Impact Risk maps as the birds have a widespread distribution pattern in the non-breeding period.

Razorbill (*Alca torda*)

The Impact Risk found on razorbills seems to be spread homogenously throughout most of the study area, although it is less in the middle of the North Sea and below the coast of Norway. Impact Risk increases with increasing OWF surface, most noticeable away from the shore. Razorbills are sea-bound birds that only come to land for reproduction (BirdLife International, 2021).

Atlantic puffin (*Fratercula arctica*)

Impact Risk on Atlantic puffins is concentrated mostly west and to the north, following their breeding distribution. Atlantic puffins make rare appearances in the south. Impact Risk is highest near the coast, where Atlantic puffins breed on rocky hills near the shore, or islands away from the mainland. Foraging trips go up to 100 km offshore, preferring areas more near when chicks are present. New wintering areas can be discovered with new recruits searching for alternatives (BirdLife International, 2018). Wintering in the open sea results in Impact Risk occurring far from the breeding areas. New OWFs impact Atlantic puffins mostly on the eastern shore of the UK, where breeding and foraging trips could interfere with the presence of the OWF.

3.1.2 Aggregation across all bird species

In this section, the results of the assessment of the Impact Risk of human activities on bird populations in the North Sea are presented in an aggregated way to reveal the influence of activities, pressures and future scenarios. Table 3.1 gives a summary of the total Impact Risk of bird species in the North Sea pilot, as well as percentual changes.

Table 3.1 Numerical Cumulative Impact Risk per bird species and scenario in North Sea pilot. Change is relative to the baseline. Marked changes over time are highlighted, i.e. increase in red and decrease in green.

Common name	Scientific name	Baseline (IR)	Short-term (IR)	Long-term (IR)	Difference short-term future /baseline (%)	Difference long-term future/baseline (%)	Coastal (C) versus offshore (O) or both (CO)
Divers	<i>Gavia</i>	95.54	96.72	96.12	0.8	0.6	C
Northern fulmar	<i>Fulmarus glacialis</i>	68.76	68.74	89.64	0.0	30.4	O
Northern gannet	<i>Morus bassanus</i>	79.37	80.05	91.96	0.9	15.8	O
Great cormorant	<i>Phalacrocorax carbo</i>	89.10	89.01	91.97	-0.1	3.1	C
Common scoter	<i>Melanitta nigra</i>	86.75	86.49	83.41	-0.3	-4.0	C
Great skua	<i>Stercorarius skua</i>	72.99	73.20	91.50	0.3	25.3	O
Little gull	<i>Hydrocoloeus minutus</i>	82.06	82.37	93.80	0.4	14.3	CO
Herring gull	<i>Larus argentatus</i>	71.96	72.28	89.05	0.5	23.7	C
Lesser black-backed gull	<i>Larus fuscus</i>	75.85	76.50	92.93	0.9	21.1	CO
Great black-backed gull	<i>Larus marinus</i>	75.72	75.87	93.00	0.3	22.7	CO
Black-legged kittiwake	<i>Rissa tridactyla</i>	72.79	74.54	91.48	0.6	23.3	O
Sandwich tern	<i>Thalasseus sandvicensis</i>	99.02	98.59	97.94	-0.4	-1.1	C
Common guillemot	<i>Uria aalge</i>	85.61	86.24	95.49	0.7	11.5	O
Razorbill	<i>Alca torda</i>	92.96	93.83	97.21	0.9	4.5	O
Atlantic puffin	<i>Fratercula arctica</i>	92.35	93.28	97.15	1.0	5.2	O

Table 3.1 gives a view on how the cumulative Impact Risk is distributed over the bird species and scenarios. In the Baseline Scenario, the Sandwich tern experiences the highest IR, which is also the case for the Short-term and Long-term Scenarios. Sandwich tern has a relatively average OWF-sensitivity score and a relatively low sensitivity score (see section 2.3). The high Impact Risk could therefore be a consequence of high abundance in coastal areas (BirdLife International, 2019), where they can experience conflict with a high absolute number of activities, which can also be seen in the spatial maps. The future scenarios of section 2.3 depict decreasing activities of fishing and oil and gas, which could explain the decreasing future trend, with the decrease over the short term being the highest.

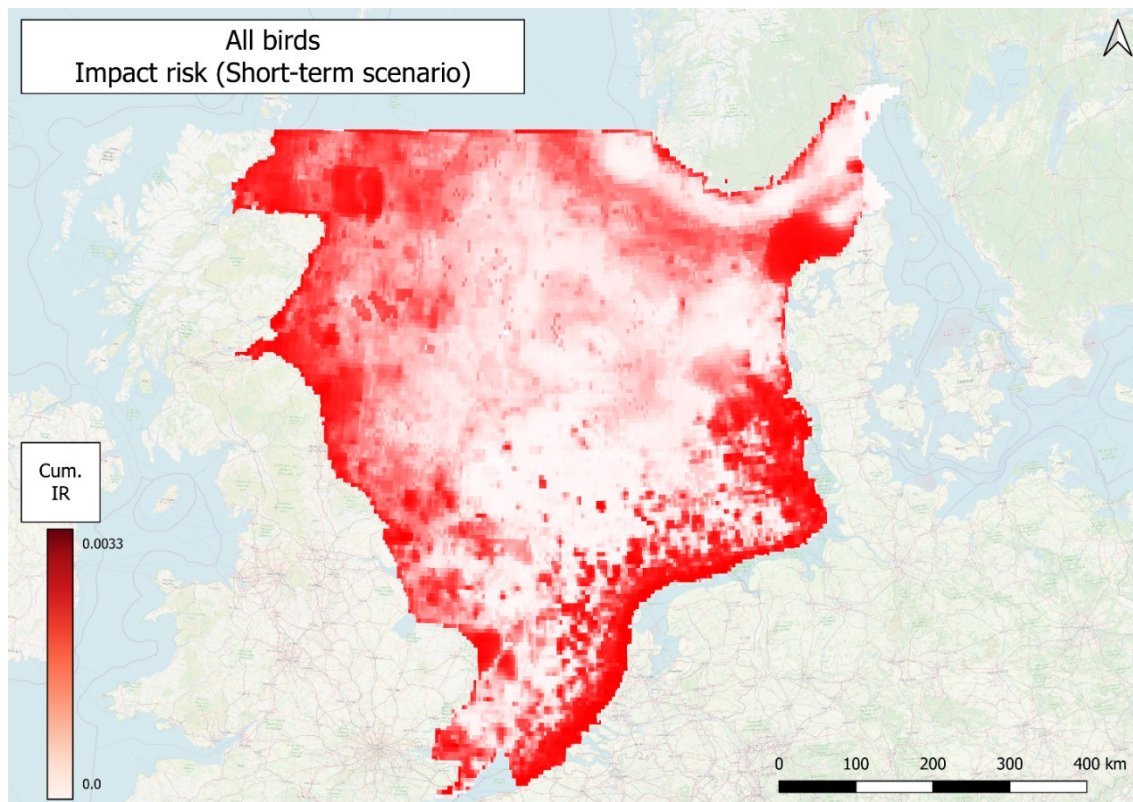
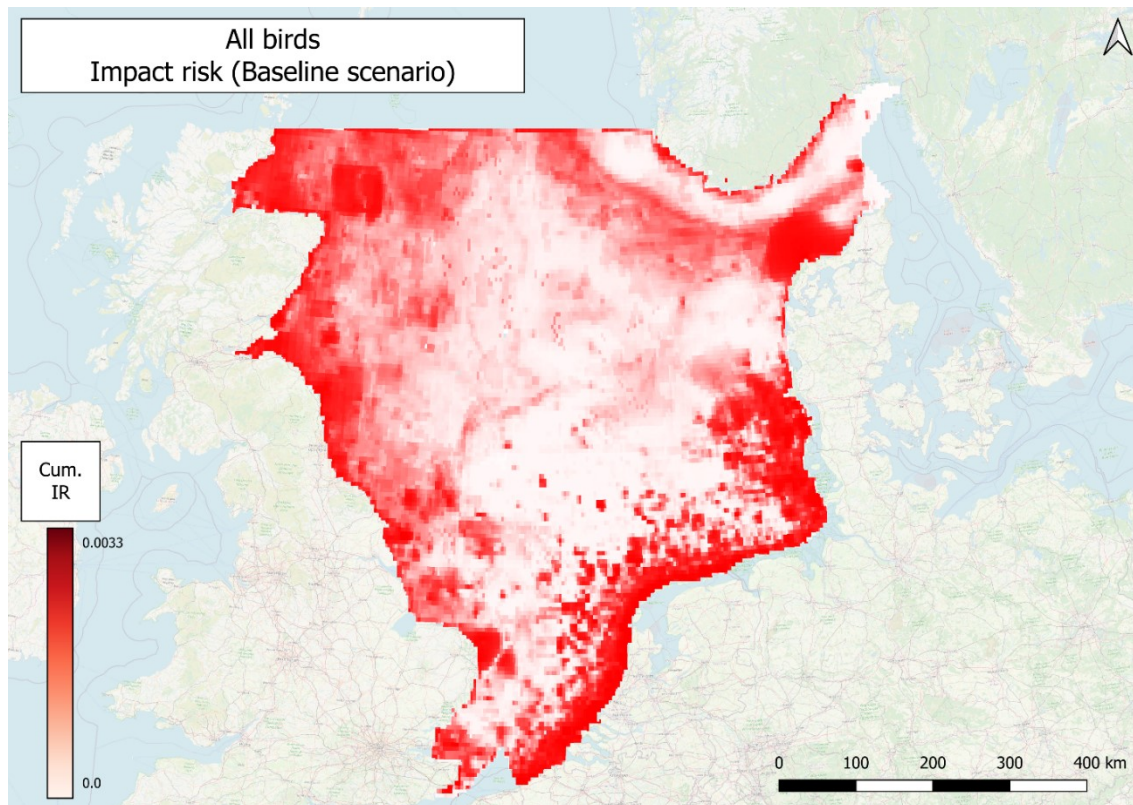
Divers experience the 2nd to highest Impact Risk in the first two scenarios, and the 3rd to highest in the Long-term scenario. The two species experience a slight, but average increase in IR. Divers have found to be sensitive to the displacement caused by OWFs and shipping (Maclean et al. (2009); Leopold et al. (2014); Soudijn et al. (2022); Fliessbach et al. (2019)), which could explain the relatively high Impact Risk score.

The *Alcidae* razorbill and Atlantic puffin experience the 3rd to highest risk in the Baseline and Short-future scenarios. They experience the 2nd to highest Impact Risk in the Long future scenario, where the common guillemot also experiences high Impact Risk. They experience medium to high sensitivity for OWFs and shipping. The family can be sea-bound, and experience Impact Risk from increasing activities offshore, as well as from coastal activities near seasonal breeding sites.

Northern fulmar, herring gull and great skua experience the lowest Impact Risk in the Baseline Scenario but high increases under the long-term future scenarios.

The changes in values of the Short-term scenario are limited, ranging from a small decrease of -0,4 to a small increase of 1,0. The long-term scenario however, shows large increases in IR, with the highest values relating to the northern fulmar, great skua and herring gull. With the Northern fulmar and great skua being typical offshore birds (BirdLife international, 2018), they can experience a high increase in Impact Risk due to increased shipping and OWFs shifting to further offshore. However, this effect is also measured the short-term

scenario, as can be seen in Table 3.1. Lesser black-backed gull, great black-backed gull and black-legged kittiwake, which also reside (partially) offshore, could experience a similar phenomenon. The more coastal bound Herring gull could suffer from a combination of increasing activities. In the figure 3.3 cumulative Impact Risk across all bird species is shown. Cumulative Impact Risk is calculated by the aggregated Impact Risk measured in a cell divided by number of different species present in this cell.



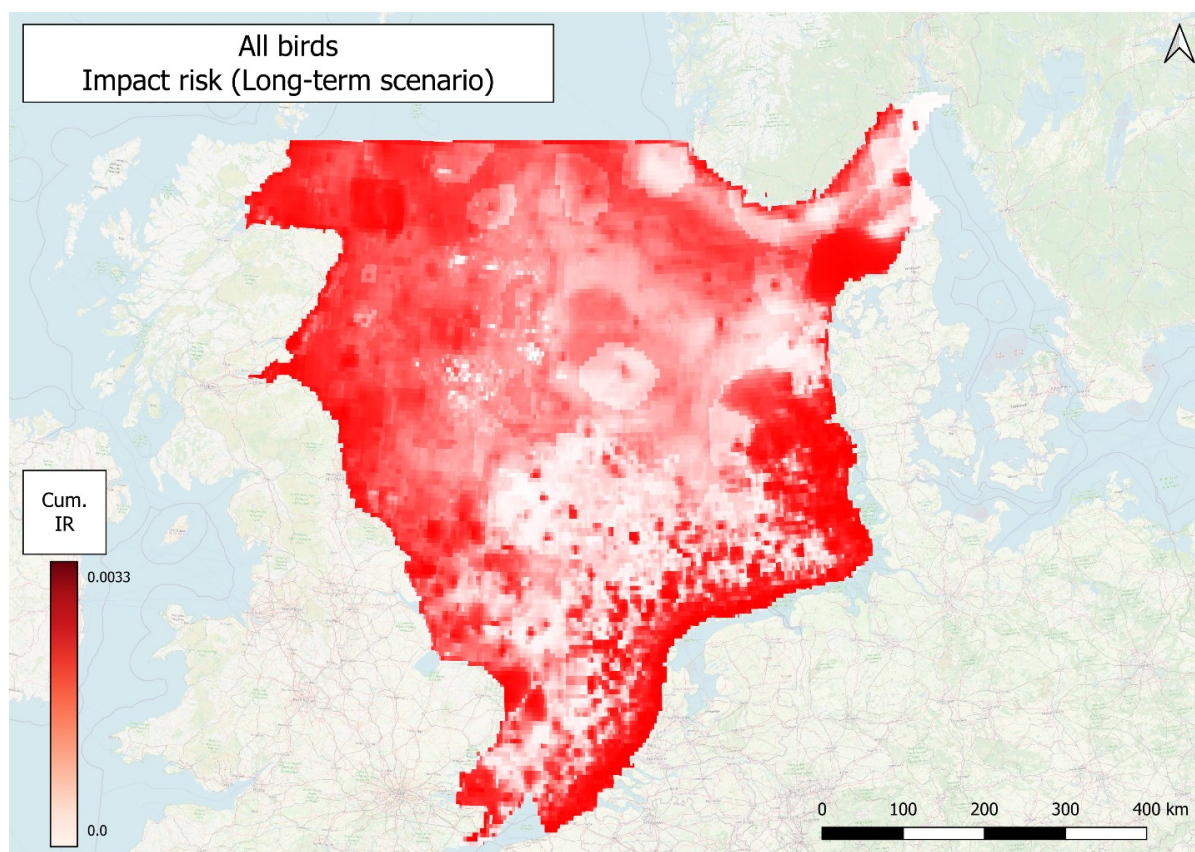


Figure 3.3 Cumulative Impact Risk for all selected North Sea bird species in three scenarios (Baseline, Short-term future and Long-term future).

Impact of Offshore Wind Farms and in relation to other activities

The figures below show how each activity (Operation) contributes to the total Impact Risk per species and per scenario. Figure 3.4 shows all activities, while figure 3.5 specifically highlights the contribution of only the OWF activities.

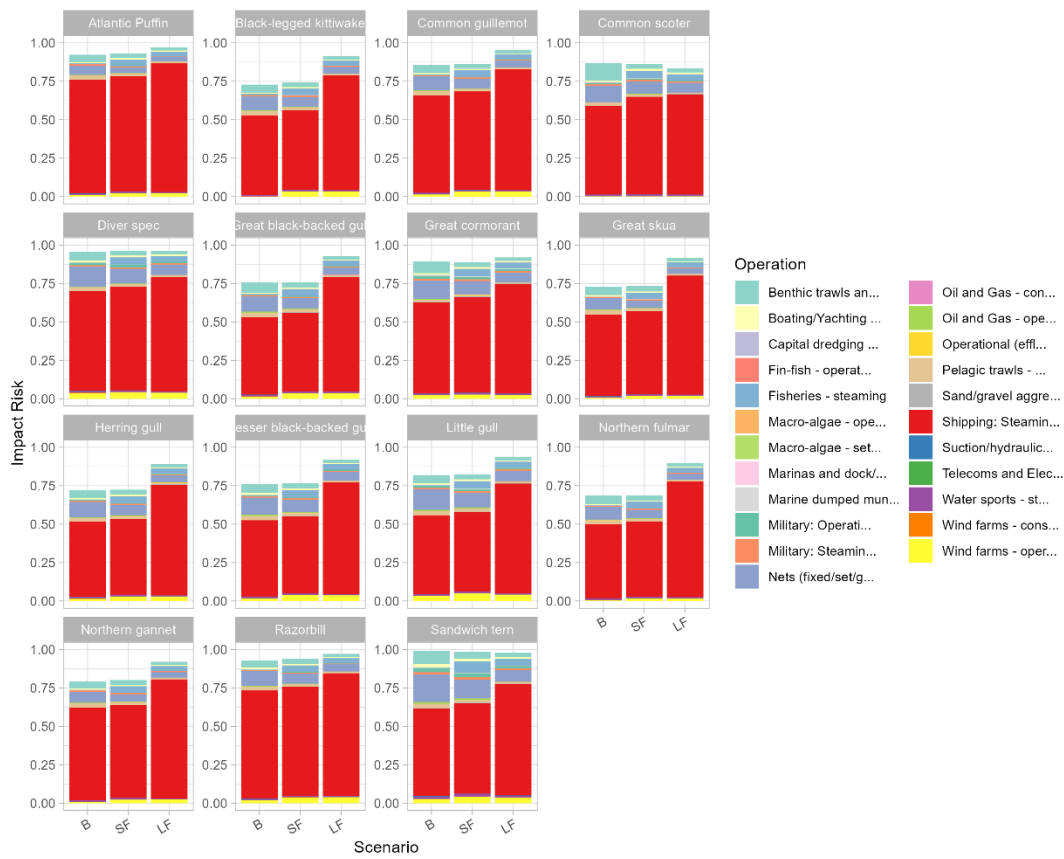


Figure 3.4 Impact Risk grouped by activity for each bird species selected for the North Sea pilot.

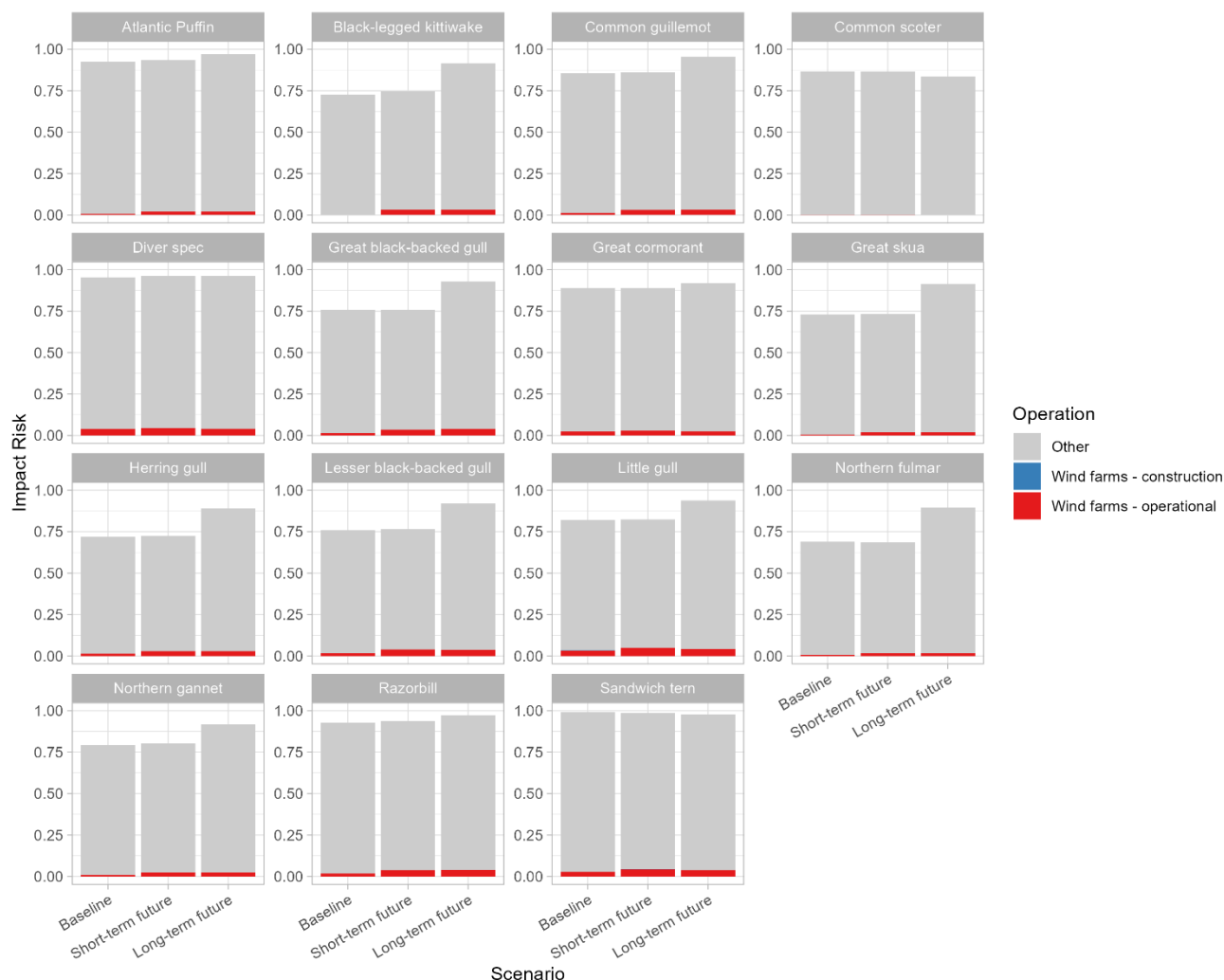


Figure 3.5 Impact Risk grouped by activity for each bird species selected for the North Sea, with OWFs highlighted. Other refers to all other activities as given in figure 3.4.

Impact Risk for the birds species is comprised of some major and many minor activities. Shipping, by far, contributed to most of the Impact Risk due to its spatial extent and displacement effects. Shipping causes negative impacts on birds (Fliebsbach et al., 2019), and is likely to increase with a growing human population and globalization, as well as ship movements necessary for other offshore activities, such as maintenance for OWFs. The translation of the metric on which the shipping spatial distribution maps are based into a SCAIRM parameter, i.e. frequency, could well result in an overestimation of the IR. The significant contribution of shipping together with the large uncertainty indicate that while shipping is an activity to be reckoned with it also requires further studies to improve the accuracy of these estimates and reduce uncertainty. The main activities contributing to the Impact Risk are benthic trawls, fixed nets, shipping and (operational) OWFs.

Impact of Pressures

The figures below show the contribution to Impact Risk by each pressure. Figure 3.6 shows the contribution of each pressure. Figure 3.7 highlights pressures Death or injury by Collision and (Visual) Disturbance of Species, which are mostly caused by, but are not specific to, OWFs.

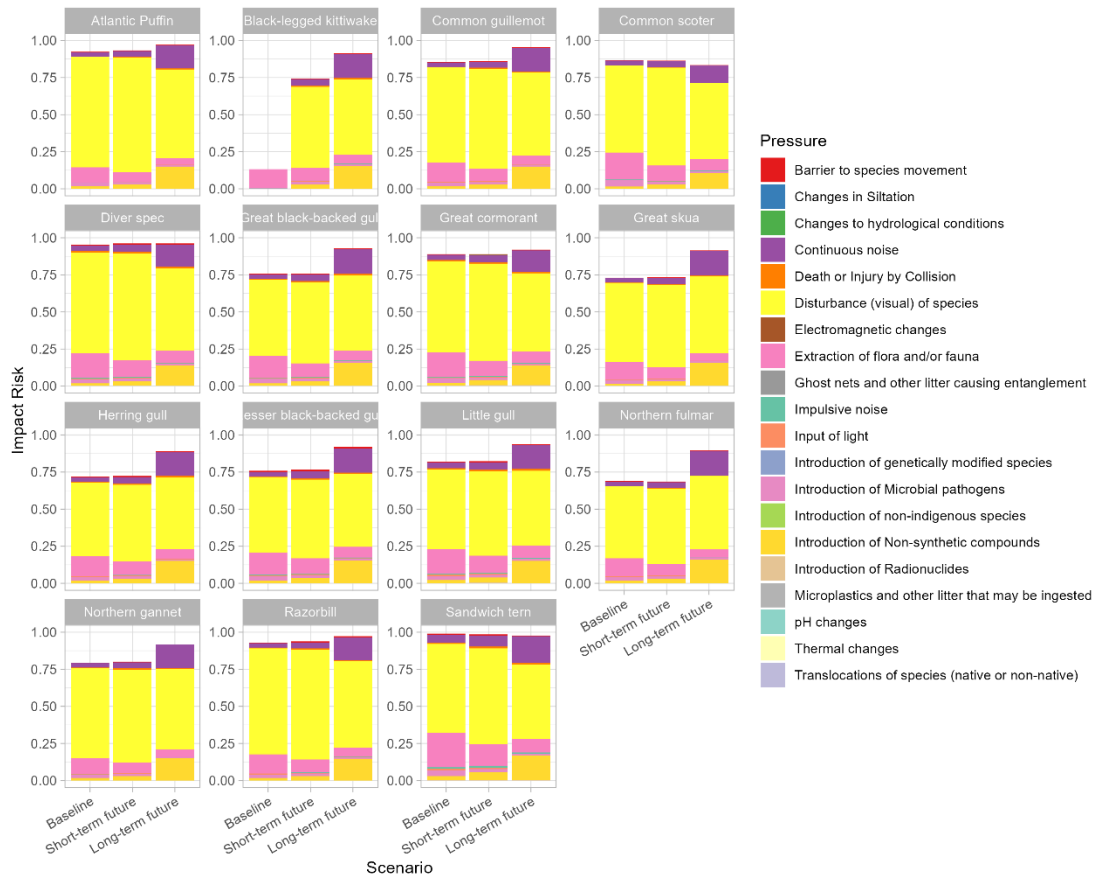


Figure 3.6 Impact Risk per pressure under three scenarios, i.e. baseline short term and long term, for each bird species selected for the North Sea.

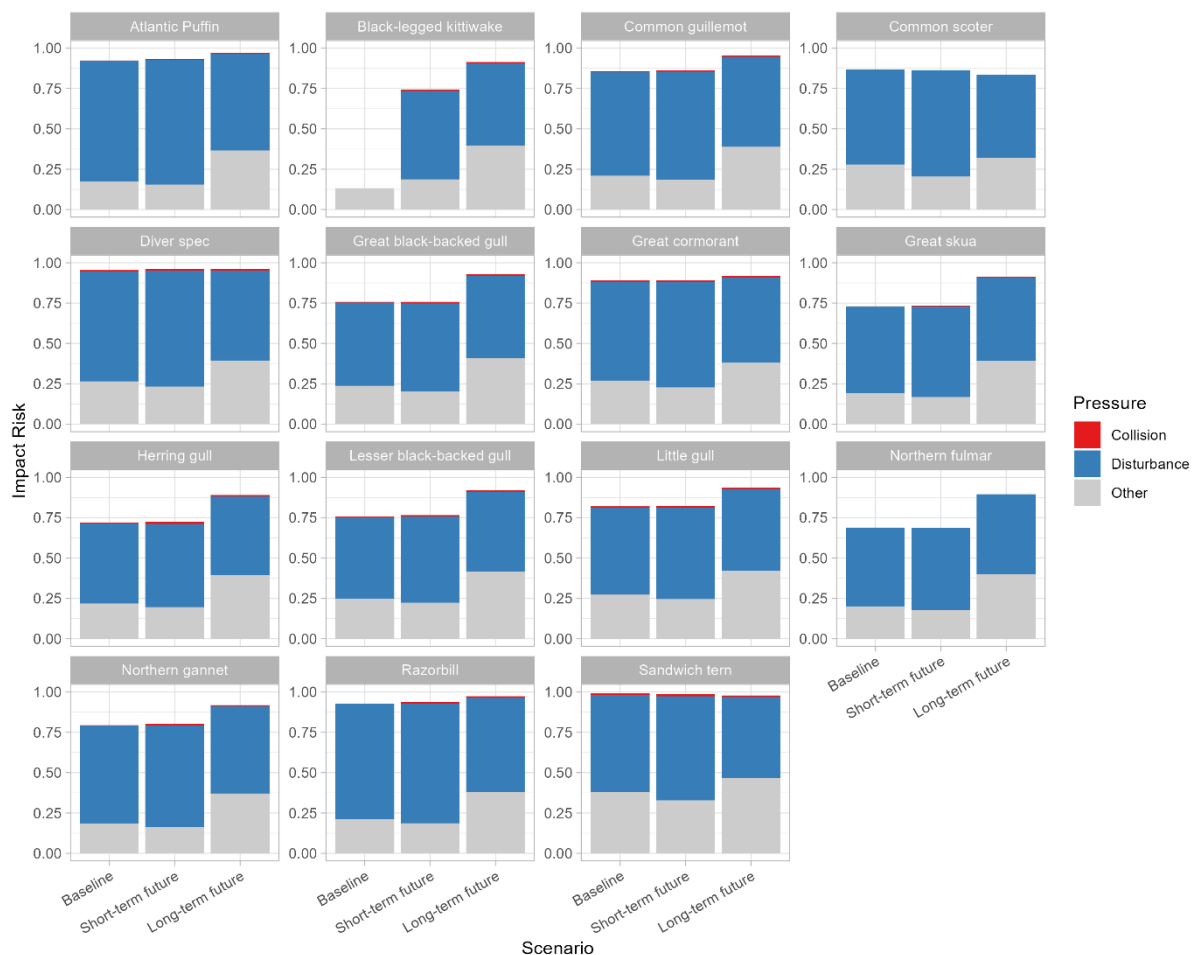


Figure 3.7 Impact Risk for each bird species selected for the North Sea, with pressures Collision and Disturbance highlighted.

As with the activities, Impact Risk on Atlantic puffin and great skua seem to consist of fairly similar contributions. Two pressures related to OWFs are noticeable in the chart: Death or injury by collision (red) and disturbance (visual) of species (blue). Death or injury by collision looks to be increasing in all bird species. Disturbance (visual) of most bird species is increasing in the short-term future scenario but decreasing again in the long-term future scenario. The relative contribution of pressures like Extraction of flora and/or fauna is decreasing due to the decrease in fisheries in the future scenarios. Continuous noise is also decreasing in Impact Risk on sandwich tern, despite also being caused by OWFs. Barrier to species movement is related to OWF as well but without species-specific parametrization in this analysis. Impulsive noise is also decreasing slightly, most noticeable for sandwich tern. When more OWFs are installed and construction ceases, so does Impulsive noise. This is most noticeable in the Long-term scenario, where construction of OWFs as an activity is left out. Sandwich terns, who experience wide ranged seasonal migration, most likely would experience more impact from a barrier of species movement. More species-specific parameterization would be beneficial for this type of analysis. The Impact Risk of the **pressures** of all human activities for birds (Figure 3.6) shows that four pressures cause the largest contribution, which are extraction, disturbance, continuous noise, introduction of microbial pathogens and introduction of nonsynthetic compounds. Most significant changes in the contribution to Impact Risk for future scenarios occur due to continuous noise and the introduction of nonsynthetic compounds. (Figure 3.6).

3.2 Celtic Sea

The results of the assessment of the Impact Risk of human activities on bird populations in the Celtic Sea are presented in section 3.2.1 (for northern gannet) and the Annexes (for each of the selected species), with spatial maps for 2 spatial scenarios representing a baseline for offshore wind farms and a baseline for some human activities including offshore wind farms. Differences in Impact Risk-scores between these analyses may occur. Although the Effect Potential is applied equally, some activities in the spatial analysis may be missing or vice versa. The remaining extent of the activities and the exposure of the birds can also vary, since in the spatial analysis the activities and birds are derived from maps, and in the qualitative analysis they are estimated. The varied scores could also point to interesting differences between the two methods and point out knowledge gaps.

3.2.1 Spatial maps

In the Celtic Sea, one OWF scenario is analysed. Single impacts of OWFs (left) and cumulative impacts of OWFs with other activities (right) are shown for the Northern gannet in figure 3.8 and each of the 12 Celtic Sea bird species in the Annex.

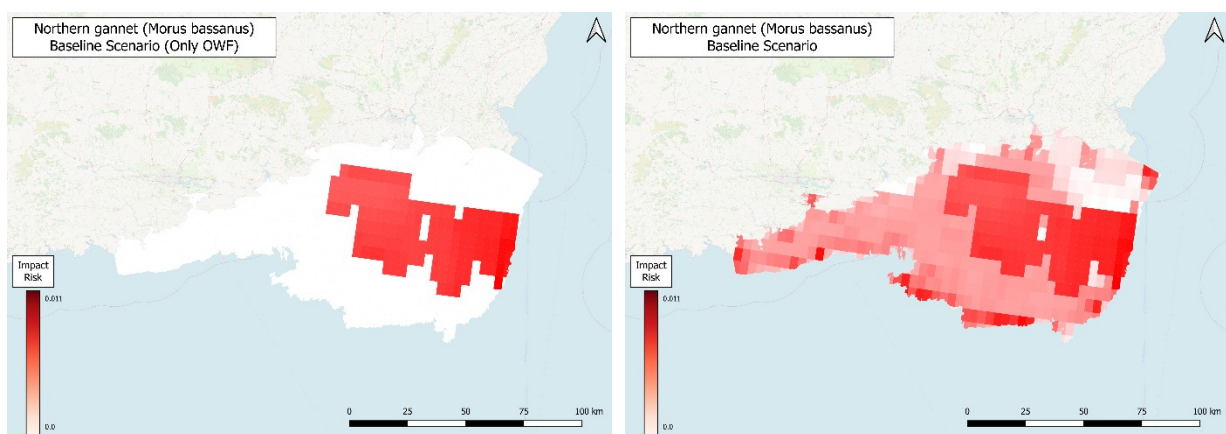


Figure 3.8 IR for northern gannet caused by OWF (left panel) or multiple activities (right panel) in the DMAP area of the Celtic Sea.

3.2.2 Aggregated results of the qualitative Celtic Sea assessment

Aggregated rankings and Impact Risk of the qualitative assessment

Across all the investigated scenarios, rankings of Impact Risk across sectors remain remarkably consistent, with the top 4 activities remaining unchanged (Table 3.2). Wind farms rank fourteenth during the early construction and operational phases, increasing to sixth with increasing number of wind farms by 2050, and rising to fifth once potential trade-offs with the fishing industry are considered. It is important to note that the overall risk in the system changes depending on the scenario, with cumulative additive risk scores increasing with the addition of offshore wind, until possible trade-offs with fishing (through removal and/or displacement) are considered. While these trade-offs may result in a decreased ecological Impact Risk score for the DMAP area, displaced effort will result in additional impacts in neighbouring systems, and removed effort (e.g. through decommissioning or otherwise) directly affects individuals and coastal communities through loss of employment and revenue which are not further detailed or captured here. It is also interesting to note that S2 (construction only) contributes very little to the overall risk to seabirds, echoing the results from a previous North Sea qualitative assessment.

Table 3.2 Change in rankings of sectoral activities across the 5 investigated qualitative scenarios for the Celtic Sea pilot.

Activity	S1: 2025 (no OWF)	S2: pre 2030	S3: 2030	S4: 2050	S5: 2050 + fishing
Land-based Industry	1	1	1	1	1
Wastewater management	2	2	2	2	2
Shipping	3	3	3	3	3
Tourism & Recreation	4	4	4	4	4
Pelagic Trawling	5	5	5	5	11
Benthic Trawling	6	6	6	7	6
Net Fishing	7	7	7	8	8
Dredge Fishing	8	8	8	9	9
Beam Trawling	9	9	9	10	7
Agriculture	10	10	10	11	10
Coastal Infrastructure	11	11	11	12	12
Potting	12	12	12	13	13
Aquaculture	13	13	13	14	14
Wind farms	N/A	14	14	6	5
Navigational Dredging	14	15	15	15	15
Oil and Gas	15	16	16	16	16
Research	16	17	17	17	17
Telecoms & Electricity	17	18	18	18	18
Harvesting & Collecting	18	19	19	19	19
Total Risk Score	29.1	29.2	29.3	30.7	28.3

Across all the investigated scenarios, rankings across pressures also remain relatively consistent (see Table 3.3, with the top three pressures remaining unchanged across all five scenarios. The primary changes observed are increases of the pressures of 'death or injury by collision' and 'barriers to species movement', which are associated, but not necessarily restricted to, the introduction and expansion of offshore wind farms.

Table 3.3 Change in rankings of pressures across the 5 investigated scenarios for the Celtic Sea pilot.

Pressure	S1: 2025 (no ORE)	S2: pre 2030	S3: 2030	S4: 2050	S5: 2050 + fishing
Macrolitter	1	1	1	1	1
Contaminants	2	2	2	2	2
Microlitter	3	3	3	3	3
Bycatch	4	4	4	5	5
Total habitat loss	5	5	5	6	6
Death or Injury by Collision	7	7	6	4	4
Continuous noise	6	6	7	8	8
Impulsive noise	10	8	8	11	10
Input of organic matter	8	9	9	10	11
Disturbance (spatial)	9	10	10	9	9
Barrier to species movement	N/A	N/A	11	7	7
Changes in siltation	11	11	12	12	12
Input of light	12	12	13	13	13
pH Changes	13	13	14	14	14
Total risk score	29.1	29.2	29.3	30.7	28.3

For the birds, total Impact Risk scores in percentage are presented rather than rankings to better illustrate the relative vulnerability across different species and scenarios. Northern gannet and northern fulmar consistently experience the highest risks across the multiple scenarios, likely due to their wide distribution and residential year-round status in the region and interactions with multiple activities and coupled pressures. Northern gannets also have a relatively high estimated collision rate (see section 2.3.1.3) associated with OWF development, while impacts on fulmars are expected to be lower. An already high Impact Risk score could therefore explain the remaining high level of Impact Risk in the future. Common guillemots and razorbills demonstrate smaller-scale seasonal migrations, where in some moments (during breeding, nesting) overlap with shore-bound activities. Manx shearwater, European storm petrel and lesser black-backed gull are migratory, leading to less frequent interactions with sectors and pressures in the region, relative to the *Alcidae*. Storm-petrels are flagged as a high vulnerability species for OWF collisions, the low Impact Risk score could be explained in regards to their relatively low abundance and therefore exposure in the study area. Herring gulls and lesser black-backed gulls regularly interact with fisheries, are known to fly at heights that may lead to collision, and have been observed resting on and near turbines, however, the Impact Risk score is relatively low, although herring gulls do experience a relatively high increase across scenarios from S1 to S4 possibly through the increased exposure in which collision can occur. Of the remaining species, the European shag is coastally restricted, the great skua is a passage migrant in this area, and while the Atlantic puffin is similar in habit to razorbills and guillemots, it is not as widespread and winters further out to sea, outside of the study area.

It is striking that with the OWF developments the Impact Risk for all bird species increases (S4 in Table 3.4). However, this is offset (and more) by the expected decrease in Impact Risk caused by fishing especially for several of the bird species with the highest Impact Risk (S5 in Table 3.4).

Table 3.4 Summed Impact Risk scores of the assessed seabird species across the 5 investigated scenarios for the Celtic Sea pilot. The % change relative to baseline are given for three future scenarios. Marked changes over time are highlighted, i.e. increase in red and decrease in green.

Bird Species	Impact Risk absolute					Relative to baseline		
	S1: 2025 (no ORE)	S2: pre 2030	S3: 2030	S4: 2050	S5: 2050 + fishing	S3	S4	S5
Northern gannet	4.98	4.98	5.00	5.15	4.46	0.4	3.4	-10.4
Northern fulmar	4.54	4.54	4.56	4.71	4.23	0.4	3.7	-6.8
Common guillemot	3.08	3.08	3.09	3.25	2.75	0.3	5.5	-10.7
Razorbill	2.70	2.71	2.72	2.88	2.69	0.4	6.3	-0.7
Black-legged kittiwake	2.70	2.71	2.72	2.83	2.64	0.4	4.4	-2.6
Manx shearwater	2.70	2.71	2.72	2.83	2.64	0.4	4.4	-2.6
European storm petrel	2.70	2.71	2.71	2.78	2.59	0.0	2.6	-4.4
Herring gull	1.24	1.24	1.25	1.41	1.41	0.8	13.7	13.7
Lesser black-backed gull	1.24	1.24	1.25	1.36	1.36	0.8	9.7	9.7
European shag	1.10	1.10	1.11	1.22	1.22	0.9	10.9	10.9
Atlantic puffin	1.06	1.06	1.08	1.18	1.18	1.9	11.3	11.3
Great skua	1.06	1.07	1.07	1.11	1.11	0.0	3.7	3.7

Additional analyses on Scenario 3

To better assess the SCAIRM approach, and with comparisons to previous assessments (Pedreschi et al. 2018, 2023), additional analyses are illustrated here for Scenario 3 (single site OWF development, ongoing construction activity initiated at a second site, no change to other activities and pressures).

The proportional contributions of each assessed component to the overall risk (or relative vulnerability as a receptor) can be seen in the Sankey diagram, figure 3.9. The top-ranking pressures of land-based industry (22% relative contribution), wastewater management (21%), shipping (13%), and tourism/recreation (12%) are illustrated by the thicker bars and associated linkages. However, it is worth noting that 'Fishing' as a sector has been represented here by its various activity types (e.g. beam trawling, benthic trawling, dredge fishing, etc.) - if these were combined and treated as a single component, they would have the highest associated Impact Risk relative contribution at 26%.

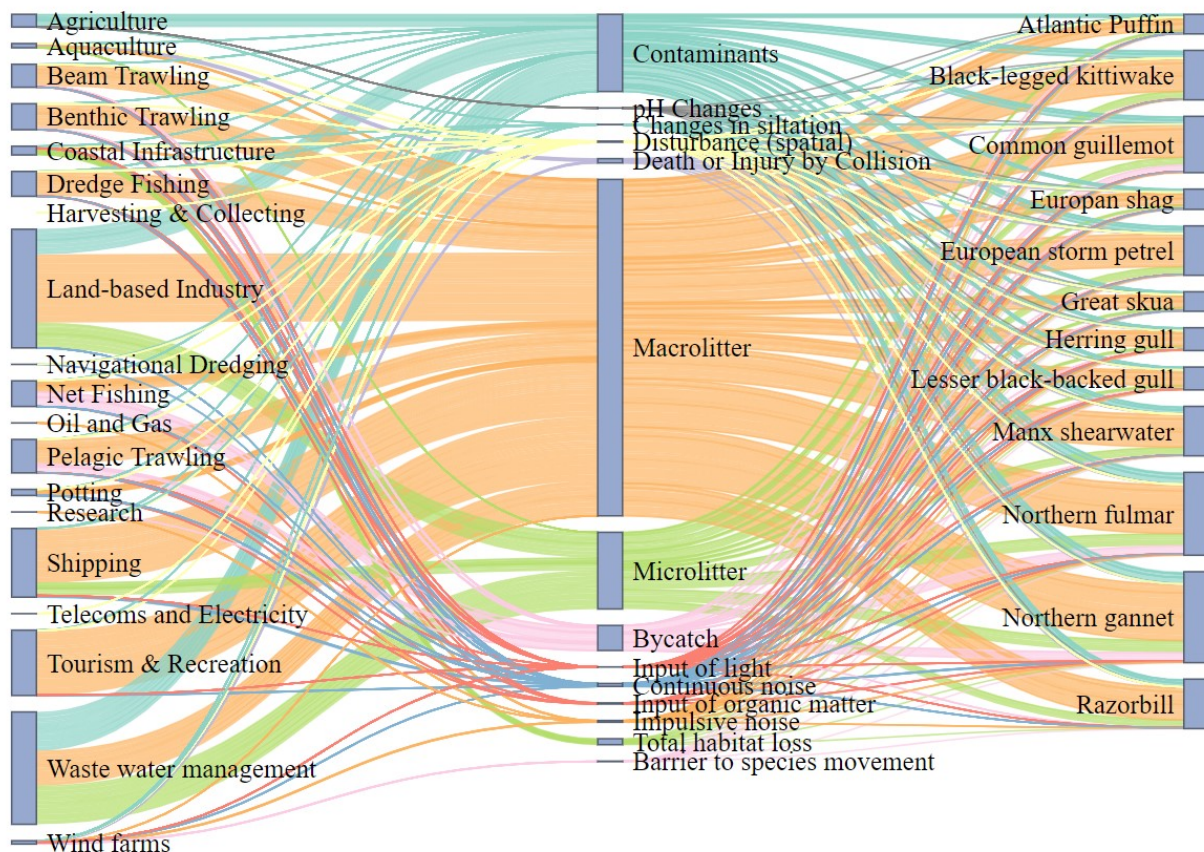


Figure 3.9 Sankey diagram of impact chains between activities (left), the pressures these exert (middle) and the seabirds affected (right) as assessed during the OSPAR bird pilot qualitative SCAIRM assessment of the Celtic Sea DMAP area, illustrating pressure pathways of Scenario 3. Scenario 3 is based on the year 2030, where DMAP area A has been developed, and construction is ongoing in one/some of the other development areas (B-D). The width of lines (colour-coded according to pressures) represents the Impact Risk score. This thickness of the grey bars indicates the summed Impact Risk score for that component.

In relation to the pressures, the aggregated risk score associated with each pressure is highly associated with their persistence score, with long-lived pressures such as litter (macrolitter 63%, microlitter 14%) and contaminants (14%) vastly outweighing all other pressures. For the seabirds three main groupings can be distinguished. Northern gannet (17%) and northern Fulmar (15.5%) experiencing the highest risk scores, guillemot, black-legged kittiwake and razorbill, Manx shearwater and European storm petrel experiencing medium risk (9-10.5%), and Black-backed Gull, herring gull, European shag, Atlantic puffin and great skua experiencing 3.5-4% relative Impact Risk under this scenario.

The above findings are further illustrated in figure 3.10, which provides boxplots of both the proportional connectance, the Impact Risk and ranks for each assessed component. This figure enables us to examine where there are few, high contributing impact chains, (e.g. pressures *microlitter*, and *total habitat loss*), or where they may be high connectance with relatively low scoring impact chains (e.g. activity *Windfarms*, and pressure *Input of Light*).

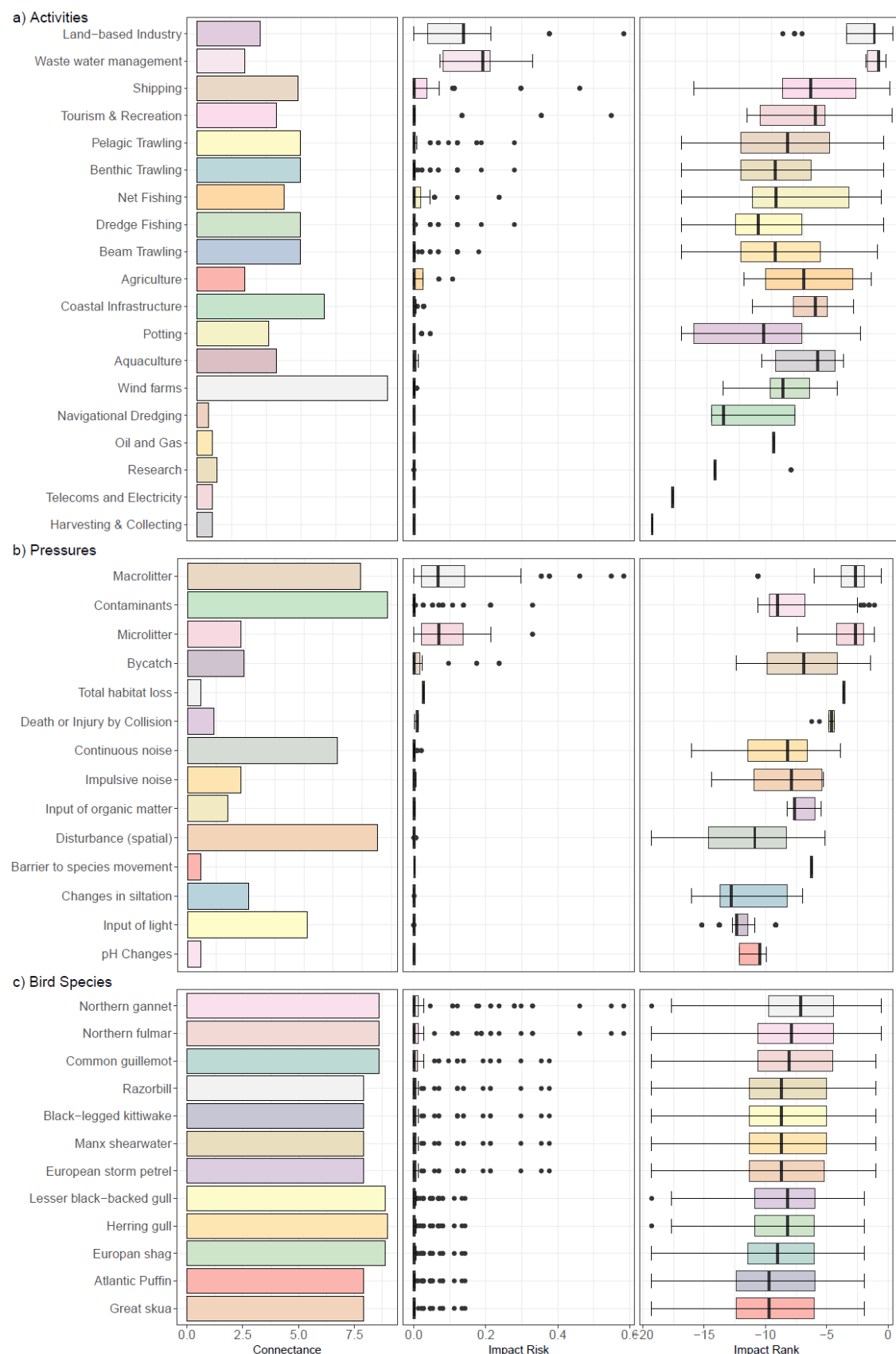


Figure 3.10 Details of Scenario 3 (2030) illustrating the proportional connectance, absolute Impact Risk scores, and ranked Impact Risk scores for each of the Activities, Pressures and Bird Species assessed listed in order of its average Impact Risk score. The thick black vertical lines on the boxplots indicate the median values, with the box lengths representing the 25% quartiles and the whiskers representing 1.5 times the interquartile range. Outliers are shown as black dots. The small Impact Risk scores have been log-transformed ('Impact Rank') to allow visual comparison between the assessed components.

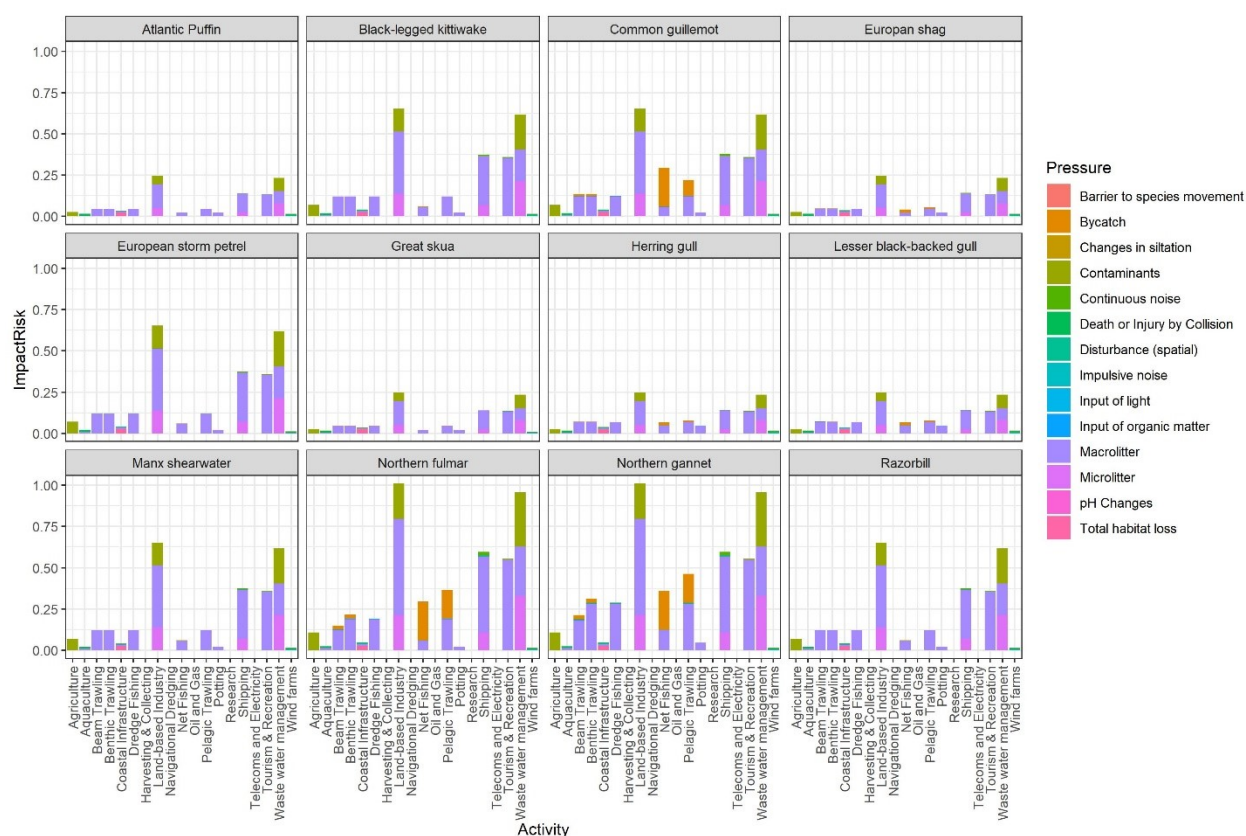


Figure 3.11 Alternative representation for the preceding figure 3.10.

Overall, the top-ranking activities and pressures within the DMAP area using the qualitative SCAIRM approach reflected the findings of the previous adapted ODEMM assessment (Pedreschi et al., 2023), with the same activities/sectors listed in the top 5. The pressures differ to those presented in Section 2.3.2.1 as these were based on the **Impact Risk** scores, but they largely reflect the findings of the ODEMM **Total Risk** scores, which are highly driven by the persistence and resilience components (see Pedreschi et al., 2023 for discussion). Within the previous assessment seabirds were treated as a single group, however, risks arising from litter and contaminants were ranked the highest, as was the case in the current qualitative assessment.

Offshore Wind Only

Sub-setting the data to focus on only OWF pressures and impacts facilitates understanding of the range of pressures relevant to various stages of the development process, including their relative impact. Figure 3.12 illustrates the construction and operational phases associated with scenarios 2, 3, 4 and 5. Relative contribution to overall risk remains relatively low during the earlier development phases, increasing substantially with full operational deployment in 2050 (scenario 4) (Figure 3.13). However, even at this point, only 5.25% of the Impact Risk in the system arises from OWF (ranked 6th across all activities, see Table 3.2).

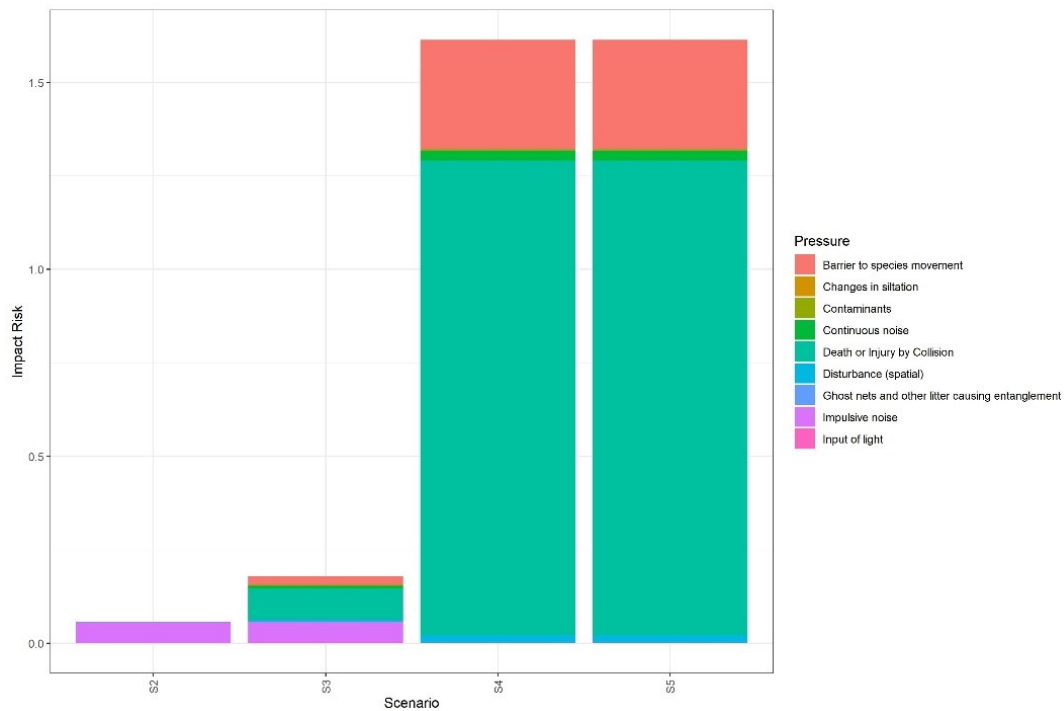


Figure 3.12 Summed species Impact Risk scores across OWF related pressures under scenarios 2 (construction only, pre-2030), scenario 3 (construction and operational, single sites 2030), and scenario 4 (four operational OWF areas, 2050) and scenario 5 (S4 plus fishing displacement). Colours indicate relative contributions of each pressure to the overall risk score. Note: the absolute risk score does not change for OWF between scenarios 4 and 5, but the relative proportion associated with OWF increases as fishing activity decreases in scenario 5 (see Table 3.4).

Changes in siltation, impulsive noise, and macrolitter are primarily associated with the construction phase, whereas continuous noise, death or injury by collision, and barriers to species movement only become relevant once wind farms become operational. Figure 3.13 shows the relative contributions of each pressure arising from OWF affecting each bird species and how they change across scenarios.

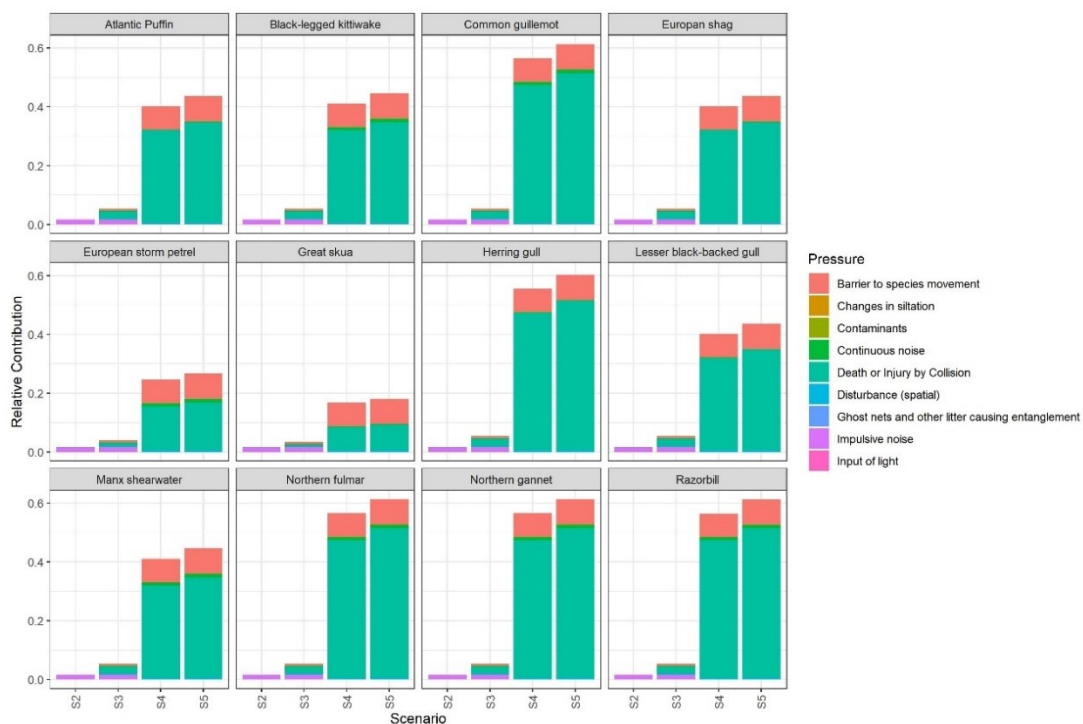


Figure 3.13 Relative contribution to risk per pressure associated with each OWF scenario (S2-S5) for each individual bird species. Note: the absolute risk score does not change for OWF between scenarios 4 and 5, but the relative proportion associated with OWF increases as fishing activity decreases in scenario 5.

3.3 Bay of Biscay and Iberian Coast

3.3.1 Individual Impact Risk Assessment

In this study area, OWF Impact Risk was evaluated under two separate scenarios: the construction phase and the operational phase. The baseline scenario was not considered as OWF activity does not represent a significant extent in the region. Each scenario was mapped spatially to illustrate its geographic scope and the predicted Impact Risk. This spatial representation provides a thorough understanding of how OWFs could affect various seabird species, including those that breed within OSPAR Region IV, those with residual breeding populations in its northern sector, and migratory species that traverse the region (refer to density distribution and breeding distribution maps in the Annex).

Among the seabird species assessed in OSPAR Region IV, 44% are widespread breeders occurring throughout the region. This group includes the Great Black-backed Gull, European Storm Petrel, Herring Gull, Lesser Black-backed Gull, Cory's Shearwater, European Shag, and Yellow-legged Gull (see Section 3 of the Annex for distribution maps). Another 44% primarily breed in the northern part of the region, particularly around the Bay of Biscay, which marks the southern edge of their breeding range, as these species predominantly nest in northern Europe. Representative species in this category include the Black-legged Kittiwake, Northern Gannet, Atlantic Puffin, Razorbill, Manx Shearwater, Common Guillemot, and Northern Fulmar. The remaining 12%—such as the Balearic Shearwater and Great Skua—are migratory, either passing through the region or spending the non-breeding season in OSPAR Region IV without establishing breeding colonies there.

Maps with the calculated Impact Risk are presented in this section for northern gannet in figure 3.14 and for each of the selected species in the Annex. Northern gannet is a species with a widespread distribution including the three pilot areas and therefore, chosen for presentation in this section.

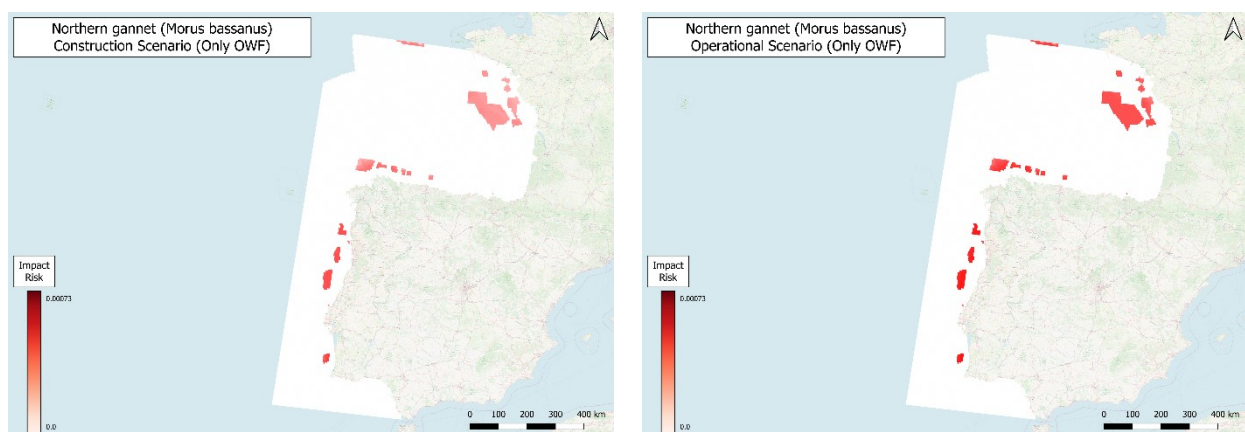


Figure 3.14 Predicted short-term future Impact Risk (IR) for northern gannet caused by OWF construction (left panel) and long-term Impact Risk caused by OWF operation (right panel) in the Bay of Biscay and Iberian Coast.

Northern fulmar

The density of fulmars is higher in the northern Bay of Biscay, with a general latitudinal decrease in density towards southern Portugal (Evans et al., 2021). In northwest Spain, fulmars exhibit medium density values. These areas are where the northern fulmar is more susceptible to the risks posed by offshore wind farms. The northern fulmar is a migratory seabird that frequents the area during specific times of the year, primarily while foraging during its extensive pelagic movements (Evans et al., 2021). Breeding is confined to suitable coastal cliffs in northern Europe, from the English Channel to northward to Iceland, Svalbard, and Norway (Keller et al., 2020). While some breeding still occurs in the Bay of Biscay, the southernmost extent of the species' breeding range, core breeding activity is concentrated further north (see Annex). Birds from these northern colonies often use OSPAR region IV as a migratory corridor or wintering area. This species is classified as Least Concern according to the criteria of the International Union for Conservation of Nature (IUCN) (BirdLife 2025). The figure in the Annex illustrates the Impact Risk (IR) for fulmars was generally moderate, with higher values concentrated in the northern area of OSPAR region IV, which follows species distribution, particularly in the

northern Bay of Biscay and in specific certain offshore wind farm (OWF) polygons off the coast of northwest Spain.

Manx shearwater

The figure in the Annex presents the estimated Impact Risk (IR) for Manx shearwaters, revealing a generally low level of risk across OSPAR Region IV. This low Impact Risk is primarily due to the species' limited presence in the area. Manx shearwaters are long-distance migratory seabirds that breed in the temperate North Atlantic and pass through OSPAR Region IV during their trans-equatorial migrations (Freeman et al., 2013), en route to their non-breeding grounds in the South Atlantic, mainly off the coasts of Brazil and Argentina (Keller et al., 2020). The species breeding occurs particularly in high densities on just three islands off the coasts of Britain and Ireland, concentrating approximately 75% of the global breeding population (Keller et al., 2020). In contrast, colonies in OSPAR Region IV—such as those in northwestern France—are small and mark the southern limit of the breeding range (see Annex). Seasonal presence in the region is largely due to migratory movements from northern Europe. The low-Impact Risk shown in the maps could point that no wind farms are within a critical distance of these small, local colonies. Reflecting its broad distribution and stable population trends, the Manx shearwater is currently classified as Least Concern by the International Union for Conservation of Nature (BirdLife, 2025).

Cory's shearwater

Cory's shearwater (*Calonectris borealis*) showed overall intermediate Impact Risk levels, higher in the southern portion of OSPAR Region IV particularly along the western Portuguese coast, compared to the Bay of Biscay. This spatial pattern aligns with the species' breeding distribution, as Cory's shearwaters nest extensively along the western Iberian coastline. Key breeding sites include the Berlengas Archipelago off Peniche, Portugal, and several islands in Galicia, northwestern Spain—most notably the Cíes, Sisargas, and Coelleira islands (Keller et al., 2020; Munilla et al., 2016). The Berlengas Archipelago is among the most important breeding areas for the species in mainland Portugal, offering suitable nesting habitats and access to productive foraging grounds. Similarly, the Galician islands provide rocky cliffs and islets that support large breeding colonies, with the Cíes Islands standing out for their particularly dense populations (Keller et al., 2020). These regions share ecological characteristics that favor successful reproduction, including abundant marine food resources. Despite regional pressures, Cory's shearwater maintains a stable global population and is currently listed as Least Concern (BirdLife International 2025). Its widespread presence across OSPAR Region IV reflects both its ecological adaptability and the availability of suitable breeding and foraging habitats throughout the area (see Annex).

Balearic shearwater

The Balearic shearwater exhibits a higher Impact Risk in the southern area of OSPAR region IV, particularly along the Portuguese coast (see Annex). This increased Impact Risk can be attributed to the species' preference for shallow shelf and coastal habitats, which are abundant in this region (Araújo et al. 2017). In the North West Iberian sector, the shallower areas of the proposed offshore wind farms exhibit higher Impact Risk values, reflecting a bathymetrical gradient from offshore to onshore, aligning with the species' known habitat preferences (Louzao et al. 2019, García-Barón et al. 2020). This species is found predominantly in shallow shelf waters, which are rich in food resources due to upwelling and high chlorophyll concentrations. The Balearic shearwater has an annual cycle divided into two phases: breeding in the western Mediterranean and migrating to the northeast Atlantic post-breeding, ranging from southern Spain to the English Channel (Guilford et al., 2012; Pérez-Roda et al., 2017). The species shows individual interannual spatial consistency in its NE Atlantic foraging destinations, with most individuals returning to the same non-breeding areas annually (Ramírez et al. under review). This behaviour suggests that Balearic shearwaters select their non-breeding foraging destinations based on predictable resource distribution, benefiting from site familiarity and memory (Lewin et al. 2024). Recent observations indicate a northward shift in distribution areas, with more individuals visiting the Bay of Biscay over the last decade (Lewin et al. 2024). Previous studies identified the Western Iberian Peninsula as the main non-breeding area, followed by the Bay of Biscay (Guilford et al., 2012; Pérez-Roda et al., 2017). However, recent data shows a higher proportion of individuals staging in the Bay of Biscay, suggesting a northward migration shift driven by food availability rather than temperature changes (Luczak et al., 2011). Phenotypic plasticity in Balearic shearwaters may enable them to follow shifting resources in response to climate change (Lewin et al. 2024). The Balearic shearwater is classified as critically endangered by the IUCN and the implementation of offshore wind farms in these regions must consider the potential impacts on this threatened species and their habitats, the Impact Risk calculations can give direction on this.

European storm-petrel

The European storm petrel (*Hydrobates pelagicus*), Europe's smallest seabird, exhibited a consistently high Impact Risk across nearly all offshore wind farm (OWF) projects within OSPAR Region IV, which encompasses the Bay of Biscay and the Iberian Coast (see Annex). This trend was particularly pronounced along the southern reaches of the region, notably the Iberian Coast. The area's rich and dynamic marine ecosystems—shaped by a mosaic of continental shelves, slopes, and abyssal plains—provide ideal foraging and migratory conditions for the species. While the core breeding population of the European storm petrel is concentrated in northern Europe, the species is widely distributed across the OSPAR Region IV (see Annex). Migratory individuals from the north contribute to its seasonal presence in the region. It typically nests in rocky coastal environments such as cliffs, caves, and boulder-strewn slopes, often nesting in burrows and crevices (Keller et al., 2020), with breeding colonies commonly found on remote offshore islets, including several sites along the Spanish Atlantic breeding sites (Keller et al., 2020; de Juana & García, 2015). Despite regional variability in population size—with many countries hosting only a few thousand breeding pairs—the species maintains a stable global population and is currently classified as Least Concern by the IUCN (BirdLife International, 2025).

Northern gannet

The Northern Gannet exhibited a persistently intermediate-high Impact Risk across OSPAR Region IV, with particularly elevated levels along the Portuguese continental shelf (see figure 3.14). This heightened risk corresponds to the notably high density of Northern Gannets observed in this area (see figure 2.5). This is especially true during the operational phase of OWFs. The Northern Gannet breeds in northern Europe, with major colonies established along the coasts of the Celtic Sea, the North Sea, and the northeastern Atlantic (Keller et al., 2020). The British Isles host the largest share of the global breeding population, supporting approximately two-thirds of the total. Additional significant colonies are found in northern France, particularly along the English Channel (Keller et al., 2020). Although the species still breeds in the Bay of Biscay, located in the northern part of OSPAR Region IV, its primary breeding range lies further north, making this region the southern limit of its reproductive distribution. Outside the breeding season, Northern Gannets disperse widely, ranging from the North Sea to the West African coast, with OSPAR Region IV serving as a non-breeding foraging ground (Fort et al., 2012). According to the IUCN, the species is currently classified as Least Concern (BirdLife International, 2025).

European shag

The overall Impact Risk of the European shag was intermediate. During the construction phase, the Impact Risk of offshore wind farms (OWFs) on the European shag was lower than during the operational phase and was more spatially concentrated along the coast (see Annex). This coastal concentration aligns with the species' distribution, which shows higher densities in nearshore areas (see Annex). However, certain OWF polygons—particularly in southern and northern Portugal and northwestern Spain—showed significantly higher impact levels during this phase. The European shag breeds across northwestern Europe, from the Iberian Peninsula to western Russia, with higher concentrations in the British Isles, Scandinavia, and northern Spain (Keller et al., 2020). While some northern colonies can number in the thousands, most breeding groups elsewhere are much smaller, typically comprising a few dozen to a few hundred pairs. As a result, the species is broadly distributed throughout OSPAR Region IV (see Annex). Some populations are partially migratory, with individuals either remaining at breeding sites year-round or dispersing during the non-breeding season (Keller et al., 2020). The IUCN Red List currently classifies the European shag as Least Concern (BirdLife International 2025).

Herring gull

The Impact Risk for the species is particularly high in coastal OWF polygons along the northern Bay of Biscay in France, compared to much lower values in offshore OWF areas in the same region, as well as in NW Spain and along the Portuguese continental shelf (see Annex). This pattern mirrors the species' spatial density distribution, with higher concentrations in coastal zones of the northern Bay of Biscay (see Annex). Similar trends were observed under both scenarios. The species breeds widely across Europe, including Iceland, the Faroe Islands, the British Isles, and extending from western France into western Germany (Keller et al., 2020). In winter, its range shifts southward to include the northern coast of the Iberian Peninsula (del Hoyo et al., 2019), resulting in a broad distribution throughout OSPAR Region IV (see Annex). The region functions as both a stopover and a wintering site for birds migrating from northern Europe. This species is currently listed as Least Concern by the International Union for Conservation of Nature (IUCN).

Lesser black-backed gull

The lesser black-backed gull exhibited high Impact Risk values across the OWF polygons in OSPAR region IV under both scenarios, with higher magnitude of impact observed during the operational phase (see Annex). Species density was generally moderate to high across the entire continental shelf of the pilot area, with particularly high concentrations along parts of the French continental shelf in the Bay of Biscay and the Portuguese continental shelf (see Annex). This species mainly breeds in northern and western Europe, with Great Britain representing its core breeding area (Keller et al., 2020). Significant populations also found in Iceland, Belgium, the Netherlands, and southern Fennoscandia. In recent decades, the breeding range has expanded southward and eastward (Keller et al., 2020), leading to a regular breeding presence throughout OSPAR Region IV (see Annex). Additionally, individuals from northern Europe migrate through or overwinter in this region. Under the IUCN classification system, the species is considered to be of Least Concern (BirdLife International 2025).

Great black-backed gull

The intermediate Impact Risk for the great black-backed gull exhibited a latitudinal gradient, decreasing from north to south, along with an onshore-to-offshore decrease in the northern Bay of Biscay within French waters under both scenarios (see Annex). This spatial pattern closely mirrors the species' density distribution, as the highest concentrations—defined by the 95th percentile—are located along the French continental shelf (see Annex). In Europe, the species is widely distributed along most northern and western Atlantic coasts and adjacent areas, with the largest populations found in Norway, Sweden, the United Kingdom, and Iceland. Notably, recent observations indicate a southward expansion of its breeding range, now extending along the Iberian Peninsula (Keller et al., 2020). As a result, the species is broadly present as a breeder within OSPAR Region IV. In addition to breeding populations, individuals from northern Europe frequently migrate to or overwinter in this region. The IUCN currently lists the species as Least Concern (BirdLife International, 2025).

Black-legged kittiwake

The figure in the Annex shows the Impact Risk of the black-legged kittiwake in OSPAR region IV. Under both scenarios, the spatial patterns showed intermediate impact levels in the Bay of Biscay, with a latitudinal decline toward the south. This trend aligns with the species' abundance distribution, which is highest along the northern French continental shelf (see Annex). In Europe, black-legged kittiwakes predominantly breed along the coasts of northwestern France, the British Isles, Svalbard, and Norway (Keller et al., 2020). With an estimated population of around four million mature individuals, it is considered the most abundant gull species globally (Keller et al., 2020). Although the species still nests in the Bay of Biscay—marking the southern edge of its breeding range within northern OSPAR Region IV—its core breeding areas remain in northern Europe (see Annex). While a few breeding pairs were historically recorded in northwestern Spain, the most recent census found no evidence of ongoing breeding activity (Xunta de Galicia, 2024). In addition to its breeding presence, the region also serves as a key migratory corridor from northern populations. The species is currently listed as Vulnerable on the IUCN Red List of Threatened Species (BirdLife International, 2025).

Great skua

In both scenarios, the Impact Risk for the great skua was highest along the Portuguese continental shelf in the southern part of OSPAR Region IV, with intermediate levels observed across the Bay of Biscay (see Annex). This pattern aligns with predicted species density, which is notably higher along mainland Portugal, particularly in areas identified within the 95th percentile of the density distribution (see Annex). The great skua breeds exclusively in Europe, with its range confined to the northeastern Atlantic and the Barents Sea, primarily nesting on remote islands and coastal moorlands (Keller et al. 2020). Core breeding populations are concentrated in Scotland and Iceland, which represent the species' main strongholds. After the breeding season, most individuals migrate southward to winter along the coasts of Spain and West Africa (Keller et al. 2020), while juveniles may disperse more widely, occasionally reaching the western Atlantic (del Hoyo et al. 2019). Consequently, some individuals pass through OSPAR Region IV during migration, while others remain and overwinter within the region. The IUCN has evaluated the species as being of Least Concern (BirdLife International 2025).

Common guillemot

The offshore wind farm impact assessment revealed higher risk levels in the northern sector of the Bay of Biscay, particularly along the northern French coast, under both scenarios (see Annex). This elevated risk

corresponds with the highest species density areas, defined by the 95th percentile of the density distribution, which were concentrated in this coastal zone. Additionally, within individual OWF polygons, Impact Risk was consistently higher in coastal areas compared to offshore zones—a pattern observed both in the Bay of Biscay and along the Iberian Peninsula’s continental shelf (see Annex). The common guillemot primarily breeds along the northern and western coasts of Europe, with major population concentrations in the British Isles, Iceland, Scandinavia (Keller et al., 2020). Although its breeding range reaches as far south as northwestern France, the Bay of Biscay—located in the northern part of OSPAR Region IV—marks the southern limit of its breeding distribution (see Annex). While a few breeding pairs were historically recorded in northwestern Spain, the most recent census found no evidence of continued breeding activity in that area (Xunta de Galicia, 2024). Despite this, the region remains important for the species, serving as both a migratory corridor and a wintering ground for individuals from northern populations. This species does not currently face significant threats and is listed as Least Concern by the IUCN (BirdLife International 2025).

Razorbill

The Impact Risk for the razorbill was highest in the northern part of OSPAR Region IV, particularly over the French continental shelf, with intermediate levels along the southern Portuguese shelf and low risk in northwestern Spain. This pattern was consistent across both scenarios (see Annex). These results align with predicted abundance patterns, which show the highest densities in the northern Bay of Biscay, as well as notable concentrations along a narrow coastal band in southern Portugal within the southern portion of OSPAR Region IV (see Annex). Razorbills have a broad but patchy distribution along the northern European coast, with the highest population densities found in Iceland, Britain, and Ireland (Keller et al., 2020). Their southernmost breeding colonies are located in Brittany and Normandy, France, marking the edge of their breeding range. Consequently, while breeding activity still occurs in the Bay of Biscay—within the northern part of OSPAR Region IV—this area represents the southern limit of the species’ breeding distribution (see Annex). According to the IUCN Red List, the razorbill is currently classified as Least Concern (BirdLife International, 2025).

Atlantic Puffin

The Impact Risk for the Atlantic puffin was low during the construction phase but increased during the operational phase (see Annex). Spatially, the level of impact was relatively uniform across OSPAR Region IV, reflecting the species’ general distribution patterns. However, distinct hotspots of higher density were identified in southern Portugal, northwestern Spain, and northern France (see Annex). The Atlantic puffin’s global breeding range is restricted to the North Atlantic Ocean, with 99% of the European population concentrated in just four countries: Iceland, Norway, the United Kingdom, and the Faroe Islands (BirdLife International 2015, 2017). Northwestern France, particularly the Bay of Biscay in the northern part of OSPAR Region IV, hosts small breeding populations of the Atlantic puffin, constituting the southernmost point of its breeding distribution (see Annex). Additionally, the region serves as a migratory corridor and wintering area for individuals from northern European colonies. According to the latest IUCN assessment, the Atlantic Puffin is classified as Vulnerable, reflecting ongoing concerns about population declines and threats across its range (BirdLife International 2025).

Yellow-legged gull

The Impact Risk for the yellow-legged gull was generally high across OSPAR Region IV, with a higher magnitude observed during the operational phase and consistent spatial patterns under both scenarios (see Annex). Predicted spatial densities indicate a strong preference for habitats over the continental shelf, with high-density areas concentrated around the Iberian Peninsula’s shelf region (see Annex). The yellow-legged gull, particularly the subspecies *Larus michahellis michahellis*, is widespread across Europe, including OSPAR Region IV (Keller et al., 2020). While largely sedentary, some populations show partial migratory behavior along Atlantic coasts (del Hoyo et al., 2019). Core breeding areas are found in the Iberian Peninsula, southern France, the Adriatic Basin, and the Macaronesian archipelagos (Keller et al., 2020), resulting in a broad breeding distribution throughout OSPAR Region IV (see Annex). Based on IUCN criteria, the species is not currently threatened and is listed as Least Concern (BirdLife International 2025).

3.3.2 Community-level Impact Risk assessment

The aggregated results for the seabird community are presented as the cumulative Impact Risk of individual species in relation to OWFs within OSPAR Region IV (Figure 3.15). The spatial distribution of Impact Risk highlights two main areas of elevated community-level risk: the French continental shelf in the northern part and the southern OWFs located on the Portuguese continental shelf. In contrast, OWFs situated off the northwest coast of Spain exhibited low to intermediate Impact Risk values. Although Impact Risk values were generally higher during the operational phase compared to the construction phase, the overall spatial pattern of predicted risk remains consistent across both scenarios.

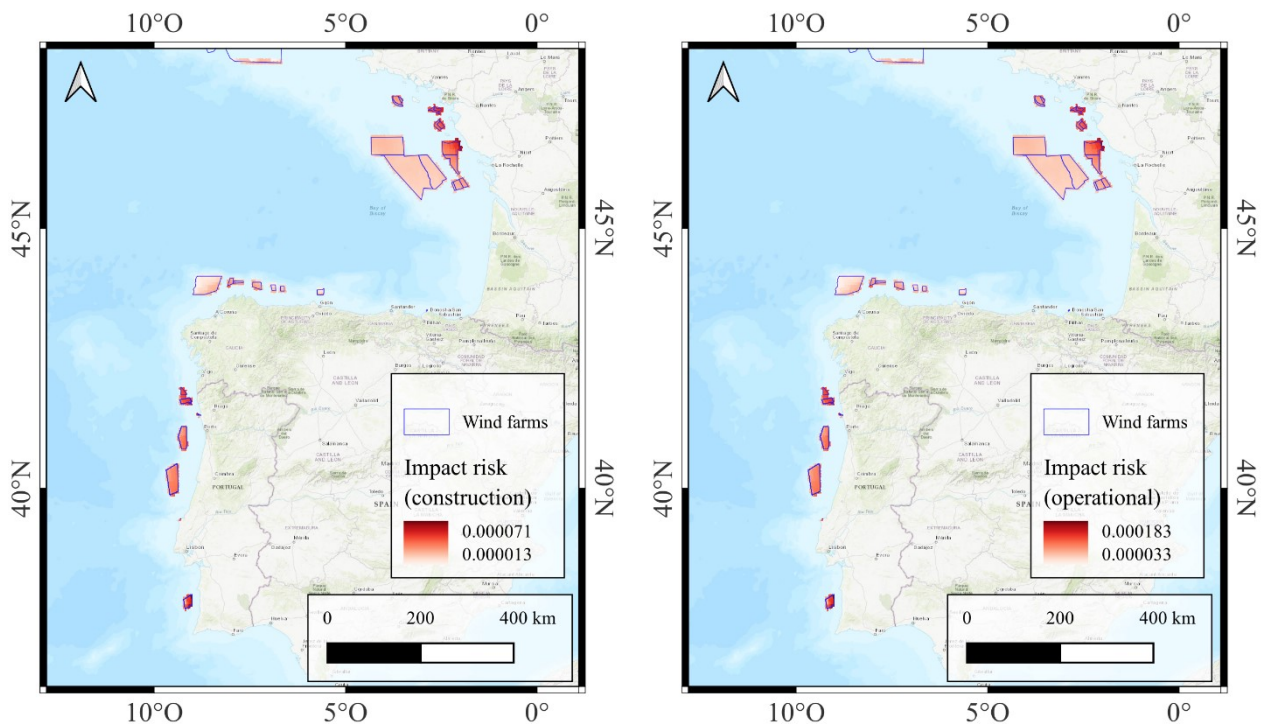


Figure 3.15 Cumulative Impact Risk for the seabird community during offshore wind farm construction (left), and operational (right) phases in OSPAR Region IV, represented as the average of individual species' Impact Risk.

To further refine the analysis, we identified high-risk areas by applying the 95th percentile threshold of predicted Impact Risk, following the methodology of Astarloa et al. (2021), for both the construction and operational scenarios within the same region (Figure 3.16). During the construction phase, five offshore wind farms (OWF) located in the northern sector of the French continental shelf were classified as high-risk for at least one species. Additionally, four OWF on the Spanish continental shelf and six OWF on the Portuguese continental shelf were classified as high Impact Risk for at least one species. The highly risk OWF for a higher number of species considered are in Portuguese continental shelf, and in French continental shelf. A similar spatial pattern was observed during the operational phase, indicating consistent areas of elevated Impact Risk across both project stages.

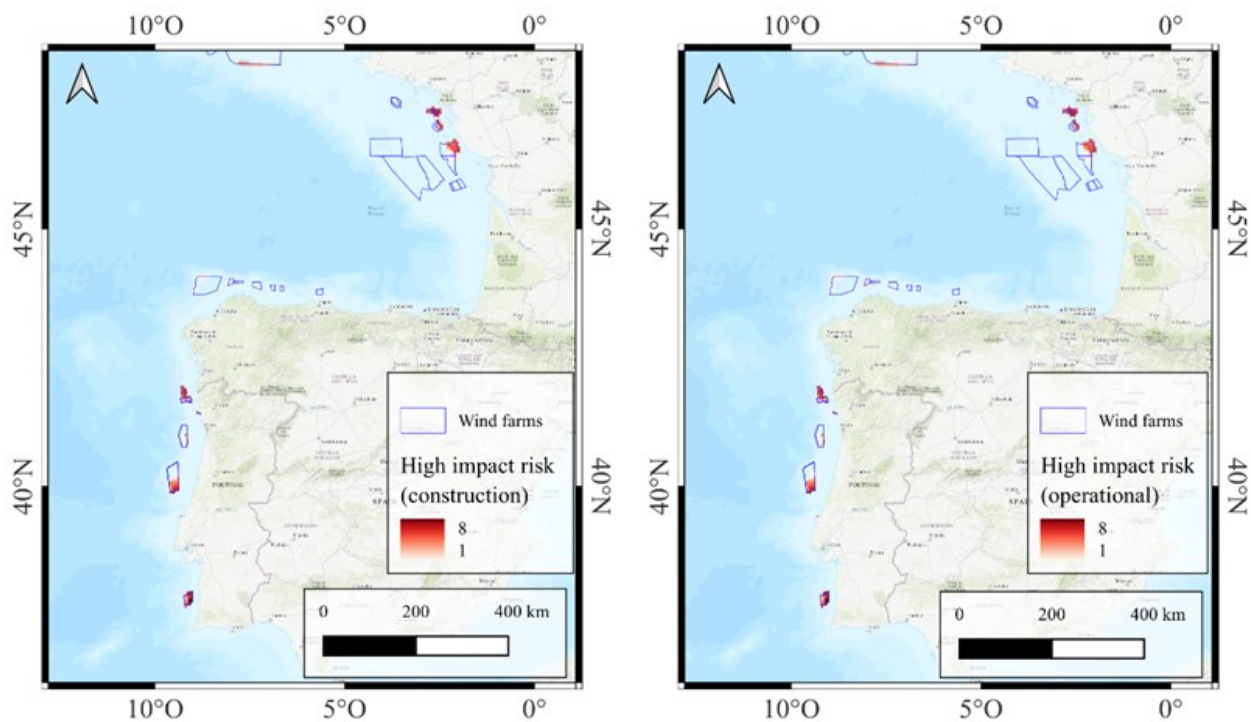


Figure 3.16 3Number of seabird species experiencing high Impact Risk within each grid cell intersecting the polygons representing offshore wind farm locations during the construction phase (left) and operational phase (right) in OSPAR Region IV.

To place the results in the context of the broader seabird community, we generated cumulative density maps for the 16 seabird species considered in the analysis. Additionally, we produced a map illustrating the number of species exhibiting high-density areas within each grid cell across OSPAR Region IV, based on individual species' density maps using the 95th percentile threshold to define high-density zones (Figure 3.17). The cumulative seabird density was highest in the southern sector of the study area, particularly over the Portuguese continental shelf, which also coincided with areas of elevated predicted Impact Risk from OWFs. In contrast, the northern sector, including the Bay of Biscay, showed intermediate seabird densities despite also exhibiting high predicted Impact Risk. This suggests that while seabird density contributes to the spatial patterns of Impact Risk, additional factors—such as species-specific sensitivity or exposure—also play a significant role. A similar spatial trend was observed in the distribution of high-density species: the central French continental shelf showed an intermediate number of species with high-density areas, whereas the Portuguese continental shelf supported a higher number of such species, aligning with zones of elevated predicted impact. These findings highlight the spatial heterogeneity of potential impacts and underscore the importance of region-specific conservation strategies to mitigate risks in areas of heightened vulnerability.

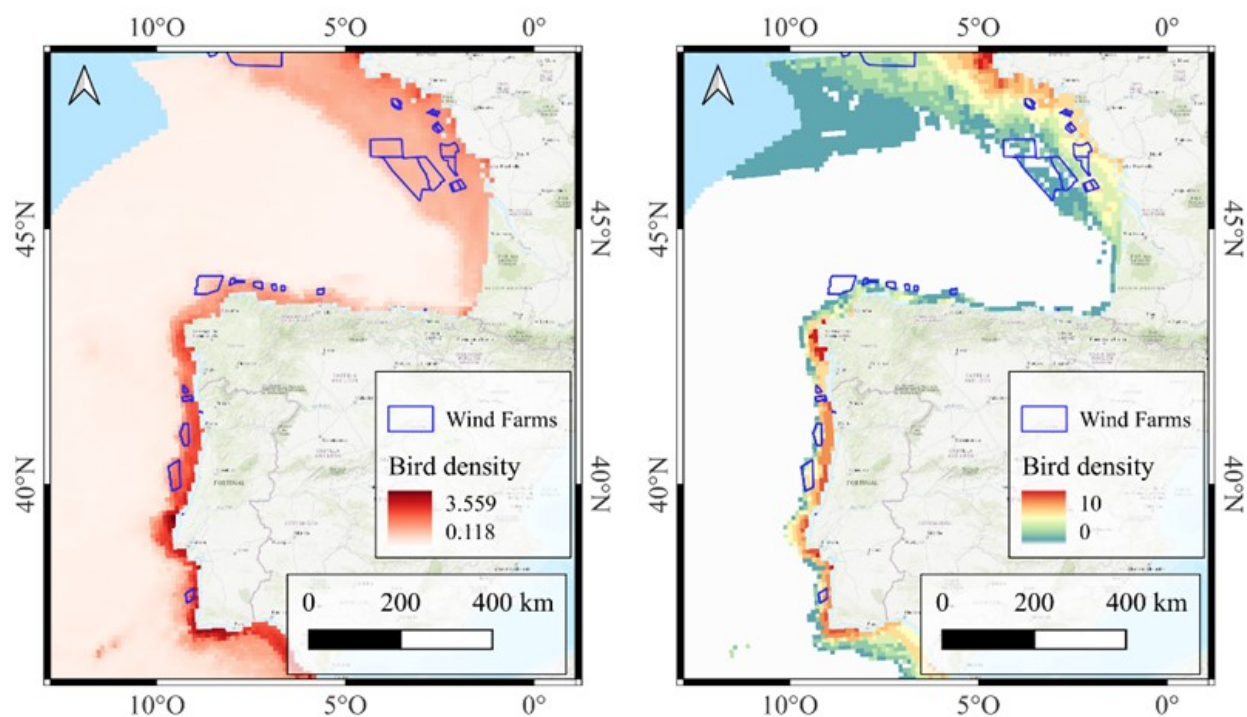


Figure 3.17 Seabird density across OSPAR Region IV is illustrated through two complementary metrics: the left panel shows the maximum seabird density, calculated as the cumulative sum of individual species' densities (individuals per km²) for all 16 seabird species considered; the right panel displays the number of species with high-density areas in each grid cell, identified using the 95th percentile threshold applied to individual species' density maps to define zones of elevated seabird presence.

To enable a comparison of Impact Risk across species, we created bar plots illustrating the relative importance of various pressures associated with the construction and operational phases of offshore wind farms (Figure 3.18). For all species, Impact Risk was lower during the construction phase than during the operational phase. During construction, the primary pressure was 'impulsive noise,' followed by general disturbance. In contrast, during the operational phase, the dominant pressures varied by species—either 'death or injury by collision' or 'visual disturbance'—with 'barrier to species movement' consistently ranking as a secondary pressure. These patterns are further detailed in Figure 3.19, which highlights species-specific responses to pressures such as collision risk and disturbance.

During the operational phase (see Figure 3.19), the species with the highest total Impact Risk ($IR > 0.08$) included the Balearic shearwater—the most critically endangered seabird in Europe—and the European storm-petrel, one of the smallest seabirds. For the Balearic shearwater, displacement risk was significantly higher than collision risk, whereas the European storm-petrel experienced similar levels of collision and disturbance risk. Also in this high-risk group were three members of the Alcidae family—Atlantic puffin, common guillemot, and razorbill—for which disturbance was the dominant pressure. Additionally, three species from the Laridae family—herring gull, lesser black-backed gull, and yellow-legged gull—were included in this group, with collision risk being particularly prominent for the herring and yellow-legged gulls. Species with intermediate Impact Risk values (IR between 0.04 and 0.08) included two additional Laridae species—the black-legged kittiwake and the great black-backed gull—along with Cory's shearwater, European shag, great skua, northern fulmar, and northern gannet. For all of these species, disturbance risk was greater than collision risk. The remaining species, such as the Manx shearwater, exhibited low Impact Risk values ($IR < 0.04$) during the operational phase, primarily driven by disturbance-related pressures.

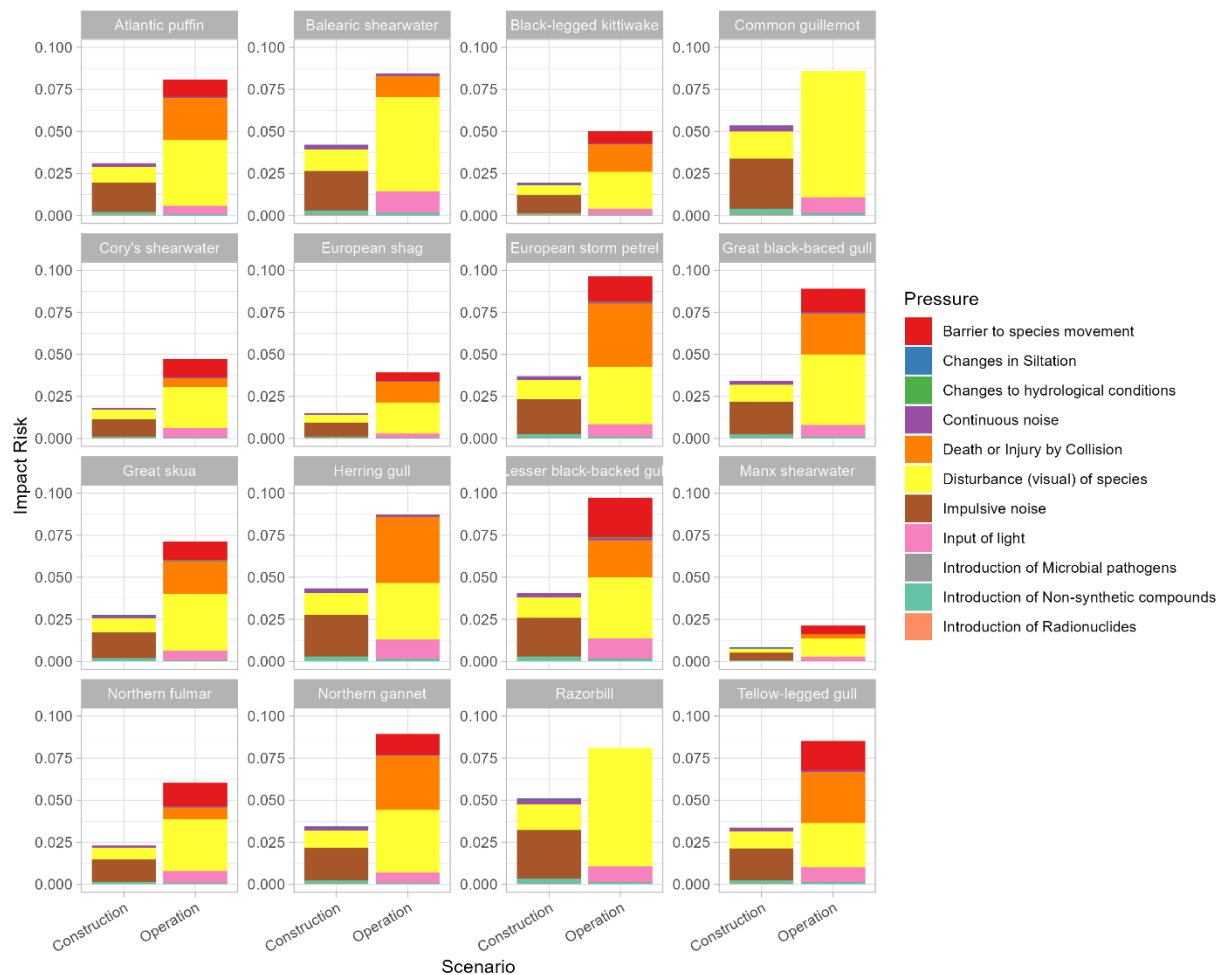


Figure 3.18 Impact Risk from offshore wind farms, grouped by pressure type, for each seabird species selected in the Bay of Biscay and Iberian Peninsula (OSPAR Region IV).

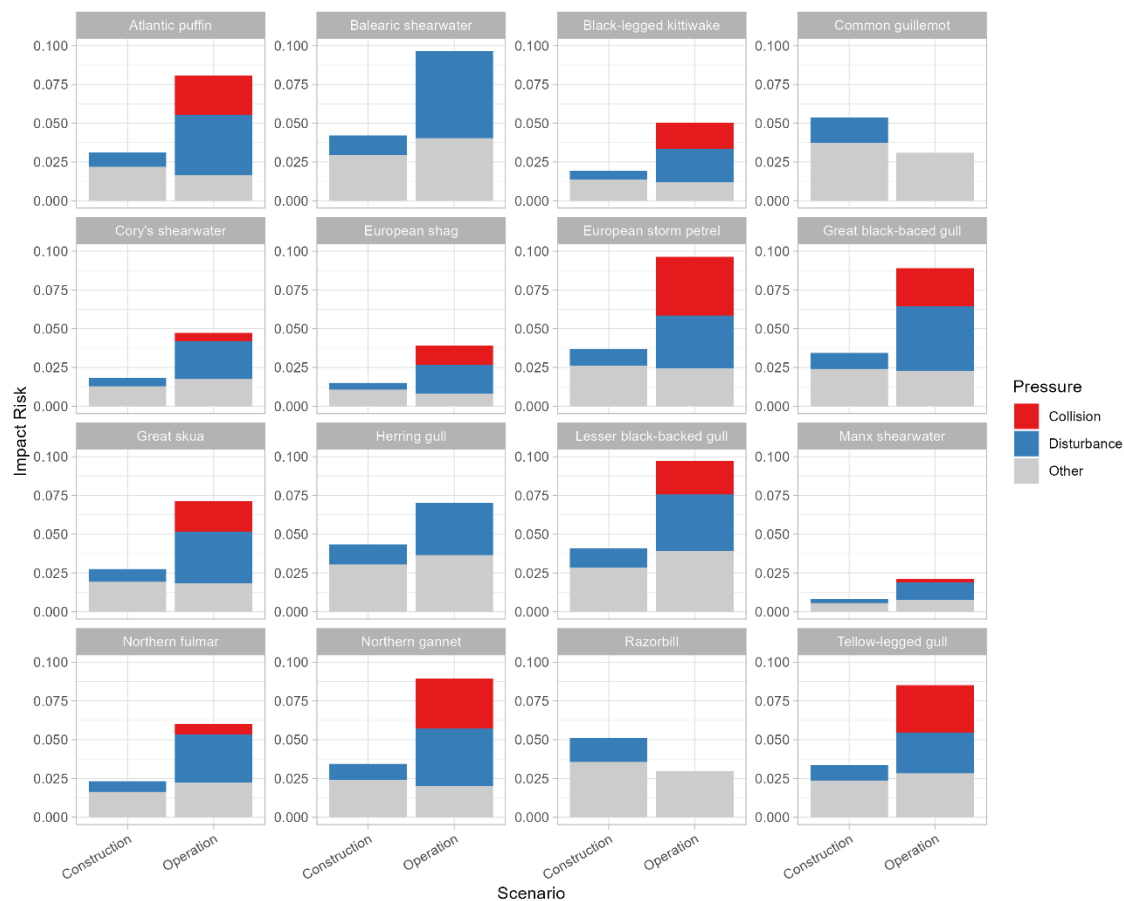


Figure 3.19 Impact Risk from offshore wind farms for each seabird species in the Bay of Biscay and Iberian Peninsula (OSPAR Region IV), with a focus on specific pressures such as collision and disturbance, alongside the combined impact of all remaining pressures.

4 Discussion

From the development of this CIA method, i.e. SCAIRM, and its application in the different pilots some principles can be identified that apply for such assessments. For an understanding and in-depth discussion of the results presented in this report, it is necessary to first acknowledge some of the limitations of the applied CIA method, i.e. SCAIRM, and then consider its suitability to address the request of conducting a cumulative impact assessment on birds in different pilots within the OSPAR maritime area. This suitability depends on how the methodology can operate both in data-rich as well as data-poor situations and how data limitations may affect the outcome of the approach. The lessons learned from this exercise on the three pilots will be discussed and forms the basis for advice on the suitability of this method to be applied in the wider OSPAR area and/or to other ecosystem components than birds with an indication of the challenges involved.

4.1 General principles for a CIA

For these principles, we distinguish between the two parts that make up the CIA approach:

- The linkage framework that fits to cause-consequence-response frameworks such as the modified DPSIR-related (Drivers, Pressures, State, Impacts, Response) frameworks like DAPSES-MMM (Drivers-Activity-Pressures-State-Ecosystem Services-Management (Policies and Governance)- Measures-Monitoring (CSWD, 2020) or DAPSI(W)R(M) (Drivers-Activities-Pressures-State change-Impacts (on human Welfare)- Responses (using management Measures) (Elliott et al., 2017). This linkage framework should be:
 - Comprehensive in that it consists of all manageable activities and any pressure through which any ecosystem component (i.e. biodiversity) may be impacted. For this study focusing on bird species, every potential impact on the ecosystem should be covered by an impact chain connecting Activity-Pressure-Species.
 - Consist of meaningful categories, recognizable for all relevant stakeholders in the socio-economic system and governance actors.
- The risk-based approach is needed to quantify the threat caused by each impact chain. This risk-based approach should:
 - Be applicable both in data-rich and data-poor ecosystems
 - Apply the best information available
 - Allow a piecemeal improvement process without compromising its operability
 - Be transparent in that the outcome can always be traced back to the information used
 - Be climate change proof

4.2 The suitability of SCAIRM: issues and considerations

The application of the SCAIRM method to conduct this CIA requires some discussion on its limitations, suitability and challenges to advance the method. These limitations apply to the current configuration of the SCAIRM method and mostly come from pragmatic choices deemed necessary for its practical application given the limitations in the available knowledge. Most of these limitations can be resolved but they come with requirements for additional science and data.

- It only considers impacts on the biota, not necessarily the abiotic/physical environment. This implies that when impacts on habitats are considered this only involves its associated biotic component (e.g. the benthos, not the sediment).
- It only includes direct effects, i.e. effects via food web relations and other cascading effects are not included.
- It includes only negative impacts and consequences, and it is hard to include potentially beneficial aspects (e.g. artificial reef formation improving biodiversity)

- Climate is considered an extraneous driver and as such not part of the regionally manageable activities and their pressures. If information becomes available on how this affects the spatial distribution of the bird species or their sensitivities to the pressures included in the assessments, then this can be incorporated. The method does not prevent the incorporation of climate change in the assessment, this is caused by the lack of information.
- SCAIRM is a risk-based approach and hence provides some degree of risk, i.e. Impact Risk. No risk-based approach can be used to predict the actual values for specific indicators (e.g. MSFD).
- Because knowledge on the interaction mechanisms of multiple stressors (additivity, synergy, antagonism) is lacking, the approach is cumulative in an additive fashion (following e.g. Halpern & Fujita, 2013; Judd et al., 2015) and does not consider or account for interactions between pressures such as synergistic or antagonistic effects. This is not a methodological issue but rather a matter of data availability.

For an understanding of the SCAIRM output metric the following points apply:

- Impact Risk is the main output of the model and reflects the potential risk from the (additive) cumulative anthropogenic pressures. It can be used to provide an integrated perspective on the (change in) vulnerability of the ecosystem as a whole (within the boundaries of a specific study area like the Greater North Sea, Celtic sea, Bay of Biscay and Iberian coast) as well as each of the different ecosystem components, e.g. birds as in this study.
- While Impact Risk is an estimate of the potential change in the state of the various ecosystem components it does not represent an actual decrease in abundance and hence cannot be related to specific indicator values. It is intended as the common metric that allows the integration of different pressures, ecosystem components etc. when assessing some (future) alternative situations relative to a baseline/reference situation. For such future scenarios applies that as long as Good Environmental Status is not achieved the precautionary principle would require that the total Impact Risk should not increase relative to the baseline.
- Impact Risk can be used to indicate the main threats to the ecosystem or specific ecosystem components. It identifies the main human activities and their pressures that compromise ecosystem health and hence the achievement of policy objectives and allows a comparison of their relative contributions. This information is the basis for ecosystem-based management.
- While this assessment only covers the ecological system the SCAIRM method can be applied as part of a social-ecological system as the activities are harmonized with NACE (Classification of economic activities in the European Union) and the impacts on the ecosystem components can be extended to also include the ecosystem services according to CICES (Common International Classification of Ecosystem Services) (Piet et al., 2024).

4.3 Limitations in the available information

There is much uncertainty about future scenarios, especially for the more distant futures. Future developments of activities are rarely known and often not spatially elaborated. And as applies to any future scenario it is dependent on unforeseen political and economic developments. In this report, the spatial OWF scenarios for the North Sea are relatively well-developed and recently updated but the applied future scenarios for activities other than OWF on the North Sea were based on a query carried out in 2021 involving a limited selection of stakeholders. As this was readily available they were assumed adequate to illustrate the necessity of considering all activities when evaluating future scenarios. For the Bay of Biscay and Iberian Peninsula, existing national plans have been consulted. Based on such documents, existing OWFs have been considered, as well as those that are planned to be constructed. Nevertheless, the uncertainty of the installed production capacity and wind turbine technical characteristics is considerable. In general terms, the area is characterized by its narrow continental shelf and the variation in depth in areas close to the coastline. Thus, existing plans are also considering the installation of floating wind turbines. As this is a new kind of technology, the expected pressures and estimated impacts of those OWF come with high uncertainty.

For calculations of future scenarios of all activities except OWFs only a factor relative to baseline was available (see Table 2.7, Table 2.8) to reflect the increase or decrease of an activity over time. For application to evaluate scenarios this factor needed to be translated into one of the SCAIRM parameters reflecting the magnitude or intensity of the pressure. For now, the frequency was the chosen parameter. While in some cases, the

frequency will be a realistic measure (e.g. shipping passages), in other cases it is not (e.g. aquaculture plots, which are either there or not but likely to increase in extent). This needs to be improved for future assessments. In general, the future scenarios of all activities except OWF are speculative at best and should be improved. The reason for including them is to stress the point that any single-sector future scenario (OWF or otherwise) should be assessed in the context of future scenarios of (ideally all) other activities.

Species-specific sensitivity towards activities and their pressures is only applied for OWF in relation to the pressures of collision and disturbance during the operational phase (i.e., not considering the construction, nor the decommissioning phases). This needs to be expanded with species-specific sensitivities for other activity-pressure combinations. Examples of that can be found in Piet et al. (2021a) with elaborations for the activity-pressure combination gillnet fishery-bycatch for common guillemots. Disturbance by shipping is another option for which Fliessbach et al. (2019) provide a disturbance vulnerability index for many bird species, including 14 species of the 21 species studied here. There are some activities and pressures for which relatively large variability in the sensitivity among bird species can be expected due to their behaviour and foraging habitats, e.g. deep divers and surface feeders.

Results are heavily dependent on the applied spatial distributions of species. The applied species distributions could genuinely reflect the species' area preferences, but they may also be affected by limitations in monitoring coverage. Another issue concerning the available species distributions is that these distributions may be affected by (past and present) human activities resulting in lower Impact Risk estimates of those activities and causing biased Impact Risk estimates for other activities. The application of fundamental spatial distributions only determined by habitat suitability might resolve this but are mostly not available and therefore also never tested. Moreover, it can be expected that even a representative species distribution based on a period in the past may differ considerably in the future as a consequence of e.g. climate change. Much of the same applies to the spatial distributions of human activities, although for those the future distributions are more likely to be affected by socio-economic drivers like the energy transition.

The actual impact of any human activity on the species is determined by the pressure, some of which are known to disperse. While the spatial distribution of those activities can be considered a good enough proxy for the non-dispersing pressures, other dispersing pressures like contaminants, noise, visual disturbance, and litter require additional information to determine their spatial distribution, as their impacts extend beyond the immediate location of the activity. This could not be addressed in this study and remains an area for further improvement.

For the OWF spatial distribution, their entire search areas were provided. Clearly this results in a huge overestimation of Impact Risk. This was resolved by applying so-called utilisation factors for the ratio between realistic areas and the search areas. When assessing the displacement effect, it is also necessary to take into account a species-specific displacement zone surrounding an OWF. Various studies have now shown that this effect can be substantial, with the most extreme cases documented for the red-throated diver (Garthe et al., 2023) and the common guillemot, the latter exhibiting impact distances of lowered densities due to displacement of up to 19.5 kilometres (Peschko et al., 2024; Soudijn et al. 2025).

For the analyses we have adopted 0.5 degree C-squares because of the size of the study areas and due to computational constraints. This implies grid cells from approximately 30*55 km² in the North Sea and Celtic Sea to approximately 40*55 km² in the Bay of Biscay & Iberian coast. This may be crude considering the extent of the OWF but was assumed adequate for this analysis and the quality of the information (both the OWF search areas and the bird species distributions) available. Better data would allow the application of a higher resolution.

4.4 Improving access and processing of information

The following points to advance the access and processing of information:

- Information on OWF investigative licensing, proposed development areas, preferred spatial allocation of the wind farms within the identified areas, type of windfarm, turbines and grid layout, etc., would greatly improve analyses across all regions and better prediction of potential pressures, and thus, the estimation of Impact Risk. Table 2.6 is intended to facilitate the transfer of information OWF into CIA.
- More detailed, and preferably spatial, information on the future development of other marine activities and associated pressures is required for a better estimation of Impact Risk and evaluation of future scenarios.

- Species distribution models of birds should be improved. A limited spatial coverage is available for some of the selected bird species in the Greater North Sea not covered by Waggitt et al. (2020) and Evans et al. (2021). This is likely to apply (and possibly even more so) to other species than birds.
- For many impact chains the information required for data-driven parametrisation is lacking, this includes interactions/encounter rates between ecosystem components and pressures, estimation of hazard (e.g. dose-effect relationships, P-S relationships, increased mortality from the presence of microplastics in guts) or recovery rate as used for the population dynamics. This often involves an improved understanding of how observed individual effects manifest at a population level.
- For the processing of the information and harmonisation of the work in the different pilots there is the SCAIRM cookbook which is a living document providing what is essentially the Material & Methods for the application of SCAIRM and where users can comment if instructions are unclear so that it can be continuously improved. This has also occurred as part of this project and the cookbook has benefitted from the application in the two other pilots. However, it was still felt that instructions could be made clearer and/or more consistent with better explanations of what the various equations are doing, not just where the numbers are coming from (improve understanding) make supporting materials such as examples and analytical scripts available. If not based on our own R-scripts then we need to move to open-access software where possible. Another improvement to consider would be the recording of some training materials.

The different units used in the available distribution maps may have consequences for the calculated outputs. Waggitt et al. (2020), use the chance of an encounter. When reprojected in the c-squares format the grid cells all contain a chance of encounter value >0. While the ESAS/MWTL data, where the unit is in density, do produce grid cells where the value =0. This can lead to differences in the visualisation of the maps. Also, in the different case studies, a different maximum Impact Risk was derived which has consequences when turning them into normalized distribution maps. The colour range of the maps was set relative to the maximum Impact Risk found across grid cells. The maximums are set according to Table 4.1:

Table 4.1 Maximum Impact Risk per pilot.

Pilot	Species	Impact Risk
North Sea	Great cormorant	0.031
Celtic Sea	European storm petrel	0.011
Bay of Biscay and Iberian Coast	European shag	0.00073*

*The maximum Impact Risk is lower, as this applies only to OWF without any of the other human activities.

4.5 Project objectives achieved

The project has succeeded in conducting a CIA in each of the three regional pilots, i.e. North Sea, Celtic Sea and Bay of Biscay and Iberian coast. The pilots had in common that they all included OWF and a selection of the main bird species for the respective regions with several species in common. While the method was applied consistently to the extent possible the pilots differed in the level of detail and the extent to which other human activities were included. For example, the North Sea pilot consisted of 24 activities, 20 pressures, 15 bird species resulting in 120-143 impact chains per bird species and a total of approx. 2000 impact chains for all 15 bird species combined. For Celtic Sea this was 19 activities, 14 pressures and 12 bird species while for the Bay of Biscay and Iberian peninsula this included only a single activity with 11 pressures and 16 bird species. As proof that a more data-driven CIA is feasible, available quantitative information was applied to improve the parametrization of the risk-based approach. This included spatial information, not just OWF but in the case of the North Sea also other activities, as well as quantitative information on the potential effects of certain OWF pressures, i.e. displacement and collision mortality, on birds. While the available spatial information covered only part of the activities and hence part of the Impact Risk (in the North Sea respectively 29% and 44%) there is scope for further improvement through the application of good-enough proxies which would increase this to respectively 44% and 82%. Considerably more work is required to improve the effect parametrisation and estimation. The take-home message, however, is that it is possible to apply quantitative information in SCAIRM allowing a further improvement of the method.

All three pilots show that overall, the OWF development cause an increase in Impact Risk which continues to increase as the OWF extent expands with (further) future developments. However, the two pilots that assessed future scenarios of OWF together with other human activities, i.e. North Sea and Celtic Sea, showed that this may be (partly) offset by a reduction in fisheries-induced Impact Risk as fishing effort declines. For the North Sea this even resulted in a net decrease in Impact Risk for Common scoter (-4%) and Sandwich tern (-1%), for the Celtic Sea this was for seven bird species of which Northern gannet and Common guillemot showed a net decrease in Impact Risk of more than 10%. These findings that the increased Impact Risk from OWF developments may be partly offset by declines in other activities (which are often even interlinked, e.g. specific fisheries not allowed in OWF), again confirms the importance to conduct the CIA with multi-sector scenarios as part of a fully integrated ecosystem assessment. From a conservation perspective the main outcome is that the (multi-sector) scenarios in the different pilots showed that for at least some bird species the Impact Risk is likely to increase. This is despite the decrease of effects from activities other than OWF (e.g. fisheries in the North Sea). Conclusion is therefore that the future plans of OWF are likely to further compromise sustainability and the achievement of conservation goals unless additional management interventions are implemented. The planning of such management interventions can also be informed using SCAIRM as this includes a module that links specific management interventions to the selected activities and pressures so that the effectiveness of these interventions can be assessed.

4.6 Relevance to inform management approaches.

The application of SCAIRM to guide management provides a more strategic management perspective that should precede any sectoral management targeting specific activities, including OWF, and their pressures, aimed at achieving policy objectives for birds. The first management guidance to mitigate current threats can be obtained from the results presented in this study showing for each bird species the level of cumulative Impact Risk and the relative contribution of the different stressors (A-P). SCAIRM together with a management decision-support system improved from what is in Piet et al. (2023) can guide the selection of operational ecosystem-based management, i.e. management measures, which can be expected to effectively reduce the impacts of the cumulative pressures that compromise specific objectives for birds. What SCAIRM (or any other CIA) cannot provide is how much of those operational controls are required to achieve a state of bird populations according to the policy objectives. The application of SCAIRM (or any other CIA) to guide EBM should therefore always be part of an adaptive management process where it can guide decision-making towards more effective management measures. The actual progress towards the achievement of policy objectives, however, can only be assessed through monitoring the state of bird populations relative to established thresholds or targets. SCAIRM together with its module for management interventions would be a key tool to assess how any new Programme of Measures (PoM) is likely to perform compared to the previous PoM and thus the extent to which new management can be expected to advance toward achieving policy objectives. Conclusions and way forward

SCAIRM consists of a linkage framework with many activity-pressure-ecosystem component impact chains for which a risk-based approach is applied consisting of two aspects, Exposure and Effect Potential. For this study on a single ecosystem component, i.e. birds, but consisting of many different species there is the option to use species-specific information if available. The Exposure was based on the overlap of the species-specific spatial distributions with those of the pressures. For the Effect Potential, however, species-specific parameters were only available for two of the OWF pressures (for operation-collision and operation-displacement). For the remaining pressures, the same parameters were applied for every bird species. More information and better species parameterization will allow for an even more distinctive comparison between the species.

SCAIRM is probably the most elaborate method for CIA but comes with extensive parametrization requirements to take full advantage of its possibilities. For the estimation of the Exposure aspect of risk, it is similar to the method by (Halpern et al., 2008) but has improved the estimation of the Effect aspect of risk which is based on a single parameter, i.e. sensitivity, which suffers from a lack of a sound theoretical basis (Kallio et al., 2025). The ODEMM method attempted to (partly) resolve this by introducing several parameters to estimate the Effect aspect of risk but still without a theoretical basis. SCAIRM attempted to resolve this by embedding the ODEMM parameters with proper definitions in a mechanistic approach involving population dynamics. This had the added benefit that the estimated Impact Risk is an interpretable metric reflecting the potential abundance compared to an undisturbed situation. However, despite the definitions and guidance provided, the

other pilots still found it quite challenging to score those parameters in practice, specifically Hazard and Magnitude. The translation, or integration from similar approaches such as ODEMM turned out to be not as straight-forward as anticipated due to different understanding/interpretations of the parameters.

The elaborate parametrization of SCAIRM can better capture and illustrate mechanistic understanding and nuances of the various linkage chains through the inclusion of information on e.g. dispersal, behaviour. However, without the required data expert judgment is the fall-back option which comes with higher associated uncertainty. A piecemeal process has started to move from expert judgment to data-based parametrisation. To assist the application of such quantitative information across OSPAR regions a distinction is made between parameters deemed specific to the regional context (e.g. magnitude or frequency) and those deemed generic (e.g. hazard or behaviour).

The current use of proprietary software (FME) for notably the spatial analyses limits accessibility and transparency and hampers the application in other regions. WMR carried out the spatial analyses for the Celtic Sea and Bay of Biscay and Iberian Peninsula pilots because of these challenges, resulting in being unable to assess the transferability of the approach. This was supposed to be resolved by making R-code available to all partners. The supporting code for performing all the analysis, however, only became available when all analysis were completed shortly before the end of the project. This prevented those outside the development team to be able to apply the approaches within their pilots. Generating and checking the code for analyses and output should become a coordinated effort by dedicated parties from across the OSPAR area and beyond.

As with all approaches, the use and usefulness of the SCAIRM tool, or other CIA methods, depends on the needs of the study. In some cases, it may be more desirable to use more simple approaches if broad scale risk assessment or impact scoping is the goal. However, the power of SCAIRM is in the ability to facilitate additional quantitative knowledge and spatial information when available, and as such, the assessment can evolve in tandem with the knowledge. SCAIRM is perhaps most useful in context such as these pilots, where various research questions apply, and specific ecosystem components are identified. Moreover, its extension with the management module would allow further application to guide mitigation measures.

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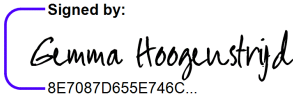
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Justification

Report: C076/25
Project Number: 4315100224

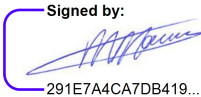
The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: G. Hoogenstrijd, MSc
Researcher

Signature:  Signed by:
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Date: December 17, 2025

Approved: A.M. Mouissie, PhD
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Signature:  Signed by:
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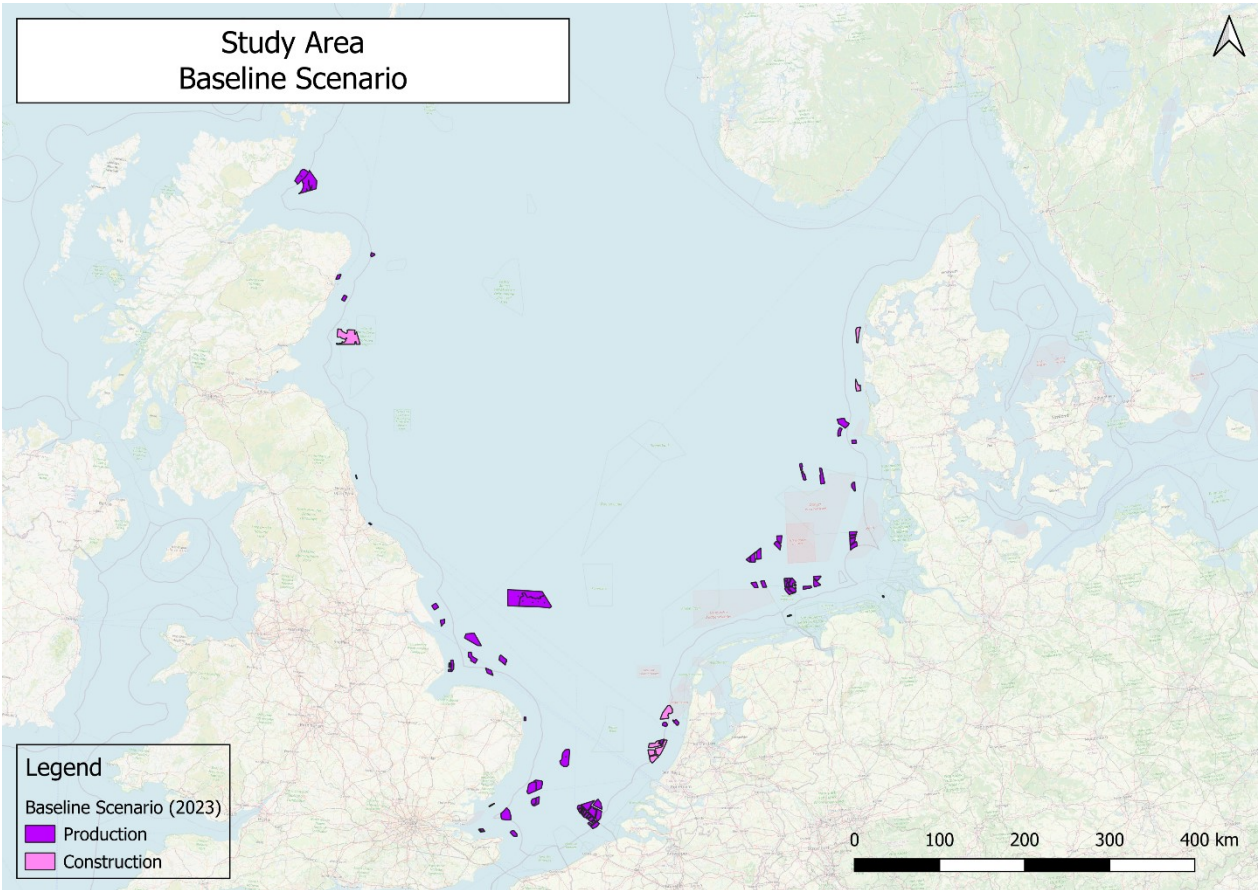
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Annex 1: List of acronyms

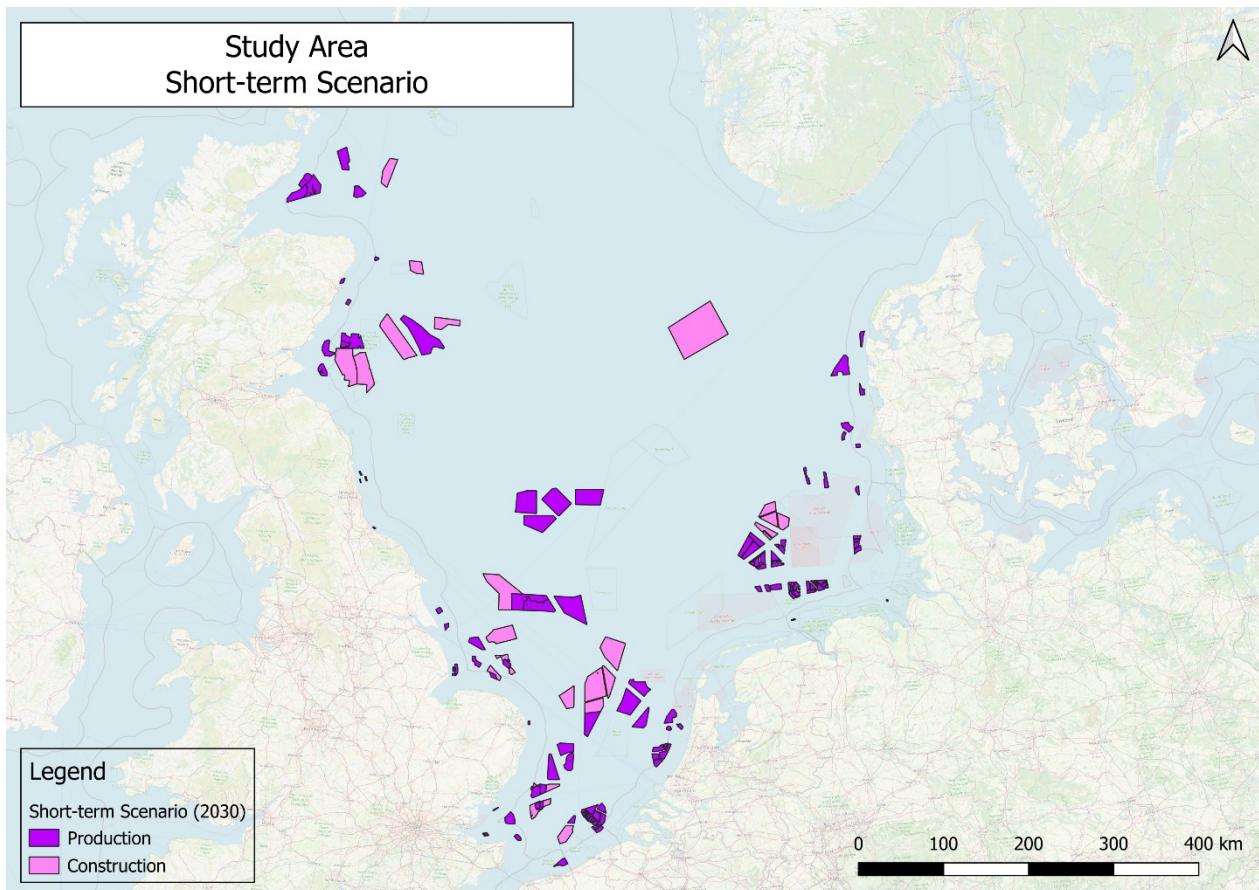
Acronym	Full name
BHD	Birds and Habitats Directive
CIA	Cumulative Impact Assessment
DMAP	Designated Maritime Area Plan
EBM	Ecosystem based management
EB-MSP	Ecosystem-based marine spatial planning
EMODnet	European Marine Observation and Data Network
GES4SEAS	Achieving Good Environmental Status for maintaining ecosystem services, by assessing integrated impacts of cumulative pressures. (Project, funded by the European Union under the Horizon Europe program (grant agreement no. 101059877))
ICES	International Council for the Exploration of the Sea
MSFD	Marine Strategy Framework Directive
NMPF	National Marine Planning Framework
ODEMM	Option for Delivering Ecosystem-based Marine Management (Project, more information: https://www.liverpool.ac.uk/odemmm/)
OWF	Offshore wind farms
RWS	Rijkswaterstaat, the Dutch Ministry of Infrastructure and Water Management
SPAs	Special Protection Areas
VMS	Vessel Monitoring System
WGCEAM	Working Group on the Cumulative Effects Assessments for Management

Annex 2: OWF scenarios North Sea

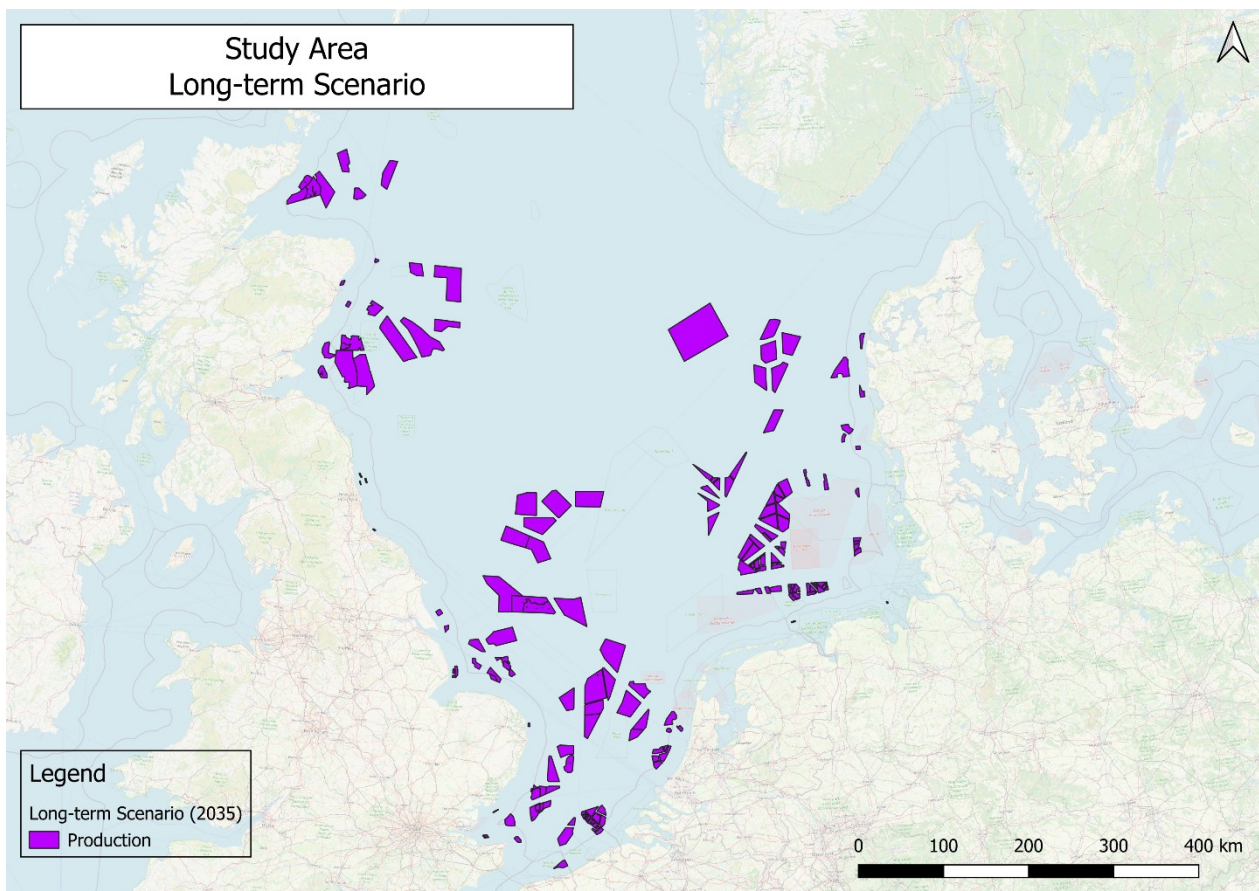
Below are given high resolution maps of the different OWF scenarios. Note that the Utilization factor has not yet been taken into account in these maps.



Study Area – Baseline Scenario (2023).



Study Area – Short-term Scenario (2030).



Study Area – Long-term Scenario (2035).

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