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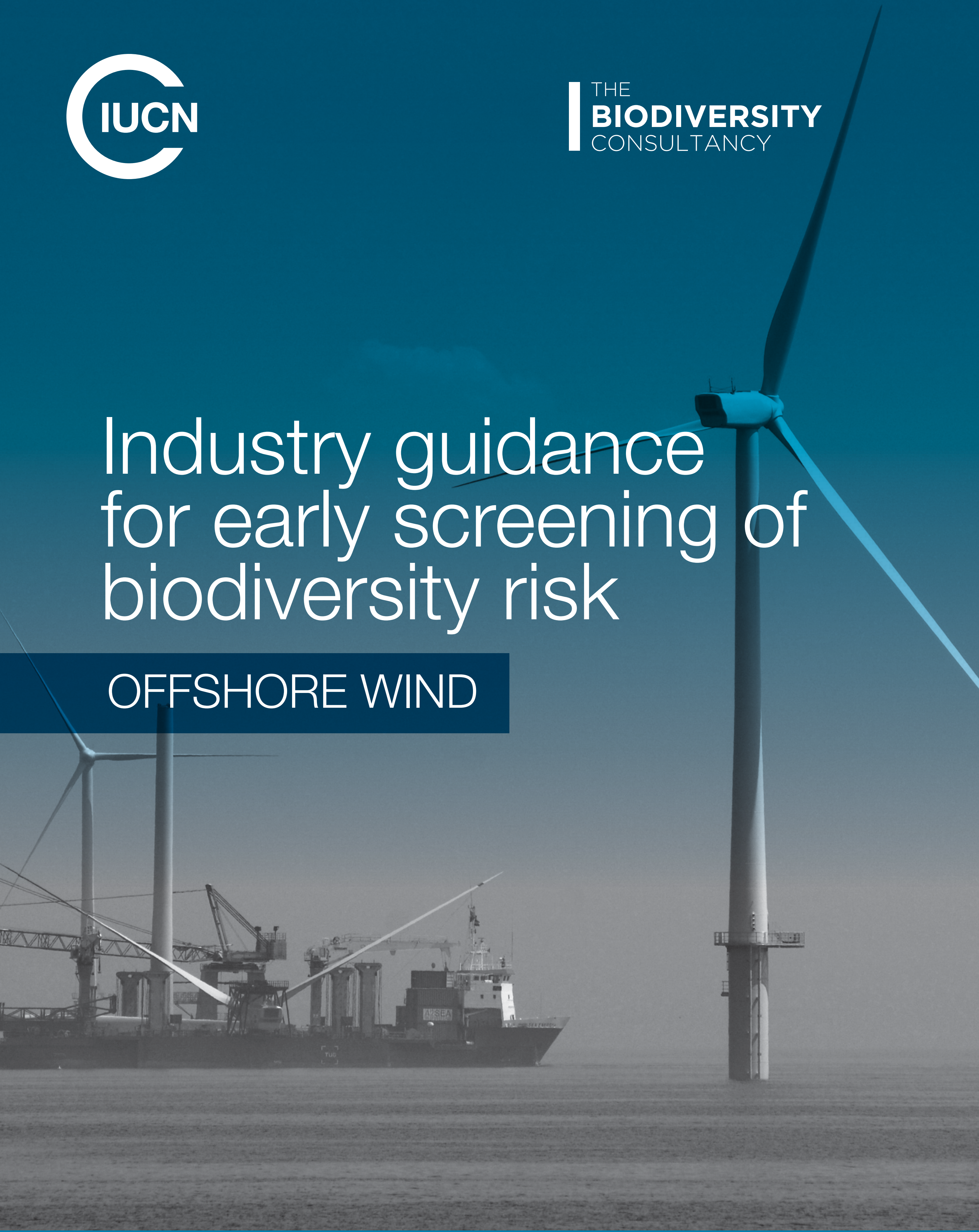
Industry guidance for early screening of biodiversity risk

OFFSHORE WIND



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The Biodiversity Consultancy is a specialist consultancy in biodiversity risk management. We work with sector-leading clients to integrate nature into business decision-making and design practical environmental solutions that deliver nature-positive outcomes. We provide technical and policy expertise to manage biodiversity impacts at a project level and enable purpose-driven companies to create on-the-ground opportunities to regenerate our natural environment.

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Table of contents

Introduction

This document provides brief practical guidance on early risk screening for offshore wind projects. It outlines how to identify and avoid areas of high biodiversity sensitivity, based on the IUCN/TBC Guidelines for Mitigating biodiversity impacts associated with solar and wind energy development.[1] It is relevant to both project financers and developers and is applicable to developments around the world.

The guidance focuses on early desk-based risk screening, as part of the early planning and design phase of a development (Figure 1).[2] Siting projects away from sensitive areas (such as important wildlife habitats and migration routes) can help to avoid significant negative impacts, and in turn reduce the need for expensive and prolonged survey, mitigation, and approval processes.

Financers may need to screen projects at different stages of development. The approaches used in early risk screening may be helpful to flag risks for projects that are at later stages of planning, but a range of other due diligence questions may also need to be considered.[3]

1 Bennun, L., van Bochove, J., Ng, C., Fletcher, C., Wilson, D., Phair, N., Carbone, G. (2021). Mitigating biodiversity impacts associated with solar and wind energy development. Guidelines for project developers. Gland, Switzerland: IUCN and Cambridge, UK: The Biodiversity Consultancy. https://doi.org/10.2305/IUCN.CH.2021.04.en

2 See Figure 3.2 in the Guidelines for further detail.

3 See the IBAT briefing note, *Considering biodiversity for solar and wind energy investments.*

Considerations for early risk screening

Early risk screening is a valuable tool to assess if a particular site or sites may pose an elevated biodiversity risk. It does not provide information on whether suitable but less risky locations exist elsewhere. Spatial plans and wildlife sensitivity mapping can provide this information (see Figure 1 and Section 3 of the Guidelines).

- Early risk screening can indicate potential elevated risk but does not provide a definitive picture. It is not an alternative to site-specific assessment for mitigation planning. Risks may be present that were not evident during screening, while on the other hand potential risk does not always translate into actual risk (for example, migrating birds might be present but routinely flying well above the height of turbines).
- Risks will depend not only on project location but on the size and design of the project.
- Risk screening results should be interpreted carefully, bearing in mind that:
    - There may be data gaps, especially in less-studied regions. Absence of data does not indicate absence of risk.
    - In regions where offshore wind developments are relatively new there may be limited information on which species could be most at risk (e.g., from collision with turbines or behavioural displacement), although experience from elsewhere provides some indication.
    - For species that range very widely (such as some cetaceans or open-ocean seabird species) or that make long-distance movements, the mapped presence of the species overlapping a site may not in itself provide a good indication of risk. Supplementary information or expert advice should be used where possible to aid interpretation.

In addition to informing site selection, a risk screening can help scope further site-specific assessments to assess the presence and status of the full range of sensitive biodiversity features at risk from the project. Multiple rounds of surveys across one or more years may be needed to develop a good understanding of a species' ecological requirements, population and seasonal distribution.

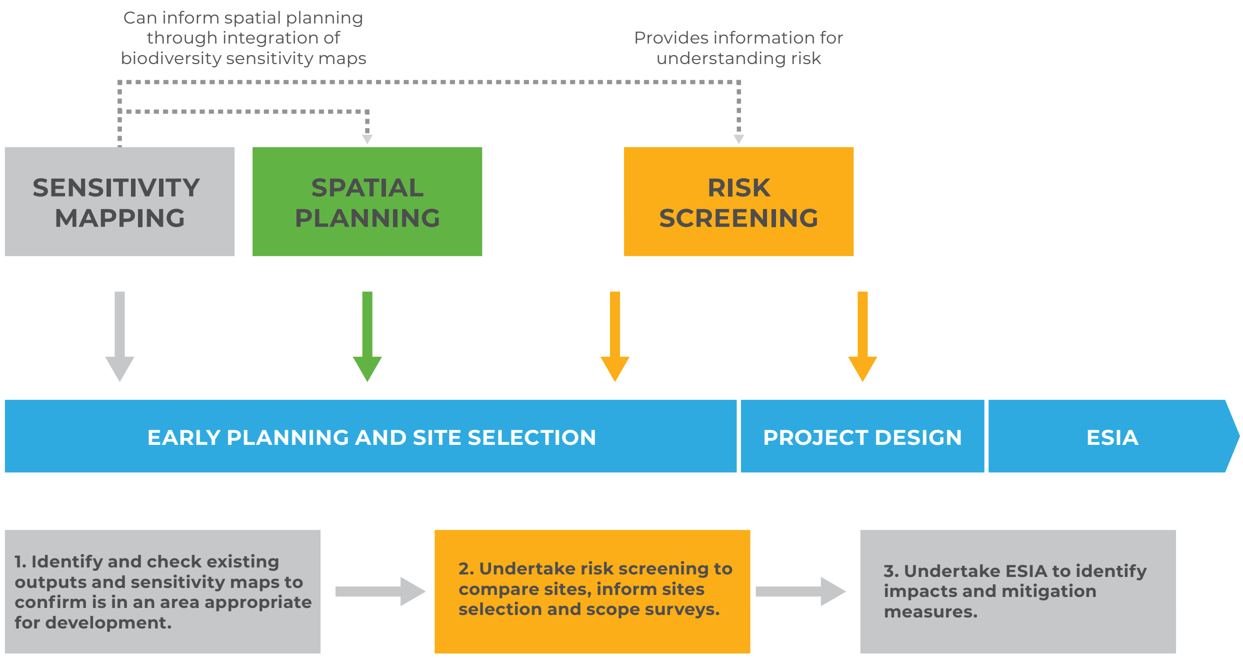

Figure 1. This guidance is applicable to the risk screening stage of the early planning phase of a project. Screening can also be used to inform project design, following confirmation of the project site. Provisional site selection and screening should ideally be guided by spatial planning and/or wildlife sensitivity mapping where these exist. It is important that developers and financers identify such information sources and where available use them to confirm that the proposed development site is not known to overlap with sensitive areas. Additional guidance on sensitivity mapping, spatial planning and Environmental and Social Impact Assessment (ESIA) can be found in Section 3 of the Guidelines.

Biodiversity data sources and interpretation

Important biodiversity data and information sources for early screening are identified in Table 1. Depending on project location, other relevant national or regional datasets may be available.

The Integrated Biodiversity Assessment Tool (IBAT) is a key resource and the usual starting point for screening. IBAT provides commercial users[4] with spatial data for global biodiversity from several key datasets, such as the IUCN Red List of Threatened Species™, the World Database on Protected Areas and the World Database of Key Biodiversity Areas (which includes Important Bird and Biodiversity Areas). Reports showing the proximity of a particular area of interest in relation to these features can be generated in IBAT. In this document we show how these reports can be used to identify potential risks associated with biodiversity features including threatened species.

Additional datasets are needed to assess some other risk factors, such as overlap with important marine ecosystems or concentrations of marine mammals. Where available, these are included in Table 1.

Screening should consider the wider area around a project site. This is to account for potential direct and indirect impacts associated with the project and its associated facilities (e.g., powerlines and roads), as well as potential movements of wide-ranging species. A buffer of at least 20 km around the proposed wind development is recommended (IBAT allows users to set up to three buffers between 1 km and 50 km in its site reports). This may need to be scaled up if the planned activity (e.g. vessel movements or laying of cables) is more extensive, or if high-risk, wide-ranging species are likely to be present.

For offshore wind, it is also important to screen the associated onshore elements, including the export cable landfall, onshore substation and any transmission lines.

It is recommended to work with biodiversity specialists to help undertake the screening and interpret the findings. Specialists will also be able to help investors and developers understand the implications for aligning with biodiversity safeguards and to scope further work, including field surveys and Environmental Impact Assessment.

Further guidance on risk screening can be found in Section 3 of the Guidelines.

4 IBAT data can be accessed either as a pay as you go service or through an annual subscription service. See here for costs and details and here for IBAT's briefing note on considering biodiversity for solar and wind energy investments.

Framework for integrating biodiversity into project planning

Table 1 presents the key types of risk associated with project location and specific construction and operational features where relevant, based on four broad categories of impact:

i. **Footprint**: including habitat loss, degradation, barriers to movement and/or fragmentation (including through behavioural change in wildlife), hydrodynamic changes and introduction of new hard-substrate habitat associated with the physical presence of project infrastructure;
ii. **Collision**: bird and/or bat mortality due to collisions with offshore turbines and collision/electrocution on associated onshore transmission lines;
iii. **Underwater noise**: marine mammal, fish and turtle injury/mortality due to underwater construction noise;
iv. **Vessels**: marine mammal, fish and turtle disturbance, injury and mortality (vessel strike) associated with vessel activity.

Further context and guidance are provided in Table 1 to help understand risk. The guidance and information sources in Table 1 are not exhaustive – it is important to work with specialists to locate and interpret relevant information. Section 7 of the Guidelines identifies other potential impacts and mitigation approaches, including opportunities to enhance biodiversity through proactive conservation actions.

Sensitive species groups are referenced where such information is known and supported by scientific research. See Annex 1 for a detailed table of vulnerable species with references. These are examples to aid screening and not intended to be a comprehensive list.

Table 1. Key biodiversity risks associated with offshore wind developments, and means to identify risk based on existing information sources. Specific references to studies on species known to be sensitive to wind developments resources can be found in Annex 1.

Potential impacts	What indicates potentially high risk?	How can I assess risk?	IBAT and additional information sources not available through IBAT
Impact category: Project footprint			
• Loss or degradation of seabed (benthic) habitat • Habitat fragmentation • Displacement of wildlife • Barriers to wildlife movement • Ecological change via introduction of new hard-substrate habitat • Hydrodynamic changes (e.g. wind-wake effects, scour around turbine foundations) • Impacts of electromagnetic cables	Footprint in or near designated Protected Areas	Protected areas have been mapped globally. Projects within or adjacent to protected areas may be incompatible with protected area objectives, and risk impacting the biodiversity values for which they are designated. In some cases, risks may be associated only with particular times of the year, for example where important concentrations of marine mammals are present only during the breeding period. This might mean offshore wind project activities are incompatible only during these key sensitive periods.	• IBAT Proximity or Multisite reports, which include World Database of Protected Areas • Important Marine Mammal Area E-Atlas (IMMA E-Atlas) • Ecologically or Biologically Significant Marine Areas (EBSAs)
	Footprint in or near Key Biodiversity Areas	Key Biodiversity Areas have been identified globally. Projects within such areas risk impacting the biodiversity values for which they were designated, particularly where these have been identified based on species or ecosystems sensitive to offshore wind impacts.	• IBAT Proximity or Multisite reports, which include the World Database of Key Biodiversity Areas
	Footprint within the range of threatened or restricted-range species	Species range maps are available through the IUCN Red List to identify potential overlap with project sites. Threatened and restricted-range species are at highest risk. For example, some threatened seabirds are known to be at high risk of collision with offshore turbines (see below), and some threatened shorebirds could be at risk from disturbance associated with the export cable landfall. Other threatened birds and bats are known to be at high risk of collision with onshore transmission lines (see below). Some threatened marine mammals are potentially at risk from underwater noise and vessel activity (see below). Some species (such as sharks, rays and some fish) may also be impacted by electromagnetic effects of subsea cables.	• IBAT Proximity or Multisite reports
	Within or overlapping with a migratory corridor or bottleneck for birds or bats	Migratory birds are potentially at risk of displacement where offshore wind farms are sited on a migratory bottleneck, where migrants are forced to cross stretches of sea between land masses. Otherwise, migratory birds are less likely to encounter turbines, compared to seabirds. Species range maps are available through the IUCN Red List. Species that migrate by soaring flight are potentially vulnerable, including: • Vultures • Raptors • Cranes • Storks Information on bat migration is still relatively limited, but migratory species are known to occur seasonally offshore.	• IBAT Proximity or Multisite reports • BirdLife International Migratory Soaring Birds Project • BirdLife International Seabird Tracking Database • Atlas of Seabirds at Sea (AS@S)
	Footprint in or near wetland	Important wetlands have been identified for most parts of the world. Wetlands often support significant populations of birds and are usually classed as Natural Habitat according to the IFC PS6 definition. Projects for which the export cable makes landfall within or near to wetlands risk impacting the habitat and the biodiversity values it supports, and transmission lines near wetlands may pose a collision risk (see below).	• Global surface Water dataset - includes important seasonal and intermittent wetlands • Ramsar site information service - generates site reports which can be downloaded • Regional wetland databases such as the Critical Sites Network
	Footprint in natural or semi-natural habitat	Potential areas of Natural Habitat have been mapped globally based on IFC PS6 definitions. Developments within or adjacent to areas of Natural Habitat are likely to be high risk for development. Some types of Natural Habitat that are likely to be sensitive and high risk for offshore wind development have also been the subject of specific mapping - including coral reefs, seagrass, saltmarshes and mangroves. Areas of Modified Habitat (e.g., very heavily trawled areas) may still support sensitive species so are not necessarily low risk. Offshore wind farms may alter the hydrodynamic regime, with consequences for seabed/marine/coastal habitats. Offshore wind farm components can also constitute new hard substrate for colonisation by marine organisms, which can alter community structure and affect the food chain.	• Natural and Modified Habitat map - free for commercial use with appropriate attribution • Multiple global datasets are available for different marine and coastal habitat types • Multiple global datasets are available for different marine and coastal habitat types, including (but not limited to) the Global Distribution of Seagrass, the Global Mangrove Watch, and the Global Distribution of Coral Reefs. Multiple other habitat datasets are also available via the UNEP-WCMC Ocean Data Viewer. The Global Ecosystem Typology provides broad ecosystem mapping, classified based on ecosystem function.
	Footprint in mapped Critical Habitat	Areas of potential or likely Critical Habitat have been identified and mapped globally based on the IFC PS6 criteria and a range of biodiversity data. Developments within or adjacent to areas of Critical Habitat are likely to be high risk for development.	• Critical Habitat map - free for commercial use with appropriate attribution

Impact category: Collisions with turbines			
Fatalities, or injuries to birds	Within range of bird species vulnerable to collisions	Range maps for most vulnerable birds are available through the IUCN Red List. Birds known to be vulnerable to collision risk include: • Seabirds (including true seabirds, marine birds, waterfowl and waders) - this group is at the highest risk of collision with offshore wind turbines • Migratory birds (non-marine, including vultures, raptors, cranes and storks). Collision risk to these species is highest if projects are located on migratory bottlenecks, such as short water crossings between land masses (see below, and above under 'Project footprint'). Birds that are threatened or have a restricted range are at the highest risk.	• IBAT Proximity or Multisite reports • BirdLife International Migratory Soaring Birds Project • BirdLife International Seabird Tracking Database • Atlas of Seabirds at Sea (AS@S)
	Within range of bat species vulnerable to collisions	Range maps for most vulnerable bats are available through the IUCN Red List. Bats vulnerable to collision risk include open-air foragers and migratory species. Information on bat movements and migration is still relatively limited, but migratory species are known to occur seasonally offshore. Bats that are threatened or have a restricted range are at highest risk.	• IBAT Proximity or Multisite reports
	Overlapping with, or near to, migratory stopover sites, corridors and 'bottlenecks' for birds or bats	Areas along migratory corridors that support high concentrations of migratory birds or bats such as at staging areas, and stopover sites (for onshore components) and 'bottleneck' areas such as narrow straits.	• The Soaring Bird Sensitivity Map tool - provides distribution maps of soaring bird species along the Rift Valley / Red Sea flyway • Movebank - provides freely available data on satellite tagged migratory species including birds
	In or near Protected Areas or Key Biodiversity Areas	As well as posing high footprint risk, such areas are more likely to hold species that are vulnerable to collisions with turbines. See 'Project Footprint' section above.	• See 'Project Footprint' section above
Fatalities or injuries to birds or bats	Within range of bird species vulnerable to collisions	Range maps are available through the IUCN Red List. Species known to be vulnerable to transmission line collisions include those with high wing-loading and low manoeuvrability, notably: • Bustards • Cranes • Flamingos • Geese • Ground Hornbills • Spurfowl • Storks Species that are threatened or have a restricted range pose the highest risk.	• IBAT Proximity or Multisite reports which include the IUCN Red List • MoveBank online platform for sharing animal movement data
Impact category: Collisions with transmission lines			
Fatalities or injuries to birds	Close to wetlands	Important wetlands have been identified for most parts of the world. Wetlands often support significant populations of birds at high collision risk. Range maps for most vulnerable wetland bird species are available through the IUCN Red List. Wetland birds known to be vulnerable to collision risk include those with high wing-loading such as: • Cranes • Flamingos • Geese • Pelicans • Storks Birds that are threatened or have a restricted range are at highest risk. See 'Close to wetlands' section above.	• Global surface Water dataset - includes important seasonal and intermittent wetlands • Ramsar site information service - generates site reports which can be downloaded • Regional wetland databases such as the Critical Sites Network • See 'Close to wetlands' section above. • MoveBank online platform for sharing animal movement data

<table>
<tr><td colspan="4">Impact category: Underwater noise</td></tr>
<tr><td rowspan="5">Fatalities, injuries or behavioural impacts on marine mammals, fish and turtles</td><td>Footprint in or near designated Protected Areas</td><td rowspan="5">Marine mammals, fish and turtles are potentially at risk of lethal or sub-lethal exposure to underwater noise from activities throughout the wind farm lifetime, including during site characterisation (e.g., seismic survey airguns), construction (e.g., piling), operations (e.g., operational turbines) and vessel activity (e.g., engines and propellers), and noise associated with decommissioning the wind farm. All marine mammals (cetaceans and pinnipeds) are sensitive to underwater sound, and hearing specialist fish (such as herring and cod) are vulnerable. Relatively little is known about potential underwater noise impacts on turtles.

These sources of noise are likely to be incompatible with the objectives of designated protected areas and present a risk to biodiversity values for which protected areas and Key Biodiversity Areas were designated.

In terms of marine species migration and spawning/breeding, underwater noise impacts may be of greatest concern at these key times, and lower risk at other times. Threatened and restricted range species are at highest risk throughout.</td><td>• ‘Project Footprint’ section above</td></tr>
<tr><td>Footprint in or near Key Biodiversity Areas</td><td>• ‘Project Footprint’ section above</td></tr>
<tr><td>Footprint within the range of threatened or restricted-range species</td><td>• ‘Project Footprint’ section above</td></tr>
<tr><td>Footprint within or overlapping with a migratory corridor for marine mammals or turtles</td><td>• IBAT Proximity or Multisite reports which include the IUCN Red List</td></tr>
<tr><td>Footprint within or near to fish spawning or nursery areas, seal haul-out/foraging site or turtle nesting beaches</td><td>• IBAT Proximity or Multisite reports which include the IUCN Red List, the World Database of Protected Areas, and World Database of Key Biodiversity Areas
• Important Marine Mammal Area E-Atlas (IMMA E-Atlas)
• MoveBank online platform for sharing animal movement data</td></tr>
<tr><td colspan="4">Impact category: Collision with vessels</td></tr>
<tr><td rowspan="4">Fatalities, injuries or behavioural impacts on marine mammals and turtles</td><td>Vessel activity within or near to fish spawning or nursery areas, marine mammal concentrations, seal haul-out/ foraging sites or turtle nesting beaches</td><td rowspan="4">Vessels operating within the wind farm area and/or transiting to and from the coast pose a collision risk (known as ‘vessel strike’) to marine mammals and turtles. This risk is well known for marine mammals. Turtles (particularly adults during the breeding/nesting season) may be at risk when they surface to breathe, bask or forage.</td><td rowspan="4">• IBAT Proximity or Multisite reports which include the IUCN Red List, the World Database of Protected Areas, and World Database of Key Biodiversity Areas
• Important Marine Mammal Area E-Atlas (IMMA E-Atlas)
• MoveBank online platform for sharing animal movement data</td></tr>
<tr><td>Vessel activity within designated Protected Areas or Key Biodiversity Areas</td></tr>
<tr><td>Vessel activity within range of threatened or range-restricted species susceptible to vessel strike</td></tr>
<tr><td>Vessel activity within a migratory corridor for marine mammals or turtle</td></tr>
</table>

Annex 1. Species known to be vulnerable to offshore wind developments

Class	Species group	Species sub-group	Family (example)	Species (example)	Potential impacts	References to examples (not comprehensive)
Marine megafauna (mammals, sharks & rays and sea turtles)	**Cetaceans**	**Whales**	**Monodontidae**	Should apply to all as a precautionary approach	Vessel strike; Injury/behavioural effects of underwater noise (e.g. vessels, piling, maintenance); Barrier or displacement effect	Normandeau Associates, Inc. 2012 (https://www.cbd.int/doc/meetings/mar/mcbem-2014-01/other/mcbem-2014-01-submission-boem-04-en.pdf); Sparling et al. 2017 (http://data.jncc.gov.uk/data/e47f17ec-30b0-4606-a774-cdcd90097e28/JNCC-Report-607-FINAL-WEB.pdf); Riefolo et al., 2016 (https://www.onepetro.org/conference-paper/ISOPE-I-16-317); Thomsen et al. 2006 (https://tethys.pnnl.gov/sites/default/files/publications/Effects_of_offshore_wind_farm_noise_on_marine-mammals_and_fish-1-.pdf)
			Balaenidae			
			Cetotheriidae			
		Dolphins	**Delphinidae**			
		Porpoises	**Phocoenidae**	Harbour porpoise (*Phocoena phocoena*). Should apply to all as a precautionary approach		
	Pinnipeds	**True seals**	**Phocoidea**	Harbour seals (*Phoca vitulina*). Should apply to all as a precautionary approach	Vessel strike; Injury/behavioural effects of underwater noise (e.g. vessels, piling, maintenance); Displacement effect	Sparling et al. 2017 (http://data.jncc.gov.uk/data/e47f17ec-30b0-4606-a774-cdcd90097e28/JNCC-Report-607-FINAL-WEB.pdf); Hastie et al. 2015 (https://doi.org/10.1111/1365-2664.12403); Hastie et al. 2019 (https://doi.org/10.1002/eap.1906); Riefolo et al., 2016 (https://www.onepetro.org/conference-paper/ISOPE-I-16-317); Thomsen et al. 2006 (https://tethys.pnnl.gov/sites/default/files/publications/Effects_of_offshore_wind_farm_noise_on_marine-mammals_and_fish-1-.pdf)
		Walruses and fur seals	**Otarioidea**	Should apply to all as a precautionary approach		
	Sirenians	**Dugongs**	**Dugongidae**	Should apply to all as a precautionary approach	Vessel strike; Injury/behavioural effects of underwater noise (e.g. vessels, piling, maintenance); Displacement effect	Sparling et al. 2017 (http://data.jncc.gov.uk/data/e47f17ec-30b0-4606-a774-cdcd90097e28/JNCC-Report-607-FINAL-WEB.pdf); Hastie et al. 2015 (https://doi.org/10.1111/1365-2664.12403); Hastie et al. 2019 (https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/eap.1906); Riefolo et al. 2016 (https://www.onepetro.org/conference-paper/ISOPE-I-16-317)
		Manatees	**Trichechidae**			
	Sea turtles		**Chelonioidea**	Should apply to all as a precautionary approach	Vessel strike; Injury/behavioural effects of underwater noise (e.g. vessels, piling, maintenance), Barrier or displacement effect	Normandeau Associates, Inc. 2012 (https://www.cbd.int/doc/meetings/mar/mcbem-2014-01/other/mcbem-2014-01-submission-boem-04-en.pdf); Riefolo et al., 2016 (https://www.onepetro.org/conference-paper/ISOPE-I-16-317); Dow Piniak et al. 2012 (https://www.semanticscholar.org/paper/Underwater-hearing-sensitivity-of-the-leatherback-(-Piniak-Eckert/3ec87364f6a6dfc28ebf4d733a8fec7c68ce9e61)
	Elasmobranchs		**Varied**	Could apply to all coastal species as a precautionary approach	Behavioural effects of electromagnetic fields associated with wind farm cables	Normandeau Associates, Inc. 2012 (https://www.cbd.int/doc/meetings/mar/mcbem-2014-01/other/mcbem-2014-01-submission-boem-04-en.pdf); Riefolo et al., 2016 (https://www.onepetro.org/conference-paper/ISOPE-I-16-317)
Fish	**Fish with a swim bladder**		**Varied**	Atlantic salmon (*Salmo salar*), Atlantic cod (*Gadus morhua*), Atlantic herring (*Clupea harengus*)	Injury/behavioural effects of underwater noise (e.g. vessels, piling, maintenance)	Normandeau Associates, Inc. 2012 (https://www.cbd.int/doc/meetings/mar/mcbem-2014-01/other/mcbem-2014-01-submission-boem-04-en.pdf); Weilgart 2018 (https://www.oceancare.org/wp-content/uploads/2017/10/OceanNoise_FishInvertebrates_May2018.pdf); Thomsen et al. 2006 (https://tethys.pnnl.gov/sites/default/files/publications/Effects_of_offshore_wind_farm_noise_on_marine-mammals_and_fish-1-.pdf)
	Fish without a swim bladder		**Varied**	Dab (*Limanda limanda*)	Injury/behavioural effects of underwater noise (e.g. vessels, piling, maintenance)	Thomsen et al. 2006 (https://tethys.pnnl.gov/sites/default/files/publications/Effects_of_offshore_wind_farm_noise_on_marine-mammals_and_fish-1-.pdf)
	Vocal fish		**Varied**	Salmonid species (*Salmo, Salvelinus and Oncorhynchus*)	Injury/behavioural effects of underwater noise (e.g. vessels, piling, maintenance)	Normandeau Associates, Inc. 2012 (https://www.cbd.int/doc/meetings/mar/mcbem-2014-01/other/mcbem-2014-01-submission-boem-04-en.pdf); Weilgart 2018 (https://www.oceancare.org/wp-content/uploads/2017/10/OceanNoise_FishInvertebrates_May2018.pdf)

Class	Species group	Species sub-group	Family (example)	Species (example)	Potential impacts	References to examples (not comprehensive)
Birds	Seabirds	Duck	Anatidae	Greater scaup (*Aythya marila*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Duck	Anatidae	Common eider (*Somateria mollissima*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Duck	Anatidae	Long-tailed duck (*Clangula hyemalis*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Duck	Anatidae	Common scoter (*Melanitta nigra*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Duck	Anatidae	Velvet scoter (*Melanitta fusca*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Duck	Anatidae	Common goldeneye (*Bucephala clangula*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Duck	Anatidae	Red-breasted merganser (*Mergus serrator*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Gaviidae	Red-throated diver (*Gavia stellata*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Gaviidae	Black-throated diver (*Gavia arctica*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Gaviidae	Great northern diver (*Gavia immer*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Hydrobatidae	European storm-petrel (*Hydrobates pelagicus*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Hydrobatidae	Leach's storm-petrel (*Oceanodroma leucorhoa*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Phalacrocoracidae	Great cormorant (*Phalacrocorax carbo*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Alcidae	Black guillemot (*Cepphus grylle*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Migratory aquatic bird	Sulidae	Northern gannet (*Morus bassanus*)	Collision risk with turbines	Furness et al. 2013 (10.1016/j.jenvman.2013.01.025)
Birds	Seabirds	Migratory aquatic bird	Scolopacidae	Red-necked phalarope (*Phalaropus lobatus*)	Collision risk with turbines; Barrier or displacement effect	Bradbury et al. 2014 (doi:10.1371/journal.pone.0106366)
Birds	Seabirds	Auk	Alcidae	Common guillemot (*Uria aalge*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Auk	Alcidae	Little auk (*Alle alle*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Auk	Alcidae	Razorbill (*Alca torda*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Auk	Alcidae	Atlantic puffin (*Fratercula arctica*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Shearwaters	Procellariidae	Balearic shearwater (*Puffinus mauretanicus*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Shearwaters	Procellariidae	Manx shearwater (*Puffinus puffinus*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds	Shearwaters	Phalacrocoracidae	Common shag (*Phalacrocorax aristotelis*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Seabirds		Procellariidae	Northern fulmar (*Fulmarus glacialis*)	Collision risk with turbines; Barrier or displacement effect	Humphreys et al. 2015 (https://www.bto.org/sites/default/files/shared_documents/publications/research-reports/2015/rr669.pdf); Goodale et al. 2019 (https://doi.org/10.1088/1748-9326/ab205b)
Birds	Raptors	Large resident eagles	Accipitridae	White-tailed eagle (*Haliaeetus albicilla*)	Collision risk with turbines; Barrier or displacement effect	Dahl et al. 2013 (DOI: 10.1002/wsb.258); BirdLife international 2012 (http://migratorysoaringbirds.undp.birdlife.org/sites/default/files/factsheet%20Solar%20Developer%20v1H.pdf)

Class	Species group	Species sub-group	Family (example)	Species (example)	Potential impacts	References to examples (not comprehensive)
Birds	Raptors	New world vultures	Cathartidae	Turkey vulture (*Cathartes aura*)	Collision risk with turbines; Barrier or displacement effect	Villegas-Patraca et al. 2014 (https://doi.org/10.1371/journal.pone.0092462)
		Other migratory raptors	Accipitridae	White-tailed Hawk (*Buteo albicaudatus*)		
				Swainson's hawk (*Buteo swainsoni*)		
	Gulls and relatives		Laridae	European herring gull (*Larus argentatus*)		Furness et al. 2013 (DOI: 10.1016/j.jenvman.2013.01.025); Thaxter et al. 2017 (https://doi.org/10.1098/rspb.2017.0829); BirdLife international 2012 (http://migratorysoaringbirds.undp.birdlife.org/sites/default/files/factsheet%20Solar%20Developer%20v1H.pdf); Bradbury et al. 2014 (doi:10.1371/journal.pone.0106366)
				Great black-backed gull (*Larus marinus*)		Furness et al. 2013 (DOI: 10.1016/j.jenvman.2013.01.025); Bradbury et al. 2014 (doi:10.1371/journal.pone.0106366)
				Lesser black-backed gull (*Larus fuscus*)		
				Mediterranean gull (*Ichthyaetus melanocephalus*)		Bradbury et al. 2014 (doi:10.1371/journal.pone.0106366)
				Black-legged kittiwake (*Rissa tridactyla*)		
				Common gull (*Larus canus*)		
				Glaucous gull (*Larus hyperboreus*)		
				Iceland gull (*Larus glaucoides*)		
			Sulidae	Northern gannet (*Morus bassanus*)		
	Shorebirds	Waders	Scolopacidae	Great Knot (*Calidris tenuirostris*)	Collision risk with turbines	Thaxter et al. 2017 (https://doi.org/10.1098/rspb.2017.0829)
Bats	Insectivorous bats		Vespertilionidae	Daubenton's bat (*Myotis daubentoni*)		Ahlén et al. 2007 (https://www.naturvardsverket.se/Documents/publikationer/620-5571-2.pdf); Lagerveld et al. 2017 (https://library.wur.nl/WebQuery/wurpubs/fulltext/417091)
				Common noctule (*Nyctalus noctula*)		
				Lesser noctule (*Nyctalus leisleri*)		
				Common pipistrelle (*Pipistrellus pipistrellus*)		
				Nathusius' pipistrelle (*Pipistrellus nathusii*)		
				Soprano pipistrelle (*Pipistrellus pygmaeus*)		
				Serotine bat (*Eptesicus serotinus*)		
				Northern bat (*Eptesicus nilssonii*)		Ahlén et al. 2007 (https://www.naturvardsverket.se/Documents/publikationer/620-5571-2.pdf)
				Parti-coloured bat (*Vespertilio murinus*)		
				Pond bat (*Myotis dasycneme*)		
				Big brown bat (*Eptesicus fuscus*)		Pelletier et al. 2013 (https://tethys.pnnl.gov/sites/default/files/publications/BOEM_Bat_Wind_2013.pdf); Peterson 2016 (https://www.osti.gov/servlets/purl/1238337)
				Silver-haired bat (*Lasionycteris noctivagans*)		
				Eastern red bat (*Lasiurus borealis*)		
				Tricolored bat (*Perimyotis subflavus*)		
				Hoary bat (*Lasiurus cinereus*)		

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