Guidelines for monitoring seabirds at sea

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1. Background

The efforts of HELCOM to conserve the Baltic Sea environment are aggregated in its Baltic Sea Action Plan. Measures to guarantee the environmental integrity of the Baltic Sea need to be backed by science-based environmental data. To get this information, HELCOM is conducting holistic assessments, which include various components of the Baltic Sea ecosystem.

Seabirds (marine birds including coastal waterbirds) are substantial components at various levels of the food web and serve as herbivores of littoral vegetation and predators of macroinvertebrates, fish, other birds, carcasses and fishery discard in the Baltic marine environment. While breeding seabirds are concentrated along and around their breeding sites at the coast or on islands, non-breeding seabirds are distributed across the entire marine area of the Baltic Sea. In the second holistic assessment of the Baltic Sea (HOLAS II), the abundance of wintering seabirds was assessed by the HELCOM Core Indicator “Abundance of waterbirds in the wintering season” (HELCOM 2018). In HOLAS II, the assessment of wintering seabirds relied on coastal (land-based) counts only, thus any conclusions were restricted to the coastal waters. In order to expand the validity of the indicator to the entire marine area of the Baltic Sea, the indicator needs to include assessments of birds wintering off the coast. This expansion needs surveys and monitoring at sea, and these guidelines describe the designing and methodology of such surveys.

Beyond assessing the abundance of seabirds wintering offshore, at-sea survey data serve other components of bird assessments, especially the distribution of seabirds (currently no candidate indicator available) and the disturbance of seabird habitat (indicator under development). In addition, bird numbers derived from at-sea surveys are an important component of the assessment of bycatch in fishing gear (HELCOM Core Indicator “Numbers of drowned mammals and waterbirds in fishing gear”). All these assessments shall be used by EU Member States for the reporting of the state of the Baltic Sea according to Article 8 of the Marine Strategy Framework Directive (2008/56/EC).

At-sea surveys give important reference to Important Bird Areas (IBA), Special Protected Areas (SPA) designated under the EU Birds Directive (2009/147/EC) and other Marine Protected Areas (MPA), which need to be re-assessed due to changing distributions of wintering waterbirds as response to climate change (Pavón-Jordán et al. 2019). This information also contributes to HELCOM Recommendation 34E/1 “Safeguarding important bird habitats and migration routes in the Baltic Sea from negative effects of wind and wave energy production at sea”, may serve as valuable reference data in impact assessments and feeds into reporting the status of bird species in the frame of the Birds Directive.

In a scenario with climate change affecting the winter distribution of marine birds, local changes in distribution can be caused by larger scale redistribution of a species (Fox et al. 2019). A common survey protocol and data collection scheme is an essential prerequisite for being able to distinguish between population fluctuations and site re-distribution.

1.1 Introduction

Economic interests and activities at sea (e.g. shipping activities, fisheries, bridges, developments for renewable energy and oil and gas infrastructure) affect the marine ecosystem in many ways and can cause risk to the marine environment and biodiversity. These activities are constantly increasing in number and intensity. Climate change further intensifies these threats. Thus, there is urgent need to identify and mitigate these negative impacts.

Being highly mobile top-predators, seabirds are exposed to various anthropogenic impacts and can serve as highly visible indicators for an increasing number of pressures and their impacts on biodiversity.

In the Baltic Sea, Seabirds at sea monitoring schemes are implemented or at least envisaged by all HELCOM Contracting Parties except for Russia. Robust assessments of seabird populations are however impaired by differing survey schemes in each country. The extent of areas covered and the species monitored differ between nations, as well as the sampling design, sampling methods, time frames and database structures (Appendix 1).

Despite the existence of several manuals of seabird survey methodologies and monitoring guidelines (e.g. Camphuysen et al. 2004, HELCOM 2015), methodologies differ e.g. in time resolution, coding or classification, even when the same sampling platform or method is used. Thus, data are often not fully compatible and joint data analyses are limited.

Not only survey methodologies, but also timing of at sea surveys lack synchronization among Baltic Sea countries. Especially during the non-breeding season, seabirds of the same population can cover large areas of the Baltic Sea, encompassing different countries. Their high mobility allows seabirds to quickly adjust their distribution according to weather conditions, ice cover and occurrence of prey. Uncoordinated seabird counts in different parts of the Baltic Sea may cause incorrect numbers and trends for Baltic Sea wide assessments by missing or double-counting birds.

National coordinators of seabird surveys have recently begun to coordinate and harmonize their efforts. A first attempt to internationally coordinate survey efforts was the large-scale survey of wintering seabirds in the Baltic Sea in 2016, when all participating countries (SE, FI, EE, LV, LT, PL, DK, and DE) carried out fieldwork within two months. Synchronized surveys in all major parts of the Baltic Sea were carried out, data were collated and external datasets for the modelling process were collected. First results have been presented at the 2019 annual meeting of the Joint OSPAR/HELCOM/ICES Working Group on Seabirds (JWGBIRD) in Sept/Oct 2019 in Tartu, Estonia (ICES 2020). The network of Baltic Sea partners initiated a second joint-survey in early 2020 and successfully complemented it in midwinter 2021.

Despite these temporally coordinated surveys, there were still many gaps in spatial coverage and differences in data structure. Continuing and intensifying efforts for coordinated seabird surveys will achieve a higher quantity and quality of data for Baltic Sea seabird assessments and management plans.

1.2 Purpose and aims

Comprehensive assessments and effective conservation management require the coordination and harmonization of the national seabirds at sea monitoring schemes in all Baltic Sea countries. The HELCOM guidelines for monitoring seabirds at sea provide the necessary background and tools for enabling a monitoring strategy serving the national monitoring requirements as well as the reporting and management commitments of HELCOM, MSFD and Birds Directive.

In the following, we describe a framework for long-term coordinated seabird monitoring in the Baltic Sea which is based on the existing or envisaged national monitoring schemes. This framework includes a common monitoring strategy, synchronized survey efforts, harmonized methodology and survey designs, a common data model and a system to store and share the data as well as joint analyses of datasets.

2. Monitoring methods

2.1 Monitoring features

The Baltic Sea is home to a multitude of species of seabirds and waterbirds that use the area for resting, feeding, moulting, breeding and wintering. It is one of the world's most important sites for wintering birds, especially for seaducks, but also for other diving species like grebes and divers. During winter, numbers reach several million birds. However, over the recent decades, numbers have declined dramatically (Skov et al. 2011).

Diving species often concentrate in huge numbers over shallow offshore banks, foraging for molluscs and fish. Other species like surface-feeding gulls and piscivorous species foraging in the pelagic zone are more widely dispersed. Several species occur predominantly in the offshore areas far from the coast and cannot be adequately assessed by land-based counts. In particular, seaducks, divers, alcids and some grebe and gull species have to be mostly surveyed at the open sea by seagoing ships or twin-engined aircrafts (Table 1). At-sea surveys also provide relevant data on cormorants, mergansers and other diving ducks, which mainly inhabit coastal areas but also use offshore waters. Due to the vast study area and the dispersed distribution of seabirds, numbers and distribution patterns cannot be assessed by total counts but have to be monitored using a sampling survey design (as for instance line transect distance sampling) covering representative sub-areas. Synchronization of the nationally performed surveys is essential to account for the high mobility of seabirds.

Table 1. Coverage of HELCOM wintering waterbird indicator species by seabirds at sea surveys in the Baltic Sea (adjusted from ICES 2015). Focal species in bold print (main distribution area can only be assessed by the help of at-sea surveys). Standard print = at-sea surveys overlap only partly with main distribution in HELCOM assessment area. (Species in brackets: main distribution area not covered by at-sea surveys). Note that proportions of birds found at sea (and sometimes the foraging habitat/mode) may differ between subregions of the Baltic Sea.

Functional Group	Wintering waterbird indicator species
Wading feeders	NA
Surface feeders	Common gull **Herring gull** **Great black-backed gull** **Little gull** (Black-headed gull)
Water column feeders	**Red-throated diver** **Black-throated diver** **Razorbill** **Common guillemot** **Black guillemot** **Slavonian grebe** **Red-necked grebe** Great crested grebe

	Red-breasted merganser (Great cormorant) (Goosander) (Smew)
Benthic feeders	**Common eider** **Steller's eider** **Long-tailed duck** **Common scoter** **Velvet scoter** Greater Scaup Common Goldeneye (Common pochard) (Tufted duck)
Grazing feeders	(Mute swan) (Whooper swan) (Gadwall) (Eurasian wigeon) (Eurasian teal) (Mallard) (Northern pintail) (Eurasian coot)

2.2 Time and area

Monitoring surveys need to focus on seasons of most important bird occurrence. Given the high mobility of birds, it is wise to conduct large-scale surveys at the time of lowest amount of movements. Although flights between staging sites do occur on both a local and regional scale also in winter, that season fits best the demands of large-scale surveys, with respect to avoiding double-counting and achieving complete coverage. In addition, most seabird species reach their maximum numbers in the Baltic Sea areas during winter. In many countries, winter seabird/waterbird counts are traditionally not only conducted from the coast (e.g. in the frame of the International Waterbird Census IWC, Wetlands International 2010). Most of the monitoring programmes running at sea are also focusing on winter. Compared to migratory seasons (mainly spring and autumn), the lower amount of movements overrides disadvantages such as short length of day (especially at northern latitudes) and variable or unpredictable conditions regarding inclement weather and ice-cover. When assessing the status of marine areas at a smaller scale, it is advisable to additionally pay attention to the seasons that are most important with respect to occurrence of relevant bird species. For example, some marine areas are valuable owing to their role as moulting areas. Regarding trend assessments it is possible, and at least in some cases recommendable, to combine results from different seasons, whereas this is not an option for assessments of population sizes.

The HELCOM agreement covers the whole territory of the Baltic Sea. The "marine waters under the sovereignty and jurisdiction of Member States of the European Union" are in scope of the MSFD and reporting obligations cover territorial and EEZ waters. Thus it is recommended that the territorial scope of the national marine bird monitoring programmes for the Baltic Sea are not limited to territorial waters and cover EEZ waters too, especially if they include sand banks, reefs or other sites holding significant waterbird populations. The Birds Directive applies to all species of naturally occurring birds in the wild state in the European territory of the Member States.

2.3 Monitoring procedure

Seabirds at sea surveys are carried nationally out by ships and/or aircrafts using different sampling methods. These include so called total count censuses (where the surveyor attempt to count all birds present within the survey area), strip transects, distance sampling, line transect, digital aerial imaging (still photo, video) and combinations of these. A key element of the common monitoring strategy is the continuation of the nationally performed monitoring programmes. In general, existing monitoring programmes should retain the established elements of their survey schemes as far as possible and applicable, i.e. with respect to survey design, platform and other methodological details. We provide considerations and guidance for the designing of new survey schemes as well as for additional elements in existing programmes supporting the harmonization of national schemes to achieve a common monitoring framework.

Surveys of marine birds at sea should ideally cover all species encountered. The focus of seabirds at sea monitoring schemes will however be on species with high concentrations in offshore waters that cannot be assessed well by land-based counts. At a Baltic Sea wide scale, this comprises the groups of seaducks, divers, auks and to some extent also gulls, grebes, mergansers and cormorant (Table 1, but note that there may be local differences, e.g. good feasibility of covering the majority of the Swedish occurrence of wintering Common and Velvet Scoters by land-based counts). Other groups of birds, e.g. songbirds or raptors, can also get recorded when time allows. Even if some species might not be covered in every national monitoring scheme, the respective species can still be assessed in part of the area, e.g. in subbasins.

2.3.1 Sampling methods and equipment

Recommendations for the choice of sampling platform and method. A combination of ship-based and aerial counts using line transects with distance sampling is recommended for large-scale monitoring surveys of seabirds in the Baltic Sea. Running monitoring schemes should maintain the same type of counting platform over years.

Ship-based and aerial surveys both have advantages and disadvantages (see e.g. Camphuysen et al., 2004). In general, both platforms were used extensively in the past four decades, and can provide reliable data for assessing seabird status. Both survey types apply comparable methods (mostly line-transect counts) and produce results in the same units (bird numbers per area surveyed, i.e. bird densities). Choice of the platform depends on the demands concerning the area and species to be covered, but also on the “tradition” of such investigations in different countries and not least on the availability of suitable ships/aircrafts and the respective funding. Though currently too expensive for the purpose of large-scale monitoring, digital imaging from aircrafts (Buckland et al., 2012) may be another option in future. Results from digital imaging appear to be well combinable with those from surveys done by observers from ships or aircrafts (Mercker et al. 2021).

Ship-based surveys outperform aerial surveys with regard to bird detection and species identification. They are usually preferred if it is essential to achieve faunistic precision and precise numbers of rare or inconspicious species. General bird identification skills are usually sufficient for ship-based surveys, but estimation of bird numbers in big flocks and distance estimation need special training. Ship-based surveys are less weather sensitive than aerial surveys and especially in wintertime, with often unfavourable weather conditions, ship surveys might be the only option to carry out offshore surveys. On the other hand, ship speeds do not allow covering large areas. In countries with huge offshore areas, the amount of ship-time needed to cover large areas, might be unrealistic due to available days with suitable weather conditions. Especially in wintertime when days are short, the ratio of waiting time and counting time is not cost-efficient. Additionally, most ships suitable for bird counting are not able to approach close to the coastline or cross shallow banks. Classical parallel line sampling design is not cost effective for ship surveys. Instead, zigzag line transect designs are recommended for ship-based surveys (Strindberg and Buckland, 2004).

Aerial surveys allow to cover large areas in relatively short time, because flight speed is much higher than ship speed (usually 100 knots vs. 10-20 knots). Particularly for countries covering large areas or island-rich and very shallow areas, aerial surveys are the only feasible choice for full-scale surveys. Moreover, aerial surveys are also advantageous in wintertime, when daylight is short and days with suitable weather conditions are limited. Aircrafts can efficiently use short periods with appropriate survey conditions. However, aerial surveys need better weather conditions during the survey. This can be a major obstacle if the time frame for the survey is very narrow. Specifically, during transition times (e.g. migration) when birds are very mobile, this can cause very time-fragmented surveys that do not represent accurate bird occurrences. Other disadvantages of aerial surveys are a tendency to underestimate large seabird flocks (e.g. Bellebaum et al., 2014) and more challenging conditions regarding bird identification. Therefore, aerial observers need further training on bird recognition, species identification and flock size estimation. Some seabird species can only be identified to genus or even higher taxonomic level during aerial surveys. Note that taking photographs of big and mixed flocks alongside the standard surveys may help to overcome these difficulties. Aerial surveys are generally less suitable for small, inconspicuous species (such as grebes and auks), in particular in mixed-species aggregation. However, aerial surveys cause fewer disturbances to some species groups such as divers.

Line transects vs strip transects. The two sampling techniques are relevant for both aerial and ship-based surveys. Using strip transects, objects outside the strip are not counted. Width of the strip should not be larger than the area where detectability of the objects is 100 %. In practice, this assumption rarely is true, even for narrow strips, thus resulting in underestimation of the population size (Ronconi and Burger, 2009). The proportion of undetected birds varies between the species. Line transect surveys apply distance sampling to account for decreasing detection of birds with increasing distance of birds from the observer (Thomas et al., 2002). Due to the high number of sightings in combination with the high cruising speed, observations are usually grouped in distance bins rather than measuring absolute distance. Species and observer specific detection curves allow more robust population estimates than those obtained in the strip transects. The area under the aircraft can not be surveyed, because there is a blind angle. Thus binned data collection has an offset to the side of the track line (called a left-hand truncation).

Aerial imaging. A possible alternative to the conventional counting platforms is aerial imaging (Gordon et al., 2013; Groom et al., 2013, 2007; Thaxter and Burton, 2009). Some studies comparing visual counts and aerial imaging show considerable differences in the results of both types of surveys (Kulemeyer et al., 2011, Žydelis et al. 2019). Aerial imaging can provide more precise estimates (especially when large flocks are encountered), by improving bird detection and reducing biases due to imperfect detectability of birds in conventional methods. It establishes a traceable sampling method which allows storing of collected samples for later reuse. Nevertheless, presently the method still is considerably more expensive than the conventional methods. It requires considerable investments and steep learning curve to establish the workflow, especially developing an automated rule-set based recognition of candidate image segments for birds; it does not reduce the overall man-time needed. Due to the current cost-effectiveness, it is presently not recommended to fully replace the observer-based counts with aerial imaging in the national monitoring programmes.

Recommended standards for ship surveys. The methodology described by Camphuysen et al. (2004) and Lewis (2020) is recommended for ship-based monitoring surveys in the Baltic Sea. The preferred ship type is a motor vessel with a forward viewing possibility at least at 5 m above sea level, although higher viewing points are preferred. The ship should be able to keep a constant speed of preferably ~10 knots (~20 km/h) with a minimum speed of ~5 knots (~10 km/h).

Observed birds have to be allocated to the distance bands (see Appendix 3 for recommended parameters of the distance). To avoid an overestimation of numbers of flying birds, a regular snapshot of birds in flight over the transect bands and within 300 m ahead of the ship (at a speed of ~10 knots, other distances are listed in the snapshot table in Appendix 3) should be implemented.

More detailed information for counting seabirds during ship surveys and an appropriate device list is available in Appendixes 2 and 4.

Recommended standards for observer-based aerial surveys. Aerial survey techniques described by Camphuysen et al. (2004) and Petersen et al. (2006) are recommended as standard for aerial offshore bird monitoring in the Baltic Sea. The standard altitude for these surveys is 250 feet (76 m), and the flight speed should not exceed 100 knots (185 km/h). Species recognition will decrease if aircrafts fly at higher altitudes or faster. Furthermore, the viewing angles for distance bands (Appendix 3) are calculated for an altitude of 250 feet and are not applicable to other altitudes.

Observations have to be allocated to distance bands. Appendix 3 gives the parameters of the distance. These parameters are only valid for the flight altitude of 250 feet.

Detailed information for counting seabirds during aerial surveys and a device list is available in Appendixes 2 and 4.

2.3.2 Monitoring strategy

Coordinated large-scale surveys provide the data basis for accurate estimates of population sizes and reliable trends in the sizes of populations. In case of no restrictions on funding resources, an optimal sampling design delivering a robust dataset for both purposes would consist of coordinated full-scale surveys at short survey intervals (i.e. at least one survey per year). However, resources are limited and allow for a restricted sampling design only. This necessitates careful consideration of the desired output as the sampling design is subject to a trade-off between enhancing the reliability of population estimates on the one hand and enhancing the reliability of population trends on the other hand. The first objective is best served by surveys with complete coverage, the latter objective requires surveys at a high frequency. The experts of JWGBIRD recommend conducting (1) synchronous full-scale surveys covering major parts of the HELCOM and OSPAR regions at least once per six year reporting cycle and (2) surveys covering a subset of relevant areas at higher frequency in the years in between (index counts). This approach offers a compromise between estimating population sizes in reasonable time intervals, whereas trend calculation is facilitated by more frequent index counts. This makes it possible to serve the demands from various directives (e.g. Bird Directive, MSFD) and national monitoring schemes.

Coordinating efforts. Except for RU, all HELCOM Contracting Parties reported that they are aiming for large scale surveys of wintering populations at least once in 6 years in their monitoring programmes. Many countries even have reported such surveys every 3rd or 2nd year. For Baltic Sea wide population estimations and assessments, we recommend an internationally coordinated survey at least once during the MSFD reporting cycle (6 years). The national institutions responsible for marine bird monitoring are invited to harmonize financing plans of the national monitoring programmes to allow carrying out large scale surveys during the same winter. If possible, surveys in all contracting parties should also be harmonized and synchronized in time. Efforts should be taken to carry out the surveys of all countries in an agreed short period of time, preferably January and/or February. However, weather constraints and availability of suitable aircrafts might interfere with these ambitions. If the weather prevents a Baltic wide survey in the suggested winter, it should be carried out in the next suitable winter.

Synchronisation of large-scale surveying of moulting populations is recommended as well. However, before establishing coordinated monitoring of moulting populations, baseline surveys and designation of important moulting sites is needed in the majority of the Baltic Sea countries.

In other seasons and during migration, seabird distributions are very dynamic and bird numbers fluctuate strongly. Synchronized monitoring surveys are therefore less feasible. During these seasons, there will be a stronger focus on addressing monitoring scheme and monitoring schedules at a national/sub-regional level. Next to surveys of resting numbers at sea, migration movements are assessed by land-based counts at bottleneck sites, delivering invaluable data on numbers, phenology and population structure (e.g. Kjellen 2019, Lehikoinen 2019, Ellermaa & Lindén 2020).

Time of the year. Populations of wintering birds are to be monitored during the winter months (mid-December – end of February). If the weather allows, January is preferred. During winter, synchronized surveys are needed to avoid double-counting or undercounting birds due to freezing of suitable areas in the northern part of the Baltic Sea and cold-weather movements of birds.

For monitoring moulting populations, July and August are preferred and surveys should be harmonized and synchronized as well.

Time of the day. Seabirds should be counted during the light time of the day when the sun is highest, and thus reflection is lowest in order to enhance detectability of birds. That time window differs from season to season. Depending on focal species, adaptation of sampling time to diurnal cycles of bird activity can be useful.

Weather conditions. Seabird surveys can only be conducted in suitable weather condition. The most important driver is sea state, which should not exceed 5 Beaufort during ship-based surveys and 3 Beaufort during aerial surveys, respectively. Good visibility and appropriate light conditions are also essential for detecting birds. Fog and strong precipitation should be avoided. It is not mandatory to have sunny weather, but good light conditions are essential. Slightly overcast weather is even better than sunshine, because glare (sun reflections) can reduce detectability, especially of birds sitting on the water.

Spatial design. Based on the pre-selection of season and species, but also on the choice of survey platform, meaningful spatial coverage and transect design have to be aspired. Currently, national monitoring programmes vary from full coverage to concentration on coastal areas or SPAs or commercial (wind farm) areas. To derive an optimal sampling design, preliminary analyses should identify strata of differing abundance and provide estimates of the proportion of area that needs to be covered in the different strata to derive a reliable data basis. These analyses should be based on available data from earlier surveys. An optimal large-scale transect design should include both the retention of the established national transect designs as well as specific extensions, e.g. of previously not covered hotspots and of the generally insufficiently surveyed offshore waters of the central Baltic Sea.

Ice-covered areas can frequently occur during surveys for wintering seabirds in the Baltic Sea. Careful consideration during the preparation of the survey design as well as during the execution of the survey is needed to achieve a comprehensive dataset. We recommend including at least partial surveys of ice-covered areas for different reasons. In general, this approach will enable comprehensive analyses including ice coverage as a predictor variable, preventing false extrapolation during data analyses. It also provides necessary baseline data for long-term studies including warmer years/periods if birds are (likely to be) present in the respective areas during periods with no ice cover. In addition, the approach minimizes the risk of underestimating actual bird occurrence by providing data on numbers of birds in ice-covered areas, given that ice cover is <100 %. Observations have frequently shown that high numbers of birds may squeeze into the tiniest ice-free spots. For these reasons, it is highly recommended that surveys/counts do not stop/start at the ice edge when ice covers are actually encountered during a survey. Transects should rather continue, preferably – in case of smaller areas - all the way through the ice or – in case of the extensive areas - at least for a certain part of the transect). The feasibility and extent of surveying ice-covered areas largely depends on the size of the ice coverage and the respective logistic and economic conditions. The northern Baltic Sea with the Bothnian Bay and the Gulf of Finland hosts very extensive ice coverage in most winters. These areas may and should not be surveyed completely but rather by partial surveys covering at least the transition zone at the ice edge and preferably additional longer sample transects.

Transect design. The sampling design usually depends on the survey platform. Typically, the survey design consists of parallel lines that are either randomly or systematically spaced to cover different physical and environmental factors in the survey area and which might influence the abundance and distribution of the birds. The systematic spacing is more practical with a constant and relatively short turning and transit between the successive line ends.

Ships are often not able to move straight forward from one transect end point to the next start point due to curved coast line. This could be avoided by adjusting the survey design but leads to further decreases in cost efficiency. In consequence, ship-based surveys often use a zig-zag line transect with no idle time between the transect lines.

For coordinated large-scale surveys it may be beneficial to include additional transect lines in areas not covered by national survey designs in order to get a good coverage regarding population size estimates. The spatial coverage of both coordinated large-scale surveys and those used for trend analyses has to ensure that analyses can be undertaken at the level of subdivisions. HELCOM uses a system of different scales of assessment units for the Baltic Sea, with scale 1 being the entire Baltic and scale 2 a total of 17 subbasins.

It is highly recommended to always carry out surveys along the same transect lines in order to minimize the between-year variance. However, especially during ship-based surveys this is not always feasible since transects might need to be adjusted ad-hoc in reaction to other marine traffic as well as to weather conditions, i.e. intensity and direction of sun, wind and waves.

Sampling line orientation. The statistically most efficient transect design consists of lines running along the major environmental gradient. For most marine birds in the Baltic Sea this is increasing water depth that usually runs perpendicular to the shoreline. Thus, transect lines should start from the shoreline running out into deeper water. However, visibility could also be a major concern. Glare from sun can decrease detectability of seabirds, especially during aerial surveys. Particularly in winter time, it might be advantageous to position transect lines in north-south direction. Having the sun either from front or back reduces the glare on transect bands. Taking both considerations simultaneously into account for survey planning is often not possible.

A suitable transect design is also dependent on the methodology of data analyses. If the design consists of a series of transects, where the whole transect line is treated as a single sampling unit, the lines should be placed along the main environmental gradient. If the transect lines are further divided into segments, and spatial modelling is used for calculating the population size, positioning the lines against the gradient is less important. In that case, it might be more beneficial to place the lines in north-south direction in order to improve the detection rate.

Distance between the sampling lines. For aerial surveys a distance of 3 to 10 km is recommended for larger designs. Fine scale studies, such as site surveys or EIAs, may use a transect spacing as low as 2 km. In theory, this small-scale design covers the full target area, because distance band C reaches up to 1 km from the transect line (except for the area directly below the aircraft). A smaller distance between the lines is not recommended to avoid double counting of birds and to minimize the effect of disturbance movements of birds on neighbouring transect lines.

Over deep waters the density of marine birds is usually very low. To avoid a large sampling effort in these areas it is recommended to adjust the line placement interval to each stratum with a higher sampling density in areas that are more suitable for marine birds. The maximum recommended distance between sampling lines is 10 km to generate a confident estimate of bird numbers. A minimum distance of 4km between the lines is recommended to minimize the disturbance effects of the survey platform on sensitive bird species.

2.3.3 Data preparation

To ensure an optimal and consistent data collection and analysis, a standard data exchange format should be used by all contributing countries when transferring data to be used in joint analyses. The European Seabirds At Sea (ESAS) database is an example that already exists with such a common format, following recommendations of standard monitoring techniques. The ESAS database has been developed in the early 1980s. Since then, it has undergone several cumulative changes to adjust for advancements in the fieldwork protocols and methods of data analyses. Several institutions carrying out seabird monitoring surveys have made their own modifications and extensions to the ESAS database to promote storing of additional important information. For the HELCOM region, amendments for a new common standard data model have been discussed and developed within the BalticBOOST project and during JWGBIRD meetings (ICES 2016, 2020). ESAS partners are currently working on an update of the ESAS data model to include relevant modifications and extensions, e.g. for integrating aerial survey data. Details of the current version of the ESAS data model as revised in the ESAS Revitalization project funded by Rijkswaterstaat, NL, are given in Appendix 5.

2.4 Data analysis

Bird abundance is used as the standard basic unit in data analysis, for visualisation of spatio-temporal patterns in seabird occurrence and in indicator-based assessments. It is calculated based on numbers counted and corrected for survey effort and usually given in the unit individuals/km^2.

Integration of Seabirds at Sea-data into the HELCOM wintering bird abundance indicator calls for two methodological considerations (ICES 2016). The main objective is the development or identification of an adequate methodology for calculating trend analyses based on at-sea data. Secondly, it is beneficial to combine these analyses with already existing trend analyses based on land-based waterbird counts to feed into a single indicator. Integrating at-sea data with land-based count data can either be performed during the calculation of indicator indices or during the evaluation process based on separately achieved results. An exemplary approach for deriving trends from seabirds at sea data as well as for combining these with results from land-based monitoring programmes is described by Mercker et al. 2021.

Seabirds at Sea-data consist of temporal-spatial bird count data from moving survey platforms (ship or aircraft). The analysis of these data on bird abundance and trends is challenging and several aspects need to be considered:

1. Raw data usually show high temporal and spatial autocorrelation, complicated by the fact that temporal correlation may appear on the scale of minutes as well as on the scale of years.

2. Detection probability of birds decreases with increasing distance from the observer and is highly influenced by various covariates (less relevant in digital surveys).
3. Detection of birds on the transect line can be imperfect and is influenced by additional covariates.
4. A variety of covariates influences bird abundances and these dependencies often show a highly nonlinear behaviour (e.g. seasonal patterns).

To prevent data analyses from bias and to increase the precision of trend estimates, an appropriate differentiation between all mentioned processes, corresponding covariates and existing autocorrelation structures is indispensable. Mercker et al. 2021 propose to use Generalized Additive (Mixed) Models for trend analyses based on Seabirds at Sea data, combining different modelling approaches in a flexible framework.

The combination of trend analyses based on Seabirds at Sea-data and data from land-based counts requires adequate mathematical tools, too. Due to their different nature, the two different datasets cannot be pooled in one joint analysis. Instead, Mercker et al. 2021 recommend to combine results of separately performed trend analyses by an approach frequently used in meta-analysis studies. This is done by calculating average annual population change as a weighted average, with weights corresponding to the percentage of the overall monitored population using the respective habitat (offshore or coastal region).

3. Data reporting and storage

The raw seabird monitoring data are stored in national databases following country-specific routines for quality assurance and storage. Most national databases use a data format equalling or compatible to the data model of the ESAS database, in order to facilitate data sharing and joint analyses (see chapter 2.3.3).

Future large-scale assessments would benefit immensely from a common database for all collectors of Seabirds at Sea data in the Baltic Sea and other European countries. Seabird experts of the Baltic Sea countries agreed along with colleagues from the North Sea / OSPAR region to revive the ESAS database and use it as a common data sharing platform (ICES 2017). A dedicated ESAS subgroup of JWGBIRD was formed to steer the ESAS database work. The steering group has initiated discussions with ICES Data Centre to take over the hosting, maintenance and development from the current hosts. The ESAS database is envisaged to cover the entire ICES area, and can be used for both OSPAR and HELCOM assessments. Seabird data will be stored alongside a collection of other marine environment datasets thereby facilitating data linking needed for interdisciplinary ecological studies and analysis of conflicts with pressures.

4. Quality control

4.1 Quality control of methods

The quality of the data derived by the applied survey methods within the different seabird monitoring programmes is assured on a national level in alignment with the here presented guidelines.

Preparation and implementation of surveys require experience in handling challenging logistics and continuous monitoring of weather conditions. Surveys need to be carried out by experienced observers with excellent skills in bird recognition, species identification and flock size estimation. Observers need to be familiar with all details of the survey methods (e.g. transect distance bands, estimation of transect distance with ruler or similar methods, snapshot method, see Appendix 3). Furthermore, observers should have knowledge of generally used categories of seabird behaviour and possible associations with other biological features or non-biological structures (see appropriate codes in Appendixes 6 and 7).

We recommend exploring options of digital data collection during ship-based surveys using weatherproof tablets and a custom-built data collection application. Respective apps provide a row of benefits that reduce data handling time and increase data quality by implementing data validation during data entry. However, applicability of these data collection apps during the challenging survey conditions of surveying marine birds occurring in dense mixed species flocks still has to be assessed. Aerial seabird surveys are carried out at speeds that do not allow data entry during the flight.

4.2 Quality control of data and reporting

Data quality is assured on a national level in alignment with the here presented guidelines. Preparation of data for the database should be done timely after the surveys and needs to include various validation steps. Quality assurance is supported by applying a data format compatible to the agreed common data model as well as respective database lookup tables based on the agreed coding lists (see Appendixes 5, 6 and 7). Data entry forms or a web-based interface for data entry or uploading into the database can further increase data quality by integrating automatic validation protocols.

5. Contacts and references

5.1 Contacts

Contacts of Seabirds at Sea survey schemes in HELCOM contracting parties (see Appendix 1):

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Latvia: Ainārs Auniņš

Lithuania: Mindaugas Dagys

Poland: Włodzimierz Meissner (wlodzimierz.meissner@ug.edu.pl), Dominik Marchowski

Russia: Julia Bublichenko (Gulf of Finland), Gennady Grishanov (Kaliningrad region 2003-2015), Julia Loshchagina (Kaliningrad region since 2016)

Sweden: Fredrik Haas (fredrik.haas@biol.lu.se)

The guidelines have been compiled by national experts of Germany (Jana Kotzerka (kotzerka@dda-web.de), Nele Markones, Volker Dierschke) and Latvia (Ainārs Auniņš) and were revised by JWGBIRD experts and contacts of the other contracting parties (see above).

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Overview of Appendixes

1. Seabirds at Sea monitoring schemes of HELCOM countries
2. Methodology of ship-based and aerial Seabirds at Sea surveys
3. Device list for ship-based and aerial Seabirds at Sea surveys
4. Distance bins for Seabirds at Sea surveys for ship and aircraft
5. ESAS data model
6. ESAS behaviour codes for birds and marine mammals
7. ESAS association codes for birds and marine mammals
8. Additional features and measures to assess alongside Seabirds at Sea surveys

Appendix 1 – Seabirds at Sea monitoring schemes of HELCOM contracting parties

All HELCOM Contracting Parties are running regular Seabirds at Sea monitoring programmes, or at least have been involved in these. Coordinators of all countries have initiated a network to collaborate on joint large-scale surveys to provide data for overall population estimates, trends and distribution and sensitivity maps. In early 2016 all contracting parties (except Russia) have synchronized and combined their survey efforts to cover major parts of the Baltic Sea for a joint wintering bird survey. Data have been collated and first results were presented at the annual meeting of the Joint OSPAR/HELCOM/ICES Working Group on Seabirds (JWGBIRD) in Sept/Oct 2019 in Tartu, Estonia (ICES 2020). In early 2020, a second joint survey was started. Some countries had favourable weather conditions and could successfully carry out comprehensive surveys. Weather conditions in other parts of the Baltic Sea were unfavourable, and several countries were not able to successfully carry out their aerial surveys. Estonia, Germany, Latvia, and Lithuania have rescheduled all or parts of their survey effort to midwinter 2021.

Finland
The national monitoring programme consists of aerial surveys that cover the regularly ice-free areas during winter.

Previous surveys: In the Åland Sea and Archipelago Sea there are four monitoring routes that were regularly covered by ship-based surveys. Three of these routes started in the early 1970s and have been covered annually since 1996. The total length of these three routes is ca. 200 km. The fourth route is along the shipping route from the mainland to Åland, in the middle of the Archipelago Sea. This route is ca. 80 km long and has been surveyed regularly since 1994.
Contact: Pekka Rusanen, Markku Mikkola-Roos

Estonia
The national monitoring programme started in winter 2015/2016 with the full coverage winter survey (last full scale winter survey performed in early 2021). Further monitoring surveys will be conducted by aircraft in spring, summer (moulting period, August) and winter. A full coverage winter survey is scheduled for every sixth year. In the remaining years and seasons, partial surveys with shifting geographical focus will be carried out.

Previous studies: BALTIC MPA (2006-2008), ESTMAR (2011), GORWIND (2011/2012), MARMONI (2014), NEMA (2016), LOODE-HIIUMAA (2014-2015), SÕRVE (2021), PÕÕSASPEA migration (2004-2019), RISTNA migration (2011), KABLI migration (2002-2020), VÄINAMERI migration (1992-1993, 2008-2009), SÕRVE migration (1998-2009)
Contact: Leho Luigujõe

Latvia
The national monitoring programme started in winter 2015/2016 with the full coverage winter survey. Further monitoring surveys in autumn and winter will be conducted by aircraft. Spring surveys will be carried out by ship. Full coverage aerial surveys are scheduled at least once per six-year period in winter (next full scale winter survey planned for 2021). Partial coverage aerial surveys (index counts) are scheduled every winter, except those when full scale surveys are carried out. So far index counts have been carried out in winters 2018/19 and 2019/20.

In addition to winter surveys, the monitoring programme plans full scale autumn surveys two times per six-year period, while SPA sites should be covered three times per six-year period by ship-based surveys in spring. Winter and spring surveys have not been funded so far and there are no estimates when funding might become available.

Previous studies: During the GORWIND project in 2011/2012, aerial surveys have been carried out in the Gulf of Riga in all seasons and during the MARMONI project in winter 2014. During the Baltic MPA project (2006-2008), most parts of the Latvian territorial waters have been covered by ship in different seasons.
NB: The biodiversity monitoring programme has been underfunded, so there is no guarantee to have funding for all the planned activities. Priority has been given to winter surveys so far.
Contact: Ainārs Auniņš

Lithuania
A new State environment monitoring programme has come into force in the beginning of 2017 and includes seabird surveys in marine Natura 2000 sites. MSFD requirements completely cover the marine Natura 2000 sites as well as expand beyond their boundaries to include additional areas of interest, therefore Natura 2000 (Birds Directive) monitoring is planned to be combined with MSFD-driven monitoring of seabirds and waterbirds in Lithuania. Once in three years, three ship-based surveys should be conducted from December-March.

Previous studies: Aerial surveys approximating total counts were conducted since the late 1980s (for several years also the Russian waters of the Kaliningrad Region were included), but they covered only coastal waters and ended in the early 2000s. From 1993-1997, G. Vaitkus surveyed offshore areas from various ships for his doctoral thesis. In March 1999, another offshore ship-based survey was carried out. Several LIFE-Nature projects that included ship-based waterbird surveys were carried out in 2006–2015.
NB: The monitoring programme is known to be underfunded so there is no guarantee to have funding for the planned activities.
Contact: Mindaugas Dagys

Russia
Currently, no official fixed seabird monitoring scheme is conducted in the Kaliningrad region and the Gulf of Finland, neither by ship nor by aircraft.

Previous studies: In spring 2016, two aerial surveys have been carried out in the Gulf of Finland for “Nord Stream 2 AG”, which have been the first surveys of that kind for that region. In the Kaliningrad region, seabird monitoring has been carried out in previous years to assess the impact of oil extraction by "Lukoil - Kaliningradmorneft". The database and Geographic Information System «Ecomorneft» for the study period from 2003 to 2015 is owned by “Lukoil – Kaliningradmorneft. A further study was carried out in summer 2016 (June-September) for “Lukoil - Kaliningradmorneft”.
Contact: Julia Bublichenko (Gulf of Finland), Gennady Grishanov (Kaliningrad region 2003-2015), Julia Loshchagina (Kaliningrad region since 2016)

Poland
The national monitoring programme started in 2011. It encompasses yearly ship-based surveys in January along a fixed route and most of the important wintering areas for seabirds are covered. The entire territorial sea waters zone and selected (the most important for sea birds) parts of EEZ: Słupsk Bank and Pomeranian Bay are included in the annual monitoring. A large part of EEZ with deeper waters (more than 30 m) is not

monitored. Also, the Polish part of the Southern Middle Bank, which is partly in the Polish EEZ and was indicated by Skov et al. 2011 as an important wintering site e.g. for Long-tailed duck, is not included.
Contact: Włodzimierz Meissner, Dominik Marchowski

Sweden

Currently, there is no long-term monitoring program for aerial or ship-based surveys of offshore areas in Sweden. In 2016 and 2020, Sweden took part in the joint Baltic Sea survey for wintering birds. Survey data are currently stored in a PARADOX database, but will be transferred to another format as PARADOX is no longer supported. The new database structure will be influenced by the exchange formats that are available for international exchange and reporting. Data structure from 2019 and onward follows ESAS standard. Before that, the structure differs.
Previous studies: There have been several offshore surveys since 2007, with large-scale surveys in 2009, 2016 and 2020. Furthermore, regional authorities have carried out several aerial surveys in the southern part of Kattegat during the winter season 2019/2020 and 2020/2021.
Contact: Fredrik Haas, Leif Nilsson

Denmark

The national monitoring programme started in the year 2000. Currently, it encompasses a full coverage of inner Danish waters. Surveys are carried out every third winter as well as reduced parts in summer every six years for moulting surveys. The present monitoring scheme for wintering and moulting waterbirds will continue from 2020-2026 with only minor changes. Under a different scheme, monitoring requirements in relation to the MSFD are also carried out.

Previous studies: National midwinter surveys were conducted in 2000, 2004, 2008, 2013, 2016 and 2020. Deviation from the "every three winter" intention was caused by administrative reasons and due to weather constrains. Summer surveys were carried out in 2006, 2012 and 2018. Additionally, annual total counts and line transect surveys are derived for a subset of areas for trend analyses (three days of aerial surveys plus land-based counts). Since 2014, the Danish authorities have conducted additional monitoring of marine birds related to the MSFD, e.g. surveys of moulting seaducks in the Kattegat, Smålandsfarvandet and in Sejerøbugten in the years of 2014 to 2017, and a survey of surface feeders in the Danish part of the Baltic, east of Bornholm.
Furthermore, there is access to seabird monitoring data from a number of offshore wind farms. These data, collected in restricted areas and with a high temporal frequency, have proven valuable in combination with more large-scale surveys at lower temporal frequency.
In a new approach, survey data are used to calculate bird days per area in selected SPAs, allowing to estimate food consumption of benthic feeding seaducks. These data should relate bird occurrence more closely to management requirements (Petersen et al., 2016).
Contact: Ib Krag Petersen

Germany

In 2008, the national Natura 2000/MSFD offshore monitoring programme was initiated. It comprises large-scale aerial surveys, which are supplemented by ship-based surveys (dedicated surveys and ships of opportunity). Full-coverage aerial surveys of the German Baltic Sea areas are carried out two to three times per six-year period in winter. A subset of the most important areas is covered in the years between as well as during other seasons. Performance of digital survey methods is currently evaluated and compared to observer-based surveys.

Previous studies: A comprehensive dataset comprising ship-based survey data from the year 2000 onwards as well as large-scale aerial survey data from 2002 onwards is maintained using an ESAS compatible data structure.
Contact: Nele Markones, Kai Borkenhagen

Table 1. Overview of national offshore seabird monitoring programmes in the HELCOM region as of December 2019.

	FI	EE	LV	LT	RU	PL	SE	DK	DE
Status monitoring programme (running **R**; in prep. + survey concept available **PC**; in prep. + no formal plans yet **PN**; no plans **N**; other **O**)	R	R	R	R	N	R	R	R	R
Start year monitoring	2016	2016	2016 (2011)	2019 (2012)	-	2011	(2007)	2000	2008 (2002)
Does monitoring include **winter surveys?** (**NO / FULL** coverage **/ PART**s covered)	PART	FULL (almost)	FULL + PART	PART	NO	PART	FULL (almost)	FULL + PART	FULL + PART
Interval of winter surveys (No. of surveys per 6 year period)	1	1	FULL: 1, PART: 5	2	0	6	FULL: 1?	FULL: 2, PART: 6	FULL:2, PART: 4
Other seasons during which monitoring takes place (spring **SP**, summer **SU**, autumn **AU**)		SP, SU, AU	(SP, AU)	SP				SU	SP, SU, AU
Platform (ship **S**, plane **P**)	P (S)	P (S)	P (S)	S	S/P	S	P	P	P (S)
Line transect **LT** / strip transect **ST** / other **O**		LT	LT	LT		LT	since 2020 LT (formerl y ST)	LT	LT
Shape of transect lines or study area available? (**Y/N**)	Y	Y	Y	Y		Y	Y	Y	Y
Archived data of earlier Seabirds at sea studies available? (**N/** give sampling years)	1970-now	1992/1 993, 2011/ 2012, 2014	2011/ 2012 2014 2016 2019 plane; earlier ship data	1993-1997 1999 2006–2008 2012–2013 2016	2003–2016		2007–2016, …		NS: 1990–now, BS: 2000–now
Database management system / data format		Xls, MDB	XLS MDB	xls, mdb		xls			Oracle csv, xls,…
Data structure? (compatible with **ESAS** / Other **O**)		ESAS	ESAS	ESAS			(ESAS)		ESAS
Data is / will be transferred to ESAS / HELCOM db (**Y/N**)	Y	Y	Y	Y	N	Y	Y	Y	Y

Appendix 2 – Methodology of ship-based and aerial Seabirds at Sea surveys

Ship-based surveys

- Preferably zig-zag transect design (in some circumstances a parallel transect design) → endpoints entered into the ship's GPS as waypoints.
- Use of seagoing ships with preferably high observer positions that are protected against adverse weather conditions (however do not survey from inside the bridge).
- Preferred observer position at least 5 m above the water surface.
- Preferably 2-3 observers on each side, each with binocular and one digital watch per side.
- Sailing speed: preferably 10 kn (at least 5 kn).
- The time of each observation is recorded to the minute.
- Distance bands are determined by a personalized handheld ruler - predetermined lines below the horizon measured abeam the sailing direction are marked on the ruler (see additional description in Appendix 3).
- General meta-information about the survey, project etc. is noted on the header sheet.
- On transect start, observer names, exact time of transect start, date, observation side, weather conditions (seastate, visibility) are noted (other weather conditions that might influence the counts (glare, ice, precipitation, foam) should be noted alongside the observations with precise time (see Appendix 5).
- Generally, birds are spotted without binoculars (except for some species that are very sensitive to disturbance and fly off far ahead, like divers and seaducks) and species, age, sex, behaviour, etc. are then determined by binocular.
- During rough conditions, binoculars with electronic image stabilizer substantially improve identification of birds, and may also support detection of individuals flushing on the transect line far ahead of the approaching observation platform (e.g. seaducks and divers).
- Observations are recorded on observation sheets as they incur, including information on precise time to the minute, species, number, transect band and appropriate transect indicator (see Appendix 5).
- In order not to overestimate or double count, flying birds they are recorded using the snapshot method (Appendix 3).
- When time allows and if detectable, behaviour, association, age, sex, prey and additional information like groups or flight height and escape distance may be recorded and pictures of seabird flocks, especially seaducks, can be taken in order to estimate age and sex ratios (see Appendixes 5, 6, 7, 8).
- Flight height can be determined by estimation or using a Rangefinder binocular.
- Flock size is recorded as precisely as possible, bigger flocks are estimated.
- The main focus should be on birds within the transect with detection on the transect line (i.e. the innermost transect belt) aiming at 100 %.
- Birds outside the transect only give additional information and should only be recorded when time allows.

- Changing survey or weather conditions are recorded at the time they incur.
- Records should also cover abiotic objects and incidents that might influence birds (ships, fishing vessels, sailboats (with details on activity), wind farms, fronts and sea lines, oil slicks, etc.).
- Survey parts, where data collection is not possible (due to fog, land, sandbanks, very low ship speed, technical problems, feeling unwell, etc.) are recorded with exact start and stop times.
- Survey track data (longitude and latitude, time) is tracked continuously to the minute by a GPS unit.
- Precise transect end time has to be recorded on the observation sheet.
- Data collection is recommended only at sea states < 6, observation data collected at higher sea states should not be used for standard analyses.
- Visibility should exceed 3 km, in habitats that do not host species sensitive to disturbance, it may be less but not falling below 1 km.
- Glare or precipitation will also reduce detectability of birds. In cases of severe glare or strong wind driven precipitation, counts should be temporarily discontinued on the affected side.

Observer-based aerial surveys

- Pre-defined transect lines → endpoints entered into the aircraft's GPS as waypoints.
- Use of high-winged, twin-engined aircrafts with bubble windows (e.g. Partenavia P.68).
- Flight altitude: 250 feet.
- Flight speed: not faster than 180 km/h (100 knots).
- At least one observer on each side of the aircraft with dictaphone and precise watch (aligned with GPS time to the second).
- Prior to start, distance bands are determined with the help of clinometers - predetermined angles below the horizon are measured abeam the flight direction and marked with tape on the window (see further description in Appendix 3).
- Beneath the aircraft, a band of 44 m on each side of the flight track is not well visible and thus excluded.
- All observations, information on survey conditions and further details are recorded on Dictaphone.
- The time of each observation and remark needs to be recorded to the second.
- General information about the flight, project etc. are recorded at the beginning of each flight.
- On transect start, observer name, exact time of transect start, date, seat, weather conditions (ice, seastate, glare, sun, clouds, foam, turbidity, sight, precipitation) are recorded (see Appendix 5).
- Observations are continuously recorded, including information on species, number, activity, distance band and precise time.
- If time allows and if visible, behaviour, age, sex and additional information can be recorded (see Appendix 5, 6, 7).
- Each observation needs to be allocated to the exact distance band, only exceptional circumstances of very high bird concentrations might require integrating over multiple distance bands (see Appendix 5).
- Flock size is recorded as precisely as possible, bigger flocks are estimated.

- The main focus should be on birds within the transect with detection on the transect line (i.e. the innermost transect belt) aiming at 100%.
- Birds outside the transect belts give only additional information and may only be recorded when time allows.
- Changing flight or weather conditions are recorded to the time they incur.
- Recordings should also cover abiotic objects and incidents that might influence birds (ships, fishing vessels, sailboats (all with activity), wind farms, fronts and sea lines, oil slicks, etc.).
- Survey parts, where data collection is not possible (due to fog, land, sandbanks, higher flight height over wind farms, technical problems, feeling unwell, etc.) are recorded with exact start and stop times.
- Flight track data (longitude and latitude, time) is tracked continuously by a GPS unit (at one second intervals, if tracked at larger intervals, e.g. five-seconds, it will later be interpolated per second).
- At the end of each transect, exact end time is recorded, giving an overall evaluation of survey conditions for the respective transect (good, moderate, bad).
- Survey results are highly sensitive to weather conditions because detectability of birds on the sea surface is severely reduced by whitecaps and waves.
- Surveys may only be carried out at wind speeds not exceeding 3 bft = max. 5.5 m/s.
- Visibility should be preferably over 5 km (at least 2 km).
- Glare will reduce detectability of birds. In cases of severe glare, it might be advisable to cease observations on the affected side of the aircraft temporarily. Preferably, do not use the first hours after sunrise and the last hours before sunset for aerial surveys.

Appendix 3 - Distance bins for Seabirds at Sea surveys for ship and aircraft

Ship-based surveys

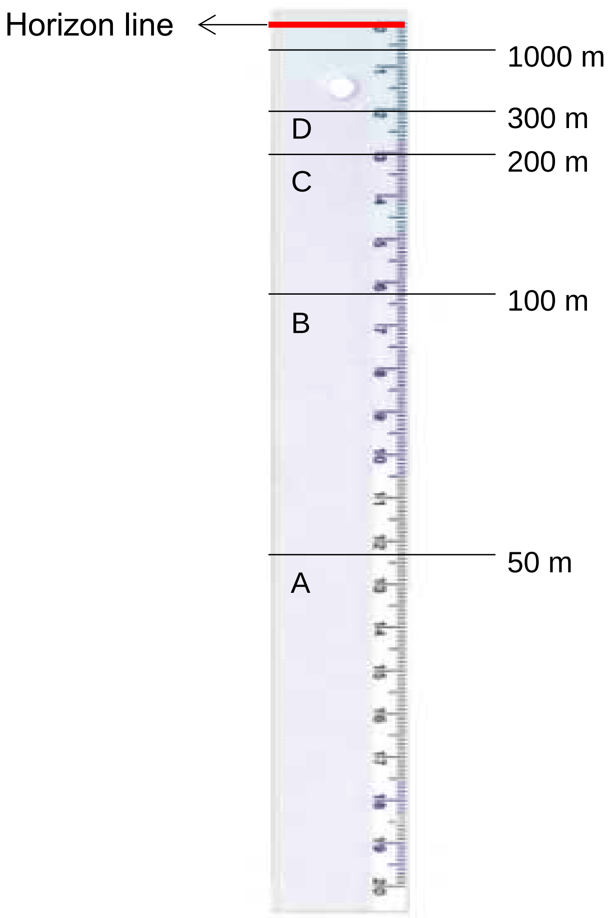
Transect band distances (distance from observer position):

- A → 0 – 50 m
- B → 50 – 100 m
- C → 100 – 200 m
- D → 200 – 300 m
- E → further than 300 m
- W → opposite site of ship (used only when surveys are only conducted from one side of the ship)
- F → used for all flying birds (inside and outside transect bands)

Birds recorded in distance bands A – D are ‘in transect’. Birds recorded in bands E and W are ‘outside transect’.

Flying birds are only ‘in transect’ if they are at the snapshot (see below) inside 300 m from observer position, otherwise they are ‘outside transect’.

In order to estimate transect band distances as precise as possible, it is recommended to use a ruler as a rangefinder. Each observer should have its own personalized ruler for each survey. The ruler is used by lining the marked horizon line with the horizon, while it is being held out at arm’s length from the observer. The observer then uses lines marked previously on the ruler to delineate the different distance bands on the sea surface. The lines on the ruler are marked by using the ‘Heinemann equation’ (see below) that considers the height of eye while observing above the sea level and the individual observers arm length measured from its eye. The increments derived from the equation are marked on the ruler as accurately as possible, with the distance bands marked starting with band E at the top (horizon line at the 0 cm marking) and band A towards the bottom end. Lines marked with a permanent marker on a plastic ruler can easily be removed with alcohol. For easier estimation of greater distances (e.g. ships) an additional line for 1000 m distance can be added:



Heinemann-equation (Heinemann 1981)

Distance in cm measured from horizon line at the ruler = $\left(\frac{A*B\left(3838*B^{0.5}-C\right)}{B^{2}+3838*B^{0.5}*C}\right)*100$

A = observers arm length (in meters)

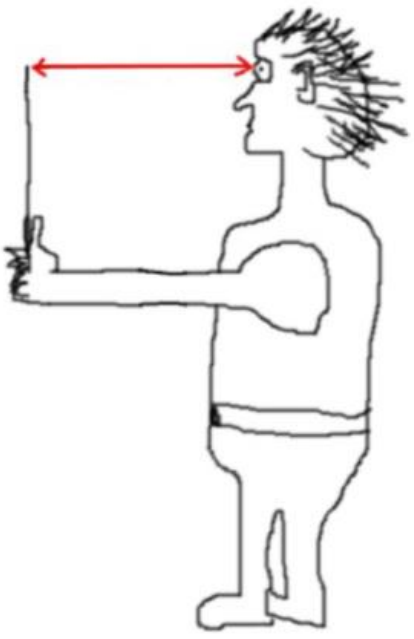
B = height of eye above sea level (in meters)

C = transect band distance (in meters)

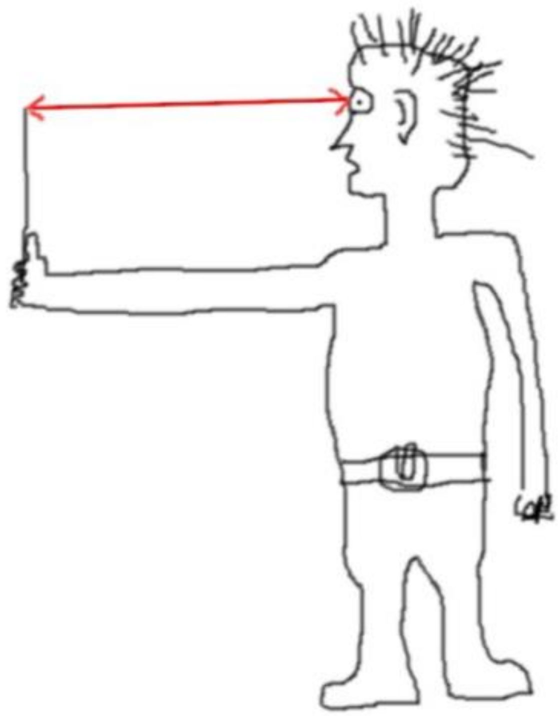
It is important when surveying (and when taking bearings)

1) That you stand in the same way as you aim for the bird.
2) That especially the arm length is always the same as possible.
3) That the ruler is held as vertical as possible, i.e. not towards or away from the eye tilted.

There are different approaches to achieve 1) and 2). Some pull their shoulders in and then aim forwards (a). Others extend their arm to the maximum and take a bearing over shoulder and arm, i.e. on the side (b).
The lateral direction finding with an extended arm has two advantages (Borkenhagen 2020, unpubl.): The arm length does not depend on body rotation (because you automatically turn exactly 90 ° to the bird) and is therefore more easily reproducible. The absolute arm length is greater, thereby the lines on the ruler move further apart, which makes reading easier and thereby increases accuracy.
Point 3) is a matter of practice. You can ask colleagues to correct you.



a



b

Snapshot

In order not to overestimate or double-count flying birds, they are only 'in transect' when counted at the "snapshot time" in any height in a defined area and at a given 'instantaneous' count time. This is usually in a ca. 300 m x 300 m box, which correspond to the same area covered by bands A – D for birds on the water. Snapshot time is defined by the ship speed. For example, it is one minute for ships with a speed of ca. 10 kn. The snapshot time interval has to be adjusted according the ship speed, especially when this is changing during the survey. It is recommended to maintain the 300 m x 300 m snapshot area and adjust the frequency of the count interval (e.g. increasing frequency with higher speeds and decreasing frequency with lower speed). It is also possible to adjust the size of the snapshot area while maintaining the frequency of counts. However, it is recommended to change the frequency of counts and keep the 300 m x 300 m snapshot area because observers will become adept at defining this area (Lewis 2020). Additional values can be found in table 2 and 3 (taken with permission from Lewis 2020)

Table 2: Snapshot timing with changeable time period.

Decimal knots	Variable distance in metres									
Knots	**0**	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
1	31	34	37	40	43	46	49	53	56	59
2	62	65	68	71	74	77	80	83	86	90
3	93	96	99	102	105	108	111	114	117	120
4	124	127	130	133	136	139	142	145	148	151
5	154	158	161	164	167	170	173	176	179	182
6	185	188	191	195	198	201	204	207	210	213
7	216	219	222	225	229	232	235	238	241	244
8	247	250	253	256	259	263	266	269	272	275
9	278	281	284	287	290	293	296	300	303	306
10	309	312	315	318	321	324	327	330	334	337
11	340	343	346	349	352	355	358	361	364	368
12	371	374	377	380	383	386	389	392	395	398
13	401	405	408	411	414	417	420	423	426	429
14	432	435	439	442	445	448	451	454	457	460
15	463	466	469	473	476	479	482	485	488	491
16	494	497	500	503	506	510	513	516	519	522
17	525	528	531	534	537	540	544	547	550	553
18	556	559	562	565	568	571	574	578	581	584
19	587	590	593	596	599	602	605	608	611	615
20	618	621	624	627	630	633	636	639	642	645
21	649	652	655	658	661	664	667	670	673	676
22	679	683	686	689	692	695	698	701	704	707
23	710	713	716	720	723	726	729	732	735	738
24	741	744	747	750	754	757	760	763	766	769
25	772	775	778	781	784	788	791	794	797	800

Constants
Knots to KPH 1.853

Changeables
Time period **1** (minutes)

Example:

Use this table if looking ahead at a fixed time (e.g. 1 minute) ahead of the ship for your snapshot counts.
If your ship is travelling at 9.7 knots, read down the left-hand column to the row labelled '9' then across this row until in the column headed '0.7'. The value in this cell, '300', means that you should look ahead 300 metres for each snapshot count.

Table 3: Snapshot timing with changeable distance.

Decimal knots Knots	Variable time in seconds 0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
1	583	530	486	448	416	389	364	343	324	307
2	291	278	265	253	243	233	224	216	208	201
3	194	188	182	177	171	167	162	158	153	149
4	146	142	139	136	132	130	127	124	121	119
5	117	114	112	110	108	106	104	102	100	99
6	97	96	94	93	91	90	88	87	86	84
7	83	82	81	80	79	78	77	76	75	74
8	73	72	71	70	69	69	68	67	66	65
9	65	64	63	63	62	61	61	60	59	59
10	58	58	57	57	56	56	55	54	54	53
11	53	53	52	52	51	51	50	50	49	49
12	49	48	48	47	47	47	46	46	46	45
13	45	44	44	44	43	43	43	43	42	42
14	42	41	41	41	40	40	40	40	39	39
15	39	39	38	38	38	38	37	37	37	37
16	36	36	36	36	36	35	35	35	35	34
17	34	34	34	34	33	33	33	33	33	33
18	32	32	32	32	32	32	31	31	31	31
19	31	31	30	30	30	30	30	30	29	29
20	29	29	29	29	29	28	28	28	28	28
21	28	28	27	27	27	27	27	27	27	27
22	26	26	26	26	26	26	26	26	26	25
23	25	25	25	25	25	25	25	25	24	24
24	24	24	24	24	24	24	24	24	24	23
25	23	23	23	23	23	23	23	23	23	23

Constants
Knots to KPH 1.853

Changeables
Distance **300 (metres)**

Example:

Use this table if looking ahead a fixed distance (e.g. 300 metres) ahead of the ship for your snapshot counts.
If your ship is travelling at 9.7 knots, read down the left-hand column to the row labelled '9' then across this row until in the column headed '0.7'. The value in this cell, '60' means that you should do snapshot counts every 60 seconds.

Aircraft-based surveys

Transect band distances (values are only valid for a flight height of 76 m = 250 feet):

- A → 44 – 163 m (60° to 25°)
  - A1* → 44 – 91 m (60° to 40°)
  - A2* → 92 – 163 m (40° to 25°)
- B → 164 – 432 m (25° to 10°)
- C → 433 - 1000 m (10° to 4°)
- (D) → 1000 – 1500 m (3° to 4°)

*in some survey protocols currently in use (e.g. Research and Technology Centre (FTZ), University of Kiel) the band A is split into A1 and A2 as it has been shown that the detection rate decreases within the band A and detection is lower in A2 than in A1.

**although usually discarded from the data analysis due to very low detection in band D, it is recommended to keep this band in the survey protocol to avoid observers attributing distant flocks to band C.

In order to estimate transect band distances as precisely as possible, they are measured with inclinometers (prismatic protractors). Distance bands are marked with tape on the bubble windows of the aircraft prior to survey start. It is useful to apply the markings to the preferred posture during the survey (if the head is moved, the markings do not indicate the transect bands correctly anymore).

Appendix 4 - Device list for ship-based and aerial Seabirds at Sea surveys

(essential items in bold)

Ship

- **Binoculars for all observers (preferably 10x40 or 16x50), one binocular with electronic image stabilizer recommended**
- **2 GPS, plus batteries/rechargeable batteries + charger and connecting cable**
- **Rulers for measuring distance bands (personalized for every observer, calibrated for the eye level of the observer above the sea surface and the observer's arm length applying the formula of Heinemann (1981), see Appendix 3)**
- **Observations sheets**
- **Clipboard**
- **Rubber bands or clips (to fix sheets on the clipboard during windy conditions)**
- **Pens and pencils**
- **Identification guides**
- Weather-proof survey manual
- Digital watch
- Cloth (to dry the equipment in/after rain)
- Compass rose (for fast estimations of flight directions)
- Water resistant observation sheets for rainy weather
- Rangefinder for measuring distances/flight heights
- (Chocolate etc.)
- **Header sheets (to record meta-information of survey days)**
- **Laptop**
- **Nautical maps / GIS software for ad-hoc planning of transect lines**
- **External harddrive/USB memory stick**
- Heinemann formula (on computer, for distance calculation with rulers)
- **Sea safety and survival equipment (basic equipment on board)**

Aircraft

- **(Digital) dictaphone for every observer**
- **Digital watch with GPS synchronized time or 1 GPS device for every observer**
- **2-3 GPS devices with external antenna plus batteries/rechargeable batteries, one unit should sit under front window for best satellite coverage**
- **Inclinometer (for every observer or at least each row of seats (front and 2nd row))**
- **Tape for delineating the distance bands on the window screens**
- **Intercom headphones (if not provided by flight company)**
- Map with transect design and list of waypoints and transects
- Manual (to remind observers of the details to report on Dictaphone)
- Power bank (10000 mAh)
- **Rescue suits**
- **Life jackets**
- **Further sea safety and survival equipment (EPIRB, PLB, life raft, torches, ...)**
- (Chocolate etc.)
- There is equipment that has to wait on the ground and be used right after the flight – laptop and cables for downloading the GPS tracks and audio files, as well as USB sticks for observers receiving their audio files for deciphering

Appendix 5 – ESAS data model

Below is a draft ESAS database model (specifying table content as well as data type, relation and description for each parameter) developed by BalticBOOST based on BALSAM guidelines and updated with the JWG Bird meeting 2018 & 2019 outcomes. The current version further incorporates changes resulting from the generation of new lookup tables in the course of the ESAS revitalisation project commissioned by Rijkswaterstaat (NL), and conducted by INBO (BE), BuWa (NL) & FTZ (GE).

Additions to the original ESAS database structure are indicated in the comments field. The mandatory fields are marked***.**

Trip data table: lists all surveys (identified by a unique Tripkey number) and includes relevant survey-specific parameters.

Column	**Data type**	**Relation**	**Description**	**Comments**
Tripkey*	Integer	Primary key	Unique number to identify each record in the trip table (8 – 9 digits) E.g. for origin 50 (FTZ & Vogelwarte Helgoland) this key ranges between 50,000,000 & 59,999,999 – see the Origin column lookup table for further details on key ranges for each data supplier	Each record represents a single survey. If you have multiple observers producing independent data streams, use a separate Tripkey for each of them (hence for the classical plane survey setup with 2 observers on each side of plane independently recording their observations, there should be 2 separate Tripkeys)
Year*	Integer		The year (4 digits)	
Month*	Integer		The month (1 - 12)	
Day*	Integer		The day of the month (1 - 31)	
Base_type*	Categorical	Foreign key	The platform used for carrying out observations: 1 Ship 2 Helicopter 3 Aeroplane 4 Aeroplane (digital survey)	
Platform_code*	Categorical	Foreign key	Code for the ship name (Base_type = 1) or the call sign (unique identifier of the aircraft) (Base_type = 2 or 3). Use with precursor: 3 digit code for the data provider with 5 digit code for the platform (xxx_xxxx) – see lookup table	
Flying height	Integer		The flying height of the aeroplane or helicopter (m)	*Newly added column since ESAS v5*
Transect_width*	Integer		The width of the strip transect (m)	

Campaign_key	Integer		Aggregates parts of a campaign, i.e. different sides of the platform or counts in different parts of a study area covered on different days or by different platforms. The Campaign_key should equal the Tripkey of the 1st entry of the particular campaign. (8 – 9 digits)	*Newly added column since ESAS v5*
Route	Text (< 50 bytes)		Short description of the area covered or route followed	*Newly added column since ESAS v5*
Count_type*	Categorical	Foreign key	The type of observation method being applied: 1 Full ship transect method with snapshot for flying birds and distance estimation 2 On water transect, no snapshot for flying birds 3 All observations, but no transect operated 4 Presence / absence data 5 Full ship transect, but no scan data for outside the transect 6 Ship-based strip transect, no snapshot, no distance estimation 7 Ship-based strip transect, with snapshot, no distance estimation 8 Visual aerial survey line transect method with distance sampling 9 Visual aerial survey strip transect, no distance estimation 10 Visual aerial survey total counts 11 Digital aerial – video 12 Digital aerial – stills	
Species_observed*	Categorical	Foreign key	The species (groups) which were being counted: 1 All species recorded (standard) 2 All species except *Larus* gulls 3 All species except fulmars 4 All species except *Larus* gulls, fulmars and kittiwakes 5 Auks only 6 Auks and seaduck only 7 All species except eiders and gulls 8 All species except gannets 9 Auks and unusual seabirds only 10 All species except auks and divers 11 All species except small gulls (Little, Black-headed & Common Gull / Black-legged Kittiwake) 12 All species except Lesser Black-backed Gulls 13 All species except seaduck and divers 14 All species except gannets, fulmars and kittiwakes 15 All species except fulmars and gannets 16 Cetaceans only 99 Other (to be specified in the comments field)	

Use_of_binoculars*	Categorical	Foreign key	The extent to which binoculars were used to detect birds: 1 No binoculars used for detection of birds or cetaceans 2 Binoculars used for detection of birds far ahead of the ship (e.g. for seaduck and diver surveys) 3 Binoculars used extensively for scanning ahead and to the side, naked eye used for close observations (e.g. for cetacean surveys)	
Behaviour_coding*	Categorical	Foreign key	Indicates if and how behaviour has been recorded: 0 Behaviour not recorded 1 Typical detailed ship-based activity / behaviour recording (provide codes in Behaviour_ship_based column) 2 Typical aeroplane-based activity / behaviour recording (provide codes in Behaviour_aerial column)	*Newly added column since ESAS v5*
Base_side	Categorical	Foreign key	Side of platform used for counting (ship) or seat of the observer (aeroplane): 1 Aerial survey: right front 2 Aerial survey: left back 3 Aerial survey: right back 4 Aerial survey: left front 5 Ship-based survey: port side 6 Ship-based survey: starboard side 9 Observers both left and right producing single data stream	*Newly added column since ESAS v5*
Observer_role*	Categorical	Foreign key	Indicates the role of the observer. Important for surveys using the double observer platform. Default is 1 (Primary). 1 Primary (the only observer(s) on the platform or if double observer approach used, the observer who's recordings should be used in data analyses where only a single data stream can be included) 2 Secondary (the additional observer(s) to the primary observer in the double observer platform) If there are more than 2 observers (e.g. triple observer approach), each additional observer is assigned an increasing integer (3, 4, etc.)	*Newly added column since ESAS v5*
Origin*	Categorical	Foreign key	Origin of data (e.g. data owner or supplier): 10 Joint Nature Conservation Committee 11 Royal Society for the Protection of Birds 15 Coastal Seabird Research Group 20 Netherlands Institute for Sea Research 30 Ornis Consult 40 Norwegian Institute for Nature Research 50 FTZ & Vogelwarte Helgoland 51 Institute for Avian Research "Vogelwarte Helogland" 52 University of Kiel (incl. FTZ Büsum)	*Newly added column since ESAS v5* See lookup table for minimum and maximum values of the trip, position and species keys per data supplier

			53 Prokon-Nord, Leer; c/o "Vogelwarte Helgoland" 54 University of Hamburg 60 University of Lund 70 Vrije Universitiet Brussel 80 Tidal Waters Division 90 National Environmental Research Insitute 100 Netherlands Seabird Group 110 Research Institute for Nature and Forest 120 Alterra 130 Theo Postma 140 Bureau Waardenburg 150 CSR 160 EC Discard Projects 170 NIOZ/CSR 180 CSR Wildlife Cruises 190 NZG K7/K8 platform 200 University College Cork 210 Sociedade Portuguesa Para O Estudo Das Aves 220 Cork Ecology *- Will get updated by data owners from Baltic Sea -*	
Access_level*	Categorical	Foreign key	Level of public data access: 1 Open access 2 Restricted access (via request to data owner)	*Newly added column since ESAS v5* Note: Restricted data will nevertheless be used for presence-absence or aggregated data products
Direction_of_travel_type	Categorical	Foreign key	The way how directions of ships and birds is recorded: U Unknown A Absolute R Relative (to direction of platform) Z Number P Arrow K Not recorded	*Newly added column since ESAS v5*
Number_of_observers*	Integer		Number of observers producing the data stream of this specific Tripkey	The number of observers does not include observers that record independent observations (thus producing different data streams that are included in the database under different Tripkeys).
Observer1*	Categorical	Foreign key	Code for the observer name – see lookup table	
Observer2	Categorical	Foreign key	Code for the observer name – see lookup table	*Newly added column since ESAS v5* Report only the observers assisting the Observer1 in the fields Observer2 and Observer3. Do not report the other

				observers producing their own data streams.
Observer3	Categorical	Foreign Key	Code for the observer name – see lookup table	*Newly added column since ESAS v5* Report only the observers assisting the Observer1 in the fields Observer2 and Observer3. Do not report the other observers producing their own data streams.
Notes	Text (<250 bytes)		Additional details related to the survey	*Newly added column since ESAS v5*

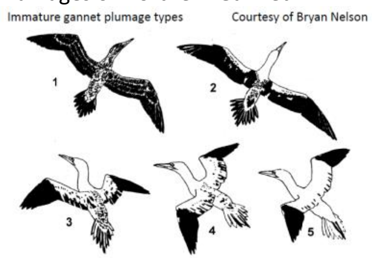
Position data table: lists all count locations (identified by a unique Poskey number) and includes relevant position-specific parameters; has a many-to-one relationship with the Trip data table and a one-to-many relationship with the Species data table.

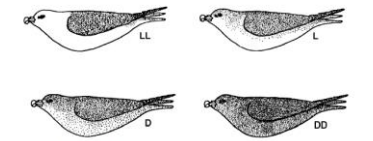
Column	Data type	Relation	Description	Comments
Poskey*	Integer	Primary key	A unique number to identify each record in the Position table (8 – 9 digits) – see the Origin column lookup table for further details on key ranges for each data supplier	Each record represent an observation period, characterised by a position, this being the middle point of the trajectory sailed or flown during the observation period. Each position recorded during the survey is reported in the Position table. For plane surveys this usually means a position for each second of the survey. For ship surveys this usually means a position for each minute of the survey.
Tripkey*	Integer	Foreign key to Tripkey in Trip table	The link to the trip information related to each position record (8 – 9 digits)	
Time_hour*	Integer		The hour component of the time (0 - 23)	
Time_minute*	Integer		The minute component of the time (0 - 59)	
Time_second*	Integer		The second component of the time (0 - 59)	*Newly added column since ESAS v5*
Latitude*	Number (double)		The latitude of the position in the middle of the observation period in decimal degrees (geographic coordinate system WGS84; EPSG code: 4326).	Use maximum precision as recorded by GPS or calculated.
Longitude*	Number (double)		The longitude of the position in the middle of the observation period in decimal degrees (geographic coordinate system WGS84; EPSG code: 4326).	Use maximum precision as recorded by GPS or calculated.
Transect_ID	Categorical	Foreign key	Name or number of the transect with a leading 2-letter country code. Format: XX(X)_YYYYYYYYYY, where XX(X) is the 2 or 3-letter country code and YYYYYYYYYY is a transect ID according to the national classification.	*Newly added column since ESAS v5* This field serves as a link (Foreign key) to the GIS dataset with the monitoring transects. This is not a mandatory field, however, it is recommended for all monitoring surveys using predefined transects.
Km_travelled*	Number (double)		The distance travelled during the observation period in km (as recorded by GPS)	
Beaufort*	Ordinal	Foreign key	Sea state according to the Beaufort scale: 0 Sea like mirror 1 Ripples with appearance of scales, no foam crests 2 Small wavelets, crests of glassy appearance, not breaking 3 Large wavelets, crests begin to break, scattered whitecaps	

			4 Small waves becoming longer, numerous whitecaps 5 Moderate waves, many whitecaps, some spray 6 Larger waves, whitecaps everywhere, more spray 7 Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind 8 Moderately high waves; edges of crests begin to break into the spindrift; foam is blown in well-marked streaks along the direction of the wind 9 …. Better stop counting! See lookup table for further descriptions	
Visibility*	Categorical	Foreign key	Visibility code: A Poor (< 1 km) B Fair / moderate (1 – 5 km) C Good / very good (5 – 10 km) D Excellent / infinity (> 10 km) **Alternatively visibility can be indicated in km** (see lookup table)	
Glare	Ordinal	Foreign key	Glare affecting the observer: 0 no glare 1 weak glare (sun angle 60°-90°) 2 medium glare (sun angle (30°-60°) 3 strong glare (sun angle 0°-30°)	*Newly added column since ESAS v5*
Sun_angle	Integer		Angle of the sun in relation to the observer (0 – 360)	*Newly added column since ESAS v5*
Cloud_cover	Integer		Cloud cover expressed as x/8 (octas) (0 – 8)	*Newly added column since ESAS v5*
Precipitation	Categorical	Foreign key	0 none 1 rain 2 snow 3 fog	*Newly added column since ESAS v5*
Ice	Integer		Ice cover of survey area in % (0 – 100)	*Newly added column since ESAS v5*
Notes	Text (< 250 bytes)		Additional details related to the position	*Newly added column since ESAS v5*

Species data table: lists all bird or marine mammal records (identified by a unique Species_key number) and includes relevant observation-specific parameters; has a many-to-one relationship with the Position data table; no entries need to be made for locations or observation periods without observations.

Column	Data type	Relation	Description	Comments
Species_key*	Integer	Primary key	A unique number for each record in the Species table (8 – 9 digits) - see the Origin column lookup table for further details on key ranges for each data supplier	Each record represents a single observation of (a group of) birds or (a pack of) marine mammals
Poskey*	Integer	Foreign key to Poskey in Position table	The link to the position table for each species record (8 – 9 digits)	
Transect*	Categorical	Foreign key	States whether the observation was in or out the transect: 1 Out of transect 2 Inside transect	
Euring_species_code*	Categorical	Foreign key	The species code – see relational lookup table linking the codes with the English and Latin species names.	The species codes are largely based on the EURING list but supplemented with 'uncertainty codes' commonly used by ESAS partners to indicate species groups that are often difficult to identify in at-sea field conditions.
WoRMS code*	Categorical	Foreign key	Standard WoRMS codes supplemented with codes for 'non-marine species' and 'identification uncertain' – see lookup table	*Newly added column since ESAS v5*
Number_of_birds*	Integer		The number of birds or marine mammals counted or estimated	This should equal the number without distance correction!
Distance*	Categorical	Foreign key	This is the distance at which the bird(s) or marine mammal(s) were observed. Different coding is used for ship-based and aerial surveys: **For ship-based surveys (Base_type = 1):** A standard 300 m transect is assumed for birds in contact with the water: A In contact with the water, 0 - 50 m B In contact with the water, 50 - 100 m C In contact with the water, 100 - 200 m D In contact with the water, 200 - 300 m E In contact with the water, > 300 m, beyond strip transect F Flying, no contact with water U Unknown W In contact with the water, but distance not recorded **For plane surveys (Base_type = 3):**	

			V 0 – 44 m G 44 – 163 m L 44 – 91 m M 91 – 163 m J 163 – 432 m K 432 – 1000 m R > 1 km U Unknown T Total counts **Alternatively distance bands can be specified by supplying a distance range in the following format: X – X m**	
Age_class	Categorical	Foreign key	Age class or information on primary moult: A Adult I Immature X Active primary moult Y No active primary moult (Primary moult codes only used for fulmar, auks, divers and seaduck)	
Age_year	Integer		Age (calendar-year) of immature birds	*Newly added column since ESAS v5* Example: a second calendar year bird should be coded as Age_class=I and Age_year=2
Plumage	Categorical	Foreign key	Plumage types: B Breeding (summer) plumage T Transient plumage (moulting between winter & summer plumage or vice-versa) W Non-breeding (winter) plumage L Light morph (skuas / double light ‘LL’ fulmars) C Coloured morph (‘L’, ‘D’ & ‘DD’ fulmars) I Intermediate morph (skuas) D Dark morph (skuas) For immature auks (Guillemot & Razorbill): A1 ½ or less than adult size A2 over ½ adult size A3 about same size as adult For immature Northern Gannets: G1 plumage 1 G2 plumage 2 G3 plumage 3 G4 plumage 4 G5 plumage 5	Example: an adult bird in winter plumage should be coded as Age_class=A and Plumage=W. Plumages of Northern Gannet:  Plumages of Northern Fulmar:

				 Fulmar plumage phases Courtesy of Jan van Franeker
Sex	Categorical	Foreign key	F Female M Male	*Newly added column since ESAS v5*
Group	Integer		Identifier of aggregations of individuals of one or several species; the number assigned to each group should be unique among all observations from the same Tripkey.	
Direction_of_travel	Categorical	Foreign key	The direction in which the bird is travelling: 0 No data 1 Flying, no apparent direction 2 Heading N 3 Heading NE 4 Heading E 5 Heading SE 6 Heading S 7 Heading SW 8 Heading W 9 Heading NW	
Prey	Categorical	Foreign key	Observed prey (type) caught or carried by the bird – see lookup table	
Association	Categorical	Foreign key	Code for associations between observed birds/cetaceans and vessels/structures/floating matter – see lookup table	
Behaviour_aerial	Categorical	Foreign key	Indicates what the species was doing when observed: 1 On water/swimming 2 Diving 3 Flushing 4 Flying 5 Completely submerged (marine mammals) 6 Breaching surface (marine mammals) 7 On artificial piece of something (platform, pole…)	*Newly added column since ESAS v5* Can for example be used as covariate for detection probability models
Behaviour_ship_based	Categorical	Foreign key	Indicates what the species was doing when observed – see lookup table	
Notes	Text (< 250 bytes)		Additional details related to the observation	*Newly added column since ESAS v5*

Appendix 6 – ESAS behaviour codes for birds and marine mammals

Behaviour	Description	Category
0	No data	No data
30	Holding fish	Foraging behaviour
31	Without fish	Foraging behaviour
32	Feeding young at sea	Foraging behaviour
33	Feeding, method unspecified	Foraging behaviour
34	Wading, filtering or probing	Foraging behaviour
35	Scooping prey from surface	Foraging behaviour
36	Aerial pursuit	Foraging behaviour
37	Skimming	Foraging behaviour
38	Hydroplaning	Foraging behaviour
39	Pattering	Foraging behaviour
40	Scavenging	Foraging behaviour
41	Scavenging at fishing vessel	Foraging behaviour
42	Dipping	Foraging behaviour
43	Surface seizing	Foraging behaviour
44	Surface pecking	Foraging behaviour
45	Deep plunging	Foraging behaviour
46	Shallow plunging	Foraging behaviour
47	Pursuit plunging	Foraging behaviour
48	Pursuit diving, or bottom feeding	Foraging behaviour
49	Actively searching	Foraging behaviour
60	Resting or apparently asleep	General behaviour
61	Courtship display	General behaviour
62	Courtship feeding	General behaviour
63	Copulating	General behaviour
64	Carrying nest material	General behaviour
65	Guarding chick	General behaviour
66	Preening or bathing	General behaviour
67	Colony rafts	General behaviour
68	Kleptoparasiting	General behaviour
69	Haul-out (pinnipeds)	General behaviour
70	Wheeling or swimming slowly	Cetaceans
71	Escape from ship (rooster tail)	Cetaceans
72	Swimming fast, not avoiding ship	Cetaceans
73	Breaching clear out of the water	Cetaceans
74	At the bow of the ship	Cetaceans
75	Apparently feeding: herding behaviour	Cetaceans
76	Apparently feeding: other behaviour	Cetaceans
77	Calf at the tail of adult	Cetaceans
78	Calf swimming freely in herd	Cetaceans
79	Basking, afloat	Cetaceans

80	Spy-hopping	Cetaceans
81	Lob-tailing	Cetaceans
82	Tail/flipper slapping	Cetaceans
83	Approaching ship	Cetaceans
84	Only blow visible (whales)	Cetaceans
85	Only splashes visible (dolphins)	Cetaceans
86	Acrobatic leaps	Cetaceans
87	Sexual behaviour	Cetaceans
88	Play	Cetaceans
89	Sailing	Cetaceans
90	Under attack by kleptoparasite	Misfortune, disease
91	Under attack (as prey) by bird	Misfortune, disease
92	Under attack (as prey) by mar. mammal	Misfortune, disease
93	Escape diving	Misfortune, disease
94	Flying off (disturbance)	Misfortune, disease
95	Injured	Misfortune, disease
96	Entangled in fishing gear or rope	Misfortune, disease
97	Oiled	Misfortune, disease
98	Sick, unwell	Misfortune, disease
99	Dead	Misfortune, disease
111	Not foraging	General behaviour

Appendix 7 – ESAS association codes for birds and marine mammals

Association	Description	Category
0	No data	No data
10	Associated with fish shoal	Associations
11	Associated with cetaceans	Associations
12	Associated with front	Associations
13	Associated with line in sea	Associations
14	Sitting on or near floating wood	Associations
15	Associated with floating litter	Associations
16	Associated with oil slick	Associations
17	Associated with floating seaweed	Associations
18	Associated with observation base	Associations
19	Sitting on observation base	Associations
20	Deliberately approaching observ. base	Associations
21	Associated with other vessel	Associations
22	Associated with or on buoy	Associations
23	Associated with offshore platform	Associations
24	Sitting on offshore platform	Associations
25	Sitting on marking pole or stick	Associations
26	Associated with fishing vessel	Associations
27	Associated with or on sea ice	Associations
28	Associated with land (e.g. colony)	Associations
29	Associated with sand banks	Associations
50	MSFA participant, no further details	MSFAs
51	MSFA participant, joined by others	MSFAs
52	MSFA participant, joining flock	MSFAs
53	MSFA participant, scrounger type	MSFAs
54	MSFA participant, solitary diver	MSFAs
55	MSFA participant, beater	MSFAs
56	MSFA participant, social feeder	MSFAs
57	Type II MSFA participant	MSFAs
58	Type III MSFA participant	MSFAs

Appendix 8 - Additional features and measures to assess alongside Seabirds at Sea surveys

Ship-based Seabirds at Sea surveys may be augmented by monitoring additional features such as population structure or taking measurements like flight heights and escape distances. These will not only enhance our knowledge about seabird behaviour and population structure but will also allow assessing the health of seabird populations and evaluating pressures on seabirds by human activities at sea.

According to MSFD, the status of seabirds amongst other is to be reported based on population demographic characteristics (criterion D1C3). So far, criterion D1C3 is only partly addressed. JWGBIRD has proposed to also assess demography in wintering birds (ICES 2018), e.g. by identifying the sex ratio and the proportion of juveniles through observation or based on birds shot by hunters (Hario et al. 2009, Fox et al. 2016). Although proportions of juveniles reflect breeding success and thus are related to conditions outside the Baltic Sea Region in some species, they may substantially contribute to understanding changes in population sizes. In addition, breeding performance may in some cases be closely linked to the situation in the wintering area, because the effect of conditions in the wintering area is carried over to the breeding grounds and may have significant influence on breeding success (e.g. of Common Eiders; Lehikoinen et al. 2006, Laursen et al. 2019). Age and sex can be identified in some seabird species based on plumage features. This is in particular true for seaducks. However, due to their high disturbance reaction and the large flock sizes, it is not possible to identify age and sex-specific plumage features quantitatively during Seabirds at Sea surveys. In these cases, taking pictures of flushing flocks that can later on be analysed is an adequate methodology to determine age and sex, thereby deriving measures of breeding success and population structure.

Ship traffic intensity is increasing, causing disturbance in many areas and thus excerting a pressure on many seabird species, especially in areas where vulnerable species aggregate. Measurements of species specific escape distances will help to support the integration of conservation needs in Marine Spatial Planning and can be used to develop vulnerability indices as management tools. These indices will allow quantifying the vulnerability of species to disturbance by ship traffic and have important management implications (Fliessbach et al. 2019).

The continuing development of offshore wind farms causes another threat to many seabirds. Measuring species specific flight heights is therefore an important tool to determine the collision risk with these constructions (Borkenhagen et al. 2018). Offshore windfarm can have different effects on seabirds. While some species will avoid these areas and lose their habitat (e.g. divers *Gavia* spec. and northern gannets *Morus bassanus, Dierschke et al. 2016*), others will be attracted and use them for foraging and/or resting (e.g. great cormorant *Phalacrocorax carbo*, lesser black-backed gull *Larus fuscus*, herring gull *Larus argentatus*, black-legged kittiwakes *Rissa tridactyla*, great black-backed gulls *Larus marinus*; Dierschke et al. 2016, Vanermen et al. 2015). Measuring flight heights of seabirds can therefore help improving collision risk assessments for offshore wind farms but also related to other large constructions (e.g. bridges).