JWGBIRD REPORT 2018

Report of the Joint OSPAR/HELCOM/ICES Working Group on Marine Birds (JWGBIRD)

1–5 October 2018

Ostende, Belgium

ICES Advisory Committee

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International Council for the Exploration of the Sea
Conseil International pour l’Exploration de la Mer

H. C. Andersens Boulevard 44–46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Executive summary

Hosted by the Flanders Marine Institute, the Joint ICES/OSPAR/HELCOM Working Group on Seabirds met in Ostende, Belgium, 1–5 October 2018. The meeting was co-chaired by Morten Frederiksen, Ian Mitchell and Volker Dierschke, and was attended by 15 members representing 11 countries. Following the tradition of the preceding meetings, the objectives of the meeting were to develop and implement indicators for seabirds under the Marine Strategy Framework Directive (MSFD), as well as to review and discuss seabird-related issues relevant for human uses of the sea. The meeting consisted of a series of interconnected workshops, where subgroups with floating membership discussed Terms of Reference. Report chapters were drafted by Term of Reference leads and collated by the chairs.

Further refinements of the existing indictor for breeding productivity in OSPAR were discussed. The suggested approach uses matrix population models to assess the impact of the observed level of breeding productivity on population growth rate, and relates the projected growth rate to IUCN criteria for species red-listing.

Links between trends in population abundance (HELCOM) and potential drivers were explored. Preliminary results are complex and require further interpretation.

A combined mid-winter aerial survey of the offshore Baltic was carried out in early 2016. The data have been collated, but results are not ready yet.

The group discussed integration rules for GES assessments of birds under MSFD, both within and across species. ICES workshops in 2018 resulted in advice on these rules. JWGBIRD mostly agree with this advice, but propose a few changes.

JWGBIRD reviewed the UK national assessment of seabirds under MSFD, and made suggestions for further development of indicators.

A reporting template for the periodic assessments of OSPAR Threatened and/or Declining Species and Habitats was tested for the black-legged kittiwake.

The group reviewed the progress so far on assessing bycatch mortality of marine birds in the NE Atlantic. The main limitation currently is the near absence of regular monitoring data on bycatch of birds. This also hampers the definition of threshold values for the MSFD indicator D1C1. The information collated by JWGBIRD will be used to inform a joint OSPAR-HELCOM workshop to examine possibilities for developing indicators for incidental by-catch of birds and marine mammals, planned for September 2019.

JWGBIRD provided input to the HELCOM indicator review process as well as to the HELCOM workshop on migratory waterbirds in November 2018.

1 Introduction

The Joint OSPAR/HELCOM/ICES Working Group on Seabirds (JWGBIRD), chaired by Ian Mitchell (OSPAR/UK), Morten Frederiksen (ICES/Denmark) and Volker Dierschke (HELCOM /Germany), met at the Flanders Marine Institute in Ostende, Belgium, 1–5 October 2018 to address the following terms of reference:

a) Construct an indicator of breeding productivity and conduct a trial assessment using the target setting approach developed by the JWGBIRD in 2017.

b) Continue analyses of trends from OSPAR and HELCOM assessments to identify variables and processes that may explain key outcomes. (This task will be progressed intersessionally before presenting results at 2018 meeting).

c) Review of techniques for measuring and communicating confidence in assessments. No progress was made on this task.

d) Review of the analysis of the abundance and distribution of birds from the combined 2016 midwinter offshore (at-sea) surveys of the Baltic.

e) GES integration rules for birds – test various methods for integrating within species of assessments of multiple criteria (as per revised MSFD Commission Decision 2017); taking into account the outputs from WKDIVAGG in May 2018 and the subsequent ICES advice.

f) Review national MSFD assessments relating to OSPAR Candidate indicators on birds and recommend future action on these indicators. Develop thinking on what the next round of OSPAR indicator assessments would be like and in what ways development beyond the IA2017 would be desirable.

g) Review and sign-off a trial assessment of black-legged kittiwake in the OSPAR Maritime Area, drafted by UK & NO.

h) Provide a concise report on progress made so far in the NE Atlantic and Baltic on the following tasks, in relation to assessing mortality in marine birds from bycatch.

- Identify risks for species groups associated with specific gears
- Identify high risk areas based on species occurrence/density and occurrence/effort of gears associated with risk
- Identify already existing data sources related to by-catch numbers and fishing effort
- Identify data needs to trigger effective monitoring/pilot projects
- Identify suitable methods of target setting.

i) Consider input and data provisioning for the HELCOM workshop on migratory waterbirds (MIGRATORY BIRD WS 1-2018).

j) Provide input to the currently ongoing HELCOM indicator review process by filling in the provided questionnaires.

The meeting was attended by 15 group members (Annex 1), and three further members (Matt Parsons, Tycho Anker-Nilssen, Pep Arcos) and the following non-members provided input via correspondence: Sven Koschinski, Signe Christensen-Dalsgaard (Norwegian Institute for Nature Research), Sue O'Brien (Joint Nature Conservation Committee), Ariel Brunner (BirdLife Europe).

2 Development and testing of a revised indicator of marine bird breeding productivity

2.1 Background

The OSPAR Intermediate Assessment 2017 included an indicator of marine bird breeding success / failure developed and assessed by JWGBIRD (OSPAR 2017). The 2017 assessment acknowledged some limitations with the approach taken. The assessment methods for the indicator currently focus on the extreme events of almost no chicks being produced by a colony, on average, per year. In doing so, they fail to identify other years where poor breeding success could still have significant negative impacts on the population in the longer term. However, it is not straightforward to categorise annual breeding success as 'good' or 'poor', because the number of chicks that need to be produced each year to sustain a population or cause it to grow varies substantially as other demographic parameters (e.g. survival rates) also vary between years and not least species. Information on demographics such as survival rate, age at first breeding and immature survival rates are more resource demanding to measure owing to the need to monitor individual birds from year to year. For well-studied species and at a few intensively studied sites, these data do exist.

At the 2017 meeting in Riga, JWGBIRD suggested a potential way forward towards a revised indicator that reflected better the variation in breeding productivity between years and the full life history of the species, in order to predict the effect on population growth, without requiring detailed information or data on demographic parameters. The initial suggestion of the group was to work with six 'model' seabird life histories, assign each actual regional population to one of these six life histories, and score observed breeding productivity into five categories relative to the level required to keep the population stable (ICES 2017).

However, on reflection, several steps in this proposed process seem arbitrary. Firstly, shoehorning the full variation in seabird life histories into six discrete 'models' is an oversimplification. The decision on which 'model' a given species or population belongs to has potentially critical consequences for the breeding productivity required to keep the population stable, and thus the assessment of status for the population (see Table 2.2 in ICES 2017). Secondly, the thresholds used for the five categories into which observed breeding productivity should be scored (see Table 2.3 in ICES 2017) are essentially arbitrary.

JWGBIRD addressed these issues during the 2018 meeting in Oostende and tested a revised approach with actual monitoring data from the Greater North Sea OSPAR Region for black-legged kittiwake and common guillemot (source: data snapshot for OSPAR assessment of marine bird breeding success failure (OSPAR 2017) available at https://odims.ospar.org/documents/191/downloadindicator).

2.2 Principles of the new approach

We propose the following approach for assessing levels of breeding productivity in each species of marine bird included in the OSPAR indicator.

1) Set up a baseline demographic model for each regional population that needs to be assessed. Choosing an appropriate structure (number of age classes) and parameterisation of this model is critical, and we propose that these models are peer reviewed (see below). Each model is parameterised with a value for breeding productivity that ensures a stable population over time.

2) Calculate mean annual breeding productivity for each regional population from monitoring data. The exact method used for calculating this mean needs further thought (see below).

3) Calculate a running six-year mean breeding productivity, to reflect the assessment schedule in OSPAR.

4) Substitute the running means into the demographic model, and calculate the resulting expected asymptotic population growth rate (λ^E).

5) Calculate expected generation time (GT) using the demographic model produced in step 1.

6) Use GT to calculate threshold values for λ (λ^T), derived from IUCN Red List criteria for categories Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) (see below for how to derive thresholds from these criteria).

7) Score the expected λ (λ^E) against the threshold values for λ (λ^T). We propose a graphical scoring process, as shown in the examples below.

2.2.1 Deriving thresholds for λ (λ^T) from IUCN criteria

IUCN defines criteria for red-listing of species as thresholds for observed population decline over 10 years or three generations, whichever is the longer. The following thresholds apply, unless the decline has ceased, the reasons are understood, and the decline is reversible (i.e. in practically all cases) (IUCN 2012):

- CR (critically endangered): ≥ 80 % decline
- EN (endangered): ≥ 50 % decline
- VU (vulnerable): ≥ 30 % decline

For seabirds, three generations is always more than 10 years. To derive threshold values of λ (the annual asymptotic growth rate) for a specific species or population, we use the baseline demographic model to assess generation time (Caswell 2001, see R script below). We then calculate λ^T as $\sqrt[3*GT]{(1-T^{IUCN})}$, where GT = generation time and T^{IUCN} = IUCN threshold value (0.8, 0.5 or 0.3, as appropriate).

2.3 Examples

2.3.1 Black-legged kittiwake

The suggested baseline model for black-legged kittiwake has the following structure and parameterisation:

Parameter	Value
Age of first breeding	4
Breeding productivity	0.872
First-year survival	0.52
Second-year survival	0.75
Third-year survival	0.83
Fourth-year survival	0.85
Adult annual survival	0.88
Primary sex ratio	0.5

This model has a λ^E of 1, and a generation time of 11.3 years. These values are fairly realistic for the species, but a more comprehensive validation of the model should be included in a formal, peer-reviewed assessment process.

Black-legged kittiwake breeding productivity was monitored in at least one year in 70 colonies in the Greater North Sea during 1986–2015; the annual sample included 20–42 colonies, largely in the UK. We calculated the simple annual mean breeding productivity (see below for more refined options), and smoothed these values using a six-year running mean (Fig. 2.1).

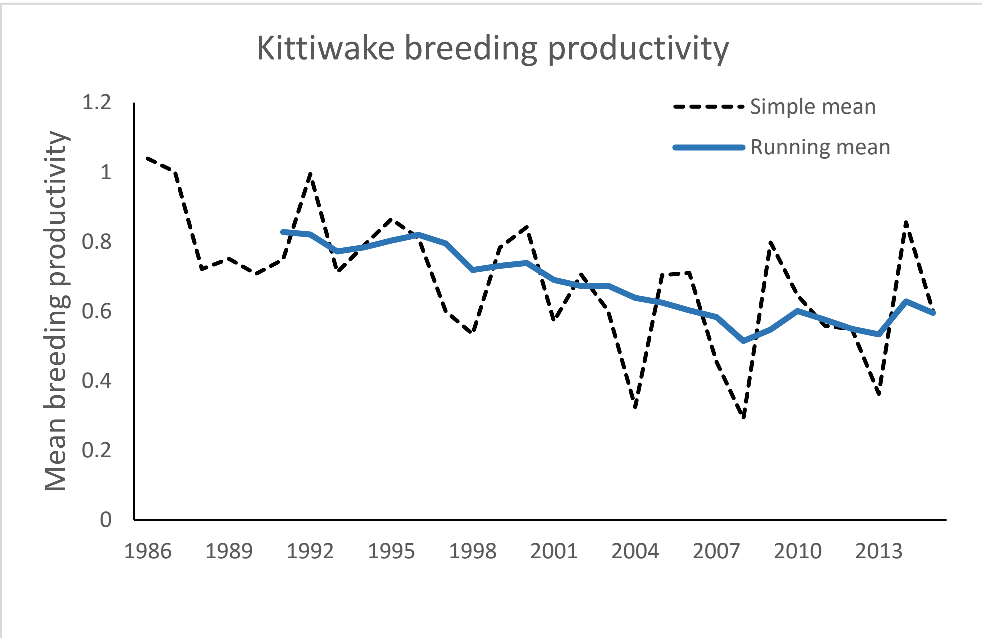

Figure 2.1. Observed annual mean breeding productivity of black-legged kittiwakes in OSPAR region II, and a six-year running mean centred on the last year in each six-year period.

By substituting the running mean breeding productivity into the baseline model, and calculating the corresponding λ^E (Fig. 2.2), it is apparent that the number of chicks produced by kittiwakes in OSPAR region II is much too low to ensure population stability. This modelling approach indicates that for the last 15 years, the expected long-term growth rate has been so low that if realised it would correspond to an IUCN classification as EN. The species is red-listed as VU both globally (BirdLife International 2017a) and in Europe (BirdLife International 2017b), and is regarded as a 'threatened and/or declining species' by OSPAR (OSPAR 2011). For the period 2007–2015, mean λ^E was 0.967, whereas the mean observed growth rate for the same period (based on the D1C2 abundance indicator for the Greater North Sea) was 0.940. It thus appears that our base model is too optimistic, with some of the other demographic parameter values being unrealistically high.

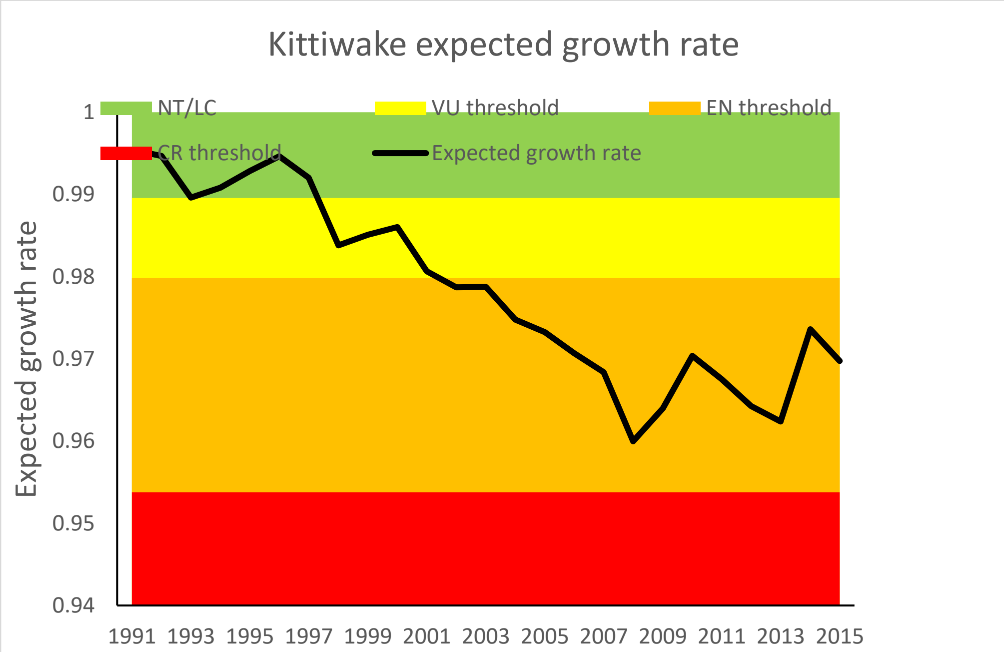

Figure 2.2. Expected long-term population growth rate λ^E of black-legged kittiwakes in OSPAR region II, predicted from a demographic model given the observed values of breeding productivity. Background colour-coding indicates levels of λ^T corresponding to IUCN Red List criteria for categories CR (red), EN (orange), VU (yellow) and NT/LC (green).

2.3.2 Common guillemot

The suggested baseline model for common guillemot has the following structure and parameterisation:

Parameter	Value
Age of first breeding	6
Breeding productivity	0.516
First-year survival	0.56
Second-year survival	0.79
Third-year survival	0.90
Fourth-year survival	0.92
Adult annual survival	0.92
Primary sex ratio	0.5

This model has a λ^E of 1, and a generation time of 17.5 years. These values are fairly realistic for the species, but a more comprehensive validation of the model should be included in a formal, peer-reviewed assessment process.

Common guillemot breeding productivity was monitored in at least one year in 20 colonies in the Greater North Sea during 1986-2015; the annual sample included 3-13 colonies in the UK. We calculated the simple annual mean breeding productivity (see below for more refined options), and smoothed these values using a six-year running mean (Fig. 2.3).

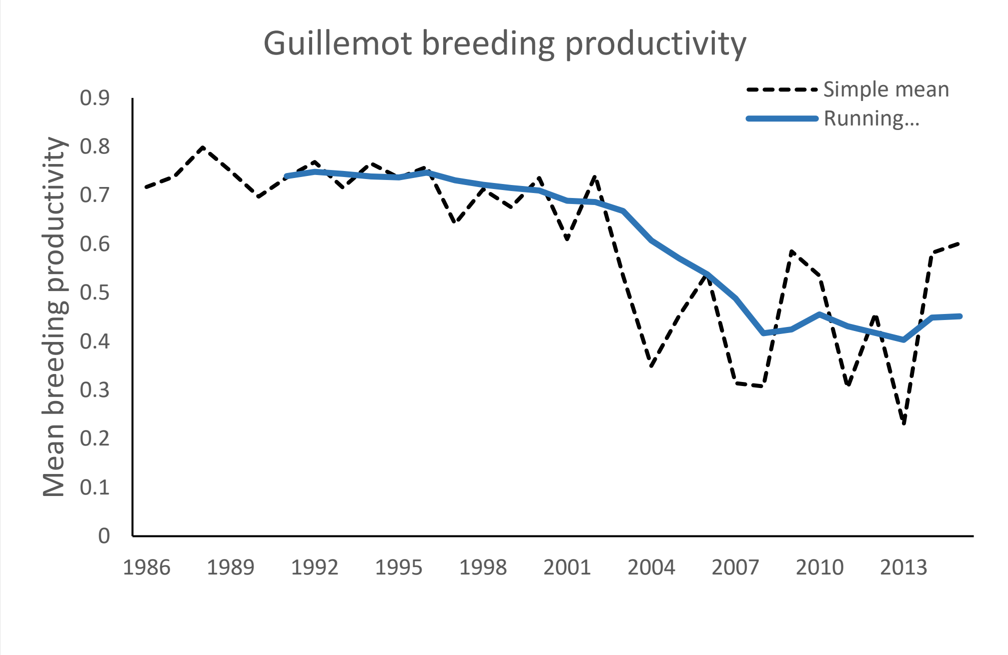

Figure 2.3. Observed annual mean breeding productivity of common guillemot in OSPAR region II, and a six-year running mean centred on the last year in each six-year period.

By substituting the running mean breeding productivity into the baseline model, and calculating the corresponding λ^E (Fig. 2.4), it is apparent that the decline in the number of chicks produced by guillemots in the Greater North Sea has been sufficient to reduce the expected long-term growth rate of the population. If the baseline model input parameters can be considered reliable, the current level of breeding productivity should keep the population stable in the coming years. The common guillemot is regarded as Least Concern on the global Red List (BirdLife International 2016), and Near Threatened in Europe (BirdLife International 2017b).). For the period 2007-2015, mean λ^E was 1.000, whereas the mean observed growth rate for the same period (based on the D1C2 abundance indicator for the Greater North Sea) was 1.007. It thus appears that our base model is quite realistic for this species.

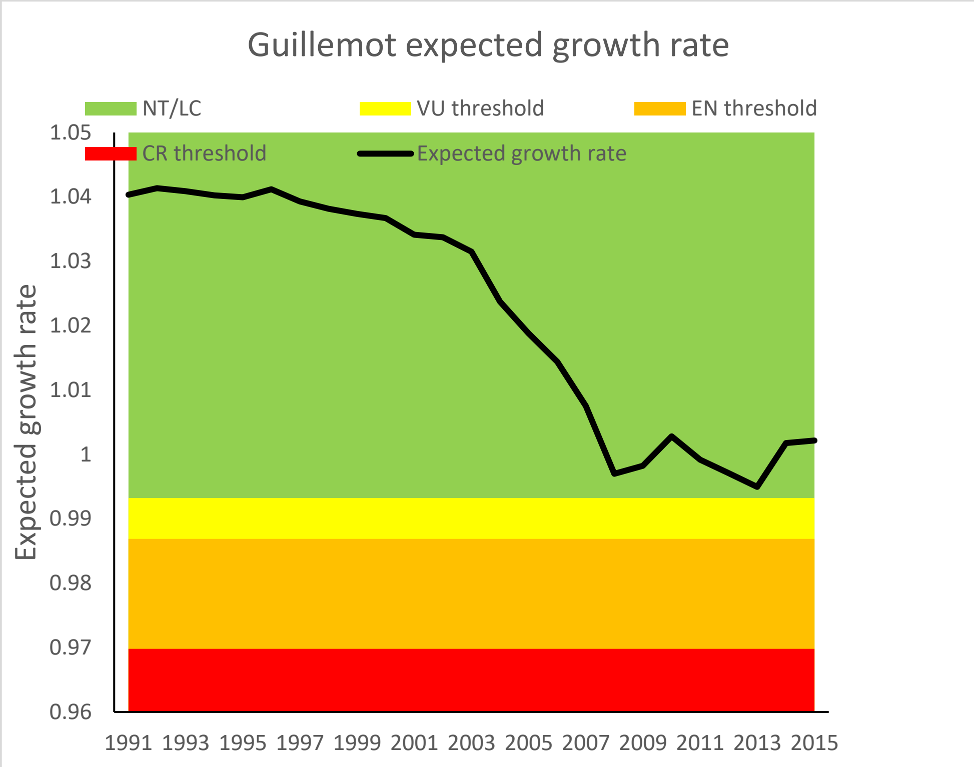

Figure 2.4. Expected long-term population growth rate λ^E of common guillemot in OSPAR region II, predicted from a demographic model given the observed values of breeding productivity. Background colour-coding indicates levels of λ^T corresponding to IUCN Red List criteria for categories CR (red), EN (orange), VU (yellow) and NT/LC (green).

2.4 Further issues to be addressed

2.4.1 Interpreting the indicator

It is important that a model-based indicator of this type is interpreted correctly. The indicator expresses the long-term expected growth rate of the population, given the mean observed breeding productivity in the most recent six-year period, and given that no major changes occur (or have occurred) in other demographic parameters. For a few species, where data on breeding success are more widely available than data on breeding abundance, this indicator could be used on its own to assess the status of these species. However, changes in e.g. adult survival would lead to a different relationship between breeding productivity and expected population growth rate.

For most species included in the current OSPAR indicator of breeding success/failure, an indicator of breeding abundance is also available. Moving forward, we need to determine how the revised indicator of productivity will be used alongside indicators of abundance to assess the status of individual species, which is now required under the Marine Strategy Framework Directive. Chapter 5 of this report investigates how assessments of different indicators could be integrated to assess the status of a species. An alternative or additional approach could be to use the level of correlation between the abundance and productivity indicators to identifying likely drivers of change in the population. For example, the good correspondence between the expected growth rate (productivity indicator) and the observed population trend (abundance indicator) for common guillemot indicates that no major changes in other demographic parameters have occurred for this species, and thus that the baseline demographic model has remained valid throughout the 30-year period. In other words, it appears that declines in breeding productivity is the main mechanism explaining the change in population growth rate of common guillemot in the North Sea since 1990. However, for other species a similar comparison might reveal a poor correspondence between growth rates predicted by the two indicators, which could indicate that other factors (e.g. survival) were driving population change, or that poor productivity levels were indicative of future population declines, not yet evident.

2.4.2 Parameterising the species-specific demographic model

Here, we have used within-group expert knowledge to parameterise the baseline demographic model for each species. This parameterisation is critical and may affect the expected population growth rates quite strongly. Basically, if the level of breeding productivity required to keep the population stable is lower (e.g. because adult survival is higher than assumed), the expected growth rate given observed breeding productivity will be higher, and the status of the species will be assessed more positively. We therefore suggest that should the approach suggested above be adopted, some form of peer review of the species-specific baseline demographic model is necessary.

2.4.3 Data aggregation across colonies

In the examples included here, we have simply taken the annual mean of all available estimates of breeding productivity. There are at least two potential issues with this approach:

- The data set is far from balanced, and there are many missing values in the colony-year matrix. Some colonies are thus much better represented than others, and the annual mean will to some extent reflect exactly which colonies were monitored in that year. One way to address this issue is to calculate so-called least-squared means (or expected marginal means), which use observed differences between colonies and years to 'reconstruct' what the annual mean might have been if there were no missing values. In this approach, colonies which have only been monitored in very few years would have to be excluded from the data set.
- The observed data on breeding productivity might not be entirely representative of the region as a whole. Only a selection of colonies are monitored, and these are of widely varying size. A fully representative regional mean should be affected more by monitoring results from larger colonies. One way to approach this would be to weight the annual mean by the best available estimate of the size of each monitored colony. However, some very large colonies, or potentially even larger sub-regions, may not be monitored at all, in which case this approach would not be sufficient. This is particularly a problem for species monitored at only a few colonies.

It is not clear how the issues outlined above affect the estimates of mean annual breeding productivity. It would be useful to explore this further, either by applying the suggested partial solutions to existing monitoring data, or by simulation.

2.4.4 Including survival monitoring data in the indicator

In principle, the approach suggested here could also be used for any other demographic parameter that is monitored annually. In practice, only adult survival is sufficiently well monitored to be included (and only for some species). A demographic model could be used to explore the impact of observed variation in adult survival and breeding productivity on population growth rate, either for each parameter separately or in combination. The number of species for which adult survival is sufficiently well monitored to be included in a demographic indicator is limited, but with the increased emphasis on species-level assessment of GES in the revised decision of the EC, this might nevertheless be worthwhile. For such species, it will be possible to combine monitoring data for both these key parameters and produce a much more dynamic and realistic indicator of growth rate, which could be presented in the same way as that suggested for productivity above.

For long-lived animals such as seabirds, variation in adult survival has a much stronger impact on expected annual population growth rate than variation in breeding productivity. On the other hand, this relationship means that adult survival theoretically is expected to show much less year-to-year variation than breeding productivity: when resources are scarce, individuals are expected to prioritise their own chances of surviving to attempt reproduction in another year at the expense of their offspring in the current year (Cairns 1987, Sæther & Bakke 2000, Gaillard & Yoccoz 2003). Despite this extreme ability to buffer bad conditions on the breeding grounds, incidents of excessive mortality of adult seabirds do occur irregularly, especially outside of the breeding season, and some of these incidents are also reflected by substantial temporal reduction in survival rates or breeding numbers in the populations involved (e.g. Mesquita *et al.* 2015, Anker-Nilssen *et al.* 2017).

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3 Identifying drivers of species trends in OSPAR and HELCOM assessments

Seabird indicators developed by JWGBIRD have successfully been applied in the status assessments of marine areas in the Northeast Atlantic and in the Baltic Sea, i.e. in the Intermediate Assessment 2017 (IA2017: OSPAR 2017) and in the Holistic Assessment 2 (HOLAS2: HELCOM 2018a). These indicators are addressing the abundance of seabirds (NE Atlantic, Baltic Sea) and their breeding success/failure (NE Atlantic only). During its 2017 meeting, JWGBIRD has tried to identify reasons for the status of species by comparing the indicator results to different traits. A general result was that foraging guild as expressed by the five functional groups the individual species belong to explain the status of species better than traits related to breeding biology, distribution and other traits related to foraging (ICES 2017). However, it was considered useful to look at combinations of traits being responsible for the status. Therefore, it was formulated as a task for JWGBIRD to apply one- and two-way ANOVA to the indicator results and discuss them at the 2018 JWGBIRD meeting.

To meet this task, the species results of both HELCOM waterbird abundance indicators (HELCOM 2018b, 2018c) were examined again. It is important to consider that these results stem from the latest application of the indicators, whereas the preliminary analysis by JWGBIRD in 2017 refers to the results from the preceding indicator assessment, which was a test run for HOLAS2. The new indicator assessments differ from the earlier ones by

i) covering the whole MSFD reporting period (2011-2016 instead of 2011-2015),
ii) a better coverage in the breeding waterbird abundance indicator (mainly due to the inclusion of Danish data for the first time) and
iii) not including any more those species, which occur predominantly offshore, as the coastal counts used for the wintering waterbird indicator are thought to be not representative for them (following a recommendation by JWGBIRD, ICES 2017).

Further, both indicators were applied to the entire Baltic Sea (as before), but also to seven subdivisions. However, the following analyses only refer to the results from the entire Baltic Sea and cover 29 species of breeding and 22 species of wintering waterbirds.

The HELCOM waterbird abundance indicators are based on species-specific annual index values derived from breeding bird surveys and land-based midwinter counts. The geometric mean (GM) of the six index values of the MSFD reporting period (2011–2016) is compared to the average of the index values from the baseline period (1991–2000), and a species is treated as being in good status if the geometric mean is at least 70% of the baseline average (80% in species laying only one egg per year). Trends and related slopes are given as additional information. More details are given in the indicator reports (HELCOM 2018b, 2018c).

The trait analyses for both breeding and wintering birds were done twice, one each with the geometric means of 2011–2016 (concentrating on the species condition in the MSFD reporting period compared to the baseline situation) and with the trend slopes (reflecting the changes over the whole period 1991–2016). As dependent variables, the

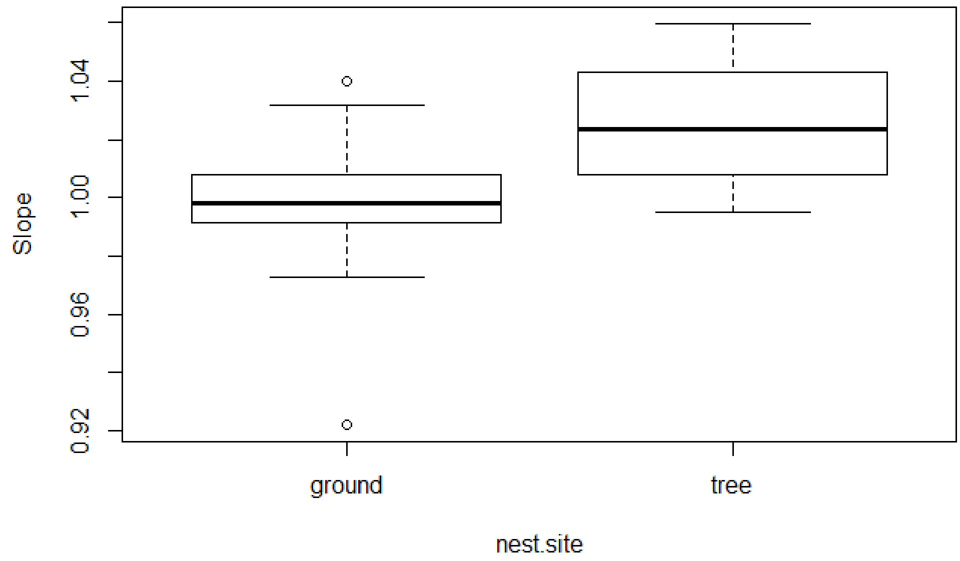
GMs and slopes of all breeding and wintering species were analysed with one-way and two-way ANOVAs using the following traits as predicting variables:

- Wintering area (NW Europe including Baltic, SW Europe, Africa; breeding birds only),
- Breeding area (Arctic incl. High Arctic, taiga, temperate; wintering birds only),
- Functional group (grazing feeders, wading feeders, surface feeders, pelagic feeders, benthic feeders),
- Breeding strategy (colonial breeder, non-colonial breeder),
- Nest site (ground, cliff, tree),
- Clutch size (1 egg, 2-4 eggs, >4 eggs),
- Niche width (generalist, specialist),
- Use of discards from fisheries (yes, no),
- Predicted reaction on climate change (according to Huntley *et al*. 2007: breeding range extension expected, major shift in breeding range expected, decrease in breeding range expected, no change expected; breeding birds only).

Niche width could be applied only to breeding birds, because there were no specialist feeders among the wintering birds.

To account for the differences in the confidence intervals of both trend slopes and GM indices among the species, inverse standard errors were used as weights in the models. Thus, more weight was given to the species with narrower confidence intervals. The performance of the competing models was compared using their AIC. The best models were those having lower AIC values.

3.1 Results wintering birds



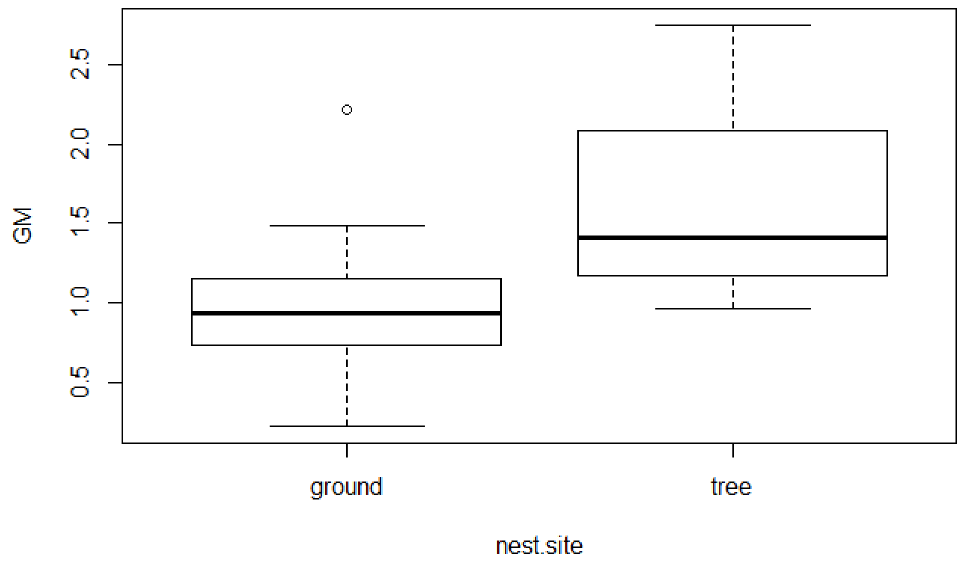


Fig. 3.1. The best single-factor model suggests that for wintering birds the tree-nesting species are doing significantly better than the ground nesting species. This has been observed both for the trend slopes (1991-2016; upper graph) and the GM indices (2011–2016; lower graph).

When looking at one factor at a time, both approaches (slopes 1991–2016 and GM of 2011–2016 compared to baseline 1991–2000) revealed the same result (Table 3.1). Differences between wintering species are best explained by nest site (tree-nesting species doing better than ground-nesting species; Fig. 3.1), followed by breeding area (taiga and temperate breeders better than Arctic breeders), and clutch size (2–4 eggs better than >4 eggs) or breeding strategy (colonial breeding better than non-colonial breeding). The effect of the last 2 factors is not distinguishable since the groups are identical (i.e. all species laying 2–4 eggs were colony breeders and all species laying more than 4 eggs were not colony breeders).

Table 3.1. Performance of 1- and 2-way ANOVA models explaining trends and indices of wintering birds. All 1-way models and only the four best of the 2-way models included in each model category.

Explained	Predictors in model	Multiple R-squared	AIC
Trend slope	Nest site	0.1978	-101.87
	Breeding area * Breeding strategy	0.3224	-101.58
	Breeding area * Clutch size	0.3224	-101.58
	Nest site * Use of discards	0.2114	-100.24
	Breeding area	0.2278	-100.70
	Breeding area * Nest site	0.3410	-100.19
	Clutch size	0.0324	-97.74
	Breeding strategy	0.0324	-97.74
	Use of discards	0.0009	-97.04
	Functional group	0.0669	-94.54
Geometric mean index of the last 6 years	Nest site	0.2763	37.04
	Nest site * Use of discards	0.2974	38.39
	Breeding strategy * Nest site	0.3003	40.30
	Clutch size * Nest site	0.3003	40.30
	Breeding area	0.2193	40.71
	Breeding area * Breeding strategy	0.2696	41.24
	Clutch size	0.0043	44.06
	Breeding strategy	0.0043	44.06
	Use of discards	0.0012	44.13
	Functional group	0.1630	44.24

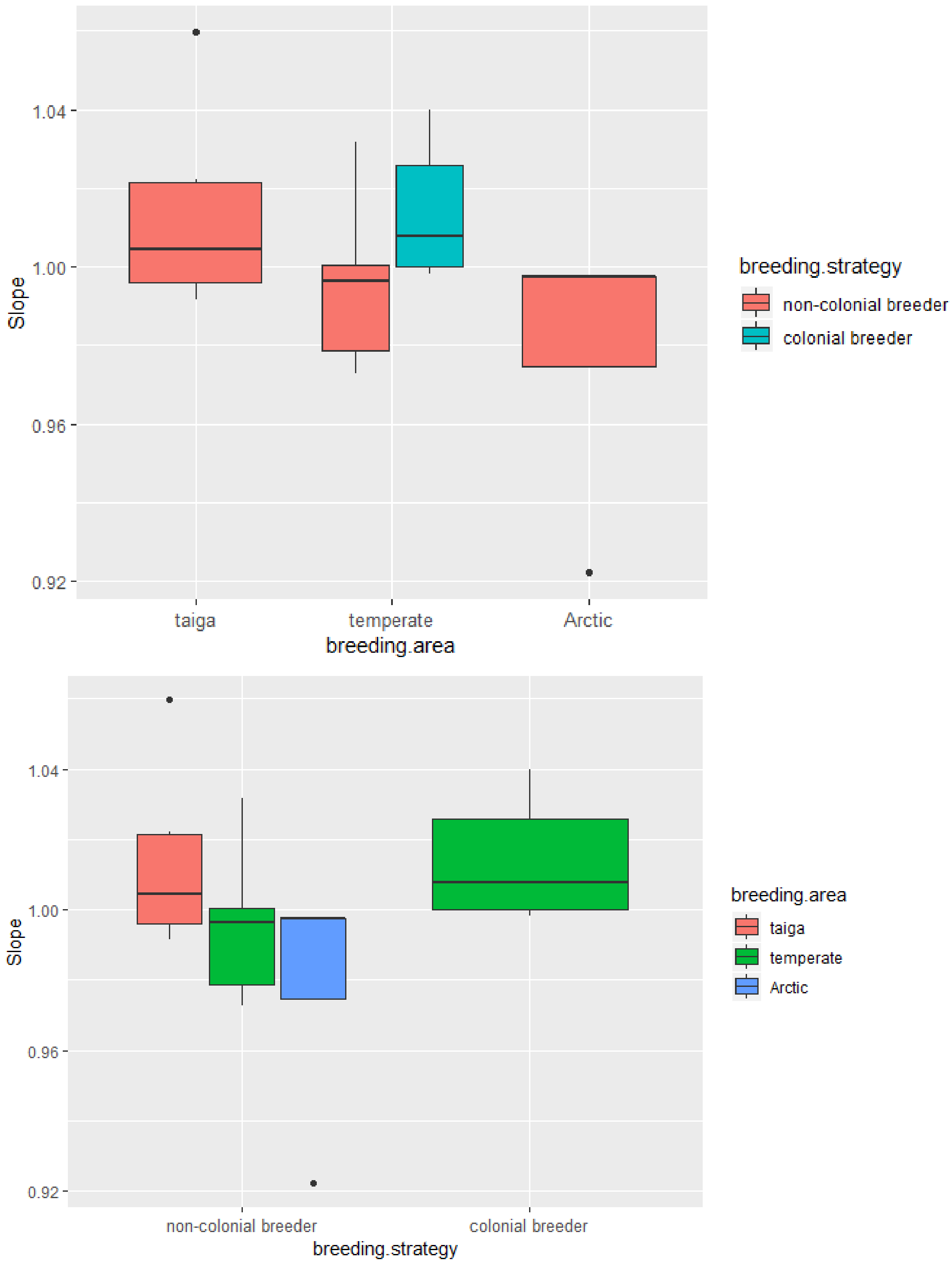


Fig. 3.2. The best two-factor model for the trend slopes (1991–2016) of wintering birds tells that for the non-colonial breeders (or species laying more than 4 eggs) the breeding area is important – taiga breeders have better trends than species breeding in the temperate region and Arctic. The breeding area of all colonial breeders was the temperate region.

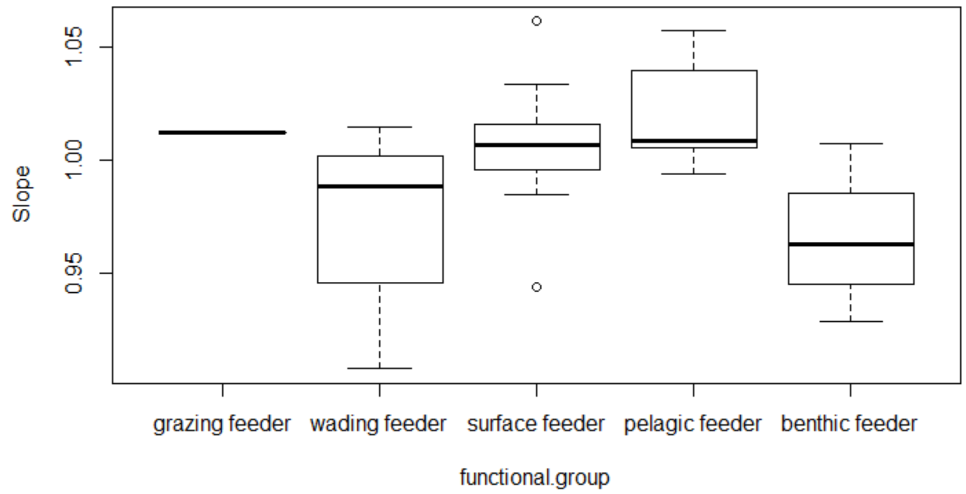
Two-way ANOVAs for the slope results gave best fits for the models comprising breeding area and breeding strategy (Fig. 3.2) as well as breeding area and clutch size (expressing that in the temperate zone colonial breeding and laying 2–4 eggs is better than non-colonial breeding and laying more than 4 eggs). Again, the effect of the breeding strategy and clutch size is not distinguishable since the two groups are identical. The performance of this model is the same as the single factor model.

In contrast, the best fitting model for the GM results comprises nest site and the use of discards, followed by the models nest site * breeding strategy and nest site * clutch size. These three models clearly express that tree-nesting is better than ground-nesting in those areas where the Baltic wintering birds are breeding. This is certainly connected to the bad status of Arctic breeding birds, which are obligatory ground-nesters. None of the two-factor models had better performance than the best single factor model. This tells that those additional traits in the best two-factor models are uninformative.

3.2 Results breeding birds

One-way ANOVAs with the slopes 1991–2016 as response variable gave the functional group (i.e. the foraging guild) as the best explaining predicting variable (Fig. 3.3). While four of the functional groups did not differ much from each other, benthic feeders were clearly doing worse than the other groups. The second best model is the one with niche width, meaning that specialists (five tern species) fared better than generalists (all the other species). The third best model classified species which do not use discards better than discard feeders. ANOVAs with the GM 2011-2016 gave best fitting for niche width (Fig. 3.3), followed by use of discards and distributional response to climate change. That last result comprises that the only species with no expected change in the Baltic Sea region (Great Crested Grebe) is in better status than those expecting range shift or even facing range reduction (according to maps shown in Huntley *et al*. 2007).

Two-way ANOVAs with slopes gave wintering area and functional group as best explaining combination of predicting variables (Table 3.2), highlighting the bad status of benthic feeders wintering in NW Europe and of wading feeders wintering in Africa (Fig. 3.4). The second best model combines wintering area and breeding strategy, again reflecting worst slopes observed in waders wintering in Africa, but also showing that among colonial breeders, those wintering in Africa (terns) were doing best and those wintering in NW Europe were doing worst. Two-way ANOVAs with GMs favoured the same two combinations of predicting variables, but in this case, the one with wintering area and breeding strategy is the best fitting model (Fig. 3.5). The two two-factor models both for slope and GM indices performed better than the best corresponding single factor model, so the two-factor models are preferred.



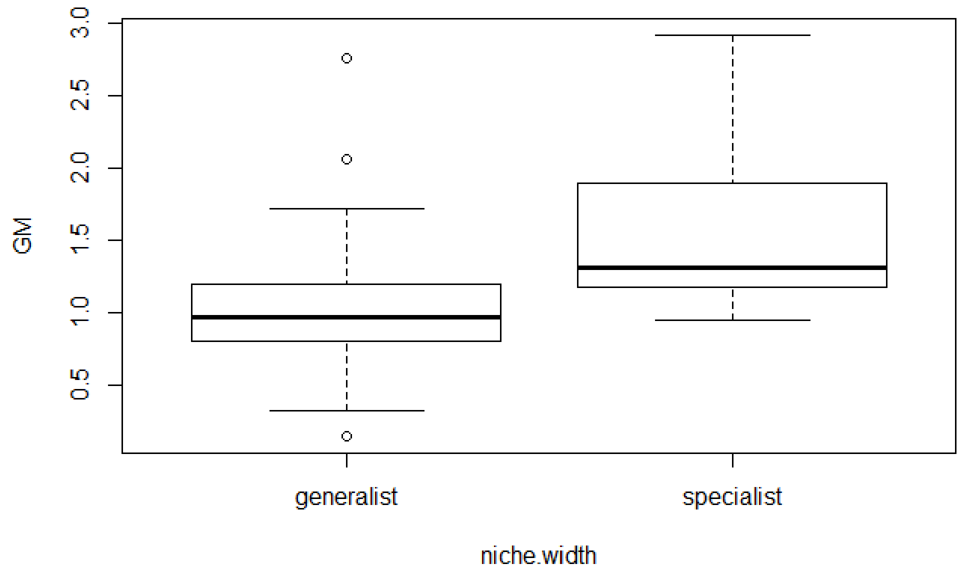


Fig. 3.3. The best single-factor models suggest that the trend slope (1991-2016) of breeding birds is best explained by the functional group with the pelagic feeders and the only grazing feeder doing significantly better than benthic (upper graph) and that the GM indices (2011-2016) of breeding birds are best explained by the niche width with the specialist species (all terns) are doing better than the generalists (the rest of the species; lower graph).

Table 3.2. Performance of 1- and 2-way ANOVA models explaining trends and indices of breeding birds. All 1-way models and only the four best of the 2-way models included in each model category.

EXPLAINED	PREDICTORS IN MODEL	MULTIPLE R-SQUARED	AIC
Trend slope	Wintering area * Functional group	0.5616	-112.91
	Wintering area * Breeding strategy	0.3663	-112.23
	Functional group * Niche width	0.3984	-111.74
	Functional group * Use of discards	0.3774	-110.74
	Functional group	0.2753	-108.34
	Niche width	0.0663	-106.99
	Use of discards	0.0626	-106.87
	Breeding strategy	0.0203	-105.59
	Climate change	0.1415	-105.42
	Nest site	0.0663	-104.99
	Clutch size	0.0405	-104.20
	Wintering area	0.0031	-103.09
Geometric mean index of the last 6 years	Wintering area * Breeding strategy	0.3692	41.08
	Wintering area * Functional group	0.5326	42.39
	Clutch size*Niche width	0.2911	42.47
	Wintering area * Niche width	0.2785	42.98
	Niche width	0.1210	44.70
	Use of discards	0.0942	45.58
	Climate change	0.1526	47.64
	Clutch size	0.0978	47.46
	Nest site	0.0702	48.34
	Breeding strategy	0.0001	48.44
	Functional group	0.1775	48.78
	Wintering area	0.0133	50.06

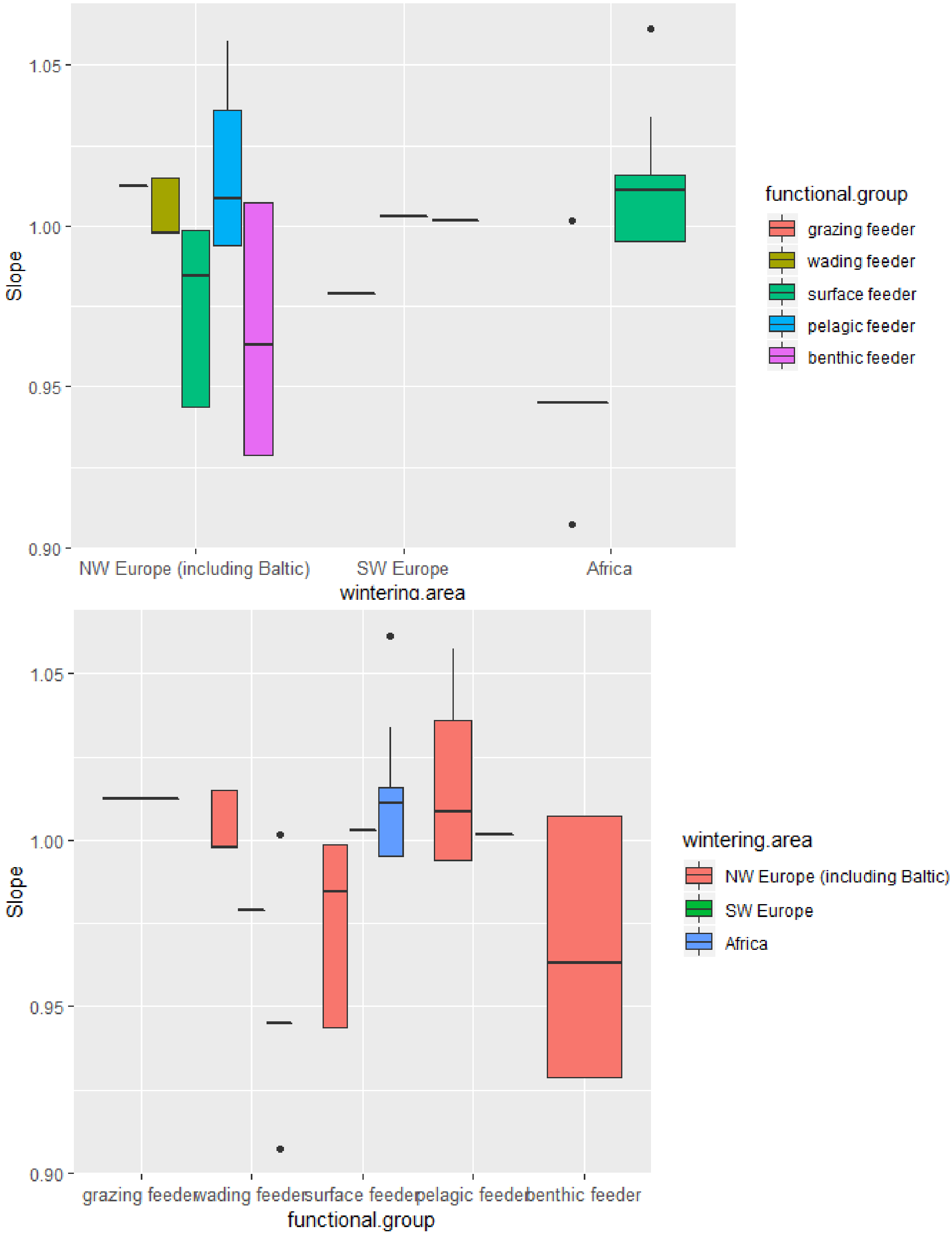


Fig 3.4. The best two-factor model for the trend slopes (1991–2016) of breeding birds tells that for the surface feeding species the wintering area is important – the species wintering in Africa (all terns) have better trends than species wintering in the NW Europe (all gulls). Among waders, the species wintering in Africa and SW Europe are doing worse than the species wintering in NW Europe. The wintering area of all benthic feeders was NW Europe (including Baltic).

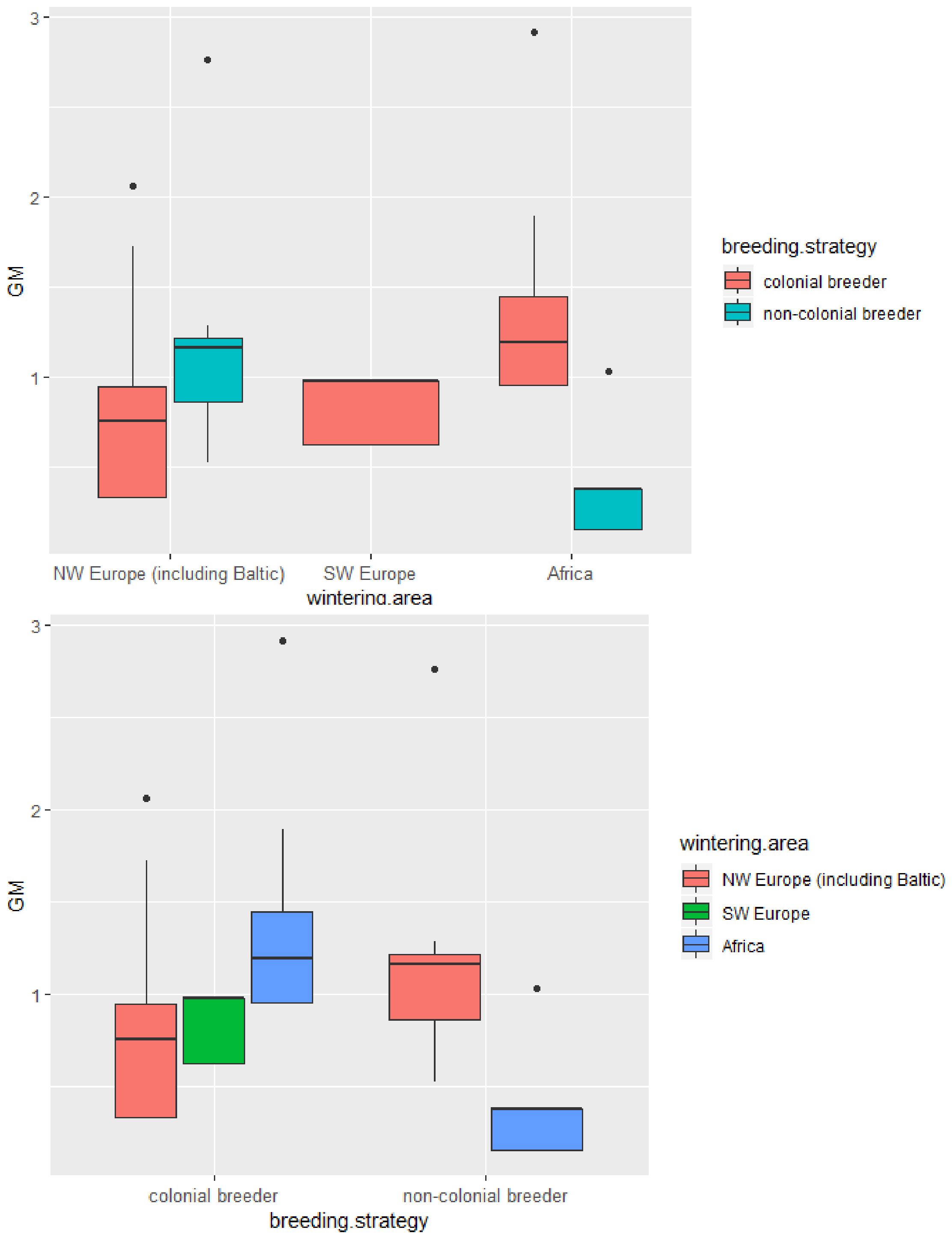


Fig.3. 5. The best two-factor model for the GM indices (2011–2016) of breeding birds tells that the wintering area and their breeding strategy is important: for the non-colonial breeders (all waders) the indices are significantly worse than the rest of non-colonial species, and for colonial breeders indices of species wintering in Europe are worse than for the species wintering in Africa (all terns).

3.3 Discussion

Waterbirds breeding and/or wintering in the Baltic Sea belong to various bird families and can be grouped according to foraging mode in five groups. As they also differ in how they are breeding and where they are roaming throughout the annual cycle, there are numerous combinations of variables describing their performance. Given that analyses comprise trend data from only 29 breeding and 22 wintering species, many categories of the tested factors used in models consisted of few to no species. Thus, the results for single traits as well as trait-combinations have to be treated with caution. Many combinations of variables have no entry and others comprise only one species. Still, results give indications for the importance of several traits:

It appears that ground-nesting is unfavourable, and related to this (but probably also to other reasons such as climate change), Arctic breeders wintering in the Baltic Sea are in bad status. For Baltic breeding birds, benthic feeders perform poorly, whereas colonial breeding specialists wintering in Africa, i.e. the five species of terns, are in best status. All species treated in the indicators are migratory, meaning that their fates are also influenced by factors operating outside the assessment area, the Baltic Sea. Therefore, the results of the above analyses have to be examined carefully, especially when conclusions are drawn concerning the status of the Baltic Sea.

The analyses and results presented here are preliminary. After more thorough examination of the results it is planned to produce scientific papers dealing with the observed trends and the reasons for them.

3.4 References

HELCOM 2018a. State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Baltic Sea Environment Proceedings 155. HELCOM, Helsinki.

HELCOM 2018b. Abundance of waterbirds in the breeding season. HELCOM core indicator report. http://www.helcom.fi/Core%20Indicators/Abundance%20of%20waterbirds%20in%20the%20breeding%20season%20HELCOM%20core%20indicator%202018.pdf (15 October 2018)

HELCOM 2018c. Abundance of waterbirds in the wintering season. HELCOM core indicator report. http://www.helcom.fi/Core%20Indicators/Abundance%20of%20waterbirds%20in%20the%20wintering%20season%20HELCOM%20core%20indicator%202018.pdf (15 October 2018)

Huntley B, Green RE, Collingham YC & Willis SG 2007. A climatic atlas of European breeding birds. Durham University, The RSPB and Lynx Edicions, Barcelona.

ICES 2017. Report of the OSPAR/HELCOM/ICES Working Group on Marine Birds (JWGBIRD), 6-10 November 2017, Riga, Latvia. ICES CM 2017/ACOM:49. 98 pp.

OSPAR 2017. Intermediate Assessment 2017. https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/ (15 October 2018)

4 Progress on the combined 2016 mid-winter offshore survey of marine birds in the Baltic

Status assessments of marine health as well as of single species depend on accurate knowledge of population numbers and trends. Current evaluations for waterbirds in the HELCOM and OSPAR region are lacking up-to-date information on population size and trends, especially for species with high concentrations in offshore areas (ICES 2016). This knowledge gap is even more severe in the light of the results of previous waterbird population estimates for the Baltic Sea, which have shown massive declines in wintering numbers for several species (Skov *et al*. 2011). The most severe decreases in numbers have been reported for all seaducks, with reductions in numbers of 50-65%. In reaction to these alarming results, seaducks have been listed on the global Red List of Threatened Species (IUCN) as well as the Baltic Sea Red List of Wintering Birds (HELCOM). International Single Species Action Plans (AEWA) have been developed for long-tailed duck and velvet scoter to assess and meet the increasing conservation needs.

These evaluations have highlighted the strong need for an update of population estimates to assess the current situation of seaducks and other species of high conservation concern. Such updated estimates will deliver the basis for fulfilling international reporting commitments according to MSFD and to the regional conventions of OSPAR and HELCOM, and will support the development of adequate conservation measures. To answer these needs, a coordinated survey of offshore birds in a large part of the Baltic Sea as well as the Southern North Sea was conducted in January to March 2016 (ICES 2016). Survey data will be used to update population numbers and distribution patterns of offshore species at the regional level. The Baltic Sea survey data have been collated by the individual countries, and are gathered for Distance Sampling analyses on a common platform, performed by Latvia.

It is an achievement to manage coordinated surveys of offshore birds at such a geographical scale. The coordination of the surveys was performed by national representatives, without a project driven platform. While the coordination of the surveys was successful, the process of analysing the data on a common platform has been challenging. That work is in progress. The "project" would hugely benefit from a more formal platform to support the needed network activities, and to secure analysis products from the combined data set. There is at present no agreed solution to that challenge. The final combined 2016 Baltic data set will be collected in 2018. Estimations of total numbers, densities and distributions can thereafter be produced.

The aspects of such coordinated survey efforts are nevertheless promising. The intention is therefore to plan regular updates of coordinated surveys for the Baltic Sea with the next one in 2020, and even to extend the coordination into the North Sea and the western European coast.

Mid-winter offshore surveys are scheduled in monitoring programs in some countries, not in others. In discussions between relevant institutes/persons in Baltic and east European countries, it has become clear that a coordinated survey could be scheduled for 2020. Future coordinating activities will intensify information exchange within the network of partners and focus on compiling details on the number of participating countries and planned survey coverage for the individual countries, as well as on discussion of methodological and logistical issues.

Table 4.1 shows the countries that have expressed interest in participation in the survey, and have secured funding for the task.

Table 4.1. Overview of potential participating countries in the planned 2020 coordinated survey

COUNTRY	INTEREST?	FUNDING?
Germany	Yes	Yes
Denmark	Yes	Yes
Sweden	Yes	Yes
The Netherlands	Yes	Yes
Belgium	Yes	Applied
Poland	Yes	Yes
Finland	Yes	Applied
Estonia	Yes	Applied
Latvia	Yes	Yes
Lithuania	Yes	Applied
France	Yes	Applied?
Spain	Yes	Applied?
Norway	Yes	Applied?
United Kingdom	Yes	No
Faroe Islands	Yes	No
Iceland	Yes	No
Portugal	Yes	Applied?

4.1 References

ICES. 2016. Report of the OSPAR/HELCOM/ICES Working Group on Marine Birds (JWGBIRD), 10–14 October 2016, Thetford, UK. ICES CM 2016/ACOM:29. 124 pp.

Skov H, Heinänen S, Zydelis R, Bellebaum J, Bzoma S, Dagys M, Durinck J, Garthe S, Grishanov G, Hario M, Kieckbusch JJ, Kube J, Kuresoo A, Larsson K, Luigujoe L, Meissner W, Hehls NW, Nilsson L, Petersen IK, Roos MM, Pihl S, Sonntag N, Stock A, Stipniece A, Wahl J. 2011. Waterbird populations and pressures in the Baltic Sea. Nordic Council of Ministers, Copenhagen, Denmark.

5 Integration rules for multiple criteria of within- and across-species assessment of GES for birds

5.1 Introduction

JWGBIRD has reviewed the advice from ICES (2018c), which tested various methods for integrating within species, assessments of multiple criteria (as per revised MSFD Commission Decision 2017). The revised MSFD Commission Decision (EC 2017/848) requires species-specific assessments to be carried out based on each criterion of Good Environmental Status (GES). Methods for integrating the results of each criterion for each species need to be developed. This is not straightforward, because not all species are assessed using the same criteria. Integration will be possible but careful consideration needs to be given to the methods used in order to avoid any bias in species status assessments. These methods will enable species-specific assessments to be made using OSPAR Common Indicators and HELCOM Core Indicators respectively.

In May and June 2018, ICES held workshops on MSFD biodiversity of species D1 aggregation (WKDIVAGG; ICES, 2018a) and on extinction risk of MSFD biodiversity approach (WKDIVExtinct; ICES 2018b). The workshops investigated ways of integrating assessments within species of marine birds, mammals, reptiles and fish and also between species to assess the achievement of GES in functional species groups. JWGBIRD 2018 considered the outputs from both workshops and the subsequent ICES Advice to DG Env of the European Commission (ICES 2018c) in proposing integration methods for use in future OSPAR and HELCOM assessments.

5.2 Integration structure

Figure 5.1 outlines the integration structure required in order to assess the achievement of GES for a species group (e.g. surface-feeding birds) and for an ecosystem component (e.g. marine birds) under Descriptor 1, following the approach in the 2017 Commission Decision.

The ICES advice (ICES 2018) concentrated on the following integration levels (see Figure 5.1):

a) for criteria to species, (i.e. within species)

b) for species to species groups (i.e. across species), and

c) species groups to ecosystem component (i.e. across species groups).

It should be noted that the Commission Decision 2017 specifies that GES is assessed per species group and not necessarily for the entire ecosystem component, but the EC did request advice from ICES on how to present the extent to which GES has been achieved for each ecosystem component. Integration on the level of ecosystem component may be useful when presenting assessment results to policy makers and the public.

Below, we consider for each of these integration levels, the integration methods/rules advised by ICES and assess whether these should be applied to future assessments of bird species using HELCOM and OSPAR indicators. We have proposed changes to the ICES advice where we think appropriate.

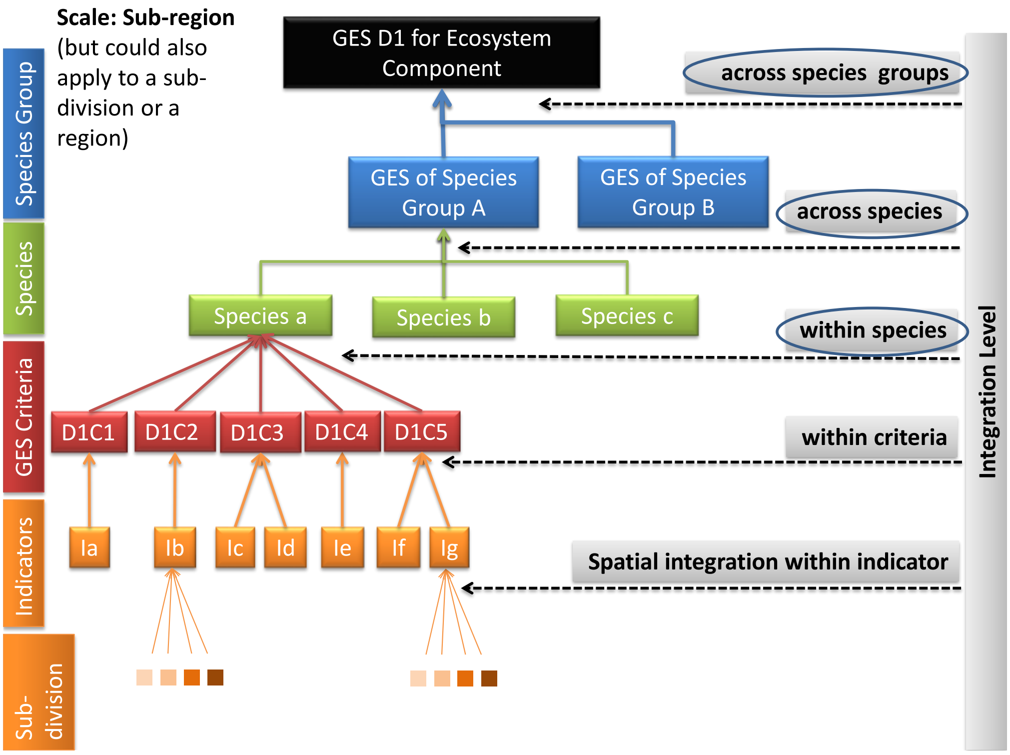


Figure 5.1 – Integration structure for assessing the achievement of GES under Descriptor 1, following the approach of the 2017 MSFD Commission Decision. The top three Integration levels are considered in this paper.

5.3 Integration of criteria to species

The revised MSFD Commission Decision 2017 states that "The status of each species shall be assessed individually, on the basis of the criteria selected for use". Table 5.1 lists the core/common and candidate indicators for birds in both OSPAR and HELCOM. Almost all species assessed in the OSPAR IA2017 and all species in the HELCOM HOLAS II were included in the indicators of abundance (breeding, non-breeding or both) and could therefore be assessed under the primary criterion D1C2. Assessments of marine bird bycatch under the other primary criterion D1C1 - incidental bycatch rates, are currently not possible in the OSPAR Area or in the Baltic. While bird bycatch indicators have been proposed under OSPAR and developed under HELCOM, none are operational because there is no systematic monitoring of seabird bycatch on a regional scale.

Of the secondary criteria, assessments of D1C3 - population demographics are currently possible in the OSPAR Area only, using the OSPAR common indicator B3 - marine bird breeding success/failure.

Table 5.1: GES Criteria in the Commission Decision 2017 (2017/848) and the corresponding OSPAR and HELCOM indicators

Revised Criteria - 2017	Corresponding OSPAR indicators	Corresponding HELCOM indicators
*D1C1 Incidental by-catch rates (Primary)	B5 – Marine bird bycatch (candidate)	Number of drowned mammals and birds in fishing gears (Core)
*D1C2 Population abundance (Primary)	B1 – Marine bird abundance (common indicator)	Abundance of waterbirds in the breeding season (Core) Abundance of waterbirds in the non-breeding season (Core)
D1C3 Population demographics (secondary)	B3 – Breeding success status of marine birds (common indicator) B2 Breeding success of kittiwake (candidate)	
D1C4 Species distributional range and pattern (secondary)	B6 – Marine bird distribution (candidate)	Distribution of wintering seabirds (candidate)
D1C5 Habitat for the species (secondary)	B4 – Non-native/invasive mammal presence on island seabird colonies (candidate)	

When assessing the ICES (2018c) advice we assumed that:

a) Most, but not all species would be assessed using D1C2 – abundance (using currently operational indicators)

b) Bycatch indicators (D1C1 primary) would be operational for some species in the future

c) D1C3 (secondary) would be assessed in populations of some species (using currently operational indicators of breeding success/failure or in the future, possibly indicators of other demographic parameters)

d) D1C4 and/or D1C5 may be assessed in some species in the future, depending on indicator development and appropriateness to the species.

JWGBIRD agrees with the ICES (2018c) advice that breeding and non-breeding populations of the same species should be assessed separately. This is because non-breeding populations (i.e. present in an area during migration or over-winter) may be made up of individuals originating from different sub-populations to those breeding in the same area. Breeding and non-breeding populations may use different habitats at different times of year and therefore may be affected by different activities and pressures. It is therefore useful for the interpretation of assessment results and would help management advice, if a distinction is made between the two populations. This approach would also be consistent with how breeding and non-breeding populations of the same species are reported separately under the Birds Directive. For the sake of easy reading, the following integration rules are discussed for species, but actually apply to the breeding or non-breeding population respectively of a given species.

It is clear, for birds, that the number of criteria assessed will differ between species, even when all indicator development is completed. This is because a) data on some criteria may not be available for some species, chiefly because they are difficult or unfeasible to collect; and/or because b) certain criteria are not appropriate for the assessment of some species because they do not reflect factors affecting the status of the species. As pointed out in ICES (2017, 2018b), this presents a problem when assessing the status of each species, particularly if a simple conditional rule is applied within a species. For instance, if a 'one out-all out' rule was applied across all criteria, the species is considered to be in poor status if one or more indicators has not achieved the required thresholds. The laws of probability entail that the likelihood of one indicator failing and therefore, a species not achieving good status, will increase as more indicators are assessed, if the one out all out rule is applied. Hence, well-studied species are more likely to be assessed as in poor status than species assessed by a single indicator, all else being equal. It is therefore imperative that appropriate integration methods are applied within species, otherwise bias will be introduced into the assessments.

JWGBIRD agrees with ICES (2018c) that conditional rules should be used to integrate assessments of criteria to assess the state of a species. We also agree with ICES (2018c) that these rules should reflect the difference in importance between primary criteria (D1C1 and D1C2) and secondary criteria (D1C3, D1C4 and D1C5) (listed in Table 5.1 for reference). However, JWGBIRD disagrees with the assumption that a secondary criterion status cannot overrule a primary criterion status. For instance, the OSPAR indicator of breeding success/failure proved to be an important component in assessing the status of breeding populations of some species and can provide an indicator of impacts from changes in food availability, predation and other key factors affecting the growth of marine populations (OSPAR 2017a, ICES 2017). JWGBIRD are developing the OSPAR breeding success indicator that could make it more sensitive to such impacts.

ICES (2018c) proposed a series of species status outcomes that are dependent on the assessments of each primary and secondary criterion (Table 5.2). Where secondary criteria are assessed quantitatively, they should be integrated by averaging the normalised1 values of each criteria (ICES, 2018c).

ICES (2018c) advised that in cases where one or more of the secondary indicators are categorical, they should be integrated by the following rules (see Table 5.2):

a) All criteria are at GES: combined criterion C3–C5 is at GES

b) Two criteria are at GES, one criterion not at GES, missing or not applicable: combined criterion C3–C5 is at GES

c) One criterion is at GES, two criteria are missing or NA: combined criterion C3–C5 is at GES

d) All other combinations: combined criterion C3–C5 is not at GES

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1 Normalisation is carried out to adjust values of different criteria that are measured on different scales to a notionally common scale. This is necessary before the average value of different criteria is calculated. A criterion value is normalised by dividing it by the threshold and the standard deviation of the criterion.

Table 5.2 – Conditional rules for assessing the status of a species based on the outcomes of assessments of each criterion (from ICES 2018c), showing changes proposed by JWGBIRD in BOLD. See JWGBIRD amendments below.

	Assessment Scenario											
Criteria	1	2	3	4	5	6	7	8	9	10	11	12
C1 BYCATCH	Y	Y	Y	N	N	N	NA	NA	O	O	Y	N
C2 ABUNDANCE	Y	N	N	N	Y	Y	Y	N	Y	N	O	O
C3 – C5	Y, N, O or NA	Y	Y, N, O or NA	Y, N, O or NA	Y	Y, N, O or NA	Y, N, O or NA	Y, N, O or NA	Y, N, O or NA	Y, N, O or NA	Y, N, O or NA	Y, N, O or NA
SPECIES STATUS	Good	~~Good~~ Poor	Poor	Poor	~~Good~~ Poor	Poor	Good	Poor	Good	Poor	Good	Poor

5.3.1 JWGBIRD amendments

Scenario 2: ICES (2018c) proposed this outcome for recovering populations where management measures or natural influences on populations are likely to result in recovery to good status within the assessment cycle, and instances where population abundance is low for natural reasons (e.g. disease) and there is evidence from other secondary criteria (e.g. demographic characteristics) that suggest no management action is required. But for birds, it is unlikely that such a tight relationship between management and status of D1C2 would exist. Therefore, we would suggest a precautionary approach and assess the species as poor if D1C2 was below target, even if it was recovering.

Scenario 5: ICES (2018c) suggested a likely contradictory outcome, where evidence from secondary criterion on demographics is required to be in good status and to explain the outcome. ICES (2018c) assumed this scenario would lead to the reassessment of bycatch thresholds. However, JWGBIRD could foresee a scenario where bycatch mortality is impacting on a population, but has not yet affected abundance trends (D1C2) and breeding success (D1C3). The precautionary principal would conclude poor status in this scenario.

Scenarios 11 & 12: these were added by JWGBIRD because we did not assume all species would be assessed using D1C2- abundance (see above). We could envisage scenarios where bycatch mortality could be assessed despite there being no abundance trend data available to assess D1C2.

5.3.2 JWGBIRD alternative approach

An alternative and simpler approach to integrating criteria to assess a species of marine birds is proposed by JWGBIRD in Figure 5.2. This uses most of the principles proposed by ICES (2018c) and outlined above in Table 5.2, but applies them to the most likely scenarios to be encountered in assessments of marine birds. The approach includes the following rules:

a) If an assessment of D1C1 – bycatch or of D1C2 – abundance is below the threshold, then the status of the species is 'poor', regardless of assessment outcomes for secondary criteria C3-C5.

b) If both D1C1 – bycatch and D1C2 – abundance are above the threshold, status will be dependent on the weighted average of the normalised criteria D1C2-C5; where D1C2 is double the combined weight of D1C3-C5:

Weighted average D1C2-C5 = ((2*D1C2)+(average D1C3-C5))/3

This weighting approach enables secondary criteria to overrule primary criteria only in that case abundance is just above threshold, but e.g. breeding success (D1C3) is far below threshold.

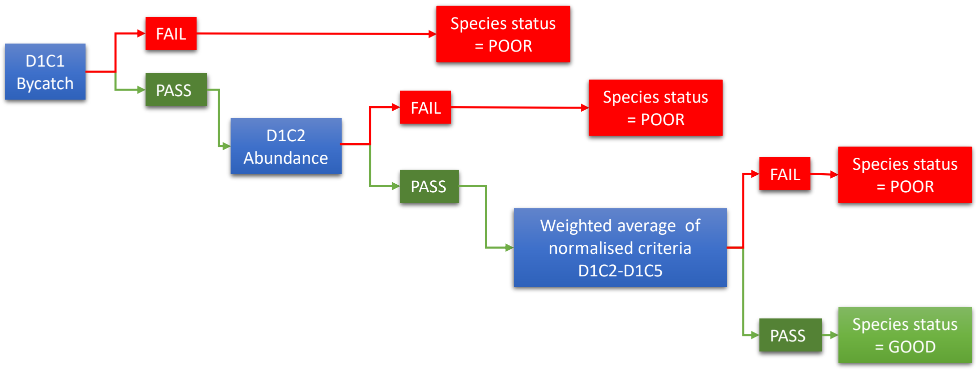

Figure 5.2: JWGBIRD proposed rules for integrating criteria to assess the status of a marine bird species.

5.4 Integration of species to species groups

JWGBIRD agrees with ICES (2018c) that a proportional rule is appropriate for integrating species assessment outcomes in order to assess the achievement of GES for a species group. A threshold of 75% of species was used in the assessment of marine bird abundance in the OSPAR IA2017 (OSPAR 2017) and was originally proposed by ICES (2008) for the OSPAR EcoQO on seabird population trends. This is consistent with the ICES (2018c) advice to use "regionally established thresholds of fixed proportions of species in the order of 60–80% (to be decided by managers/decision makers)".

ICES (2018b) pointed out that binomial probability theory means it is highly unlikely that a small group of five or less species can be considered to be in GES if one or more species is in poor status. JWGBIRD agrees with ICES (2018c) that a one-out-all-out rule be applied to groups containing five or less species or populations2. Groups of five or less species/populations currently exist only in OSPAR Arctic Waters (see Figure 5.3). Furthermore, GES in groups of 6–10 species or populations would probably not be achieved if more than one species was in poor status (see ICES 2018b). Groups of 6–10 species/populations currently exist in all OSPAR Regions and in the Baltic (see Figure 5.3).

5.5 Integration of species groups to ecosystem component

JWGBIRD agrees with ICES (2018c) that in principle, a proportional rule is appropriate when integrating the outcomes for each species group when assessing the extent to which GES has been achieved for the entire ecosystem component. There are, however, only five species groups of marine birds, so if one group is not at GES, binomial probability theory dictates that marine birds will not have achieved GES (ICES, 2018b). This also makes ecological sense: a functional group of species in poor condition cannot be balanced by another functional group of species that is in good condition (i.e. the pelagic fish-feeding species such as guillemots would not start feeding on benthos if benthic feeders disappeared).

However, this one-out-all-out approach to integration across species groups assumes that the sample of species in each group is equally representative in each functional group, in terms of species composition and data quality. The number of bird species within each group is highly variable across the different regions (see Figure 5.3). There is also likely to be variation in the level of confidence in the species assessments within each group, so that confidence in GES assessments for each group will vary.

In such cases, to avoid giving equal weighting to poorly-represented groups, a pragmatic option discussed at the JWGBIRD meeting could be integrating the assessments of all marine bird species using a proportional approach, as proposed by ICES (2018c). Therefore, GES for marine birds would be achieved when 75% or more of species are in good status. However, as mentioned above, this does not necessarily make ecological sense as poor conditions of individual functional groups cannot be balanced by a good status of another group. Additionally it should be noted that an assessment of GES in marine birds is not required by the MSFD Commission Decision 2017.

[2] Breeding populations and non-breeding populations of a species will be assessed separately.

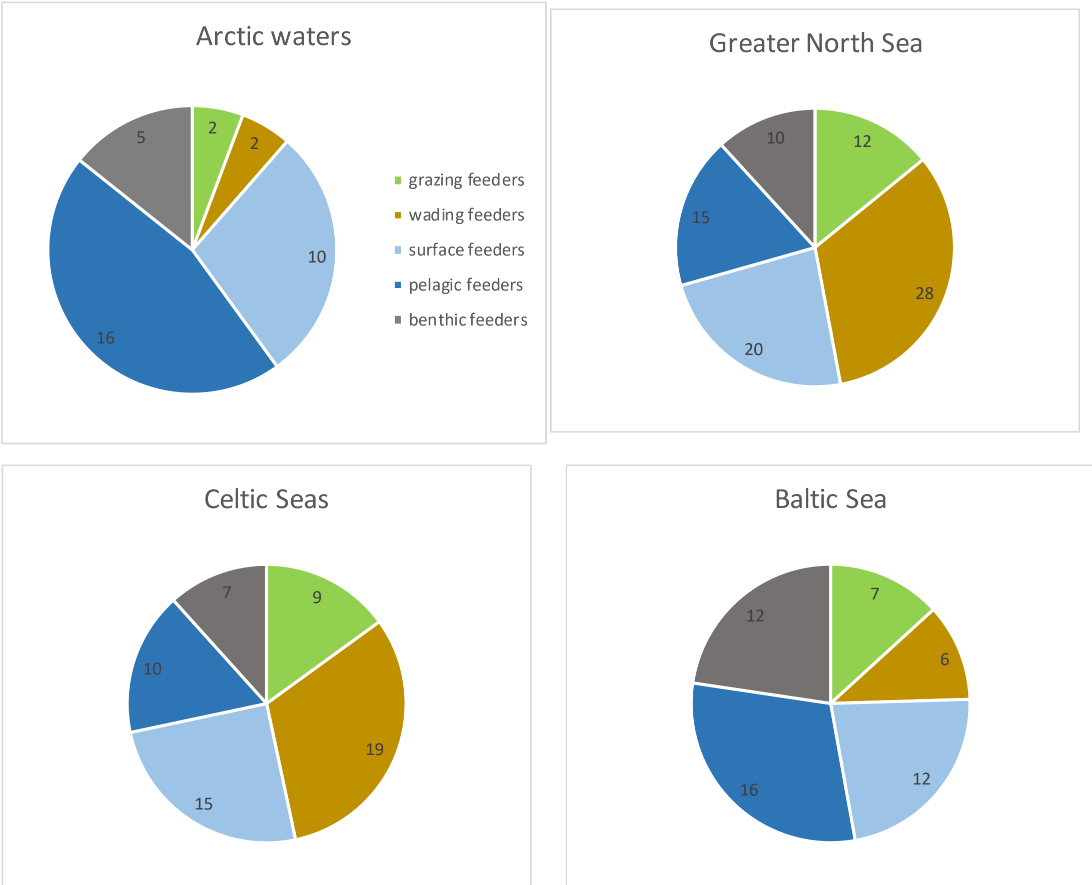

Figure 5.3: Number of marine bird species assessed during the OSPAR IA2017 and HELCOM HOLAS II assessments. Non-breeding populations and breeding populations of the same species are counted separately.

5.6 Accounting for risk of extinction in MSFD

ICES (2018b) suggest that the presence of taxa (including birds) listed as threatened by IUCN could either create an alert or be used to create a separate threatened species indicator. JWGBIRD has so far not addressed this issue, but a number of threatened species are already included in the recent assessments of the Northeast Atlantic and the Baltic Sea (OSPAR 2017a, 2017b, HELCOM 2018).

5.7 Summary

JWGBIRD agrees mostly with the advice on integration from ICES (2018c), but have proposed a slightly different conditional rule for integrating criteria to assess the status of each species. Breeding and non-breeding populations of the same species should be assessed separately in order to aid interpretation and management advice. The proposed integration framework is shown in Figure 5.4 and contains the following rules:

1) Species status is assessed as follows (see Figure 5.4):

   a) If an assessment of D1C1 bycatch or of D1C2 – abundance is below the threshold, then the status of the species is 'poor', regardless of assessment outcomes for secondary criteria C3-C5.

b) If both D1C1 bycatch and D1C2 – abundance is above the threshold, status will be dependent on the weighted average of the normalised criteria D1C2-C5; where D1C2 is double the combined weight of D1C3-C5.

2) A group of bird species will achieve GES if 75% or more species or populations are in 'good' status (or all species in groups of five or less).

3) Marine birds will have achieved GES if all five bird species groups have achieved GES (assuming that each group is well represented in terms of species composition and assessment quality).

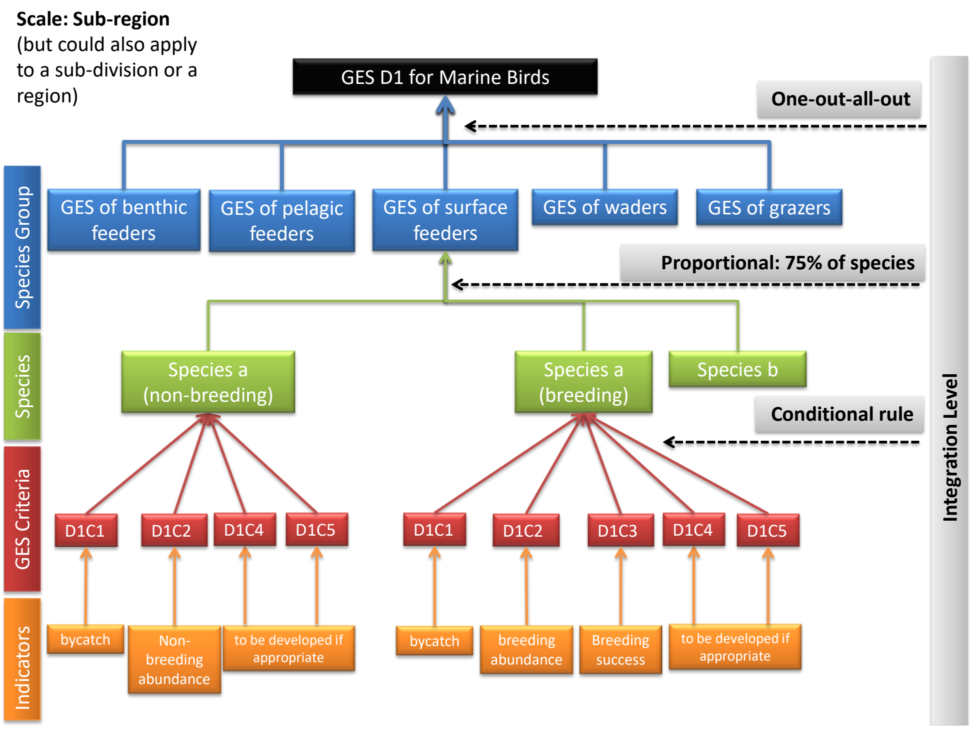

Figure 5.4: JWGBIRD proposed integration framework for assessing GES in marine birds.

5.8 References

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6 Review of national MSFD assessments relating to OSPAR candidate indicators and recommendation of future action on seabird indicators

Progress on this task is limited in 2018, because UK assessments of OSPAR candidate indicators on distribution, kittiwake breeding success and invasive predatory mammals will not be available for review until 2019. However, the meeting used the opportunity to discuss the future of indicators in the light of needs for reporting according to Article 8 and assessing Good Environmental Status according to Article 9 of the Marine Strategy Framework Direction (MSFD, Directive 2008/56/EC). While some EU member states may have reported also for other MSFD criteria, regional indicators of OSPAR and HELCOM were available only for the criteria "population abundance" (D1C2) and "population demographic characteristics" (D1C3), the latter only in the OSPAR region (Table 6.1). The new approach of seabird assessments in MSFD with first integrating criteria within species and then integrating species to species groups (EU COM Dec 2017/848) requires including the primary criterion "mortality rate from bycatch" (D1C1) for those species affected by drowning in fishing gear, but also points to assessments for the criteria "distributional range and pattern" (D1C4) and "habitat for the species" (D1C5) – see also this meeting's session about integration rules (chapter 5).

Table 6.1: Coverage of MSFD criteria by regional indicators in current MSFD assessments for the reporting period 2011-2016 (x: indicator available, - no indicator available).

MSFD criteria	NE Atlantic (OSPAR)	Baltic Sea (HELCOM)
D1C1: mortality rate from bycatch	-	(x)[1]
D1C2: population abundance	x	x
D1C3: population demographic characteristics	x	-
D1C4: distributional range and pattern	-	-
D1C5: habitat for the species	-	-

[1] Assessment impossible due to lack of data.

In order to adequately report the status of seabirds in the next cycle of MSFD (2017-2022), regional indicators for the primary criterion D1C1 and for the secondary criteria D1C3 to D1C5 have to be developed (D1C3 in HELCOM only). Preparations for an OSPAR bycatch indicator and problems with implementing the HELCOM core indicator on bycatch are dealt with in chapter 8.

While the criterion D1C2 (population abundance) is covered and only needs the inclusion of offshore data, the criterion D1C3 (population demographic characteristics) is only partly addressed by the OSPAR indicator B3 "Breeding success/failure of marine birds", which is currently under further development by JWGBIRD (see chapter 2). Although assessments have been made for parts of the OSPAR region in the Intermediate Assessment 2017 (OSPAR 2017), such an indicator is still lacking in the HELCOM region. As there are very few monitoring schemes running in the Baltic Sea, the assessment of breeding success appears to face problems not solvable in the near future (ICES 2016). A promising approach could be the use of breeding success data from the large auk colonies near Gotland, but the existing data belong to scientific projects and it remains unclear whether they can be used for HELCOM indicator assessments.

In addition to breeding success, two other approaches were discussed with regard to the demography criterion (D1C3). Almost all seabirds are long-lived, slowly reproducing species, meaning that the survival of adult individuals is a crucial demographic parameter for the long-term development of seabird population trends. Adult survival can be calculated from bird ringing data and can help to explain trends in the abundance of seabirds and is a necessary tool for interpretation of the breeding success indicator according to the further developed concept (see chapter 2). However, at this stage JWGBIRD is of the opinion that creating an indicator assessing adult survival under MSFD is not straightforward, for instance because analytic work would be extensive and monitoring is not available in most countries of the OSPAR and HELCOM regions. Adult survival of several seabird species is monitored on a broad scale only in Norway (Anker-Nilssen *et al*. 2018), whereas long-term data from case studies are available from other countries (e.g., Stubbings *et al.* 2017).

Another proposal with respect to criterion D1C3 referred to the population structure of seabirds, e.g. the sex ratio and the proportion of juveniles or other subadult age classes in the population. This approach could be useful to explain changes in population size especially in indicators dealing with wintering seabirds. Proportions of age classes (and sexes) could help to assess the status of a given seabird population. Examples of earlier applications are the proportion of juveniles among Long-tailed Ducks passing Finland during migration (Hario 2009) or the Danish Wing Survey (based on ducks shot by hunters, e.g. Fox *et al.* 2016). Data required for an indicator assessing population structure could easily be collected in the frame of those monitoring programmes dedicated to measure population sizes. However, to quite a large extent population structure may reflect conditions in the breeding areas (often outside the assessment area) rather than pressures in the assessment areas. On the other hand, 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). JWGBIRD will follow up on these ideas and further explore the possibility of creating an indicator suitable to assess the status of seabirds in OSPAR and HELCOM regions.

The distribution criterion (D1C4) is currently not covered by regional core indicators, although an OSPAR candidate indicator was explored in U.K. (Humphreys *et al*. 2012) and a concept was developed by HELCOM (2012). The OSPAR approach was mainly based on breeding and wintering bird survey counts aggregated in tetrads of different size, looking at changes in distributional range and pattern. This approach is applicable to coastal counts of breeding and wintering birds, for example by using atlas data as presented during the meeting using real data from German breeding bird atlas projects. The HELCOM concept is applicable to seabirds in offshore areas and compares the main distribution area (expressed, for example, as the 75 percentile of density measures) with baseline distribution (earlier data or modelled distribution). JWGBIRD fears that it is difficult to get clear messages from changes in distribution with respect to the status of seabird species and feels that development of regional distribution indicators is of minor importance. However, as distribution has to be reported under the Birds Directive and required data stem from the same sources as for population abundance, national approaches to assess distribution may be used in MSFD reporting.

Among the MSFD criteria, D1C5 (habitat for the species) has gained least attention during the past years. At the meeting, two possible approaches were presented, which are pressure-related and may indicate problems seabird species are currently facing. It was argued that predation, often by non-indigenous, invasive mammals, may cause severe damage in seabird breeding colonies, but also affect non-colonial seabirds.

OSPAR's candidate indicator B4 "Non-native/invasive mammal presence on island seabird colonies" addresses this and focusses on seabird islands in UK. JWGBIRD has explored more general approaches for this indicator earlier (ICES 2015), but failed to recommend a scheme applicable over the total spectrum of seabird breeding sites found in the OSPAR and HELCOM regions. While it may be straightforward to monitor presence and absence of predators in many breeding colonies, this appears to be difficult or even impossible at other breeding sites, especially in archipelagos. Therefore, for assessing habitat quality in terms of presence or absence of predators, JWGBIRD recommends national approaches rather than developing region-wide applicable indicators.

Many human activities disturb seabirds in their marine habitats resulting in habitat loss. This impact can be long-lasting, e.g. when benthic habitats are disturbed by bottom-trawling fisheries or aggregate extraction (Dayton *et al.* 1995, Cook & Burton 2010), or when seabirds avoid offshore wind farms (Dierschke *et al.* 2016, Mendel *et al*. 2019). It can also be temporary in the case of ship traffic, with birds returning to disturbed locations after minutes or hours (Schwemmer *et al*. 2011). JWGBIRD recommends to develop an indicator for MSFD criterion D1C5, which relates the amount of habitat of a given species disturbed by human activities to the amount of habitat available for that species naturally, i.e. by calculating the proportion of habitat lost / not usable in the assessment period. The baseline extent of a species' habitat could either refer to a known "pristine" distribution pattern (i.e. the occurrence before disturbing activities started), but could also be attained from modelling (based on known habitat preferences). Such an indicator would be strongly pressure-related, could even address the cumulative impact of various activities and appears to suit MSFD requirements well, because it allows derivation of management measures precisely related to kind and location of activities having impact on seabirds. Therefore, JWGBIRD is going to develop an indicator concept suiting criterion D1C5 (see task list 2019).

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7 Trial assessment of the black-legged kittiwake in the OSPAR Maritime Area

This task was added to the meeting as part of intersessional task a – to respond to requests from OSPAR's ICG-POSH (Protected Habitats and Species). ICG-POSH is in the process of developing guidelines for the periodic status assessment of OSPAR threatened and/or declining species and habitats. Test assessments are being completed during 2018 to gather more information on the resources required to complete an assessment, as well as experiences in using the draft guidelines. The UK, with support from Norway, volunteered to carry out a test assessment of black-legged kittiwake (*Rissa tridactyla*), led by Ian Mitchell. An initial draft of the assessment was discussed and worked on by JWGBIRD during the 2018 meeting. The trial assessment was submitted to ICG-POSH's meeting in Paris on 9–11 October 2018 as paper ICG-POSH 18/3/3 (available at https://www.ospar.org/meetings/archive/intersessional-correspondence-group-on-the-implementation-follow-up-of-measures-for-the-protection-and-conservation-of-species-2).

8 Progress on assessing bycatch mortality of marine birds in the NE Atlantic and Baltic

8.1 Introduction

Bycatch - here defined as the direct mortality resulting from interactions between seabirds and fishing gears - is widely considered one of the major threats for seabird populations (Northridge *et al*. 2017; Žydelis *et al*. 2009, 2013; Croxall *et al.* 2012; Reeves *et al.* 2013).

JWGBIRD was requested by OSPAR's ICG-COBAM and by HELCOM to provide an update of the level of evidence currently available to enable future assessments of seabird bycatch. This request is part of the preparation for a joint OSPAR-HELCOM workshop to examine possibilities for developing indicators for incidental bycatch of birds, seals, cetaceans, turtles and non-commercial fish. Seabird bycatch is currently a candidate indicator under OSPAR and a core indicator under HELCOM, but these indicators are not yet operational, largely due to lack of comprehensive data on seabird bycatch in both the NE Atlantic and Baltic Sea. The absence of an operational seabird bycatch indicator was considered to be a gap by OSPAR's Biodiversity Committee (BDC) in 2018, not least because of needs arising from the revision of the European Commission Decision on assessing Good Environmental Status (GES) under the Marine Strategy Framework Directive (EC 2017). The revised EU Commission Decision includes the incidental bycatch of birds, seals, cetaceans, turtles and non-commercial fish as a primary criterion for assessing GES.

JWGBIRD was requested to provide the following:

- collate possible risks for species groups associated with specific gears,
- collate any existing national or regional proposals for high risk areas based on species occurrence/density and occurrence/effort of gears associated with risk, including the methods used to identify the areas,
- collate and list information on already existing data sources related to by-catch numbers and fishing effort,
- collate any existing national or regional indicator assessment methods of threshold setting for the species group, such as Catch Limit Algorithm advice by ICES for marine mammals.

8.2 Collate possible risks for species groups associated with specific gears

Pott and Wiedenfeld (2017) reviewed the global literature for seabird-fisheries interactions during 1974–2015. They found that 228 species of seabird and other marine bird have been recorded caught by fisheries, worldwide. The most susceptible families are Gaviidae (divers/loons), Podicipedidae (grebes), Diomedeidae (albatrosses) and Sulidae (gannets and boobies). Pott and Wiedenfeld (2017) also found that set and drift gillnets had the greatest number of documented cases of marine bird bycatch, with set and drifting longlines and handlines a close second.

Table 8.1 lists the families found in the North Atlantic, for which Pott and Wiedenfeld (2017) found references to bycatch globally.

Very limited monitoring of marine bird bycatch has been done in European waters. ICES (2013) reviewed the documented risks of seabird bycatch to identify monitoring priorities (see Table 8.1), while Žydelis *et al*. (2009) focused on gillnet fisheries and highlighted that Anatidae (ducks) and Alcidae (auks–e.g. common guillemot, razorbill) were of most concern in northern Europe. Overall, the risk of being taken as bycatch for different groups of seabirds depends on both the presence and the behaviour of the birds. For instance, surface-feeding seabirds such as gulls, gannets, shearwaters and fulmars are more susceptible to bycatch in longline fisheries, whereas diving species are mostly affected by gillnets and pots/traps (see Table 8.1). However, Bradbury *et al*. (2017) pointed out that surface-feeding seabirds are susceptible to being caught in any type of gears during the deployment phase. Recent research has shown that fulmars, for example, are caught in high numbers in Norwegian gillnet fisheries (Bærum *et al*. 2018). Given the limited evidence of bycatch in UK and European waters, Bradbury *et al.* (2017) used the behaviour traits of each bird species to predict where in the water column the risk of encountering fishing gears is the highest. From this, they inferred the entrapment risk for each species in each gear type (see Table 8.1).

Bærum *et al.* (2018) showed that coastal fisheries might represent a more general threat to a wider range of seabird species, as opposed to longline fisheries (e.g. Fangel *et al.* 2017). Gillnets and/or hook gears (hand- and longlines) are reported to be the deadliest fishing gears for seabirds. Nevertheless, the authors emphasize that important gaps remain in the understanding of seabird bycatch, and that some fisheries, such as industrially deployed seines or artisanal fisheries, and some geographical areas, such as Arctic waters and the Canary Current, in the NE Atlantic remain poorly studied.

8.2.1 Summary

Table 8.1 summarises the most recent reviews of marine bird bycatch – globally (Pott and Wiedenfeld 2017) and in European waters (Bradbury *et al*. 2017; ICES 2013). There have only been few programmes dedicated to the monitoring of seabird bycatch in European waters. Surface, midwater or benthic entrapment risks are directly linked to specific seabird behavioural traits. For instance, surface-feeding seabirds are more inclined to bycatch in longline fisheries or when fishing gears are being deployed, while diving species are more at risk with bottom-set gears, such as nets and traps.

Table 8.1: Summary of evidence of the sensitivity/vulnerability of marine bird species and families to bycatch.

Gear type		Section of water-column where gear is most likely to catch seabirds (Bradbury *et al.* 2017)			Species/families known to be bycaught in NE Atlantic European waters (ICES 2013)	Species groups globally reported as bycatch in the respective gear type (number of publications in parentheses) (Pott and Wiedenfeld 2017)
Metier Level 2/3	Metier level 3	Surface	Pelagic	Benthic		
Seines/surrounding nets	Purse Seine (PS)	X	X		Balearic shearwater, Cory's shearwater, northern gannet, gulls, auks	Shearwaters (5) Sulids (4) Cormorants (5) Gulls (3) Ducks (1) Auks (4)
Trawls/Pelagic Trawl	Midwater otter trawl (OTM) Midwater pair trawl (PTM)	X	X		OTM – northern gannet	OTM: Petrels (8) Shearwaters (4) Storm petrels (3) Sulids (1) Auks (1) PTM: Sulids (1)
Trawls/Bottom trawls	Beam trawl (TBB) Bottom otter trawl (OTB) Multi-rig otter trawl (OTT) Bottom pair trawl (PTB)	X		X	OTB: northern gannet, shearwaters, great cormorant, European shag, gulls, guillemots,	OTB & TBB: Petrels and fulmars (7) Shearwaters (6) Storm petrels (2) Sulids (2) Cormorants (4) Gulls (4) Auks (1) PTB: Storm petrels (1)
Dredges	Bottom Dredge (DRB)				None	Divers (1) Shearwaters (1) Gulls (2)
Nets	Trammel net (GTR) Set gillnet (GNS) Driftnet (GND)	X	X	X	GTR, GNS - shearwaters, northern gannet, great cormorant, European shag, common scoter and other diving ducks, divers, grebes, auks	GNS: Ducks (16) Divers (5) Petrels and fulmars (6) Shearwaters (10) Storm petrels (2) Grebes (4) Sulids (2) Cormorants (14) Gulls (5) Auks (15) GND: Ducks (9) Divers (4) Petrels and fulmars (7) Shearwaters (11) Storm petrels (3) Grebes (3) Sulids (3) Cormorants (4) Phalaropes (1) Terns (1) Gulls (7) Skuas (3) Auks (21)
Hooks and Lines/Longlines	Set longlines (LLS) Drifting longlines (LLD)	X	X	X	LLD, LLS: Northern fulmar, Balearic shearwater, Cory's shearwater, northern gannet, great cormorant, European shag, great skua, gulls, terns, auks	Longlines set on or near the seafloor: Petrels and fulmars (11) Shearwaters (10) Storm petrels (2) Sulids (4) Cormorants (3) Gulls (17) Skuas (2) Auks (2) Longlines set near surface: petrels & fulmars (13) Shearwaters (11) Storm

Gear type		Section of water-column where gear is most likely to catch seabirds (Bradbury *et al.* 2017)			Species/families known to be bycaught in NE Atlantic European waters (ICES 2013)	Species groups globally reported as bycatch in the respective gear type (number of publications in parentheses) (Pott and Wiedenfeld 2017)
Metier Level 2/3	Metier level 3	Surface	Pelagic	Benthic		
						petrels (1) Sulids (7) Cormorants (1) Gulls (7) Skuas (5) Auks(2)
Traps	Pots and Traps (FPO)	X	X	X	European shag	Petrels and fulmars (1) Shearwaters (2) Cormorants (10) Auks (1)
Most sensitive species to bycatch in UK waters (Bradbury *et al*. 2017)		Northern gannet Northern fulmar Common guillemot Razorbill Black guillemot Atlantic puffin	Northern gannet Common guillemot Razorbill Black guillemot Atlantic puffin European shag Great northern diver	Common guillemot European shag Great northern diver Greater scaup Common eider Common scoter Great cormorant		

8.3 Collate any existing national or regional proposals for high risk areas based on species occurrence/density and occurrence/effort of gears associated with risk including the methods used to identify the areas

Interactions between seabirds and fisheries are complex and understanding them is a pre-requisite for advancing conservation strategies, and enhancing and easing discussion between stakeholders (Le Bot *et al.* 2018). Toward that end, collecting data on both the distribution of seabirds at sea and on fishing effort is essential. At-sea surveys of seabird densities from boats and aircraft, and more recently tracking studies, combined with fisheries effort data, allow the identification of high-risk areas of bycatch, i.e. areas where interactions between seabirds and fisheries are potentially the highest. High-resolution fishing effort data can be derived from different sources collected and stored by different Regional Fisheries Management, such as VMS (Vessel Monitoring System) and AIS (Automatic Information System). Small vessels are however not required to use VMS or AIS. This data gap impairs risk assessments for gillnet fisheries which pose the highest bycatch risk for seabirds since gillnets are mostly deployed from small vessels. For these vessels, logbooks can also provide information. However, in this case, fishing effort may be difficult to calculate because the spatial resolution of logbook information (if available at all) is often too coarse (e.g., at ICES rectangles of 30 x 30 nm). Additionally, the use of electronic monitoring (EM) associated with CCTV has proven an efficient or cost-effective way of collecting data on fishing (Bartholomew *et al*. 2018) as well as bycatch data (Kindt-Larsen *et al*. 2012, 2016).

Here, we summarise recent spatial assessments performed in Northern Europe, in the Baltic Sea (Sonntag *et al*. 2012) and in UK waters (Bradbury *et al.* 2017). Both studies employed similar mapping approaches that assessed the vulnerability of seabirds to bycatch. They firstly developed a sensitivity index for each species. Areas of vulnerability were then identified by incorporating the species-specific sensitivity indices into maps of seabird density (i.e. numbers of each species per unit area):

Vulnerability to bycatch = Sensitivity x Seabird Density

Both studies then combined the vulnerability mapping with maps of the exposure to fisheries that are likely to cause bycatch, in order to identify those areas where seabirds are at the greatest risk from bycatch:

Bycatch Risk = Vulnerability to bycatch x Fishing effort

Each study calculated bycatch risk slightly differently – see below.

8.3.1 Baltic Sea

Sonntag *et al.* (2012) addressed diving bird bycatch in set-nets in the Baltic Sea. They looked at seasonal overlap between set-net fishing activities (based on VMS and ship-based counts of set-net flags) and vulnerability of seabirds for the 2000-2008 period, taking into account species-specific sensitivity to bycatch in set-nets. The vulnerability index was based on weighted bird abundance derived from ship-based and aerial surveys. The sensitivity to bycatch of each species i was estimated by qualitatively ranking biological traits related to life history (adult survival rate, c; biogeographic population size, d), behaviour (diving behaviour, a; aggregation behaviour, b) and European conservation status (Species of European Conservation Concern, SPEC, e). Based on literature review or expert judgment, each trait was given a score reflecting its importance with regards to bycatch. The scores of all traits were then combined to a weighting factor WFi, giving the overall sensitivity as:

$$WF_i = \frac{a_i+b_i}{2} * \frac{c_i+d_i+e_i}{3}$$

For each species, the vulnerability was obtained by multiplying its abundance (per 2x3 km grid cell) by the weighting factor, and for each grid cell, the total vulnerability was expressed as the sum of vulnerabilities of all diving species (Figure 8.1).

Finally, the bycatch risk in each grid cell was expressed in terms of "potential for conflict" (PC) as the product of total vulnerability and fishing effort and classified into five discrete categories (Figure 8.2).

This study highlighted that the spatial and temporal distribution patterns of birds and fisheries were overlapping. The potential conflict was higher during specific seasons (winter and spring) in coastal waters and around shallow offshore grounds. The vulnerability index identified important areas and seasons based on bird abundance, independent of the fishing effort that could be the target of appropriate conservation and management actions. Sonntag *et al.* (2012) emphasise the relevance of this approach in identifying the potential impact of seabird bycatch in fisheries that are difficult to monitor.

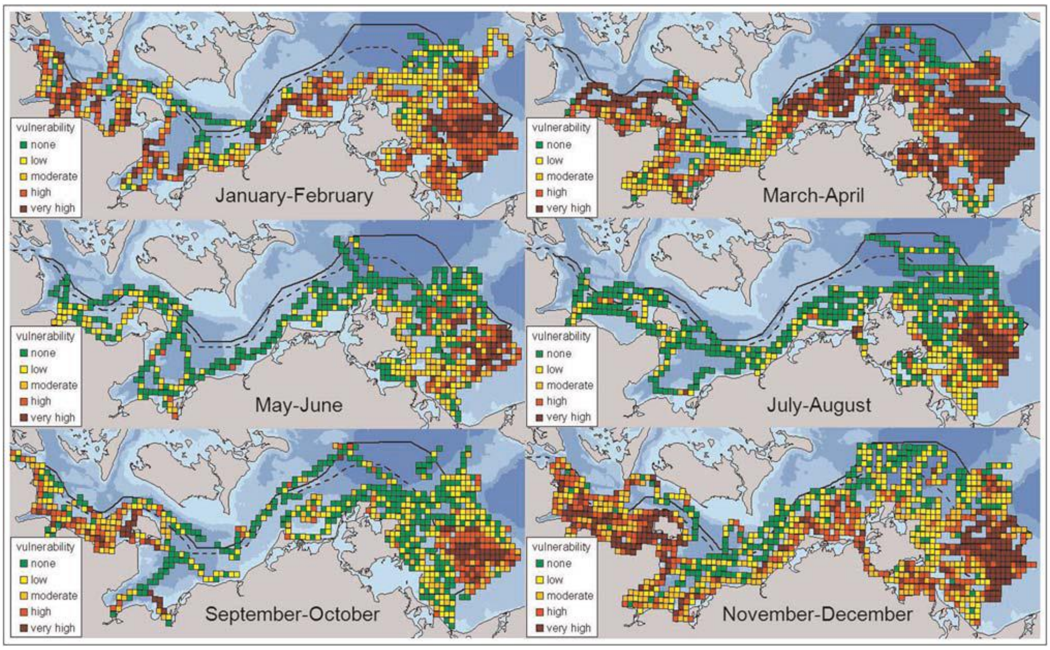

Figure 8.1. Vulnerability of birds to bycatch mortality in set-net fisheries in the German sector of the Baltic Sea (data from 2000–2008). A 5-point scale vulnerability index was calculated based on the weighted abundance of 17 species of diving birds: none (green), 0; low (yellow), 0–14.81; moderate (orange), 14.81–65.19; high (red), 65.19–274.95; very high (dark red), >274.95. Source: Sonntag *et al.* 2012.

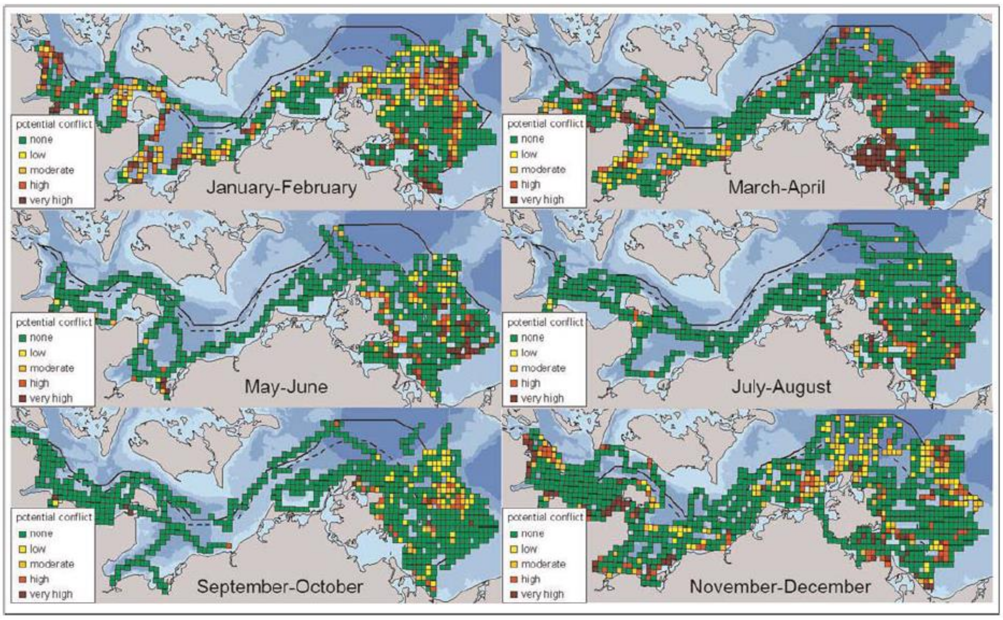

Figure 8.2 Potential for conflict (data from 2000–2008), showing the seasonal overlap of set-net fisheries and of diving seabirds in the Southern Baltic Sea area. A 5-point scale of potential conflict for 2000–2008 was calculated for each quartile: none (green), 0; low (yellow), .0–1.41; moderate (orange), .1.41–7.69; high (red), .7.69–38.64; very high (dark red), .38.64. NB: very shallow waters have not been surveyed by ship. Source: Sonntag *et al*. 2012.

8.3.2 UK waters

The objective of the study by Bradbury *et al.* (2017) was to estimate the relative risk of UK seabird species to bycatch from fisheries operating in UK waters (within the UK Exclusive Economic Zone, but extended to the boundary of the Continental Shelf).

Seabird density was mapped by modelling two main datasets: the European Seabirds at Sea (ESAS) database (1979–2011) and WWT Consulting's visual aerial survey database (2001–2011). Additional datasets were included to increase the sampling coverage.

The sensitivity of each species was estimated by scoring known traits of conservation status, demography/ecology and behaviour (see Table 8.2, and compare to the similar approach of Sonntag et al. (2012) described above). The traits were selected from a review of previous studies that measured sensitivity of seabirds to bycatch in the southern hemisphere (Small *et al.* 2013; Tuck *et al*. 2011; Waugh *et al*. 2012), and other impacts in European waters, such as from oil and gas (e.g. Tasker *et al*. 1990) and impacts from marine renewable developments (e.g. Garthe and Hüppop 2004; Furness *et al.* 2012).

Table 8.2. Attributes used by Bradbury *et al.* (2017) to score the sensitivity to fisheries bycatch in UK EEZ for each seabird species in the study. The Seabird Sensitivity Index SSI was calculated as SSI = (a + b + c + d) * (e * f).

Conservation status	Demographic/ecological factors	Behaviour factors
a) % of biogeographic population in the UK	c) Adult survival rate	e) Entrapment risk
b) UK threat status	d) Habitat specialisation	f) Response to fishing activity

Each trait was scored and weighted, depending on the trait importance related to by-catch. A panel of nine experts scored each species against each attribute. The 'triangular fuzzy numbers' approach of McBride *et al*. (2012) was used to obtain a median score across experts and to record the variation in expert opinion and thereby quantify the confidence in the scores.

A Seabird Sensitivity Index (SSI) was calculated for each species by first summing the median scores for conservation status and demography/ecology and multiplying them by the scores for behaviour (see Table 8.2). The behavioural scores (i.e. entrapment risk and response to fishing activity) describe the likelihood of a species being caught if it is in the vicinity of fishing vessels. Species that actively pursue fishing vessels in search of food (e.g. Northern fulmar) are more likely to be caught than species that fly away from vessels (e.g. red-throated diver) during active fishing (not applicable to static gears). The entrapment risk scoring described how likely the species would be caught based on its foraging behaviour around a fishing vessel. Bradbury *et al.* (2017) felt there was too little evidence of bycatch in UK or European waters to be able to score entrapment risk for each species in each gear type. Thus, they used the behaviour of each species to predict where in the water column they were most likely to encounter fishing gear. From this, they inferred which gears are most likely to catch seabirds. All gears were likely to catch some species at the surface when they are being deployed. Of the species with the highest SSI, most were sensitive to being caught in more than one section of the water column and by more than one gear type.

Vulnerability to bycatch for each species was mapped by combining the species' SSI with maps of their density distribution at sea during summer (April to September) and winter (October to March), using the equation:

$$Bycatch\ vulnerability = \sum \left(\ln(\text{density}_{species} + 1) * SSI_{species} \right)$$

The seasonal seabird density predictions, and the associated Coefficients of Variations (CVs), were mapped on a 3km x 3km grid covering UK territorial waters. For each grid cell, the resulting vulnerability scores were summed across species. This resulted in total seabird vulnerability maps for each season and gear category. Figure 8.3 and Figure 8.4 show respectively the relative vulnerability of seabird populations to bycatch in surface gears and in pelagic gears.

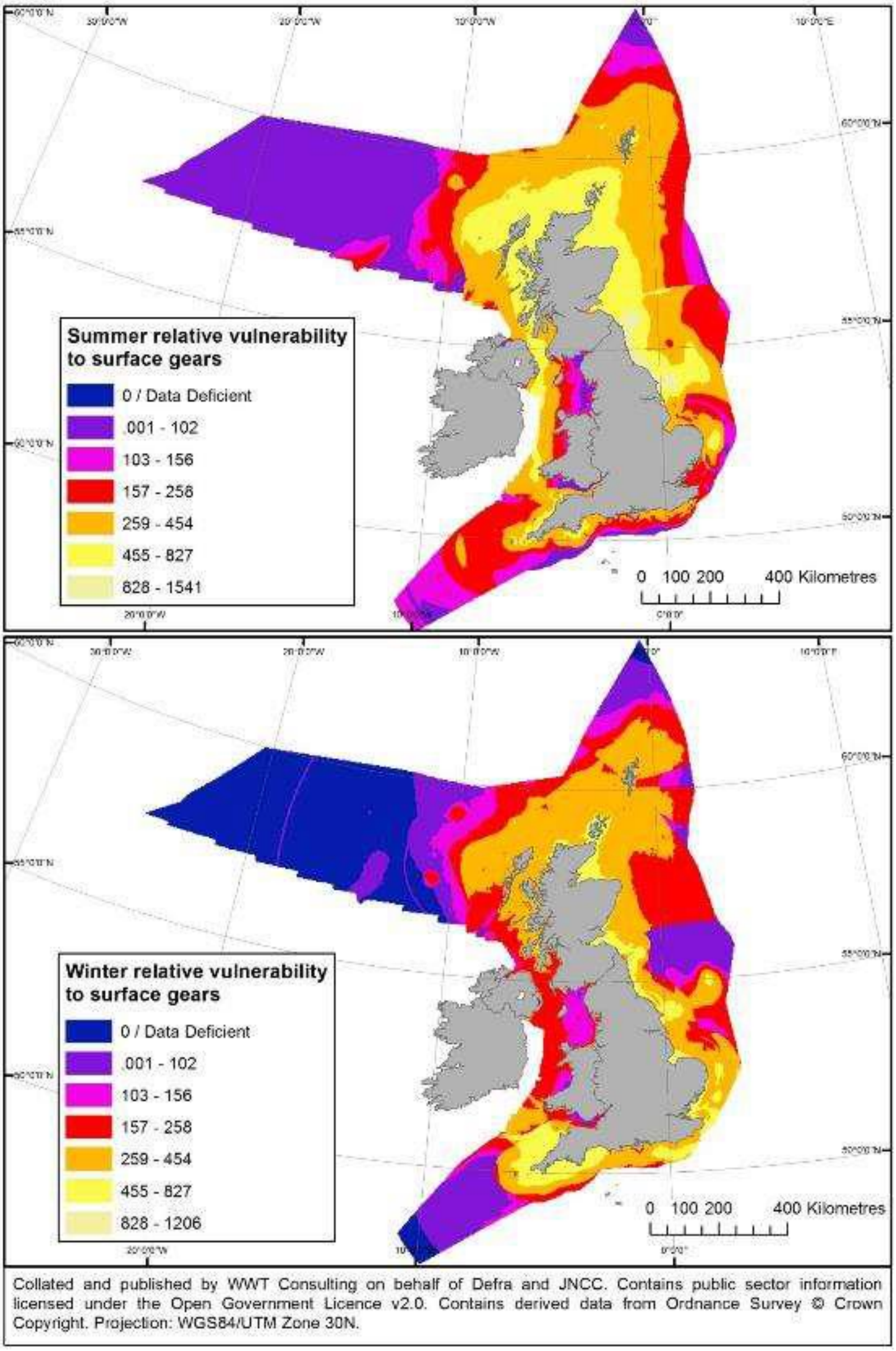

Figure 8.3 Relative vulnerability of seabird populations to bycatch in fishing gears at the sea surface in summer and winter. Values are the sums of the products of seabird species densities and their SSIs. The '0 / Data Deficient' category denotes grid cells which have no positive value, but a mix of scores for individual species of zero and more than zero but with low confidence in the density data (CVs >0.5). Source: Bradbury *et al.* (2017).

Seabird bycatch risk was then mapped by overlaying these vulnerability maps with fishing effort (exposure):

$$Bycatch\ risk = Fishing\ effort * Bycatch\ vulnerability$$

Fishing effort (in hours) was derived from Vessel Monitoring System (VMS) data from the UK fishing fleet between 2009 and 2013 for different gear classes (Figures 8.3 and 8.4). However, it is worth noting that VMS data from non-UK-registered vessels were omitted despite being available. This is because the UK had limited access to daily logbooks from foreign vessels, so that it was not possible to identify, with any degree of certainty, which gear type was being used at a particular time. Still, effort from non-UK-registered vessels was significant: non-UK-registered EU fishing boats landed on average 58% of the total catch by weight and 61% of pelagic fish by weight in the UK Exclusive Economic Zone during the period 2012-2014 (Napier, 2016). Additionally, Bradbury *et al*. (2017) noted that the distribution of non-UK vessels might potentially differ from that of UK vessels. There may thus be significant additional risk (i.e. risk not incorporated into the assessment of Bradbury *et al*. (2017)), e.g. from demersal longline and deep-water gillnets from non-UK-registered vessels in the area west of Scotland (Dan Edwards, pers. comm.). Moreover, the information on effort from smaller inshore vessels was either inconsistent or incomplete spatially and temporally. The relative VMS coverage represented only a small fraction of the gillnet effort (40% of the landings by weight) and of the trap fisheries (23% of the landings by weight). Estimating the fishing effort as the vessels' time presence is probably adequate for active mobile gears, but it is not so for passive non-mobile gears such as static nets, pots and traps. For these fisheries, VMS data is not able to give a reliable estimate of the effort, but instead provides an insight of the areas where these gears are employed. Yet, the vulnerability maps show that coastal areas are potentially highly impacted by fishing activities.

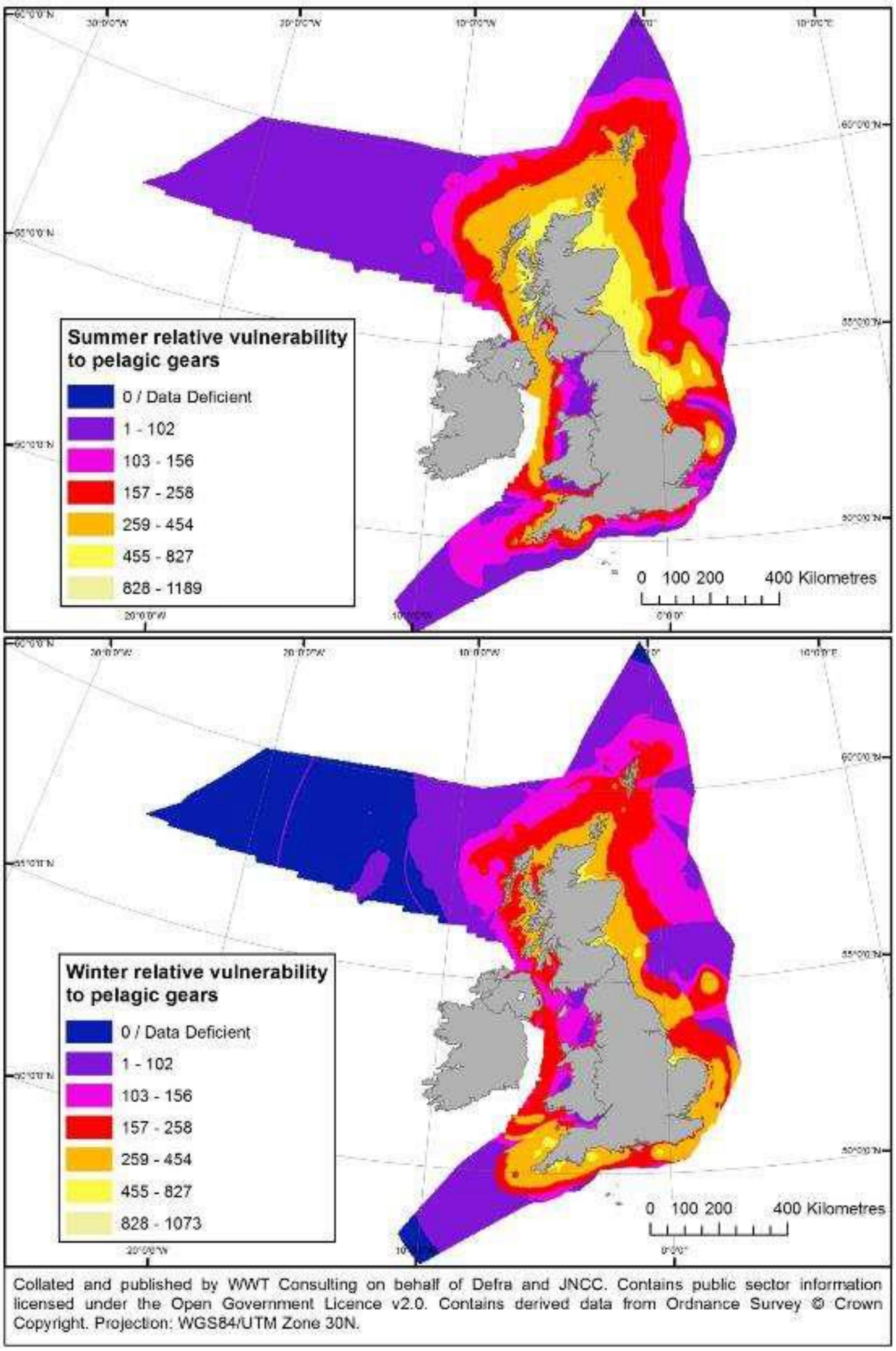

Figure 8.4 Relative vulnerability of seabird populations to bycatch in fishing gears in the pelagic zone in summer and winter. Values are the sums of the products of seabird species densities and their SSIs. The '0 / Data Deficient' category denotes grid cells which have no positive value, but a mix of scores for individual species of zero and more than zero but with low confidence in the density data (CVs >0.5). Source: Bradbury *et al.* (2017).

The workflow of the approach used by Bradbury *et al*. (2017) is illustrated in Figure 8.5.

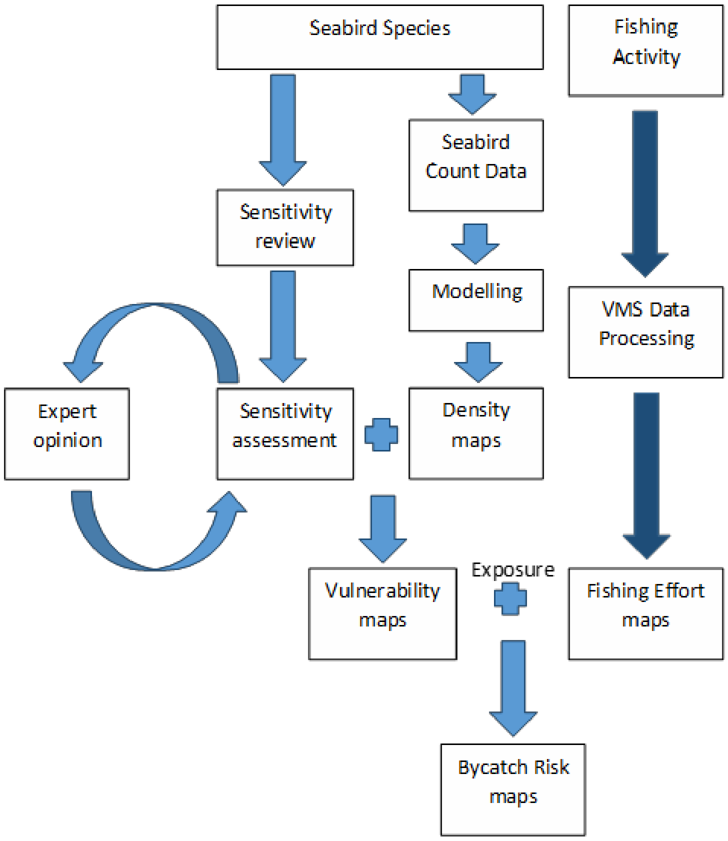

Figure 8.5 Methodological approach used by Bradbury *et al.* (2017) to obtain seabird bycatch risk maps in UK waters. Figure from *Bradbury et al.* (2017).

8.3.3 Conclusions

- Two studies have assessed the vulnerability of seabirds to bycatch in parts of the NE Atlantic based on species occurrence/density: Bradbury *et al*. (2017) for UK waters, and Sonntag *et al.* (2012) for the German section of the Baltic Sea. Both used available data on fishing effort to estimate and map the risk to seabirds from bycatch.
- Assessments of seabird bycatch vulnerability or risk require spatial and temporal data on a) at-sea abundance and distribution of seabirds (from boat-based and aerial surveys) and b) fishing effort (from VMS/AIS on large vessels and logbooks from small vessels). The availability of these data will limit the ability to carry out bycatch assessments throughout the NE Atlantic and Baltic.
- Bradbury *et al*. (2017) present a method for estimating the sensitivity of seabird species to bycatch, which does not need detailed information on actual bycatch in different gear types. Bradbury *et al*.'s (2017) methods were developed for UK waters, but could easily be adapted for use elsewhere.
- For further assessments of seabird bycatch vulnerability or risk there is a need for more information on the entrapment risk of different seabird species groups to different gear types and fisheries. This information will enable a more nuanced analysis of in which areas and seasons seabirds are most vulnerable.

8.4 Collate and list information on already existing data sources related to bycatch numbers and fishing effort

There are currently important gaps in the understanding of seabird bycatch in European waters because of a relative scarcity of reliable data on scale, spatial distribution and importance of incidental catch in EU fisheries (Pott and Wiedenfeld 2017; James 2016). Although the EU Data Collection Framework Regulation 2017/1004 (DCF) establishes the need to assess the impact of Union fisheries on protected, endangered and threatened species (PETS), and the Commission implementing decision 2016/1251 (DC-MAP: Data Collection Multiannual Plan) even obliges to collect bycatch data of such species from a table of species to be monitored under protection programmes in the Union or under international obligations, the extent of seabird bycatch in particular remains essentially unknown.

Historically, bycatch data collection has largely focused on cetaceans, notably to comply with the obligation to report to the European Commission following the Regulation 812/2004 (EC 2004). In recent years, to comply with the Common Fisheries Policy (EC 2009) and the revised Commission Decision on the Marine Strategy Framework Directive (EU 2017), according to which the assessment of the primary criterion D1C1 ("mortality rate from bycatch") is mandatory, an emphasis was also put on collecting data on bycatch of other protected species, including seabirds (EC 2008a). The ICES Working Group on Bycatch of Protected Species (WGBYC) identified a number of data sources related to bycatch numbers and fishing effort (Table 8.3), but these are often incomplete with regards to seabird bycatch. Bycatch data are only valuable if they contain information about observer effort that can be attributed to fishing effort. Apart from the UK, no member state has yet implemented a dedicated PETS observer programme. This is raising concerns about the under-reporting of seabird bycatch in countries where non-dedicated observers are collecting bycatch data (ICES 2015). Besides, fisheries effort is usually reported as days-at-sea, whereas in order to assess the scale and magnitude of seabird bycatch, more robust metrics would be more appropriate (e.g. for gillnet fishing: length x soak time; for longlines: length of longlines (in km) and number of hooks per km).

In Norway, the Norwegian Reference Fleet (NRF), a group of Norwegian fishing vessels contracted by the Institute of Marine Research (IMR), provides detailed information on their fishing activity, to improve stock assessments and fisheries management (www.imr.no/temasider/referanseflaten/en). The self-reported data collected by the NRF include bycatch of marine mammals and seabirds. This has resulted in a 10-year long time series of seabird bycatch data related to the fishery data from a large fleet of small-scale vessels fishing with gillnets along the Norwegian coast, and enabled estimation of the total bycatch of seabirds in the Norwegian small-vessel gillnet fishery (Bærum *et al*. 2018). The NRF has proven an effective way of collecting seabird bycatch data, yet caution is required when interpreting self-reported fisheries information.

Furthermore, the coverage of small-scale fisheries (SSF), which represent 83% of the European fleet, is very limited (Natale *et al.* 2015). Under the Common Fisheries Policy, only fishing vessels above 12 meters are required to use an electronic logbook; vessels above 10 meters length overall have to keep a logbook and need to submit landing and transhipment declarations (EC 2009). For vessels below 10 meters, no logbook is required, except for fisheries with a quota targeting Baltic Sea cod (EC 2016); below 8 meters, no logbook is required anymore, which is the case for many recreational and part-time fishing vessels. Many of these vessels use passive gears such as gillnets which are associated with high risks of bycatch for diving birds, including seaducks and divers. As a result, there is likely a significant under-estimation of the overall extent of bird bycatch in coastal and inshore waters, in particular in Northern Europe, where gillnet fishing is very common both for commercial and recreational fishermen (Žydelis *et al*. 2009). For instance, lumpsucker (*Cyclopterus lumpus*) is targeted mostly by North-Atlantic small-scale gillnetters. These vessels use bottom-set nets with large meshes (usually more than 200mm), which, associated with long soak times in relatively shallow waters, often result in very high number of seabird bycatch (Petersen 2002; Merkel 2011; Fangel *et al*. 2015).

Over the last decade, bycatch in gillnet fisheries has been identified as the principal source of seabird mortality in European waters (Bradbury *et al*. 2017; Žydelis *et al.* 2009). However, gillnetters remain mostly under-monitored since fishermen are not required to report their catch of seabirds, and gillnet vessels are usually too small to accommodate an on-board observer in charge of data collection on fishing activities. Recently, the use of electronic monitoring (REM) and on-board CCTV cameras have allowed increasing the coverage of small-scale gillnet fisheries in some areas. REM systems improve both the quality and the quantity of the data collected in these metiers, and are a cost-effective solution to estimate fishing effort and bycatch of seabirds (among other PETS) in gillnet fisheries (Kindt-Larsen *et al.* 2012; Bartholomew *et al*. 2018).

In addition to direct at-sea observations, indirect observation methods can also give an overview of potential high-risk areas (e.g. using strandings, fishermen interviews). These methods are low-cost but usually only provide low-resolution and/or low-quality data (see e.g. Bellebaum *et al.* 2013).

8.4.1 Conclusions

The sum of information collected in European fisheries – through on-board observers, electronic monitoring (REM) or indirect observation methods – seems to be largely insufficient to obtain a reliable estimate of seabird bycatch. In particular, the under-monitoring of small-scale fishing vessels (the ones that contribute the most to seabird bycatch) explains this knowledge gap.

Better reporting of seabird bycatch is thus necessary. For commercial fishing vessels in particular, seabird bycatch data may be systematically collected as already required by Commission implementing decision 2016/1251, and long-time monitoring programmes implemented to evaluate trends, similarly to what already exists for commercial fish species. Since existing observer programmes are not able to ensure sufficient data collection on small-scale vessels, REM systems are an effective and cost-efficient way to boost data collection of fishing effort and bycatch.

In addition, mandatory reporting seabird bycatch in logbooks would help getting a better overview of the current situation. However, most often, no species information can be derived from these data. So far, logbook sheets do not contain a field for PETS bycatch. New technologies, e.g. mobile phone apps, could however easily be used and implemented to collect high-resolution data in currently under-monitored fisheries, including those where logbooks are not currently required. Nowadays, "electronic logbook" apps using GPS tracking already allow the extraction of effort data. In case a non-target species is caught, the mobile phone camera can be used to store a picture of the individual(s), and the resulting image(s) of the bycatch can be linked to the fishing activity. Later on, experts with access to the (anonymised) data can then identify the species. In the near future, the development of artificial intelligence software may even automate the whole process.

Table 8.3 Inventory of current monitoring programmes in the ICES/OSPAR region in which seabird bycatch data can be collected (Source: ICES 2018)

Country	Year the survey started	Type of monitoring	Main objective of monitoring scheme	Target population	Sampling frame	Sampling selection methods	Number of trips sampled in 2017	Proportion of trips covered by sampling in 2017	Temporal stratification	Species / groups of species identified
Germany	1980	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	OTB targeting Greenland halibut In XII, XIV, Va	List of vessels	opportunistic randomised	2	12.50%	seasonal fishery	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Germany	1995	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	Trawlers targeting mackerel, herring in IV, VIId	List of vessels	opportunistic randomised	5	12.00%	quarter	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Germany	1995	DCF- sea sampling (observer) programme	catch composition fish/crustacean species, bycatch of birds and mammals	Trawlers targeting gadoids in IV, IIIa	List of vessels	opportunistic randomised	5	1.90%	quarter	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Germany	1995	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	OTM targeting small pelagic species in VI, VIIbcjk, VIIe, VIIfgh, VIII, V-XIV, (IVa)	List of vessels	opportunistic randomised	4	17.40%	seasonal fishery	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Germany	1995	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	OTM targeting redfish in XII, XIV, Va	List of vessels	opportunistic randomised	0 from 4 trips all together in this	0.00%	seasonal fishery	All fish species, all commercial crustacean, since ca 2014 all birds and mammals

Country	Year the survey started	Type of monitoring	Main objective of monitoring scheme	Target population	Sampling frame	Sampling selection methods	Number of trips sampled in 2017	Proportion of trips covered by sampling in 2017	Temporal stratification	Species / groups of species identified
							metier in 2016			
UK	1996	Habitats directive - on-board observer programme	Protected species bycatch	Gillnetters >12m	>12m gillnetters	Random/ad-hoc	166	0.58%	annual	all, protected species numbers, commercial/non-commercial species catch weight estimate
Germany	1998	DCF- sea sampling (observer) programme	catch composition fish/crustacean species, bycatch of birds and mammals	Beam trawl targeting flat fish in IV	List of vessels	opportunistic randomised	4	1.00%	quarter	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Germany	1998	DCF- sea sampling (observer) programme	catch composition fish/crustacean species, bycatch of birds and mammals	OTB targeting plaice in IV	List of vessels	opportunistic randomised	1	3.40%	quarter	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Germany	1998	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	Trawlers targeting cod, saithe in I, II	List of vessels	opportunistic randomised	1	33.00%	seasonal fishery	All fish species, all commercial crustacean, since ca 2014 all birds and mammals

Country	Year the survey started	Type of monitoring	Main objective of monitoring scheme	Target population	Sampling frame	Sampling selection methods	Number of trips sampled in 2017	Proportion of trips covered by sampling in 2017	Temporal stratification	Species / groups of species identified
Germany	1998	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	Trawlers targeting herring in II (ASH)	List of vessels	opportunistic randomised	1	33.00%	seasonal fishery	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Netherlands	2004	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Pelagic Trawlers	Vessel list of trawlers	Random/ad-hoc	12	10.00%	year	All fish species, all birds, mammals and turtles
Germany	2009	DCF- sea sampling (observer) programme	catch composition fish/crustacea species, bycatch of birds and mammals	Beam trawl targeting brown shrimp in the German coastal area	List of vessels	opportunistic randomised	7	0.10%	seasonal fishery	All fish species, all commercial crustacean, since ca 2014 all birds and mammals
Germany	2009	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	Demersal trawlers	List of vessels	random draw from randomised list	4	<1%	year-round	All fish, birds and mammal species
Germany	2009	DCF- sea sampling (observer) programme	catch composition fish species, bycatch of birds and mammals	Demersal gillnetters and longliners	List of vessels	random draw from randomised list	16	<1%	year-round	All fish, birds and mammal species
Denmark	2010	Directed study by Electronic Monitoring	Bycatch of birds and mammals	Gillnetters	Vessel list of gillnetters	Fishermen from different ports along the coast	3829	<1%	year-round	all birds and marine mammals

Country	Year the survey started	Type of monitoring	Main objective of monitoring scheme	Target population	Sampling frame	Sampling selection methods	Number of trips sampled in 2017	Proportion of trips covered by sampling in 2017	Temporal stratification	Species / groups of species identified
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Demersal/nephrops trawlers	All vessels with landings in this area	vessel list/ad-hoc	264	0.02%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Demersal/nephrops trawlers	All vessels with landings in this area	vessel list/ad-hoc	1306	0.00%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Trips carried out by demersal/nephrops trawlers	All vessels with landings in this area	vessel list/ad-hoc	3454	0.01%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Static gears, gillnets/trammel	All vessels with landings in this area	vessel list/ad-hoc	716	0.00%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Demersal trawlers	All vessels with landings in this area	vessel list/ad-hoc	2804	0.00%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Static gears, gillnets/trammel	All vessels with landings in this area	vessel list/ad-hoc	388	0.01%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals

Country	Year the survey started	Type of monitoring	Main objective of monitoring scheme	Target population	Sampling frame	Sampling selection methods	Number of trips sampled in 2017	Proportion of trips covered by sampling in 2017	Temporal stratification	Species / groups of species identified
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Pelagic trawlers	All vessels with landings in this area	vessel list/ad-hoc	188	0.01%	Annual	All fish species, all birds, mammals and reptiles
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Pelagic trawlers	All vessels with landings in this area	vessel list/ad-hoc	165	0.04%	Annual	All fish species, all birds, mammals and reptiles
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Pelagic trawlers	All vessels with landings in this area	vessel list/ad-hoc	217	0.02%	Annual	All fish species, all birds, mammals and reptiles
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Pelagic trawlers	All vessels with landings in this area	vessel list/ad-hoc	429	0.01%	Annual	All fish species, all birds, mammals and reptiles
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Potters	All vessels with landings in this area	vessel list/ad-hoc	5217	0.00%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Potters	All vessels with landings in this area	vessel list/ad-hoc	480	0.01%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals

Country	Year the survey started	Type of monitoring	Main objective of monitoring scheme	Target population	Sampling frame	Sampling selection methods	Number of trips sampled in 2017	Proportion of trips covered by sampling in 2017	Temporal stratification	Species / groups of species identified
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Potters	All vessels with landings in this area	vessel list/ad-hoc	263	0.01%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Potters	All vessels with landings in this area	vessel list/ad-hoc	1987	0.01%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of fish species	Pelagic trawlers	All vessels with landings in this area	vessel list/ad-hoc	72	0.01%	Annual	All fish species, all birds, mammals and reptiles
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of Whelks	Potters targeting Molluscs	All vessels with landings in this area	vessel list/ad-hoc	2144	0.00%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals
Ireland	2013	DCF- sea sampling (observer) programme	Bycatch of birds and mammals, catches/discards of scallops, razors, cockles and fish species	Scallop dredgers	All vessels with landings in this area	vessel list/ad-hoc	2485	0.00%	Annual	All fish species, all commercial crustacean, all birds reptiles and mammals

8.5 Collate any existing national or regional indicator assessment methods of threshold setting for the species group, such as Catch Limit Algorithm advised by ICES for marine mammals.

Under the Marine Strategy Framework Directive, Good Environment Status (GES) Criterion D1C1 on incidental bycatch rates specifies that "the mortality rate per species from incidental by-catch is below levels which threaten the species, such that its long-term viability is ensured". This should be reported as "the mortality rate per species and whether this has achieved the threshold value set" (EC 2017).

Assessments of marine bird bycatch under D1C1 are currently not possible in the OSPAR area or in the Baltic Sea. While bird bycatch indicators have been proposed under OSPAR and developed under HELCOM, none are operational because, as mentioned above, there is no systematic monitoring of seabird bycatch on a regional scale.

Determining the threshold, above which bycatch mortality is threatening the long-term viability of a species, can potentially be done using a variety of statistical and population modelling methods. Potential Biological Removal (PBR) is a simple algorithm, first developed by Wade (1998) for use with marine mammal populations, that needs only information on adult survival, age at first breeding and population size to provide a value for a theoretically sustainable level of additional mortality. Therefore, it can be used when the availability of demographic information is minimal. PBR has been used in a number of instances in marine bird bycatch assessments to assess thresholds of additional annual mortality, which could be sustained by a population (Zador *et al.* 2008, Žydelis *et al.* 2009). Niel and Lebreton (2005) and Dillingham and Fletcher (2008) demonstrated its use to assess the significance of bycatch in longline fisheries on marine bird populations, by comparing mortality estimates to PBR levels (Žydelis *et al.* 2009). Additive mortality exceeding PBR could indicate potentially overexploited populations and the need for more detailed analysis (i.e. population modelling) or management action (i.e. mitigation measures) (Žydelis *et al*. 2009). However, by necessity, "additive mortality" would be additive mortality from any source (not just bycatch) as PBR was not designed to look at the population level effect of individual sources of mortality (e.g. that of bycatch alone). As it is very difficult to account for all sources of additive mortality (given existing data gaps) this must be recognised as a serious limitation of the method.

PBR also incorporates a recovery factor (f), which can be adjusted depending on the level of precaution deemed appropriate. Potential factors that might influence the use of more precautionary f values might be species conservation status, a declining population trend, uncertainty in parameter estimates, etc. Dillingham and Fletcher (2008) used an f = 0.5 for stable populations, f = 0.3 for declining populations, and f = 0.1 for rapidly declining populations. It should be noted that PBR is particularly sensitive to the f value selected, and therefore decisions regarding the recovery factor should be taken with care.

O'Brien *et al*. (2017) recently tested the use of PBR to examine the acceptability of potential impacts of offshore wind farms on marine bird populations. They used PBR to estimate the number of additional mortalities that a 'typical seabird population' could theoretically sustain. They found that in some cases the sustainable levels of mortality predicted by PBR in fact led to declines in the modelled population. O'Brien *et al*. (2017) concluded that unless the implicit assumptions underlying PBR are met, it is an inappropriate tool for assessing the impact of additional mortality on a population.

PBR should not be used as a threshold-setting tool, against which bycatch 'allowable take' may be set (O'Brien *et al* 2017). However, in some instances it is a useful tool for identifying those marine bird populations that may be impacted by bycatch, which have hitherto been overlooked, and for which possible mitigation should be considered.

Another modelling approach to assessing the impact of bycatch mortality on seabird populations is to use Population Viability Analysis (PVA), commonly implemented using Leslie matrix models (Caswell, 2001). For example, Genovart *et al*. (2017) used matrix models to assess population-level effects of bycatch in the Mediterranean Sea on three species of seabird. PVA is a quantitative risk-assessment approach that assesses the viability of a population, usually in terms of extinction risk dependent on different management scenarios (Akçakaya & Sjörgren-Gulve, 2000; Beissinger & McCullough, 2002). PVA offers a useful modelling framework for better understanding how a population is likely to respond to different management scenario, i.e. to assess relative changes in a population under two or more scenarios, rather than to make absolute predictions of future population size or growth rate. PVA does require more demographic information than PBR, e.g. annual survival rate of different age classes, productivity rate, age at first breeding and, in some models, information on how these rates change with population size (density-dependent regulation) (Genovart *et al*. 2016). However, where demographic parameters are unknown, users can make an explicit informed decision on what proxy value to select, rather than allowing a tool, such as PBR, to assign values according to implicit assumptions that may not be upheld. Consequently, PVA is generally recommended over PBR for investigating population response to anthropogenic mortality (O'Brien *et al*. 2017).

As with all other population models that incorporate a density dependent growth function, there is often insufficient information to determine the strength and form of density dependence for marine bird populations. For example, in a review of density dependence in seabirds, Horswill *et al*. (2017) found depensatory density dependence to be present in some tern and gull populations i.e. that as population size declined, so did population growth rate, unlike the more common compensatory density dependence where population growth rate generally increases at lower population sizes. Misspecifying the form of density dependence can lead to erroneous predictions about a population's response to anthropogenic mortality (O'Brien *et al*. 2017).

Other possible methods that have so far not been used to assess seabird bycatch mortality are Removal Limits Algorithm (RLA) and Integrated Population Models (IPM).

The Removals Limit Algorithm Approach (RLA; Hammond *et al*. 2018) is similar in concept to the Catch Limit Algorithm approach developed under the Revised Management Procedure of the International Whaling Commission to set limits to baleen whale catches (IWC, 2012). Hammond *et al*. (2018) build on previous work based on a CLA-type approach (Winship 2009) to determine limits of anthropogenic removal of small cetaceans. The RLA is a simple population model describing a population with density dependent growth and subject to anthropogenic removals. A population model is developed for simulation testing of the ability of the RLA to achieve pre-defined conservation/management objectives under a variety of removal and uncertainty scenarios. During simulations, the population model is used to generate survey estimates of population size, with a given level of uncertainty, that are used in the fitting of the RLA. The fitted RLA is then used to calculate the limit to the number of animals that could be removed as a result of human activities (from any source) in subsequent years, Estimates of the number of animals actually removed are subtracted from the population each year. Simulations are used to tune the parameters of the RLA until the conservation objectives are met, at which point the limit to removals can be determined. Such an approach has, to our knowledge, not been applied to marine bird populations.

Integrated Population Models (IPM) permit the estimation of abundance and demographic parameters simultaneously from a single model fitted to data from multiple sources, typically some or all of the following: annual counts (indices of abundance), mark-recapture data (from which mortality can be estimated) and counts of breeding success or numbers of fledged young.

Freeman *et al* (2014) used Integrated Population Models to assess the potential impacts of planned offshore wind developments in the Forth & Tay region of Scotland on four seabird species. Whilst this modelling approach was found to be extremely powerful at predicting population size a substantial amount of population-specific demographic and census/count data is required for this approach, and thus, IPMs would not be feasible for data-poor populations. They are also computationally intensive to run, and so may not always be practical to use.

8.5.1 Conclusions

- Seabird bycatch indicators have been proposed under OSPAR and developed under HELCOM, however none are currently operational because, as mentioned above, there is no systematic monitoring of seabird bycatch on a regional scale.
- Potential Biological Removal (PBR) has been used in a number of assessments of marine bird bycatch to assess thresholds of additional annual mortality, which could be sustained by a population. However, the underlying assumptions on density dependence and population trajectory have been found to potentially lead to significant overestimates of ‘allowable mortality’ and should not be used to set thresholds for seabird bycatch under D1C1. PBR is probably best used as an indicative guide to identify those marine bird populations that may be impacted by bycatch and for which possible mitigation should be considered.
- Other possible methods which could be used to assess bycatch mortality are Leslie Matrix Models in Population Viability Analysis (PVA), Removal Limits Algorithm (RLA) and Integrated Population Models (IPM).

8.6 Setting threshold values for bycatch under MSFD

The revised Commission Decision (EC 2017/878) on the Marine Strategy Framework Directive (MSFD) requires that species-specific threshold values are set at regional level for all descriptors and criteria, including D1C1 (incidental bycatch rates). Methods for setting these threshold values were discussed at a workshop convened by the Joint Research Centre in Varano Borghi, 16–17 January 2019. Six members of JWGBIRD attended the workshop and discussed thresholds for birds in a subgroup with four additional attendees. The subgroup felt that setting threshold values could be premature, given that no conservation objectives for bycatch had been agreed. If these conservation objectives required thresholds to be set, the most appropriate method would vary between groups of species depending on the availability of demographic data. Alternatively, the group agreed on the following suggested approach:

1) Set regionally agreed conservation objectives, based on existing agreements and legislation. Examples include:
   a) The EU Birds Directive, which states that it is illegal to kill wild birds except under a derogation.
   b) The EU Plan of Action on Seabird Bycatch, which aims to minimise or eliminate where possible seabird bycatch.
   c) The MSFD, which puts an obligation on the EU Member States to establish threshold values for mortality from incidental bycatch and apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status.
2) Monitor bycatch in fisheries to estimate levels of bycatch.
3) Use demographic modelling to report on the biological significance of the estimated levels of bycatch in relation to the conservation objectives and the populations of species affected - based on either existing data from bycatch monitoring or on hypothetical bycatch rates. Modelling could show how much population growth rate would be affected by estimated levels of bycatch mortality (e.g. using stochastic population models or Population Viability Analysis). If the objective of minimising or eliminating bycatch is adopted, a potential threshold value could be 1% of all mortality of the species, as an approximation of zero bycatch while assuming that some birds will still be caught, even with effective measures in place. This threshold is taken from the definition of 'small numbers' of birds that could be taken as part of derogations under the Birds Directive (EC 2008b). The mortality rate should relate to the population assessed, i.e. include hunting pressure etc. acting on that population
4) Use the predicted biological significance of bycatch mortality to advise on the level of mitigation measures required. This could incorporate the setting of 'triggers' and 'limits' (ASCOBANS 2015). 'Triggers' could sit below environmental limits and be used to signal the need for certain kinds of management action, such as:
   a) Low predicted impact – bycatch prevention measures (e.g. weighted lines, streamers).
   b) High predicted impact – fishery closure.

8.7 References

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9 Consider input and data provisioning for the HELCOM workshop on migratory waterbirds (MIGRATORY BIRD WS 1-2018)

In order to support its 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“, which is led by Sweden and co-led by Germany, HELCOM is preparing a workshop on bird migration in the Baltic Sea region. The workshop is scheduled for 20–22 November 2018 in Helsinki and aims to produce maps showing migration routes of waterbirds and seabirds (including waders). This shall be done by merging data and information from different methods of observing bird migration, including tracking of individuals (satellite telemetry, GPS data loggers, geolocators), radar tracks, observation of active migration at coastal sites and counting birds stopping over, staging or wintering.

10 Provide input to the HELCOM indicator review process

After finalizing the holistic assessment of the Baltic Sea (HOLAS2), HELCOM evaluates its indicators in order to improve future assessments. Questionnaires about indicator functionality and data solutions were filled in by Baltic Sea seabird experts during the JWGBIRD 2018 meeting and supplied to the HELCOM Secretariat. This input covers the indicators "Abundance of waterbirds in the breeding season", "Abundance of waterbirds in the wintering season" and "Number of drowned mammals and waterbirds in fishing gear".

Annex 1: List of participants

Name	Institute	Country (of institute)	Email
Ainars Aunins	Univeristy of Latvia	Latvia	ainars.aunins@lu.lv
Antti Lappalainen	Natural Resources Institute Finland	Finland	antti.lappalainen@luke.fi
David Michael Fleet	The Schleswig-Holstein Agency for Coastal Defence National Park and Marine Conservation	Germany	david.fleet@lkn.landsh.de
Eric Stienen	Instituut voor Natuur- en Bosonderzoek	Belgium	eric.stienen@inbo.be
Fredrik Haas	Lund University	Sweden	fredrik.haas@biol.lu.se
Gaëlle Simian	National Museum of Natural History	France	gsimian@mnhn.fr
Gildas Glemarec	DTU Aqua -National Institute of Aquatic Resources	Denmark	ggle@aqua.dtu.dk
Ian Mitchell *(co-chair)*	Joint Nature Conservation Committee	UK	ian.mitchell@jncc.gov.uk
Ib Krag Petersen	Aarhus University	Denmark	ikp@bios.au.dk
Leho Luigujoe	Estonian University of Life Sciences	Estonia	leho.luigujoe@emu.ee
Maite Louzao Arsuaga	AZTI-Tecnalia	Spain	mlouzao@azti.es
Morten Frederiksen *(co-chair)*	Aarhus University	Denmark	mfr@bios.au.dk
Nele Markones	Research and Technology Centre	Germany	markones@ftz-west.uni-kiel.de
Hans Schekkerman	SOVON Dutch Centre for Field Ornithology	Netherlands	hans.schekkerman@sovon.nl
Volker Dierschke *(co-chair)*	Gavia EcoResearch	Germany	volker.dierschke@web.de

Annex 2: JWGBIRD terms of reference for the next meeting

The **Joint Working Group on Marine Birds** (JWGBIRD), chaired by Nele Markones, Germany, Ian Mitchell, UK and Volker Dierschke, Germany, will meet in Tartu, Estonia, 30 September–4 October 2019.

Meeting tasks and justifications

a) Impacts on populations of extreme events incl. oil spills and extreme weather. Lead: Maite Louzao

Most studies of the impacts of external drivers on the demography and population dynamics of seabirds are concerned with annual variation in e.g. climate or food abundance, or in some cases a gradual trend over time. However, impacts of extreme events (e.g. prolonged winter storms, summer storms and tidal surges, pollution events such as oil spills) may in some cases be more important. Extreme events are by their nature rare and therefore difficult to study using traditional correlative approaches. This task will review the available literature and summarise the information on observed impacts of various types of extreme events on seabird populations.

b) Review of techniques for measuring and communicating confidence in assessments. Lead: TBC

During the production of the OSPAR and HELCOM assessments, it became apparent that there are multiple ways of assessing confidence. This task will review these methods and propose the most appropriate to use in future assessments of marine birds.

c) Plan OSPAR and HELCOM updates of assessments. Leads: Volker Dierschke & Ian Mitchell

The OSPAR co-chair of JWGBIRD submitted a plan to OSPAR's Biological Diversity Committee in March 2019 on how marine birds will be assessed for OSPAR's Quality Status Report in 2023 (QSR2023). The plan states that the OSPAR Common Indicator on marine bird abundance will be updated and the Common Indicator on marine bird breeding success/failure will be amended following developments by JWGBIRD and subject to agreement by OSPAR Contracting Parties (see task i). In contrast to the IA2017, the marine bird Common Indicators will be disaggregated into individual species assessments of abundance (breeding and /or non-breeding) and breeding success. These trends will be assessed and then integrated to determine the status of each species and each species group, following the methods based on proposals by JWGBIRD 2018. These species-specific status assessments follow the approach required under the 2017 MSFD Commission Decision and subsequent developments in the frame of MSFD. Value will be added to the species-specific assessments by also comparing trends in both indicators across species, as was done in the IA2017. These cross-species comparisons are not required explicitly for MSFD reporting, but are very useful for providing insight into the likely causes of change.

In 2019, JWGBIRD shall discuss and agree on a plan to produce of test assessments in 2020 and whether this should use the IA2017 dataset or an updated dataset, which would require a data call in November 2019.

HELCOM bird experts will discuss intersessionally the optimal timing for at-sea monitoring and optimal frequency of data deliveries (see intersessional task c). The results will be reported to HELCOM State & Conservation, but will also be presented and discussed at JWGBIRD 2019.

d) Impacts of litter on seabirds (i.e. ingestion, entanglement) – reviewing evidence and proposing further research priorities. Lead: David Fleet

Impacts of litter (mainly litter made of artificial polymers = "plastics") on seabirds through entanglement, ingestion and possibly the transfer of chemicals from ingested plastic items are widespread. Entanglement has been recorded in 25% and ingestion in 40% of all seabird species. Whereas harm through entanglement is evident, harm through ingestion is not so obvious and is likely to be underestimated. Research on this topic, especially into ingestion of plastics by seabirds, has expanded greatly over the last few years and continues to expand rapidly. Species-specific regional monitoring programmes for ingestion of plastics by seabirds have been implemented (e.g. OSPAR Common Indicator on the ingestion of plastics by fulmars in the North Sea). Further monitoring programmes for ingestion as well as entanglement are under development for MSFD purposes. A review of the present literature on the impacts of litter on seabirds and proposals for further research and monitoring would assist in this process and in similar processes in other marine areas.

e) Inclusion of at-sea data in future assessments. Lead: Nele Markones

In both the NE Atlantic and the Baltic Sea, the abundance of seabirds is a metric in some of the indicators, namely OSPAR indicator "B1 Marine bird abundance", HELCOM indicator "Abundance of waterbirds in the breeding season" and HELCOM indicator "Abundance of waterbirds in the wintering season". So far, these indicators are built on data from breeding bird surveys and from coastal surveys of non-breeding birds. The validity of conclusions from the latter surveys is clearly restricted to coastal marine areas. In the case of breeding birds, it is less clear to which specific marine area seabird trends are connected, mainly because many of the species are wide-ranging even during the breeding season. Thus, the abundance indicators in their current versions cannot directly assess the environmental state of offshore sections of the marine regions, which is required e.g. by EU Marine Strategy Framework Direction (MSFD). It is therefore considered highly relevant to include data from at-sea surveys into the seabird abundance indicators.

The JWGBID 2016 report provided first steps of the process leading to an inclusion of these data by compiling existing monitoring programmes in the OSPAR and HELCOM regions and presenting concepts for large-scale surveys and ways for analysing the resulting data. During the 2017 and 2018 meetings, JWGBIRD progressed further by agreeing on leading an update of the existing European Seabirds at Sea database in collaboration with ICES datacentre and initiating a platform for the coordination of harmonized large-scale survey activities.

This task will provide an update of recent activities and define next steps needed for achieving an inclusion of at-sea data in future assessments.

f) Review of results from offshore (at-sea) surveys of the Baltic and planning future work. Lead: Ainars Aunins and Ib Krag Petersen

In winter 2015/16, a coordinated seabird survey was conducted across large parts of the Baltic Sea, incorporating researchers from most HELCOM Contracting Parties and applying distance sampling from aircrafts and ships. The results will be presented and discussed, including the planning of future coordinated surveys.

g) Review 2018 MSFD Article 8 national assessments of birds. Leads: Volker Dierschke and Ian Mitchell

In the status assessments of European marine areas according to Article 8 of the EU Marine Strategy Framework Direction (MSFD, Directive 2008/56/EC), seabirds were assessed in Descriptor D1 (biodiversity). Though MSFD in general follows a regional approach, reporting is done on a national level by EU Member States. National seabird assessments of 2018 are largely based on indicators for the criteria D1C2 (abundance) and D1C3 (demography), which have been developed in collaboration with OSPAR and HELCOM by JWGBIRD and its predecessors. Until Union-wide, international, regional or subregional lists of criteria elements, methodological standards, and specifications and standardised methods for monitoring and assessment are established, EU Member States may use results of monitoring programmes established on a national level (EU Com Dec 2017/848). This task shall review how individual countries have made use of the regional indicator and which other assessments (national monitoring) have been included. This review shall give feedback to JWGBIRD about how suitable and applicable the indicators are, and which issues can be addressed to make their application more successful.

h) Develop an indicator of offshore habitat disturbance under MSFD criterion D1C5 - habitat for species. Lead: Volker Dierschke

Bird assessments in the frame of MSFD (Directive 2008/56/EC , Art 8) shall be based on two primary criteria (D1C1 bycatch in fisheries, D1C2 abundance) and three secondary criteria (D1C3 demography, D1C4 distribution, D1C5 habitat for the species) (EU Com Dec 2017/848). For the NE Atlantic and the Baltic Sea, regional indicators have been developed for D1C1 (HELCOM only), D1C2 (OSPAR and HELCOM) and D1C3 (OSPAR only). During its 2018 meeting, JWGBIRD has explored possibilities to create additional indicators in order to fill gaps currently existing in the MSFD bird assessments. It was found to be promising to develop an indicator for criterion D1C5, which compares marine habitats currently used by or available for seabirds with earlier (or even pristine) patterns of habitat use, the latter defined by either earlier seabird data or by modelling approaches. Differences may be attributed to temporal or permanent disturbance from human activities such as shipping, offshore wind farms, aggregate extraction or fishery. As the potential indicator results are directly pressure-related, an immediate link could be drawn to management measures according to MSFD Art 13.

i) Further development of the indicator of breeding productivity and conduct a trial assessment using the target setting approach developed by the JWGBIRD in 2017-18. Leads: Morten Frederiksen and Tycho Anker-Nilssen.

In 2017 and 2018, JWGBIRD has made considerable progress in developing a better indicator of breeding productivity (relevant to MSFD D1C3), which reflects how the measured breeding productivity may impact population growth rate. Although good progress has been made, further development is necessary. The results of the development will be used to produce a proposal to OSPAR's ICG-COBAM (Nov 2019) and Biological Diversity Committee (Feb/March 2020) for the adoption of the changes to B3 in terms of how it is constructed and assessed.

j) Review assessments of OSPAR Threatened and Declining Species

JWGBIRD will review status assessments of three OSPAR-listed threatened and declining (T&D) species/sub-species of seabird: Balearic shearwater (*Puffinus mauretanicus*), Iberian guillemot (sub-species: *Uria aalge ibericus*) and lesser black-backed gull (sub-species: *Larus fuscus fuscus*). The assessments will be drafted by lead contracting parties of OSPAR (to be confirmed) and will follow the format that was tested on black-legged kittiwake by JWGBIRD in 2018.

The basis for JWGBIRD's involvement is provided by action #36 in the OSPAR Road Map for collective actions on T&D species and habitats, which is also captured in JWG-BIRD's joint OSPAR/ICES/HELCOM workplan 2018–2021. The reviews will support the leads in submitting the assessments to OSPAR's Intersessional Correspondence group on Protected Species and Habitats (ICG-POSH)

None of these three species/subspecies are included in the OSPAR common indicators, so their assessments will likely rely more on third party data and expert judgement. Balearic shearwaters breed in the western Mediterranean and spend only part of their annual lifecycle at sea in the NE Atlantic, from where there is little data on distribution and abundance. The Iberian guillemot is a subspecies of common guillemot and is confined to breeding along northern coast of Spain and Portugal where only a few pairs remain. The OSPAR list of T&D species refers only to the *L. f. fuscus* sub-species of lesser black-backed gull, which is confined to northern Scandinavia in Norway, Sweden and Finland. The OSPAR Common Indicators includes this and other sub-species of lesser black-backed gull, but does not distinguish between them so cannot provide the information needed to conduct an assessment of the *L. f. fuscus* subspecies. Cross-border assessment with HELCOM may be required: the subspecies is also on the HELCOM Red List.

Intersessional tasks

a) HELCOM Workshop Bird on migration

From 10–22 November 2018, a HELCOM workshop on migration of waterbirds was held in Helsinki. The aim was to produce maps with migration routes of waterbird species (e.g. seabirds, ducks, waders) covering the entire Baltic Sea Region. Such maps shall provide background for the 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". The results, i.e. some preliminary maps for example species based on various data sources (mostly tracking data), will be presented to HELCOM STATE & CONSERVATION in May 2019. Depending on further requirements, it was considered to form a subgroup of JWGBIRD and other experts that continues to work on bird migration maps intersessionally.

b) Support HELCOM conservation initiatives and assessments

JWGBIRD is supporting work of HELCOM State & Conservation by supplying relevant information about seabirds according to inquiries, occasionally at short notice. Information about conservation measures for threatened bird species compiled in 2018 shall be amended with information regarding the sources of the Standard Data Forms of coastal Special Protected Areas according to Birds Directive. The information shall be further elaborated with suggestions regarding prioritization of conservation efforts, i.e. proposals for species (and possible associated areas) where measures under HELCOM would bring added value to the conservation efforts, e.g. due to a gap in other policies (no current measures or current measures estimated as not sufficient). In relation to this, wherever possible, proposals for effective measures for these species should be presented.

c) Guidance on best practices, methods and reporting for at-sea monitoring of seabirds in the Baltic Sea

JWGBIRD is supporting work of HELCOM State & Conservation by supplying relevant information about seabirds according to inquiries, occasionally at short notice. To help support improved monitoring underpinning the HELCOM indicators, the group has been invited to identify best practices and recommend methods to monitor seabirds, as well as suggest optimal timing for at-sea monitoring and optimal frequency of reporting from Contracting Parties to HELCOM.

d) Joint OSPAR-HELCOM workshop to examine possibilities for developing indicators for incidental bycatch of birds and marine mammals.

JWGBIRD members may be requested to attend this workshop, which will be held in Copenhagen, Denmark on 3–5 September 2019. The objective of the workshop is to develop methods to assess, for conservation purposes, the pressure of incidental bycatch of birds and marine mammals. The focus is on the identification of cost-effective approaches for assessment and data collection. JWGBIRD task h 2018 (chapter 8 of this report) will contribute to the background information on seabird bycatch to be used at the workshop. The workshop could lead to further requests for information on bycatch from JWGBIRD during 2019/20.

Annex 3: Recommendations

No recommendations were made.