Partnership for nature and people

Summary Report

Impact of offshore wind development on seabirds in the North Sea and Baltic Sea: Identification of data sources and at-risk species.

BirdLife INTERNATIONAL

EUROPE AND CENTRAL ASIA

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We would like to thank all BirdLife partners and contacted experts for their contribution and expertise during the online workshops.

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Background

Increased offshore wind farm development plays a key role in Europe's plans for renewable energy development, in order to meet the European Green Deal objective of becoming carbon neutral by 2050 (European Commission, 2019).

The European Union's (EU) long term decarbonisation strategy proposes that offshore wind will supply 30% of Europe's electricity demands by 2050, around 20 times the offshore wind capacity available in Europe today (European Commission, 2018). Starting from today's installed offshore wind capacity of 12 GW, the Commission estimates the objective to have an installed capacity of at least 60 GW of offshore wind and at least 1 GW of ocean energy by 2030, with a view to reach by 2050 a total 300 GW and 40 GW of installed capacity, respectively.

This means a massive change of scale for the sector in less than 30 years, at a speed unparalleled by the past development of other energy technologies (European Commission, 2020). The largest global player in offshore wind, the United Kingdom (UK), has committed to increase the country's offshore wind energy generation to 40 GW by 2030, and offshore renewables could account for 30% of the emissions reductions needed by 2050. (Oil and Gas Authority's (OGA) Energy Integration Project report 2020)

Already, today's seas face severe cumulative anthropogenic pressures that result in poor environmental and ecological status. The 2020 conservation targets to maintain clean, healthy, and productive seas meeting Good Environmental Status (GES) standards under the Marine Strategy Framework Directive (2008/56/EC) were not met.

It is, therefore, of greater importance that future vast planning of offshore wind development includes strategies to ensure the protection of nature and ecosystem biodiversity and that the cumulative impacts of development are considered, so as not to exceed the carrying capacity of the seas.

The largest global player in offshore wind, the United Kingdom (UK), has committed to increase the country's offshore wind energy generation to 40 GW by 2030.

Offshore renewables could account for

30% **of the emissions reductions needed by 2050.**

Photo © Tyler Butler

In line with the Birds (2009/147/EC) and Habitats Directives (92/43/EEC), the health of seabird populations, in terms of their distribution, abundance, and conservation status and the protection of natural habitats they rely on, form a key part in achieving Good Environmental Status.

Strategic, ecosystem based marine spatial planning (MSP) is regarded as the way forward for Member States to meet this goal inside and outside designated protected areas. There is a need for careful examination of the potential impacts to nature and seabird populations, which are already under extreme pressure by multiple threats (Dias et al., 2019). It is timely that understanding the spatial sensitivity of seabirds is explored as marine spatial plans are currently being drawn up across Europe, under the Marine Spatial Planning Directive (2014/89/EU).

These plans will be used to identify areas suitable for development with the aim of minimising impact to wildlife by avoiding areas of highest sensitivity. Spatial tools, such as bird sensitivity maps, are extremely useful resources for spatial planning of wind energy development (Bradbury et al., 2014).

BirdLife Europe participates in the Offshore Coalition for Energy and Nature (OCEaN), a European multi-stakeholder working group which includes environmental NGOs, transmission system operators (TSOs), and the wind industry. This group is facilitated by the Renewables Grid Initiative (RGI) and aims to build a collaborative effort in protecting nature and biodiversity, while supporting necessary offshore wind energy development in line with the carrying capacity of the North Sea and Baltic Sea. The initiative shall further work towards the sustainable development of offshore energy infrastructure that protects our marine ecosystems, by supporting an ecosystem-based approach in the application and implementation of marine spatial planning in the different Member States.

Together, the working group identified actions needed for better maritime spatial planning in Europe starting with the North Sea and Baltic Sea. One of the most urgent areas identified by the working group pertains to the poor availability and accessibility of data, in particular environmental data, needed to inform marine spatial planning and the siting of future offshore wind development.

This Report

This report has been complied by BirdLife Europe & Central Asia to address the availability and accessibility of environmental data, focusing on a review and summary of seabird data sources in the North Sea and Baltic Sea.

Aims and Objectives

The aim of this work is to identify available environmental data, experts, and current research on seabirds at-sea and their interactions with offshore wind farms. These resources will be compiled into a database, that directs users to spatial and temporal data on the distribution and abundance of seabirds to support the development of marine spatial plans in the North Sea and Baltic Sea.

This work has four main objectives:

1. Identify available data sources for seabird distribution and abundance for the North Sea and Baltic Sea, with particular focus on data sets held by BirdLife partners, that may not be accessible to the broader public

2. Review current knowledge of so called "high-risk species" of seabirds and identify the criteria needed to assess the sensitivity of seabirds to offshore wind farms

3. Identify existing survey methods and technologies for the collection of data on seabirds at-sea and consult with experts on the best practise, methods, and relative ability of different survey techniques to also collect data for sensitivity mapping

4. Identify data gaps and focal areas for future studies

Photo © Arthur Knoepflin

Methodology

Research Approach

This work included a combination of a systematic literature review and an online database search to identify current research, data sources, and leading experts, who collect data on seabird distribution and abundance in the North Sea and Baltic Sea.

The literature review also covered research on the impacts and interactions between offshore wind farms and seabirds, in order to identify high-risk species and current guidelines and methods for surveying and monitoring seabirds at-sea. To focus our search on data not currently shared with the wider public (grey literature), a questionnaire was created **(Annex 1)** to quickly gather information from BirdLife partners **(Table 1)**. Follow-up online interviews were conducted to supplement and clarify information gathered from questionnaires.

Communications and interviews were also carried out with pre-selected experts to discuss current research and data gathering efforts already in place and to establish the location and accessibility of additional data sources.

Expert Workshops

BirdLife partners and experts were consulted during two online workshops to discuss and review identified data and to provide additional input on data sources and guidelines for survey methods.

The workshops were comprised of presentations of the data sources being reviewed and an interactive discussion session. The session included a white board application (MIRO) which allowed participants to provide written responses to questions. During both workshops, participants were consulted regarding their opinions on data and knowledge gaps in the available spatial and temporal distribution data of birds at-sea and on best practise guidance for data collection and survey methods.

Table 1. BirdLife Partners consulted in this study.

Country/Territory	Organization
Estonia	Estonian Ornithological Society (EOS)*
Latvia	Latvian Ornithological Society (LOB)*
Lithuania	Lithuanian Ornithological Society (LOD)* **
Finland	BirdLife Finland*
Poland	Polish Society for the Protection of Birds (OTOP) *
Sweden	Swedish Ornithological Society (SOF)* **
Germany	Nature and Biodiversity Conservation Union (NABU) **
Denmark	BirdLife Denmark (DOF)
Norway	Norwegian Ornithological Society (NOF)
Iceland	BirdLife Iceland – (ISPB)*
UK	Royal Society for the Protection of Birds (RSPB)**
Ireland	BirdWatch Ireland**
Faroe Islands	Faroes Ornithological Society
Belgium	Natuurpunt*
Netherland	Society for the Protection of Birds (VBN)**
France	Ligue pour la Protection des Oiseaux (LPO)*

*** Partners that provided responses to the questionnaire (written responses and/or follow up interviews).**

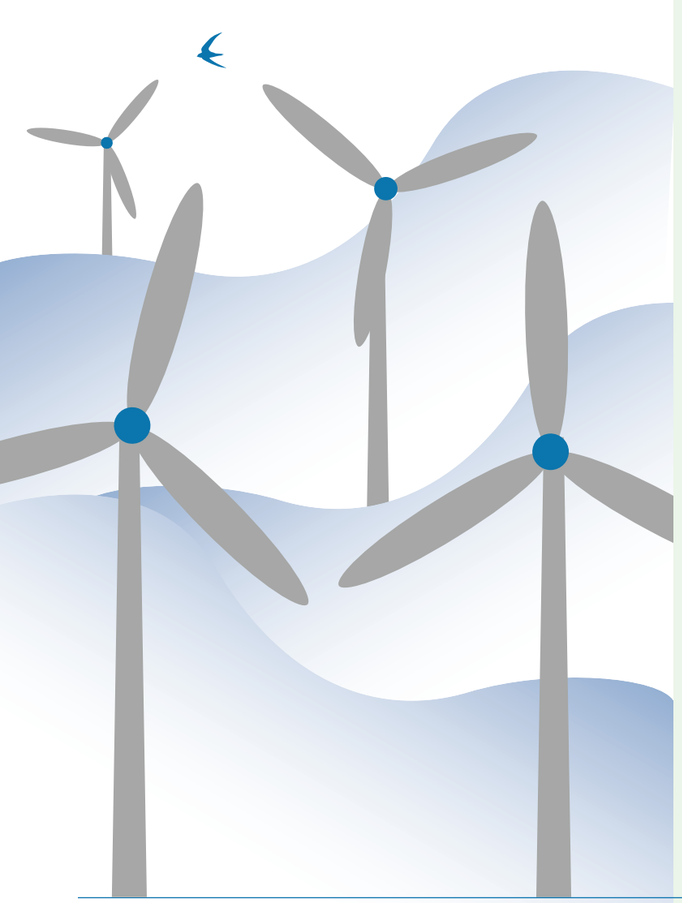
**** Partners that provided input through online workshops.**

Research Output

While identifying independent and scattered data sources, a metadata database was created for regional-scale baseline-data, along with individual databases for national data sources identified by BirdLife partners.

The databases contain information on the existing spatial data sets, including descriptions of the data, the species covered, location and temporal coverage of the study, and the data owner or data holder who can provided accesses to the data set. Additionally, an expert contact list and reference library were created for future reference.

A table of seabirds for the North Sea and Baltic Sea, along with their 2015 European population sizes, conservation statuses, and vulnerability rankings, were also created.



Data Sources

Seabird Abundance and Distribution

The North Sea and Baltic Sea support internationally important populations of seabirds, seaducks, and other waterbirds.

Most seabirds spend the majority of their lives in the marine environment. However, they are not evenly distributed at sea and are frequently aggregated in key areas influenced by prey distribution and habitat features, such as shelf edges and ocean fronts.

Potential sites for development of offshore wind farms include locations that may support these aggregations, making these locations highly sensitive to human development. The identification of important marine areas for seabirds is a challenge, as they are highly mobile and use different habitats at different times of the year, with changes occurring among different age groups within each species.

Therefore, the full impact of wind farm development can only be understood with broad temporal and spatial data for species using a given area.

Marine spatial planning should aim to account for the year-round distribution and abundance of seabirds and consider corresponding variability across the breeding, over-wintering, and migration periods and across different age classes (e.g., adults, immatures, juveniles).

To identify important at-sea areas for seabirds, and to carry out a spatial assessment of locations that are sensitive to development, key information is needed including:

1. Bird locations, including seasonal and age-related variations
2. Colony locations, including the connectivity between the at-sea distributions and breeding colonies, as well as population-specific migratory pathways
3. Site-specific activities: are birds foraging, resting, or commuting between colonies and their feeding grounds
4. Species vulnerability: species-specific conservation, life history characteristics, and ecology

Baseline Data Sets

Available seabird distribution and abundance data for the North Sea and Baltic Sea were identified to support the development of marine spatial plans and seabird sensitivity maps.

Spatial data sets include information on:

Abundance – Counts of seabirds at-sea, land-based winter and passage counts and population counts at breeding colonies and over-wintering sites

Distribution – The location of seabirds at-sea during different times of the year and locations of major breeding colonies and overwintering sites

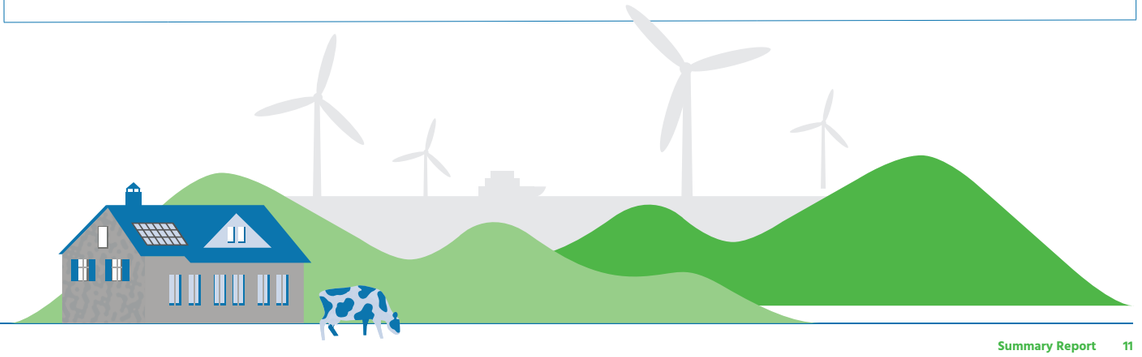
Movement – The connectivity between colonies and potential development sites, foraging movements, and migration pathways

The following table **(Table 2)** provides a summary of the identified baseline data sets that are collected for seabirds within these sea basins.

Photo © Shubham Shrivastava

Table 2. Baseline data sources for seabird abundance and distribution in the North Sea and Baltic Sea.

Data Set	Description	Data Holder	Sea Basin	Season and Data Type
European Seabirds at Sea (ESAS)	The European Seabirds at Sea (ESAS) database was established in 1991 as a collaboration between individuals and institutes around Europe. The database is comprised of ship and aerial at-sea survey data from national parties covering seabird and marine mammal distribution in offshore areas. It contains over 3 million records of seabirds, cetaceans, pinnipeds, and other marine megafauna from Northwest European and North Atlantic waters. It is the largest database of at-sea seabird distributions, with data collected and contributed by the 10 European countries comprising the ESAS partnership.	JNCC ICES Data Centre	Greater North Sea Northeast Atlantic	All Year, Abundance and Distribution data
Reports and site links: Camphuysen et al (2004). Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the U.K.: a comparison of ship and aerial sampling methods for marine birds, and their applicability to offshore wind farm assessments (PDF, 2.7 mb), NIOZ report to COWRIE (BAM – 02-2002), Texel, 37pp. https://tethys.pnnl.gov/sites/default/files/publications/Camphuysen-et-al-2004-COWRIE.pdf. Kober et al (2010). An analysis of the numbers and distribution of seabirds within the British Fishery Limit aimed at identifying areas that qualify as possible marine SPAs, http://jncc.defra.gov.uk/page-5622 **Data Set Download available at:** JNCC (Version 5.0, data from 1979-2011) - https://hub.jncc.gov.uk/assets/5c7d5eca-9b5f-4781-809f-f27c94d94661 OBIS-SEAMAP (Version 4.1, data range 1979 – 2000) http://seamap.env.duke.edu/dataset/427 **Database Update**- Rijkswaterstaat (Dutch ministry of Infrastructure and Water Management) has commissioned a consortium of the Belgian INBO (Institute for Forest and Nature Research), the Dutch consultancy Bureau Waardenburg B.V. and the German University of Kiel to update the ESAS database with surveys available (from UK, Belgium, The Netherlands, and Germany). The updated data set (ESAS version 6.1) will be transitioned to the ICES datacentre.			
Volunteer Seabirds at Sea (VSAS)	Volunteer collected seabird data from scheduled ferry routes. Data collection follows ESAS protocols.	JNCC *https://jncc.gov.uk/our-work/volunteer-sea-birds-at-sea-surveys/*	North Sea (UK)	All Year, Abundance, and Distribution data
Visual Aerial Bird Survey Data	Visual aerial survey data collected for seaducks, divers, grebes, and little gulls. Data were collected visually from aircraft, at sites identified as holding potentially important aggregations of non-breeding waterbirds. The data collected were used to inform SPA recommendations.	JNCC *https://hub.jncc.gov.uk/assets/10f6f1b-6d8d-449c-a572-f9411dd65d46*	North Sea (UK)	Non-Breeding, Abundance, and Distribution data
Seabird Tracking Database	The BirdLife International Seabird Tracking Database serves as a central store for seabird tracking data from around the world and holds the largest collection of seabird tracking data.	BirdLife International *http://www.seabirdtracking.org/*	Global	Breeding, Non-breeding, and Foraging ranges, Distribution data
Movebank Tracking Database	Movebank is a free, online database of animal tracking data hosted by the Max Planck Institute of Animal Behaviour. Seabird tracking data for the North and Baltic Sea can be searched and relevant data holders contacted to request access.	MoveBank *https://www.movebank.org/cms/movebank-main*	Global	Breeding, Non-breeding, and Foraging ranges, Distribution data
Seabird at-sea distribution maps and breeding population trends, Norway	SEAPOP (SEAbird POPulations) is a long-term monitoring and mapping programme for Norwegian seabirds that was established in 2005. The programme covers seabird populations in Norway, Svalbard, and adjacent sea areas. Seabird distribution maps constructed from at-sea transect surveys can be downloaded from their online data portal. Data also include population trends (abundance, productivity, survival, diet) for seabirds breeding in Norway.	SEAPOP *https://seapop.no/en/*	North Sea, Norwegian Sea, and Barents Sea	Breeding and Non-breeding. Abundance and Distribution data
Reports and site links: **SEAPOP 2019 Seabird monitoring and population trends in Norway:** Anker-Nilssen, T., Barrett, R., Christensen-Dalsgaard, S., Dehnhard, N., Descamps, S., Systad, G.H.R., Moe, B., Reiertsen, T.K., Bustnes, J.O., Erikstad, K.-E., Follestad, A., Hanssen, S.A., Langset, M., Lorentsen, S.-H., Lorentzen, E., Strøm, H. (2020). Key-site monitoring in Norway 2019, including Svalbard and Jan Mayen. SEAPOP Short Report 1-2020: 15 pp. https://seapop.no/en/publications/published-seapop/published-2020/			
GLS tracking data, non-breeding	Seatrack database holds GLS (global location sensor) data on the non-breeding distribution of 10 seabird species breeding in colonies encircling the Labrador, Greenland, Barents, Norwegian, North and Irish Seas, which includes colonies in Canada, Greenland, Russia, Norway (incl. Svalbard and Jan Mayen), Iceland, the Faroe Islands, Ireland, and the United Kingdom.	SEATrack database (SEAPOP). Information and data requests are available from *https://seatrack.seapop.no/map/*	North Sea, Norwegian Sea, and Barents Sea	Non-breeding, Distribution data
Future of the Atlantic Marine Environment (FAME) Project and Seabird Tracking and Research (STAR)	The two projects have organised the tracking of seabirds on the coast of Britain and Ireland (2010 – present). Data are available on foraging routes and distances of selected individuals. Additional tracking of herring and lesser black-backed gulls, as part of a wider project, are also available.	RSPB Access to open data portal and data request form are available at: *https://www.rspb.org.uk/our-work/conservation/conservation-and-sustainability/mapping-and-gis/*	Northeast Atlantic, North Sea	Breeding, Non-breeding, and Foraging ranges, Distribution data
Reports and site links: **Technical Report:** Cleasby, I.R., Owen, E., Wilson, L. and Bolton, M., (2018). Combining Habitat Modelling and Hotspot Analysis to Reveal the Location of High Density Seabird Areas Across the UK: Technical Report (No. 63). RSPB Research Report. https://www.rspb.org.uk/globalassets/downloads/documents/conservation-science/cleasby_owen_wilson_bolton_2018.pdf **Published models of species distributions using collected tracking data:** Wakefield, E.D., Owen, E., Baer, J., Carroll, M.J., Daunt, F., Dodd, S.G., Green, J.A., Guilford, T., Mavor, R.A., Miller, P.I. and Newell, M.A., (2017). Breeding density, fine-scale tracking, and large-scale modeling reveal the regional distribution of four seabird species. Ecological Applications, 27(7), pp.2074-2091. https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/eap.1591			
Marine Ecosystems Research Programme – Top Predator Project	MERP scientists undertook a major project to collate a data resource from observations in the Northeast Atlantic, covering seas from Norway to Portugal. The study looked at data resulting from 2.19 million km of cetacean surveys and 1.36 million km of seabird surveys. This comprised 226,000 hours of aerial and vessel surveys, covering 2,148,000 km2 and 127 species. From this, density surfaces for the 12 most common seabirds and the 12 most common cetacean species, at 10Km and monthly resolutions over 32 years were produced. **Seabird species include:** Atlantic puffin, black-legged kittiwake, common guillemot, European shag, European storm petrel, great skua, herring gull, lesser black-backed gull, Manx shearwater, northern fulmar, northern gannet, razorbill	James Waggitt, Bangor University, *https://www.marine-ecosystems.org.uk/Research_outcomes/Top_predators*	Northeast Atlantic, North Sea	All Year, Distribution data
Reports and site links: **Published data:** Waggitt, James et al, (2020). Distribution maps of cetacean and seabird populations in the North-East Atlantic. Journal of Applied Ecology, 57(2), 253–269. https://doi.org/10.1111/1365-2664.13525 Waggitt, James et al, (2019). Data from: Distribution maps of cetacean and seabird populations in the North-East Atlantic, Dryad, Data Set, https://doi.org/10.5061/dryad.mw6m905sz				



Data Set	Description	Data Holder	Sea Basin	Season and Data Type
IWC (International Waterbird Census) Mid-winter waterbird census.	The International Waterbird Census (IWC) is a site-based counting scheme for monitoring waterbird numbers, organised since 1967 by Wetlands International, formerly the International Waterfowl and Wetlands Research Bureau (IWRB). The census takes place every year in over 100 countries with the involvement of around 15,000 counters, most of whom are volunteers. More than half the effort is concentrated in Europe. In the Northern Hemisphere a co-ordinated midwinter census takes place in mid- January and remains the most important contribution of national waterbird monitoring schemes to IWC. Details of the counts and the sites where they take place are held on the IWC database. Counts are conducted on land, by boat, and by aerial surveys. Specialised methods to supplement standard counts are often used, including counting roost sites, colonial nesting seabirds and separation of age classes	Wetlands International *http://wpe.wetlands.org/*	Includes North Sea and Baltic Sea nearshore and inshore areas	Non-breeding, Distribution and Abundance data
HELCOM HOLAS II Core Indicator Project – Abundance of waterbirds	The HOLAS II Project gives an update on the overall state of ecosystem health in the Baltic Sea. The assessment follows up on the goals of the Baltic Sea Action Plan and is developed so that the results can support reporting under the EU Marine Strategy Framework Directive (MSFD) by those Contracting Parties to the Helsinki Convention that are also EU member states. The project includes core indicator assessments for biodiversity including the status of abundance of wintering and breeding waterbirds in the Baltic Sea region. Data are available only for coastal areas.	HELCOM *https://helcom.fi/helcom-at-work/projects/holas-ii/*	Baltic Sea	Breeding and Non-breeding, Distribution and Abundance data
Reports and site links: **HELCOM core indicator report 2018**: Abundance of waterbirds in the breeding season- https://helcom.fi/wp-content/uploads/2019/08/Abundance-of-waterbirds-in-the-breeding-season-HELCOM-core-indicator-2018.pdf **HELCOM core indicator report 2018:** Abundance of waterbirds in the wintering season - https://helcom.fi/wp-content/uploads/2019/08/Abundance-of-waterbirds-in-the-wintering-season-HELCOM-core-indicator-2018.pdf **Data download available:** **Breeding:** http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/86bb9eaa-4932-4fa7-830e-30a3dbc10e3a **Wintering:** http://metadata.helcom.fi/geonetwork/srv/eng/catalog.search#/metadata/a3c594e0-969e-4aee-b5a7-643c4b853de4				
Seabird Monitoring Programme (SMP), UK	Annual monitoring programme of 25 species of seabird that regularly breed in Britain and Ireland - includes annual reports and trends that can be viewed online, as well as colony counts that can be downloaded as an excel spreadsheet.	JNCC	North Sea (UK)	Breeding, Abundance data
Reports and site links: **Background Information JNCC:** https://jncc.gov.uk/our-work/seabird-monitoring-programme/ **Seabird Monitoring Programme Online database:** https://app.bto.org/seabirds/public/index.jsp **Monitoring methods:** Walsh, P.M., Halley, D.J., Harris, M.P., del Nevo, A., Sim, I.M.W. & Tasker, M.L. (1995). Seabird monitoring handbook for Britain and Ireland. JNCC / RSPB / ITE / Seabird Group, Peterborough. ISBN 1 873701 73 X. https://hub.jncc.gov.uk/assets/bf4516ad-ecde-4831-a2cb-d10d89128497				
Seabird Censuses, UK	National seabird census recording entire seabird population of Britain and Ireland (except gannets), initially carried out between 1998 and 2002. More recent census (Seabirds Count) started in 2015 and expected completion for 2021.	JNCC *https://jncc.gov.uk/our-work/seabird-censuses*	North Sea (UK)	Breeding, Abundance data
Reports and site links: Seabird Populations of Britain and Ireland: results of the Seabird 2000 census 2004, https://hub.jncc.gov.uk/assets/1dae7357-350c-483f-b14d-7513254433a5 Mitchell, P.I., Newton, S.F., Ratcliffe, N. & Dunn, T.E. (2004). Seabird Populations of Britain and Ireland, JNCC, Peterborough, ISBN 0 7136 6901 2. https://data.jncc.gov.uk/data/1dae7357-350c-483f-b14d-7513254433a5/S2000-seabird-pop-exec-summary.pdf Seabird colony data downloadable; https://webarchive.nationalarchives.gov.uk/20190301135521/http://jncc.defra.gov.uk/page-4460-theme=default				

Trilateral Wadden Sea Cooperation -Trilateral Monitoring and Assessment programme (TMAP) - Joint Monitoring Breeding Bird Group	Joint monitoring programme of the Wadden sea. TMAP is carried out by national and regional authorities in charge of monitoring from Denmark, Germany and the Netherlands. Monitoring of breeding birds within TMAP has been carried out for a selection of coastal breeding birds since 1991 and is co-ordinated by the Joint Monitoring Breeding Bird group in the Wadden Sea (JMBB). Since 2009-2010, monitoring of breeding success has been added as TMAP parameter. 35 breeding bird species are monitored, most species are counted annually in the entire Wadden Sea to retrieve yearly total. (species include: shorebirds (Charadriiformes); ducks, geese and swans (Anseriformes); divers (Gaviiformes); grebes (Podicipediformes); cormorants (Suliformes); and gulls, terns and auks (Charadriiformes). Every six years, a total count is carried out for all TMAP-breeding bird species, to monitor changes in total population size and distribution.	Wadden Sea World Heritage *https://qsr.wadden-sea-worldheritage.org/reports/breeding-birds*	Wadden Sea, Southern North Sea	Breeding, Abundance data
Trilateral Monitoring and Assessment programme (TMAP)_ Joint Monitoring of Migratory Birds (JMMB) in the Wadden Sea and Wadden Sea Flyway Initiative (WSFI)	Joint Monitoring of Migratory Birds (JMMB) in the Wadden Sea, carried out in the framework of Trilateral Monitoring and Assessment Program (TMAP), consists of (a) at least two synchronous, complete counts each year, one of them in January, the other one in another month shifting from year to year and (b) frequent (bi-monthly to monthly) spring tide counts at 60 counting sites, (c) additional three counts for geese (March, May, November), and (d) aerial counts for Eider in winter and for Shelduck during wing moult (July/August) in Germany and the Netherlands. At present a total of 594 counting units from the Wadden Sea are included in the analyses. These surveys allow statistically sound estimations of numbers, phenology, and trends.	Wadden Sea World Heritage *https://qsr.wadden-sea-worldheritage.org/reports/migratory-birds*	Wadden Sea, Southern North Sea	Non-breeding, Abundance data

National Data Sources

To access a wider range of data sources that may not be publicly available, BirdLife partners from countries with territorial waters and exclusive economic zones (EEZ) in North Sea and/or Baltic Sea were approached by questionnaire and interview to request information on any relevant data they may hold.

Representatives from 10 partner countries responded with completed questionnaires and/or participated in follow-up interviews **(as detailed in Table 1)**.

An overview of the identified National data sources are provided in **Annex 2**. These data sources include national offshore survey programmes and archived offshore surveys **(Table 3)**, national breeding and winter bird counts, and independent research and telemetry tagging studies.

Data sources for seabirds in the North Sea and Baltic Sea are collected and held by a range of organisations. In addition to BirdLife's national partners, regional and national data sets collected or held by external parties were identified. These included data from research institutes and universities, NGOs, environment agencies, intergovernmental organizations, regional sea conventions, and statutory advisory bodies. A list of national organisations and research institutes contacted are included in **Annex 3**.

Knowledge of seabird distribution and their interactions with offshore wind farm development is continuously improving. The identified data sources and research projects provided in this document and in the supplementary materials are not an exhaustive list. There is a large amount of bird data collected to inform coastal and marine development as part of Environmental Impact Assessments (EIA) and post-construction monitoring. These data are often held by industry and developers and are not always easily accessible or publicly available; however, in some cases the data may be made public or be requested from national government regulatory bodies or public bodies such as The Crown Estate in the UK.

Sensitivity Maps

The use of spatial seabird data at an early stage will increase the likelihood of finding pragmatic solutions, through marine spatial planning, to mitigate the negative impacts on seabirds and promote suitable areas for offshore wind development.

Table 3. Years in which national offshore boat and/or aerial surveys were conducted in the North Sea or Baltic Sea. Blue cells indicate a survey took place that year. Red cells indicate the year in which a national monitoring programme was adopted.

Country	1970-79	1980-89	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Norway - North Sea																																
UK																																
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At BirdLife we recommend using spatial tools, such as sensitivity mapping, to identify important areas for seabirds. Priority data needed for sensitivity mapping includes:

- Seabird Species (e.g., focussing on key species, such as very-high risk species)
- Breeding Colony Size
- At-Sea Distribution and Density of Seabird Species
- Connectivity to Breeding Colonies
- Foraging Ranges
- Risk Scores (Species Sensitivity Indices)

The use of a range of data sources, such as those identified in **Table 2**, will allow for a composite of seabird data to be utilised and provide information for each of the input data needs for sensitivity mapping.

The ESAS survey data is an important resource tool for sensitivity mapping, providing data on seabird abundance, distribution, and behaviour at sea.

For at-sea distributions and densities, we recommend combining the ESAS survey data and national offshore survey data with other distribution data sets, such as seabird tracking studies, utilising all available evidence to identify seabird 'hotspots'.

Detailed seabird and marine mammal distribution maps have been created for the Northeast Atlantic using ESAS data and other identified at-sea surveys (Waggitt et al., 2020). Maps like these provide a basis for the development of sensitivity maps. Once sensitive species have been identified, planners can map the distribution and abundance of these species, at different times of year, for individual sensitive species or all species using the same area. Combining species densities with seabird sensitivity scores will further highlight sensitive areas. Such an analysis should help identifying offshore areas that are of likely importance for seabirds, as well as areas which have lower seabird activity and may be better suited to development.

These spatial outputs can then be compared with planned activities to guide development in areas with lower vulnerability or lower seabird activity.

Current examples and methods for developing seabird sensitivity mapping for offshore wind development are the SeaMaST project, developed by Natural England (Bradbury et al., 2014), and the Scottish Maine Seabird Sensitivity tool, developed by the Centre of Ecology and Hydrology in collaboration with the Offshore Renewable Joint Industry project (ORJIP; Searle et al., 2019).

Vulnerable Seabird Species

In Europe, many marine birds breed within Special Protection Areas (SPAs) and are protected by European law under the Birds Directive (2009/147/EC).

The development and operation of offshore wind farms has the potential to negatively impact protected marine birds at an individual (Dierschke et al., 2016) and population level (Masden & Cook, 2016; Thaxter et al., 2015). These negative effects are a result of direct mortality by collision, or by loss of habitat and changes in distribution through displacement and barrier effects (Dierschke et al., 2016; Drewitt & Langston, 2006; Furness et al., 2013; Vanermenet al., 2015a).

To improve understanding of seabird interactions with offshore wind farms, research into the specific characteristics that determine a species' vulnerability have been the focus of many studies.

These include biological characteristics that can influence collision risk, such as body size, flight height, and flight speed (Masden & Cook, 2016; Thaxter et al., 2015), and behavioural characteristic ranging from complete avoidance, that can lead to the loss of habitat, or attraction to sites, that can lead to an increased risk of collision with turbines (MacArthur et al., 2012; Peschko et al., 2020a; Vanermen et al., 2015b).

The interactions of seabirds with offshore wind turbines ultimately depend on the placement of offshore developments and how these overlap with seabird habitats and movements/distribution. Seabird distribution and use of habitats are diverse and species specific. Individuals and populations will be differentially exposed depending on their breeding, foraging, and migratory strategies (Peschko et al., 2020b; Skov et al., 2016; Waggitt et al., 2020). These seasonal changes in distribution need to be considered when assessing the impact of offshore wind and determining which species may be at risk through their lifecycle.

To identify seabird species at high-risk in the North Sea and Baltic Sea, we reviewed current literature on seabird sensitivity and interactions with offshore wind farms and summarised the criteria used to assess species risk and create seabird sensitivity indices **(Table 4)**.

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Criteria for Assessing Seabird Sensitivity Indices

There is a strong incentive to improve understanding of the risks of offshore wind to seabirds and to develop better directed monitoring. A means to identify which species are most vulnerable is therefore necessary.

A well-established approach has been to use indices of sensitivity, or population vulnerability, to particular hazards (Garthe and Hüppop, 2004; Furness et al., 2013). Sensitivity indices are used by regulators and developers during initial scoping and impact assessments. They are also used in sensitivity maps, combined with data on seabird densities, to identify "hotspot" areas of high risk (Bradbury et al., 2014; Gove et al., 2013; Leopold & Dijkman, 2007; Searle et al., 2019).

Garthe and Hüppop (2004) developed an index of seabird sensitivity to offshore wind farms based on conservation importance scores for different species and perceived behaviour-related risks of collision and displacement.

These scores were combined into a single index to give a species vulnerability score. These seabird sensitivity indices have since been updated by incorporating new data and expanding the species lists (Bradbury et al., 2014; Humphreys et al., 2015).

The criteria to assess sensitivity has also been adapted by separating species assessments for collision and displacement, resulting in two unique index scores (Furness et al., 2013). This is particularly useful, as the species that are most at risk from collision tend to differ from those most at risk from displacement. Recent work has taken this further by separating displacement risk into two scores based on displacement by structures and displacement by ship or helicopter traffic (Wade et al., 2016). The criteria scored in these assessments and sensitivity equations are given in detail in **Table 4**.

Table 4. List of criteria and sensitivity equations used in seabird sensitivity indices as measures of vulnerability to offshore wind farms.

Conservation Important	Description	
Birds Directive	Considers the species status as classified by the European Commission under the Birds Directive. E.g., Furness et al. (2013) scored Annex 1 species as 5 (most vulnerable), migratory birds which are feather of Special Protected Areas (SPAs) as 3, and other bird species as 1 (least vulnerable)	
Percent of Biogeographical Population	Emphasis on the importance of species in the focal area and local endemism	
Adult Survival	Considers the impact of added mortality to adult birds with high or low natural survival rates. (i.e., added mortality to species with high natural survival rates and corresponding low productivity, has a greater impact on population dynamics than added mortality to populations with low survival rates)	
Threat Status	Reflects the conservation status of the species for the given country or for the regional scope of the assessment. E.g., a species national Red List Status or European Red list Status	
Behavioural Attributes	**Description**	**Pressure Type**
Flight Altitude	Typically presented as a percentage of time flying at blade height - Considered to be the most important factor for assessing risk to collision of marine birds with offshore wind turbines	Collision
Flight Manoeuvrability	Typically presented as a percentage of time flying at blade height - Considered to be the most important factor for assessing risk to collision of marine birds with offshore wind turbines	Collision
Percentage of Time Flying	Indicates the risk of collision because marine birds that spend more time flying while at sea are more likely to be at risk of collision	Collision
Nocturnal Flight Activity	Estimated time spent flying at night based on published literature	Collision
Disturbance by Wind Farm Structures	Based on published literature of a species avoidance or attraction behaviour	Displacement
Disturbance by Ship and Helicopter Traffic	Based on published literature of a species avoidance or attraction behaviour	Displacement
Habitat Specialisation	Represents the range of habitats that species use and whether they use these as specialists or generalists	Displacement

Seabird sensitivity index equations created by Furness et al., (2013).

Collision Risk = Flight altitude x (Flight Manoeuvrability + % time flying + Nocturnal activity)/3 X Conservation Importance

Displacement Risk = ((Displacement by wind farm structure x Displacement by ship and helicopter traffic) x Conservation Importance)/10

High-risk Species in the North Sea and Baltic Sea

To identify priority seabird species at potential risk from offshore wind development in the North Sea and Baltic Sea, a comprehensive list of species for these regions was compiled **(Annex 3)**.

This list is based on a BirdLife International Seabird Species list for the North Sea and Baltic Sea combined with HELCOMs Core indicator species (Helcom, 2018a, 2018b) for the Baltic Sea. The HELCOM indicator list also includes waterfowl and wader species.

These species were kept in the assessment as they are deemed important marine indicators for the Baltic Sea region. There are many other non-marine bird species, such as raptors, cranes, and passerines, which also have the potential to be negatively impacted by offshore wind. These are not included in this report, which is focused on species commonly associated with marine environment.

However, some of these species are addressed when reviewing expert opinions on priority at-risk species.

Risk categories were applied to the complete list of species **(Annex 3)** from published seabird sensitivity scores (Humphreys et al., 2015). Seabird species identified as being at very high or high-risk to collision or displacement effects of offshore wind farms in the North Sea and Baltic Sea are shown in **Table 5**.

Seabirds identified as being at very high or high risk should be prioritised for further assessment and monitoring by regulators and developers when planning wind development.

For this assessment, risk categories published in Humphreys et al. (2015) were used, as these were based on scores excluding conservation criteria from the final population vulnerability scores.

It was deemed more appropriate in this assessment to use a scoring system based solely on flight characteristic and overall species ecology to look beyond a national conservation level.

The priority of species based on their conservation scores will depend on the scale of interest, i.e., the conservation status and priority of a species is different at national, EU, or Global scales.

However, it should be recognised that currently published species sensitivity scores are largely based on indirect knowledge of seabird behaviour and responses to offshore wind farms, in which there is still large amounts of uncertainty. This is in part due to the infancy of the industry and corresponding seabird research but also the logistical challenges and inadequate procedures used to carry out field-based research as part of Environmental Impact Assessments (EIA; Green et al., 2016).

Table 5. Identified seabird species in the North Sea and Baltic Sea that are at very high or high risk of experiencing negative impacts from offshore wind development through collision or displacement effects. Collision and displacement scores are taken from Humphreys et al., 2015.

Common Name	Species	Sea Basin	Collision Risk	Displacement Risk
Lesser black-backed gull	*Larus fuscus*	North and Baltic	V.HIGH	V.LOW
European Herring gull	*Larus argentatus*	North and Baltic	V.HIGH	V.LOW
Glaucous gull	*Larus hyperboreus*	North Sea	V.HIGH	V.LOW
Iceland gull	*Larus glaucoides*	North Sea	V.HIGH	V.LOW
Great black-backed gull	*Larus marinus*	North and Baltic	V.HIGH	V.LOW
Sabine's gull	*Xema sabini*	North Sea	HIGH	LOW
Northern gannet	*Morus bassanus*	North Sea	HIGH	V.LOW
Black-headed gull	*Larus ridibundus*	North and Baltic	HIGH	V.LOW
Mediterranean gull	*Larus melanocephalus*	North and Baltic	HIGH	V.LOW
Common gull	*Larus canus*	North and Baltic	HIGH	V.LOW
Little gull	*Hydrocoloeus minutus*	North and Baltic	HIGH	V.LOW
Black-legged Kittiwake	*Rissa tridactyla*	North Sea	HIGH	V.LOW
Greater Scaup	*Aythya marila*	North and Baltic	LOW	HIGH
Common Goldeneye	*Bucephala clangula*	North and Baltic	LOW	HIGH
Common Scoter	*Melanitta nigra*	North and Baltic	LOW	HIGH
Goosander	*Mergus merganser*	North and Baltic	LOW	HIGH
Red-throated diver	*Gavia stellata*	North and Baltic	LOW	HIGH
Black-throated diver	*Gavia arctica*	North and Baltic	LOW	HIGH
White-billed diver	*Gavia adamsii*	North Sea	LOW	HIGH

As a result there is a lack of direct and scientifically sound empirical evidence related to seabird behaviour at operational offshore wind farm sites. The quantity and quality of data behind individual species scores is highly variable. Sensitivity scores may rely on data from anecdotal observations or indirect studies, or may be based on direct studies at wind farms sites and studies using robust methods such as radar and GPS (Wade et al., 2016).

Sensitivity scores should be viewed as a work in progress and should be updated with the most recent data as research continues. It is important to acknowledge the level of uncertainty for individual species sensitivity scores and to identify future areas of research to alleviate this issue. Wade et al. (2016) highlighted several species scores that are currently based on a high level of uncertainty **(Table 6)** and species which need additional research and monitoring.

Table 6. Species identified by Wade et al. (2016) as having high levels of uncertainty in their vulnerability assessment to offshore wind farms.

Species
European storm petrel (*Hydrobates pelagicus*)
Leach's storm petrel (*Oceanodroma leucorhoa*)
Sooty shearwater (*Ardenna grisea*)
Artic Skua (*Stercorarius parasiticus*)
Common Goldeneye (*Bucephala clangula*)
Greater Scaup (*Aythya marila*)
Long-tailed duck (*Clangula hyemalis*)
Manx shearwater (*Puffinus puffinus*)
Roseate tern (*Sterna dougallii*)
Velvet scoter (*Melanitta fusca*)
Little tern (*Sternula albifrons*)
Grebe spp.

To date, most published seabird sensitivity indices for offshore wind development have focused on North Sea species. We have highlighted species from our list **(Annex 3)** that have not been assessed under any sensitivity scoring and have an unknown risk to the impacts of offshore wind farms **(Table 7)**.

Many of the unknown species are from the Baltic Sea, or they are rare visitors to the North Sea. There is a need to create sensitivity indices that include Baltic Sea species. Some of the unknown species on our list are coastal or estuarine species, not typically included in sensitivity indices for offshore wind development, however, they may still be impacted during migrations.

Table 7. List of species with unknown sensitivity to collision or displacement risk of offshore wind farms.

Common Name	Species
Harlequin duck	*Histrionicus histrionicus*
King eider	*Somateria spectabilis*
Steller's eider	*Polysticta stelleri*
Brunnich guillemot	*Uria lomvia*
Caspian gull	*Larus cachinnans*
Yellow-legged gull	*Larus michahellis*
Common gull-billed tern	*Gelochelidon nilotica*
Caspian tern	*Hydroprogne caspia*
Black-necked grebe	*Podiceps nigricollis*
Red-necked grebe	*Podiceps grisegena*
Mute swan	*Cygnus olor*
Whooper swan	*Cygnus cygnus*
Tundra swan	*Cygnus columbianus*
Eurasian wigeon	*Mareca penelope*
Mallard	*Anas platyrhynchos*
Northern pintail	*Anas acuta*
Eurasian coot	*Fulica atra*
Common pochard	*Aythya ferina*
Tufted duck	*Aythya fuligula*
Smew	*Mergellus albellus*
Eurasian Teal	*Anas crecca*
Greylag goose	*Anser anser*
Common shelduck	*Tadorna tadorna*
Eurasian oystercatcher	*Haematopus ostralegus*
Pied avocet	*Recurvirostra avosetta*
Ringed plover	*Charadrius hiaticula*
Turnstone	*Arenaria interpres*
Dunlin	*Calidris alpina*

International Workshop

Data Sources and High-Risk Species

National data sources and species lists were sent to all participating partners to review before the online workshop.

Partners were asked to verify the list of identified data sources for their country and provide information on additional data not listed. Partners were also asked to verify the high-risk species and to highlight priority species, not currently identified as priorities, for their countries.

To get feedback from all partners, the workshop was comprised of an open discussion and interactive whiteboard session, with a set of questions to lead the discussion **(Table 8)**. The main discussion and interactive session were carried out in two breakout rooms, split by participants representing either the North Sea or Baltic Sea. Main points identified by participants at the workshop are highlighted in **Box 1**.

Table 8. Set of questions asked during the online workshop.

Webinar Questions
Which of the very high or high-risk species from the list are a priority at a national level? ■ From the complete list, are there other species that should be considered as high-risk to OWF? ■ Are there non-seabird species not listed that are also of high concern?
Are the species identified above likely to be affected directly or indirectly or both? ■ What data sources are a priority for these high-risk species? e.g., tracking data, offshore surveys, colony counts?
What are the key knowledge gaps? ■ What key knowledge gaps are there to help determine vulnerability to offshore wind farms? ■ What are the key spatio-temporal knowledge gaps at a national level regarding species distribution and habitat use?
Which species and locations should receive more attention?

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Box 1: Main points identified by partners

North Sea – Review of high-risk species

In agreement with identified high-risk species:

- Priority high-risk species identified for the North Sea were northern gannets, lesser black-backed gulls, and red-throated divers

Suggested updates to the high-risk species list:

- Red throated divers should be assessed as very high-risk, at least for Belgium and Germany
- Displacement risk is higher than indicated for northern gannets and needs updating
- Kittiwake displacement is also higher than indicated, particularly during the breeding season
- Gull species should remain as very high-risk, but further data is needed to understand within species behavioural differences in avoidance and attraction responses
- Sandwich terns, common guillemots, and razorbills should also be assessed as high-risk

High-risk non-seabird species:

- Passerines, in particular species migrating between the UK and Belgium

North Sea – Review of data needs and knowledge gaps

Suggested priority data needs:

- Population modelling
- Tagging and tracking studies for all high-risk species

Important knowledge gaps were identified as:

- The lack of known flight heights and micro-scale behaviours inside offshore wind farm sites
- Poor understanding of barrier effects and the use and effectiveness of corridors created within and between wind farms
- More data is needed on the distribution of prey species that can strongly influence the distribution of seabirds at sea

Baltic Sea – Review of high-risk species

In agreement with identified high-risk species:

- Priority high-risk species identified for the Baltic Sea were common scoter, greater scaup, lesser black-backed gull, herring gull, black-throated divers, and red-throated divers.

Suggested updates to the high-risk species:

- All seaduck species in the Baltic should be considered as high-risk
- Specific species that should be upgraded to high-risk were long-tailed duck, Caspian tern, velvet scoter and common eider

High-risk non-seabird species:

- White-tailed eagles, short-eared owls, hen harriers, and birds that migrate across the open sea, such as grey herons, white egrets and cranes

Baltic Sea – Review of data needs and knowledge gaps

Suggested priority data-needs and identified knowledge gaps:

- Empirical data on collision risk
- Distribution and movement data from tracking studies for seabirds and seaducks in the Baltic Sea
- Feeding distribution data and tracking studies
- Sensitivity mapping
- Emphasis: data needs are particularly important for migrating seaduck populations that winter in the Baltic Sea

Identified challenges:

- Very little cross-border collaboration on tracking of species and lack of information sharing
- No national or EU regulations to guide what data must be collected for impact assessment and what monitoring should be done

Areas for future research:

- Tracking studies for seaducks, divers, local colonial birds, Caspian terns, lesser black-back gull spp., auks, and kittiwakes (Swedish OSPAR region)
- Development of sensitivity maps for Sweden that include Caspian terns, lesser black-backed gulls, auks, and kittiwakes

Photo © Meritt Thomas

Methods and Technologies to Monitor Seabirds At-Sea

Detailed knowledge on the spatial and temporal patterns of seabird distribution and abundance have been identified as critical components for marine spatial planning updates and environmental impact assessments for future offshore wind development.

Dedicated surveys to sample the number and distribution of seabirds in proposed development sites are a basic requirement for developers (Gove et al., 2013, Trendall et al., 2011).

Monitoring Methods and Available Guidelines

Existing survey techniques were reviewed, identifying the strengths and weaknesses of each method, these were presented to experts. From the existing techniques, experts were asked to identify the best currently available methods for collecting seabird distribution and density data at-sea. Monitoring methods and technologies used to collect data on seabird biological parameters and behavioural responses at offshore wind sites were also identified. The literature was searched for existing guidelines and best practise protocols for the collection of at-sea seabird data and monitoring of impacts.

Based on the review, a basic score of either good, fair, or poor was given to each of the standard survey techniques **(Table 9)**.

Table 9. Survey type ranked as either Good/Fair/Poor/Not available at collecting at-sea seabird abundance and distribution data. *Animal attached telemetry: depends on tag type and additional sensors; temporal coverage often restricted to the breeding season, when birds are most accessible; and depending on additional sensors, different behaviours can be captured.

	Vantage Point	Ship Based	Visual Aerial	Digital Aerial	Animation Attached Telemetry
Spatial Coverage	Poor	Good	Good	Good	Good
Temporal Coverage	Fair	Fair	Fair	Fair	Good*
Population Distribution	Fair	Good	Good	Good	Fair
Abundance	Good	Good	Good	Good	Not available
Detection	Good	Good	Fair	Fair	Not available
Species Identification	Good	Good	Fair	Fair	Not available
Behaviours	Good	Good	Fair	Fair	Good*
Connectivity	Poor	Poor	Poor	Poor	Good
Diurnal Activity	Good	Good	Good	Good	Good
Nocturnal Activity	Not Available	Not Available	Not Available	Not Available	Good

Based on the review of current survey methods, boat-based surveys were identified as a good method for providing data for almost all the criteria needed to assess seabird distribution and abundance. They also fared better than most survey types for their ability to detect and identify a wide range of species.

An additional advantage of boat-based surveys, compared with other techniques, is the ability to collect detailed behavioural information from seabirds during surveys. Constraints of boat-based methods included poor temporal cover, slow survey speeds, high costs, and high effort for surveys, which restrict monitoring frequency and spatial coverage when compared to other methods (excluding vantage point surveys). Also, boat-based surveys have been reported to attract or displace certain species (e.g., northern gannets, fulmars, and some gull species are attracted to boats and diving species, such divers and seaducks, tend to avoid vessels), potentially biasing data (Camphuysen et al., 2004).

Digital aerial surveys have been ranked as fair at detection and species identification. However, recent advances in digital technology and improved camera resolution have improved these surveys, and they are comparable to boat-based surveys for identifying and detecting species. They may also improve species and individual detections, compared to visual aerial surveys. Their efficiency may also allow for increased sample sizes when creating species distribution models (Žydelis et al., 2019).

Though not a standard survey tool, animal attached telemetry can provide high-resolution, species-specific data on both at-sea distribution and behaviour. It also provides information on the connectivity of breeding colonies to development sites, which may be vital for understanding population level impacts and adverse effects to specific SPAs (Butler et al., 2020).

Combining telemetry data with standard survey methods can provide important supplementary information that other methods are unable to collect, including high-resolution behavioural and movement data and diurnal and nocturnal activities. Telemetry studies also provide tracking data during adverse weather events, when other survey methods are not feasible.

Methods and technologies used to collect data on seabird biological parameters and behaviour were also reviewed. **Table 9** and **Table 10** were created to outline available methods and provide a reference for surveying experts for advice on preferred survey techniques and technologies.

There have been a number of standardised guidelines developed for at-sea survey methods (Tasker et al., 1984; Camphuysen et al., 2004; Trendall et al., 2011; HELCOM, 2015). These guidelines provide an overview of the standard survey methods available. Each potential wind energy site will have its own unique characteristics, and therefore, a single standardized protocol would not be appropriate for all developments.

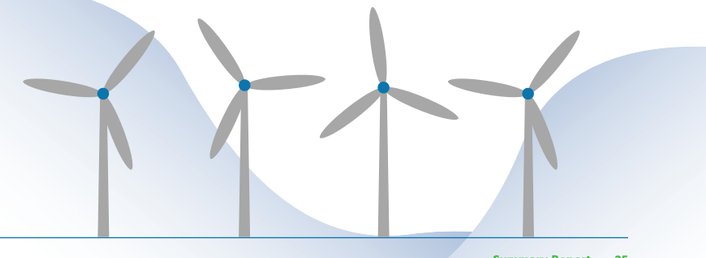
Expert input on site-specific survey and monitoring requirements is essential and must account for the location and scale of the development and the species associated with the site. In the UK, this input is typically carried out during an early consultation process between industry, Statutory Nature Conservation Bodies (SNCBs), and government regulatory bodies to sign off on the survey methods and study design to be used.

Key guidance documents were identified during communications with UK SNCBs, however, not all guidance available for North Sea and Baltic Sea countries were reviewed. Either these documents do not exist, or they are not easily assessable without prior knowledge of regulatory procedures and assistance from regulators at a national level. Communications with national environmental regulators would be beneficial to understand the different procedures and guidelines available for offshore wind developers in all EU countries. From our knowledge there is no single standardised protocol at an EU level.

Identified existing protocols were generally established for traditional methods, such as boat-based and visual aerial surveys. However, recommended survey methods in the UK and Germany have transitioned to digital aerial survey techniques. While there are many other promising technologies available for remote monitoring (i.e., radar, lidar, and animal-attached telemetry), no standardised protocols for their use were found. Many of these methods are still being tested and are more commonly used in scientific studies. A review of remote sensor methods by Largey et al., 2021, has provided an updated framework of how available remote monitoring methods could be incorporated into the impact assessment processes during planning of offshore wind development.

Table 10. Yes/No table depicting the ability of methods/sensors to collect specific bird behavioural characteristics. Species Level Identification – Y* Method provides poor species level identification and can only identified certain species during post processing. Activity in Adverse Weather – Y* Bad weather conditions can interfere with the sensors ability to detect birds.

	Vantage Point	Ship Based	Visual Aerial	Digital Aerial	Animal Attached Telemetry	Radar	Lidar	Laser Range Finder	Microphone Array	Thermal Animal Detection
Flight height	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Flight Speed	N	N	N	N	Y	Y	N	Y	N	N
Species level identification	Y	Y	Y	Y	N	Y*	N	N	Y	Y*
Diurnal Activity	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Activity in adverse weather	N	N	N	N	Y	Y*	N	N	Y*	Y*
Nocturnal activity	N	N	N	N	Y	Y	N	N	Y	Y
Avoidance	N	N	N	N	Y	Y	N	N	Y	Y
Migration	Y	N	N	N	N	Y	N	N	Y	Y



International Workshop

Monitoring Guidelines, Methods and Technologies

Photo © David Clode

Experts were consulted during an online workshop to gain insights for methods and guidelines for surveying seabirds-at sea, and to get input on preferred survey techniques to collect data for sensitivity mapping.

The workshop was comprised of an open discussion and interactive whiteboard session with a set of questions to lead the discussion **(Table 11)**. Main points from the workshop are highlighted in **Box 2**.

Table 11. Set of questions asked during the online webinar.

Webinar Questions
Seabird abundance and distribution
Are current standard survey methods and guidelines for the collection of baseline seabird distribution and abundance data up to date? ■ Are there methods now available that should be used over others (e.g., digital over visual methods)?
Can these survey methods also be used to collect distribution and abundance data at large spatial scales needed for sensitivity mapping? ■ Which methods are best for sensitivity mapping? ■ What are the advantages and disadvantages of the different survey techniques for collecting data for sensitivity mapping?
Seabird abundance and distribution
What are the knowledge gaps for bird biological parameters? Which need further information (flight height, flight speed, nocturnal activity, avoidance)?
How should measures of these parameters be obtained? ■ From the list recommend methods for collecting bird biological parameters. ■ Do these need to be collected at each new development? ■ When should methods to collect bird parameter data be used (baseline surveys, post-consent monitoring, both)?
Can these methods coincide with baseline surveys to collect more accurate bird parameters for risk assessment? ■ Should these be set as new guidelines?
Recommendations & Discussion on Guidelines for Industry
How can we improve/update existing guidelines? ■ From the topics discussed are there any further recommendations? ■ Are there new guidelines being developed?

Box 2: Main points identified by experts

Standardized monitoring methods and guidelines

- Monitoring and survey guidelines in the UK have not been recently updated, but still broadly cover the required process to monitor seabirds at offshore wind farm sites
- In the UK and Scotland, there are pre-evidence and scoping requirements where methods and survey designs are discussed with corresponding statutory nature conservation bodies (SNCBs)
- It seems to be the consensus from the discussion group that having fixed guidelines in the UK would not be beneficial and may make the overall process and design of the surveys less flexible, especially with the current rapid pace of research and understanding in this area
- It was noted, however, that though the process generally requires industry to have methods signed off before surveys, this rarely happens
- In Germany, there are set protocols and monitoring methods for offshore wind development. They work well to standardise methods across wind farms. In general, developers are happy to have standard methods to follow
- Some of the standard monitoring methods cannot be used once wind farms have been constructed, such as visual aerial surveys
- There is no single method that suits all. This largely depends not only on the phase of the development, but the species being investigated, and the questions being asked
- Different methods are suitable for different species, and therefore, flexibility in design is needed. Location and size of the development may also dictate which methods are more appropriate
- Recommended best methods to collect distribution and abundance data were digital aerial surveys and animal attached telemetry

Knowledge gaps for bird behaviours and biological parameters

- Lack of data on avoidance, particularly micro-avoidance behaviour within wind farm sites
- Lack of data for shearwater and petrels
- Poor understanding of the variation in individual behaviour to offshore wind farms

Best Methods to collect seabird parameters and behavioural data

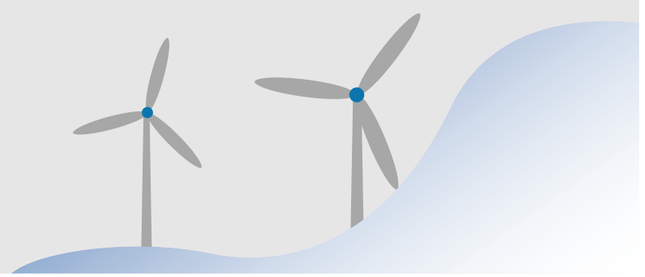
- The use of animal attached telemetry and radar were favoured
- Lidar, joint with digital aerial surveys, was identified as a valuable method for collecting data on flight height
- The use of device mounted cameras, combined with radar and lidar, is a new method that allows the assessment of micro-avoidance movements close to the turbines during post construction monitoring

Methods for sensitivity mapping

- It is important to include a variety of methods so that all available data can be used
- Boat-based surveys are advantageous due to the large amount of historical data and the ability to collect behavioural data that most other methods cannot provide

Improvements for current guidelines

- More strategic oversight to facilitate data collection that is useful for developing predictive models - e.g., simultaneous data collection across multiple locations (regions/countries)
- Important not to focus on only one wind farm and/or survey large areas around wind farm to be able to detect effects
- Be clearer on opportunities for combining methods and technologies: e.g., LiDAR alongside Digital Aerial survey provides flight height and distribution and abundance to species level
- Provide more transparency on benefits and limitations of methods
- Important to make data available for the public/research
- Clarity on species limitations of each method
- Important to agree on data protocol in order to analyse data in combination/across different wind farms/countries
- Concentrate on knowledge gaps in joint effort



Expert responses on the advantages and disadvantages of the different survey techniques for collecting data for sensitivity mapping.

Survey Method	Positives	Negatives
Vantage Point Surveys	■ Potential to be more useful if combined with e.g., colour ringing, or can be 'automated' (e.g., PIT or MOTUS receiver rather than human observer) ■ Can get flight height data with laser range finder ■ Very useful when platform in windfarm for micro avoidance studies ■ Cost effective	■ Very limited reach ■ Very difficult offshore ■ Usually limited to coastal/inshore sites ■ Limited spatial/temporal coverage ■ Human error
Ship Surveys	■ Can follow individual birds ■ Good Species identification ■ Good behavioural data ■ Flight height with laser range finder ■ Can get coverage in lower light conditions ■ Standardised methodology, comparable between areas	■ Disturbance of Divers and Sea-ducks ■ Presence of boat can alter behaviour ■ Low coverage ■ Attraction to boats biases data ■ Temporal mismatch when surveying large bodies of water ■ Data analysis more complex than digital aerial - need to use distance sampling techniques ■ Potentially more challenging to use at far offshore sites than visual/digital aerial ■ Limited geographical scale or too costly
Visual Aerial Surveys	■ More options to record behaviour compared to digital surveys ■ Less time-consuming post survey analysis of the data than with digital surveys ■ Can cover a large area in a short time	■ Strong observer bias ■ Not safe in windfarms ■ No flight height or speed data ■ No audit trails ■ No behaviour data ■ Impossible to identify all species (gulls or medium gulls, etc.) ■ Not all species identified
Digital Aerial Surveys	■ No observer bias ■ No disturbance ■ Better safety ■ Can cover large areas ■ Can re-visit the images later if required ■ Less sources of bias compared with visual ■ Video allows review of data to improve ID rates ■ Able to get density and flight height from a single survey system ■ Large coverage ■ Species' identification in most of the cases ■ High repeatability of the survey ■ Recommended by several SNCBs already; can get large data sets ■ Can be checked and counted later (and assessed for observer error)	■ Does not capture night-time behaviour ■ Not always possible to identify species ■ Uncertainty around ability to record cryptic and smaller species (e.g., petrels) ■ Currently mostly proprietary technology (less transparency) ■ Too expensive for large areas ■ Image analysis very time consuming ■ Questions remain as to accuracy of flight height ■ No behaviour data ■ Impossible to identify all species
Animal Attached Telemetry	■ Does not depend on weather conditions ■ Shows diurnal activity patterns ■ Allows data collection at night ■ Can identify behaviour (feeding, etc.) ■ Can be used for estimating seasonal use of areas by birds ■ Individual tagging needed to establish connectivity back to protected source populations - and to develop models for connectivity that can then be used in conjunction with at-sea data ■ Behavioural information ■ Nocturnal/crepuscular activity recorded ■ Flight height data ■ Only technique that really provides information on connectivity	■ Assessment based on low number of individuals ■ Usually only breeding birds and often for very short time periods ■ Biased samples (breeding, access, short timeframes, etc.) ■ Impacts if devices on behaviour not sufficiently explored ■ Can affect animals' behaviour and energetics ■ Cannot assess abundancy

Data Gaps and Recommendations

The seabird data mentioned in this summary report should be used to inform the location, timing, and activities of future offshore wind farm developments. It should be recognised that the output of any planning model is only as good as the input data, and substantial data gaps and limitations were identified during this study.

A summary of our findings on data gaps and areas that require further research are presented below:

Offshore Surveys

Historically, data for offshore at-sea surveys were collected on an ad-hoc basis; the temporal and spatial coverage of offshore surveys available in the ESAS database and from national monitoring scheme are not homogenous. For example:

- There are significant data gaps in recent years for surveys that cover areas in the Northern and Eastern regions of the North Sea
- Data are skewed toward summer months, with areas surveyed less frequently during winter periods and during periods with unfavourable weather conditions
- There is a lack of historical and coordinated data for the Baltic Sea, and therefore a need to continue and support coordinated surveys in this region

To improve at-sea survey data coverage for the North Sea and Baltic Sea, collaboration should be made with the ESAS working group. Collaboration could bolster support for their goals of updating the ESAS database through continued surveys and by incorporating non-published survey data into their database.

There is a vast amount of inaccessible data collected by industry and offshore developers during environmental assessments. Such data could be valuable in the development of seabird sensitivity maps. Future work should be aimed at overcoming the regulations and restrictions that limit access to these data.

Tracking Studies

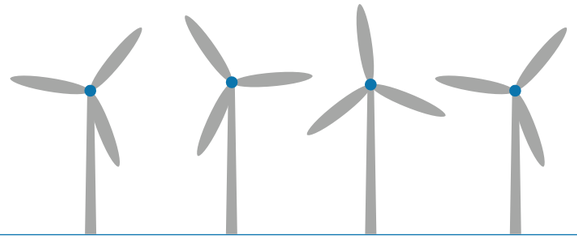
Great strides have been made in recent years to use tracking data to better understand potential interactions between seabirds and windfarms (i.e., improved flight height data from GPS tags, and high resolution at-sea distribution data and connectivity to SPAs and breeding sites). However, there are several areas where future studies could contribute valuable data:

- Winter distribution and migration routes
- Distributions for different age classes
- Tracking of high-risk species, with particular focus on species in the Baltic Sea (such as diving duck and tern species)
- Improved access to raw data from published and unpublished tracking studies

Collaboration with existing tracking databases, such as the BirdLife Seabird tracking database, Seatrack Norway, and Movebank, would help standardize seabird tracking data. This would allow researchers to share raw data more efficiently and benefit management goals such as sensitivity mapping.

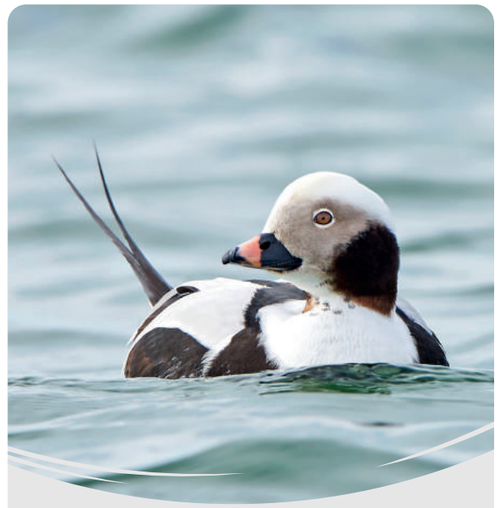
Species Assessments

Many studies have focused on understanding the impacts of offshore wind farms on seabirds. Priority high-risk species have been identified. However, due to the infancy of this research and the rapid development of offshore wind, there is need to improve our knowledge for underrepresented species and update current assessment tools.



Examples of data needs and areas where future studies could contribute valuable data include:

- Update species sensitivity indices with current data and to create sensitivity indices specific to the Baltic Sea Region
- Add species with unknown risk to offshore wind to seabird sensitivity indices (such as Caspian Terns)
- Further research and empirical data for several species which currently lack adequate data for their offshore wind sensitivity assessments **(Box 3)**
- Collect empirical data for seaducks in the Baltic Sea, focused on collision risk with offshore wind turbines and the distribution and local movement patterns (tracking studies)
- Tracking studies for seaducks, divers, colonial seabirds (Caspian terns, lesser black-backed gull spp., auks, and kittiwakes) in the Swedish OSPAR region
- Collect further data on individual variation in the response of gulls to offshore wind farms in the North Sea
- Address the lack of known flight heights and micro-scale behaviours within offshore wind farm sites
- Address the current poor understanding of barrier effects, and the use and effectiveness of corridors created within and between wind farms
- Collect more data on the distribution of prey species, which can strongly influence the distribution of seabirds at sea
- Study the impact of increased light pollution on species such as shearwaters and petrels



Box 3: List of species identified as a priority focus for future research

- **Long-tailed Duck** (*Clangula hyemalis*)
- **Common Goldeneye** (*Bucephala clangula*)
- **Greater Scaup** (*Aythya marila*)
- **Velvet Scoter** (*Melanitta fusca*)
- **Common Eider** (*Somateria mollissima*)
- **Caspian Tern** (*Hydroprogne caspia*)
- **Roseate Tern** (*Sterna dougallii*)
- **Sandwich Tern** (*Thalasseus sandvicensis*)
- **Arctic Jaeger** (*Stercorarius parasiticus*)
- **Strom Petrel species** (*Hydrobatidae spp.*)
- **Shearwater species** (*Procellariidae spp.*)
- **Grebe species** (*Podicipedidae spp.*)

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Annexes

Annex 1. Sample Questionnaire

Questionnaire: Offshore Wind Development and Seabird Data Sources

Offshore-Wind energy will be one of the central elements for the generation of renewable energy in the future. The European Commission's Long-Term-Strategy "A clean Planet for all" foresees an expansion of Offshore-Wind energy between 230 and 450 GW until 2050 in order to reach the EU-Climate-targets. The currently installed capacity is 22 GW. For its projections, the EU Commission does not consider the carrying capacity of the ocean, the cumulative effects on the marine environment and the current available space, which is being occupied by other activities, such as military, shipping, fishing, etc. However, the development of offshore wind has an impact on the marine environment, which is not sufficiently being considered in the European context.

BirdLife would like to identify available data sources on the abundance of seabirds and their interactions with renewable energy infrastructures in the North and the Baltic Seas. Therefore, we ask partners to contribute with existing data sets that are not necessarily open to the broader public and fill out this questionnaire.

Details of individual completing the questionnaire

Full name	
Organisation	
Email address	

Part 1: Your Interest

For BirdLife it is interesting to know the level of engagement of each partner. However, this is not relevant for RGI/Industry which is why it is taken out of the Questionnaire.

Please provide us with the names and institutions of at least three researchers/practitioners/ experts on offshore wind and sensitivity mapping of seabirds (if possible, in English & insert links).

Part 2: Data

1. What type of at sea bird data does your organization hold (if any)? (e.g. Species Observation Data, Tracking Data, Spatial data etc.)

2. What species are covered by the data (please specify all the different taxa)?

3. What methodology was used to collect the data?

4. What kind of data information are collected for the target species?

A) Presence/absence

B) Degree of risk of collision/interaction with wind energy installations

C) Number of individuals

D) Age (e.g. juveniles, immatures, adults - please specify)

E) Behaviour (e.g. feeding, rafting/resting, other - please specify)

F) Other (please specify)

5. Location, period covered and age of the data (Country and Colony, month(s)/season(s))

6. Nature of the Data

A) Published

B) Processed

C) Raw

7. Availability

A) BL-Partner holds all the rights to the data and has full access

B) Data is stored in a private database

C) Data is stored in an open database

D) Data-owner is known & can be contacted

E) Data-set manager is known & can be contacted

Please specify:

8. Can the data be shared?

A) Yes, with BirdLife for conservation purpose only

B) Yes, for different purposes and with wider stakeholders

C) No, it cannot be shared

9. If yes, please provide us with the contact of the data owner (e-mail/phone)

Annex 2. Overview of National data sources

UK

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
ESAS (European Seabirds at Sea)	Aerial and boat-based observation data, line-transect surveys with distance sampling, species ID, count, behaviour, XY	Multi-species	Greater North Sea, Baltic Sea, North East Atlantic, Mediterranean	1979 - 2020	Year round
VSAS (Volunteer Seabirds at sea)	Count data, with species ID, XY location	*Multi-species*	North-west offshore areas Lat: 60.84°- 49.77° Long: 8.65° - 2.0°	2018 - ongoing	Year round
RSPB tracking studies - Seabird Tracking and Research (STAR)	GPS tracking data - See meta database - species specific and BL Seabird TD for individual studies	Northern Fulmar, European Shag, Black-legged Kit-tiwake, Common Guillemot, Razorbill, Herring gulls, Lesser Black-backed gulls, Black Guillemots, Storm Petrel spp. and Atlantic Puffin	UK	2010 - 2017	Breeding
Seabird 2000 and Seabirds count, JNCC	National seabird census recording entire seabird population of Britain and Ireland (except gannets)	25 species	UK	1998 -2002 2015-2021	Breeding
Seabird Monitoring Programme, SMP	Population trends (abundance, productivity, survival, diet) for key UK seabirds and causes for changes in these trends.	25 species	UK	1986-2021	Breeding
The Crown Estate - Marine data exchange	Offshore wind farm survey data and reports e.g., EIAs, ornithological assessments and monitoring	Multi-species	England, Wales, and Northern Ireland	-	Year Round
Top Predator Project, Marine Ecosystems Research Programme	Seabird and Cetacean distribution maps at monthly and 10km for 24 species of cetacean and seabird species in the North-East Atlantic.	Multi-species (12 seabird species)	Northeast Atlantic, including North Sea	1980-2018	Year Round/ Monthly
Northern gannet tracking	GPS tracking data, Northern Gannets from Les Etacs, Alderney	Northern Gannet	Les Etacs, Alderney (49.7, -2.233)	June 2011 - June 2015	Breeding
FTZ Northern Gannet migration, Bass Rock UK	Geolocator tracking data, Northern Gannets on Bass Rock UK	Northern Gannet	Bass Rock UK (Lat: 56.078 Long: 2.639)	Sept 2002 - March 2004	Breeding
JNCC Visual Aerial Survey data	Observation data, with species, count and XY (572810 observations)	Seaduck, Diver spp., Grebe spp., and Little Gull	UK territorial waters, Lat: 60.84° - 49.77° Long: -8.65° - 2.0°	2001- 2007	Passage/Winter
WeBs- Wetland Bird Surveys (BTO) and Webs Low tide counts	Count data	Wildfowl (ducks, geese, and swans), waders, rails, divers, grebes, cormorants, and herons. Gulls and terns are optionally included	UK	1947 - ongoing	Year Round/ Monthly
Non-Estuarine Wetland Bird Surveys (BTO)	Count data	Multi-species	UK coast	1984/5, 1997/8, 1996/7, 2015/16	Winter (December-January)

Belgium

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
National Offshore Surveys	Monthly Ship based surveys, following ESAS standard methods	All seabirds and mammals	Belgium offshore waters	2001 - ongoing	Monthly
Research Institute for Nature and Forest (INBO), ESAS data (European Seabirds at Sea)	Boat based observation data, count, species, XY locations	Multi-species	Belgium North Sea	1992- ongoing (monthly surveys from 2000-2012)	Year round/ Monthly
Natura Seaduck Aerial Surveys	Aerial line transect survey	Seaducks	-	1986 - present	Unknown
INBO - CaGullaS project	GPS Tracking study	Herring gulls, Lesser Black-backed gulls	Dutch offshore wind farms	2018 - 2019	Breeding
INBO - Delta track project	GPS Tracking study	Herring gulls, Lesser Black-backed gulls, Sandwich terns	Dutch delta region, Ostend and Zeebrugge colonies	2020 - 2022	Breeding
INBO – RAVEN project	Radar data, visual observations and tracking of seabirds			2013 - 2019	Unknown
INBO - Winter waterbird monitoring in Flanders Belgium	Total counts at sample sites	Auks, ducks, geese & swans, herons, plovers, dotterels & lapwings, storks, divers, cranes, oystercatchers, gulls, pelicans, cormorants, flamingos, grebes, rails, avocets & stilts, sandpipers, skuas, ibises & spoonbills	Wetland and coastal habitats in Flanders, Belgium. (50.68° to 51.51° latitude, 2.54° to 5.92° longitude)	1991 - ongoing	Wetland and coastal habitats in Flanders (50.68° to 51.51° latitude, 2.54° to 5.92° longitude)
INBO - Breeding bird status and trends in Flanders	Publication - abundance and species trends	All breeding birds	Flanders	2013-2018	Breeding
INBO _ Atlas of Flemish Breeding Birds	Publication- Distribution	All breeding birds	Flanders	1999 - 2003	Breeding
INBO – ROSTOW project	Research project - Age specific survival of sandwich terns	Sandwich terns	Belgium	2019 - 2020	Unknown
INBO - Barrier project	Research project - Barrier effects of wind turbines on seabirds	Multi-species	Belgium	2019	Unknown
INBO - Monitoring the effects of offshore wind farms on bird life	Research project	Multi-species	Bligh Bank and Thorten Bank wind farm, Belgium	2011-2020	Year round
INBO - ASPEDA - Age specific patterns ESAS Data	Research project/ report	Multi-species	-	2019 - 2020	Year round
INBO - SASMOD	Research project - Age specific survival numbers of seabirds	Multi-species	-	2019 - 2020	-

Netherlands

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
ESAS (European Seabirds at Sea)	Aerial and boat-based Observation data, line-transect surveys with distance sampling, species ID, count, behaviour, XY	Multi-species	Greater North Sea, Baltic Sea, North East Atlantic, Mediterranean	1979 - 2020	Year round
National offshore monitoring programme	Aerial and boat-based strip and line transect (Distance) surveys, species ID, counts, locations, and behaviour recorded.	All species	Dutch Continental Shelf (DCS), Dutch Wadden Sea and Coastal Zone, Netherlands	2014 (1984) - 2021	DCS – Aug., Nov., Jan., Feb., Apr., June Dutch Wadden sea and Coastal Regions – Nov. and Jan.
Multiscale movements of lesser black backed gulls from Texel, Royal Netherlands Institute for Sea Research	GPS satellite tracking	Lesser black-backed gull	Texel Netherlands (53°00'N, 04°43'E)	2012 - 2020	Breeding
Foraging of Herring Gulls, Wageningen University and Research - Institute for Marine Resources and Ecosystem Studies (IMARES)	GPS satellite tracking	European herring gull	Wadden Sea Islands, Texel. (53°00'N, 04°43'E)	2013	Breeding
Foraging locations of Sandwich terns (IMARES)	GPS satellite tracking and accelerometer data	Sandwich tern	Wadden Sea Island Texel, (53,0895°N, 4,8981°E)	-	Breeding
Barnacle Goose Migration	GPS satellite tracking and accelerometer data	Barnacle Goose	Wadden Sea to Russian Arctic	2015	Migration
Collaborative project-Bureau Waardenburg, IMARES and INBO, Belgium	Tern ringing study, survival, and distribution	Sandwich tern	Dutch delta region	2010 - ongoing	Breeding
UvA Bird Tracking systems	GPS tracking projects	Multi-Species (Including - Lesser black-backed gulls, Herring gulls, Great Skua, Oystercatcher)	North Sea, mostly Southern North Sea.	-	Year Round
University of Amsterdam	GPS Tracking study	Lesser black-backed gull	Wadden Island, Netherlands	2010	Breeding
Bureau Waardenburg/ Delta Project Management	Research Group - Seabird Interactions with Offshore wind, also hold data on seabird breeding colony locations and counts	Multi-species	Dutch North Sea	2000s - Ongoing	-
Bureau Waardenburg/ Delta Project Management	Coastal land based and aerial surveys	Common scoter	Coastal North Holland	2016 - 2017	Winter

Netherlands conti.

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
Bureau Waardenburg/ Delta Project Management	GPS satellite tracking	Great cormorant	Dutch delta region	2012	Breeding (April - Sept)
Bureau Waardenburg/ Delta Project Management	GPS satellite tracking	Lesser black-backed gull	Dutch Delta region	2010	Breeding (May-July)
WOZEP - Dutch Governmental offshore wind ecological programme	Monitoring and Research on species directly affected by wind turbines	Species include - Curlew, Sandwich tern, Herring gull and Lesser black-backed gull	-	-	-
WOZEP - KEC programme - Framework for assessing ecological and accumulative effects	Research into the cumulative impacts of offshore wind on species populations	Species include - Curlew, Sandwich tern, Herring gull and Lesser Black-backed gull	-	-	Year round
Trilateral Wadden Sea Cooperation -Trilateral Monitoring and Assessment programme - Joint Monitoring Breeding Bird Group	Breeding bird counts from land and aerial survey. Collecting data on abundance and distribution of breeding birds and breeding success (clutch size and fate, fledgling success)	Multi-species	Wadden Sea	1991 -Ongoing	Breeding
Trilateral Wadden Sea Cooperation -Trilateral Monitoring and Assessment programme - Joint Monitoring Breeding Bird Group	Numbers, distribution, and trends.	All breeding water-birds -: shorebirds, ducks, geese, and swans; divers, grebes, and cormorants; gulls, terns, and auks	Wadden Sea	1991 - ongoing	Breeding
Trilateral Monitoring and Assessment programme - Joint Monitoring Breeding Bird Group	Breeding success	Spoonbill, Eider, Avocet, Oyster-catcher and selected colonial gull and tern species	Wadden Sea	2009 onwards (2005 onwards in the Dutch sector)	Breeding
Joint Monitoring of Migratory Birds (JMMB) in the Wadden Seabirds and Wadden Sea Flyway Initiative (WSFI)	Complete counts of migratory birds at stop over sites, migration, or wintering area	34 waterbird species	Wadden Sea	1987-ongiing	Migration and Winter stop over
SOVON Bird Research Netherlands	Breeding bird counts, winter bird counts	Multi-species	Netherlands	Unknown	Year round

Germany

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
HELCOM - HOLAS II project - Abundance of waterbirds in the breeding season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country. 99610 data points	30 breeding water-bird species* surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Germany, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Breeding
HELCOM - HOLAS II project - Abundance of waterbirds in the wintering season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country.	Multi-species *sur-veys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Estonia, Finland, Latvia, Poland, Sweden, Denmark, Germany	1991-2016	Winter
Mid-Winter Waterbird Census	Ground based transect counts, including species ID, total count, and location	Waterbirds	Mecklenburg-Western Pomerania, Schleswig-Holstein	1965 - Ongoing	Winter
Baltic Waterbird Census	Ship based and land based total counts, including species ID, total counts, and location	All waterbirds	German Baltic territorial waters	Land - 1988 - 1993, Aerial-1990 - 1993	Winter
SOWBAS - Winter waterbird census	Aerial and ship based transect counts and species distribution, including species ID, locations, total counts, XY	All waterbirds	Western Pomerania	2007 -2009	Winter
Baltic co-ordinated offshore wintering waterbirds survey - 2016	Aerial and ship based transect counts and species distribution, including species ID, locations, total counts, XY	All waterbirds	German Baltic territorial waters	2016	Winter
National coastal, offshore surveys of German EEZ	Plane and Ship based transect counts and digital aerial surveys covering wind farm areas, including species ID, total counts, locations, behaviour, XY	Waterbirds	Whole German EEZ, (Kiel Bay and Pomeranian Bay by ship)	2008 (2004 in Schleswig-Holstein area)	Winter/Summer/ Autumn
Winter population counts of Common eider, Common scoter, and Long tailed duck	Aerial survey total counts including species ID and XY location	Long-tailed duck, Common scoter, Common eider	Schleswig Holstein	Coastline since 1980, offshore since 2004	Winter
Breeding bird counts	Total counts of pairs and nest, including species ID and Location	All breeding water-birds/seabirds	Mecklenburg-Western Pomerania & Schleswig-Holstein Nature reserves	1970 - ongoing	Breeding
National Offshore surveys	Ship and aerial survey including species ID, total counts, location, XY	All species observed	German North and Baltic Sea	2002 - ongoing	Year Round
FTZ - Christian Albrechts University in Kiel - Top Space - Distributions of seabirds	Aerial and Ship surveys including species ID, total counts, location, XY	Multi-species	German EEZ, North Sea and Baltic Sea	2008-2014	Spring, Summer, Winter
FTZ - HELBIRD	GPS Tracking, Digital Based Aerial Surveys - HiDef video camera system, Platform observations	Multi-species - Common Guillemot, Northern Gannet, Black-legged Kittiwake, Herring Gull, Lesser black-backed gull)	Helgoland, German North Sea	2015-2017	Spring

Germany conti.

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
FTZ - BIRDMOVE	Animal attached tracking data	Northern gannet, Common guillemot, Lesser black-backed gull, Great black-backed gull, Razorbill, Gavia spp.	German marine area	2015 - 2019	Breeding
FTZ - PhoViComp	Video-and photo, flight-based digital strip transect survey, including species ID, location XY, total counts	All species observed	North Sea and Baltic Sea	2016-2019	Year Round
FTZ - WindBIRD	Animal attached tracking data	Herring gulls and Northern gannets	-	2011-2014	Breeding
FTZ - Digi Top	Digital recordings of sea birds in the North and Baltic Seas	All species observed	-	-	Year Round
DIVER - research project	45 adults tagged with implanted PTT satellite tags in German EEZ, 20-40 km offshore	Red-throated diver	German Bight North Sea	2014-2018	Winter
Estimating flight heights of seabirds using optical rangefinders and GPS data loggers: a methodological comparison	Boat-based survey, optical radar, GPS	All seabirds observed	German North and Baltic Sea	2010-2015	Year Round
Decline of Long-tailed duck numbers in the Pomeranian Bay revealed by two different survey methods	Ship and aerial surveys with distance bands, including species ID, total counts, densities, behaviour, location, XY	Long-tailed duck	Pomeranian Bay, Baltic sea	1988 - 2014	Winter
Trilateral Wadden Sea Cooperation - Joint Monitoring Breeding Bird Group and Join Monitoring Migratory Bird Group	Numbers, distribution, trends and breeding success of breeding birds and complete counts of migratory birds at stop over sites, migration, or wintering area	All breeding water-birds -: shorebirds, ducks, geese, and swans; divers, grebes, and cormorants; gulls, terns, and auks	Wadden Sea	1991 - Ongoing (Breeding bird counts and distribution) 1987 - Ongoing (Migratory bird counts)	Breeding and Winter

Denmark

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
HELCOM - HOLAS II project - Abundance of waterbirds in the breeding season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country. 99610 data points	30 breeding water-bird species* surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Germany, Estonia, Finland, Latvia, Poland, Sweden,	1991-2016	Breeding
HELCOM - HOLAS II project - Abundance of waterbirds in the wintering season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country.	Multi-species *surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Estonia, Finland, Latvia, Poland, Sweden, Denmark, Germany	1991-2016	Winter
Baltic Waterbird Census	Ship based and land based total counts including species ID, total counts and XY locations	All waterbirds	Danish territorial waters (Baltic, Kattegat)	1987-89, 1991-1992	Winter
SOWBAS - Winter waterbird census	Observer based; Aerial transect counts. Abundance and distribution, including species ID, total counts and XY locations	All waterbirds	Kattegat sea	2007 - 2009	Winter
Baltic co-ordinated offshore wintering waterbirds survey - 2016	Aerial transect counts, abundance, and distribution, including species ID, total counts and XY locations	All waterbirds	Full coverage of inner Danish waters	2016	Winter
National offshore monitoring programme	Offshore aerial surveys - annual total counts and line transect surveys, including species ID, and XY locations	Multi - species	Inner Danish waters and parts of North Sea	2000 - ongoing	Winter
Winter coastal bird surveys/ Mid-water waterbird census (IWC)	Annual total counts and line transect surveys, including species ID, total counts and XY locations	Coastal birds	Territorial Waters	Unknown	Winter
Winter Geese counts	Land based total counts, including species ID, total counts and XY locations	Geese	Denmark	2000	Winter
Winter Whooper Swan and Bewick's Swan counts	Land based total counts, including species ID, total counts and XY locations	Whooper and Be-wick's Swan	Denmark	2000	Winter
National Barnacle goose survey	Adult and chick counts	Barnacle goose	Selected coastal areas - Saltholm	1992	Breeding
National Caspian tern monitoring	Nest counts	Caspian tern	Coastal waters	2008 - ongoing	Breeding
National cormorant breeding sites	Ground based total counts, including species ID, total counts and XY locations	Great cormorant	Coastal waters	1983- ongoing	Breeding
National Artic tern breeding sites	Ground based total counts, including XY location	Arctic tern	Coastal waters	2008	Breeding
Sandwich Tern breeding sites	Ground based total counts including XY location	Sandwich tern	Coastal waters	2004	Breeding
Black tern breeding sites	Ground based total counts, Including XY location	Black tern	Coastal waters	2000	Breeding
Common Eider population counts	Total counts including site location	Common eider	Coastal waters	1935	Breeding
National breeding counts	Guillemot/ Razorbill including colony location	Common Guillemot, Razorbill	Denmark	Razorbill - 1960 - 2010. Guillemot - 1960-1980	Breeding

Denmark conti.

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
Long tailed duck and Velvet scoter distribution mapping	Aerial total counts during 1980 -2000. Line transect distance sampling used after 2010, including species ID, total counts and XY locations	Long tailed duck, Velvet scoter	Danish territorial waters (Baltic Sea)	2016-2018	Winter
Predicting the weather-dependent collision risk for birds at wind farms	Observational and radar data	Multi-species	North Sea - Horns Rev 1&2, Baltic Sea - Rodsand	2010-2012	Winter
Comparison of digital video surveys with visual aerial surveys for bird monitoring at sea	Digital and visual aerial surveys-species counts and distribution, including species ID, total counts and XY locations	All species present	Fehmarn Belt	2015	Winter
High-resolution sea duck distribution modelling:	Aerial and ship-based observer surveys and digital aerial surveys collecting species counts and distributions. Species distribution map	Common eider, Common Scoter and Long tailed duck	Fehmarn Belt	2008 - 2010	Winter

Norway

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
ESAS (European Seabirds at Sea)	Aerial and boat-based Observation data, line-transect surveys with distance sampling, species ID, count, behaviour, XY	Multi-species	North Sea and Baltic Sea	1979 - 2020 (Norwegian North Sea data 1981-2006)	Year round
SEAPOP - Norwegian Institute for Nature Research (NINA) and Norwegian Polar Institute (NPI)	Boat and aerial transect surveys with count, species, XY location data	Multi-species	North Sea	1981 - 2006	Summer, Autumn, Winter
SEAPOP - Norwegian Institute for Nature Research (NINA) and the Norwegian Polar Institute (NPI)	Colony locations and population estimates	Razorbill, Northern fulmar, Northern gannet, Black-legged kittiwake, Common guillemot, Atlantic puffin, Brunnich's guillemot, Great cormorant, European shag, Arctic skua	Norway	1970 - ongoing	Breeding
SEAPOP	Non-breeding coastal surveys (seaducks and seabirds) - Species counts	Multi-species	Norway	1980 - ongoing	Winter, Autumn
SEATRACK database	GLS tracking data	Atlantic puffin, Black-legged kit-tiwake, Brunnich's guillemot, Common guillemot, Common eider, European shag, Glaucous gull, Herring gull, Lesser black-backed gull, Little auk, Northern fulmar	Baltic, North, Norwegian and Barents Sea	2014-Ongoing	Passage/Winter

Sweden

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
HELCOM - HOLAS II project - Abundance of waterbirds in the breeding season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country. 99610 data points	30 breeding water-bird species* surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Germany, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Breeding
HELCOM - HOLAS II project - Abundance of waterbirds in the wintering season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country.	Multi-species *surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Winter

Sweden conti.

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
Mid-Winter Waterbird Census	Coastal counts recording species abundance, including species ID, total counts, count location	Multi-Species	Swedish coast, at fixed study sites	1967 - ongoing	Winter
Baltic Offshore Waterbird Census	Abundance and distribution, including species ID, total counts, XY location	Multi-species	Southern Kattegat – Öland/ Gotland	1992/1993	Winter
SOWBAS - Winter waterbird census	Population size (abundance)	Multi-species	Scania - Gävlebukten, West coast outer archipelago	2007-2009	Winter
Baltic co-ordinated offshore wintering waterbirds survey - 2016	Aerial strip transect survey, species counts with XY locations. distance sampling was not used in the archipelagos.	Multi-species	Mainly offshore areas and outer archipelago, Scania - Gävlebukten	2016	Winter
National breeding bird surveys	Population size (abundance), counts of breeding pairs and nest	Multi-species	Bothnian Bay coast	2010 - 2020	Breeding
National breeding bird surveys	Population size (abundance), counts of breeding pairs and nest	Multi-species	Whole Swedish coastline	2015 - 2020	Breeding
Country wide coastal wintering waterbirds survey	Population size (abundance), XY	Multi-species	Archipelagos, Skagerak-Stockholm	1971, 1988 - 89, 1993, 2004, 2015	Winter
Offshore wintering waterbirds survey	Population size (abundance)	Multi-species	Archipelagos and offshore areas, Scania – Southern Stockholm archipelago	2010-2011	Winter
Long-tailed duck distribution maps	Abundance and distribution	Long-tailed duck	Scania - Gävlebukten, West coast outer archipelago	2009, 2011,2016	Winter
Offshore wind farm monitoring programme--Birds in southern Öresund in relation to the wind farm at Lillgrund	Aerial and boat based transect surveys with species counts, XY, Distance bands, radar surveys for migrating birds	Main species of focus – Great cormorant, Long-tailed duck, Common eider, Red-breasted merganser, Herring gull	Southern Öresund	Boat 2001-2005, 2007-2011, Aerial 2004, 2008-2011	Winter
BirdLife - Caspian Tracking data	GPS tracks of foraging and migration paths, flight height, flight speed	Caspian Tern, adult and juveniles tagged	Björns archipelago Rödkallen island, Stenarna island, Långa Hållet island, Benskären island, Risskären island, Furö island	2012 - ongoing	Breeding and Migration
BirdLife -Lesser black-backed gull Tracking data	GPS tracking, data for foraging and migration	Lesser black-backed gull	Stenarna island, Tågstumparna island, Sjömärkesö island, Länsman, Eggegrund, Svartfluttu, Blåbådan, Ålänningsslangran, Ängsholmen, Gran, Stora Karlsö	2012 - ongoing	Breeding and Migration
BSP: Foraging behaviour Common Murre 2009	GPS Logger	Common guillemot	Stora Karlsö, Baltic Sea, Sweden	2009-2015	July
BSP: Foraging behaviour Razorbills 2010-2015	GPS Logger	Razorbill	Stora Karlsö, Baltic Sea	2010 -2016	Breeding (July)
BirdLife: Black guillemot	GPS Logger	Black guillemot	Gävlebukten	2021	Unknown
BirdLife: Common gull	GPS Logger	Common gull	Sweden	2014	Summer
BirdLife: Common murre	GPS Logger	Common guillemot	Gunnarsstenarna,	2017-2019	Breeding
BirdLife: Greater black-backed gull	GPS Logger	Great black-backed gull	Tågstumparna, Stenarna, Länsman	2013 - ongoing	Breeding
BirdLife: Herring gull	GPS Logger	Herring gull	Sweden	2013 - 2014	Year round
BirdLife: Razorbill	GPS Logger	Razorbill	Gunnarsstenarna	2012- 2017	Breeding
Stora Karlso and Björn Archipelago Seabird tracking study	GPS tracks of forging flight paths for 5 seabird species, along with year-round movements for Lesser black backed gulls.	Common guillemot, Mew gull, Herring gull, Great black-backed gull, lesser black-backed gull	Stora Karlsö, Gotland, Sweden (57°17′ N, 17°58′ E) and Björn Archipelago at Fågelsundet south of Gävle.	Common Guillemot - 2009,2014-2015 Lesser black-backed gull 2011-2015, Gull spp. 2012 - 2016	Breeding (year-round for some Lesser-black backed gulls)
Stora Karlso-Lesser black-backed gull tracking study	GPS tracks of foraging distribution	Lesser black-backed gull	Stora Karlsö island, (17.972°E, 57.285°N)	2009	June

Finland

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
HELCOM - HOLAS II project - Abundance of waterbirds in the breeding season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country. 99610 data points	30 breeding water-bird species* surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Germany, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Breeding
HELCOM - HOLAS II project - Abundance of waterbirds in the wintering season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country.	Multi-species *surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Winter

Finland conti.

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
Mid-Winter Waterbird Census	Ship based total counts, including species ID, total counts, and location	All waterbirds	Åland Sea, territorial waters	1968 - ongoing	Winter
Winter Coastal transects	land based transect total counts, including species ID, total counts, and location	All waterbirds	Whole coast	Mid- 1950s	Winter
Aerial surveys and expeditions by boats for identifying key wintering and staging areas	Species ID and staging locations, XY	All waterbirds	Åland islands, EEZ	2000 - ongoing	Winter
Baltic Offshore Waterbird Census	Aerial total counts, including species ID, total counts, and location	All waterbirds	Finland offshore waters and Åland	1993	Winter
SOWBAS - Winter waterbird census	Aerial and ship based total counts, including species ID, total counts, and location	All waterbirds	Baltic proper, Gulf of Finland (coastal) and Åland islands. Bothnian Sea and Bothnian Bay were not covered.	2007 - 2009	Winter
Baltic co-ordinated offshore wintering waterbirds survey - 2016	Plane and ship transect survey, including species ID, total counts, and location	All waterbirds	Åland Sea and Archipelago Sea	2016	Winter
National offshore Surveys	Ship based transect surveys, including species ID, total counts, and location	Multi-species	Åland Sea and Archipelago Sea	1970- ongoing	Winter
National Breeding Census and IBA monitoring	Population size by nest counts, including species ID and colony location	Multi-species	Coastal waters - Total of c. 2000 islands in the outer/ central archipelago. 43 areas/ units of 3-233 islets.	1984 - ongoing	Breeding
Caspian tern monitoring	Population size (abundance)	Caspian tern	Coastal waters	1984	Breeding
Cormorant breeding sites	Population size (abundance)	Great cormorant	All colonies	2005	Breeding
Birdlife Finland - Mapping of main migration routes of birds in Finland	Observational data produced by Finnish bird enthusiasts and the experiences of bird experts in associations.	Long-tailed duck, common eider, common scoter, Diver spp., Brant geese and other waterbirds	Migration routes	2014	Spring and Autumn Migration
Monitoring at regionally important MAALI-areas	Observational and distribution data for important staging, winter, migration, and breeding areas for birds	All waterbirds	-	2010	Year round
Satellite Black-throated Divers - Birdlife Finland	Satellite tracking, two individuals	Black throated diver	Southern Finland and migration path to Black Sea (via Gulf of Riga and north east coast of Estonia)	2015 - 2016	Year round
Caspian tern tracking study, collaboration with SOF Birdlife Sweden	29 adult and juvenile Caspian terns tagged with GPS data loggers	Caspian tern	Baltic Sea, Finland	2015 - Unknown	Unknown

Estonia

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
HELCOM - HOLAS II project - Abundance of waterbirds in the breeding season 2018	Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country. 99610 data points	30 breeding water-bird species* surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Germany, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Breeding
HELCOM - HOLAS II project - Abundance of waterbirds in the wintering season 2018	Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country.	Multi-species *surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Winter
Estonia Environment Agency	Breeding Seabird Counts, presence of species/taxa, number of breeding pairs- also additional data collected on number of individuals, nest counts, egg counts, chick counts, carcass surveys, predator presences, disturbance, habitat quality	Multi-species, primarily includes pelicans, cormorants, geese, and curlews	Estonia, coastal surveys	1910, (patchy monitoring of all islands prior to 2000) 2000 - ongoing Monitored 1-2 x every 6 years	Breeding
Co-ordinated East Baltic - wintering waterbird census	Line Transect surveys with distance sampling, Observational data, counts, species, X Y,	Multi-species	Estonia and Latvia offshore waters	2016	Winter (February)
Estonia Environment Agency	Mid-winter waterfowl census (land based coastal survey), including species ID, total counts, and count location	Multi-species	Coastal areas - XY of site centroid provided	1960-present, all data from 1993 - present digitised	Winter (January)
At-sea surveys in Estonia	Offshore survey, including species ID, total counts and XY data	Multi-species	Estonia EEZ	2011/2012, 2014, 2016	Summer, Winter, Spring, Autumn
Winter seaduck distribution maps in the eastern Baltic sea (Estonia and Latvia)	Data from the winter offshore survey used to create Density surface models for seaduck and seabird spp., including species ID, total counts, XY data,	Merganser sp., Little gull, herring gull, common gull, Steller's eider, long tailed duck, common scoter, Velvet scoter, Diver spp., Goldeneye, all gulls grouped, all swans grouped, ben-thos eaters grouped, fish eaters grouped	Estonia and Latvia offshore waters	2016	February
Offshore census database - BirdLife Estonia	Plane and Ship transect surveys, including species ID, total counts and XY location	Multi-species	Estonia EZZ	Unknown	Unknown
Estonia National Maritime Spatial planning	Interactive Web Map - sensitive areas to bird	Multi-species	Estonian waters	Unknown	Year round
Estonian Ornithological society	Mapping of Migration corridors	Multi-species	Estonia	Unknown	Migration
Analysis of bird staging areas	-	Multi-species	Estonia	Unknown	Winter

Latvia

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
HELCOM - HOLAS II project - Abundance of waterbirds in the breeding season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country. 99610 data points	30 breeding water-bird species* surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Germany, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Breeding
HELCOM - HOLAS II project - Abundance of waterbirds in the wintering season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country.	Multi-species *surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Winter
Mid-Winter Waterbird Census	Abundance - species counts, species ID and location of counts	All species	Latvian coast	1991 - ongoing - annual surveys	Winter
Baltic Offshore Waterbird	Total counts from land-based surveys and one year of aerial surveys (1993). Ship based transect survey, includes species ID, total counts, XY locations	All species	Gulf of Riga and Irbe Strait	Land counts 1988-93, Aerial survey 1993, ship based transect survey 1992-1993	Winter
SOWBAS - Offshore Winter waterbird census	Total species counts and ship based transect counts, includes species ID, total counts, XY locations	All species	Gulf of Riga, Irbe Strait, Latvian coast	2007, 2008	Winter
Baltic co-ordinated offshore wintering waterbirds survey - 2016 - all territorial waters and EEZ	Abundance and distribution - Species counts and XY locations	Long-tailed duck, Velvet scoter, Black scoter, Common goldeneye, Goo-sander, Red-breasted merganser, Diver spp., Gavia spp., all other seabird species seen.	All territorial waters and EEZ	2016	Winter (Jan - March)
Species distribution maps for waterbirds in Latvian and Estonian offshore waters	Abundance and distribution - created density values of analysed species/ group for each grided cell. includes species ID, total counts, XY locations	Long-tailed duck, Velvet scoter, Common goldeneye, Goosander, Red breasted merganser, Divers spp., Gavia spp., Little gull, Herring gull, Common gull, Steller's Eider	All territorial waters and EEZ	2016	Winter
National offshore surveys - Aerial full cover -Gulf of Riga	Abundance and distribution - Species counts and XY locations	Long-tailed duck, Velvet scoter, Black scoter, Common goldeneye, Goo-sander, Red-breasted merganser, Diver spp., Gavia spp., all other seabird species seen.	Gulf of Riga	2006 - 2008, 2011-2013, 2016	Spring, summer, Autumn
National Offshore survey - Aerial - Partial cover of offshore waters	Abundance and distribution - Species counts and XY locations	All species	Latvian offshore waters - partial cover	2012, 2014, 2018, 2019	Winter
National offshore survey- Ship based partial cover of Latvia offshore waters	Abundance and distribution - Species counts and XY locations	All species	Latvian offshore waters - partial cover	2006-2008, 2011/12, 2013/14	Winter, Spring, Summer
Offshore surveys held by LOB	Observer based aerial survey with distance sampling, includes species ID, total counts, XY locations	All species	All territorial waters and EEZ, Index count in Riga Gulf and Irbe Strait	Annual Index counts 2019, Full survey 2016 (Every 6 yrs.)	Winter

Lithuania

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
International Mid-Winter Waterbird Census	Coastal counts recording species abundance	Multi-species	Lithuanian coastline	2012- 2020	Winter
Baltic Offshore Waterbird Census	Abundance and distribution	Multi-species	Lithuanian offshore waters up to ~ 20km	1992/1993	Winter
SOWBAS - Offshore Winter waterbird census	Population size (abundance)	Multi-species	Lithuanian offshore waters up to ~ 20km	2007-2009	Winter
Baltic co-ordinated offshore wintering waterbirds survey - 2016	Strip transect survey, species counts with XY locations.	Multi-species	Lithuanian offshore waters up to ~ 20km	2016	Winter
National offshore survey	Species counts and XY locations	Multi-species	Lithuanian territorial waters	Full coverage 2019	Full coverage - Autumn and Winter, Spring - SPA surveys
Baltic Seabirds Transect Surveys, Institute of Ecology of Vilnius University	Count data, species, XY	Velvet scoter, Long-tailed duck, Black-throated diver, Red-throated diver, Razorbill, Common guillemot and Black guillemot, Herring gull, Great and Lesser black-backed gull, Common gull, Black-headed gull. and Little gull	Lithuanian marine waters, central and southern sectors of the Baltic Proper and the Gulf of Riga,	1993-1995	Winter (February-March)
Coastal Aerial Surveys	Total counts	Multi-species	Lithuania coast, plus Russian Kaliningrad Region	1987- 2000	Winter
National breeding bird survey	Total counts	Multi-species	Coastline, Nemunas river delta, Curonian spit national park	Each 10-15 years	Breeding
LIFE09/NAT/ LT/000234 - DENOFLIT life project	22 ship transect surveys, species counts and XY locations	Red-throated diver, Velvet scoter, Long-tailed duck, Black-throated diver, Razorbill, Common guillemot, and Black guillemot	Klaipeda-Ventspils Plateau (43200 ha, bordering Latvian waters), Sambian Plateau (43850 ha, bordering waters of Russian Federation) and Klaipeda Bank (50800 ha)	2012 - 2013	Year round

Lithuania cont.

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
LIFE09/NAT/LT/000234 - DENOFLIT life project	Georeferenced spatial distribution	Long tailed duck, Velvet scoter, Red throated diver	Klaipeda-Ventspils Plateau (43200 ha, bordering Latvian waters), Sambian Plateau (43850 ha, bordering waters of Russian Federation) and Klaipeda Bank (50800 ha)	2012 - 2013	Year round
LIFE Nature project _ "Marine Protected Areas in the Eastern Baltic Sea- LIFE 05 NAT/LV/000100	Species counts and XY	All observed species	Lithuanian offshore water up to 12Km, covering the length of two coastal SPA sites	2006-2008	December - April and August
LIFE Nature project _ "Marine Protected Areas in the Eastern Baltic Sea- LIFE 05 NAT/LV/000100	Species counts	All observed species	Two coastal SPAs	2006-2008	November - April
LIFE Nature project _ "Marine Protected Areas in the Eastern Baltic Sea- LIFE 05 NAT/LV/000100	Little gull migration counts	Little gull	Two coastal SPAs	2006-2008	July-August
MoveBank - Tagging studies	GPS tagging Studies	Birds of Prey, Black stork, Common crane, Common terns, Dabbling ducks, Eurasian wigeon, Flight Studies, Great cormorant, Herons, Hybrid and Lesser spotted eagles, Mallard, Mute swan, Northern goshawk, Seabird Telemetry, White stork, White fronted Geese, Whooper Swan	Lithuania	2014 - 2020	Breeding, Migration, and Winter
Great cormorant Lithuania 2020 GURMANAS	GPS tagging	Great cormorant	Lithuania - 55.835, 21.067	2020 - ongoing	Breeding
Dabbling duck migration Lithuania 2019	GPS tagging	European Wigeon and Northern Pintail	Lithuania - 55.265, 21.463	2019	Migration
Common Terns in Lithuania 2020	GPS tagging	Common Tern	Lithuania - 54.646, 23.993	2020 - ongoing	Unknown
Whooper Swan Lithuania GPS 2016-2017	GPS tagging	Whooper Swan	Lithuania - 55.344, 22.823	2016 -2017	Unknown
Great cormorant tagging	GPS tagging	Great cormorant	Lithuania - 55.332, 21.358	2017 & 2018	Breeding

Poland

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
HELCOM - HOLAS II project - Abundance of waterbirds in the breeding season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country. 99610 data points	30 breeding water-bird species* surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Germany, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Breeding
HELCOM - HOLAS II project - Abundance of waterbirds in the wintering season 2018	Coastal Count data. Data sets consists of site code, year, species and abundance, country, XY and unique site code with country.	Multi-species *surveys are costal and species which are dominantly found in open ocean not included	Baltic Sea, Estonia, Finland, Latvia, Poland, Sweden	1991-2016	Winter
Mid-Winter Waterbird Census	Land based total count, including species ID and count location	All sighted birds belonging to the following groups are registered: Anseriformes, Podicipediformes, Gaviformes, Phalacrocoracidae, Ardeidae, Rallidae, Laridae, Scolopacidae, Charadriidae, Falconiformes - only Haliaetus albicilla, Circus cyaneus	Western part of the Gulf of Gdansk	1984 - Ongoing (Annual)	Winter
National monitoring programme - Winter ship-based surveys	Abundance and distribution, including species ID, total counts and XY location	All sighted birds (individuals) belonging to the following groups are registered system-atic: Anseriformes, Podicipediformes, Gaviformes, Phalacro-coracidae, Ardeidae, Rallidae, Laridae, Scol-opacidae, Charadriidae, Falconiformes - only Haliaetus albicilla, Circus cyaneus	Whole Polish 12 miles zone. Two offshore areas: Slupsk Bank and Pomeranian Bay Polish part of Southern Middle Bank is not covered by monitoring	2011 - Ongoing (Annual)	Winter
Baltic offshore Waterbird Census	Ship based transect counts, including species ID, total counts and XY location	All waterbirds	Offshore territorial waters	1988, 1990, 1992, 1993	Winter
SOWBAS - Offshore Winter waterbird census	Total species counts and ship based transect counts, including species ID, total counts and XY location	All species observed	Offshore territorial waters	2003 - 2010	Winter
National Breeding Bird Survey	Population size (abundance), including species ID and colony location	Dunlin Started in 2007, Cormorant and Sandwich tern Start-ed in 2015, Shelduck, Ringed plover, Little tern and Oystercatch-er started in 2020	Almost whole coastline	2007 - ongoing	Breeding
Pomeranian Bay ship-based surveys	Ship transect survey, including species ID, total counts and XY location	All waterbirds	Pomeranian Bay	1988, 1990, 1992, 1993, 2003, 200 4,2006,2007,20 08,2011,2012,201 3,2014	Winter

Poland cont.

Name of Source	Brief Description of Data	Species	Location	Temporal Externt	Season/Months
Pomeranian Bay Aerial based surveys	Aerial transect survey, including species ID, total counts and XY location	All waterbirds	Pomeranian Bay	2003,2004, 2006, 2007, 2010, 2011, 2012	Winter
Monitoring of Birds of Poland (MBP)	Database with species counts and distribution based in survey plots. .	Multi-species	Poland	2006 - Ongoing	Breeding, Winter, Migration

Annex 3. National organisations and research groups

List of national organisations and research projects contacted in relation to seabird abundance and distribution at-sea and interactions with offshore wind farms.

UK

Expert Group	Overview
Joint Nature Conservation Committee (JNCC)	Covers projects focused on at-sea surveys, seabird colony monitoring and species-specific interactions with offshore wind, including: Offshore Wind Strategic Monitoring & Research Forum (OWSMRF) **https://jncc.gov.uk/our-work/owsmrf/**
British Trust of Ornithology (BTO) – SOSS Projects	Carries out research into the impacts of seabirds with offshore wind and distribution of seabirds including collision risk studies, species specific interactions with offshore wind, ring resighting, and breeding and winter count data. **https://www.bto.org/our-science/wetland-and-marine/soss**
Centre of Ecology and Hydrology (CEH)	Investigates and monitors impacts of marine renewables on seabirds. Cumulative Effect Framework of offshore renewable development - for seabirds and marine mammals. **https://www.ceh.ac.uk/our-science/projects/impacts-renewables-seabirds**
Royal Society for the Protection of Birds (RSPB)	Hold data on tracking studies, species distributions, hotspot areas. **https://www.rspb.org.uk/our-work/policy-insight/marine-and-coastal/offshore-renewables/#**
Offshore Renewables Joint Industry Project (ORJIP)	ORJIP Ocean Energy is a UK-wide collaborative programme of environmental research with the aim of reducing consenting risks for wave, tidal stream, and tidal range projects. **http://www.orjip.org.uk/oceanenergy/about**
Marine Ecosystems Research Programme – Top predators	Quantifying the distribution and populations sizes of cetaceans and seabirds in the North East Atlantic. **https://www.marine-ecosystems.org.uk/Research_outcomes/Top_predators**
Marine Scotland Science Research	Develop research projects and tools studying the impact of marine renewable energy on seabirds including:Scottish Marine Energy Research (ScotMER) programme and the Ornithology Specialist Receptor Group, concerned with evidence gaps related to seabird ecology and the potential impacts of offshore renewables on seabirds. **https://www.gov.scot/publications/ornithology-specialist-receptor-group/**
Crown Estate – Marine data exchange	The Marine Data Exchange (MDE) is a system to store, manage, and disseminate offshore survey data provided by our offshore renewable and marine aggregates customers. Also provides outputs from several collaborative research projects, such as the COWRIE (Collaborative Offshore Wind Research into the Environment) database, which this system replaces are also available. **https://marinedataexchange.co.uk/faq.aspx**

Belgium

Expert Group	Overview
Institute for Nature and Forests (INBO)	INBO is conducting research into the disruptive effects of offshore wind farms on seabirds and the likelihood of seabirds colliding with the turbines. **https://www.vlaanderen.be/inbo/en-GB/projects/monitoring-van-de-effecten-van-de-windmolenparken-op-zee-op-de-avifauna-evinbo**

Netherlands

Expert Group	Overview
Wageningen IMARES - Institute for Marine Resources & Ecosystem Studies	Conducting research into the distribution of seabirds at-sea and their interactions with offshore wind. Also, involved in several long-term monitoring studies with seabirds. **https://www.wur.nl/nl/Onderzoek-Resultaten/Onderzoeksinstituten/marine-research/Themas/Mariene-natuur-en-biodiversiteit/Zeevogels.htm**
WOZEP - offshore wind ecological programme	The WOZEP research programme was launched in 2016 to explore the knowledge gaps relating to the ecological effects of offshore wind energy. Projects cover seabird distribution at-sea and interactions with offshore wind farms (displacement and collision risks) and the Framework for the Assessment of Ecological and Cumulative Effects (KEC). **https://www.noordzeeloket.nl/en/functions-and-use/offshore-wind-energy/ecology/offshore-wind-ecological-programme-wozep/newsletter-wozep/wozep-newsletter-2/framework-assessment/** **https://www.noordzeeloket.nl/en/functions-and-use/offshore-wind-energy/ecology/offshore-wind/**
Bureau Waardenburg	An independent research and advice consultancy working in the fields of ecology, nature, the environment, and landscape design. It is involved in several projects investigating the ecology and distributions of seabirds in the North Sea and other coastal waters. Seabird Monitoring - **https://www.buwa.nl/en/coastal-and-seabird-research.html** Tagging and tracking studies - **https://www.buwa.nl/en/specialist-bird-research.html** Offshore aerial surveys - **https://www.buwa.nl/en/aerial-surveys-seabirds-north-sea.html**
NIOZ - Royal Netherlands Institute for Sea Research	Holds at-sea survey data for seabirds and marine mammals. **https://www.nioz.nl/en/news/nioz-north-sea-expeditions-2019-three-pelagia-cruises-to-study-the-carrying-capacity-of-north-sea**
UvA BiTS – University of Amsterdam Bird Tracking Systems	Developed GPS tracking devise and collaborates with research projects to tag and track birds. Several collaborative tracking projects involve tracking seabirds and seabird movements arounds offshore wind farms. **https://www.uva-bits.nl/**

Germany

Expert Group	Overview
Research and Technology Centre (FTZ, Kiel University) – ECOLAB - Group Animal Ecology, Conservation & Science Communication	Reach group that monitors the populations of seabirds as well as their temporal and spatial patterns, based on ship-based and aerial survey, GPS loggers and other sensors. **https://www.ftz.uni-kiel.de/en/research-divisions/ecolab-marine-animal-ecology**
BioConsult SH	BioConsult SH compiles expert reports for environmental impact studies, risk assessment, baseline research, appropriate assessment in accordance with the Habitats Directive and feasibility studies. Specialises in digital aerial surveys for seabirds and is involved with several projects focused on estimating collision risk in seabirds and migrating birds. **https://bioconsult-sh.de/en/projects/offshore-wind-farms/**

Denmark

Expert Group	Overview
Aarhus University - National Environmental Research Institute (NERI)	Holds at-sea seabird distribution data and is responsible for breeding and wintering seabird and seaduck counts. They have also published or are affiliated with several research studies looking into the impact of offshore renewables on waterbirds. **https://dce.au.dk/en/publications/scientific-reports/nr-301-350/abstracts/nr-327-number-and-distribution-of-birds-in-and-around-two-potential-offshore-wind-farm-areas-in-the-danish-north-sea-and-kattegat/**

Norway

Expert Group	Overview
Norwegian Institute for Nature Research (NINA)	Created the SEAPOP and SEATRACK projects. Responsible for at-sea surveys of seabirds. Monitoring population size and success of breeding, wintering, and migratory seabird species in Norway. **https://seapop.no/en/**

Sweden

Expert Group	Overview
Lund University	Has carried out independent studies into seabird interactions with offshore wind farms in Sweden and research studies tracking seabird distribution in the Baltic Sea. Tracking database **https://www.canmove.lu.se/database**

Finland

Expert Group	Overview
Finland Natural History Museum (LUOMUS)	Coordinates the winter waterbird surveys for Finland, as a part of the IWC winter bird counts, including offshore boat surveys. **https://laji.fi/en/project/MHL.3/stats?tab=species&species=MX.26442&year=2020**
Finnish Environmental Institute (SKYE)	Coordinates the breeding bird counts in Finland. **http://www.syke.fi/en-US**

Estonia

Expert Group	Overview
Estonia University of Life Sciences	In collaboration with the University of Latvia and the Latvian ornithological society has carried out analysis of at-sea aerial survey data, creating distribution density maps for wintering seabirds and seaduck in Estonia and Latvia.

Latvia

Expert Group	Overview
University of Latvia	In collaboration with the Latvian ornithological society and Estonia University of Life Science has carried out analysis of at-sea aerial survey data creating distribution density maps for wintering seabirds and seaduck in Estonia and Latvia.

Lithuania

Expert Group	Overview
Nature Research Centre – Laboratory of avian ecology	Research into anthropogenic impact on birds (changes of population status, vulnerability, and adaptations). With a focus on waterfowl research and conservation issues in the Baltic Sea. **https://gamtostyrimai.lt/lt/users/viewGroup/id.22**
Ornitela	Specialises in advanced telemetry applications for studying wild birds and have collaborated and provided tags for several seabird distribution studies in the North and Baltic Sea. **https://www.ornitela.com/**

Annex 4. Complete Seabird Species List

A list of important seabird and waterbird species that use the marine environment in the North Sea and Baltic Sea was created by combining two species lists for these regions. Theses being the BirdLife Internationals seabird species list for the North Sea and Baltic Sea and HELCOMS list of indicator species for the Baltic Sea.

Common Name	Species	Sea Basin	Collision Risk	Displacement Risk
Lesser black-backed gull	*Larus fuscus*	North and Baltic	V.HIGH	V.LOW
European Herring gull	*Larus argentatus*	North and Baltic	V.HIGH	V.LOW
Glaucous gull	*Larus hyperboreus*	North Sea	V.HIGH	V.LOW
Iceland gull	*Larus glaucoides*	North Sea	V.HIGH	V.LOW
Great black-backed gull	*Larus marinus*	North and Baltic	V.HIGH	V.LOW
Sabine's gull	*Xema sabini*	North Sea	HIGH	LOW
Northern gannet	*Morus bassanus*	North Sea	HIGH	V.LOW
Black-headed gull	*Larus ridibundus*	North and Baltic	HIGH	V.LOW
Mediterranean gull	*Larus melanocephalus*	North and Baltic	HIGH	V.LOW
Common gull	*Larus canus*	North and Baltic	HIGH	V.LOW
Little gull	*Hydrocoloeus minutus*	North and Baltic	HIGH	V.LOW
Black-legged Kittiwake	*Rissa tridactyla*	North Sea	HIGH	V.LOW
Great cormorant	*Phalacrocorax carbo*	North and Baltic	MOD	MOD
European shag	*Gulosus aristotelis*	North and Baltic	MOD	LOW
Little tern	*Sternula albifrons*	North and Baltic	MOD	LOW
Sandwich tern	*Thalasseus sandvicensis*	North and Baltic	MOD	LOW
Common tern	*Sterna hirundo*	North and Baltic	MOD	LOW
Black tern	*Chlidonias niger*	North and Baltic	MOD	LOW

Common Name	Species	Sea Basin	Collision Risk	Displacement Risk
Roseate Tern	*Sterna dougallii*	North Sea	MOD	LOW
Great skua	*Catharacta skua*	North Sea	MOD	V.LOW
Arctic Skua	*Stercorarius parasiticus*	North and Baltic	MOD	V.LOW
Pomarine Skua	*Stercorarius pomarinus*	North Sea	MOD	V.LOW
Long-tailed Skua	*Stercorarius longicaudus*	North Sea	MOD	V.LOW
Red-necked Phalarope	*Phalaropus lobatus*	North and Baltic	MOD	V.LOW
Grey Phalarope	*Phalaropus fulicarius*	North Sea	MOD	V.LOW
Greater Scaup	*Aythya marila*	North and Baltic	LOW	HIGH
Common Goldeneye	*Bucephala clangula*	North and Baltic	LOW	HIGH
Common Scoter	*Melanitta nigra*	North and Baltic	LOW	HIGH
Goosander	*Mergus merganser*	North and Baltic	LOW	HIGH
Red-throated diver	*Gavia stellata*	North and Baltic	LOW	HIGH
Black-throated diver	*Gavia arctica*	North and Baltic	LOW	HIGH
White-billed diver	*Gavia adamsii*	North Sea	LOW	HIGH
Velvet Scoter	*Melanitta fusca*	North and Baltic	LOW	MOD
Red-breasted Merganser	*Mergus serrator*	North and Baltic	LOW	MOD
Common Eider	*Somateria mollissima*	North and Baltic	LOW	MOD
Great Northern diver	*Gavia immer*	North and Baltic	LOW	MOD
Great Crested Grebe	*Podiceps cristatus*	North and Baltic	LOW	MOD
Arctic tern	*Sterna paradisaea*	North and Baltic	LOW	LOW
Long-tailed Duck	*Clangula hyemalis*	North and Baltic	V.LOW	MOD
Black Guillemot	*Cepphus grylle*	North and Baltic	V.LOW	MOD
Slavonian Grebe	*Podiceps auritus*	North and Baltic	V.LOW	MOD
Razorbill	*Alca torda*	North and Baltic	V.LOW	LOW
Atlantic Puffin	*Fratercula arctica*	North Sea	V.LOW	LOW
Common Guillemot	*Uria aalge*	North and Baltic	V.LOW	LOW
Little Auk	*Alle alle*	North Sea	V.LOW	V.LOW
Northern fulmar	*Fulmarus glacialis*	North Sea	V.LOW	V.LOW
Manx shearwater	*Puffinus puffinus*	North Sea	V.LOW	V.LOW
Leach's storm-petrel	*Hydrobates leucorhous*	North Sea	V.LOW	V.LOW
European storm-petrel	*Hydrobates pelagicus*	North Sea	V.LOW	V.LOW
Harlequin Duck	*Histrionicus histrionicus*	North Sea	Unknown	Unknown
King Eider	*Somateria spectabilis*	North Sea	Unknown	Unknown
Steller's eider	*Polysticta stelleri*	North and Baltic	Unknown	Unknown
Brunnich guillemot	*Uria lomvia*	North Sea	Unknown	Unknown
Caspian gull	*Larus cachinnans*	North and Baltic	Unknown	Unknown
Yellow-legged gull	*Larus michahellis*	North and Baltic	Unknown	Unknown
Common gull-billed tern	*Gelochelidon nilotica*	North Sea	Unknown	Unknown

Common Name	Species	Sea Basin	Collision Risk	Displacement Risk
Caspian tern	*Hydroprogne caspia*	North and Baltic	Unknown	Unknown
Black-necked Grebe	*Podiceps nigricollis*	North and Baltic	Unknown	Unknown
Red-necked Grebe	*Podiceps grisegena*	North and Baltic	Unknown	Unknown
Mute swan	*Cygnus olor*	North and Baltic	Unknown	Unknown
Whooper swan	*Cygnus cygnus*	North and Baltic	Unknown	Unknown
Tundra swan	*Cygnus columbianus*	North and Baltic	Unknown	Unknown
Eurasian wigeon	*Mareca penelope*	North and Baltic	Unknown	Unknown
Mallard	*Anas platyrhynchos*	North and Baltic	Unknown	Unknown
Northern pintail	*Anas acuta*	North and Baltic	Unknown	Unknown
Eurasian coot	*Fulica atra*	North and Baltic	Unknown	Unknown
Common pochard	*Aythya ferina*	North and Baltic	Unknown	Unknown
Tufted duck	*Aythya fuligula*	North and Baltic	Unknown	Unknown
Smew	*Mergellus albellus*	North and Baltic	Unknown	Unknown
Eurasian Teal	*Anas crecca*	North and Baltic	Unknown	Unknown
Greylag goose	*Anser anser*	North and Baltic	Unknown	Unknown
Common shelduck	*Tadorna tadorna*	North and Baltic	Unknown	Unknown
Eurasian oystercatcher	*Haematopus ostralegus*	North and Baltic	Unknown	Unknown
Pied avocet	*Recurvirostra avosetta*	North and Baltic	Unknown	Unknown
Ringed plover	*Charadrius hiaticula*	North and Baltic	Unknown	Unknown
Ruddy Turnstone	*Arenaria interpres*	North and Baltic	Unknown	Unknown
Dunlin	*Calidris alpina*	North and Baltic	Unknown	Unknown

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