Pilot assessment of cumulative impacts of offshore renewables on birds

Inception Report

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Wageningen Marine Research rapport C026/24

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Summary

The aim of this contract is to provide technical assistance to OSPAR in further developing an approach and tool(s) for cumulative impact assessment, including carrying out different pilot assessment 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 activities on birds and can be expanded to include other ecosystem components as well. In this study the CIA is applied in three pilots covering the North Sea, Celtic Sea and Bay of Biscay that are intended as proof of concept. The pilots differ in terms of information available and hence their level of development and operational readiness. The North Sea pilot is 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 covering more activities than offshore wind, will be evaluated. The Celtic Sea local pilot is also intended to be comprehensive in their 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 and hence scenarios can be evaluated. The Celtic Sea and Bay of Biscay pilot covers a wider area determined by geographical boundaries according to the MSFD as well as OSPAR limits but is limited in that it only includes offshore wind and all its pressures. All pilots cover a wide range of bird species, most of which are common in all three pilots. State-of-the-art information will be applied in the CIA depending on availability and scenarios of at least offshore wind developments will be evaluated to the extent possible. Based on the findings in these pilots a way forward will be proposed in further improving the method in view of the aims of ICG-ORED and ICG-EcoC and how this can be applied to provide options for actions by OSPAR to minimize the impacts.

1 Introduction

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.

1.1 Knowledge question and research objective

The aim of this contract 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 implementation of offshore wind and the types of other activities and their pressures to assure that these are sufficiently representative of the whole OSPAR area.

This call 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
- The aim is 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 includes 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.

2 Cumulative Impact Assessment method

The development of 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/odemm/) 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., 2015, 2017, 2019. 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. The CIA method has been further developed and applied (including Piet et al., 20121a, 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 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., 2021). 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). Following Weißhuhn et al. (2018) stating that sensitivity is the susceptibility to hazard, resistance was estimated 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 introduces Impact Risk (IR) as the key concept that allows cumulation across pressures. There is a wealth of categorical risk-based approaches that have estimated IR in various guises (Knights et al., 2015; Piet et al., 2015; 2017; 2019; Borgwardt et al., 2019, Galparsoro et al., 2021, Galparsoro et al., 2022). Piet et al. 2021) recently provided a roadmap towards a fully quantitative calculation of IR, defined as the change in 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 IR 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).

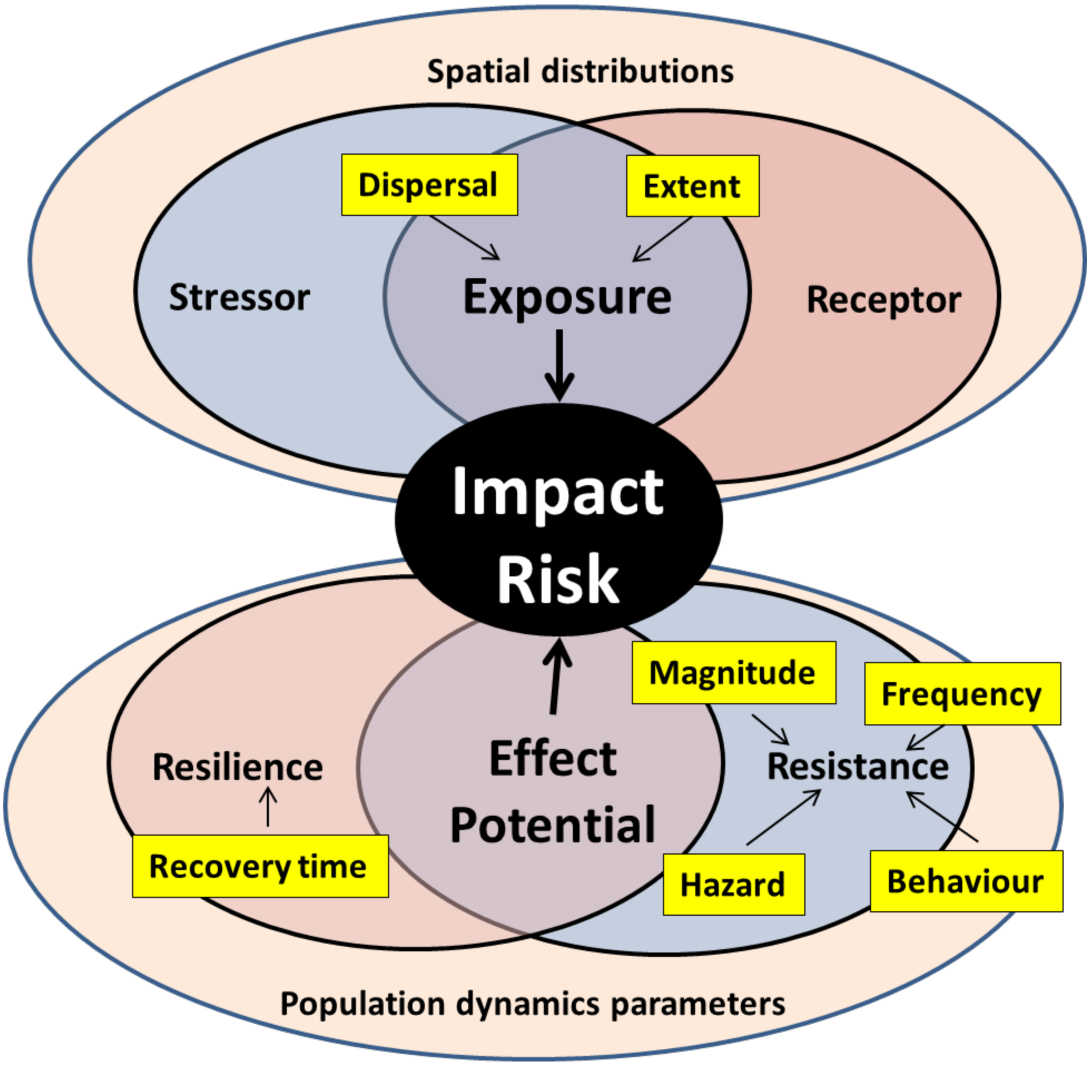

Figure 2.1. Calculation of Impact Risk as the key concept that allows cumulation across pressures from Exposure and Effect Potential. These, in turn, can be estimated from respectively the spatial distributions of the stressor (i.e. activity-pressure combinations) and receptor (i.e. ecosystem components) 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 judgement.

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., 2021) 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.

2.1.1 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 the 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).

2.1.2 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 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; Piet et al., 2015; 2017; 2019; Borgwardt et al., 2019), but altered them where needed so as to obtain an IR that is conceptually identical to the IR 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, 2018), 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 spatial distribution of both the pressure and the ecosystem component. In that case Piet et al. (2021) applies who distinguishes increasingly more accurate Exposure metrics depending on data availability, i.e. spatiotemporal information on pressure magnitude and ecosystem component density.

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 determine, in 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 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 populations' resistance is reflected in the depletion rate and the resilience in the population growth rate. For further detail and equations see the supplementary material in Piet et al. (2023).

2.2 Rules and limitations

The following rules and limitations apply to SCAIRM.

- 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 to the relevant policy frameworks, i.e. MSFD, BHD.
- It only considers impacts on the biota, not the abiotic/physical environment. Also, when impact 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.
- Climate is considered an extraneous driver and as such not part of the 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 that were 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.
- Because knowledge on the interaction mechanisms of multiple stressors (additivity, synergy, antagonism) is lacking, first assumption is that they will act in an additive fashion (following e.g. Halpern & Fujita, 2013; Judd et al., 2015).
- Impact Risk is the main output of the model and reflects the potential risk from the cumulative anthropogenic pressures. It can be used to provide an integrated perspective on the (change in) vulnerability of the ecosystem as a whole (in a specific study area like the Greater North Sea) as well as each of the different ecosystem components.
- While Impact Risk is an estimate of the expected change in state of the various ecosystem components it does not represent an actual abundance. It is intended to be used to assess some (future) alternative situations relative to a baseline/reference situation. Application of the precautionary principle and the fact that Good Environmental Status is not achieved implies 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 provides ranking orders of main contributors to the overall threat caused by human activities.
- It cannot be used to predict the actual values for specific indicators (e.g. MSFD).
- Unless spatial information is available the distribution of ecological component groups is assumed to be homogenous over the study area of the pilots. Therefore, the output of the CIA has currently only limited value in providing spatially-explicit advice, but the development of a spatially-explicit and quantitative CIA method has started by Piet et al. (2021a) allowing to some activity-ecological component combinations to be included already. In this quick scan that will be done at least for a selection of offshore wind-bird species combinations.

3 Definition of the Bird pilots

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 3-1). The different pilots are intended to cover regional differences in terms of bird species, the availability of information, the advancement of implementation of offshore wind and the types of other activities and their pressures to assure 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 in the scenarios they can evaluate.

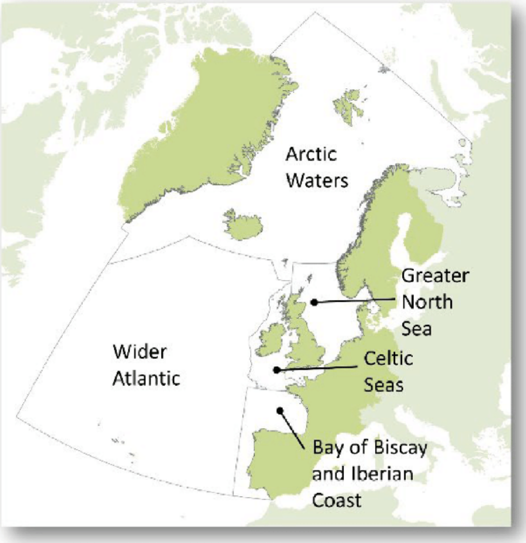

Figure 3-1 OSPAR areas

3.1 North Sea

3.1.1 Geographical delimitation

The North Sea pilot area is according to the Greater North Sea as in the MSFD.

3.1.2 Bird species included

Based on a "long list" of bird species from the OSPAR ORED and send to us by RWS, we propose to select 16 bird species for the assessment for the North Sea. The bird species are shown in the table below, together with an indication of the availability of density maps.

Table 1 List of bird species for the assessment of the North Sea

Bird species	Bird species	Selected for North Sea	Availability of density map for CS North Sea	Availability of density maps for NE Atlantic
English name	Scientific name		**Source: ESAS+MWTL data**	**Source: Waggitt et al. (2019)**
Red-throated diver	Gavia stellata	x	x	
Black-legged kittiwake	Rissa tridactyla	x	x	x
Northern gannet	Morus bassanus	x	x	x
Atlantic puffin	Fratercula arctica	x	x	x
Razorbill	Alca torda	x	x	x
Great black-backed gull	Larus marinus	x	x	
European storm petrel	Hydrobates pelagicus			x
Leach's storm petrel	Oceanodroma leucorhoa			
Manx shearwater	Puffinus puffinus			x
Balearic shearwater	Puffinus mauretanicus			
Sooty shearwater	Puffinus griseus			
Great shearwater	Puffinus gravis			
Northern fulmar	Fulmarus glacialis	x	x	x
Common scoter	Melanitta nigra	x	x	
Herring gull	Larus argentatus	x	x	x
Little gull	Hydrocoloeus minutus	x	x	
Lesser black-backed gull	Larus fuscus	x	x	x
Common guillemot	Uria aalge	x	x	x
Cory's shearwater	Calonectris diomedia			
European shag	Phalacrocorax aristotelis		x	x
Sandwich tern	Thalasseus sandvicensis	x	x	
Roseate tern	Sterna dougallii			
Yellow-legged gull	Larus michahellis			
Great cormorant	Phalacrocorax carbo	x	x	
Great skua	Stercorarius skua	x	x	x
Black-throated diver	Gavia arctica	x	x	

3.1.3 Scenarios

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 exposures is estimated based on expert-judgement.
- Top 9 activities where Exposure is calculated from spatial GIS-based information (mostly obtained from EMODnet) and scenarios involving spatial information can be evaluated:
    - Fishing: Benthic trawling
    - Fishing: Nets (explanation, is this static gear?
    - Fishing: Pelagic trawls
    - Aquaculture
    - Mining: extraction of materials
    - Oil and Gas
    - Shipping
    - Telecoms and Electricity
    - Wind farms

3.1.4 Information sources

Main (top 9) human activities (and their different phases) will be 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 the scenarios were previously derived by Piet et al. (2021b). For wind farms, baseline and future scenarios have been updated by WMR in April 2023 using data provided by RWS (see Annex 1 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.

3.2 Celtic Sea local pilot assessment

3.2.1 Geographical delimitation

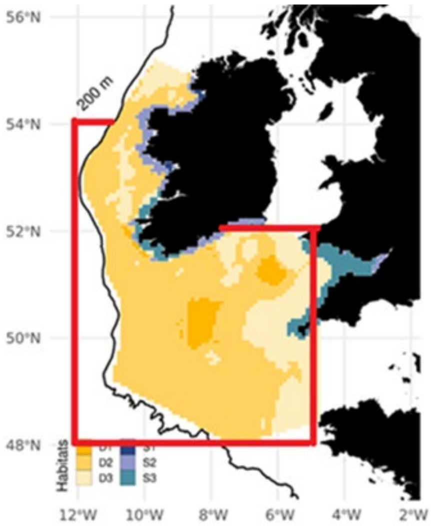

Figure 3.2.1. Celtic Sea pilot area, outlined in red.

In the GES4SEAS project, the Celtic Sea Learning Site area takes in the Celtic Sea (south of Ireland) and the west of Ireland Atlantic shelf (Figure 3.2.1). 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 date 17 sectors, 20 pressures and 26 ecological components and their interactions have been identified and assessed for risk (see Section 3.2.3). Additionally, recurrent stakeholder engagement has been carried out, including identifying issues and questions relevant to the stakeholders. The questions have centered 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 ORE 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 match the Celtic Sea/Bay of Biscay region, but will focus specifically on the South Coast Designated Maritime Area Plan (DMAP) Proposal, published in July 2023 (Figure 3.2.2). The DMAP puts forward an initial 'proposed' geographical area within which future offshore renewable energy development may take place. The current site investigation licence locations can inform the choice of scenarios/scale of impacts moving forward.

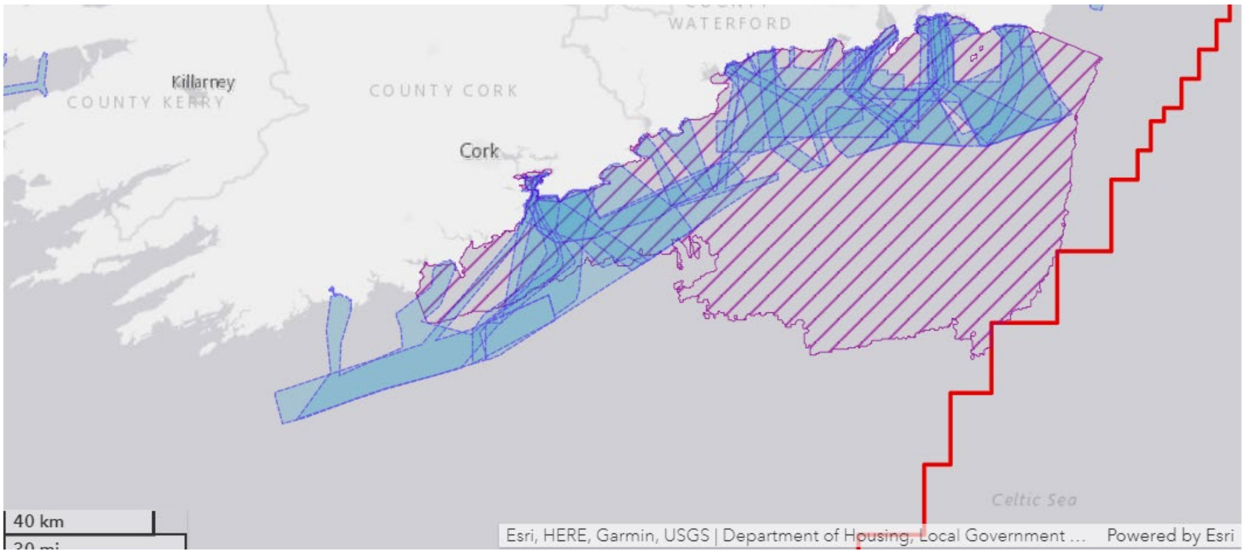

Figure 3.2.2. The South Coast Designated Maritime Area Plan (DMAP) area (purple hatching) and the current ORE Foreshore Site Investigation licence locations related to potential offshore renewable energy related infrastructure, and current offshore renewable energy project locations (Blue polygons).

Carrying analyses out at this scale allows us to compare between region wide effects (the Celtic Sea/Bay of Biscay pilot assessment) and impacts at the actual scale site of activity. Combined these pilot assessments illustrate the adaptability of the approach, and its potential use and application at different scales depending on the require question/purpose. Additionally, this allows us to compare the data challenges of working at varying scales.

3.2.2 Bird species included

We propose selection of 12 bird species for the Celtic Sea. These species all have distribution data available from Waggitt et al. (2019) and additional data from seabird observers and the North East Atlantic predictive seabird atlas as indicated on the below table.

Table 2 List of bird species for the assessment of the Celtic Sea, X in the third column indicates that it's proposed for the Celtic Sea pilot assessment

Bird species	**Scientific name**	**Proposed for Celtic Sea**	**Source: seabird Observer Survey Data**	**Source: NEA Predictive Seabird Atlas**	**Source: Waggitt et al. (2019)**
Red-throated diver	Gavia stellata		no sightings		
Black-legged kittiwake	Rissa tridactyla	x	x	x	x
Northern gannet	Morus bassanus	x	x	x	x
Atlantic puffin	Fratercula arctica	x	x	x	x
Razorbill	Alca torda	x	x	x	x
Great black-backed gull	Larus marinus		x - south coast and north west	x	
European storm petrel	Hydrobates pelagicus	x	x	west coast only	x
Leach's storm petrel	Oceanodroma leucorhoa				
Manx shearwater	Puffinus puffinus	x	x	x	x
Balearic shearwater	Puffinus mauretanicus		no sightings		
Sooty shearwater	Puffinus griseus				
Great shearwater	Puffinus gravis				
Northern fulmar	Fulmarus glacialis	x	x		x

Common scoter	Melanitta nigra		no sightings		
Herring gull	Larus argentatus	x	south coast	x	x
Little gull	Hydrocoloeus minutus		very rare sightings		
Lesser black-backed gull	Larus fuscus	x	x	x	x
Common guillemot	Uria aalge	x	x	x	x
Cory's shearwater	Calonectris diomedia				
European shag	Phalacrocorax aristotelis	x	very rare sightings	limited (coastal)	x
Sandwich tern	Thalasseus sandvicensis		very rare sightings	limited, sites	
Roseate tern	Sterna dougallii				
Yellow-legged gull	Larus michahellis				
Great cormorant	Phalacrocorax carbo			limited (coastal)	
Eurasian curlew	Numenius arquata		no sightings		
Common starling	Sturnus vulgaris				
Great skua	Stercorarius skua	x	x		x
Black-throated diver	Gavia arctica				

3.2.3 Scenarios

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. To date 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 and Tourism and Recreation accounting for 92% of the observed risk to the system (Figure 3.2.3). When focusing on seabirds, 11 pressures arising from 16 sectors were found to be relevant, with particular risks from litter and contaminants.

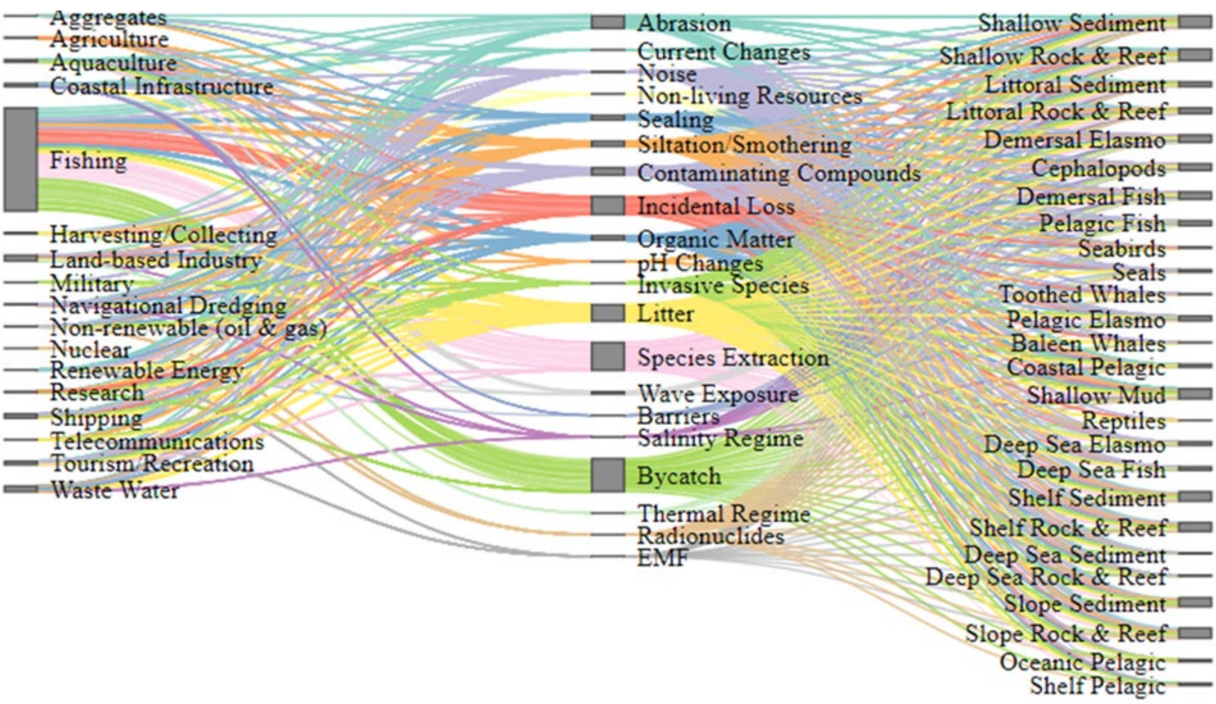

Figure 3.2.3**.** Sankey diagram of pathways between sectors (left), the pressures these exert (middle) and the ecosystem components these impact (right). The width of lines (colour coded according to sectors) represents the impact risk score (product of overlap, frequency and degree of impact). This thickness of the grey bars indicates the summed impact risk score for that component.

This work will build on the current assessment which is based on an adapted ODEMM assessment (Pedreschi et al. 2023). The overall assessment will inform the relevant sectors and pressures (e.g. top five) affecting seabirds in the region to be included in the species level SCARIM analyses. The scenarios and species will be aligned with the wider Celtic Sea/Bay of Biscay pilot assessment to ensure comparability between studies. The assessment will be informed by data (e.g. spatial maps) where such information is available, and by literature and/or expert opinion where it is not.

There are no currently operational ORE sites within the Celtic Sea. The pilot assessment will expand the analyses to include realistic potential scenarios of ORE expansion within the region, and their potential impacts (see Section 3.2.1).

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 (and will be refined with feedback from OSPAR);

A. Scenarios of varying spatial extent developed based current regional spatial plans, e.g. short-term vs. longer term views at 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.

3.2.4 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 the AZTI expertise. 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).

3.3 Celtic Sea and Bay of Biscay pilot assessment

3.3.1 Geographical delimitation

The Bay of Biscay area is delimited by the geographical boundaries defined by the MSFD, includes Celtic Seas subregion and extends further offshore the OSPAR limits (Figure 3.3.1). It is not planned to expand the analysis region to the whole Western Iberian Peninsula (e.g. Portugal).

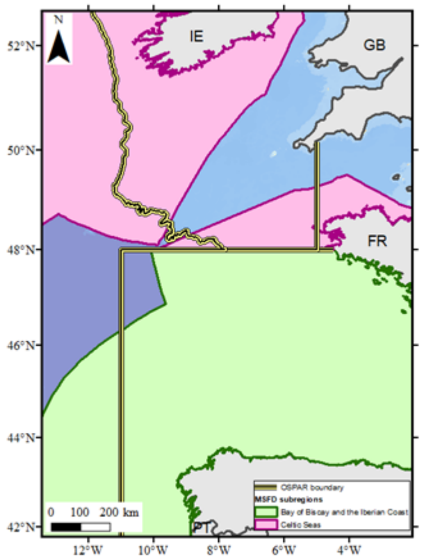

Figure 3.3.1. Celtic Sea pilot assessmentarea Pink and green polygons are referring to MSFD boundaries, while the yellow line delimitates OSPAR boundary. Both boundaries will be combined for the assessment region.

3.3.2 Bird species included

Based on the OSPAR ORED list of bird species, we propose selecting 15 bird species for the assessment of the Celtic Sea and Bay of Biscay pilot assessment. The bird species are presented in the table below, along with an indication of the availability of density maps.

Table 3 Bird species selected for the assessment of the Celtic Sea and Bay of Biscay pilot assessment. 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. Data availability: (*) Available in Waggitt et al. (2019); (**) Available in Evans et al. (2021).

English name	**Scientific name**	**Selected for Bay of Biscay-Celtic Sea**	**NE Atlantic (*)**	**NE Atlantic (**)**	**Bay of Biscay (**)**	**Celtic Sea (**)**
Red-throated diver	*Gavia stellata*	x				x
Black-legged kittiwake	*Rissa tridactyla*	x	x	x	x	x
Northern gannet	*Morus bassanus*	x	x	x	x	x
Atlantic puffin	*Fratercula arctica*	x	x	x	x	x
Razorbill	*Alca torda*	x	x	x	x	x
Great black-backed gull	*Larus marinus*					
European storm petrel	*Hydrobates pelagicus*	x	x			
Leach's storm petrel	*Oceanodroma leucorhoa*					
Manx shearwater	*Puffinus puffinus*	x	x	x	x	x
Balearic shearwater	*Puffinus mauretanicus*	x			x	
Sooty shearwater	*Puffinus griseus*					
Great shearwater	*Puffinus gravis*					
Northern fulmar	*Fulmarus glacialis*	x	x	x	x	x
Common scoter	*Melanitta nigra*					
Herring gull	*Larus argentatus*	x	x	x	x	x
Little gull	*Hydrocoloeus minutus*					
Lesser black-backed gull	*Larus fuscus*	x	x	x	x	x
Common guillemot	*Uria aalge*	x	x	x	x	x
Cory's shearwater	*Calonectris diomedia*	x			x	
European shag	*Phalacrocorax aristotelis*	x	x	x	x	x
Sandwich tern	*Thalasseus sandvicensis*					
Roseate tern	*Sterna dougallii*					
Yellow-legged gull	*Larus michahellis*					
Great cormorant	*Phalacrocorax carbo*					
Eurasian curlew	*Numenius arquata*					
Common starling	*Sturnus vulgaris*					
Great skua	*Stercorarius skua*	x	x			
Black-throated diver	*Gavia arctica*					

The overall assessment will be focused on the cumulative pressures produced by wind turbines affecting seabirds in the region. The assessment will be performed at the species level and based on the SCAIRM approach. The assessment will firstly rely on available data (e.g. spatial maps) where such information is available, literature and/or expert opinion will be used.

3.3.3 Scenarios

The pilot assessment will analyse the realistic potential scenarios of ORE expansion within the region, based on national spatial plans and the areas identified by national authorities to expand ORE facilities. Potential impacts of such new areas will be analysed.

The scenarios and species will be aligned with the Celtic Sea local pilot assessment to ensure comparability between studies.

3.3.4 Information sources

The information sources to be used for the analysis will be based on publicly available data sources and geographic information data servers. In case such data would not be available, French and Spanish national contact points will be approached. Predicted seabirds' spatial and temporal distribution will be obtained from the density distribution maps produced by Waggitt et al. (2020) and Evans et al. (2021). ORE existing and planned facilities will be obtained for Spain from https://infomar.miteco.es/ and for France from https://cerema.maps.arcgis.com/apps/MapJournal/index.html?appid=b25ad4b280304f5891af975141716a3f#. Other data sources needed to perform the analysis will be downloaded from EMODnet.

4 Outline of the final report

Below is the proposed outline of the final report of which the chapters 1 and 2 mainly consist of the contents of this inception report but with additions from the further work in these pilot assessments.

Executive Summary

1 Introduction and background
   - Objectives
   - Description of the pilots
2 Approach consisting of
   - Description of CIA method
   - Selected bird species
   - Applied scenarios
3 Results
   - Effects and impacts on populations
   - Maps and illustrations depicting the assessment results;
4 Discussion and conclusions
   - Suitability and limitations of the CIA method
   - Description of assumptions and uncertainties, how these were dealt with and how they affect result validity
   - Description of knowledge and data gaps;
5 Way forward
   - Improving the method in view of the aims of ICG-ORED and ICG-EcoC.
   - Options for actions by OSPAR to minimize the impacts through impact mitigation measures.

5 Work plan

A detailed work plan and timetable for implementation of the project with relevant milestones.

Milestones in project	Delivery schedule	Meetings and presentation
Step 1 - Inception	Inception report six weeks from kick-off meeting – 7th of May 2024	
Step 2 – CIA development		
Outline CIA: Linkage framework	Draft by 26th July 2024	Online meeting to discuss draft: 1 before summer 1 end of August 2024
Final CIA Risk-based approach	Final by 1st May 2025	
Step 3 – Bird pilots		
• Outline pilots • Delimitation and characterisation of the two study areas. • List of bird species. • Scenarios.	Draft by 7th October 2024	Steering group meeting + presentation of draft 15-16 October 2024 Live - at office in Gothenburg / Hybrid
Final cumulative impact assessment results	Final by 1st May 2025	EIHA 2025 (end of March, beginning of April) ORED meeting Presentation of draft Live – location t.b.d.
Step 4 – Reporting	Draft by 21th February 2025 Feedback ICG-ORED by 12th March 2025 Final draft report by 1st May 2025	
Monthly meetings		Monthly meeting for check up
Final presentation	End of May, beginning of June 2025	

6 References

Borgwardt F, Leonie Robinson, Daniel Trauner, Heliana Teixeira, Antonio J Nogueira, Ana Lillebø, Gerjan Piet, Mathias Kuemmerlen, Tim O'Higgins, Hugh McDonald, Juan Arevalo-Torres, Ana Luisa Barbosa, Alejandro Iglesias-Campos, Thomas Hein, Fiona Culhane Exploring variability in environmental impact risk from human activities across aquatic realms. Science of the Total Environment, VSI: EBM in aquatic ecosystems 2018.

Evans, P.G.H., Carrington, C.A., and Waggitt, J.J. (2021) Risk Mapping of Bycatch of Protected Species in Fishing Activities. Sea Watch Foundation & Bangor University, UK. European Commission Contract No. 09029901/2021/844548/ENV.D.3. 212 pages.

Galparsoro, I., I. Menchaca, J. M. Garmendia, Á. Borja, A. D. Maldonado, G. Iglesias, J. Bald, 2022. Reviewing the ecological impacts of offshore wind farms. npj Ocean Sustainability, 1: 1 https://doi.org/10.1038/s44183 022-00003-5

Galparsoro, I., M. Korta, I. Subirana, Á. Borja, I. Menchaca, O. Solaun, I. Muxika, G. Iglesias, J. Bald, 2021. A new framework and tool for ecological risk assessment of wave energy converters projects. Renewable and Sustainable Energy Reviews, 151: 111539 https://doi.org/10.1016/j.rser.2021.111539

Halpern BS, Walbridge S, Selkoe KA, Kappel CV, Micheli F, D'Agrosa C, et al. A global map of human impact on marine ecosystems. Science 2008; 319: 948-952.

IUCN. IUCN Red List Categories and Criteria: Version 3.1. Second edition. In: Gland SaC, UK: IUCN. iv + 32pp., editor, 2012.

Jongbloed, R.H., J.E. Tamis, J.T. van der Wal, P. de Vries, A. Grundlehner, G.J. Piet (2023): Quick scan of cumulative impacts on the North Sea biodiversity. With a focus on selected species in relation to future developments in offshore wind energy. Wageningen Marine Research report C074/23 https://doi.org/10.18174/642357

Lonsdale JA, Nicholson R, Judd A, Clarke C, Elliott M. A novel approach for cumulative impacts assessment for marine spatial planning. Environmental Science and Policy 2020; 106: 125-135.

Piet GJ, Tamis JE, Volwater J, de Vries P, van der Wal JT, Jongbloed RH. A roadmap towards quantitative cumulative impact assessments: Every step of the way. The Science of the total environment 2021; 784: 146847.

Pitcher CR, Ellis N, Jennings S, Hiddink JG, Mazor T, Kaiser MJ, et al. Estimating the sustainability of towed fishing-gear impacts on seabed habitats: a simple quantitative risk assessment method applicable to data-limited fisheries. Methods in Ecology and Evolution 2017; 8: 472-480.

Piet G.J., Tamis J.E., van der Wal J.T., Jongbloed R.H. (2021): Cumulative impacts of wind farms on the North Sea ecosystem. Wageningen Marine Research report C081/21. https://doi.org/10.18174/556024Piet, G., Grundlehner, A., Jongbloed, R., Tamis, J. & de Vries, P. (2023): SCAIRM: A spatial cumulative assessment of impact risk for management. Ecological Indicators 157 (2023) 111157. https://doi.org/10.1016/j.ecolind.2023.111157

Stelzenmuller V, Coll M, Mazaris AD, Giakoumi S, Katsanevakis S, Portman ME, et al. A risk-based approach to cumulative effect assessments for marine management. Science of the Total Environment 2018; 612: 1132-1140.

Tillin HM, Hull SC, Tyler-Walters H. Development of a sensitivity matrix (pressures-MCZ/MPA features). In: Report to the Department of Environment FaRAfA, Southampton and the Marine Life Information Network (MarLIN) Plymouth: Marine Biological Association of the UK. , editor. Defra Contract No. MB0102 Task 3A, Report No. 22., 2010.

Justification

Report C026/24
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: Ruud Jongbloed
Researcher

Signature: DocuSigned by:
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Date: 7th of May 2024

Approved: Cas Wiebinga
Business Manager Projects

Signature: DocuSigned by:
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Date: 7th of May 2024

Annex 1 Typologies

Table 4 Human Activities (in bold) and their operations with crosses (X) indicating their occurrence in each pilot assessment

Activities and operations	NS	CS	CS/BoB
Agriculture	X		
Cultivation of crops and maintenance of pasture	X		
Atmospheric emissions, runoff of nutrients due to livestock	X		
Angling and sport fishing	X		
Catch, release and stocking	X		
Artificial reefs	X		
Construction (habitat change, emissions from boats)	X		
Operations (causing localised changes in hydrography)	X		
Beach replenishment	X		
Habitat change, smothering, contaminants	X		
Yachting/Watersports (without engine)	X		
Operations	X		
Boating/Watersports (with engine)	X		
Boating - General (anti-fouling, ballast water exchange, litter, waste)	X		
Boating - Mooring/anchoring/beaching/launching (interaction with seafloor)	X		
Boating - Steaming (collisions)	X		
Diving - general (anti-fouling, litter, waste)	X		
Diving - mooring/anchoring/beaching/launching (interaction with seafloor)	X		
Diving - operations (trampling, spp extraction)	X		
Diving - steaming (collisions)	X		
Water sports - mooring/anchoring/beaching/launching	X		
Water sports - steaming (collisions, atmospheric emissions)	X		
Collecting (bird eggs, individuals, curios, bait)	X		
Bait digging - (trampling, interaction with seafloor)	X		
Bird eggs - (trampling, removal of individuals)	X		
Curios and keeping aquariums - (trampling, removal or release of individuals)	X		
Peels (boulder turning) - (trampling, removal of individuals)	X		
Shellfish hand collecting - (trampling, removal of individuals)	X		
Commercial Cruise (large)	X		
Cruise ships	X		
Culverting lagoons	X		
Construction (habitat change, smothering)	X		
Operations (causing localised changes in hydrography)	X		
Dredging (including capital and maintenance)	X		
Capital dredging - extraction of substrate	X		
Capital dredging - spoil/waste disposal	X		
Maintenance dredging - extraction of substrate	X		
Maintenance dredging - spoil/waste disposal	X		
Ex-situ aquaculture	X		
Water abstraction, waste discharge	X		
Fishing: Benthic trawling and suction/hydraulic dredges	X		
Benthic trawls and dredges - general (e.g. anti-fouling, litter, lost gear)	X		
Benthic trawls and dredges - mooring/anchoring	X		
Benthic trawls and dredges - operations	X		
Benthic trawls and dredges - steaming	X		
Suction/hydraulic dredges - general	X		
Suction/hydraulic dredges - mooring/anchoring	X		
Suction/hydraulic dredges - operations	X		
Suction/hydraulic dredges - steaming	X		
Fishing: Nets, potting/creeling	X		
Nets - general (litter, lost gear, antifoulants)	X		
Nets - operational (catch, bycatch, waste products)	X		
Nets - set up/recovery (interaction with seafloor, atmospheric emissions)	X		
Potting/creeling - general (litter, lost gear)	X		
Potting/creeling - operational (catch, bycatch, waste products)	X		
Potting/creeling - set up/recovery (interaction with seafloor)	X		
Fishing: Pelagic trawls and long-line pelagic	X		
Pelagic trawls - general (anti-fouling, ballast water, litter, lost gear)	X		
Pelagic trawls - mooring/anchoring (interaction with seafloor)	X		
Pelagic trawls - operations (catch, bycatch, waste products)	X		
Pelagic trawls - steaming (atmospheric emissions, collisions)	X		
Flood and coastal defence - Artificial Structures	X		

Construction sea walls/breakwaters/groynes	X
Operations (causing localised changes in hydrography)	X
Forestry	X
Cultivation of forestry (e.g. irrigation, drainage)	X
Hunting, including wildfowling and spearfishing	X
Wildfowling (shooting, lead shot, boating)	X
In-situ aquaculture	X
Fin-fish - operational[1]	X
Fin-fish - set-up[2]	X
Macro-algae – operational[1]	X
Macro-algae - set-up[2]	X
Shellfish - operational[1]	X
Shellfish - setup[2]	X
Land claim and conversion (including construction and operation)	X
Construction (e.g. habitat change, smothering, increased turbidity)	X
Operations (causing localised changes in hydrography)	X
Manufacturing: Industry with discharges - operational	X
Industry with discharges into coastal waters	X
Marinas and dock/port facilities	X
Construction (e.g. habitat change, sealing)	X
Operations (e.g. litter, light, noise, waste disposal)	X
Military	X
Marine dumped munitions	X
General (e.g. anti-fouling, ballast water exchange, litter)	X
Mooring/anchoring/beaching/launching	X
Operations (e.g. seismic activities, sonar)	X
Steaming (atmospheric emissions, collisions)	X
Mining, extraction of materials	X
Inorganic mine and particulate waste - extraction of substrate	X
Inorganic mine and particulate waste - spoil/waste disposal	X
Maerl - extraction of substrate	X
Maerl - spoil/waste disposal	X
Rock/Minerals - coastal quarrying - extraction of substrate	X
Rock/Minerals - coastal quarrying - spoil/waste disposal	X
Sand/gravel aggregates - extraction of substrate	X
Sand/gravel aggregates - spoil/waste disposal	X
Non-renewable power stations (land-based, coastal)	X
Construction (jetties and intake wells)	X
Operations	X
Oil and Gas	X
Construction (e.g. drilling, laying pipelines, oil spills)	X
Decommissioning (e.g. oil spills, removal of infrastructure)	X
Exploration (e.g. seismic surveys, exploratory drilling)	X
Operations (e.g. waste fluids and particulates, oil spills)	X
Research	X
General (e.g. anti-fouling, litter, oils leaching)	X
Mooring/anchoring/beaching/launching	X
Operations	X
Steaming	X
Shipping	X
General (e.g. anti-fouling, ballast water exchange, litter)	X
Mooring/anchoring/beaching/launching	X
Steaming	X
Shore recreational activities	X
Public beach - general (trampling, litter)	X
Seawater swimming pool	X
Telecoms and Electricity	X
Operational communications (electromagnetic)	X
Laying electric cables	X
Tidal sluices and barrages	X
Tidal barrages - construction (e.g. localised sealing of habitat)	X
Tidal barrages - operational (e.g. barrier to movement)	X
Tidal sluices - construction (e.g. localised sealing of habitat)	X
Tidal sluices - operational (e.g. localised changes in hydrography)	X
Tourist resort	X
Construction (e.g. habitat change, sealing, smothering)	X
Operations (e.g. effluent discharge, abstraction of water, litter)	X
Transport (land-based)	X
Run off from roads, emissions, etc.	X
Urban dwellings and commercial developments	X
Construction (e.g. habitat change, sealing)	X

[1] waste products, anti-fouling, predator control, disease and disease control, infrastructure effects on local hydrography, escapees, litter, anchoring/mooring of boats

[2] atmospheric emissions for transport of brood stock/juveniles, interaction with seafloor during set-up of infrastructure, loss of gear

Operational (e.g. contaminants e.g. from petrol stations, litter)	X	
Waste management - operational disposal including sewage treatment	X	
Operations (effluent discharge, thermal discharge)	X	
Wave energy	X	
Construction (cable laying - localised habitat change, noise)	X	
Operations (electro-magnetic cables, localised change in flow of water)	X	
Wind farms	X	X
Construction (e.g. installation of turbines on seafloor, laying cables)	X	X
Operations (e.g. active cables on seafloor, moving turbines)	X	X

Table 5 Anthropogenic pressures (Groupings in bold) with crosses (X) indicating their occurrence in each pilot assessment

Pressures and their groupings	NS	CS	CS/BoB
Biological disturbance	X		
Extraction of living resources	X		
Introduction of genetically modified species	X		
Introduction of Microbial pathogens	X		
Introduction of non-indigenous species	X		
Translocations of species (native or non-native)	X		
Chemical changes, chemicals and other pollutants	X		
Changes in input of organic matter	X		
Ghost nets and other litter causing entanglement	X		
Introduction of Non-synthetic compounds	X		
Introduction of Radionuclides	X		
Introduction of Synthetic compounds	X		
Microplastics and other litter that may be ingested	X		
N&P Enrichment	X		
pH changes	X		
Salinity changes	X		
Energy	X		
Continuous noise	X		
Electromagnetic changes	X		
Impulsive noise	X		
Input of light	X		
Thermal changes	X		
Physical change	X		
Abrasion/Damage	X		
Barrier to species movement	X		
Changes in Siltation	X		
Changes to hydrological conditions	X		
Death or Injury by Collision	X		
Disturbance (visual) of species	X		
Extraction of non-living resources	X		
Smothering	X		
Total Habitat Loss	X		

Table 6 Selected bird species with crosses (X) indicating their occurrence in each pilot assessment

OSPAR Bird species (English name)	Scientific name	NS	CS	CS/BoB
Red-throated diver	Gavia stellata	x		
Black-legged kittiwake	Rissa tridactyla	x	x	
Northern gannet	Morus bassanus	x	x	
Atlantic puffin	Fratercula arctica	x	x	
Razorbill	Alca torda	x	x	
Great black-backed gull	Larus marinus	x		
European storm petrel	Hydrobates pelagicus		x	
Leach's storm petrel	Oceanodroma leucorhoa			
Manx shearwater	Puffinus puffinus		x	
Balearic shearwater	Puffinus mauretanicus			
Sooty shearwater	Puffinus griseus			
Great shearwater	Puffinus gravis			
Northern fulmar	Fulmarus glacialis	x	x	
Common scoter	Melanitta nigra	x		
Herring gull	Larus argentatus	x	x	
Little gull	Hydrocoloeus minutus	x		
Lesser black-backed gull	Larus fuscus	x	x	
Common guillemot	Uria aalge	x	x	
Cory's shearwater	Calonectris diomedia			
European shag	Phalacrocorax aristotelis		x	
Sandwich tern	Thalasseus sandvicensis	x		
Roseate tern	Sterna dougallii			
Yellow-legged gull	Larus michahellis			
Great cormorant	Phalacrocorax carbo	x		
Eurasian curlew	Numenius arquata			
Common starling	Sturnus vulgaris			
Great skua	Stercorarius skua	x	x	
Black-throated diver	Gavia arctica	x		

Annex 2 Expert-judgement scores

Exposure (based on Extent and Dispersal)
This can be based on the combined extent and dispersal categories in Borgwardt et al. (2019), where the extent score reflects the overlap between the activity and the ecosystem component which is then combined with a pressure-specific dispersal (see Figure SM1.0 and Table SM1.1). The dispersal scores were slightly modified in order to align with data-driven approaches and achieve more realistic spatial overlap values. Instead of a dispersal score of 1 in case of high dispersal because "the pressure can disperse beyond the local environment" (Borgwardt et al., 2019), a more realistic score was assumed equal to the Extent category "local", i.e. 0.37. By simply multiplying numerical scores of extent and dispersal (or frequency and persistence), spatial (or temporal) effects may be either underestimated (when the scores are both small) or overestimated when they are both large. Moreover, no overlap without any dispersal would always result in a 0 score even though a pressure with moderate to high dispersal may result in co-occurrence despite a lack of actual overlap between the marine activity and the ecosystem component, or in case of a land-based activity the position of the river outlet. Therefore, the two scores were considered as chance processes when combining them into an overall spatial exposure score. This can be achieved by scaling the scores of both aspects between 0 and 1 and treat them as dependent chance processes to represent the likelihood of co-occurrence. The combined 'likelihood' is subsequently calculated according to a standard probability equal to the sum of both chances minus the product of both chances.

Table SM1.1. Interpretation and estimation of Exposure, as the likelihood that an ecosystem component is co-occurring with the pressure and hence potentially affected by it, based on Extent and Dispersal categories from previous studies, i.e. Knights et al. (2015) and Borgwardt et al. (2019), but with slightly adapted scores. Extent is defined as the overlap between the Activity and the Ecosystem Component. Dispersal as the potential of the pressure to spread and increase its spatial overlap with an Ecosystem Component beyond that of the Extent. Note that in the calculations the scores are expressed as fractions (0-1) but for presentation purposes we have expressed them as percentages (0-100%).

Exposure		**Dispersal**		
		None	Moderate	High
Extent		0	5	15
No overlap	0	0	5	15
Trace	1	1	6	16
Site	3	3	8	18
Local	37	37	40	46
Widespread Patchy	67	67	69	72
Widespread Even	100	100	100	100

Resistance (based on Hazard, Magnitude, Behaviour and Frequency)
Table SM1.2. Hazard categories, their scores and how these can be interpreted in a conservation context. Hazard is defined as the relative depletion of the receptor from a single interaction with the stressor at maximum magnitude. Note that in the calculations the scores are expressed as fractions (0-1) but for presentation purposes we have expressed them as percentages (0-100%).

Hazard	**Score**	**Interpretation**
Negligible	0.001	No hazard. Similar to undisturbed or pristine
Sublethal low	0.1	Potentially unsustainable at low recovery potential*
Sublethal high	1	Potentially unsustainable at moderate recovery potential*
Lethal low	10	Potentially unsustainable at high recovery potential*
Lethal high	100	Likely to be causing serious or irreversible harm

* Thresholds for potentially unsustainability were based on the Resilience values in relation to sustainability.

Table SM1.3. Magnitude categories, their scores and how these can be interpreted in a conservation context. Magnitude is defined as the average strength of the Pressure in the Exposure area where it is co-occurring with the Ecosystem Component. Note that in the calculations the scores are expressed as fractions (0-1) but for presentation purposes we have expressed them as percentages (0-100%).

Magnitude	**Score**	**Interpretation**
Very low (VL)	0.1	Traces of the pressure with no adverse effects. Not different from pristine.
Low (L)	1	Adverse effects expected but ≤ 1% of maximum
Medium (M)	10	Adverse effects ≥ 1% but ≤ 10% of maximum

High (H)	50	Adverse effects ≥ 10% but ≤ 50% of maximum
Maximum (VH)	100	Causing highest adverse effects known for that pressure

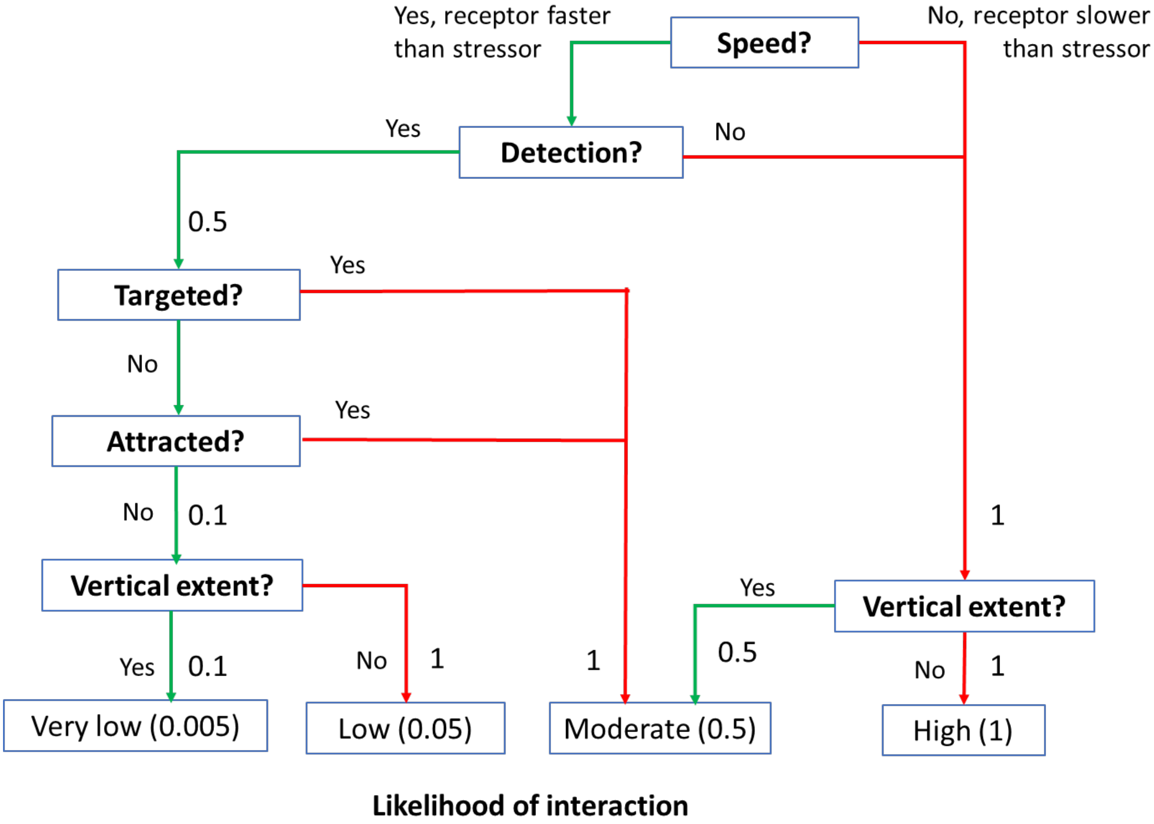

Figure SM1.4. Schematic presentation explaining how different behavioral responses determine the likelihood of interaction score.

Table SM1.5. Resistance of a receptor to a stressor, interpreted as what remains of that receptor after 1 year exposure to that stressor, calculated for two interaction mechanisms depending on various parameters. For Continuous interactions these are only Hazard and Magnitude, for Intermittent interactions this is also Behaviour (to the extent that it affects the likelihood of interaction) and Frequency. Frequency represents how often a stressor and receptor interact and can be any number, but here we have only presented three values, i.e. 0.1 (once every 10 years), 1 and 10 interaction events per year. Note that in the calculations the parameter values are expressed as fractions (0-1) but for presentation purposes we have expressed them as percentages (0-100%).

Hazard		Magnitude		Continuous	Intermittent												
					0.5	0.5	0.5	5	5	5	50	50	50	100	100	100	**Behaviour**
					0.1	1	10	0.1	1	10	0.1	1	10	0.1	1	10	**Frequency**
Negligible	0.01	Very low	0.1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
	0.01	Low	1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
	0.01	Medium	10	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	
	0.01	High	50	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.98	100.00	100.00	99.95	
	0.01	Maximum	100	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00	99.99	99.90	
Sublethal low	0.1	Very low	0.1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	
	0.1	Low	1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	
	0.1	Medium	10	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00	99.99	99.90	
	0.1	High	50	99.95	100.00	100.00	100.00	100.00	100.00	99.98	100.00	99.98	99.75	99.99	99.95	99.50	
	0.1	Maximum	100	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
Sublethal high	1	Very low	0.1	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.99	

	1	Low	1	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00	99.99	99.90	
	1	Medium	10	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
	1	High	50	99.50	100.00	100.00	99.98	100.00	99.98	99.75	99.97	99.75	97.53	99.95	99.50	95.11	
	1	Maximum	100	99.00	100.00	100.00	99.95	99.99	99.95	99.50	99.95	99.50	95.11	99.90	99.00	90.44	
Lethal low	10	Very low	0.1	99.99	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	99.95	100.00	99.99	99.90	
	10	Low	1	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
	10	Medium	10	99.00	100.00	100.00	99.95	99.99	99.95	99.50	99.95	99.50	95.11	99.90	99.00	90.44	
	10	High	50	95.00	100.00	99.98	99.75	99.97	99.75	97.53	99.75	97.50	77.63	99.49	95.00	59.87	
	10	Maximum	100	90.00	99.99	99.95	99.50	99.95	99.50	95.11	99.49	95.00	59.87	98.95	90.00	34.87	
Lethal high	100	Very low	0.1	99.90	100.00	100.00	100.00	100.00	100.00	99.95	99.99	99.95	99.50	99.99	99.90	99.00	
	100	Low	1	99.00	100.00	100.00	99.95	99.99	99.95	99.50	99.95	99.50	95.11	99.90	99.00	90.44	
	100	Medium	10	90.00	99.99	99.95	99.50	99.95	99.50	95.11	99.49	95.00	59.88	98.95	90.00	34.87	
	100	High	50	50.01	99.97	99.75	97.53	99.75	97.50	77.63	97.16	75.00	5.63	93.30	50.01	0.10	
	100	Maximum	100	0.01	99.95	99.50	95.11	99.49	95.00	59.88	93.30	50.01	0.10	39.81	0.01	0.00	

Resilience
For resilience we adopted both the interpretation (i.e. time taken for the habitat to recover to pre-impact condition) and the expert judgement scores from Knights et al (2015).

SM1.6. Resilience estimates based on expert judgement (adopted from Knights et al., 2015).

Ecosystem component	Recovery	Time (yr) to Recovery
Littoral rock and other hard substrata	High	1
Littoral sediment		1
Pelagic water column		1
Circalittoral rock and other hard substrata	Moderate	6
Infralittoral rock and other hard substrata		6
Sublittoral sediment		6
Birds	Low	55
Deep-sea bed		55
Fish & Cephalopods		55
Mammals		55
Reptiles		55
	None	100

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