Flyway trend analyses based on data from the African-Eurasian Waterbird Census from the period of 1967-2018

Compiled by
Szabolcs Nagy and Tom Langendoen

Wetlands International
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Introduction

Waterbirds are shared resources and shared responsibility. Their conservation and sustainable management and the sites they use is therefore the subject of various international treaties, such as the Ramsar Convention on Wetlands, the Convention on Migratory Species (CMS), the African Eurasian Migratory Waterbird Agreement (AEWA), the Bern Convention on European Wildlife and Natural Habitats and the EU Birds Directive, as well as national conservation and hunting legislation.

Flyway-level trend and population size analyses inform international and national management decisions. Population size and trend estimates are used in the global and regional Red List assessments, they inform the classification of waterbird populations on Table 1 of the AEWA Action Plan. This guides the subsequent application of the provisions of the Agreement. The population size estimates provide the basis to setting the so called 1% thresholds to select internationally important sites under the framework of the Ramsar Convention, the Bern Convention's EMERALD Network, the European Union's Natura 2000 Network and the identification of Important Bird Areas.

The flyway-level trend analyses also provide contextual information to national level decisions concerning the management of waterbird populations such as regulating harvest or evaluating the effectiveness of conservation actions including actions at site level.

For more than half a century, the International Waterbird Census (IWC) has monitored a large part of Europe and, for almost three decades, Africa and Central Asia. This report presents the results of this biodiversity monitoring carried out by dedicated professionals and more than 10,000 volunteers in over 90 countries across the African-Eurasian flyways.

Wetlands International and the authors are most indebted to the IWC coordinators and their observer networks. The current IWC coordinators are Taulant Bino (Albania, Albanian Ornithological Society); Nadjiba Bendjedda & Samir Sayoud (Algeria, Direction Generale des Forets); Miguel Xavier (Angola, Instituto Nacional Da Biodiversidade e Áreas De Conservação (INBAC)); Mamikon Ghasabyan (Armenia, Armenian Society for the Protection of Birds); Norbert Teufelbauer & Johannes Laber (Austria, Birdlife Austria); Enam Ul Haque & Samiul Mohsanin (Bangladesh, Bangladesh Bird Club);Viktor Natykanets (Belarus, Scientific Practical Centre for Biological Resources of National Academy of Sciences of Belarus); Koen Devos (Belgium, Research Institute for Nature and Forest (INBO)); Jean-Yves Paquet (Belgium, La Centrale Ornithologique Aves (AVES)); Hughes Akpona & Melkior Kouchade (Benin, Direction Générale des Forêts et des Resources Naturelles (DGFRN)); Toussaint Loubegnon (Benin, Université de Kétou); Goran Topić (Bosnia-Herzegovina, Naše ptice); Stephanie Tyler (Botswana, BirdLife Botswana); Idrissa Ouedraogo (Burkina Faso, NATURAMA); Valeri Georgiev (Bulgaria, Ministry of Environment and Water); Eric Niyongabo & Arsène Manirambona (Burundi, Association Burundaise pour la Protection de la Nature); Gordon Ajonina (Cameroon, Cameroon Wildlife Conservation Society); Tommy Melo (Cabo Verde, Biosfera I); Jonas Nekema (Central African Republic, Service des Inventaires et Aménagement de la Faune, Ministère des Eaux et Forêts); Hugh Doulton & Amelaid Houmadi (Comoros, Dahari); Jérôme Mokoko Ikonga (Republic of the Congo,

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The Strategic Working Group of the African-Eurasian Waterbird Monitoring Partnership that includes Johan Mooij (Chair, representing the Members of Wetlands International), Danka Uzunova (representative of the IWC coordinators in the Western Palearctic), Miguel Xavier (representative of the IWC coordinators in Sub-Saharan Africa), Sergey Dereliev (UNEP/AEWA Secretariat), Sabine Herzog (Swiss Federal Office for the Environment), Jean-Yves Mondain-Monval and Pierre Defos du Rau (French Biodiversity Agency, OBF), Olivia Crowe, Ian Burfield and Vicky Jones (BirdLife International), Verena Keller and Jean-Yves Paquet (European Bird Census Council), Cy Griffin and David Scallan (European Federation for Hunting and Conservation, FACE), Stefan Ferger (EuroNatur), Laura Dami and Clémence Deschamps (Tour du Valat), Richard Hearn (Wildfowl and Wetlands Trust), Henning Heldbjerg (European Goose Management Platform Data Centre), Nele Markones (Joint OSPAR/HELCOM/ICES Working Group on Marine Birds, JWGBIRD), Marc van Roomen (Sovon, Dutch Center for Field Ornithology), Teresa Frost (British Trust for Ornithology) and Olivier Biber (CMS Landbird MoU) has helped tremendously developing waterbird monitoring both conceptually and on the ground focusing on special areas or groups of waterbirds.

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The Waterbird Fund

This report illustrates that we can only assess the trends of waterbirds if our national partners are able to conduct the surveys in their countries. Unfortunately, funding for waterbird monitoring is not available everywhere across the flyway as national governments also need to attend to other pressing social needs, especially in low- and medium-income countries. Recognising the need for regular and predictable support to waterbird monitoring, the organisations participating in the Waterbird Monitoring Partnership established the Waterbird Fund in 2016, which is managed by Wetlands International. If you find the information presented in this report useful and want to help improve monitoring across the flyway, please support the Waterbird Fund. For further information, visit: https://waterbird.fund/.

Materials and methods

Monitoring of waterbirds

The AEWA Table 1 includes a wide range of water- and seabird populations which require different survey and monitoring techniques to estimate their population size and trends. In general, populations can be monitored during the breeding season, during the wintering season or on migration. Monitoring during the breeding season is most suitable for colonial breeding species or for those dispersed ones that can be relatively easily found during the breeding season. Monitoring during the winter season is most suitable to monitor the populations of species that congregate at certain sites or those dispersed species that breed in otherwise inaccessible areas or difficult to observe during the breeding season. Migration counts are particularly useful for those species that are not easy to monitor neither during the breeding or during the non-breeding season but concentrate on a few sites on migration. The suitable techniques depend on the species distribution, behaviour, accessibility of the breeding and non-breeding areas, overlap between the different populations in the given season and practical considerations such as the objectives of monitoring, capacity and costs (Hearn et al., 2018).

The African-Eurasian Waterbird Census

This report is based on waterbird count data collected during the African and Western Palearctic regional schemes of the International Waterbird Census (IWC) which were joined into a flyway monitoring scheme in 2011. The IWC is a long-term site-based monitoring scheme that started in parts of the Western Palearctic in 1967 and gradually extended throughout the rest of the flyway, the African programme starting in 1990 (Fig. 1). The IWC has grown into one of the world's largest global biodiversity monitoring schemes.

Originally, the IWC was organised to estimate numbers and to monitor changes in (the Northern) wintering waterbirds. Therefore, the core IWC counts are carried out in January across the entire African-Eurasian Flyway. The IWC is also commonly referred to as the mid-winter counts, particularly in Europe. In Africa, over-wintering populations of the Palearctic may mix with local African populations during the mid-winter counts and some species do not congregate during this period. Some countries in Southern Africa also conduct counts in July as part of the IWC to better monitor these populations.

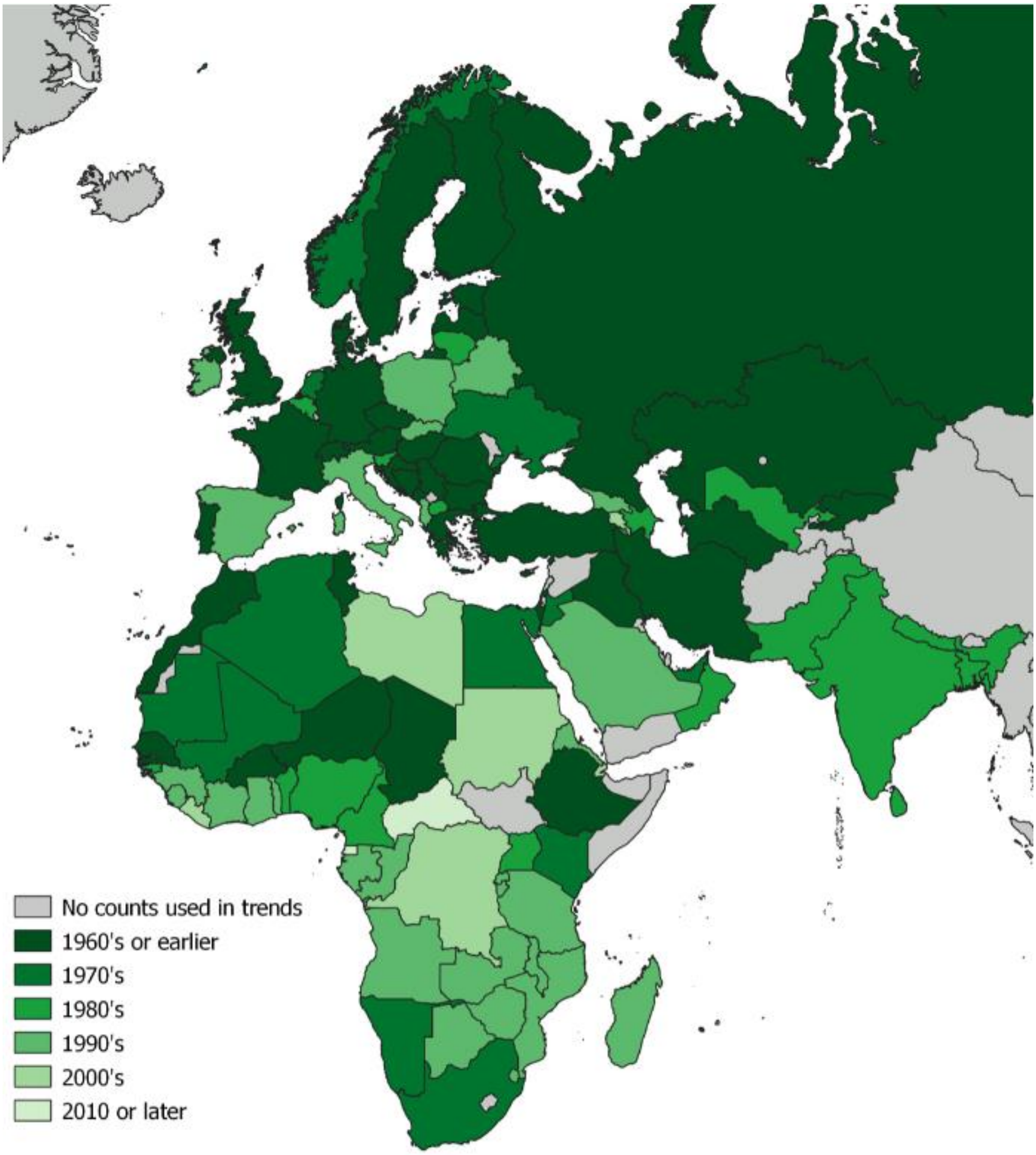

Fig. 1 Start decade for IWC for each country contributing to the CSR IWC trend calculation.

However, the IWC count methods can be extended to monitor the importance of stop-over sites during migration. Consequently, additional counts also take place in some or all other months during the non-breeding season in several countries particularly in Europe.

The IWC operates through national schemes in each country. These schemes are organised by national coordinators[1] who are affiliated with government agencies, scientific institutes or

[1] https://www.wetlands.org/our-network/iwc-coordinators/

non-governmental organisations. In turn, the national coordinators work with a large network of professional and volunteer observers. The national IWC schemes contribute to the monitoring obligations of governments under international treaties such as the Ramsar Convention on Wetlands, the African-Eurasian Migratory Waterbird Agreement and the Birds Directive of the European Union. Often it is supported by the respective governments. However, in some countries, particularly in low- and medium income ones, the counts are implemented only when financial and technical assistance is available, often from external sources. This dependency on funding results in significant variability in coverage, presenting challenges for using the count results to produce population estimates and trend assessments.

Selection of species and populations for analysis

For this report, only the 554 migratory waterbird populations listed on Table 1 of the AEWA Action Plan (AEWA, 2019) were considered for inclusion. For each population, we considered whether the size and/or the trend of the population can be estimated reliably based on IWC counts and, if not, whether there is any other alternative monitoring scheme in place.

It is not possible to produce estimates for populations that are mixed with other populations at the time of the IWC counts because allocation of individuals to the different populations would be speculative. For example, the wintering areas of some Palearctic breeding populations of herons overlap extensively with the range of the African populations of the same species.

For many European populations, particularly conspicuous ones breeding in countries with adequate monitoring schemes, breeding bird monitoring provides a rather reliable alternative source of population size and trends estimates. However, breeding bird monitoring is incomplete in the Arctic, in Eastern Europe, Southwest Asia and Africa. In the absence of other data to provide insight into the status of populations in these regions, we use the IWC data to produce estimates also for populations for which breeding bird monitoring could be theoretically a better option. We have not included goose populations that are restricted to Britain and Ireland and monitored through specialised counts there. Seaducks should also be the subject of specialised schemes but trend data is not available at flyway scale. Therefore, available data was analysed on an experimental basis.

Available data

The IWC database contains 4,088,712 count records from 109 countries from 19,048 monitoring sites in the AEWA Agreement area and from Pakistan, India, Sri Lanka, Nepal and Bangladesh[2] (Figures 2 and 3).

[2] Data from these South Asian countries were used to estimate population sizes and trends of populations whose range extend there.

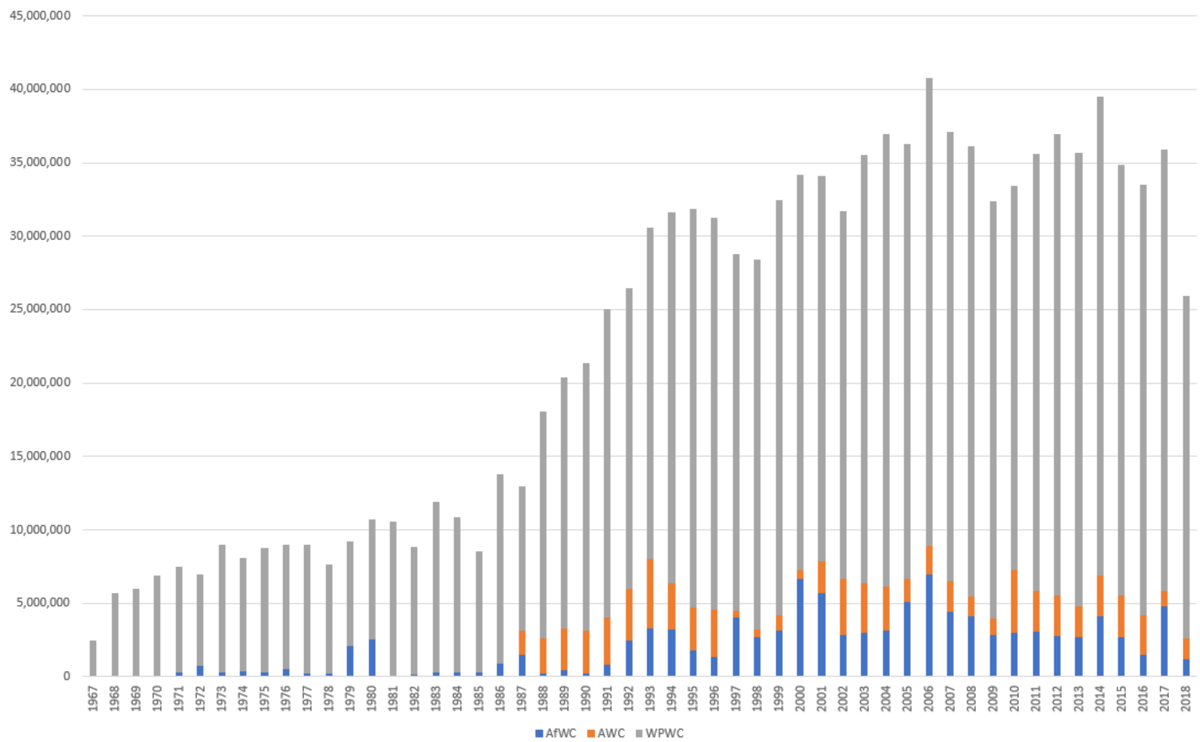

Fig 2. Total number of waterbirds reported each year from countries contributing to the trends, grouped by regional IWC census programmes: Western Palearctic (WPWC); Asian Waterbird Census (AWC); African Waterbird Census (AfWC)

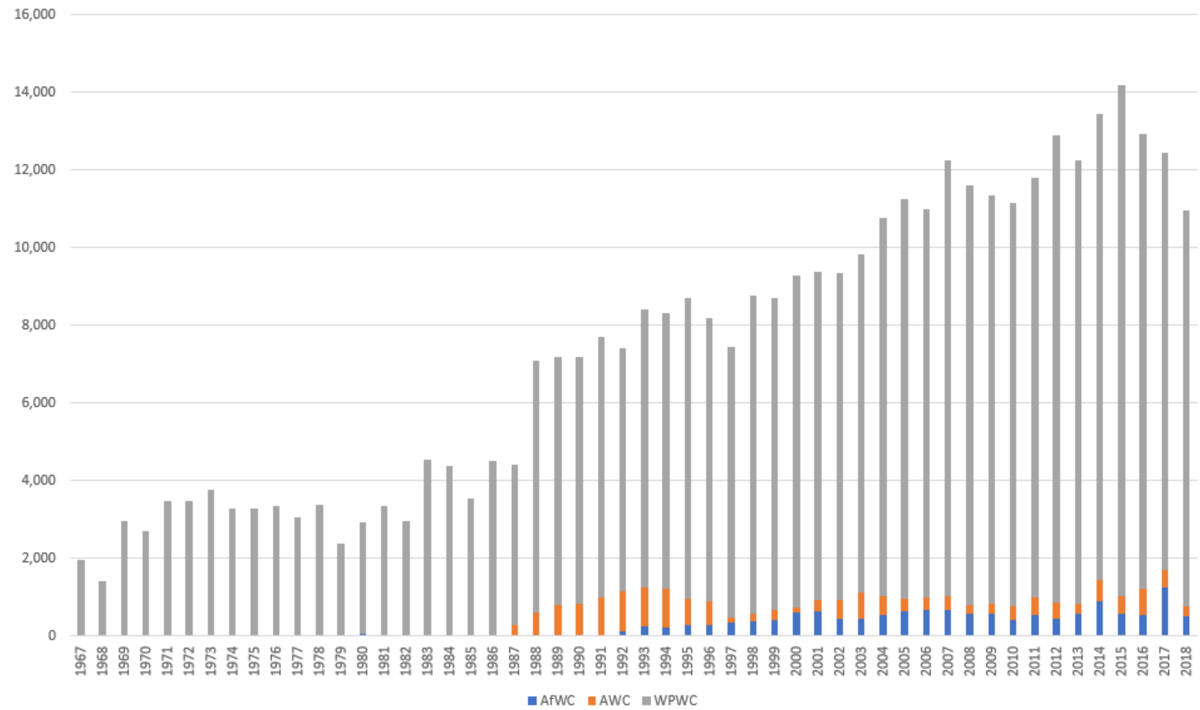

Fig 3. Total number of sites reported each year from countries contributing to the trends, grouped by regional IWC census programmes: Western Palearctic (WPWC); Asian Waterbird Census (AWC); African Waterbird Census (AfWC)

Allocation of count data to populations

Our analyses aim to contribute to the status assessment of the migratory waterbird flyway populations defined in Table 1 of the AEWA Action Plan in cases when IWC provides the best available data or where it can be used to triangulate data from other sources (Hearn et al., 2018). In the IWC trend analysis in 2014 (Nagy, Flink, & Langendoen, 2014), count sites were allocated to flyways using GIS spatial overlap procedures with the population boundaries available on the Critical Site Network Tool[3]. As manual allocation of sites in the overlapping areas of two or more flyways is a rather time consuming process and even unnecessary considering the large overlaps between flyways, we have allocated countries to populations except France (where Languedoc-Roussillon and Provence-Alpes-Côte d'Azur were allocated to the West Mediterranean, sites along the Rhine and Lake Geneva to the Central European and the rest of the country to NW European region), Germany (where Bavaria and Baden-Württemberg were allocated to Central Europe and elsewhere to North-western Europe) and Russia where Kaliningrad and St. Petersburg were allocated to the Baltic, the southwestern part of European Russia (Rostov, Krasnodar, Chelyabinsk, Adygey) was allocated to the Black Sea and other divisions to the east in European Russia were allocated to the Caspian regions. Each country or sub-region was allocated to a single population of a species except some special cases when more than one clearly separated population occurred in the country.

Estimating population size

IWC count data can be used directly to estimate population size only if an (almost) full census is possible. This might be the case for some conspicuous species, concentrated on a few sites that are all well covered by observers and counted at the same time (e.g. some goose populations) in Western Europe. For majority of the populations, annual count totals always represent just a fraction of the entire population. Count totals can be adjusted by imputing for missing counts, allowing an estimation of the population occurring within IWC sites. However, the coverage of the IWC site network varies to a large extent between countries and for different species within a country. Furthermore, the often highly congregatory behaviour of some waterbird species in the non-breeding seasons represents additional difficulties for estimating population sizes based on statistically robust samples because the higher variance requires higher sample size. As a consequence, calibration of count totals to a derived population estimate is mainly limited to dispersed species.

National population size estimates are available for some countries, particularly those required to report such figures to the European Union. However, few of these estimates are based on statistically robust procedures, instead relying on expert opinion to account for missing, variable or incomplete counts.

Each population account included in this report presents the current population estimates based on the 7th edition of the AEWA Conservation Status Report (Wetlands International, 2018), the range of count totals for the five-year period of 2014-2018 and a graph showing the evolution of count totals available in the IWC database during the overall trend period reported for the population.

[3] http://critical-sites.wetlands.org/en

Trend analyses

Following extensive testing, we have decided to apply stricter site selection criteria than in earlier analyses because sites with only a few counts can easily lead to spurious estimates of the imputed annual totals and thus can distort the trend estimates. In this analysis, we have selected sites that have been visited at least 5 times between 1980 and 2018 in Europe and between 1995 and 2018 in other regions. An additional requirement was to have at least one of the counts within the last 10 years. This resulted in the selection of 19,048 sites from the total of 42,719 for the trend analyses (Fig. 4).

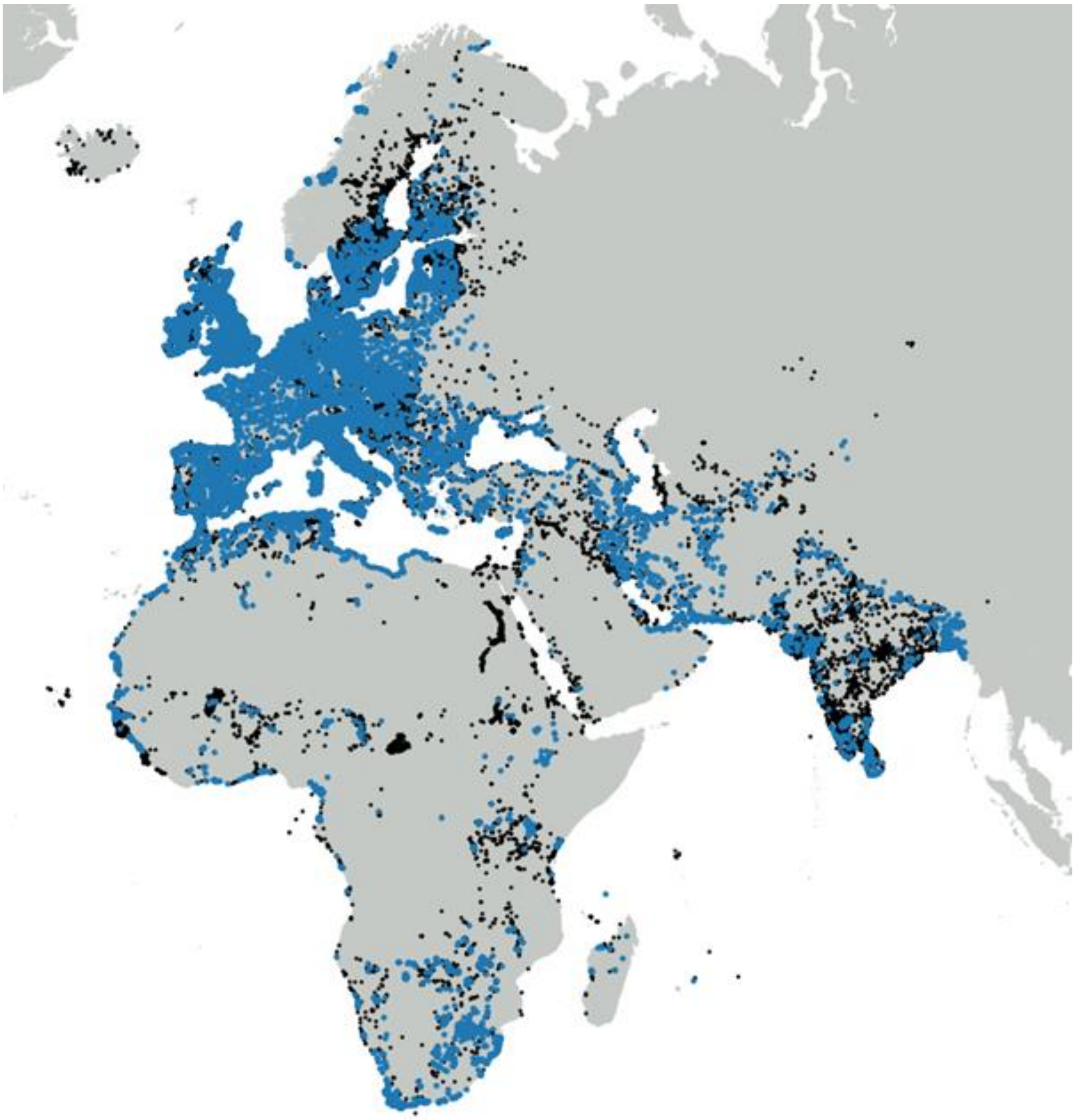

Fig. 4. IWC sites in the African-Eurasian Flyway and contributing countries from the Asian Waterbird Census. Blue: sites included into the trend analysis, black: sites excluded from the analyses due to insufficient data.

For the purpose of trend analyses, we consider the IWC as a full list method for waterbirds because observers are required to record all species they have seen even if they were not able to count them. Unreported species were considered absent, unless a relevant multispecies group (e.g. unidentified diving ducks) was reported during the count or for years before the count of the species group started in a country (e.g. only Anatidae and Coots were counted in many European and Southwest Asian countries until 1989). This assumption is probably invalid for cryptic species (such as crakes and snipes) or species that are difficult to identify without good optics (e.g. stints). Therefore, we collected information on the reliable start dates per species groups from the national coordinators and used those as the starting year for the national trends. In some cases, this has resulted in shorter overall trend periods than in the last report.

We carried out the trend analyses first at national level and then at population level following the practice of the Pan-European Common Bird Monitoring Scheme (Voříšek et al., 2020). This overcomes the weakness of earlier IWC trend analyses that were carried out at the regional (Delany et al., 1999; Gilissen, Haanstra, Delany, Boere, & Hagemeijer, 2002) or flyway-level (Nagy et al., 2014; Wetlands International, 2012). Working with such combined datasets can amplify the patterns of countries with more regular site coverage. The above-mentioned two-step process can help to remove these biases to some extent. The results of the trend analyses might still be strongly influenced by the national coverage of the IWC. Unfortunately, it is not possible to use weights in the IWC trend analyses as in Pan-European Common Bird Monitoring Scheme to correct for different coverage of the national populations because only a few countries have produced proper estimates of the national wintering populations (e.g. Frost et al., 2019). Most available estimates are simply the IWC count totals and they do not take into account of the effect of missing counts and provide estimate of the population at areas that were not counted. In certain countries, the wetlands counted support only a small fraction of the population present in the country.

We used the *rtrim* package (Bogaart, van der Loo, & Pannekoek, 2020) for the trend analyses. TRIM is a General Estimating Equation that is able model missing counts (van Strien, Pannekoek, & Gibbons, 2001). The Underhill Index (Underhill & Prys-Jones, 1994), widely used in waterbird monitoring, and TRIM produce practically the same imputed values (Bogaart, 2020; van Roomen, van Winden, & van Turnhout, 2011).

When producing the national trends, we first attempted models with the following settings: Model 2 (i.e. year-effect), automatic change-point removal, serial correlation and overdispersion. For populations with insufficient data, models were attempted without the conditions of serial correlation. We did not use models without automatic change-point removal because that would result in producing a log-linear trend, which is susceptible to produce highly unrealistic estimates if there are a lot of missing counts at national level. National trends were calculated in two steps. First, we calculated an ‘exploratory’ trend for the period between the first and the last year the country had positive count for the species. Next, we have excluded years with less than 30% of observed data in the imputed totals and truncated the national trend period to the first and last year that met this criterion to reduce the impact of spurious imputing. Years with less than 30% observed values between the first and the last year were treated as missing years for the country in the second run for the country using the truncated time period.

Flyway trends were also produced in two steps. An exploratory flyway population trend was produced based on the national time totals and covariance matrices using data from the second set of national trends. Again, years with less than 30% of observed data in the population imputed totals were excluded and treated as missing years. This left fewer but more reliable annual population estimates in the sample, particularly important for many populations from Southwest Asia and Africa. A third national trend truncated to the period of the flyway trend determined by the previous steps produced imputed national totals and covariance matrices consistent with the period of the flyway trend. We inspected the national trends for spuriously high imputing and made further adjustments either to the national trends or the trend period to exclude unreliable years. In the second flyway TRIM run, missing years were imputed using log-linear trend between years with sufficient data.

After completing the trend analyses, we produced smooth trends using locally estimated scatterplot smoothing (LOESS) on the imputed totals with the settings span = 0.75 and degree = 2, i.e. the standard settings of the MSI (Soldaat, Pannekoek, Verweij, van Turnhout, & van Strien, 2017).

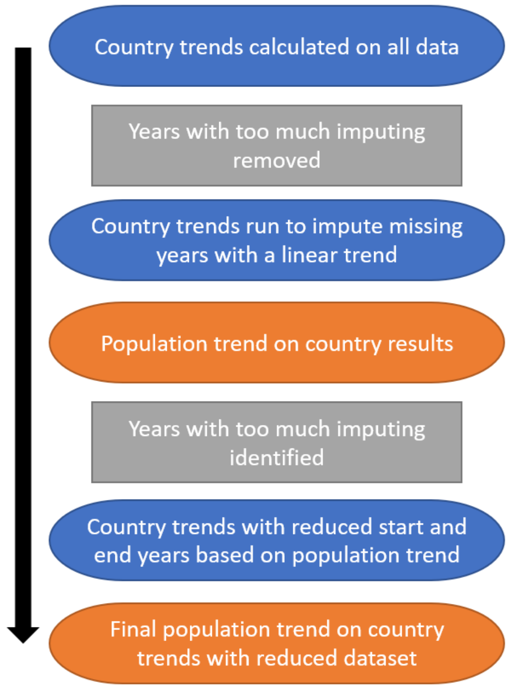

Figure 5. Step-by-step analytical process to calculate population trends.

We report log-linear trends fitted by TRIM for three periods:

- Overall trend: this is the log-linear trend for the entire period analysed. This period provides a long-term perspective;
- 3-generation trend: this covers the period covered by three generations calculated from the last year of the trend period. Generation lengths were obtained from BirdLife International based on Bird *et al.* (2020). This period corresponds to the long-term decline criterion of AEWA (2018b);
- 10-year trend: this covers the last 10 year of the trend period. This period corresponds to the short-term period used in the AEWA Conservation Status Report to measure the

actual progress towards the purpose level indicators of the AEWA Strategic Plan (AEWA, 2018a) and the rapid short-term decline criterion of AEWA (2018b).

We report the standard trend classification of TRIM:

Assessment	Criteria
Strong increase (more than 5% per year)	lower CI limit > 1.05
Moderate increase (less than 5% per year)	lower CI limit > 1.00
Moderate decrease (less than 5% per year)	upper CI limit < 1.00
Strong decrease (more than 5% per year)	upper CI limit < 0.95
Stable	0.95 < lower < 1.00 < upper < 1.05
Uncertain	any other case

Besides of the standard trend classification, we also report the magnitude of population decreases in three ways, if applicable to the population:

1. Actual population change in 3 generations: this is calculated using the imputed totals of the first and the last year of the 3-generation trend period. We only report it if the estimated decline exceeds 10% in 3 generations;
2. Population change in 3 generations based on growth rate of the overall trend and partly projected in the future: we use this method only if the overall trend period is shorter than 3 generations. We only report it if the estimated decline exceeds 10% in 3 generations and the population trend is not classified as stable;
3. Population change based on the 10-year trend projected into the future for 3 generations: We only report this value if the projected decline exceeds 30%.

Methods 1 and 2 above correspond to the long-term population decline criterion (c) of AEWA, while Method 3 checks whether the population has decreased at a rate that would qualify the population meeting the criterion of rapid short-term decline (criterion e). It is important to note, however, that reporting these values do not represent our final judgement whether a population is in long-term or in rapid short-term decline. For that assessment we need to assess the reliability of the result of the IWC trend analysis and compare it with other sources of evidence while taking into account the precautionary principle.

Results

Results of the trend analyses of 358 populations are presented on the IWC Online Portal[4]. For each population, we present the following graphs:

- The IWC count totals: showing the unadjusted number of birds counted in a given year for all sites.
- The trend graph: showing totals adjusted for missing counts at the network of monitoring sites that fulfil the site selection criteria.
- The proportional contribution of countries to the imputed totals in any given year.

Additional text provides the following information:

[4] http://iwc.test.wetlands.org/index.php/aewatrends8

- The maximum of the IWC count totals in the last 5 years compared to the population size estimates from CSR7. This helps to notice if population estimates need to be updated based on the IWC counts.
- The trend statistics for the overall, the 3 generation and for the 10-year trend periods.
- If relevant, the magnitude of the actual or projected population decrease over 3 generations.

The function of this report is only to present the result of the IWC data analysis as one of the inputs into the status assessment of AEWA populations. For many populations the IWC represents the best available information, but not for all. In some cases, there was insufficient data to produce robust trend estimates. Therefore, the results of the IWC trend analyses cannot be used uncritically to assess the status of the AEWA populations. The results of our interpretation of the IWC data and other sources of information are presented on the WPE Portal[5] under the CSR8 publication.

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