Analyzing population trends at the flyway level for bird populations covered by the African Eurasian Waterbird Agreement: details of a methodology

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SOVON-information report 2011/05
This study was commissioned by Wetlands International as part of the work performed for the 5th report on the Conservation Status of Waterbirds in the Agreement Area for the African Eurasian Waterbird Agreement

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Cover photos: Hans Gebuis
Citation: van Roomen M., van Winden E. & van Turnhout C. 2011. Analyzing population trends at the flyway level for bird populations covered by the African Eurasian Waterbird Agreement: details of a methodology. SOVON-information report 2011/05. SOVON Dutch Centre for Field Ornithology, Nijmegen, the Netherlands.

ISSN 1382-6247

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1. Introduction

The Technical Committee of the African Eurasian Waterbird Agreement has commissioned Wetlands International to produce the 5th edition of the Report on the Conservation Status of Waterbirds in the Agreement Area. An important element of the assessment of the Conservation Status is based on the population development at the level of flyway/biogeographical populations. These flyway/biogeographical populations were defined in the *Waterbird Population Estimates* publication (Wetlands International 2006) and their delineations within the African-Eurasian region were recently further defined within the WOW project, which can be viewed through the Critical Site Network webtool (see examples in Figure 2).

One of the most important data sources for the assessment of trends in waterbird numbers is the International Waterbird Census (IWC) and counts of this large scale-monitoring program have been used to calculate trends in six geographical regions for earlier AEWA assessments (Figure 1, Wetlands International 2005). As the geographical regions are not directly related to the species flyway delineations, there is no direct relation between this analysis and the assessment at flyway level. For the 5th edition of the Conservation Status Report the Technical Committee asked for analyses of the IWC data at the level of flyway/biogeographical populations. If these flyway trends can indeed be calculated, there will be a direct relation with the populations as listed in the action plan of AEWA. Besides, the population trends will be based on a biologically more meaningful geographic basis.

This change from geographical regions to flyway level trend analyses gave the opportunity for Wetlands International to review and where appropriate revise and upgrade their trend analysis methodology. For this reason a workshop was organized at October 25th, 2010 to review existing trend estimation methodologies and formulate recommendations for the future flyway trend analyses of water birds. During the workshop, which was attended by representatives from BTO, Statistics Netherlands, Japan, SOVON and Wetlands International, different methods of trend analyses were presented (TRIM, U-Index, TrendSpotter, GAM's and hierarchical modeling). It was concluded that in the present situation data quality (consistency of counting site delineations between years, the amount of missing counts in important areas and the possibility to distinguish between zero counts and missing counts) is a more important limitation for producing reliable population trends than differences between methods. However, given the limited amount of time available to produce the new report, the work should focus on the analyses instead of chasing missing data or quality checks on present data. Improvements on these subjects are only possible within a long-term investment for the coordination of the monitoring program itself. Secondly, it was decided that although a formal comparison between the different imputing and trend analysis methods is a valuable exercise, at present the funding needed for such a project is lacking. On the basis of presentations and discussions during the workshop it was difficult to decide which method can best be used at the moment, without a proper quantitative assessment of advantages and disadvantages. Therefore it was decided to use TRIM, which was also used in the former AEWA analyses at the level of geographical regions. TRIM is widely used throughout Europe for producing trend estimates on the basis of wildlife counts, and it is rather straightforward in its use.

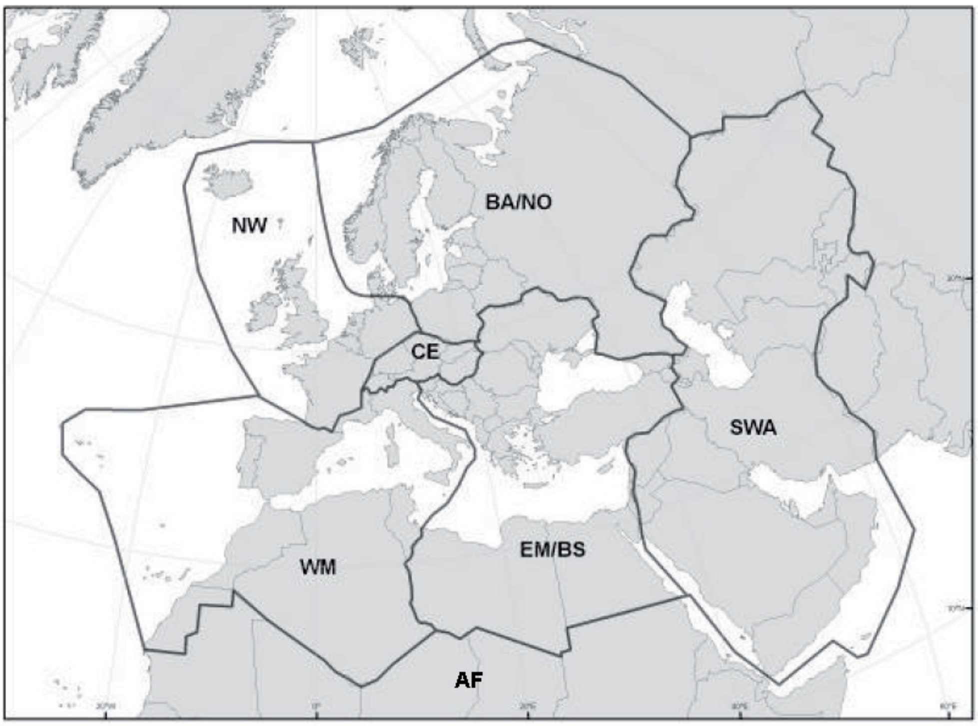
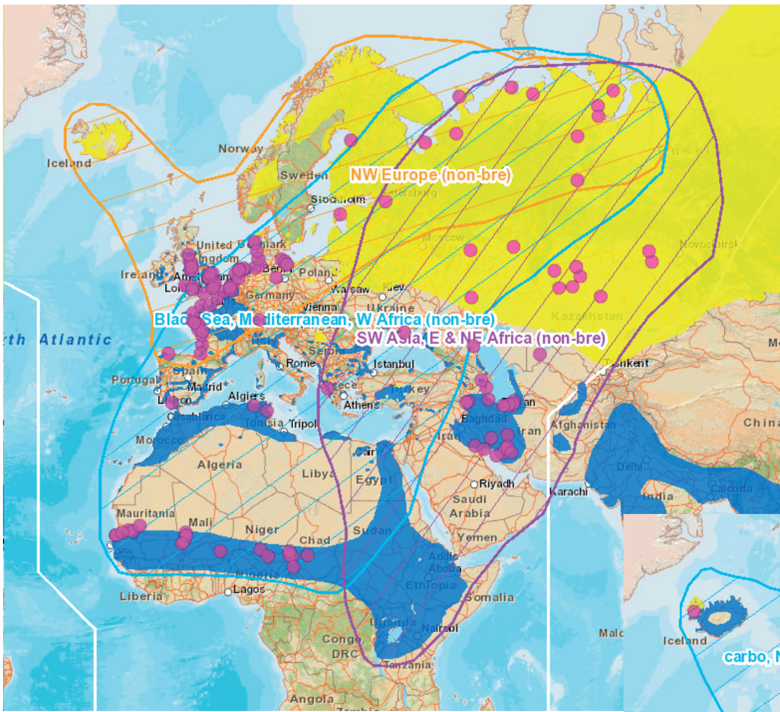


Figure 1. Geographical regions used for trend calculations in the 4th Report on the Conservation status of Waterbirds for the African Eurasian Waterbird Agreement. AF (South of Northern Africa) is added for the present analyses.

SOVON was contracted at the end of December 2010 to provide further advise and assist Wetlands International in developing a methodology to carry out flyway level trend analyses. The work should be based on the decisions taken during the workshop of October 25th, and using the data as prepared by Wetlands International. The goal of this study was to find and implement a straightforward and pragmatic approach for the calculation of the trends. It was not meant as an in-depth study into trend methodologies for water birds, in order to find the qualitatively best method available. This report will briefly summarize results for three species (Pintail, Cormorant and Dunlin, see Figure 2), which were used as example species to develop the methodology.



A Pintail

B Cormorant

C Dunlin

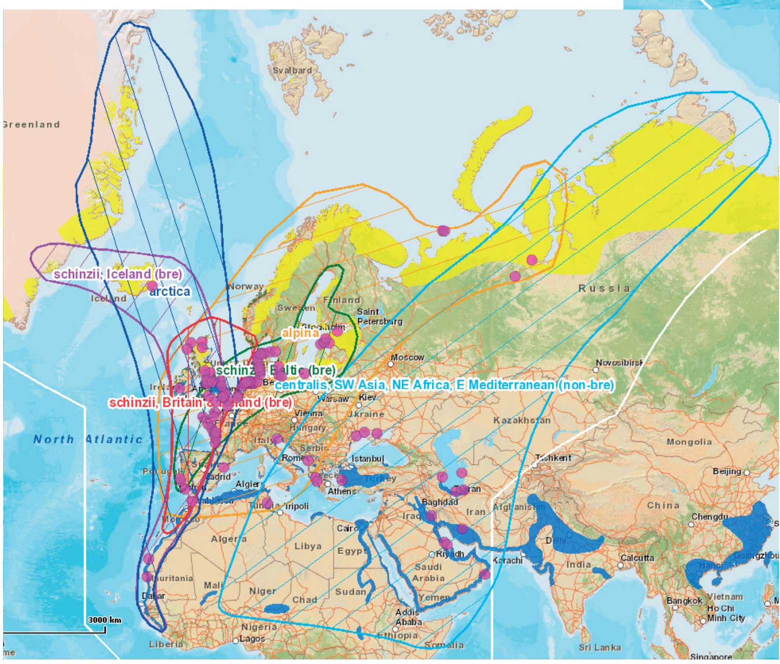


Figure 2. Flyways and biogeographical populations of A) Pintail Anas acuta*, B) Cormorant* Phalacrocorax carbo *and C) Dunlin* Calidris alpina *within the Africa-Eurasian region (source CSN Tool, http://wow.wetlands.org/informationflyway/criticalsitenetworktool /tabid/1349/language/en-US/Default.aspx).*

2. Required output for the AEWA conservation status report

The technical committee of AEWA formulated the following requirements for the trend analyses to be performed for the AEWA Conservation Status Report 5:

Long-term trend
Long-term trends need to be estimated for each population using the longest available time series of good quality data over a period of 25 years. Taking into consideration the data available in the IWC database, the time period chosen is 1983-2007. If the available time series is shorter than the period required, a long-term trend will be assessed based on a shorter period. However, this shorter period shall cover at least 9 years. Populations will be qualified as 'suffering long-term significant decline' if the estimated decrease is at least 25% over the assessment period of 25 years, or if the estimated annual rate of decrease is equal to or exceeds 1% over an assessment period shorter than 25 years.

Short-term trend
Short-term trends will be based on the most recent semi-complete 5 years' data (2003-2007) in the IWC database to highlight the most recent changes of the populations (if monitoring data is available). Populations will be classified as 'in decline' if the annual rate of decline is more than 1%.

3. Material and methods

3.1. Material

Allocation of counting sites to flyway populations
In Table 1 the theoretical extent of overlap between flyway populations at sites is presented for the three species during their yearly cycle as presented in the CSN tool (Figure 2). However the extent of mixing of different populations at single sites is limited in January, which is the month with most counting data available within the IWC. This knowledge can be used to evaluate several options to allocate sites to flyway populations. Wetlands International developed a 'key' to perform these allocations, see below. We used this key and a few additional guidelines to perform this process and select the sites on which the trends for the different populations are based (Table 1 and Figure 3).

The key to handle different degrees of overlap between populations (developed by Wetlands International, with some additions):

0. Population is not overlapping with other flyway populations.
1. Population is overlapping with a (very) small other population in January; include counting data of all sites within the flyway boundary with disregard of the occurring numbers belonging to the other population.
2. A small, disregarded population resulting from 1, for which no sites can be selected to calculate trends on the basis of IWC data.
3. Population with a small degree of overlap (1-30%) in January; start from West to East: include all sites within the flyway boundary for the western one (NW-Europe); next include all sites of the next flyway to the East (West and East Mediterranean), excluding the sites in the overlap zone with the western flyway; next include all sites of the next flyway east of these (West Asia-East Africa), but not the sites in the overlap zone with the western Flyways.
4. Population for which all sites within the boundaries of the flyway can be used.
5. Population for which no IWC data can be used to calculate trends; breeding season data need to be used instead.
6. Population with a high degree of overlap with other flyway population(s)– species-specific choices need to made to select the appropriate sites.

Counting data
The data set we used only included counts carried out in January, with some exceptions in Africa (also some counts from December included). The data selection was carried out by Wetlands International. Counts that were qualified as 'incomplete at site level' in the database were deleted. However, this qualification only applies to a small fraction of the total counts, so it had only little impact on the number of counts included. In a few cases 'double counts' occurred, defined as counts from the same site in the same month in the same year, but from different dates. The maximum count per species was selected by Wetlands International.

Coverage of counts per year and region
There exists a large variation in the number of sites counted between years and between regions (as in Figure 2) (Annex 1 and examples in Figure 4). For several flyway populations the number of sites and counts available in the first years of the study period is rather small. This variation is caused by differences in the importance of sites and regions for water birds in January, and from different starting years of the IWC in response to the amount of resources for coordination and counting available. The number of counts in 2006 and 2007 is also relatively small, as a result of delays in data supply and possibly decreases in counting effort in some regions.

3.2. Methods

Software used for trend calculations
During the workshop of October 25th 2010 it was decided that TRIM should be used for the new trend calculations. TRIM is a widely used program to analyze monitoring data in which modeling the trend and accounting for missing values can be done in the same analysis (Pannekoek & van Strien 2001). Also practical software (BirdSTATs) is available to use TRIM in combination with MS Access, the current database program used by Wetlands International. Within BirdSTATs TRIM Model 2 is used, including change points.

Interpretation of zero counts and missing counts
For any monitoring program the ability to distinguish between missing counts (site or species not counted) and zero counts (site or species counted, but not present) is of crucial importance. As 'zero's' are not recorded in the WI-database, this information needs to be inferred from counting dates and species selection Unfortunately, observers are less inclined to report zero counts or changes in species selection, and it needs additional coordination effort and 'discipline' to have this information rightly present in the database. As the IWC database for the African-Eurasian region spans a large amount of years and includes many different countries with different backgrounds of monitoring, a rather heterogeneous situation exists in relation to species selection counted and recorded information on which sites were counted or not counted. Wetlands International has developed a 'key' to help to distinguish zero counts from missing counts at the species level, by using information about site coverage in years before and after the count, counts of other species from the same family during the same count and counts of the species during the former counts.

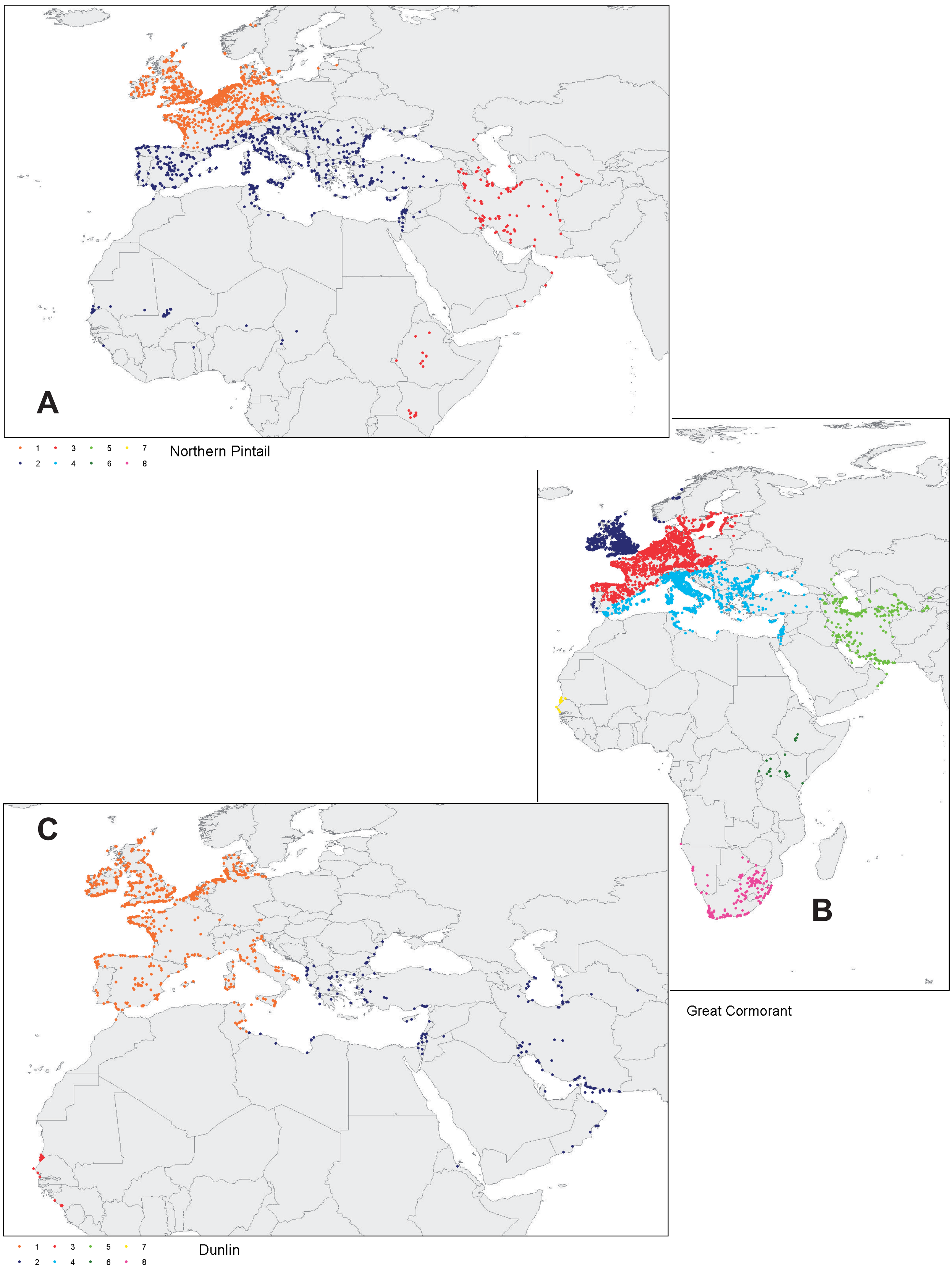


Figure 3. The allocation of sites to the different flyway populations used for further analyses in this report, A) Pintail, B) Cormorant and C) Dunlin.

Table 1. The overlap between flyway populations for A) Pintail, B) Cormorant and C) Dunlin using the year round flyway delineations (Figure 2). Presented are the number of sites and number of birds at these sites in January with potentially different combinations of populations occurring. Rows in the table with two or more crosses are overlapping populations. Also presented is the population (in bold) for which the selection(s) of sites is finally used by applying the key (see selection type).

Sites	Total	Species	457_1 NW Europe (non-bre)	457_2 Black Sea, Mediterranean, W Africa (non-bre)	457_3 SW Asia, E & NE Africa (non-bre)
832	2067282	Pintail			**X**
4002	1557925	Pintail		**X**	
698	676603	Pintail		**X**	X
2068	273542	Pintail	**X**		
6945	849838	Pintail	**X**	X	
	Selection	**type**	**4**	**3**	**3**

Sites	Total	Species	36792 carbo, NW Europe	36793 sinensis, N, C Europe	36794 sinensis, Black Sea, Mediterranean	36795 sinensis, SW Asia (non-bre)	36796 lucidus, C & E Africa	36797 lucidus, Coastal W Africa	36798 lucidus, S Africa
542	70991	Cormorant							**X**
70	29635	Cormorant						**X**	
433	35887	Cormorant					**X**		
630	810874	Cormorant				**X**			
2066	1572365	Cormorant			**X**				
7798	1555203	Cormorant		**X**					
411	231118	Cormorant		**X**	X				
1513	171215	Cormorant	**X**						
1564	429262	Cormorant	**X**	**X**					
	Selection	**type**	**6**	**3**	**3**				

Cormorant 6: Use Ireland, UK, N & W coastal France, N & W coastal Spain.

Sites	Total	Species	3056_1 alpina	3056_2 centralis, SW Asia, NE Africa, E Mediterranean (non-bre)	3056_3 schinzii, Iceland (bre)	3056_4 schinzii, Baltic (bre)	3056_5 schinzii, Britain & Ireland (bre)	3056_6 arctica
68	9519	Dunlin			**X**			X
1428	585357	Dunlin		**X**				
2951	993903	Dunlin	**X**					
188	3351	Dunlin	**X**					X
49	2	Dunlin	**X**				X	
19	609	Dunlin	**X**				X	X
4445	4314937	Dunlin	**X**			X		
386	1027383	Dunlin	**X**			X		X
59	759804	Dunlin	**X**			X	X	X
87	718	Dunlin	**X**		X			X
2404	3924300	Dunlin	**X**		X		X	X
3	564139	Dunlin	**X**		X	X		X
1287	10498029	Dunlin	**X**		X	X	X	X
846	245722	Dunlin	**X**	X				
	Selection	**type**	**3**	**3**	**6**	**2**	**2**	**2**

Dunlin 6: Use African part of range only

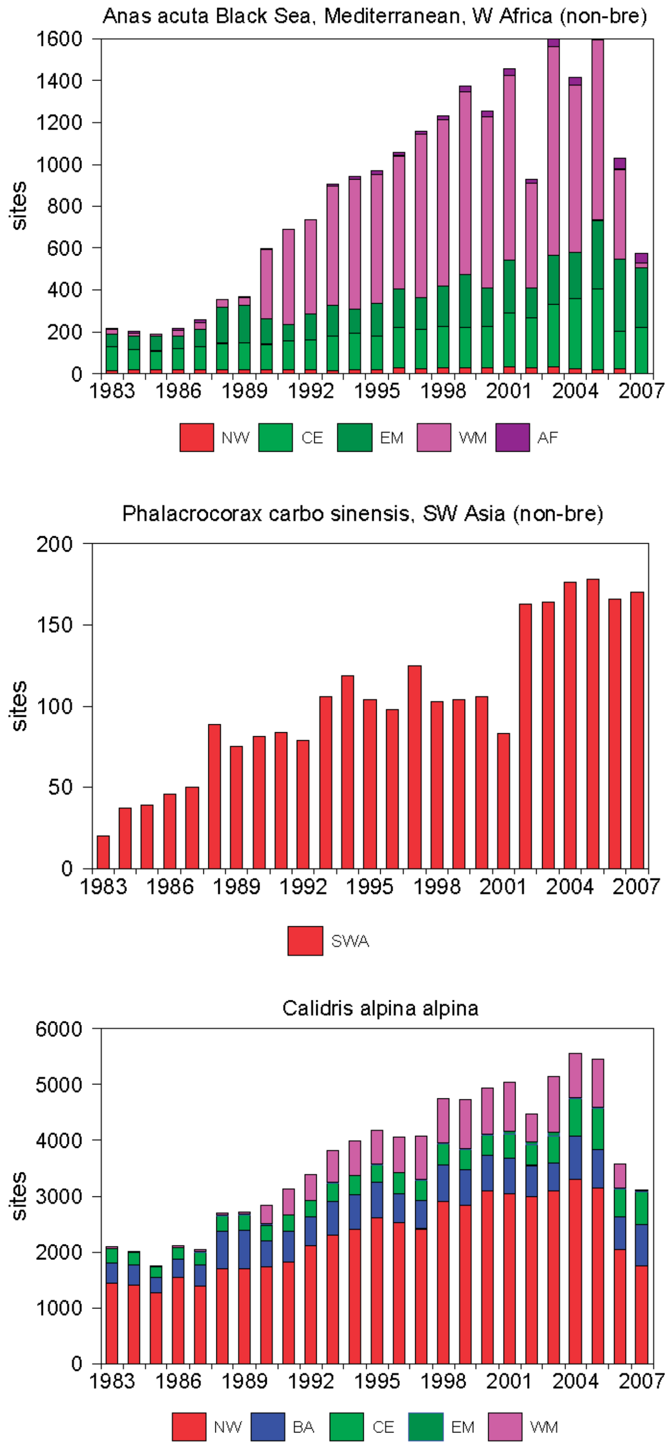


Figure 4. Three examples of the number of sites counted per year for a given flyway population within the different geographical regions as defined in Figure 1.

The steps taken and the resulting coding in the WI database to distinguish between different situations with different probabilities of the species being counted 'yes or no' is as follows:

Step 0: For certain records in the database it is indicated that the species was present but not counted, these are assigned a '-1' (missing count).

Step 1: All visits with no count of the requested species (being all waterbird species as defined in the Waterbird Population Estimates report and occurring in the Western Palearctic or Africa in January) are assigned a '-2'.

Step 2: All visits with code '-2' and a coverage $\neq$ 'C' (not complete) are assigned a '-3'. It could be that the species was present but only in the not counted part of the site. This situation is rather rare as the knowledge if a site is counted complete or not complete is mostly not known on the basis of database information and in the present analyses these counts were already excluded.

Step 3: All visits with code '-2' and a multi-species code relevant to the requested species are assigned a '-4'. This multi-species code represent unidentified individuals of a taxonomic group (i.e. geese, waders, etc)

Step 4: All visits with count '-2' prior to the first visit at which any species of the same family as the requested species was counted, are assigned a '-5'.

An important issue for this study was to assess which of the above categories most likely reflect a missing count and which most likely reflect a zero count. First we tested the impact of these choices on the trend estimates. Secondly, we made an interpretation as implemented in this key. Thirdly, these interpretations were compared with the same counting data as stored in the SOVON-database, where we have recorded more detailed information on species being counted yes or no, which is not present in the WI-database.

Strata and imputing

Many missing counts occur in the data set and imputing of missing counts is required in order to produce trends that reflect the trends in actual population sizes instead of trends in counting effort. Imputing is performed within TRIM using a model taking into account site and year factors. We additionally tested the effect of using geographic region as a covariate in the analyses (stratified imputing of missing values, in order to account for differences in trends between strata/regions). Within the flyway boundaries of a population we used the geographical regions (Figure 1) as boundaries for strata.

Selection of sites

As the number of counts available in the data set differs strongly between sites (Figure 5), one may choose to base the trends either on all sites (in order to reach optimal spatial coverage, but with large amount of missing values) or on a selection of frequently counted sites (smaller amount of missing values, but less optimal spatial coverage). We evaluated the effect of different site selection strategies on the results. Selections tested: having counts from half of the years +1 that the species actually was present, half of the years + 1 that the site was counted (species not necessarily present), using sites which were counted at least twice with the species present and by using all sites.

Selection of years

Also the counting coverage between years is rather variable (Figure 4). We tested if results differed after omitting years at the beginning of the study period, with many missing counts, from the dataset. We looked into scenario's, excluding years with 90%, 70% or 50% of imputing.

Selecting trend results

Some guidelines are needed to assess to what extent final trends are thought to be reliable. In this study we tested the suitability of criteria that are based on the percentage of imputing, the percentage of the total flyway population included in the data set and the geographical distribution of the sites covered within the trend analyses.

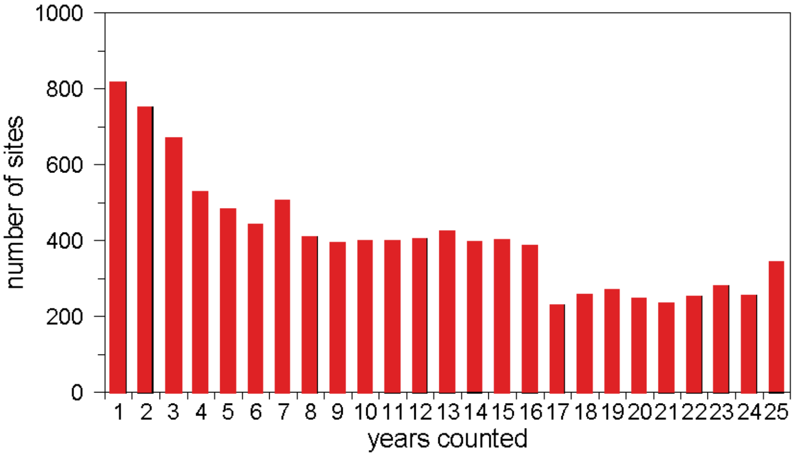


Figure 5. Frequency distribution of the number of January counts available per site in the study period (n=13.000).

4. Results

4.1. Interpretation of zero counts and missing counts

For three populations of three species we calculated the trends by 1) converting all missing counts in the dataset into a zero count and 2) converting only missing counts with code -2 in the data set into a zero count, while maintaining the others as missing counts (Figure 6). The differences are most obvious in the year totals of Cormorant, where the choice between 1) and 2) makes a huge difference in the first part of the study period. In the other species the trends do not substantially differ, but the estimated totals of birds do show differences. We conclude that it is necessary to further investigate this issue in the near future.

For now, we argue that particularly for trend calculation it is important to interpret only the most likely zero counts as zero counts, and maintain the possible and probable zero counts as missing values. For records with codes –1, –3, –4 and –5 there is at least serious doubt that the species was counted. After evaluating these choices for the same counts with the same records in the Dutch data set of SOVON (Table 2) we concluded that the interpretation that only –2 is a hard zero corresponds best with the actual situation.

Figure 6. Trends of three species based on a data set in which 1) all missing counts in the dataset are converted into a zero count and 2) only missing counts with code -2 in the data set are converted into a zero count.

Table 2. Testing if –5 (interpreted as missing values) or –2 (interpreted as hard zero's) within the IWC database are corresponding with the information in the Dutch data set of SOVON.

number code	species	% right	N
5	Great Cormorant	19	68
-5	Northern Pintail	43	14
-5	Dunlin	16	81
-2	Great Cormorant	86	263
-2	Northern Pintail	93	803
-2	Dunlin	89	446

4.2. The use of strata

From a theoretical and biological point of view the use of strata is preferred in the imputing and trend analyses. In a species like Cormorant the trends in different strata are following different trajectories (Figure 7a). If all strata are treated without covariate (effect of region) the trends become more similar (Figure 7b), resulting from non-stratified imputing of missing values. On the other hand it can also not be ruled out that the imputing is more robust in the calculations without strata, as more data is available as a reference for the imputing. In some regions the amount of missing counts is very high, which severly hampers a regionally stratified imputing.

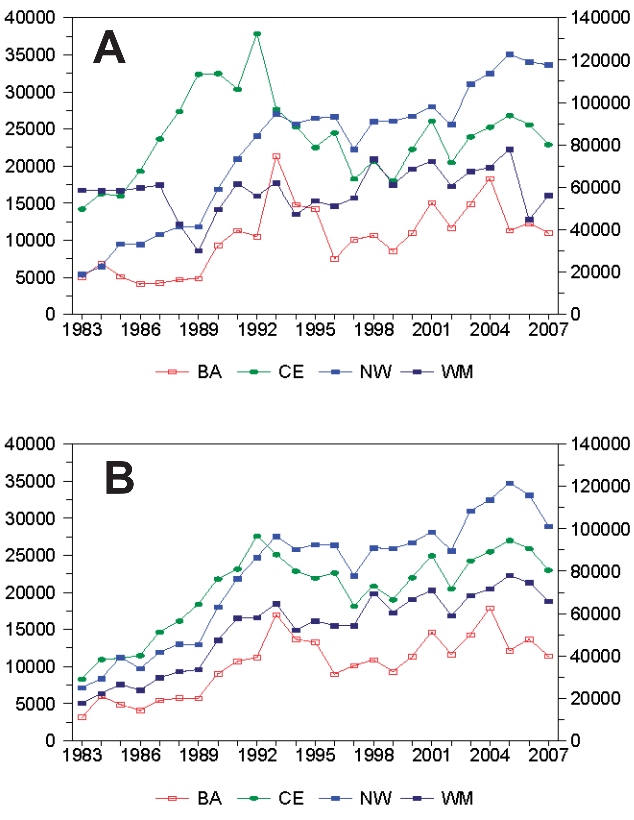


Figure 7: Trends in different strata of the same population, using stratified imputing with region as a covariate (7a) and without stratified imputing (7b).

Although TRIM can incorporate strata as a covariate, most of our calculations resulted in non-converging models. This is probably the result of strata with only few counts, or starting with several years with no counts at all. Although searching for species-specific choices may result in finding solutions in which these trends with region as a covariate can be calculated, this is at present not feasible as for approximately 240 populations trends need to be estimated. Therefore it was concluded that for now it is only feasible to run the trend models without the use of strata.

4.3. Selection of sites

Many sites in the data set are only counted 1-3 times in the 25 years period (Figure 5). Results of trend analysis may be more robust when these are only based on more regularly counted sites. However, selecting only the frequently counted sites has the risk of unrepresentative trends because of a biased selection of sites.

To test this effect, we started with a rather strict criterion of at least 13 'positive' counts (counts that the species actually was observed) or 13 counts of the sites that the species could have been present (including at least one positive one), being half of the number of years that counts could be available (25 years). Using this criterion it was only possible to calculate trends for NW Europe, as most datasets for the other regions did not meet this criterion. Secondly, for NW Europe some evidence emerged that the strong selection of sites may result in biased trend results caused by the buffer effect. At least in Cormorant P. carbo sinensis the trend stabilizes earlier during the study period when using the subset of sites with good count coverage compared to the total data set using all sites (Figure 8). Based on this result, we decided to include all counts with at least two positive counts for the species during the entire study period.

4.4. Selection of years

The trends that are based on a data set including all years show some rather unlikely patterns, especially in the beginning of the study period when the amount of missing counts is relatively large (Figure 9, Table 3). This is not always reflected by large confidence intervals (see 1983 in Pintail Black Sea population or 1983-1985 in Cormorant carbo population). This means that the confidence intervals seem not always informative in distinguishing reliable trends from unreliable trends. Therefore, we elaborated on a criterion directly based on the percentage of imputing. In Table 4 the resulting effect on the start year based on thresholds of 90%, 70% or 50% imputing are shown. Based on earlier calculations for the water bird populations in the Netherlands and in the UK (Soldaat et al 2004, Atkinson et al 2006), together with using expert judgment while evaluating the results, we adapted a criterion of 70%

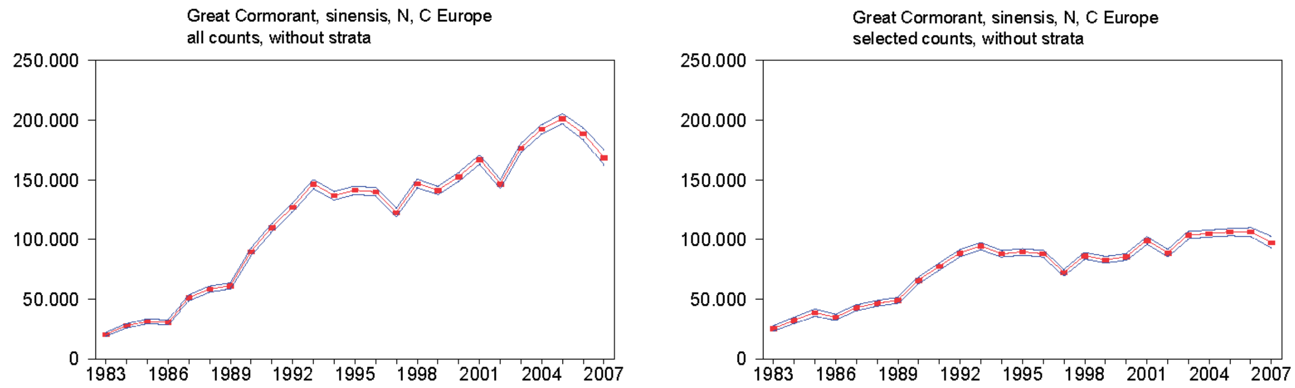


Figure 8. The trend of Cormorant based on all sites or a selection of regularly counted sites.

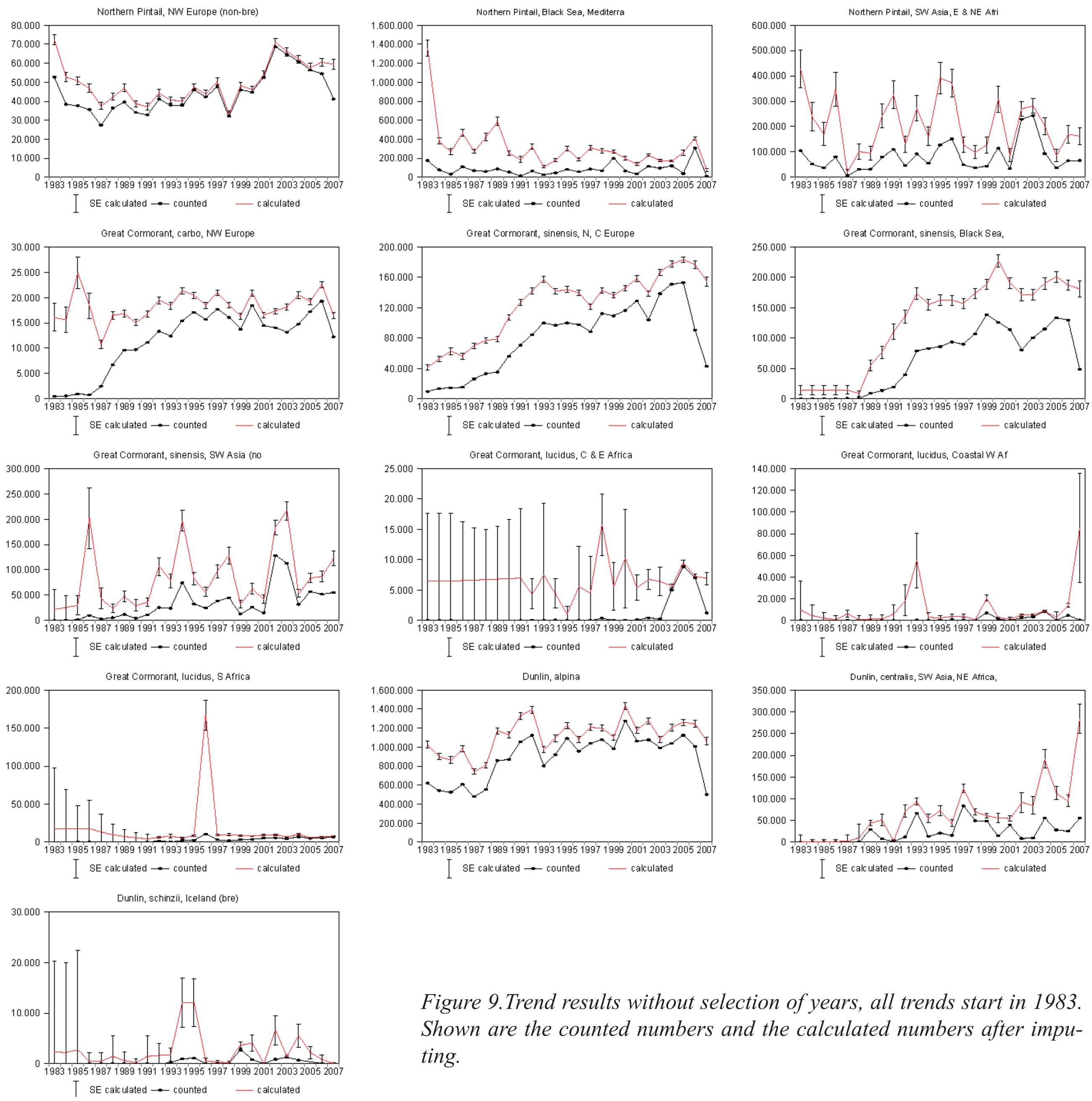


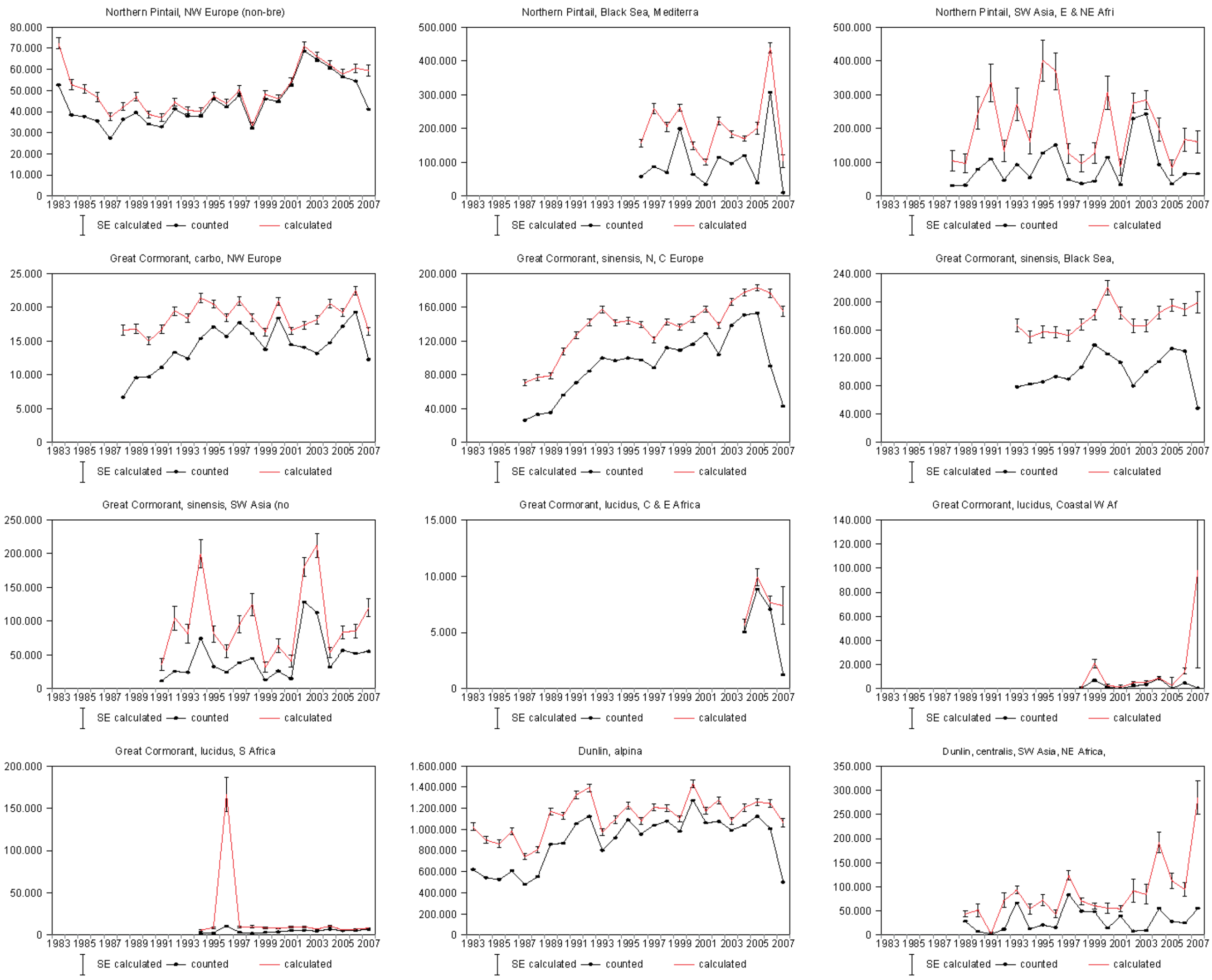
Figure 9.Trend results without selection of years, all trends start in 1983. Shown are the counted numbers and the calculated numbers after imputing.

Table 3. Amount of imputing per year per population.

year	Anas acuta NW Europe (non-bre)	Anas acuta Black Sea, Mediter-ranean, W Africa (non-bre)	Anas acuta SW Asia, E & NE Africa (non-bre)	Phala-croco-rax carbo carbo, NW Europe	Phala-croco-rax carbo sinensis, N, C Europe	Phala-croco-rax carbo sinensis, Black Sea, Mediterranean	Phala-croco-rax carbo sinensis, SW Asia (non-bre)	Phala-croco-rax carbo lucidus, C & E Africa	Phala-croco-rax carbo lucidus, Coastal W Africa	Phala-croc-orax carbo lucidus, S Africa	Calidris alpina alpina	Calidris alpina centra-lis, SW Asia, NE Africa, E Mediter-ranean (non-bre)	Calidris alpina schinzii, Iceland (bre)
1983	27	87	75	97	76	100	100	100	100	100	40	100	100
1984	27	80	78	96	74	100	97	100	100	100	40	99	100
1985	26	88	78	96	77	100	94	100	100	100	39	99	100
1986	24	76	77	96	73	100	95	100	99	100	38	99	99
1987	27	74	71	77	63	94	93	100	95	100	35	100	99
1988	14	86	69	59	57	90	76	100	99	100	32	100	100
1989	16	85	66	43	55	83	75	100	100	100	27	35	99
1990	12	79	67	36	48	82	85	100	99	100	23	85	97
1991	12	91	66	34	44	82	68	100	99	100	21	49	100
1992	7	80	64	31	41	71	76	98	100	73	19	83	100
1993	6	75	66	32	36	54	69	100	99	94	18	29	91
1994	6	75	66	28	32	47	62	98	99	61	16	76	92
1995	3	73	67	16	31	47	61	99	95	71	11	72	91
1996	4	69	59	15	30	42	57	100	95	94	12	64	92
1997	6	72	62	15	27	43	60	100	92	67	14	33	80
1998	4	75	62	13	21	38	65	98	66	82	10	30	78
1999	5	26	66	16	20	27	59	99	66	62	11	20	26
2000	3	68	63	12	20	45	58	100	53	52	11	74	80
2001	2	75	62	13	19	40	64	98	97	43	10	27	84
2002	3	51	15	19	25	53	30	93	52	41	16	91	87
2003	2	46	14	27	17	41	48	96	38	36	8	89	6
2004	2	30	54	28	15	39	40	11	7	33	14	71	87
2005	3	85	57	10	16	34	32	7	99	18	11	75	100
2006	10	25	61	14	49	31	40	3	67	22	19	73	92
2007	31	87	59	26	72	73	55	82	99	17	53	80	88

Table 4. Resulting starting years after different thresholds of imputing for the first year.

Population	**Startyear when < 90% impute**	**Startyear when < 70% impute**	**Startyear when < 50% impute**
Anas acuta NW Europe (non-bre)	1983	1983	1983
Anas acuta Black Sea, Med., W Africa (non-bre)	1983	1996	1999
Anas acuta SW Asia, E & NE Africa (non-bre)	1983	1988	2002
Phalacrocorax carbo carbo, NW Europe	1987	1988	1989
Phalacrocorax carbo sinensis, N, C Europe	1983	1987	1990
Phalacrocorax carbo sinensis, Black Sea, Med.	1989	1993	1993
Phalacrocorax carbo sinensis, SW Asia (non-bre)	1988	1991	2002
Phalacrocorax carbo lucidus, C & E Africa	2004	2004	2004
Phalacrocorax carbo lucidus, Coastal W Africa	1998	1998	2003
Phalacrocorax carbo lucidus, S Africa	1992	1994	2001
Calidris alpina alpina	1983	1983	1983
Calidris alpina centralis, SW Asia, NE Afr, E Med.	1989	1989	1989
Calidris alpina schinzii, Iceland (bre)	1997	1999	1999



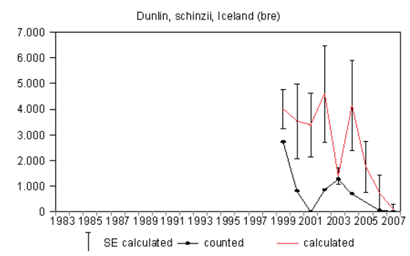


Figure 10. Trend results with use of starting years: the trend starts in the first year that the amount of imputing is below 70%.

imputing to distinguish between plausible and un-plausible results. To use an easy to handle criterion for the start of the trend across species we used the first year that the amount of imputing was less than 70% as a 'rule of thumb' for the starting year of the trend presented. The results of applying this rule are presented in Figure 10. It seems sensible to exclude other years with more than 70% imputing in the remaining times series as well in future analyses.

4.5. Selecting trend results which can be used

After all calculations for the AEWA conservation status report are preformed following the procedures as described above approximately 240 trends of individual flyway populations will be available. This does not mean that all these trends are reliable and additional criteria are needed to help in the process of trend selection:

The amount of imputing

Although no linear relation exists between the amount of imputing and the reliability of the trends (Soldaat et al. 2004), the overall amount of imputing can help in this. In table 5 the remaining amount of imputing in the time series is presented after the start of the time series with the first year with imputing below 70%. We advise that trend results with overall more than 70% imputing will not be used. However this will not be the case anymore if the start year will begin with less than 70% imputing and other years with 70% imputing will be excluded (see 4.4).

The amount of the population size included

The trend can be based on only a small proportion of the flyway population and as such likely be not representative for the whole population development. In table 4 the proportions of the flyway populations included in the trend analyses are presented showing huge differences. Note that this analysis is dependent on the quality of the population size estimates as well. (It seems unlikely that 96% of the SW Asia population of Cormorant is normally included in the yearly counts and we presume that the estimate of population size is to low.) On the basis of expert judgment we advise that the minimum level of population size included in the trend analyses should be 10%.

Geographical bias in sites included

Even when a rather reasonable proportion of the flyway population is included in the trend calculations the results can be biased if the sampled sites are only from a part of the January distribution. Especially in situations where populations are going to winter further north (because of global warming) we need to be careful to interpret the positive trends based on only northern sampled sites as 'right' if no southern sites are sampled as well. In Table 5 populations are marked where this geographical bias may occur.

Table 5. Amount of imputing in remaining part of time series after start year with less of 70% imputing, % of minimum flyway population size included in the time series in 1996-2005 for the 13 populations and populations where the trend included in the analyses are probably geographical biased.

Population	**Remaining perc. of imput**	**Perc. of population at <70% impute**	**Geograhical biased**
Anas acuta NW Europe (non-bre)	11	89	
Anas acuta Black Sea, Med., W Africa (non-bre)	55	30	X
Anas acuta SW Asia, E & NE Africa (non-bre)	43	28	X
Phalacrocorax carbo carbo, NW Europe	23	16	
Phalacrocorax carbo sinensis, N, C Europe	31	40	
Phalacrocorax carbo sinensis, Black Sea, Med.	43	52	
Phalacrocorax carbo sinensis, SW Asia (non-bre)	41	96	
Phalacrocorax carbo lucidus, C & E Africa	26	4	
Phalacrocorax carbo lucidus, Coastal W Africa	62	16	
Phalacrocorax carbo lucidus, S Africa	30	66	
Calidris alpina alpina	22	90	
Calidris alpina centralis, SW Asia, NE Afr, E Med.	61	18	
Calidris alpina schinzii, Iceland (bre)	72	0.4	

5. Conclusions and recommendations

Output needed for the AEWA conservation status report
The possibilities of analyzing the data set using TRIM were rather disappointing, since it did not allow the use of strata (non-converging models). Although we do not know if other methods perform better regarding this aspect, there are also more fundamental problems with analyzing water bird count data that need to be addressed, such as the treatment of counts as independent samples and deviations from Poisson distribution. However, given the time and budget available we think that the methods as developed now are sufficiently useful for the AEWA conservation status report. The use of TRIM is relatively fast and straightforward, and consistent with the 4th conservation status report. We implemented substantial improvements by analyzing the data at flyway level. Also some "rules of thumb" are developed to assess the starting year of the trend, to distinguish between zero counts and missing counts on the basis of the multi-interpretable information in the data set, and criteria for assessing the plausibility of the trends. The trend analyses can and need to be improved in future, but we do not expect large differences in results if other methods are used; moreover, this will not seriously affect the statements about decreasing or increasing species as defined by the AEWA technical committee. However, 5 year periods seem too short to calculate reliable trends for wintering water birds. Inter-annual fluctuations in water bird numbers are large, particularly when based on one count a year only, and 5 year trends are therefore reflecting short term fluctuations instead of real trends. Using a period of 10 year to assess short term trends corresponds better with the nature of international water bird monitoring data.

Improvements for the future
Several improvements in the future international monitoring of water birds and in analyses for the next Conservation Status Report could be formulated (see also van Roomen 2010). We think that improvements in the data set are much more urgent than improvements in the analysis methods.

- Develop and use consistent counting site lists and counting site boundaries together with National Coordinators.
- Improve the future consistency in counting coverage from year to year; organize more frequent and more compete counts in important wetlands; gather historical data to complete time series per site
- Correct and where possible add missing counts in the IWC database together with National Coordinators.
- Select sites with good temporal and spatial coverage and consistent site boundaries over the years in the database. Consider using this selection of 'high quality sites' for future trend analyses. Make a clear distinction between missing counts and zero counts at the species and site level.
- Start discussions with Specialist groups and other specialists of the allocation of sites to flyway populations during the winter period.
- Investigate the (dis)advantages of other trend analyzing methods to calculate flexible/smoothed and stratified trends (e.g. GAM's, hierarchical models or TrendSpotter). These seem more appropriate, but also more time consuming, for analyzing wintering water bird count data.
- Consider the use of national population size estimates as weighting factors in the trend analyses, to correct for unequal sampling with each flyway. Periodically update these population size estimates.
- Develop and refine criteria for identifying reliable and unreliable imputing and trends, in addition to the confidence or consistency intervals.

6. References

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