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Integration methods for Marine Strategy Framework Directive's biodiversity assessments

Descriptor 1: species

Dierschke V., A. Kreutle, N. Häubner, C. Magliozzi, S. Bennecke, L. Bergström, A. Borja, S. T. Boschetti, A. Cheilari, D. Connor, F. Haas, M. Hauswirth, S. Koschinski, C. Liquete, J. Olsson, D. Schönberg-Alm, F. Somma, H. Wennhage, A. Palialexis

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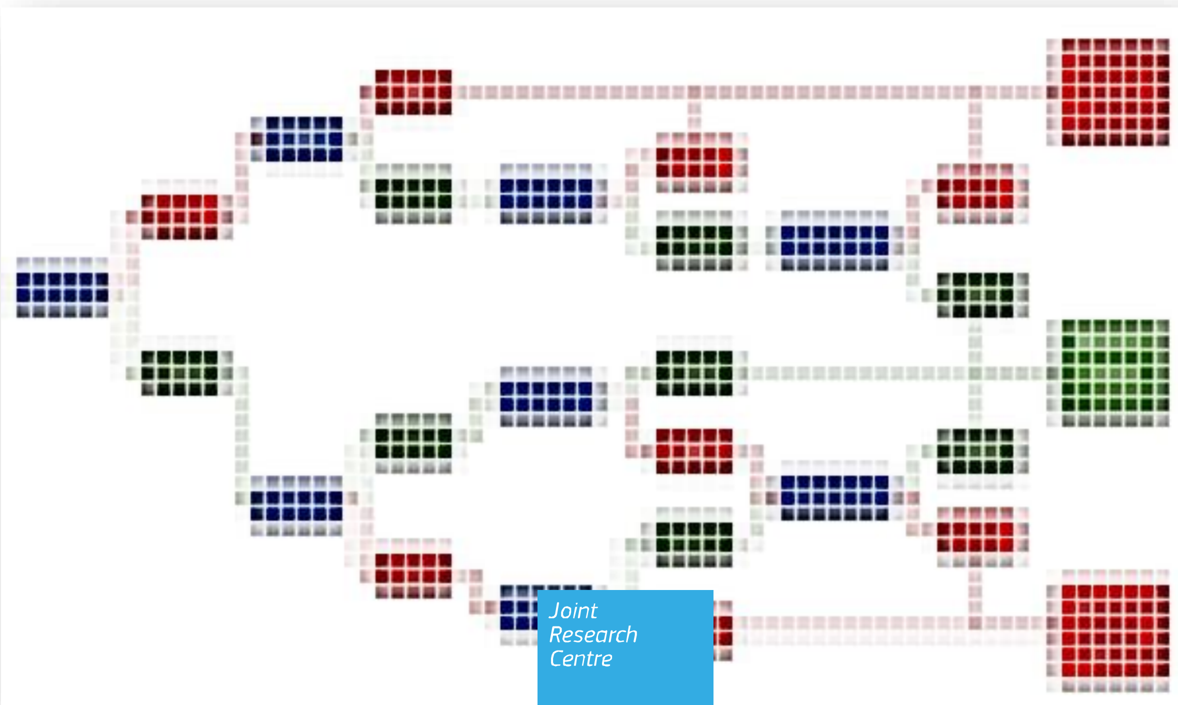

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Abstract

This report reviews the integration methods for MSFD biodiversity assessments under Descriptor 1 for species that are not covered by the Habitats Directive and are not commercial fish assessed under Descriptor 3 and used in Descriptor 1 assessments. It was carried out by experts from the MSFD Biodiversity expert network, which is coordinated by the JRC. It constitutes a knowledge base to support MSFD Article 8 assessments by evaluating the methods to integrate assessments of species at different levels: i) criteria to species, ii) species to species group, and iii) species groups/species to ecosystem component.

Real data and realistic estimates were used to provide a robust evaluation of the main MSFD integration approaches, i.e. one out all out, proportional method, averages, weighted averages, and conditional rules.

Results show that integration methods have advantages and disadvantages depending on the level of integration, the species group (including threatened species), and the available indicators for primary and secondary criteria. Therefore, different scenarios are proposed and evaluated from criteria to ecosystem components, for fish and bird species groups.

To conclude, a common integration approach is feasible, when it is based on the commonly agreed ecological impact of each D1 criterion to the species groups, and can be used in all regions.

1 Introduction

According to Article 8 of the Marine Strategy Framework Direction (2008/56/EC, MSFD), EU Member States shall assess the status of their marine waters and report on progress made towards achieving Good Environmental Status (GES) as defined in Article 9. For components of marine biodiversity, GES is assessed against Descriptor 1 (Annex 1 of the MSFD): "Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions."

Commission Decision (EU) 2017/848, repealing Commission Decision 2010/477/EU, outlines the way that components of marine biodiversity shall be assessed. For species of birds, mammals, reptiles, fish and cephalopods[2], it specifies five possible criteria that should be used to assess the status of each species individually; these in turn are used to express the extent to which GES has been achieved for the species groups listed in Table 1 of the GES Decision. The need to conclude on the status of a species requires the development of new integration[3] methods that are harmonised across Member States to generate consistent and comparable assessments. This includes the integration within the assessment hierarchy:

i) from criteria to species and
ii) from species to species group.
iii) Additionally, integration from species group to ecosystem component could be beneficial to present assessment results to decision-makers and public.

According to the GES Decision, species which are protected under the Habitats Directive (92/43/EEC) are to be assessed in the same way that Favourable Conservation Status (FCS) for these species is assessed under the Habitats Directive. This FCS method covers all species of marine mammals and reptiles, and a few diadromous fish species. Marine birds, and fish species that are not commercially used and thus assessed under Descriptor 3, are not subject to the Habitats Directive FCS integration method and therefore need integration methods to be proposed.

On request of the European Commission, the International Council for Exploration of the Sea (ICES) (2018a, 2018b) reviewed available methods for integration and provided advice on how to do integration at various levels for MSFD assessments (ICES 2018c). Regarding marine birds, the Joint OSPAR/HELCOM/ICES Working Group on Marine Birds (JWGBIRD) proposed to change the method recommended previously by ICES (ICES 2018d). No further proposal for methods to integrate species has been made. These proposed methods were presented to the Working Group on good environmental status (WG GES[4]) at its meeting in March 2019 (GES_21-2019-09) where it was concluded that there was a need for further discussion among experts on the different proposals (including approaches already used by Member States or Regional Sea Conventions). A call for data to test the methods was launched in October 2019. The European Commission's Joint Research Centre (JRC) and the MSFD Biodiversity expert network worked out the test and included the following points:

- Test of the different proposals with real assessment data supplemented by realistic estimates where real data are lacking;

- Amplification of previous approaches concerning integration methods by further exploring possible ways of integration and testing them with artificial data for anonymous species in order to evaluate the methods;

- The use of secondary criteria in the integration rules, particularly in view of Decision (EU) 2017/848 Article 3 (2);

- The inclusion of information from other forms of anthropogenic mortality, in addition to incidental by-catch from fisheries;

- The use of 'red lists'.

[2] This level of biodiversity is termed 'ecosystem component' in this report; each comprises several 'species groups', as listed in Table 1 of the GES Decision.

[3] In this report, the term 'integration' indicates the combination of different status conclusions at parameter, criterion or element level to conclude on status at the next level (i.e. criterion status from several parameters, element status from several criteria), while the term 'aggregation' refers to the combination of assessments per parameter or element to a status.

[4] WG GES is a subgroup of the MSFD's Common Implementation Strategy (CIS).

The most appropriate method of integration should be directly connected to the aims of the MSFD Article 8 assessments, i.e. to define the overall status of a species, and from this the extent to which GES has been achieved for each species group. In cases where the species is in poor status, or the species group has not achieved GES, it should then lead to implementation of appropriate measures which aim to improve the status. Rather than following theoretical considerations about the weighting of criteria, this weighting, i.e. their role in the species assessments should be evaluated in relation to the conclusions from the scientific indicator outcomes. It would be desirable that assessments of ecosystem components made by Regional Sea Conventions (RSC) could be used by EU Member States for MSFD purposes. Therefore, integration rules developed in the EU CIS process could also be used in RSC work if it fits the follow up of regional strategies. It has to be stressed that the optimal approach might differ between MSFD marine regions – not least, because the bird or fish species are not the same in the different marine regions and sub-regions. The report is based on discussions at various online meetings and a MSFD D1 integration workshop hosted by JRC and held online on 18 June 2020.

2 MSFD background information: components available for D1 (biodiversity) assessments and levels for integration

2.1 Geographic scales for assessment and reporting

MSFD Article 8 assessments for all bird species groups and for pelagic shelf fish and demersal shelf fish are to be reported at the scale of regions or their subdivisions (Baltic Sea, Black Sea) and subregions[5] (North-East Atlantic Ocean, Mediterranean Sea), respectively (Commission Decision (EU) 2017/848). Assessments for deep-sea fish are to be reported at regional scale, and assessments for coastal fish at the scale of subdivisions of a region or subregion.

In contrast, the Birds Directive (2009/147/EC) requires reports per species at a national level, not differentiating between marine waters falling into different regions; i.e. there is no differentiation between the North Sea and the Baltic Sea for DE, DK, SE or between the Atlantic and Mediterranean regions for FR and ES. The Habitats Directive also requires reports per species at national level, but these are divided by biogeographic regions similar to the MSFD regions[6].

The regional/subregional approach for undertaking the MSFD assessments ensures a more ecologically relevant scale for assessments. It remains the responsibility of Member States to report the 'regional' assessment results that are relevant for their own marine waters.

Since an ecologically relevant assessment scale should be used for the assessment of species, the geographic scale differs between the assessment of bird and fish species groups. Many populations of coastal fish species are restricted to certain areas, and so they are assessed at a finer scale (subdivision) than offshore fish. Furthermore, the distributional range of populations of demersal and pelagic shelf fish species may be smaller than an MSFD (sub)region, such that several populations of a particular species may occur within a (sub)region. Assessment of these groups at (sub)region level therefore encompasses multiple species and populations. Assessment at this scale provides a means to report on the extent to which GES has been achieved for each species group, reflecting the broad ecological differences between regions and subregions, without a necessity to report on very specific areas for individual species' populations. In cases where a species' population straddles a (sub)region, it needs to be included in both (sub)regions.

These MSFD scales are the **reporting units** for reporting the overall status of each species group. In some cases, assessments may be undertaken at finer scales (**assessment areas**), and require an aggregation of results (combination of several assessment areas into the reporting unit). This might be appropriate for some fish species, especially coastal fish species which are quite likely be assessed at finer geographic scales. If the status of a species group is defined for the relevant assessment area, and aggregated up to the larger reporting unit, a proportional method should be applied. For instance, at least 80% of the assessment areas within a larger reporting unit should achieve GES for the relevant species group.

2.2 The level of species

Commission Decision (EU) 2017/848 requires to start integration with combining the criteria within species. It also allows to assess populations which then are aggregated to species, and assessments are to be based on regionally or subregionally agreed lists of relevant species (Palialexis et al. 2018).

Regarding birds, JWGBIRD has recommended to assess breeding populations and non-breeding[7] populations of the same species separately, because within one marine area the two groups may belong to different populations with different backgrounds regarding origin, habitat use, and pressures. This approach would help management advice and is consistent with separation in Birds Directive reporting.

The work to agree regional/subregional lists for fish species is ongoing. The smallest unit for assessment of fish species should be populations per species and its distribution range in order to reflect geographical differences within a certain MSFD subregion or region and ensure consistency with the assessment of relevant (stocks) in the assessment of D3.

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[5] In this report the term '(sub)region' refers to region (for Baltic Sea and Black Sea) and to subregion (for NE Atlantic Ocean and Mediterranean Sea regions).

[6] Macaronesia is treated as a separate biogeographic region under Habitats Directive, but as a subregion under MSFD. The distinction of subregions in the Atlantic and Mediterranean under MSFD is not reflected in the Habitats Directive.

[7] Non-breeding means the population does not breed within the assessed (sub)region. They are often migratory species which breed outside Europe.

In the frame of MSFD Article 8, assessments of species (Descriptor 1) are based on five criteria:

- D1C1 – Mortality rate from incidental by-catch
- D1C2 – Population abundance
- D1C3 – Population demographic characteristics
- D1C4 – Distributional range and pattern
- D1C5 – Habitat for the species

Depending on which ecosystem component is being considered, the criteria are grouped into primary and secondary criteria. In the case of all marine bird species and those fish species not commercially exploited and not falling under the Habitats Directive, D1C1 and D1C2 are primary criteria and D1C3, D1C4 and D1C5 are secondary criteria.

Commission Decision (EU) 2017/848 states additionally that "Assessments of the adverse effects from pressures under criteria D1C1, D2C3, D3C1, D8C2, D8C4 and D10C4, as well as the assessments of pressures under criteria D9C1, D10C3, D11C1 and D11C2, shall be taken into account in the assessments of species under Descriptor 1." Nevertheless, these criteria are not directly included in the integration steps for an individual species, but aspects could be included in the assessment of criterion D1C1 anthropogenic mortality and other relevant criteria. Another possibility for Member States could be the inclusion of an analysis in their MSFD report about which pressures effect the different ecosystem components in order to plan sufficient measures.

Regarding the quite similar approaches of bird assessments in the NE Atlantic (OSPAR) and the Baltic Sea (HELCOM), the explanatory power of the five D1 criteria with respect to a biological view on the bird species is outlined in the following paragraphs. It is based on already existing indicators, but for some criteria gives perspectives to forthcoming indicator developments.

D1C1 (bycatch): A joint workshop[8] of OSPAR and HELCOM has recommended to relate the number of marine birds bycaught in fisheries (calculated from observed bycatch rates and fishing effort) to the consequences of this additional mortality to the population growth rate resulting from that increased mortality (via Population Viability Analysis, PVA, or other population modelling approaches). Thus, if the indicator finds too much mortality to maintain the population, the species is not in GES. From this follows that a species altogether cannot be in good status, if bycatch mortality is causing a negative population growth rate.

D1C2 (abundance): Both OSPAR and HELCOM indicators on marine bird abundance follow the population sizes over many years, and the status of a species is regarded as poor if the population size falls below 70% (80% in species laying only one egg per year) of the baseline population size, which is set as the population size at the beginning of the time series. Currently, no reference values compared to "natural" or "pristine" population sizes are available. However, falling below the 70% or 80% threshold means that the condition of a species is considered to be poor and thus cannot be in GES.

D1C3 (demography): The new approach for a D1C3 bird indicator proposed for OSPAR relates breeding success to expected population growth rate (ICES 2020). If current breeding success data (i.e. the measurements for the indicator) are indicating a future critical decline in population size this is treated as a clear signal that a species cannot be in GES, because the actual reproductive rate does not allow the population size to be maintained (or a depleted population to recover).

D1C4 (distribution): Changes in breeding or wintering distribution of marine birds currently occur on a large scale due to effects related to climate change (e.g. Fox et al. 2019). Smaller scale shifts can be related to anthropogenic activities, which disturb the birds themselves or their food resources, but may also have natural causes such as changing distribution of prey species, especially fish. Compared to the other criteria, the explanatory power of distributional shifts appears to be relatively low with respect to being in GES or not. However, new design of indicators may enhance the value of the distribution criterion.

D1C5 (habitat for the species): The intention of a new indicator development is to assess the amount of disturbance from human activities in the breeding or wintering ranges of marine birds (ICES 2020). Accordingly, a species is not in GES if a given proportion of its habitat is disturbed or even lost to a given degree (thresholds still to be developed).

Comparing the conclusions, which can be derived from the indicator outcomes of the five criteria, three criteria (D1C1, D1C2, D1C3) are directly telling about the fate of a population: Decrease because of too high bycatch

[8] https://portal.helcom.fi/meetings/Incidental%20bycatch%20WS%201-2019-647/MeetingDocuments/Outcome%20OSPAR-HELCOM%20incidental%20by-catch%20indicator%20workshop_final.pdf

mortality or too low reproductive rate (or both), or increase because the opposite is true. The other two criteria can also show that the status of a species is poor, because much of its habitat is disturbed/lost (D1C5) or distributional shifts are indicating insufficient conditions in formerly inhabited areas (D1C4).

According to the draft guidance for assessments under Article 8 (Walmsley et al. 2017), assessments shall be based on relevant regional (scientific) indicators, but can also include information from assessments done for the Habitats Directive (for fish species that are not commercially exploited) and Birds Directive ([9]). Any gaps can be filled by national assessments. Until 2019, regional indicators were available only for some of the criteria, with different coverage in the four MSFD regions (Table 1 and Table 2). Therefore, for marine bird assessments some Member States made use of national assessments and monitoring programmes in their 2018 reports, but still did not cover all criteria (ICES 2020). Regarding fish, there is currently a large overlap between Descriptors D1 (biodiversity), D3 (commercially exploited fish and shellfish) and D4 (food webs), and Table 2 only lists indicators assigned to D1. In the future there should be a focus in RSC and Member States' assessment work regarding D1 non-commercial fish in order to assess these species more holistically. The GES Decision further requires that D1 fish assessments at species group level should, where relevant, include commercially exploited fish species. If commercially exploited fish species are included, they have to be assessed according to D3 (also same status result per species as in D3).

Table 1. OSPAR, HELCOM and UNEP-MAP common/core indicators related to birds and operational for 2018 MSFD assessments. Apparently, no bird indicator is available for the Black Sea Commission.

MSFD criterion	**Regional Sea Convention**	**Indicator status**	**Indicator name**
D1C1	HELCOM	core	Number of drowned mammals and waterbirds in fishing gear (*)
D1C2	OSPAR	common	Marine bird abundance (B1)
D1C2	HELCOM	core	Abundance of waterbirds in the breeding season
D1C2	HELCOM	core	Abundance of waterbirds in the wintering season
D1C2	UNEP-MAP	common	Population abundance of selected species - Seabirds
D1C3	OSPAR	common	Breeding status of marine birds (B3)
D1C3	OSPAR	candidate	Breeding success of kittiwake (B2) (**)
D1C3	UNEP-MAP	common	Population demographic characteristics - Seabirds
D1C4	OSPAR	candidate	Distribution of marine birds (B6)
D1C4	UNEP-MAP	common	Species distributional range (related to seabirds)
D1C5	OSPAR	candidate	Non-native/invasive mammal presence on island seabird colonies (B4) (**)

(*) No assessment conducted due to lack of data.
(**) No regional assessment, but used for MSFD assessment in UK.

Table 2. OSPAR and HELCOM common/core indicators related to fish and operational for 2018 MSFD assessments in Descriptor 1. Indicators related to D3 (commercially exploited fish and shellfish) and D4 (food webs) are not shown**.**

MSFD criterion	**Regional Sea Convention**	**Indicator status**	**Indicator name**
D1C2	OSPAR	common	Recovery in the population abundance of sensitive fish species (*)
D1C2	OSPAR	candidate	Conservation status of fish (FC5)
D1C2	HELCOM	core	Abundance of key coastal fish species
D1C2	HELCOM	core	Abundance of salmon spawners and smolt
D1C2	HELCOM	core	Abundance of sea trout spawners and parr
D1C4	OSPAR	candidate	Distributional range (FC7)
D1C4	OSPAR	candidate	Fish distributional pattern (FC8)

(*) Assessment not consistent with requirements of Commission Decision (EU) 2017/848.

2.3 The level of species groups

The second step of integration following Commission Decision (EU) 2017/848 is to integrate the assessments of species within species groups. In regional or subregional collaboration, Member States determine which

([9]) Reporting in the Birds Directive is purely descriptive and cannot supply assessments to MSFD directly. However, data collected and analyses done for Birds Directive can support MSFD assessments.

species are representative for each species group, based on the criteria for selection of species in the GES Decision.

JWGBIRD has compiled a species list allocating marine birds to the five species groups specified in the GES Decision, based on how and where they are foraging (Table 3) – assuming that natural and anthropogenic factors are likely to act similarly on species that share same food types and foraging habitats (ICES 2015).

Table 3. Marine bird species groups (ICES 2015).

Species group	Typical feeding behaviour	Typical food types	Additional guidance
Wading birds	Walk/wade in shallow waters	Invertebrates (molluscs, polychaetes, etc.)	None
Surface-feeding birds	Feed within the surface layer (within 1 to 2 m of the surface)	Small fish, zooplankton and other invertebrates	"Surface layer" defined in relation to normal diving depth of plunge-divers (except gannets)
Pelagic-feeding birds	Feed at a broad depth range in the water column	Pelagic and demersal fish and invertebrates (e.g. squid, zooplankton)	Include only species that usually dive by actively swimming underwater; but including gannets. Includes species feeding on benthic fish (e.g. flatfish).
Benthic-feeding birds	Feed on the seafloor	Invertebrates (e.g. molluscs, echinoderms)	None
Grazing birds	Grazing in intertidal areas and in shallow waters	Plants (e.g. eelgrass, saltmarsh plants), algae	Geese, swans and dabbling ducks, coot

Fish species are grouped into coastal fish, pelagic shelf fish, demersal shelf fish and deep-sea fish, meaning that habitat is the main criterion for grouping (Rijnsdorp et al. 2010, Heessen et al. 2015). But grouping is difficult, because some species are in different groups according to their life cycle (e.g. Sarrazin et al. in prep.).

2.4 The level of ecosystem components

MSFD Article 8 does not require the integration of species groups to ecosystem components, i.e. for all birds and fish (and also mammals, reptiles and cephalopods, for which Habitat Directive does not provide such an assessment). Integration to ecosystem component could be a useful tool to present assessment results to decision-making policy and public because the more general results are easy to capture.

3 Overview integration methods proposed for MSFD D1

The subject of integrating indicator assessments has reviewed a considerable number of approaches and methods. Apart from other EU environmental legislation, proposals for integration in MSFD assessments have been discussed repeatedly. For species in biodiversity assessments in MSFD Descriptor 1, available methods of integration were reviewed and discussed, among others, at two ICES workshops in 2018, WKDIVAGG (ICES 2018a) and WKDIVExtinct (2018b). This section aims to briefly introduce integration methods specified by WKDIVAGG, WKDIVExtinct, the resulting ICES Advice (2008c) and an amendment proposed by JWGBIRD (ICES 2018d). Two methods are further elaborated here in order to get approaches specifically tailored for birds. There are also other methods used by RSCs, or EU Member States in their 2018 MSFD Article 8 assessment.

In this section, methods are explained on the level of integration from indicators to species, but most of them can be applied also on higher integration levels. Pros and cons of the individual methods are discussed in the section about the application of the methods.

Methods appearing to be not applicable to birds and fish are not discussed here. This refers to probabilistic methods, because uncertainties of indicator assessments are poorly known, and to risk-based methods, which are unsuitable when the assessed elements respond to very different pressures (ICES 2018a).

3.1 One out, all out (OOAO)

The easy-to-understand conditional rule OOAO means that all indicators have to be “good” for treating a species as being in good status (Figure 1). Any poor rating is visible at higher levels and can be directly traced back to one or more poor indicators. There is no differentiation between primary and secondary criteria. With this method, there is no ‘masking’ of poor indicators by other indicators and hence, signs of early warning for adverse effects are not ‘missed’ in the process.

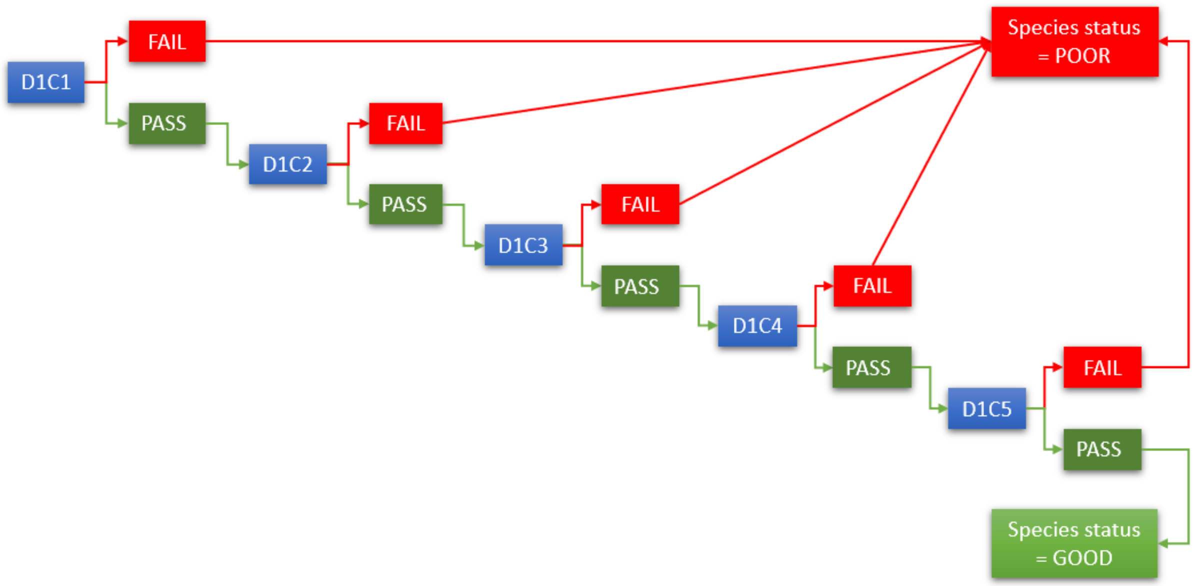

Figure 1. Proposed rules for integrating criteria to assess the status of species according to OOAO (One-Out-All-Out).

3.2 Proportional method

The proportional method specifies that a percentage or proportion of assessments must be in good status for the integrated assessment on the higher level to be considered in good status. The percentage or proportion required for good status is usually set by expert judgement. This method is easy to understand and retains information on the proportion of indicators in good or poor status. It also allows for natural variability and the chance that some indicators may not reflect good status.

3.3 Averages

The average across all assessed indicators is used as an integrated assessment, at which primary and secondary criteria are treated equally. Averaging across indicators requires using a common unit. This can be achieved by normalizing indicator results (see section 5). The underlying rationale of using averages is that a decrease in one indicator can be compensated by an increase in another indicator. In this method masking of poor indicators could occur.

3.4 Weighted averages

The average of indicator assessments is calculated by applying weights to the various indicators in the integration. Weighting of indicators can be based on their perceived importance, the area covered by the indicators or its precision and accuracy. The underlying rationale is that a decrease in one indicator can be compensated by a specified (but not equal) increase in another indicator.

3.5 Conditional rules

In 2018, workshops and working groups discussed various approaches using conditional rules for integrating mobile species assessments from criteria to species. All four variants proposed by WKDIVAGG, JWGBIRD and in the ICES Advice are weighting the indicators according to their belonging to primary or secondary criteria and include "if … then" scenarios, i.e. if a given criterion fails, then the status of a species is poor, and if a given criterion is in good status, the cascade of integration is continued. The variants can be characterized as follows (see also accompanying figures and tables):

Variant A (ICES Advice, ICES 2018c): If one of the two primary criteria fails, the status of the species is poor, except if the secondary criteria are indicating good status from their average of normalised criteria. If both primary criteria are indicating poor status, then the species status is poor regardless of the outcomes of the secondary criteria. [Figure 2, Table 4]

Variant B (JWGBIRD, ICES 2018d): If one of the two primary criteria fails, the status of the species is poor, regardless of the assessment outcomes in the secondary criteria. If both primary criteria are in good status, then the status depends on the weighted average of the normalised criteria D1C2-C5; where D1C2 is double the combined weight of D1C3-C5. [Figure 3, Table 5]

Variant C (WKDIVAGG, ICES 2018a): If one of the two primary criteria fails, the status of the species is poor, regardless of the assessment outcomes in the secondary criteria. If both primary criteria are in good status, then the status depends on the weighted average of the normalised criteria D1C2-C5; where D1C2 has the same weight as D1C3-C5 combined. [Figure 4, Table 6]

Variant D (WKDIVAGG, ICES 2018a): If one of the two primary criteria fails, the status of the species is poor, regardless of the assessment outcomes in the secondary criteria. If both primary criteria are in good status, then the status depends on the average of the normalised criteria D1C3-C5. [Figure 5, Table 7]

Table 4. Decision guide for GES decision for integrating criteria to species following conditional rule Variant A (ICES Advice, ICES 2018c). N – Criterion fails GES, Y – Criterion in GES, O – Missing data or reference level but criterion relevant to assessment, NA – Not applicable, criterion result irrelevant to assessment.

	Assessment scenario								
Criteria	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**
D1C1	Y or O	Y	Y	N	N	N	NA	NA	O
D1C2	Y	N	N	N	Y	Y	Y	N	N
D1C3-C5 combined	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	good	poor	good	poor	poor

Table 5. Decision guide for GES decision for integrating criteria to species following conditional rule Variant B (JWGBIRD, ICES 2018d). N – Criterion fails GES, Y – Criterion in GES, O – Missing data or reference level but criterion relevant to assessment, NA – Not applicable, criterion result irrelevant to assessment.

	Assessment scenario								
Criteria	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**
D1C1	Y or O	Y	Y or O	Y	Y or O	N	N	NA	NA
D1C2	Y	Y or O	Y	Y or O	N	N	Y or O	Y	N
D1C2-C5 combined	Y	Y	N, O or NA	N, O or NA	Y, N, O, or NA	Y, N, O, or NA	Y, N, O, or NA	Y	Y, N, O, or NA
species status	good	good	poor	poor	poor	poor	poor	good	poor

Table 6. Decision guide for GES decision for integrating criteria to species following conditional rule Variant C (WKDIVAGG option 1, ICES 2018a). N – Criterion fails GES, Y – Criterion in GES, O – Missing data or reference level but criterion relevant to assessment, NA – Not applicable, criterion result irrelevant to assessment.

	Assessment scenario							
Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
D1C1	Y	Y	Y	N	N	NA or O	NA or O	NA or O
D1C2	Y	Y	N	N	Y	Y	Y	N
D1C2-C5 combined	Y	N	Y or N	Y or N	Y or N	Y	N	Y or N
species status	good	poor	poor	poor	poor	good	poor	poor

Table 7. Decision guide for GES decision for integrating criteria to species following conditional rule Variant D (WKDIVAGG option 2, ICES 2018a). N – Criterion fails GES, Y – Criterion in GES, O – Missing data or reference level but criterion relevant to assessment, NA – Not applicable, criterion result irrelevant to assessment.

	Assessment scenario							
Criteria	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**
D1C1	Y	Y	Y	N	N	NA or O	NA or O	NA or O
D1C2	Y	Y	N	N	Y	Y	Y	N
D1C3-C5 combined	Y	N	Y or N	Y or N	Y or N	Y	N	Y or N
species status	good	poor	poor	poor	poor	good	poor	poor

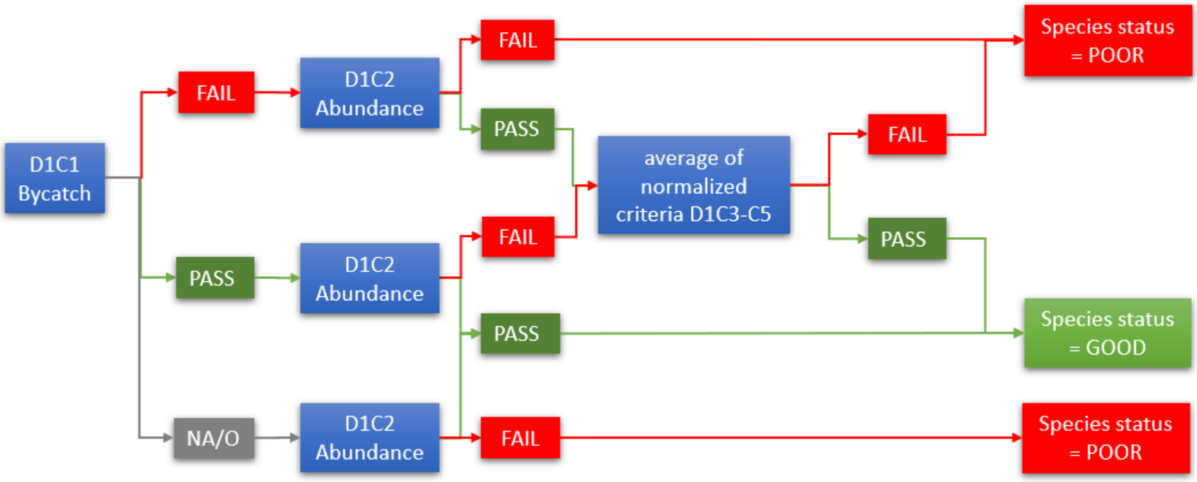

Figure 2. Proposed rules for integrating criteria to assess the status of a marine bird species according to ICES Advice (ICES 2018c); Variant A (see also Table 4).

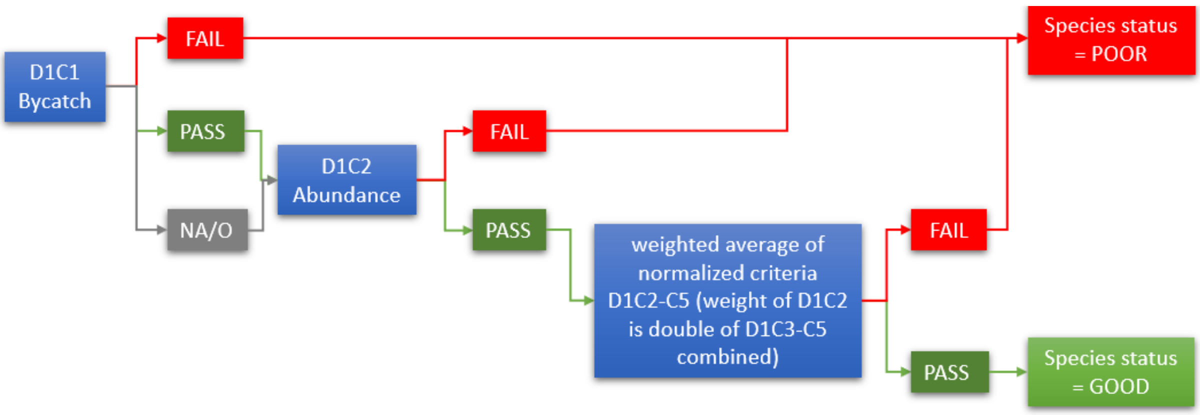

Figure 3. JWGBIRD proposed rules for integrating criteria to assess the status of a marine bird species (ICES 2018d); Variant B (see also
Table **5**).

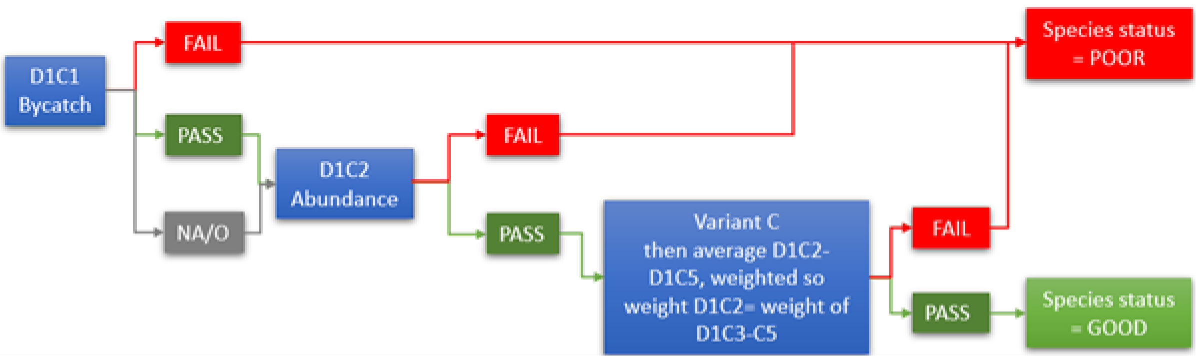

Figure 4. WKDIVAGG proposed rules for integrating criteria to assess the status of a marine bird species (ICES 2018a); Variant C (see also Table 6).

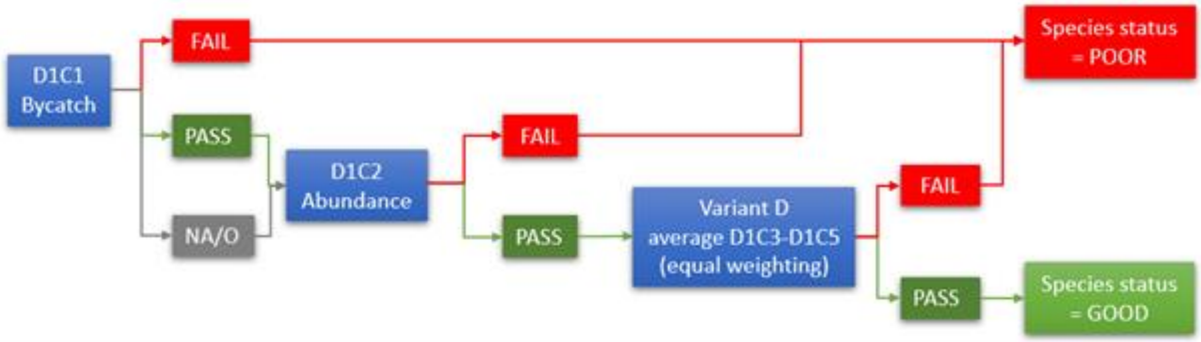

Figure 5. WKDIVAGG proposed rules for integrating criteria to assess the status of a marine bird species (ICES 2018a); Variant D (see also Table 7).

As these proposals for integrating criteria on the species level (variants A, B, C and D) give much weight to the primary criteria, but the weight of secondary criteria is practically absent or too low to affect the species assessments except for very extreme (and unrealistic) scenarios (see section 5), other variants of conditional rules to be applied to bird and fish species, respectively, are proposed in this report. Both Variant E (birds) and F (fish) refer to the informative value of the individual criteria as outlined in section 2.

Variant E (birds):

- If D1C1, D1C2 and D1C3 are in good status, then the species is in GES, even if D1C4 and D1C5 are in poor status (scenario E1, see Table 8). The population-related criteria do not reflect the bad status of the environmental conditions (D1C4, D1C5), i.e. the species seems to cope with this.
- If one out of the population-related criteria (D1C1-C3) is indicating poor status, but the other two are good, then the positive signals of two good population-related criteria give GES as long as the environmental conditions (D1C4, D1C5) are still in good status (scenarios E2, E4, E6, Table 8). If D1C4 and D1C5 are in poor status, the environment is not suitable to outweigh the negative signals from one of the criteria D1C1-C3 (scenarios E3, E5, E7). This option is only true for species where D1C3 gives information about the possible growth of the population, e.g. breeding success. If other parameters assessed by D1C3, e.g. size distribution for fish, then failure in achieving threshold values of D1C2 will not be "out-weighed" by meeting thresholds in D1C3.
- If two or three out of D1C1, D1C2 and D1C3 are in poor status, there is strong indication that the species is in sub-GES, even if environmental conditions (D1C4, D1C5) appear to be good (scenarios E8-E11).

Variant E gives species assessments on the basis of passing or failing the criteria D1C1, D1C2 and D1C3, with the weighted average of D1C4 and D1C5 (D1C5 has twice the weight of D1C4) being the determining factor in some scenarios (Figure 6).

Table 8. Decision guide for GES decision for integrating criteria to species following conditional rule Variant E with all criteria assessed (see also Figure 6). This table shows the ideal case where all criteria are applicable. In practice, it is recommended to follow Table 9 for breeding birds and Table 10 for wintering birds (see also Figure 7 and Figure 8). N – Criterion fails GES, Y – Criterion in GES. Application of new conditional method for species (breeding and wintering birds of one population) with all criteria assessed.

	Assessment scenario										
Criteria	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E11**
D1C1	Y	Y	Y	Y	Y	N	N	Y	N	N	N
D1C2	Y	N	N	Y	Y	Y	Y	N	Y	N	N
D1C3	Y	Y	Y	N	N	Y	Y	N	N	Y	N
D1C4-C5 combined	Y or N	Y	N	Y	N	Y	N	Y or N	Y or N	Y or N	Y or N
species status	good	good	poor	good	poor	good	poor	poor	poor	poor	poor

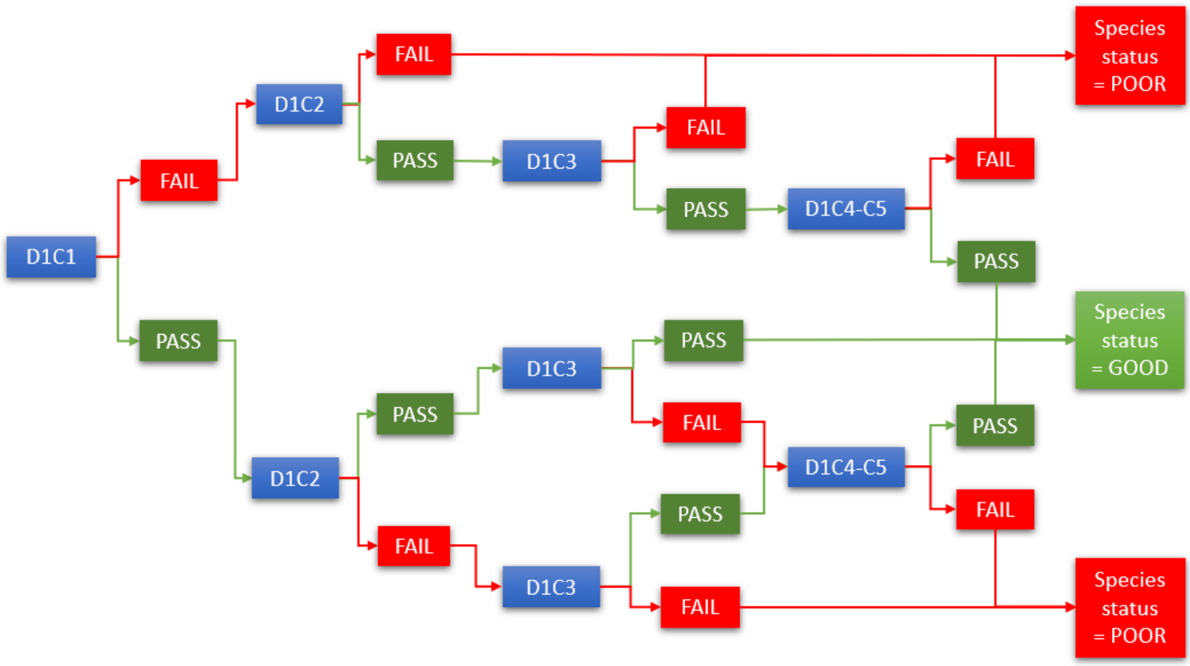

Figure 6. Proposed rules for integrating criteria to assess the status of a marine bird species according to the new approach presented in this paper (Variant E, see also Table 8). This schematic represents the ideal case that all criteria can be assessed. See Figure 7 and Figure 8 for recommended applications for breeding and wintering birds, respectively).

However, it is necessary to consider that the ideal case of all five criteria assessed for a species is quite unlikely. This is not only owing to currently lacking indicators for some criteria, but also inherent to the system: Bycatch (D1C1) is often only monitored in non-breeding birds ([10]), whereas data on breeding success can only be obtained for breeding birds. However, future developments may incorporate other anthropogenic mortality for criterion D1C1, and D1C3 could be expanded to wintering birds when, for example, the proportion of juveniles in the wintering population is assessed. The latter would not necessarily be linked to conditions in the marine region under inspection, but would still reflect the status of the population.

Acknowledging the current layout of indicators, conditional rules Variant E can be adjusted for breeding birds and wintering birds individually (Table 9 and Table 10). Thus, for use in practice the following adaptations for breeding and wintering birds are recommended:

- For breeding birds, as long as a bycatch indicator is not available for the breeding season the integration starts with criterion D1C2, which is assumed to be applicable for all species. Subsequent steps of integration consider that assessments are not always possible because indicators may not be available or applicable for a given species (Figure 7). If D1C2 fails and D1C3 cannot be assessed, the combined criteria D1C4-C5 must reflect good status for achieving good overall status in order to prevent that a species can pass without any criterion being in good status.

- For wintering birds, variant E starts with D1C1 for those species, which are at risk from incidental bycatch (see Commission Decision (EU) 2017/848). If this criterion cannot be assessed, because data are not available, the status of the species is poor for threatened and declining (and/or red-listed) species, otherwise the species passes and the integration continues with criterion D1C2 as shown in Figure 8 (see also Table 10). For species not at risk from incidental bycatch the integration always starts with criterion D1C2. If D1C2 fails or cannot be assessed, the combined criteria D1C4-C5 must reflect good status for achieving good overall status in order to prevent that a species can pass without any criterion being in good status. If no criteria at all can be assessed, the species cannot be assessed.

(10) The HELCOM core indicator “Number of drowned mammals and waterbirds in fishing gear” is directed to assess bycatch in relation to wintering populations of waterbirds. Certainly, bycatch also affects breeding birds during the breeding season, but this cannot be assessed with the current indicator design.

Table 9. Decision guide for GES decision for integrating criteria to species following conditional rule Variant E for breeding birds (see also Figure 7). N – Criterion fails GES, Y – Criterion in GES, O – Missing data or reference level but criterion relevant to assessment, NA – Not applicable, criterion result irrelevant to assessment.

	Assessment scenario					
Criteria	**E12**	**E13**	**E14**	**E15**	**E16**	**E17**
D1C2	Y	N	N	Y	Y	N
D1C3	Y	Y, O or NA	Y, O or NA	N, O or NA	N, O or NA	N
D1C4-C5 combined	Y, N, O or NA	Y	N, O or NA	Y, O or NA	N	Y, N, O or NA
species status	good	good	poor	good	poor	poor

Table 10. Decision guide for GES decision for integrating criteria to species following conditional rule Variant E for wintering birds. N – Criterion fails GES, Y – Criterion in GES, O – Missing data or reference level but criterion relevant to assessment, NA – Not applicable, criterion result irrelevant to assessment. Species not at risk from incidental bycatch are not subject of a D1C1 assessment (NA). In species at risk from incidental bycatch, missing data for criterion D1C1 are treated differently for species regionally classified as being threatened & declining or red-listed (O*) and those not classified as being threatened & declining or red-listed (O**) (see also Figure 8).

	Assessment scenario			
Criteria	**E18**	**E19**	**E20**	**E21**
D1C1	Y, NA or O**	Y, NA or O**	Y, NA or O**	N or O*
D1C2	Y	N or O	N	Y or N
D1C4-C5 combined	Y or N	Y	N or O	Y or N
species status	good	good	poor	poor

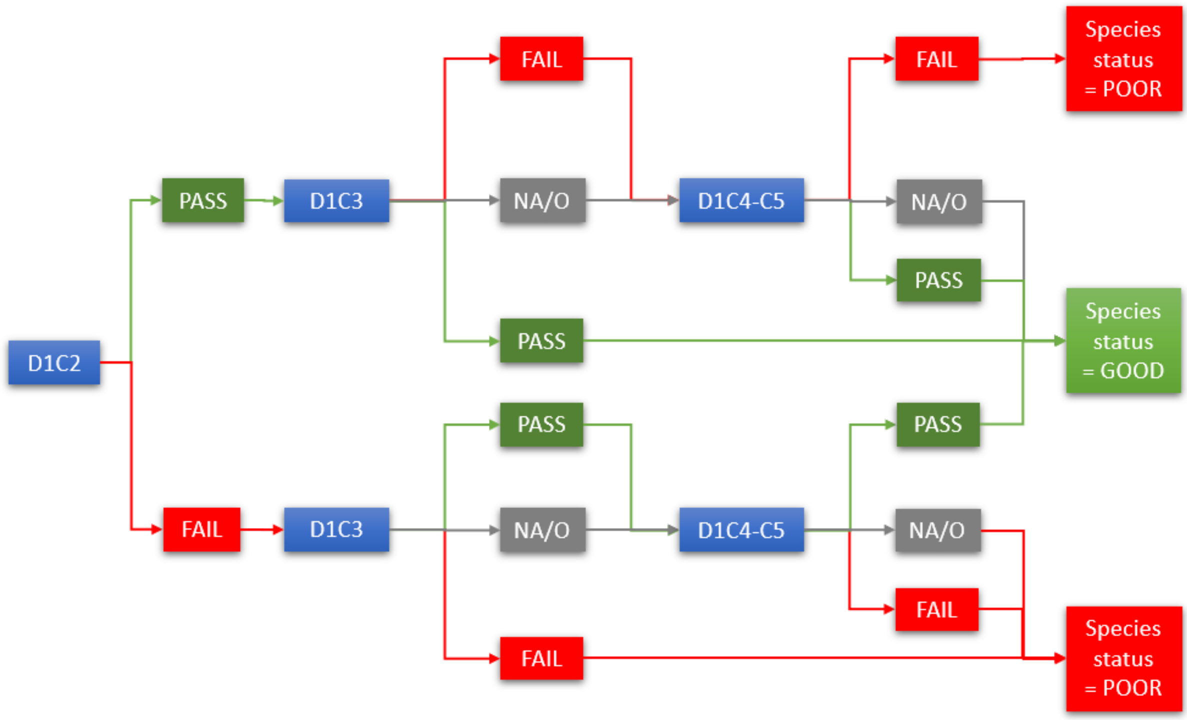

Figure 7. Proposed rules for integrating criteria to assess the status of a marine breeding bird species according to the new approach presented in this paper (Variant E, see also Table 9).

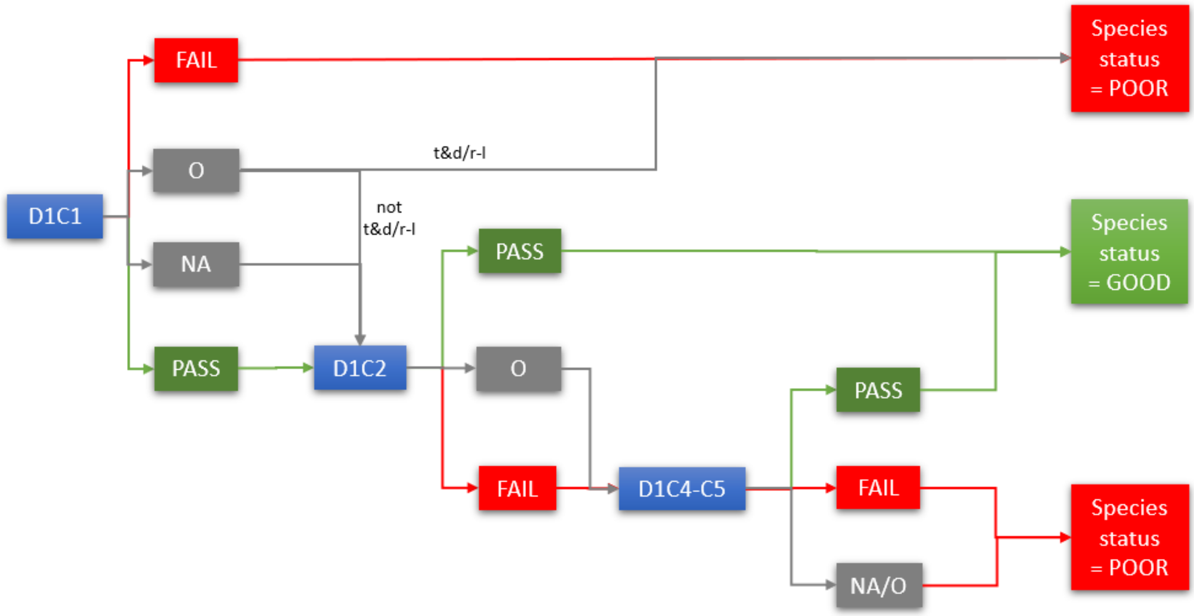

Figure 8. Proposed rules for integrating criteria to assess the status of a marine wintering bird species according to the new approach presented in this paper (Variant E, see also Table 10). Note that for species at risk from incidental bycatch two different pathways of integration have to be followed depending on their conservation status (t&d/r-l: threatened & declining and/or red-listed species).

Variant F (fish):

The weighting of secondary criteria has to be considered also for fish species. The assessment methods for both distribution range and habitat quality are still under development and especially the latter is very hard to assess, since the habitat choice of many fish species is linked to life stages and therefore many relevant pressures are affecting the habitat quality of certain species. Size distribution is a proper parameter to assess criterion D1C3 but still data is not available for all fish species. Therefore, it is quite likely that the assessment of fish species could be limited to few criteria for the foreseeable future.

Assessment scenarios for fish differ only slightly from the recommended integration methods based on ICES (2018a-c). But as mentioned earlier it is possible that the general down-weighting of secondary criteria could lead to misleading assessment results at species level. Size distribution in fish populations (D1C3) gives an indication about the state of the population in relation to fishing pressure and has been used at fish community level to assess the status of species groups as a whole (OSPAR 2017b). Furthermore, population-based size distribution is mandatory for commercial fish species in the assessment of Descriptor 3 (D3C3). We assume, therefore, that it is likely that population-based size distribution might be included in the assessment of fish species and should be treated equally, when used, to the primary criteria.

The relevance of the outcome of the assessment of both D1C4 and D1C5 is treated slightly differently compared to the bird integration (Figure 9, Table 11). For the reasons explained above both abundance and size distribution are essential for the assessment of fish species. If one or both of these fails, the status of the species must be considered poor in order to be aligned with assessments of a commercial species under Descriptor 3 and used under Descriptor 1. But both distribution (D1C4) and quality of the habitat (D1C5) are important parameters and must be included in the integration, when used. This is important especially when D1C1 is not assessed or D1C2 is assessed as relative abundance (dependent on both distribution and habitat quality), which is likely for most non-commercial species (Figure 9, Table 11). Irrespective of giving weight to D1C4 and D1C5 in the integration or not, these are important criteria to assess the future threat to populations. If D1C1-D1C3 are passing, the overall status is good, even if D1C4 and D1C5 are failing. Then, the latter two criteria are still indicating that the population is at risk to fail the next assessment. All criteria should be seen as independent parameters when used for planning programmes of measures, in order to react as early as possible to relevant adverse effects.

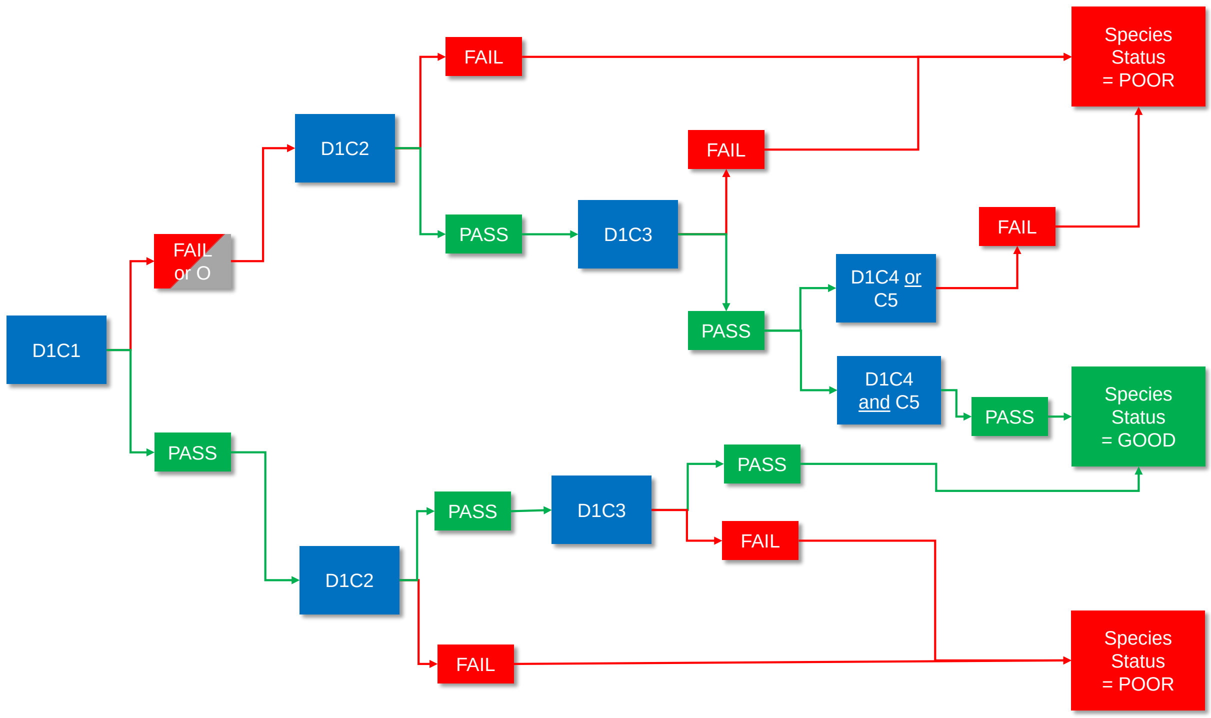

Figure 9. Proposed rules for integrating criteria to assess the status of a fish species (Variant F), based on Variant E and Table 11, slightly changed.

Table 11. Decision guide for GES decision for integrating criteria to species following conditional rule Variant F for fish species. Based on ICES (2018a), but adjusted to take account for the use of D1C3 in the assessment of fish species. N – Criterion fails GES, Y – Criterion in GES, O – Missing data or reference level but criterion relevant to assessment, NA – Not applicable, criterion result irrelevant to assessment.

	Assessment scenario												
Criteria	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**
D1C1	N or O	N or O	N or O	N or O	N or O	N or O	Y	Y	Y	N	N	NA or O	NA or O
D1C2	N	Y or N	Y	Y	Y	Y	Y	N	O	O	Y	O	O
D1C3	Y, N or O	N	Y	Y	Y	Y	Y or O	Y, N or O	N	Y	O	O	O
D1C4	Y, N or O	Y, N or O	N	Y or O	N	Y	Y, N or O	Y, N or O	Y, N or O	Y, N or O	Y, N or O	Y	N
D1C5	Y, N or O	Y, N or O	Y or O	N	N	Y	Y, N or O	Y, N or O	Y, N or O	Y, N or O	Y, N or O	Y	N
species status	poor	poor	poor	poor	poor	good	good	poor	poor	poor	good	NA	poor

4 Integration methods used in other EU directives

The integration of biodiversity assessments is a common approach to the Birds Directive (2009/147/EC) and the Habitat Directive (92/43/EEC), linked as an ecological network known as NATURA 2000, and to the Water Framework Directive (2000/60/EC, WFD) to evaluate the status of unique and valuable species, habitats, and water quality. However, methods of integration differ between these policies due to the scale of the assessment units, the types of indicators (e.g. trend-based, qualitative, quantitative, metrics etc.), and the integration approach (i.e. conditional, average etc., see section 3).

For the Habitats Directive, the conservation status of species (listed in Annexes II, IV and V of the Habitats Directive) is assessed within the Member State's biogeographic marine region, by using three main parameters[11], i.e. population, range, and habitat for the species (Table 12). These parameters are studied per species using short- and long-term trends and Favourable Reference Values (FRV) that are set from reference-based and model-based approaches (DG Environment 2017). Positive and negative changes in parameter trends are evaluated using a threshold of 1% per year (Table 12), while FRVs are set using a stepwise approach depending on data availability and species knowledge (DG Environment 2017).

The conservation status of a species, i.e. 'favourable', 'unfavourable-inadequate', 'unfavourable-bad' and 'unknown', is assigned at parameter level and across parameters (overall conservation status) using a conditional approach (DG Environment 2017). At parameter level, "if…then" scenarios consider species trends and FRVs, while across parameters the assessment builds on the status of single parameters (Table 12).

Finally, range, population and habitat of a species are evaluated by an additional parameter, i.e. future prospects, for which the conservation status is assigned based on the balance between future trends and current status (Table 12).

Table 12. Parameters and methods of the Habitats Directive to assess species conservation status.

Parameter	**Methods for assessing the parameter**	**Assessing the conservation status of the parameter**	**Overall conservation status of a species**
Population	Trends: short and long term Reference-based (at least 50 yrs data evaluations) Model-based: Population Viability Analysis (PVA), Minimum Viable Population (MVP), MPV-targets	FAVOURABLE: Population ≥ Favourable Reference Population (FRP), and reproduction, mortality and age structure not deviating from normal INADEQUATE: Population < FRP, and reproduction, mortality and age structure are deviating from normal BAD: Loss > 1% yr^{-1} within specific period, and < FRP. OR <FRP by 25%. OR reproduction, mortality and age structure are deviating from normal. UNKNOWN: insufficient data available	GREEN: all parameters are favourable OR three are favourable and 1 is unknown AMBER: one or more parameters are inadequate but not bad RED: one or more parameters are bad
Range	Trends: short and long term Potential-range methods: Species Distribution models (SDMs). Habitat suitability Flyway (for birds, migratory fishes)	FAVOURABLE: range ≥ Favourable Reference Range (FRR) INADEQUATE: range is < FRR and decreasing BAD: range is declining. Loss > 1% yr^{-1} within specific period OR < FRR by 10% UNKNOWN: insufficient data available	GREY: all are unknown or a combination of two/three unknown and one green
Habitat for the species	Trends: short and long term	FAVOURABLE: area is large or stable or increasing AND habitat quality is	

[11] These parameters are equated to the MSFD criteria in Annex 3 of SWD(2020) 62.

Parameter	Methods for assessing the parameter	Assessing the conservation status of the parameter	Overall conservation status of a species
	Area-based method and SDMs	suitable for long-term survival of the species (stable or increasing) INADEQUATE: area is decreasing AND habitat quality is decreasing or stable or unknown BAD: area cannot support long-term survival OR habitat quality is bad UNKNOWN: insufficient data available	
Future prospects	Balance between threats and measures (view of predicted future trends)	FAVOURABLE: all parameters are favourable OR one is unknown and the others are good BAD: one or more parameters is "unfavourable". Long term viability is at risk UNKNOWN: two or more unknown and no parameter with bad status	

The Bird Directive does not require a final integrated assessment of species conservations status. Bird species are studied based on the population size and trend, breeding distribution map and trends (Table 13). In addition, bird species are assessed per Member State and are not differentiated by biogeographic marine region. The reports at Member State level are used to derive conservation status for bird species at EU level.

Table 13. Parameters and methods of the Birds Directive for reporting at Member State level.

Parameter	Methods for assessing the parameter	Method for the status of the species parameter
Population size and trend	Estimates: minimum, maximum, best single value Trends: short (12 yrs) and long (from 1980 ca) term	• Type of estimate • Trend direction (stable, increasing, decreasing): overall change of 10% over the period for short-term trends, and 20% for long-term trends • Trend magnitude (increasing, decreasing, unknown): overall percentage change in population size over the trend period
Breeding distribution size and trend	Map: breeding occurrences (presence, absence) following the European Breeding Bird Atlas ([12]) as 10 km x 10 km grid. Trends: short (12 yrs) and long (from 1980 ca) term	• Surface area • Trend direction: overall change of 10% over the period for short-term trends, and 20% for long-term trends • Trend magnitude (increasing, decreasing, uncertain): overall percentage change in distribution size over the period

For the Water Framework Directive, ecological and chemical status is assessed within the River Basin Districts of the Member States, and is assessed at the scale of water bodies for surface and groundwaters (WFD Art. 4, Annex V). For surface waters, this assessment is based on the ecological status which includes biological, hydro-morphological and physico-chemical quality elements, and the chemical status based on the concentration of

([12]) http://www.ebba2.info/wp-content/uploads/2015/01/EBBA2_methodology_final.pdf, Keller et al. 2020 certain pollutants (WFD 2016). Both ecological and chemical status reflect the structure and functioning of surface aquatic ecosystems (European Communities 2003, Table 14).

The WFD requires that the quality elements are assessed for each water category (i.e. river, lake, transitional, coastal, territorial, unpopulated) and type (i.e. natural, heavily modified, artificial, unknown, unpopulated). Each quality element is evaluated based on the deviation from reference conditions and then assigned to a status category (i.e. high, good, moderate, poor, bad) (Table 14). The worst element status achieved by the quality elements determines the overall status of the water body following the OOAO integration approach (Table 14, CIS 2003).

Table 14. Ecological status and chemical status elements and final assessment of a WFD water body.

<table>
<tr><th></th><th>Elements</th><th>Methods for assessing the elements</th><th>Status of water body</th></tr>
<tr><td rowspan="3">Ecological status</td><td>Biological quality elements: phytoplankton, phytobenthos, benthic invertebrates, fish, macrophytes</td><td>Class boundaries using the ecological quality ratios (EQRs). Range 0-1, from bad to high.
High: no deviation
Good: none of the BQE can be more slightly altered from reference conditions
Moderate: one or more of BQEs may be moderately altered
Poor: major alterations to one or more BQEs
Bad: severe alterations to one or more BQEs</td><td rowspan="4">High/Good/Moderate/Poor/Bad

OOAO approach: the status of the worst element used in the assessment determines the final status.
It considers both the ecological status and the chemical status</td></tr>
<tr><td>Physico-chemical elements: nutrients, organic pollution, acidification, River Basin-Specific Pollutants</td><td>High: within the range of conditions associated with undisturbed
Good: MS standards
Moderate: MS standards
Poor: MS standards
Bad: MS standards</td></tr>
<tr><td>Hydromorphology elements: hydrology, morphology, barriers</td><td>High: very minor human alterations
Good: must support the BQEs
Moderate: must support the BQEs
Poor: must support the BQEs
Bad: must support the BQEs</td></tr>
<tr><td>Chemical status</td><td>Priority substances</td><td>Good: specific guidelines
Bad: specific guidelines</td></tr>
</table>

In conclusion, different principles are used in the Birds Directive, Habitats Directive and Water Framework Directive to integrate a number of variables (i.e. parameters, elements) into an overall assessment of status. These approaches have advantages and disadvantages (see section 3) and reflect both the structural strategy of the policies and the reliability of the elements to be aggregated.

5 Test of proposed integration methods: criteria to species

A test of the various integration methods introduced in Section 3 is most useful with real data. In this section, such a test was conducted with the example of marine birds in the German section of the Baltic Sea. However, for the German 2018 Article 8 MSFD seabird assessments, indicator assessments were only available for one criterion (D1C2). In order to produce a complete test dataset, the status of the other criteria was assessed for the species breeding and wintering in the German section of the Baltic Sea. This was done by using literature data and expert opinion. Altogether, the test integration is based on the following assumptions regarding the five D1 criteria for birds:

- D1C1: The HELCOM indicator dealing with seabird incidental bycatch has been developed and adopted by all HELCOM Contracting Parties (HELCOM 2018a), but could not be operated for assessments so far, because data on bycaught birds and fishing activities have not been available. Rather, here it was followed the recommendations of the “OSPAR-HELCOM workshop to examine possibilities for developing indicators for incidental bycatch of birds and marine mammals” (September 2019, Copenhagen) that, in the absence of an assessment for D1C1, the criterion is considered to have failed if the population is known to have a bycatch problem, according to expert judgement and bycatch records, and is treated as threatened on the regional Red List. This was applied to wintering birds treated as vulnerable, endangered or critically endangered by HELCOM (2013).

  It is assumed that diving seabirds in parts of the German Baltic Sea with extensive gillnet fishing are considerably affected (see Sonntag et al. 2012) and thus are failing the criterion, whereas species associated with habitats in areas with less fishing activity are less affected and passing. Species possibly affected only from long-line fisheries are considered to pass the criterion, because long-lining is not applied much in the German Baltic Sea and spatio-temporal overlap with concentrations of seabirds is very low (BfN 2020).

- D1C2: Real data are used from the two HELCOM abundance indicators on the geographic scale of aggregated sub-basins (here: aggregation of Kiel Bay, Bay of Mecklenburg, Arkona Basin, Bornholm Basin; see HELCOM 2018b, 2018c). The indicator results were scaled from 0 to 1, with the indicator threshold of 70% of the baseline abundance set at 0.6 (scaling according to Andersen et al. 2014).
- D1C3: No HELCOM indicator available. Existing knowledge and estimates about breeding success of seabirds at the German Baltic Sea coast was introduced into the new concept of a D1C3 indicator currently developed by JWGBIRD for OSPAR, where breeding success is related to expected population growth rates (ICES 2020).
- D1C4: No HELCOM indicator available. Existing knowledge about changes in seabird distribution were considered. For breeding birds, this was substantiated by comparing presence according to old and new species distribution atlas data (Berndt et al. 2002, Eichstädt et al. 2006, Koop & Berndt 2014, Vökler 2014).
- D1C5: No HELCOM indicator available. The passing or failing of this criterion was estimated in relation to the concept of an indicator currently under development by JWGBIRD, which compares occurrences of seabirds and human activities disturbing them (ICES 2020). The estimates are predominantly based on species-specific reactions to shipping (Fliessbach et al. 2019), offshore wind farms (Dierschke et al. 2016) and disturbance of the sea-floor by bottom trawling and aggregate extraction (benthic feeders only).

Notwithstanding the German 2018 Article 8 reporting (BMU 2018), breeding and wintering birds of the same species are treated as separate populations, just as recommended by ICES (2018c), JWGBIRD (ICES 2018d), Commission Decision (EU) 2017/848 and in line with reporting under the Birds Directive. For the sake of convenience, populations are called species hereafter.

Some of the methods require calculations with scaled assessment results. While for D1C2 the real assessment results have been used, estimates were generated for all the other criteria. More details on the procedures are given under the respective subsection.

In total, testing included 52 populations of 43 species, i.e. nine species were entered as both breeding and wintering bird populations. Twelve species were considered as breeders only, 22 exclusively as wintering birds. In order to prevent any misinterpretation, the 52 populations and the five species groups were kept anonymous.

As D1C1 (bycatch) was not applied to breeding birds ([13]) and D1C3 (breeding success) is not applicable for wintering birds, most species were given assessments for four criteria. Species not prone to bycatch due to their feeding mode were also excluded from D1C1 assessments, therefore the respective wintering populations were assessed using three criteria only. The outcomes of integration in relation to the method applied are shown in Table 15. The proportion of species in good status ranges from 42% to 65%. The background data for indicator outcomes and integration (including values for averages and weighted averages) are given in Table 18 (Annex 1).

Table 15. Outcome of integration from criteria to species for 52 waterbird species in the German section of the Baltic Sea (indicator status based on real data for D1C2 and estimated values for the other criteria).

Integration method	no. of species in good status	no. of species in poor status	proportion of species in good status
One-Out-All-Out (WKDIVAGG, ICES 2018a), Figure 1	22	30	42%
Proportional rule (WKDIVAGG, ICES 2018a)	28	24	54%
Average, normalized indicator outcomes (WKDIVAGG, ICES 2018a)	30	22	58%
Weighted average, normalized indicator outcomes (WKDIVAGG, ICES 2018a)	30	22	58%
Weighted average, normalized indicator outcomes (this paper)	29	23	56%
Conditional rules Variant A (ICES Advice, ICES 2018c), Figure 2	34	18	65%
Conditional rules Variant B (JWGBIRD, ICES 2018d), Figure 3	27	25	52%
Conditional rules Variant C (WKDIVAGG option 1, ICES 2018a), Figure 4	27	25	52%
Conditional rules Variant D (WKDIVAGG option 2, ICES 2018a), Figure 5	23	29	44%
Conditional rules Variant E (this paper), Figure 6	27	25	52%

5.1 One out, all out (OOAO)

Thirty out of 52 species (58 %) showed poor status, because at least one out of the three or four criteria was indicating poor status (Table 15 and Table 18). This method does not distinguish between primary and secondary criteria, so all five criteria contributed to failures of species.

This method is the most conservative, but it is sometimes criticised and associated with giving false alarms (sensitive to raise and overweight problematic criteria assessments to a higher integration level). OOAO has the advantage of being simple to apply, explain and understand. Any poor status rating is visible at higher levels and can be directly traced back to one or more poor status indicators and is easily communicated to the public and decision makers. It assumes that poor status in a criterion does not occur accidentally, but due to ecological connections in reaction to the effects of anthropogenic activity. In this way, there is no 'masking' of poor status indicators by other indicators and hence, alarms are not 'missed' in the process. This reflects Commission Decision (EU) 2017/848 Article 3 (2): "Secondary criteria and associated methodological standards, specifications and standardised methods laid down in the Annex shall be used to complement a primary criterion or when the marine environment is at risk of not achieving or not maintaining good environmental status for that particular criterion."

This is confirmed in this test assessment, since OOAO provides the strictest assessment.

([13]) The indicator "Number of drowned mammals and waterbirds in fishing gear" is directed to assess bycatch in relation to wintering populations of waterbirds. Certainly, bycatch also affects breeding birds during the breeding season, but this cannot be assessed with the current indicator design.

5.2 Proportional method

At species level, the conditional rule that 75% of assessed criteria have to indicate good status to result in overall good status of the species was applied. The 75% value is an established threshold in relation to indicators, e.g. already introduced in the OSPAR EcoQOs of seabird abundance (ICES 2008). The proportional method could be even used for indicators. Thus, at least three criteria in good status were required, regardless of three or four criteria were assessed. Out of the 52 species tested, 28 (54%) were in good status.

Application of this method only makes sense when at least four criteria can be assessed, otherwise it would resemble OOAO. With four criteria assessed and the 75% threshold the risk of masking poor-status indicators and thus the chance of missing alarms is only slightly higher than in OOAO. WKDIVAGG (ICES 2018a) found this approach appropriate in case of uncertainties regarding estimated indicator metrics and setting thresholds, but also when the pressure-state relationship is disturbed by other anthropogenic factors acting concomitantly. In practise, it appears unlikely that each species can be assessed by three or even four criteria. Therefore, problematic criteria assessments can be strongly decisive in the overall assessment, introducing the same uncertainties as in OOAO.

5.3 Averages

Averaging indicators requires normalising the indicator results, meaning that indicator assessments using different units (e.g. breeding pairs, expected population growth rate, proportion of habitat lost) need to be brought to a common denominator. Here, normalising was done following the BEAT tool (Andersen et al. 2014), i.e. the indicator threshold value for good status is rescaled to 0.6, values below this are rescaled to fall between 0 and 0.6 and values above rescaled to fall between 0.6 and 1. While this rescaling was applied to the real D1C2 bird indicator results, estimates reflecting the assumed distance to the threshold of good status were used for the other four criteria. Averaging was done regardless of criteria being primary or secondary. A relatively high number of species (30 out of 52 or 58%) achieved good status using this averaging method.

WKDIVAGG (ICES 2018a) highlighted that a strong advantage of this method is that it provides a direct measure of distance to the target, both for the average and for the individual criteria. Averaging implies that deficits in one criterion can be compensated by others being above the threshold. Transferred to marine birds, poor breeding success (D1C3) may be compensated for by a stable population size above threshold (because of high adult survival, at least for a while; D1C2) and by effective measures against bycatch (D1C1) and habitat loss (D1C5). While this could be seen as reflecting the realistic status of a species, on the other hand specific problems for a species could be masked. For example, severe bycatch problems of a species would not be reflected in the species assessment, when the other criteria outweigh the low value of the D1C1 assessment. In such a case, it would be detected that measures are needed because of the poor assessment of D1C1, but there would be no legal requirement to improve the situation, because the species is at GES.

5.4 Weighted averages

In principle, just like the former method, normalized averages were calculated, but the primary criteria (D1C1 and D1C2 in birds) were given more weight than the secondary ones (D1C3-C5 in birds). WKDIVAGG (ICES 2018a) used the example that the weight of D1C1 equals that of D1C2 and the combination of D1C3-C5. In this scenario, weighted averaging gave the same result as unweighted averaging, i.e. 30 out of 52 species (58%) were in good status.

Another variant of weighting is applied here in order to follow considerations about the informative value of the five criteria in the case of bird assessments. A high weight should be given to those criteria and indicators, respectively, which directly measure the status of the population: D1C1 and D1C3 (related to mortality and reproductive rates, i.e. to population growth rates) as well as D1C2 (showing trends in population size). Relatively low weight should be given to D1C4, as distribution was identified as telling least about the status of species. Intermediate weight should be given to D1C5, because quality and disturbance of habitats describe the conditions birds face and thus influence the potential to recover or maintain population sizes. This ranking is expressed by factors 3 (D1C1, D1C2, D1C3), 2 (D1C5) and 1 (D1C4) in the weighting of criteria.

To account for incomplete assessments or the varying number of applicable indicators among species, the two groups of criteria (population-related, environment-related) form separate factors in the calculation of weighted averages:

$$\text{species status} = \frac{3 * \frac{C1+C2+C3}{3} + \frac{C4+2*C5}{3}}{4}$$

While the first term represents the average of the population-related criteria (which are considered threefold), the second term represents the environment-related criteria (which are considered only once, but within this term D1C5 has double weight). If one indicator is not applicable or has no data, the quotients of the terms have to be adjusted. Further, if for instance both D1C4 and D1C5 give no data, then the quotient of the whole formula needs adjustment.

Applying this alternative way of weighting to the anonymous test data gives good status in 29 out of 52 species (56%).

In general, the same pros and cons as in the averages method apply to the weighted averages method, but weighting offers possibilities to direct the assessment to those criteria which are thought to be most meaningful when considering the status of a species in relation to pressures to be addressed by MSFD Article 13 measures. The weighting method of WKDIVAGG (ICES 2018a) is not preferable, because, just as in other approaches discussed here, the weight of D1C3 is only minor. The more advanced approach outlined here pays much more attention to the informative value of the individual criteria and could be an option for bird species assessments. However, the difference between the test results of the two variants of weighted averages are only minor (58% vs. 56% of species in good status).

5.5 Conditional rules

Depending on which of the proposed variants of conditional rules is applied, between 23 (44%) and 34 (65%) out of 52 species assessed were in good status (Table 15). The different outcomes are specific to the scenario of all individual indicator outcomes. However, because much weight is put on the primary criteria in all approaches (as predefined by Commission Decision (EU) 2017/848 and Walmsley et al. 2017), it is worth highlighting the role of the secondary criteria in the four approaches:

- Variant A (ICES Advice, ICES 2018c): If both primary criteria are assessed and one of them is poor, good status of combined D1C3-C5 can give good overall status (scenarios A2 and A5). Poor combined D1C3-C5 cannot change the result in any direction. For species, which are not relevant for D1C1 (i.e. are not prone to be bycaught), the secondary criteria are completely meaningless which is not in line with Commission Decision (EU) 2017/848. Any implication for measures owing to poor status in secondary criteria would be missed.
- Variant B (JWGBIRD, ICES 2018d): a) If both primary criteria are in good status, poor status of combined criteria D1C2-C5 can overrule this and give overall poor status (scenario B3). This is very unlikely, because D1C2 has much weight in the combination of D1C2-C5, and if D1C2 is in good status in this scenario anyway, the secondary criteria would have to exceed the threshold by a large degree in order to bring combined D1C2-C5 into poor status. It is possible that D1C2 appears to be in good status just because marine birds are usually long-lived, while alarms from the secondary criteria are missed and the need for action is obscured. b) To get overall good status combined D1C2-C5 must be good, if D1C2 is good and D1C1 is not applicable or not assessed (scenario B8). Again, because of much weight of D1C2 in the combination, it is very likely that this happens and very unlikely that combined D1C2-C5 can lead to an overall poor status (scenario B9). Thus, due to much weight of D1C2 in the combination with the secondary criteria, the influence of the latter to the overall outcome is very little.
- Variants C and D (WKDIVAGG, ICES 2018a): a) Combined D1C2-C5 (Variant C) or D1C3-C5 (Variant D) have to be in good status for getting overall good status, even if both primary criteria are in good status (scenarios C1 and D1). b) Combined D1C2-C5 (Variant C) or D1C3-C5 (Variant D) have to be in good status for getting overall good status, if only D1C2 is assessed (scenarios C6 and D6). In Variant C, the influence of secondary criteria is low, because (just as in Variant B) D1C2 is combined with them. In Variant D, the influence of secondary criteria is much higher, because they enter the assessment independently of the primary criteria.
- Variant E: Application of this conditional method to the anonymous test data gives good status for 27 out of 52 species (52%). The influence of secondary criteria is relatively strong, especially regarding D1C3, which is designed for reflecting the high informative value of that criterion in birds. In case indicator results of D1C1, D1C2 and D1C3 are contradictory, the criteria D1C4 and D1C5 may be decisive.

In summary, it is quite clear that in most proposed conditional rules the influence of the secondary criteria for the outcome of bird assessments is very low or even practically absent. Translated into the subject of the criteria (and the likely conclusions from the indicator outcomes) it means that mortality from bycatch demonstrably affecting population size negatively (D1C1) has strong weight, as has the population size itself (D1C2). In contrast, weight of problems in reproducing sufficiently to maintain the population size (D1C3), changes in distributional patterns (D1C4) and habitat loss due to human activities (D1C5) is negligible in the variants A, B and C. Only variant D allows that poor signals from the secondary criteria could adjust the outcome of a species assessment independently from the primary criteria, which is in line with Commission Decision (EU) 2017/848 Article 3 (2): "*Secondary criteria and associated methodological standards, specifications and standardised methods laid down in the Annex shall be used to complement a primary criterion or when the marine environment is at risk of not achieving or not maintaining good environmental status for that particular criterion*." This demand from the Commission Decision is best implemented in Variants D and E.

This result of comparing variants of conditional rules has to be considered when matching with the aims of MSFD (introducing Article 13 measures as response to Article 8 assessments compared to Article 9 Good Environmental Status) is aspired.

5.6 Conclusion

In this test assessment of marine birds in the German Baltic Sea, 35 out of 52 species were in an overall good status with at least one of the integration methods applied. The integration method with the highest number of species in good status (34 species when applying conditional rules Variant A according to ICES Advice) nearly matched this, i.e. only one species attained good status with another method exclusively. Overall, the species assessments are very similar regardless of the integration method applied. It needs to look at subtle characteristics of the methods accurately in order to find out which of them is best fitting the requirements of MSFD.

It is worth considering which methods would mask alarms (i.e. the failure of a single criterion) or could transport them to higher levels of integration. In this respect, OOAO is most strict, because any alarm has considerable impact on the overall assessment result, whereas other methods allow compensating individual poor assessments by good status in other criteria. Weighing the specific statements of the individual criteria against each other in order to arrive at a plausible assessment of the status of a species is best achieved with Variant E of the conditional rules.

For fish, similar results could be expected, but the range of possible criteria is limited. Based on discussions within both HELCOM and OSPAR the assessment of fish is currently restricted to abundance (D1C2), size distribution (D1C3) and possibly D1C1 and D1C4 (OSPAR pilot assessment). The assessment of incidental by-catch concerning fish has not been discussed intensively yet in either HELCOM or OSPAR. Due to the limited number of criteria and subsequently indicators used, some of the abovementioned options for integration of criteria could be excluded at the moment, i.e. proportional method (between criteria), averages or weighted averages between criteria. The OOAO method could be preferred if only D1C2 and D1C3 (size distribution) will be used in future assessments of fish species. By using this integration method consistency with the assessment of D3 is secured, since Commission Decision (EU) 2017/848 demands that all criteria within D3 are in good status. Conditional rules could be applied if even D1C1 is assessed for fish species. Preferably, a combination of a conditional rule between D1C1 and D1C2 and consecutively OOAO between D1C1/D1C2 and D1C3 could applied. This could be tested as soon as concrete plans for the assessment of D1C1 or other criteria for fish become available.

6 Test of proposed integration methods: species to species group

For birds and fish, WKDIVAGG recommended to apply proportional or probabilistic methods for the integration from species to species group, but already realised that the probabilistic method could be difficult to use because estimates of uncertainty may not be available for all indicators (ICES 2018a). However, for species groups with a small number of species, OOAO may be appropriate. Here we apply the proportional method and OOAO to the bird species assessments (Table 18 in Annex 1) stemming from the test integration from criteria to species with the conditional rules according to the ICES Advice (ICES 2018c). Neither averages and weighted averages nor conditional methods are considered in this context. The 52 species are dispersed over five species groups, and the number of species per group varies between six and 15. Again, species as well as species groups are kept anonymous, despite the test assessments relying on true data and realistic estimates (see section 5).

6.1 One out, all out (OOAO)

All the five species groups contained at least one species in poor status, therefore all species groups would fail to attain good status (Table 16). As already stated in section 5, with OOAO there is no masking of poor-status species by other species and hence, alarms are not missed. The same is true when OOAO is applied to the assessment of fish in both German and Swedish waters (Table 17).

WKDIVAGG (ICES 2018a) suggests applying OOAO for groups containing five species or less. This refers to species groups in a region which are only inhabited by a limited number of species of an ecosystem component.

6.2 Proportional method

In parallel to the bird abundance indicators of HELCOM and OSPAR (ICES 2008, HELCOM 2018b, 2018c, OSPAR 2017a), in this test assessment as well as in the bird assessments of some EU Member States a species group is considered to be in good status, if at least 75% of the species are in good status. Applied to the five bird species groups the result is that four groups are in poor status, because only between 33% and 73% of the species are in good status. Only one group achieved good status, because the limit of 75% is surpassed (89%, see Table 16). As here all bird species were assessed and could be integrated to species group assessments, it has to be clarified that the threshold of a proportion of species in good status applies to all species of the regionally agreed list, including those which could not be assessed for any reason.

In fish species group assessments conducted by Sweden and Germany, no species group achieved GES if at least 75% of the species have to be in good status. The highest proportion of species in good status in an individual species group is 67% (Table 17).

This method is easy to understand and retains information on the proportion of species in good or poor status. It also allows for natural variability (avoidance of “false alarm”) and the chance that some species may not be at GES. In the examples, between three and six bird species in poor status were encountered. Nonetheless the limit of 75% is not too strict, because it allows 25 % of the species to be in poor status. 75% is in range of possible limits (60-80%) recommended by ICES (2018c). However, if adopting the lowest limit (60%) two more bird species groups would attain good status with 70% and 73%, respectively, while a limit at 80% would give the same result as with 75% (Table 16). Also, two out of ten fish species assessments shown in Table 17 indicate good status if 60% would be the limit.

Table 16. Test assessments for species groups of waterbirds in the German section of the Baltic Sea using outcomes of species assessments with ICES Advice conditional rules in Table 18**Table 18** (Annex 1).

species group	no. species in GES	no. species in sub-GES	status of species group: OOAO	status of species group: proportional method (GES limit 75%) and proportion of species in GES
species group #A	7	3	sub-GES	sub-GES (70%)
species group #B	11	4	sub-GES	sub-GES (73%)
species group #C	6	6	sub-GES	sub-GES (50%)
species group #D	2	4	sub-GES	sub-GES (33%)
species group #E	8	1	sub-GES	GES (89%)

Table 17. Overview of assessments from the latest initial assessment 2018 from both Germany (DE) and Sweden (SE) for fish species groups (for coastal fish assessment in Sweden, see text).

species group	no. species in GES	no. species in sub-GES	no. species not assessed	status of species group: OOAO	status of species group: proportional method (GES limit 75%) and proportion of species in GES
North Sea					
demersal shelf fish (DE)	6	6	4	sub-GES	sub-GES (38%)
demersal shelf fish (SE)	7	9	14	sub-GES	sub-GES (23%)
pelagic shelf fish (DE)	2	5	2	sub-GES	sub-GES (22%)
pelagic shelf fish (SE)	1	3	3	sub-GES	sub-GES (14%)
coastal fish (DE)	2	3	1	sub-GES	sub-GES (33%)
Baltic Sea					
demersal shelf fish (DE)	4	2	2	sub-GES	sub-GES (50%)
demersal shelf fish (SE)	0	7	3	sub-GES	sub-GES (0%)
pelagic shelf fish (DE)	2	1	0	sub-GES	sub-GES (67%)
pelagic shelf fish (SE)	2	1	0	sub-GES	sub-GES (67%)
coastal fish (DE)	1	4	4	sub-GES	sub-GES (11%)

6.3 Conclusion

The narrowing to only two methods for integration from species to species groups proposed by WKDIVAGG (ICES 2018a) is feasible as is the choice of OOAO for groups with few (less than five) species and the use of the proportional method for five or more species in a group ([14]). Where the proportional method is used, it needs thorough consideration about which proportion of species in good status is set as a threshold.

Furthermore, it is important to define a threshold for the proportion of species which could be assessed within a species group for the fish assessment. In contrast to birds there will always be a number of fish species, which cannot be assessed, because many fish species cannot be covered with a statistically satisfying confidence with today's monitoring methods. The assessment of coastal fish differs between Germany and Sweden. In Sweden coastal fish was assessed first in the relevant coastal water type which corresponds with the distributional range of the assessed populations. If the majority of the populations achieved good status the costal water type was assessed as being in good status regarding coastal fish. At least 90% (used in the initial assessment of 2018, but will be revised for future assessments) of the coastal water types in the North Sea and Baltic Sea respectively have to achieve good status for assessing the whole region or sub-region as being at GES. So, for Swedish waters it would be possible to apply a proportional method, similar to the one used for demersal and coastal shelf fish species, for the assessment of coastal fish species in the coastal water type and for the aggregation of coastal water types up to region or sub-region. Germany did not distinguish between different coastal water types, but a proportional method for coastal, demersal and pelagic fish would be applicable as well.

([14]) If 75% of species is the threshold for good status of a species group with four species or less, the proportional method resembles OOAO, because with only one species in poor status the threshold would be missed.

7 Test of proposed integration methods: species/ species group to ecosystem component

Although integration to the level of ecosystem components (e.g. birds, fish) is not required by MSFD, summarising information may be useful and illustrative. WKDIVAGG suggested to integrate from species groups to ecosystem component using OOAO or integrating from species to ecosystem component (leapfrogging the species groups level) applying the proportional method (ICES 2018a). This is consistent with the number of elements to be integrated in section 6. These two approaches are tested with anonymous bird data from Table 15 and Table 16.

7.1 One out, all out (OOAO, species groups to ecosystem component)

Out of the five bird species groups tested, four were in poor status and only one achieved GES, when relying on the outcomes of integration with the proportional method from species to species group (Table 16). Thus, the ecosystem component 'birds' failed to be in GES.

No species group can replace another species group in the ecosystem, because each species group is representing a particular functional role in the marine ecosystem. Therefore, an ecosystem component cannot be considered to be in good status if one or more of the assessed species groups are considered to be in poor status (ICES 2016, 2018a). As a result of this, it is recommended that OOAO integration is used from species group to ecosystem component. Other methods could mask the alarm that a group is in poor status and its role in the ecosystem is at least partly vacant.

7.2 Proportional method (species to ecosystem component)

This suggestion is not in line with Commission Decision (EU) 2017/848 as reporting on the status of the species group is required. Regardless of which integration method from criteria to species was applied, the test assessments did not give good status for the ecosystem component birds (Table 16). The highest proportion of species in GES reached was 65% (34 out of 52 species), when the conditional rules of the ICES Advice are followed. In the ICES Advice (ICES 2018c) this proportional approach is favoured, because the risk of false alarms is much lower than in the OOAO approach, where every individual species can strongly affect the overall outcome.

7.3 Conclusion

The Commission Decision (EU) 2017/848 does not require the integration of species groups to ecosystem component, but integration at the level of ecosystem component is a useful tool to present assessment results to policy and public. A summarising outcome could be most illustrative, and OOAO integration from species groups to ecosystem component is recommended. However, if the status is sub-GES it is also important to convey which groups are not at GES.

8 Dealing with threatened and declining species

WKDIVExtinct (ICES 2018b) discussed how threatened and declining (red-listed) species can be handled in the process of integration. They suggested that critically endangered species or those upgraded to a higher risk class enter the integration from species to species group as species in poor status. However, still then alarms from species facing extinction might be obscured by GES of other species of the same species group (depending on the integration rule). WKDIVExtinct proposed to attach "red flags" to the threatened species to ensure that the signal of extinction risk remains visible throughout the integration process. In the MSFD framework this is required because status assessments under Article 8 shall trigger measures under Article 13 in cases of poor status and information about the need for measures should not be lost. Another option mentioned by WKDIVExtinct would be to create a separate "red list indicator".

WKDIVExtinct suggested to base such approaches on the global IUCN red list, considering bird and fish species listed as threatened (categories VU – vulnerable, EN – endangered or CR – critically endangered). However, global assessments, especially of widely distributed species, do not necessarily reflect the current status of the species on the regional scale, which is more important with regard to the MSFD. To address this issue and to avoid inconsistencies in national assessments between countries, regional red lists such as the OSPAR list of threatened/declining species[15] or the HELCOM Red List (HELCOM 2013) should be used, but it may be appropriate to use national red lists as well if the scale of regional red lists appears insufficient. In the end the most ecologically relevant list should be used.

Due to Commission Decision (EU) 2017/848 the selection of species is focusing on representativity, ecosystem functioning, relevance for assessment of impacts or particular life history traits. This includes threatened and declining (red-listed) species.

In birds, data deficiency is not a problem for most threatened species. Therefore, several species red-listed by OSPAR and HELCOM were included in the recent indicator assessments and the 2018 MSFD reporting from several EU Member States. Treating species, which are threatened and data deficient as being in poor status (ICES 2018b) thus would be an option for the remaining species, which could not be assessed via the indicators. This approach was also used by some EU Member States for D1 Fish assessment in MSFD 2018 reporting.

In order to avoid losing alarms and to safeguard that management measures for the recovery of threatened species are implemented, it is recommended to develop a separate system for triggering measures for threatened species in MSFD.

[15] https://www.ospar.org/work-areas/bdc/species-habitats/list-of-threatened-declining-species-habitats, 14 October 2020.

9 Recommendation /advice

Taking into account the pros and cons of the various integration methods and with reference to discussions at the DG ENV workshop held online on 18 June 2020 it is recommended to apply the following methods for integrated assessments:

A. From criteria to species

Birds: Use conditional rules of the Variant E (introduced in this paper), which allows to adjust indicator assessments of the primary criteria (D1C1, D1C2) by indicator assessments of the secondary criteria (D1C3, D1C4, D1C5) in a reasonable way. Variant E acknowledges the high informative value of criterion D1C3 without neglecting the importance of the primary criteria and with still giving weight to the other secondary criteria. It allows to trace problems that species experience in their marine environment and can inform programmes of measures (MSFD Article 13) where needed.

Fish: Use conditional rules of the Variant F (introduced in this paper). If criterion D1C3 is used it should be treated equally to D1C2 and D1C1 (if used), which practically means that a one-out-all-out approach could be used in the absence of information from the criteria D1C1, D1C4 and D1C5.

B. From species to species group

Birds: Apply proportional method if at least five species of a species group can be assessed. It is appropriate to use 75% of all species (including those not assessed) in good status as a threshold to identify a species group as being in good status: If a great majority of species in a group is doing well it is likely that the species group can maintain their ecological functions and ecosystem services. In a species group with less than five species assessments, One-out-all-out should be applied, because failure of one species can already lead to deficiencies in performing the role in the ecosystem. If species group assessments are masking extinction risk of threatened and declining species, consider developing a separate system for triggering measures for them.

Fish: In order to be consistent across groups of mobile species the same rules recommended for birds should be applied to fish species. Apply proportional method if at least five species of a species group can be assessed. It is appropriate to use 80% of all species (including those not assessed) in good status as a threshold to identify a species group as being in good status. In a species group with less than five species assessments, One-out-all-out should be applied. Populations (stocks) should be seen as independent assessment components in the respective assessment area, i.e. all populations within a relevant assessment area should be used in the integration of the species group.

If species group assessments are masking extinction risk of threatened and declining species, consider developing a separate system for triggering measures for them.

C. From species group to ecosystem component

If integration at the level of the ecosystem component is desired for communication purposes, use One-out-all-out when integrating from species groups to ecosystem component, because a failing species group cannot be replaced by another one.

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List of abbreviations and definitions

EU	European Union
GES	Good Environmental Status
HD	Habitat Directive
HELCOM	Helsinki Commission
ICES	International Council for the Exploration of the Sea
JRC	Joint Research Centre
JWGBIRD	Joint OSPAR/HELCOM/ICES Working Group on Marine Birds
MS	Member States
MSFD	Marine Strategy Framework Directive
OSPAR	OSPAR Convention
RSC	Regional Sea Convention
WFD	Water Framework Directive
WKDIVAGG	Workshop on MSFD biodiversity of species D1 aggregation
WKDIVExtinct	Workshop on extinction risk of MSFD biodiversity approach
WKSEQUIN	Workshop on Seabird Ecological Quality Indicator
UNEP-MAP	Barcelona Convention

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Annexes

Annex 1. Test assessments

Table 18. Test assessments for waterbird species breeding (bre) and wintering (win) in the German section of the Baltic Sea. Outcomes of the two HELCOM waterbird abundance indicators (subdivision Bornholm Group, HELCOM 2018b, 2018c) and data from German monitoring programmes (BMU 2018) were used for criterion D1C2, while the status was estimated from expert knowledge for all the other criteria. All estimates were normalized to the scale from 0 to 1 with 0.6 being the threshold for GES. All species groups and species are anonymised. The indicator outcomes are integrated following various methods explained in the text. For conditional rules, calculated values (averages) are only given when necessary. Green: GES, red: sub-GES (poor status). For more details see text.

	indicator outcomes						integration outcomes									
Species groups and species	**criterion D1C1 bycatch**	**criterion D1C2 abundance**	**criterion D1C3 demography**	**criterion D1C4 distribution**	**criterion D1C5 habitat for the species**		**One-Out-All-Out (ICES 2018a)**	**Proportional rule (ICES 2018a)**	**Average (ICES 2018a)**	**Weighted average (ICES 2018a)**	**Weighted average (this paper)**	**Conditional rules Variant A (ICES Advice; ICES 2018c)**	**Conditional rules Variant B (JWGBIRD; ICES 2018d)**	**Conditional rule Variant C (WKDIVAGG option 1; ICES 2018a)**	**Conditional rule Variant D (WKDIVAGG option 2; ICES 2018a)**	**Conditional rule Variant E (this paper)**
Species group #A																
species #Aa (win)	0.650	0.445		0.600	0.650				0.586	0.573	0.569	0.625				
species #Ab (bre)		0.513	0.650	0.500	0.600				0.566	0.548	0.578					
species #Ab (win)	0.650	0.833		0.650	0.650				0.696	0.711	0.719			0.742	0.650	
species #Ac (win)	0.650	0.691		0.600	0.450				0.598	0.622	0.628		0.636	0.608	0.525	
species #Ad (bre)		1.000	0.700	0.700	0.600				0.750	0.833	0.796			0.833	0.667	
species #Ad (win)	0.500	0.600		0.600	0.500				0.550	0.550	0.546	0.550				
species #Ae (win)	0.400	0.500		0.600	0.450				0.488	0.475	0.463					
species #Af (win)	0.400	0.800		0.650	0.550				0.600	0.600	0.596	0.600				
species #Ag (win)	0.450	0.600		0.650	0.550				0.563	0.550	0.540	0.600				
species #Ah (win)	0.650	0.843		0.650	0.600				0.686	0.706	0.714		0.770	0.734	0.625	
Species group #B																
species #Ba (win)	0.800	1.000		0.750	0.700				0.813	0.842	0.854		0.908	0.863	0.725	
species #Bb (bre)		1.000	0.700	0.650	0.600				0.738	0.825	0.792		0.883	0.825	0.650	
species #Bb (win)	0.700	0.669		0.600	0.650				0.655	0.665	0.672		0.654	0.647	0.625	
species #Bc (bre)		0.447	0.500	0.550	0.550				0.512	0.490	0.493					
species #Bc (win)	0.550	0.743		0.600	0.600				0.623	0.631	0.635	0.600				
species #Bd (win)	0.650	0.910		0.600	0.700				0.715	0.737	0.752		0.823	0.780	0.650	
species #Be (win)	0.450	0.600		0.600	0.700				0.588	0.567	0.560	0.650				
species #Bf (win)	0.600	0.600		0.650	0.650				0.625	0.617	0.613		0.617	0.625	0.650	
species #Bg (win)	0.450	0.600		0.600	0.400				0.513	0.517	0.510	0.500				

	indicator outcomes						integration outcomes									
Species groups and species	**criterion D1C1 bycatch**	**criterion D1C2 abundance**	**criterion D1C3 demography**	**criterion D1C4 distribution**	**criterion D1C5 habitat for the species**		**One-Out-All-Out (ICES 2018a)**	**Proportional rule (ICES 2018a)**	**Average (ICES 2018a)**	**Weighted average (ICES 2018a)**	**Weighted average (this paper)**	**Conditional rules Variant A (ICES Advice; ICES 2018c)**	**Conditional rules Variant B (JWGBIRD; ICES 2018d)**	**Conditional rule Variant C (WKDIVAGG option 1; ICES 2018a)**	**Conditional rule Variant D (WKDIVAGG option 2; ICES 2018a)**	**Conditional rule Variant E (this paper)**
species #Bh (win)	0.450	0.600		0.550	0.400				0.500	0.508	0.506	0.475				
species #Bi (bre)		0.903	0.850	0.700	0.600				0.763	0.810	0.816	0.717	0.841	0.810	0.717	
species #Bi (win)	0.800	1.000		0.800	0.650				0.813	0.842	0.850		0.908	0.863	0.725	
species #Bj (win)	0.700	0.600		0.800	0.600				0.675	0.667	0.654		0.633	0.650	0.700	
species #Bk (win)	0.600	0.600		0.650	0.600				0.613	0.608	0.604		0.608	0.613	0.625	
species #Bl (win)	0.500	0.600		0.600	0.500				0.550	0.550	0.546	0.550				
Species group #C																
species #Ca (bre)		0.363	0.500	0.600	0.500				0.491	0.448	0.457					
species #Ca (win)		0.400		0.600	0.650				0.550	0.513	0.458					
species #Cb (bre)		1.000	0.650	0.700	0.600				0.738	0.825	0.777		0.883	0.825	0.650	
species #Cb (win)	0.900	0.654		0.500	0.650				0.676	0.710	0.733		0.628	0.615	0.575	
species #Cc (bre)		0.865	0.500	0.600	0.550				0.629	0.708	0.654		0.760	0.708	0.550	
species #Cc (win)	0.900	0.400		0.500	0.650				0.613	0.625	0.638					0.600
species #Cd (bre)		1.000	0.700	0.850	0.650				0.800	0.867	0.817		0.911	0.867	0.733	
species #Ce (bre)		0.719	0.200	0.600	0.200				0.430	0.526	0.428		0.590	0.526	0.333	
species #Cf (bre)		0.106	0.300	0.300	0.300				0.252	0.203	0.227					
species #Cg (bre)		0.417	0.450	0.500	0.400				0.442	0.434	0.433					
species #Ch (bre)		0.591	0.400	0.600	0.400				0.498	0.529	0.488					
species #Ci (bre)		0.263	0.400	0.450	0.350				0.366	0.332	0.344					
Species group #D																
species #Da (bre)		0.822	0.500	0.500	0.600				0.606	0.678	0.637		0.726	0.678	0.533	
species #Db (win)		0.997		0.700	0.700				0.799	0.849	0.923		0.898	0.849	0.700	
species #Dc (bre)		0.613	0.550	0.650	0.550				0.591	0.598	0.582			0.598	0.583	0.583
species #Dd (bre)		0.580	0.450	0.500	0.500				0.508	0.532	0.511					
species #De (bre)		0.599	0.400	0.600	0.450				0.512	0.541	0.500					
species #Df (bre)		0.079	0.300	0.300	0.400				0.270	0.206	0.234					
Species group #E																
species #Ea (bre)		0.633	0.650	0.650	0.600				0.633	0.633	0.635		0.633	0.633	0.633	
species #Ea (win)		0.919		0.700	0.750				0.790	0.822	0.873		0.854	0.822	0.725	

	indicator outcomes						integration outcomes									
Species groups and species	**criterion D1C1 bycatch**	**criterion D1C2 abundance**	**criterion D1C3 demography**	**criterion D1C4 distribution**	**criterion D1C5 habitat for the species**		**One-Out-All-Out (ICES 2018a)**	**Proportional rule (ICES 2018a)**	**Average (ICES 2018a)**	**Weighted average (ICES 2018a)**	**Weighted average (this paper)**	**Conditional rules Variant A (ICES Advice; ICES 2018c)**	**Conditional rules Variant B (JWGBIRD; ICES 2018d)**	**Conditional rule Variant C (WKDIVAGG option 1; ICES 2018a)**	**Conditional rule Variant D (WKDIVAGG option 2; ICES 2018a)**	**Conditional rule Variant E (this paper)**
species #Eb (win)		0.875		0.700	0.700				0.758	0.788	0.831		0.817	0.788	0.700	
species #Ec (win)		0.460		0.600	0.750				0.603	0.568	0.520					
species #Ed (bre)		1.000	0.750	0.800	0.700				0.813	0.875	0.840		0.917	0.875	0.750	
species #Ee (win)		1.000		0.750	0.700				0.817	0.863	0.929		0.908	0.863	0.725	
species #Ef (win)		0.887		0.700	0.700				0.762	0.794	0.840		0.825	0.794	0.700	
species #Eg (win)		0.869		0.700	0.700				0.756	0.785	0.827		0.813	0.785	0.700	
species #Eh (win)	0.650	0.683		0.650	0.650				0.658	0.661	0.662		0.672	0.667	0.650	

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