CAFF
Conservation of Arctic Flora and Fauna

CIRCUMPOLAR BIODIVERSITY MONITORING PROGRAM

CAFF Assessment Series Report
September 2015

Arctic Species Trend Index: Migratory Birds Index

ARCTIC COUNCIL

ZSL LIVING CONSERVATION

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CAFF Designated Area

Conservation of Arctic Flora and Fauna

Table of Contents

Acknowledgements

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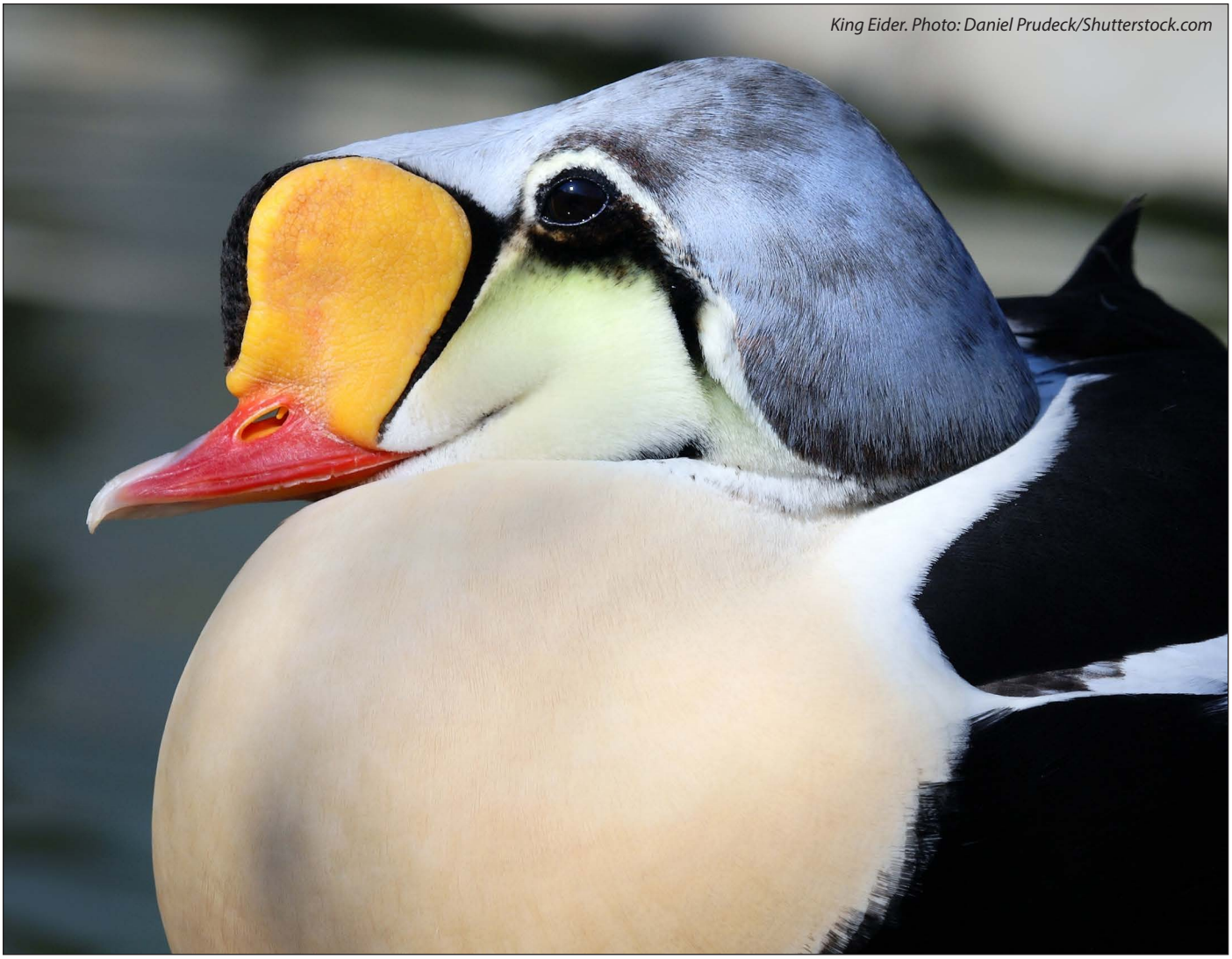
A note from the authors

Please note that this report represents a first attempt of defining the abundance trends of migrant bird species which breed in the Arctic and leave the area for the northern hemisphere winter. For this purpose, we examine a data set of all of the time-series data we were able to collate in the time frame of the project. Some of the available data spanning both Arctic and non-Arctic areas had to be excluded from analysis to reduce the number of overlaps between different monitored individuals inside and outside the region. We are aware that, as a result, this data set is not perfect and would like to emphasise that the trends presented here are not to be viewed as definitive – they only give an indication of how abundance has changed in these selected species.



King Eider. Photo: Daniel Prudeck/Shutterstock.com

Terminology

Arctic	The area and locations referred to as Arctic are defined by the Conservation of Arctic Flora and Fauna (CAFF) and include the high, low and sub-Arctic regions (Figure 1).
Species	A group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding.
Migration	The regular, seasonal movements of animals from one region to another, often between their breeding and non-breeding grounds.
Arctic migrant	A species which breeds in the Arctic and moves outside the Arctic region for the non-breeding season. This report focuses on selected species from the Arctic Biodiversity Assessment (ABA) and does not include species populations that do not leave the Arctic during their annual migratory cycle.
Migratory status	Categories defined in the ABA describing the extent to which a species as a whole undergoes regular migration. Trends reported here focus primarily on those species in categories 1 and 2, but also include species from the remaining categories, provided the individuals in question leave the Arctic for the non-breeding season 1 – the entire species breeds in the Arctic 2 – the majority of individuals breed in the Arctic 3 – only some individuals breed in the Arctic 4 – the species breeds primarily in boreal or temperate areas, although it may penetrate the Arctic in places.
Flyway	The entire range of a migratory species, or of a group of species, within which seasonal movements occur from breeding to non-breeding locations, including all intermediate resting and feeding places and areas in between. For birds, eight flyways are commonly delineated: Pacific Americas, Central Americas, Atlantic Americas, East Atlantic, Mediterranean-Black Sea, East Asia-East Africa, Central Asia and East Asia-Australasia.
Flyway region	In this report, the eight commonly delineated flyways are combined into broader flyway regions: Americas, Africa-Eurasia, Central Asia and East Asia (Figure 2).
Population	Groups of individuals of a single species that are separated through their use of a specific flyway, or discrete routes within a flyway. These rarely overlap, so trends are distinct and may be used to identify threats along these routes. In this report, the first definition is used, referring to all individuals of the same species within a flyway region as a population. If a species utilises more than one flyway region, it therefore comprises more than one population.
Time-series	A set of comparable values measured over time. Here, these values are abundance estimates of a set of individuals of the same species monitored in the same location over a period of at least two years using a comparable method.
Index	A measure of change over time compared to a baseline value calculated from time-series information.
Data set	A collection of time-series from which an index is calculated.

Key findings

1. Broad-scale, multi-species trends for Arctic migratory birds are currently unavailable, although they are necessary for designing and targeting effective conservation strategies to address reported declines in these species.

2. We use a robust method to describe trends in 129 selected Arctic migratory bird species, using abundance change estimates from inside and outside the Arctic. The selected species have increased in abundance by 40% on average between 1970 and 2011 (Figure 10).

3. This overall trend masks differences between taxa and in flyway regions, with declines in East Asia and Central Asia (-40% and -70%), and recoveries in Africa-Eurasia and the Americas (50% and 15%, Figure 12).

4. Shorebirds are in decline overall (-10%, Figure 11), with negative trends in the Americas and East Asia (-10% and -70%, Figures 15 and 17). Populations of this group are faring better in Africa-Eurasia, where abundance is 40% higher compared to 1970 (Figure 16).

5. Waterfowl have increased across all flyway regions mainly due to geese (Figures 15-17), but there are differences in the underlying trends for geese/swans and for ducks (Figure 18). Geese and swans combined more than quadrupled in abundance between 1970 and 2011 (Figure 19), showing positive change across regions (Figure 20), although coverage is too patchy for reliable conclusions. The increase in geese/swans is largely driven by geese, which make up the majority of this data set. Swans have been in decline since 1994 (Figure 19). Duck abundance is 10% lower overall (Figure 19), but there are regional differences, with a halving in the Americas and a 70% increase in Africa-Eurasia (Figure 21).

6. In the Wadden Sea, Arctic bird abundance is 75% higher in 2010 than in 1980, but the trend has been following a negative trajectory since 2002 (Figure 22).

7. A number of species in our data set showed declines across flyway regions, e.g., Red knot *Calidris canutus*. Others have increased more recently, e.g., Greater white-fronted goose *Anser albifrons*.

8. Due to data limitations, this report is a first step towards developing detailed knowledge of macroecological patterns in Arctic breeding migratory birds. Trends may differ from expert knowledge until data gaps are filled. In addition, we did not examine if abundance change is attributable to factors other than the loss of individuals, e.g., shifts in seasonal ranges.

9. Due to time and resource limitations some data on abundance change was not included, accounting for some of the data gaps. Additional gaps are due to lack of access to data and the ongoing need for more data collection. It is hoped that this report will trigger increased interest and wider participation from all countries and organisations along the migration routes as international cooperation is vital to ensure the conservation of Arctic migratory birds.

Introduction

Arctic migrants

An estimated 1,855 or 19% of bird species migrate between relatively distinct breeding and non-breeding ranges with predictable timing and destinations (Kirby et al. 2008). These seasonal migration routes may be shared between species, and movements can be summarised and delineated into flyways[1]. The Arctic represents the starting point for many of these flyways because of its brief but intensely productive summers (Boere & Stroud 2006). It is estimated to host 279 or 2% of bird species during the breeding season (Meltofte 1996, Ganter & Gaston 2013), including 50% of individual shorebirds and 80% of individual geese (Zöckler 1998, Delany & Scott 2006). In addition to an abundance of food, Arctic breeders also benefit from increased safety from predation due to continuous daylight, an overall lower number of predators and safety in numbers (Schekkerman et al. 2003b, McKinnon et al. 2010).

Recent reviews indicate that a number of migratory birds are at high risk and have an unfavourable conservation status (Kirby 2010, Ganter & Gaston 2013, Zöckler et al. 2013). In the Arctic region (Figure 1), rapid climate and environmental change in recent decades (ACIA 2005, AMAP 2012, Stroeve et al. 2012) has caused dramatic shifts in ecosystems, which are expected to be exacerbated in the future (Post et al. 2009). Fluctuating snow cover and humidity levels, increasing shrub cover, and the changing distribution and extent of tundra habitat have reportedly had a negative impact on some shorebird species (Johnson et al. 2007). Collapsing small mammal cycles caused by these environmental changes within the Arctic breeding grounds are further believed to be responsible for declines in some migratory species due to predators switching to eggs and young (Blomqvist et al. 2002), as is the case for Red knot *Calidris canutus rufa* in the Americas (Fraser et al. 2013). Other species have reaped benefits (Zöckler & Lysenko 2000), showing substantial population increases as a result of these changes, e.g., White-fronted goose *Anser albifrons* (Boyd & Fox 2008), despite observed declines in migrant birds overall (McRae et al. 2010).

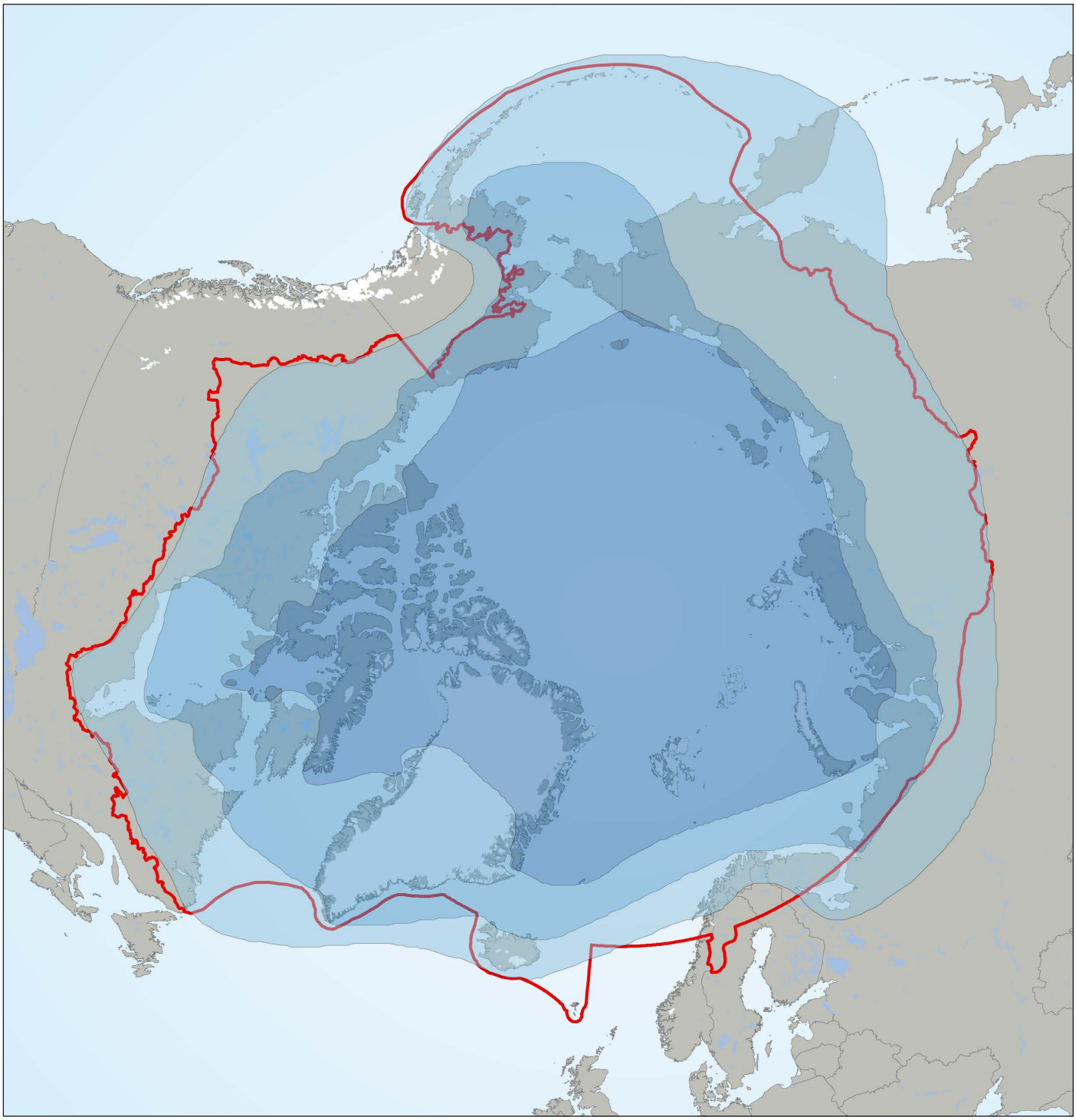
In addition to factors in the breeding area, conditions and threats along the rest of the flyways play a role in determining trends in species (Schekkerman et al. 2003a, Newton 2004, Zöckler et al. 2013), with impacts often only becoming apparent during monitoring at subsequent migratory stages (Newton 2004). While some goose species, e.g., Snow goose *Chen caerulescens*, have benefitted from the establishment of refuges, reduced hunting mortality, and, most importantly, the expansion and increased productivity of agricultural areas along the flyways (Gauthier et al. 2005), others have been less fortunate. Wader declines are attributed primarily to conditions outside the Arctic, with habitat loss through development (Yang et al. 2011), agricultural intensification (Amano et al. 2010), hunting pressures (Zwarts et al. 2009, Zöckler et al. 2010a, Morrison et al. 2012), over-exploitation of food resources (Morrison et al. 2012) and pollution (Morrison et al. 2012) highlighted as particular threats. Many species are affected by multiple processes, for example the Spoon-billed sandpiper *Eurynorhynchus pygmeus*, which has declined by more than 90% over the last 30 years and is now listed as critically endangered (Zöckler et al. 2013).

This report

This report aims to describe the broad-scale trends necessary for designing and targeting informed conservation strategies at the flyway level to address these reported declines. To do this, we examine abundance change in selected Arctic breeding bird species, incorporating information from both inside and outside the Arctic (Figure 1) to capture possible influences at different points during a species' annual cycle. The inclusion of trend information from non-Arctic locations confers a number of other advantages: data are readily available from key sites where individuals congregate in large, easy-to-count flocks; and adding these data allows for better disaggregation of trends due to larger data set size, thus providing the opportunity to elucidate the regional differences that have already been reported in the literature (Zöckler et al. 2013). Importantly, this addition also makes sense politically as the selected species are dependent on interconnected sites across the globe, meaning that suitable and effective conservation strategies can only be devised through international collaboration.

1 This delineation is achieved through analysis of morphological or genetic differences between groups of individuals, information obtained from ringing and banding results, stable-isotope ratios in feathers, and satellite-based and geolocation tracking (Kirby et al. 2008).

Figure 1. The Arctic delineated into high (blue), low (mid blue) and sub-Arctic (light blue) according to the Circumpolar Arctic Vegetation Map (CAVM Team 2003), adapted from the Arctic Biodiversity Assessment (Meltofte et al. 2013). The map also shows the CAFF boundary (dark blue line) as defined by the Conservation of Arctic Flora and Fauna (CAFF/Arctic Council Working Group 2009)

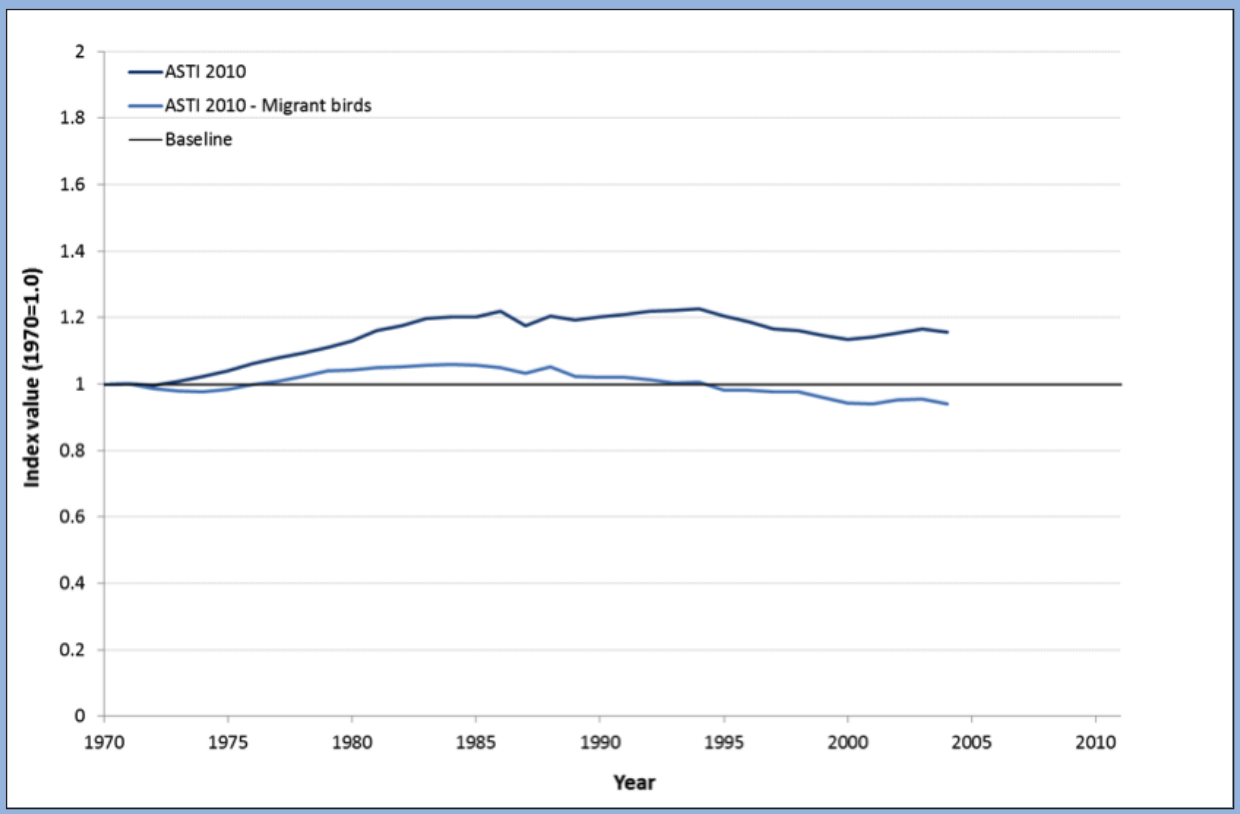


Box 1: The Arctic Species Trend Index (ASTI)

Since 2008 CAFF, UNEP-WCMC and ZSL have been leading a collaboration to build a database of abundance trends for Arctic vertebrate species. During this time, trend data were collected for 323 vertebrate species monitored within the Arctic boundary. This selection of species represents 37% of all known vertebrate species that are known to occur in the Arctic region. The time-series data from these species have been analysed using the method behind the Living Planet Index (Loh et al. 2005, Collen et al. 2009) to produce a pan-Arctic index of species abundance – the ASTI. This method has been applied to examine abundance trends in a range of vertebrate species across the Arctic (McRae et al. 2010), with subsequent work focusing on the marine system (McRae et al. 2012b), and spatial and temporal trends in Arctic monitoring activities (Böhm et al. 2012).

The first report produced in 2010 showed an increase of 16% in abundance between 1970 and 2004 (McRae et al. 2010), as depicted in Figure B1. Also shown is a subset of the index for migratory birds from the same report, which was calculated using a different data set and approach to the one used here. The 2010 migratory bird index declined by 5% between 1970 and 2004, but it only included data from locations in the Arctic region and the migratory definition used was very broad including short distance and occasional Arctic migrants. To explicitly examine trends in migratory birds we changed this approach to focus on a narrower set of species that are strictly migratory instead of following the broad definition used in previous work. Additionally, given that many migratory species are monitored in their over-wintering or stop-over sites, the next logical step in assessing trends in this important group was to focus efforts on including monitoring data globally. This undertaking has culminated in the current report. In the results section, Box 3 examines the differences the current and previous results for Arctic migratory birds.

Figure B1. The Arctic Species Trend Index for 965 time-series of 306 species (dark blue line), and the index for 424 time-series of 170 migrant bird species (light blue line) for the period 1970-2004. Both indices are adapted from the ASTI 2010 (McRae et al. 2010).



Method

To assess trends in Arctic migratory birds, time-series data at the population level were compiled for 129 selected species (see Methods section in the Appendix for a detailed description) to construct indices of abundance from 1970 to 2011 following a well-established method (Loh et al. 2005, Collen et al. 2009). This method is used for the production of a global biodiversity indicator, the Living Planet Index or LPI (McRae et al. 2012a), and has been employed in previous reports on the Arctic Species Trend Index (ASTI) to describe trends in species from locations within the high, low and sub-Arctic regions and for migratory birds (Box 1). Apart from being an indicator of biodiversity in the Arctic itself, the ASTI can also describe the state of the flyways and their relevant Arctic portions. Reliable and robust information for its construction is already available through the coordinated monitoring effort taking place in the Arctic region (see Box 2). The Living Planet Database (WWF/ZSL 2014), which holds abundance information from all around the world, provided additional time-series from outside the Arctic. It should be noted, however, that the final data set comprises data that could be easily obtained and entered within the timeframe of the project, and does not represent all data available. We would therefore like to encourage readers to contribute to the data set by contacting the authors with any missing information.

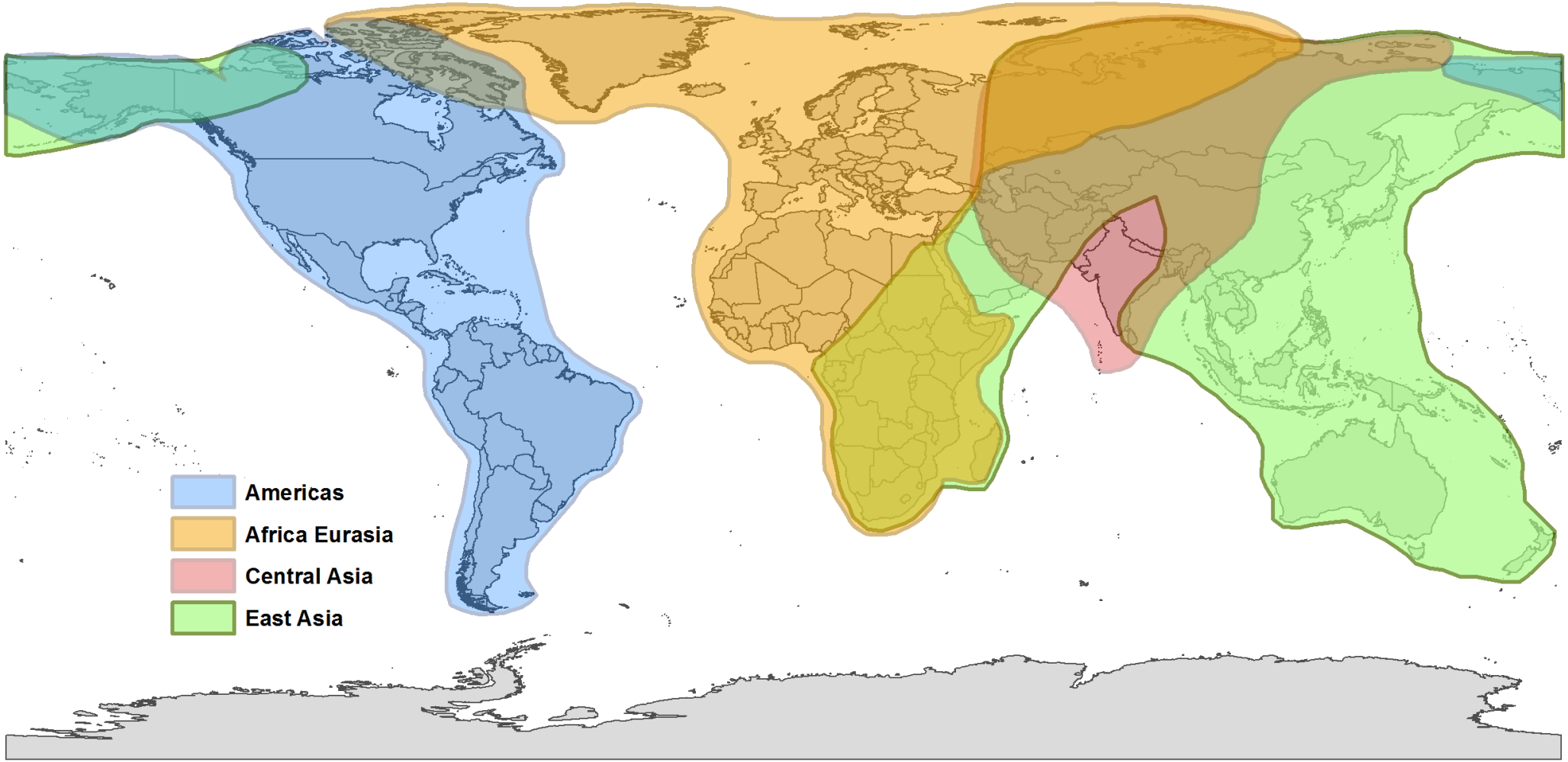
To simplify and focus our findings, information was combined from the eight standard flyways into four larger, continental flyway regions (Figure 2): Americas, Africa-Eurasia, East Asia and Central Asia[2]. Combining flyways confers similar advantages to collating information from Arctic and non-Arctic locations. Ecologically, adjacent flyways share populations and may be affected by the same threats or legislation. Politically, the interconnectivity of sites necessitates international collaboration, while conclusions drawn from pan-regional trends are often more informative for conservation efforts, which will in themselves be more effective if implemented over a larger area. Methodologically, observed trends are more representative and robust; this is because the data sets for individual flyway regions comprise information from a larger number of populations and are therefore more likely to reflect actual trends in these species more accurately. Indices for the eight flyways were calculated where data were sufficiently robust (see Figures A3 and A4). In order to make the figures presented clearer, we opted not to show confidence intervals for multi-line graphs, although they were calculated for all indices for which this was possible. However, because they are useful for determining the reliability of each trend, they are included in the Appendix (Table A4).

One important issue to mention is that of the baseline, which we set to 1970 for this report. The reason for this is data availability: more data are available from this point in time at which systematic data collection was started. As such, the trends we present here do not tell us about the current state of the species included but instead suggest whether their situation has improved or deteriorated relative to the baseline year. Positive change since 1970 could therefore likely represent a recovery from a highly depleted state reaching a peak pre-1970. Similarly, reductions in abundance since the baseline year may represent further losses from a depleted state. It is useful to keep this in mind when examining the trends presented in the following section.

Ivory Gull. Photo:Ian Davies/Shutterstock.com

2 The Central Asian Flyway remained separate as it is considered to be different from the other flyways in the Eurasian region. Apart from the Indian subcontinent being special in terms of geography, climate, and conservation issues, the Central Asian Flyway also encompasses countries that do not generally have a long history of focused and concerted conservation.

Figure 2. Flyway delineation according to BirdLife International (BirdLife International 2010g, i, b, a, f, h, e, c, d). For the purposes of this report flyways were combined into broader regions: Americas (blue; Pacific, Central and Atlantic Americas), Africa-Eurasia (orange; East Atlantic and Mediterranean-Black Sea) and East Asia (green; East Asia-East Africa and East Asia-Australasia). The Central Asian Flyway (brown) remained separate



Box 2: Arctic Migratory bird initiatives

The Foreign Ministers of the Arctic states identified migratory birds as an area of concern and a recommendation from the Arctic Biodiversity Assessment (CAFF 2013) was for the Arctic states work to reduce stressors on migratory species range-wide, including habitat degradation and overharvesting on wintering and staging areas and along flyways and other migration routes. Specific recommendations were directed towards:

- Pursuing or strengthening formal migratory bird cooperation agreements and other specific actions on a flyway level between Arctic and non-Arctic states with first priority given to the East Asian flyway
- Collaborating with relevant international commissions, conventions, networks and other organizations sharing an interest in the conservation of Arctic migratory species to identify and implement appropriate conservation actions
- Developing and implementing joint management and recovery plans for threatened species with relevant non-Arctic states and entities
- Identifying and advancing the conservation of key wintering and staging habitats for migratory birds, particularly wetlands

To implement these recommendations the Arctic Council is conducting through CAFF a range of activities intended to work towards sustainable conservation of migratory bird species both inside and outside the Arctic. Key amongst these initiatives are the Arctic Migratory Bird Initiative (AMBI), the Circumpolar Biodiversity Monitoring Programme (CBMP) and the Circumpolar Seabird expert group (CBird). CBird is an expert group within CAFF and the CBMP, which is trying to address the problems faced by migratory birds in the Arctic region through various means. This includes the development of a range of conservation strategies (for example for Ivory gull Pagophila eburnea, and eider species), as well as work on seabird harvest, bycatch and, in the future, the challenges posed by shipping.

The goal of the AMBI is to improve the status and secure the long-term sustainability of declining Arctic breeding migratory bird populations. It will be the key means by which the Arctic Council will work to increase political recognition of the challenges facing Arctic migratory birds, raise awareness, and facilitate conservation and research actions. The CBMP is an international network of scientists, governments, Indigenous organizations and conservation groups working to harmonize and integrate efforts to monitor the Arctic's living resources. The Arctic Terrestrial Biodiversity Monitoring Plan (Christensen et al. 2013) developed through the CBMP, proposes a set of avian functional groups and key related attributes that would form the foundation of a coordinated monitoring scheme. A bird expert group has been formed to direct this component of the terrestrial monitoring plan implementation and in coordination with the work undertaken by CBird and the freshwater and coastal CBMP networks, will facilitate improved monitoring to identify trends and inform conservation strategies across the circumpolar world.

Red Knots. Photo/Morten Ekker

Results and Discussion

The final data set

The ASTI data set (McRae et al. 2010, McRae et al. 2012b) was expanded with abundance information from outside the Arctic taken from the Living Planet Database (WWF/ZSL 2014). The addition of 443 records of 81 bird species almost doubled the final number of time-series to 966 and provided 10 new species, bringing the total to 129 species (Table A3). The number, distribution and length of these time-series are depicted in Figure 4.

In the final data set, the largest proportion of time-series and species are categorised as increasing (47% and 49%), i.e. they show an overall change of +5% or more. Because there are more stable trends, defined as between -5% and +5% change, recorded among time-series than among species, there is also a smaller proportion of declining time-series than species (Figure 3). Overall, time-series trends are clearly increasing and declining across the whole range of the selected species. In order to investigate whether this mixed picture occurs uniformly across flyway regions and taxonomic groups, the trends were teased out further through disaggregation (see section 'Trends').

Figure 3. Proportion of decreasing (dark blue), stable (grey) and increasing (light blue) time-series and species in the data set. A stable trend is defined as a 5% reduction or increase in abundance between 1970 and 2010. Trends were calculated to 2010 rather than 2011 because the time-series from Arctic locations ended before this point.

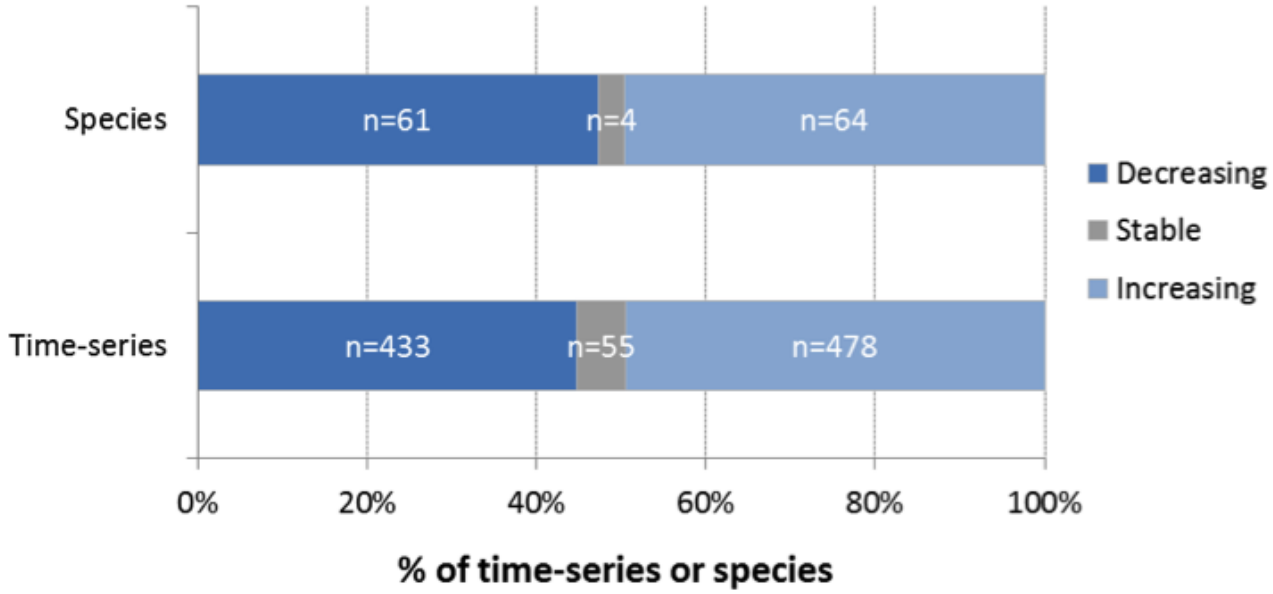
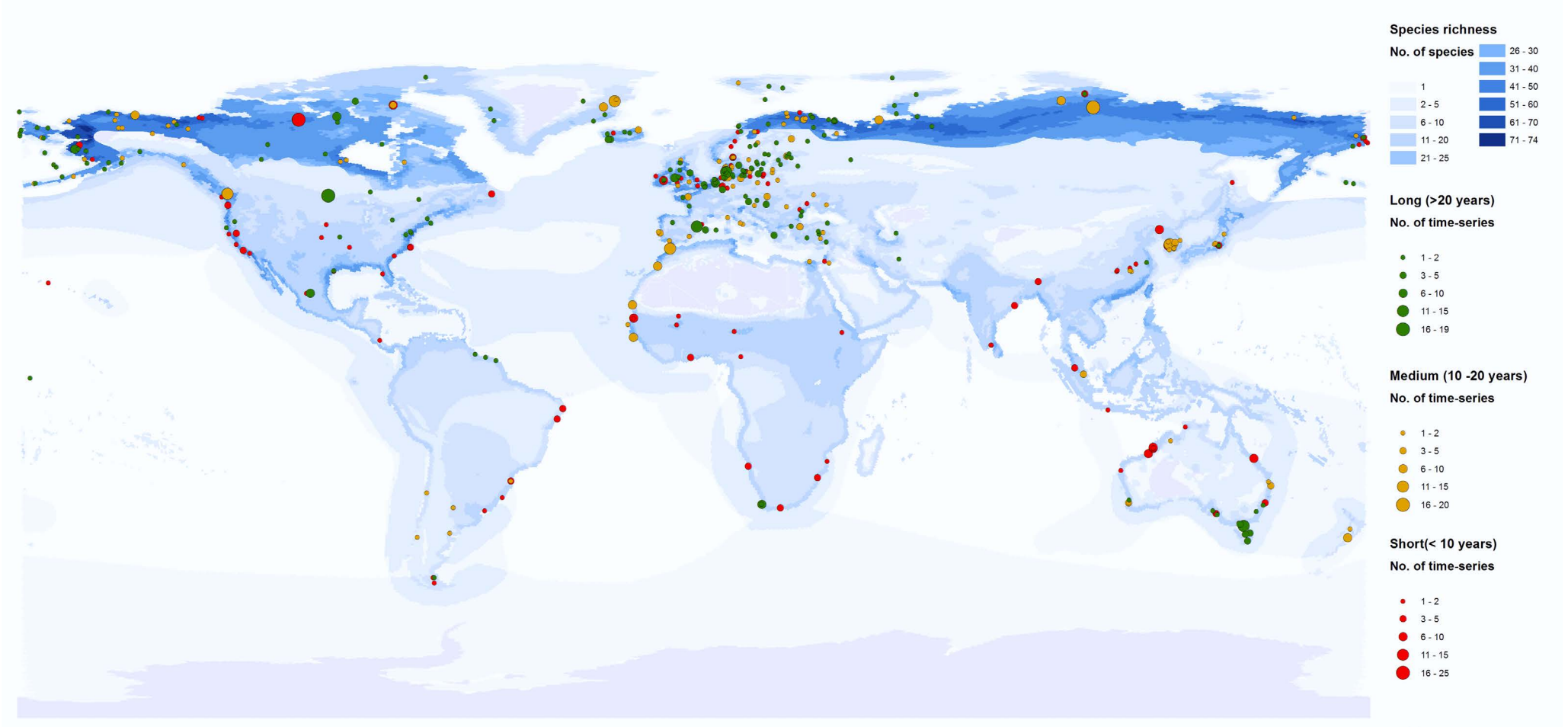


Figure 4. Spatial distribution of 966 time-series of 129 migratory bird species in the data set (circles) and expected species richness (blue shading). The size of each circle denotes the number of time-series from that location, and the colour the length of each time-series between 1970 and 2011 (red = short, yellow = medium, green = long; please note that even long time-series may have ended more than 10 years ago). For more detail on these time-series, please refer to Table A3. Blue shades describe the number of 160 species from the Arctic Biodiversity Assessment (Ganter & Gaston 2013) expected to occur across the globe. This number was based on the breeding ranges of these species for within the Arctic boundary, and non-breeding and passage ranges for outside the Arctic boundary). All range maps were from the IUCN Red List (BirdLife International and NatureServe 2012).



Coverage

The robustness and representativeness of the data was assessed by examining taxonomic, spatial and temporal coverage. Specific reference is made to the coverage within flyway regions, both in terms of the number of species and the proportion of individuals within each species that are represented.

Taxonomic coverage

The data set accounted for 81% of the 160 reference species that were selected from the Arctic Biodiversity Assessment or ABA (Ganter & Gaston 2013) as being species that breed in the Arctic and overwinter outside. Representation was better for species which are classified as being wholly or largely Arctic migrants (92% of category 1, 79% of category 2; Table 1). This is because data collection focused exclusively on these categories due to time constraints. Although no additional time-series were added for categories 3 and 4, we were able to take advantage of an existing data set, which explains the reasonably good coverage within these categories. In terms of taxonomic group, shorebirds and waterfowl are likely to yield the most reliable trends as they comprise more than 90% of the reference species (Table 1). Coverage was less than 70% for landbirds and seabirds, suggesting that underlying trend information is incomplete.

Table 1. The number of species in the data set compared to 160 Arctic-breeding reference species selected from the Arctic Biodiversity Assessment (Ganter & Gaston 2013). Taxonomic groupings and migratory status categories also follow the ABA. Migratory status categories are: 1 = confined to the Arctic during the breeding season; 2 = majority of population breeds in the Arctic, but species also occurs further south; 3 = only part of the population breeding in the Arctic; 4 = chiefly boreal or temperate breeding species that penetrate the Arctic in places.

		ABA Species	Study species	Coverage
Migratory status	Category 1	65	60	92%
	Category 2	33	26	79%
	Category 3	19	13	68%
	Category 4	43	30	70%
Taxonomic group	Landbirds	43	29	67%
	Seabirds	32	22	69%
	Shorebirds	53	49	92%
	Waterfowl	32	29	91%
Total		**160**	**129**	**81%**

Spatial and temporal coverage

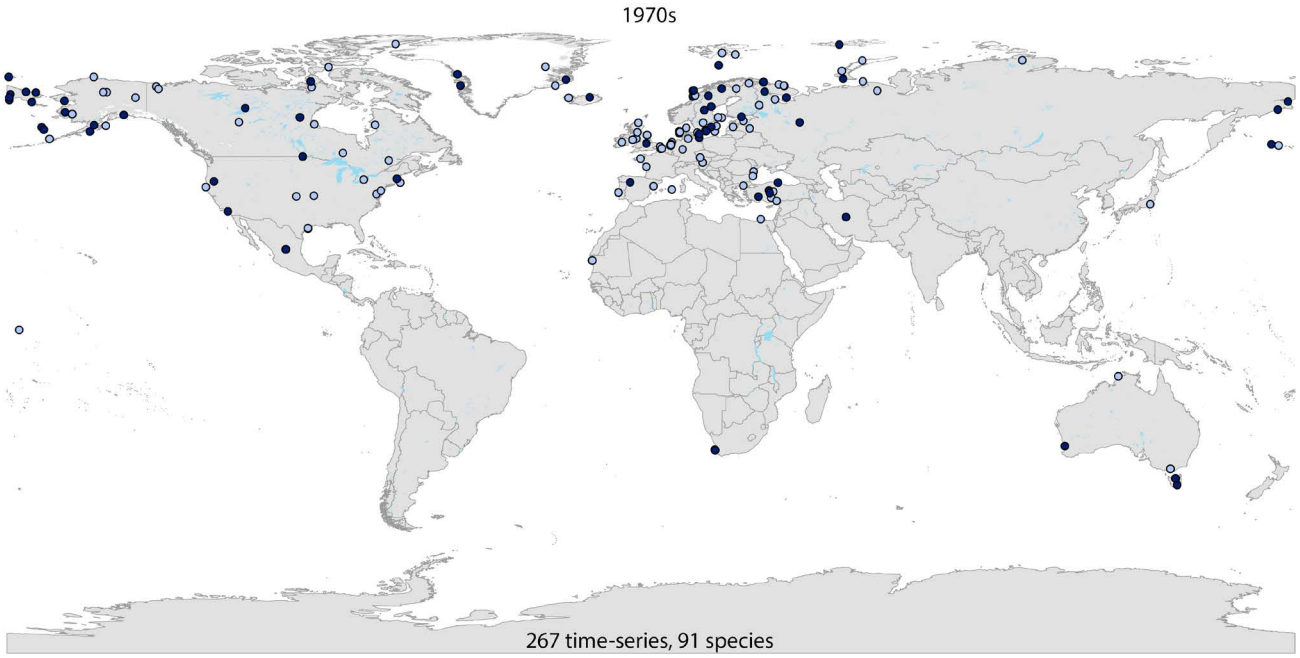
Much of the data set comprises trend information from Europe, especially the North, Baltic and Mediterranean coasts. This is true of the number of species (25%), time-series (37%), time-series of over 20 years in length (green circles, Figure 4) and time-series per decade (Figure 5). It is likely that the early establishment of long-term monitoring programmes has led to greater data availability in this region. North America contributes fewer time-series (21%) but more species (31%), while coverage is generally lower in Africa and Asia. Many of the monitored locations coincide with higher species richness (represented by darker colours in Figure 4), but gaps are discernible in coastal areas of Central and Southeast Asia, the North American Atlantic coast, and parts of the Russian Arctic (Figures 4 and 5). The shortest time-series of less than 10 years in length are found in the African subcontinent and in Australasia, where they may be the only information available (Figure 4).

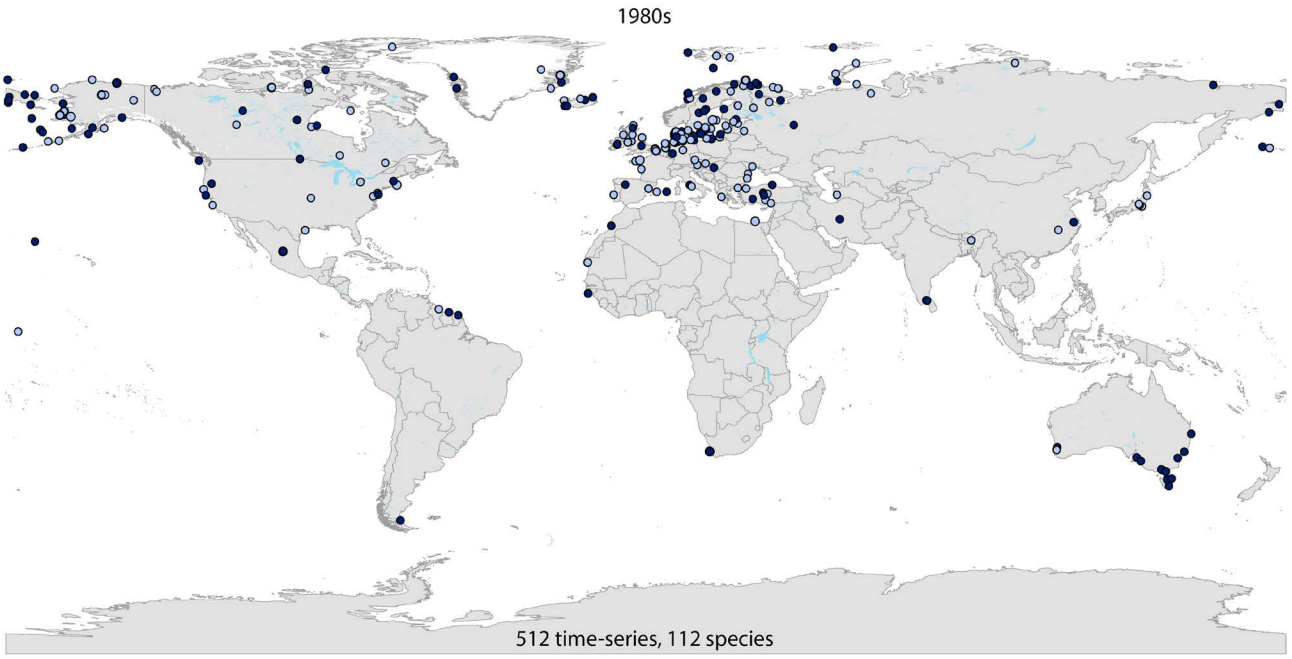
Because not many time-series span the entire study period between 1970 and 2011, the size of the data set differs in each year depending on the number of time-series contributing. The largest number of time-series contributing in any single year is 584 in 1996. When we examine contributing time-series by decade, we observe some differences in the number and distribution. The largest decadal data set is in the 1990s with a total of 735 time-series, followed 2000 and 2005, while the amount of available data declines thereafter to a level comparable to the 1980s (Figure 5). Regions with a long history of abundance monitoring such as Europe and North America are represented in all decades. Others, such as China, South Korea and South America contribute only from the 1980s, while Africa and Central Asia are data-sparse throughout. No specific pattern is discernible in terms of the spatial distribution of increasing/stable and decreasing trends over time (Figure 5).

The unequal distribution in time and space can be explained by a number of factors, which are outlined below. Further data collection would improve coverage from the 2000s and allow for the extension of the indices presented.

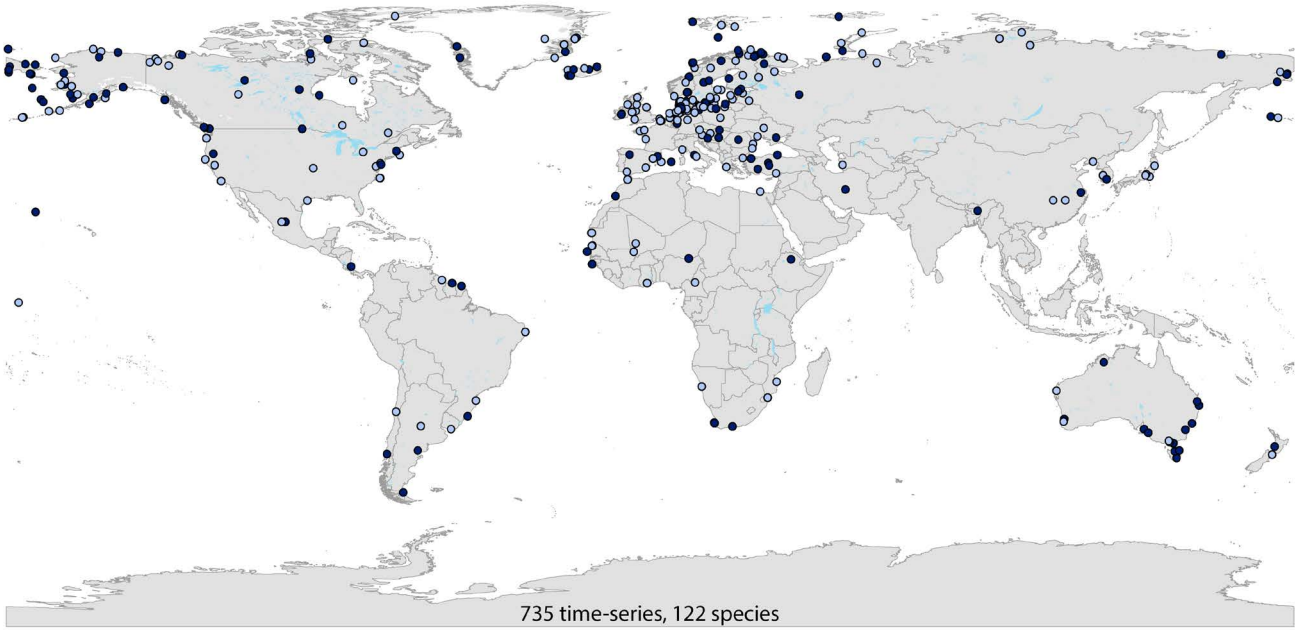
- Long-term monitoring programmes were established in North America and Europe in the 1960s and 70s, but only recently in other regions. The same is true for understudied species groups;
- Data from less well-monitored regions may have been collected ad hoc and/or as part of short-term funding programmes, leading to shorter time-series length, or the information may have only recently become accessible internationally;
- Lack of data in more recent years may be attributable to an expected but significant lag in the publication of abundance information after collection;
- Recent data are not always immediately shared with the conservation community; and
- Time-series from Arctic locations were not updated with recent data, which meant that reliable trends could only be produced up to 2011.

Figure 5. Spatial distribution of time-series in each decade, and the number of contributing time-series and species in the data set. Dark blue dots represent time-series with a decreasing trend (<-5% overall), and light blue dots represent time-series that are stable (-5% to +5%) or increasing overall (>+5%).



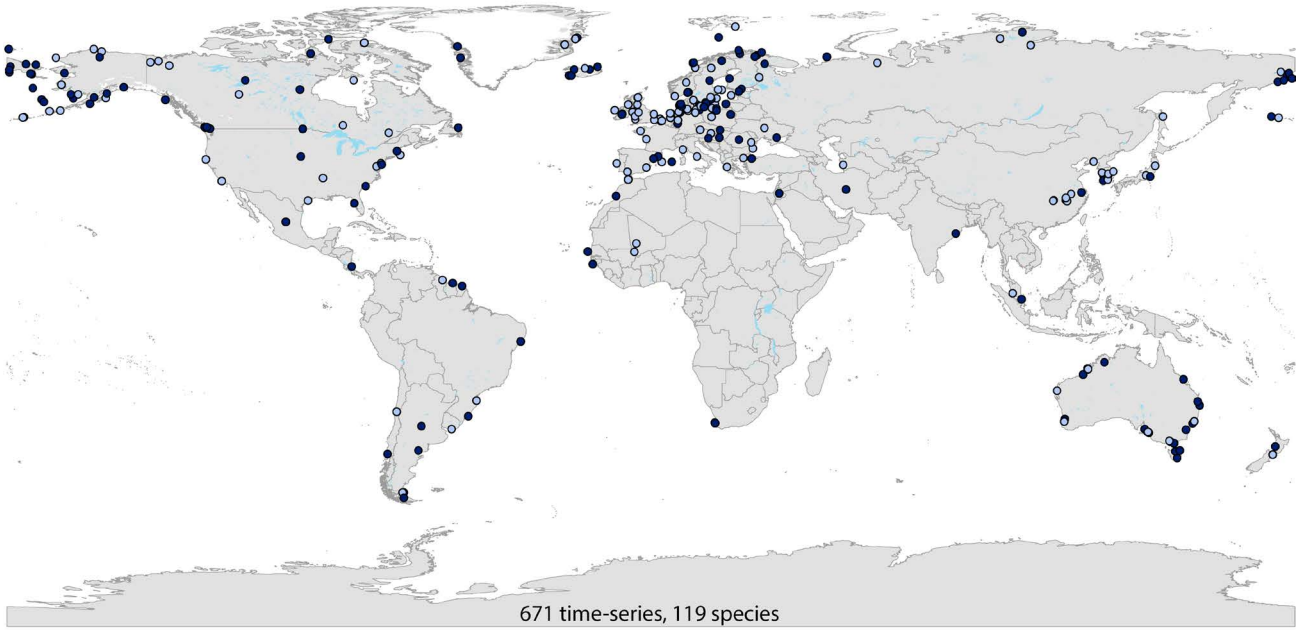


1990s



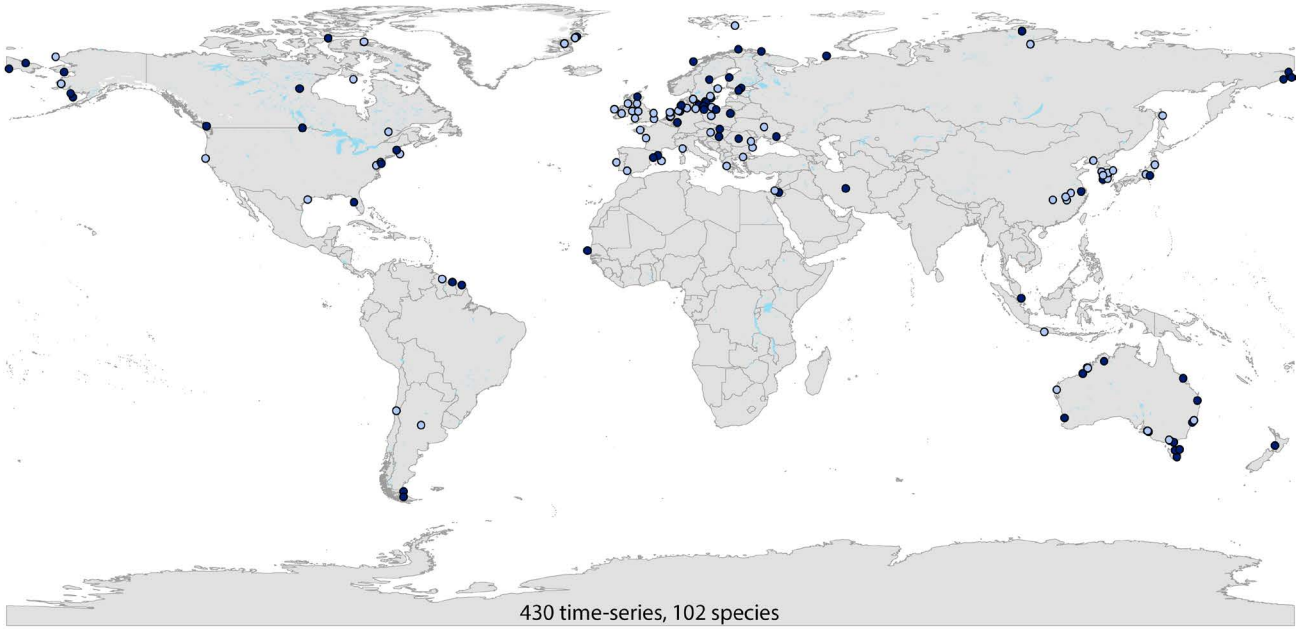
735 time-series, 122 species

2000 - 2005



671 time-series, 119 species

2006 - 2011

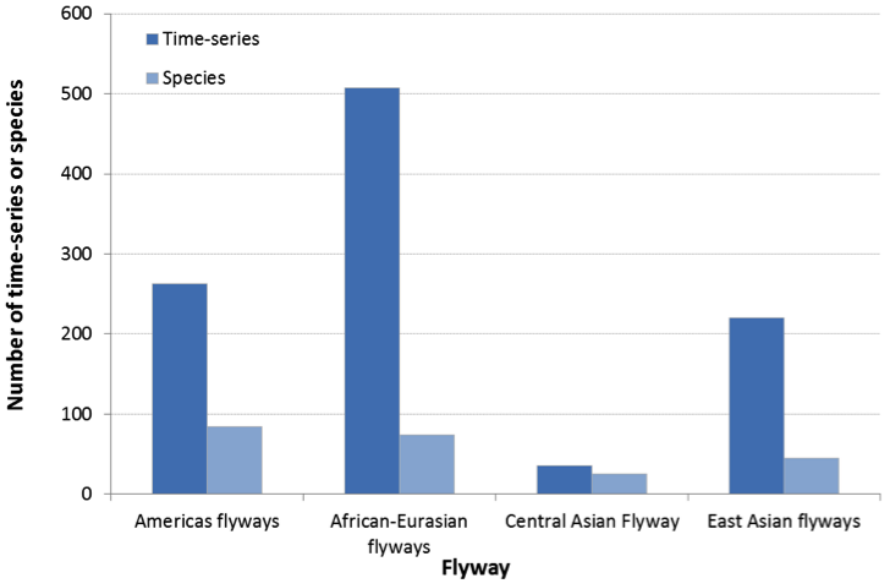


430 time-series, 102 species

Flyway coverage

In line with the regional gaps discussed above (Figure 4), the distribution of species and time-series is uneven across flyway regions, with the largest contributions from Africa-Eurasia and the Americas, followed by East Asia (Figure 6). These flyway regions are dominated by time-series from the East Atlantic, Pacific Americas and East Asia-Australasia Flyways (Figure A1). More information on the coverage within the eight standard flyways can be found in Figure A2.

Figure 6. The number of time-series (dark blue) and species (light blue) monitored in each of the four flyway regions.



Another important measure of monitoring representativeness than the actual number of species can be obtained by comparing the number of species monitored in each flyway to the number of 160 selected reference species from the ABA expected to occur here. Overall, 66% of these flyway populations are represented in the data set. The Americas and African-Eurasian region comprise around 80% of these reference species (Figure 7), with the highest proportions in the Central Americas and East Atlantic Flyways (Figure A2). The Central Asia Flyway (Figure 6) has the least complete species coverage with only 45% (Figure 7). Much of the missing coverage is likely to be due to gaps in monitoring, so there is a need to coordinate efforts across regions. This is particularly true for those species using multiple flyways, which make up 88% of the species in the data set (Figure 8).

Figure 7. Species coverage by flyway region, shown as the percentage of species in the final data set compared to the number of reference species expected to occur in each region. White numbers denote the number of species in the data set, and black numbers the total expected number. Please note that a species can occur in more than one flyway region. The expected number in East Asia is small despite the region's high species richness because a subset of 160 reference species was selected from the Arctic Biodiversity Assessment (Ganter & Gaston 2013), leading to the exclusion of species which normally occur here from the total.

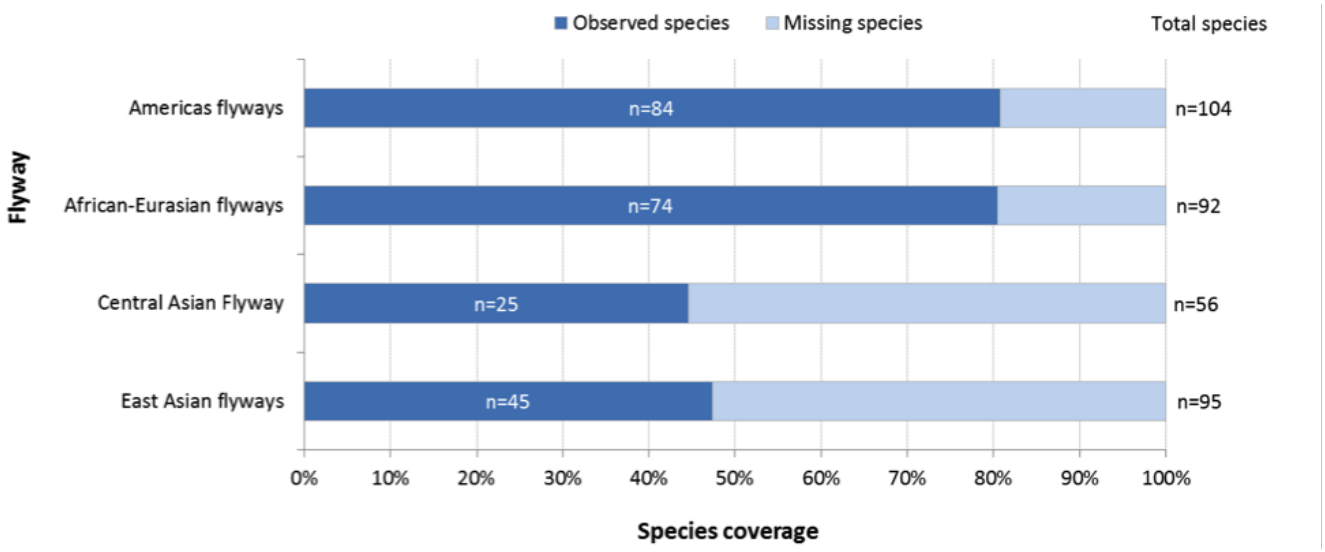
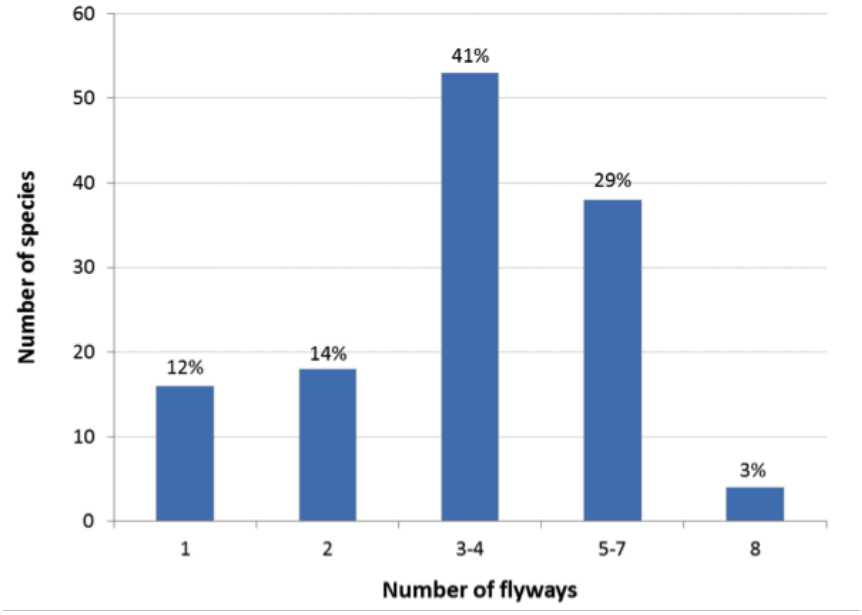


Figure 8. The number of flyways that the 129 species in the data set are expected to occur in based on visual inspection of their breeding, non-breeding and passage ranges.



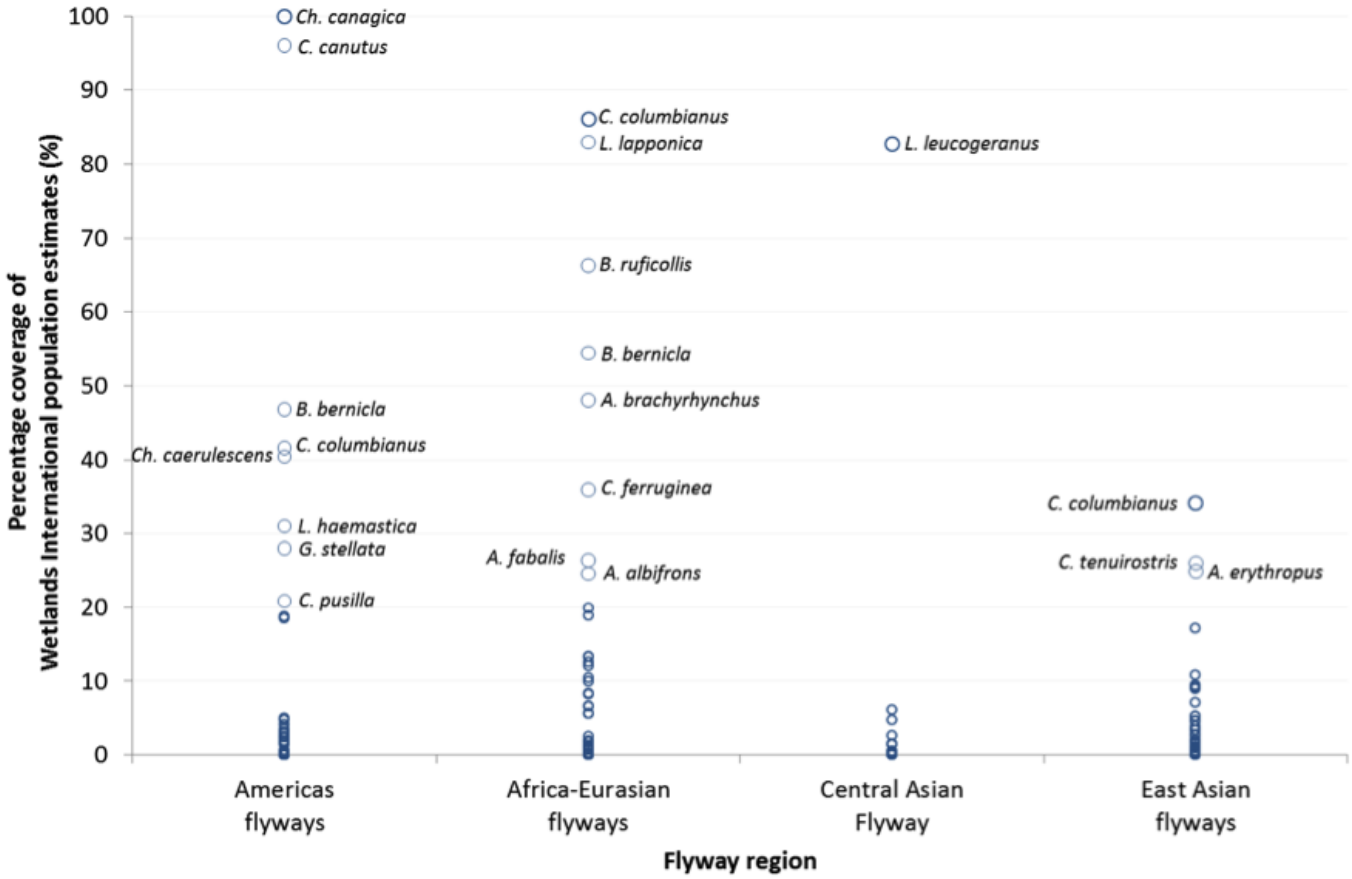
The perhaps most appropriate measure of the representativeness is not the number of species but the proportion of individuals of the total flyway population accounted for. Figure 9 shows the coverage of each species in each of the four flyway regions by comparing the maximum average number of individuals represented within the data set to the species' total population size estimated by Wetland International (Wetlands International 2014). The final values, which are shown as percentages and labelled if coverage is 20% or more, represent the very minimum coverage achieved. This is because only those time-series based on counts of individuals and those that could easily be transformed into such counts (e.g. breeding pairs) were included in the calculation[3] and the resulting value was compared to the upper population estimate from Wetlands International. Where species are missing from the figure, these either had no available flyway population size estimates or comprised abundance change information that could not be transformed into a count of individuals.

According to these estimates, the best coverage across regions is achieved for geese and swans, e.g., Tundra swan *Cygnus columbianus*, Red-breasted goose *Branta ruficollis*, and Brent goose *B. bernicla* (Figure 9). Representation is somewhat lower in other groups such as shorebirds: the only near-complete coverage in terms of the number of individuals represented in the data set is the Red knot *Calidris canutus* in the Americas. Despite this, there are a number of shorebird species that are represented by more than 20% of individuals within a flyway region, e.g., Black-tailed godwit *Limosa lapponica*, Curlew sandpiper *C. ferruginea*, and Great knot *C. tenuirostris*. A minimum representation of one-fifth is a good achievement, especially in those cases where a species' flyway population is large. For example, the population of Semipalmated sandpiper *C. pusilla* in the Americas is an estimated 2.26 million individuals strong (Wetlands International 2014), of which we are representing 450,000 in the data set (Figure 9).

The spread of species with more than 20% coverage is uneven across flyway regions. The highest numbers occur in the Americas and Africa-Eurasia (n = 8, Figure 9), adding to good species coverage here (Figure 7). This makes these two regions the most reliable for trend calculations. At the other extreme, maximum percentage values were generally low for East Asia and Central Asia, except for the Siberian crane *Leucogeranus leucogeranus*. Coverage here could potentially be improved if abundance estimates were included that were removed because the units used could not be transformed into a count of individuals. In addition, it is possible that some of the Wetlands International population estimates may be inaccurate, especially for less well-monitored species. For example, the estimates for certain populations of species within the African-Eurasian flyway region have recently been revised down, as is the case for the Curlew sandpiper in Western Siberia/West Africa, which was recently estimated to number 350,000 individuals as opposed to the previous 1,000,000 (van Roomen et al. 2014). Overall, the minimum coverage presented here is far from perfect, but it is the best estimation that could be achieved within the constraints of the project.

3 One-hundred-and-seventeen time-series (12%) were removed from the data set; these time-series tended to comprise abundance information in index form, which often came from broad-scale monitoring programmes covering a large number of individuals. Their inclusion, if it were possible, would greatly increase overall representation.

Figure 9. Coverage of the proportion of individuals represented in the data set for each species within each flyway region compared to population estimates provided by Wetlands International (Wetlands International 2014). Each circle represents the percentage coverage for one species, and all values greater than 20% were labelled with the corresponding species name. Also included is a table with all of the species names by flyway region.



Americas	Africa-Eurasia	Central Asia	East Asia
Emperor goose *Chen canagica*	Tundra swan *Cygnus columbianus*	Siberian crane *Leucogeranus leucogeranus*	Tundra swan Cygnus columbianus
Red knot *Calidris canutus*	Bar-tailed godwit *Limosa lapponica*		Great knot Calidris tenuirostris
Brant goose *Branta bernicla*	Red-breasted goose *Branta ruficollis*		Lesser white-fronted goose Anser erythropus
Tundra swan *Cygnus columbianus*	Brant goose *Branta bernicla*		
Snow goose *Chen caerulescens*	Pink-footed goose *Anser brachyrhynchus*		
Hudsonian godwit *Limosa haemastica*	Curlew sandpiper *Calidris ferruginea*		
Red-throated loon *Gavia stellata*	Tundra bean goose *Anser fabalis*		
Semipalmated sandpiper *Calidris pusilla*	Greater white-fronted goose *Anser albifrons*		

Data quality and robustness

As is apparent from the sections above, the data set used in this study shows some taxonomic (Table 1, Figure 9), spatial (Figures 4 and 5) and temporal (Figure 5) gaps. The number of species and individuals represented also differs markedly between the four flyway regions (Figures 7 and 9), and the beginning and end of the study period. To account for these gaps, the following measures were implemented:

- Indices were cut before 2011 or started after 1970 if there were not enough data available (especially species)
- Less robust indices, as indicated by low representation and erratic trend lines, are not shown
- Changes in abundance are reported as rounded values or rough descriptions, for example "doubling" (the current data set is not representative enough to use exact values)
- Findings are cross-referenced with results reported in the literature, and these are presented in a separate section (see 'Trend comparisons')

Table 2 summarises the start and end years as well as the reliability of each index. Despite some reservations, many of the underlying trend estimates are of good quality, hailing from peer-reviewed literature and large-scale, long-term monitoring programmes. Coverage is also good for selected regions and taxonomic groups, and the results are therefore useful as a first step in describing trends in Arctic migratory birds since 1970 and in highlighting potential areas of decline.

Estimates of change could be improved by targeting the gaps described. Some of these gaps are due to constraints on time and resources, which did not allow for the addition of some freely available data, e.g. from well-monitored seabird colonies in Greenland, or wetlands in India and South Africa. This is because efforts were focused on augmenting data in regions with low initial coverage. In many other cases, however, data were simply not available, meaning that a concerted effort should be made to establish monitoring protocols and launch monitoring programs in these areas. Other omissions are attributable to a lack of transparency and data sharing; this is true for areas where estimates exist but are not accessible. More emphasis needs to be placed on international collaboration in the future to establish a more complete picture of trends in Arctic migrant bird species.

Table 2. The start and/or end year for each index if different from the standard study period (1970-2011). Fields with dashes denote indices that are not shown due to small, less reliable data sets. Colours denote the reliability of each index: red = less reliable, yellow = more reliable, and green = reliable. Grey cells mark indices that are not applicable. Notes: 1 – index reliable until 2009 but shown until 2011 as a dotted line, 2 – data were combined for three of four flyway regions, 3 – sub-indices are for North America & Greenland, and Europe.

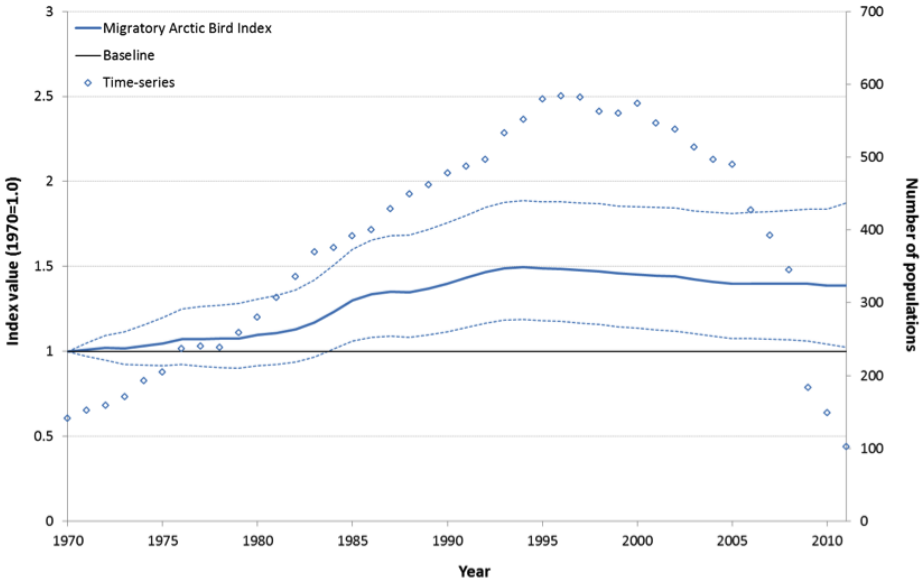
		Overall	Flyway region			
			Americas	Africa-Eurasia	Central Asia	East Asia
Overall				20111	1980-2010	
Group	Landbirds		2010	2009	-	-
	Seabirds	2007	2010	2007	-	
	Shorebirds		2010	2009	-	
	Waterfowl		2010	2009	-	
Waterfowl	Geese/swans		2010	2008	-	2010
	Geese		-	-	-	-
	Swans		-	-	-	-
	Ducks		2010	2008	-	-
Wadden Sea		1980	NA	NA	NA	NA
Species	Long-tailed duck		-	-	-	-
	GWF goose			2		
	Red knot		1982	1971-2010	-	1982
	Grey plover	1971	1983	1971-2010	-	1972
	Snow bunting	2008	20083	19993	-	-

Trend descriptions

Overall

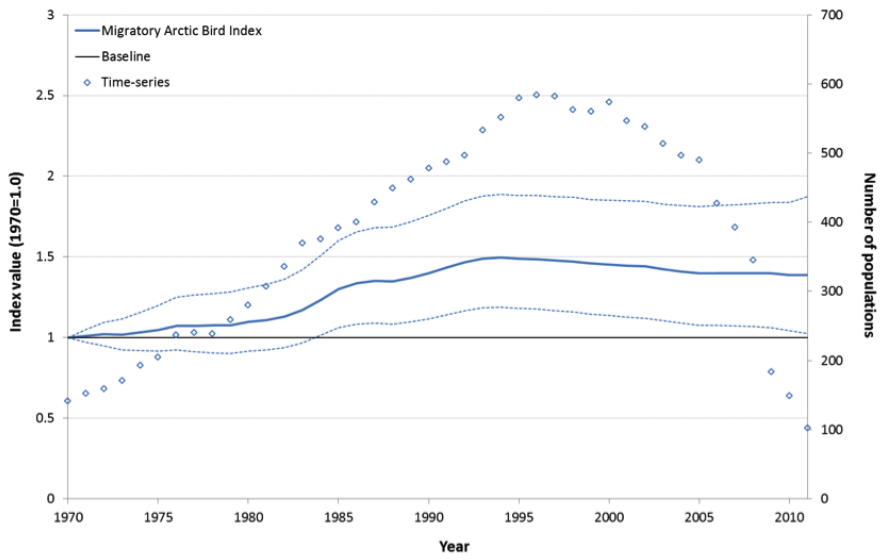
The overall trend for migratory Arctic birds is characterised by an initial steady increase of 50%, followed by a slight but steady decline from 1994 onwards (Figure 10), leading to a 40% growth in abundance by 2011. The decrease towards the end of the study period could be cause for concern, so trends are examined in more detail for taxonomic subgroups.

Figure 10. Index of abundance for 966 time-series of 129 Arctic migratory bird species monitored in locations inside and outside the Arctic boundary from 1970 to 2011 (Migratory Arctic Bird Index). Dashed lines are 95% confidence limits and diamonds the number of time-series contributing to the index in each year.



The decline from 1994 is reflected primarily in shorebirds, although the seabird trend also levels off at this point (Figure 11). Shorebirds, one of the well-represented taxonomic subsets along with waterfowl (Table 1), are the only group to decrease following a steady decline from 1993 (10% by 2011; Figure 11). Waterfowl have doubled in abundance while seabirds have increased by 50% by 2007. Trends in selected groups are examined in more detail below.

Figure 11. Indices of abundance for species monitored in locations inside and outside the Arctic boundary from 1970 to 2011. The lines represent indices for subsets of species belonging to different groups: landbirds (green line, 78 time-series, 29 species), seabirds (dark blue line, 141 time-series, 22 species), shorebirds (orange line, 478 time-series, 49 species), and waterfowl (light blue line, 268 time-series, 29 species; one time-series of Greater scaup Aythya marila *from Korea was removed because it was having a disproportionate effect on the index). Please note that the index for seabirds ends in 2007 due to data availability.*



The pattern observed in Figure 10 of an initial increase followed by a decline from the 1990s has previously been shown for migrant bird species monitored within the Arctic (McRae et al. 2010). However, the study also showed a 5% reduction in abundance between 1970 and 2004, and the reasons for the divergence in amplitude with the trends reported here are discussed in more detail in Box 3. The declining trend in the latter part of the study period is driven by shorebirds because this group contributes almost double the number of species than any other group (Table 1). Many shorebirds are at risk according to recent studies (Morrison et al. 2006, Andres et al. 2012, Zöckler et al. 2013), and this pattern also appears to be true for this species group in individual flyway regions (see 'Flyway regions' below). While only East Asian declines may be described as "severe" for this group of species, smaller negative change in other flyway regions should still be a concern. Declines have also been reported for many landbird species in North America including Nearctic-Neotropical and temperate-zone migrants (Kirby et al. 2008), and in Afro-Palearctic migrants (Sanderson et al. 2006, Vickery et al. 2014). While many of the species included in these studies are not typical Arctic-breeding birds, the representation of the landbird data set used here needs to be improved to assess the similarity of our trends and those reported in the abovementioned studies more accurately.

To develop a better understanding of the overall trend, abundance change is described at the flyway level in the following section, which also details findings for some of the taxonomic groups within these regions. Comparisons with published trends are presented for each of these sub-indices in 'Trend comparisons'.

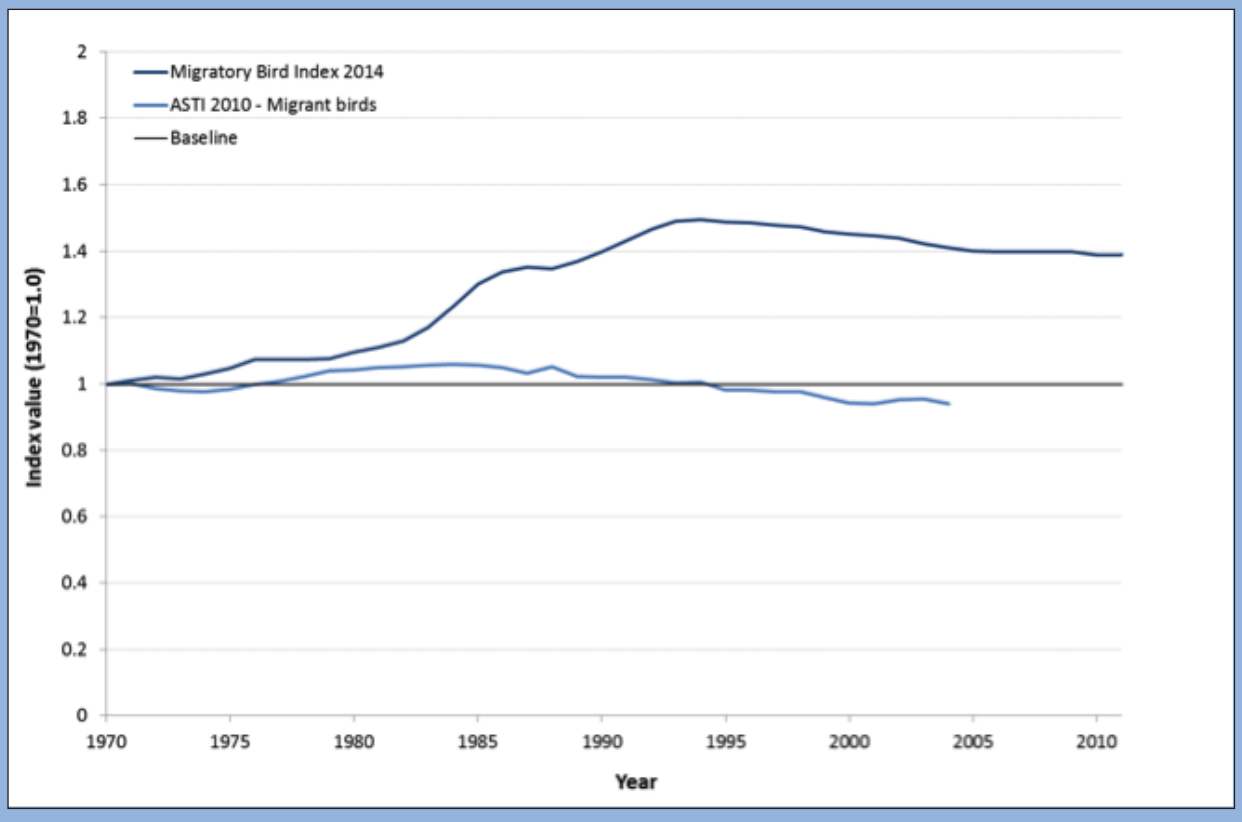
Photo: Chris Leboutillier/Shutterstock.com

Box 3: Comparison with the ASTI 2010

The ASTI 2010 for migrant birds and the migratory Arctic bird index presented in this report show slightly different trends. The method used to calculate the indices is the same but there are two reasons for the differences observed. Firstly, the data set for the 2010 report included only data from Arctic locations and no data from non-breeding areas. By including locations outside the Arctic, new species, populations and time-series were introduced into the current index. Secondly, for the 2010 report, selection was based solely on whether or not the individuals represented by the time-series were labelled as migratory according to the Global Register for Migratory Species (Riede 2004). This approach used a broad classification which did not exclude individuals or species that do not leave the Arctic during the non-breeding season. This was because we were interested in exploring the trends and possible reasons in species that are exposed to threats both inside and outside the Arctic region. In addition, it included a number of species listed in ABA categories 3 and 4, which were excluded from the outset of this analysis because the majority of individuals of these species do not migrate between Arctic and non-Arctic areas. The data selection for the 2010 was crude, and represented our first attempt at looking at migratory activity and formed only a small part of a broader report on Arctic species in general. The current report is purely focused on migratory birds, so we adopted a more targeted approach to data selection.

If we analyse only those species from the 2010 index that are also included in the 2014 migratory bird index and exclude all others, we are left with 84 out of the 170 species. The resulting trend increases by 12% between 1970 and 2004 (not shown). Although this still doesn't track the same trend as the 2014 index, it does show that the differences observed are down to the underlying data. The disparity in the final index value between the ASTI and the migratory bird index is therefore due to both the addition of new data and how the final data were selected for analysis. Given both the narrow focus on strict Arctic migrants and the broader scope of the current index to include non-breeding locations, we now have a more complete picture of trends in Arctic migratory birds.

Figure B3. Index of abundance for 966 time-series of 129 Arctic migratory bird species monitored in locations inside and outside the Arctic boundary from 1970 to 2011 (dark blue), and the Arctic Species Trend Index for migrants birds between 1970 and 2004 based on 424 time-series of 170 species (light blue, adapted from McRae et al. (McRae et al. 2010).



Flyway regions

Overview

At the flyway level, increases are observed in the Americas (10%) and in Africa-Eurasia (50% by 2009[4]), while abundance declined compared to the baseline in Central Asia (-70%) and East Asia (40%, Figure 12). A detailed description of each of the flyway trends can be found below, including for taxonomic subgroups, which have shown divergent trends at the global level (Figure 10). Central Asian results are not presented due to the lack of robustness of the trends.

Figure 12. Indices of abundance for 966 time-series of 129 species in the four flyway regions from 1970 to 2011. Please note that due to data availability the index for Central Asia starts in 1980 and the index for the African-Eurasian flyways ends in 2009, although the trend is shown up to 2011 as a dashed line.

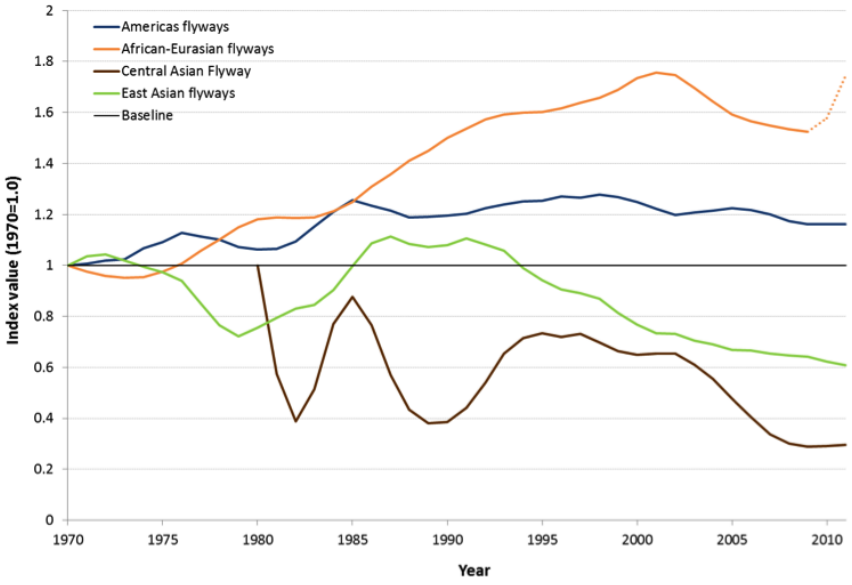
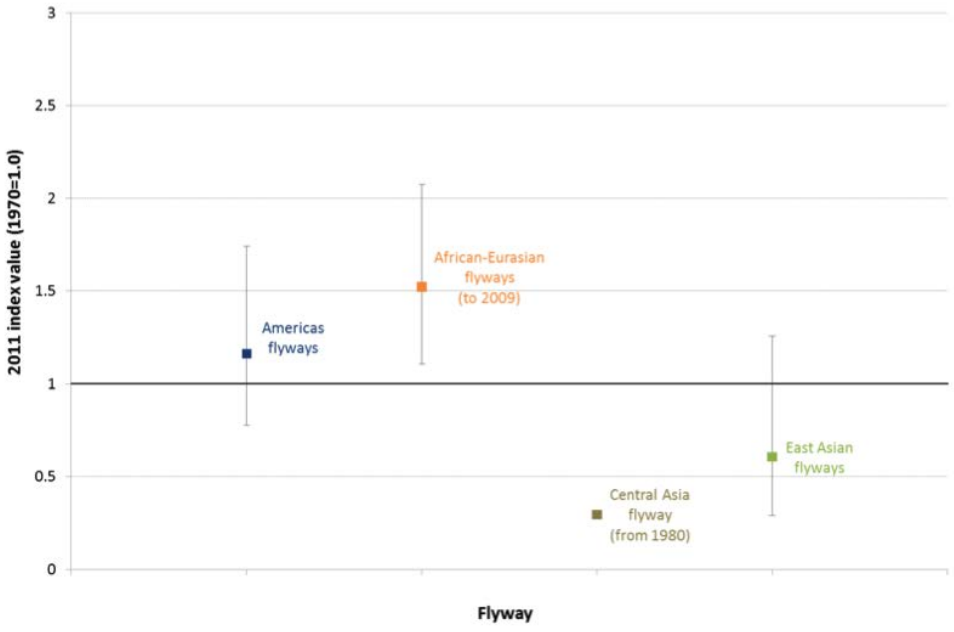
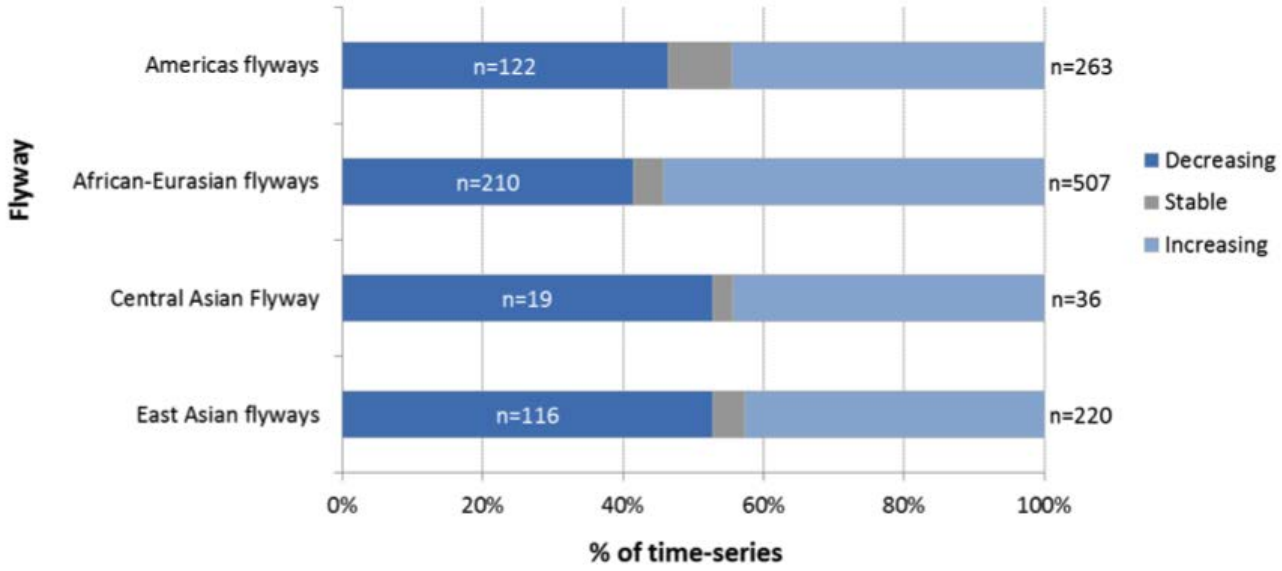


Figure 13. Final index end values and error bars for four flyway regions for 966 time-series of 129 species from 1970 to 2011. Please note that due to data availability the index for Central Asia starts in 1980 and the index for Africa-Eurasia ends in 2009.



4 The African-Eurasian trend is less reliable after 2009 due to a significant drop in data set size within the Mediterranean-Black Sea Flyway (Figure A3) and is shown as a dashed line beyond this point.

Figure 14. Proportion of decreasing (dark blue), stable (grey) and increasing (light blue) time-series for each of the four flyway regions. A stable trend is defined as a 5% reduction or increase in abundance between 1970 and 2010. White numbers denote the number of decreasing time-series or species, black numbers the total number of time-series or species in that flyway region. Please note that a time-series can contribute to more than one flyway region.

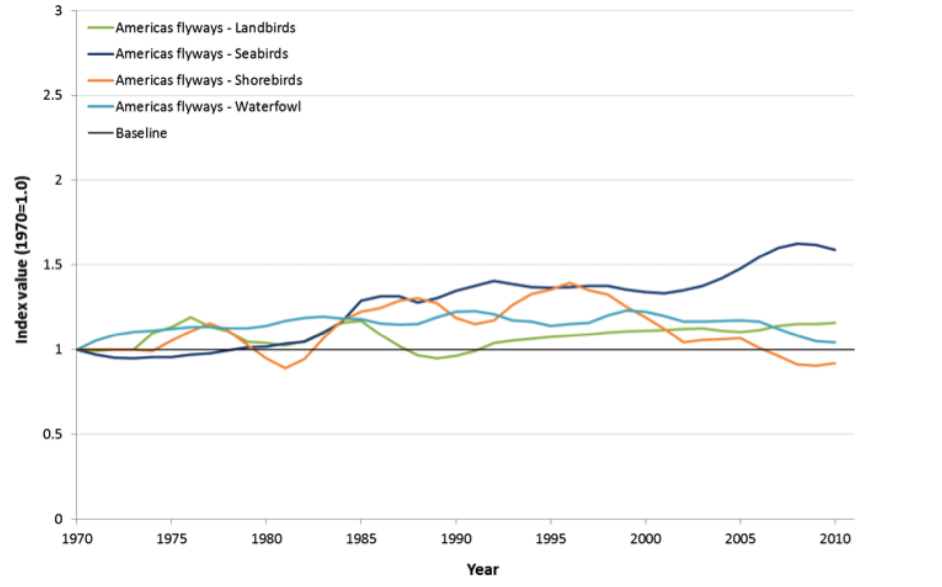


Steller's Eider. Photo: Morten Ekker

Americas

Migratory birds in the Americas have seen an increase of 10% since 1970 (Figures 12 and 13), with many of the underlying trends showing stable or increasing trajectories (Figure 14). Divergent patterns are apparent in different taxonomic subgroups (Figure 15): there is a small decline of 10% in shorebirds, a stable trend in waterfowl (5%) and an increase in landbirds (15%). The stable trend in waterfowl is at odds with the strong increases reported in the literature for some goose populations in the region (Jefferies et al. 2004, Gauthier et al. 2005, Canadian Wildlife Service Waterfowl Committee 2013), and can be attributed to reductions in duck populations (Figure 21), which are counteracting these increases (Figure 20). In our data set, seabirds have shown the greatest positive change in the Americas of over 50% (Figure 15) due to increases in auks (e.g., Pigeon guillemot *Cepphus Columba* in British Columbia), gulls (e.g., Glaucous gull *Larus hyperboreus* in Bylot Island) and skuas (e.g., Long-tailed skua *Stercorarius longicaudus* in Bylot Island, Nunavut and the Yukon Delta). However, most groups have declined in more recent years.

Figure 15. Indices of abundance for species monitored in locations within the Americas flyways from 1970 to 2011. The lines represent indices for subsets of species belonging to different groups: landbirds (green line; 29 time-series, 19 species), seabirds (dark blue line; 77 time-series, 20 species), shorebirds (orange line; 95 time-series, 25 species), and waterfowl (light blue line; 62 time-series, 20 species). Please note that all indices end in 2010 due to data availability.



Within the Americas, all three flyways show positive change until 1996-99 (Figure A3). The comparable trajectories are attributable to overlaps between the data sets, particularly in the Arctic region[5]. Abundance has reduced compared to the baseline only in the Pacific Americas (by a small proportion), a reliable data set due to its size, high annual species coverage, and low variation in the underlying trends (narrow CLs; Figure A4). The increase of 61% in the Central Americas (Figure A3) is a data artefact caused by large recoveries in small populations of waterfowl, shorebirds, and particularly seabird species (loons, gulls and skuas) between 2002 and 2011.

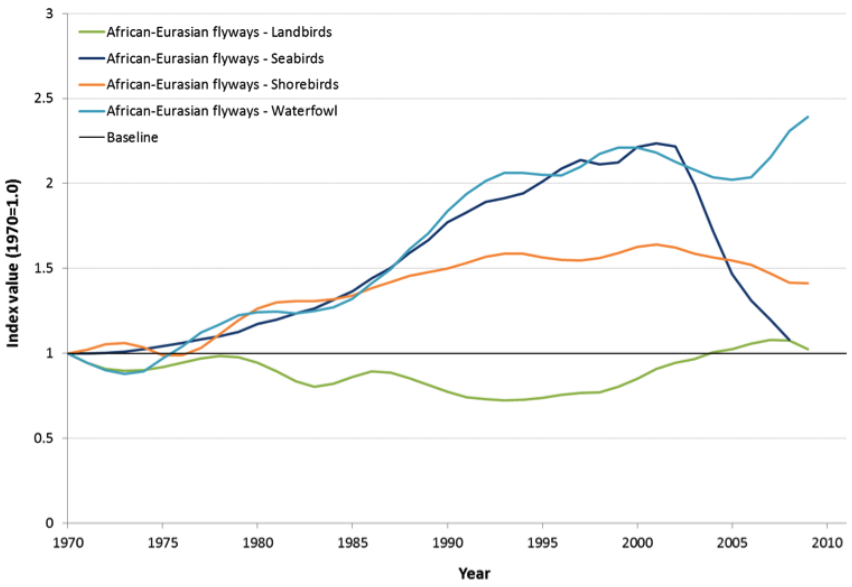
5 A quarter of time-series contribute to multiple flyways because of the difficulty in assigning migration routes based on the location of monitoring.

Africa-Eurasia

In Africa-Eurasia, the large proportion of increasing time-series (Figure 14) produce overall positive change, but there are differences in the trends for taxonomic groups (Figure 16). Small recoveries are found in landbirds (< 5%) and seabirds (< 10%). The pronounced decrease in seabirds from 2002 can be attributed to at least eight different species in the East Atlantic Flyway, making it an unusual but possibly genuine trend. The largest increase is seen in shorebirds (40%) and waterfowl, which more than doubled. Both ducks and geese/swans contribute to this increase, but the influence of the latter is greater with a near tripling by 2010 versus a 70% increase by 2008 (Figures 20 and 21). The substantial increase from 2006 can also be attributed to geese from locations across Europe, e.g., Pink-footed goose *Anser brachyrhynchus*, Barnacle goose *Branta leucopsis*, and Red-breasted goose *B. ruficollis*. While the former two species have reportedly shown an upward trend (Fox et al. 2010), the Red-breasted goose is considered to be globally endangered with a decreasing population trend (Fox et al. 2010, IUCN 2013), so this apparent increase is probably due to a highly localised increases skewing trend information which is incomplete.

Abundance change trajectories are similar for the two underlying flyways within Africa-Eurasia, although the increase is larger for the Mediterranean-Black Sea Flyway despite initial declines between 1970 and 1973 caused by waterfowl species (Figure A3).

Figure 16. Indices of abundance for species monitored in locations within the African-Eurasian flyways from 1970 to 2011. The lines represent indices for subsets of species belonging to different groups: landbirds (green line; 40 time-series, 16 species), seabirds (dark blue line; 65 time-series, 15 species), shorebirds (orange line; 209 time-series, 24 species), and waterfowl (light blue line; 193 time-series, 19 species). Please note that the seabird index ends in 2008 and all other indices end in 2009 due to data availability.



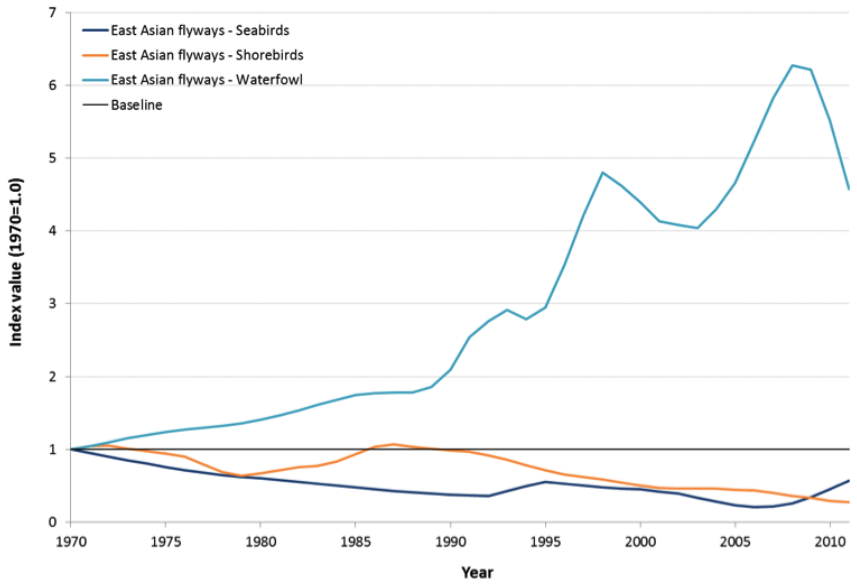
Central Asia

Due to low species (45%, Figure 7) and flyway coverage (Figure 9), the Central Asian data set is not reliable enough to present indices for anything other than the overall trend for the region (Figures 12 and 13). However, there is evidence that the 70% reduction in abundance observed here may not just be a data artefact (Zöckler et al. 2013) – see also 'Trend comparisons'.

East Asia

The 40% reduction in East Asia is driven by a large number of declining time-series (Figure 14) and this is reflected in seabirds (-40%) and shorebirds (-70%, Figure 17). Both groups follow the same negative trajectory until 1980, but the latter contributes to the increase seen in the overall index after this point (Figure 12). By contrast, waterfowl (primarily geese/swans) appear to be buffering the overall trend against showing a more pronounced decline through a quadrupling in abundance (Figure 21). Despite comprising some large-scale estimates from Japan, China and South Korea, the waterfowl trend is not considered to be robust because of small data set size and limited coverage in species (Figure 6) and flyways (Figure 9). In fact, waterfowl population estimates from the 1990s and early 2000s pointed to declines in geese along this flyway (Syroechkovskiy 2006). Data issues are also responsible for the decline from 2008, and have led to the exclusion of the landbird trend.

Figure 17. Indices of abundance for species monitored in locations within the East Asian flyways from 1970 to 2011. The lines represent indices for subsets of species belonging to different groups: seabirds (dark blue line; 7 time-series, 7 species), shorebirds (orange line; 195 time-series, 28 species), and waterfowl (light blue line; 16 time-series, 8 species).



Taxonomic subgroups

To summarise trends for taxonomic groups across flyway regions, landbirds show increases in the Americas and African-Eurasian flyways, while there is too little information for East Asia. Seabirds are recovering in the Americas, but show a decline of 40% in East Asia. In Africa-Eurasia, seabird abundance was increasing initially, but following a recent decline levels are only marginally higher than in 1970. It remains to be seen whether this trend will continue. Shorebirds show considerable declines in East Asia and a small reduction in the Americas, while abundance is higher than baseline levels in Africa-Eurasia.

The perhaps most consistent trends are found in waterfowl, with minor increases in the Americas, a doubling in Africa-Eurasia, and a quadrupling in East Asia. This group represents one of the larger data sets, with many species showing high coverage of individuals (Figure 9), so trends for this taxonomic subgroup are discussed in more detail below (see 'Case studies').

Trend comparisons

Americas

Our results suggest a decline in shorebirds in the Americas, which is in line with evidence that shorebirds are declining worldwide (Zöckler et al. 2013). In North America, studies have found decreasing trends in 56% to 80% of assessed populations of selected shorebird species (Morrison et al. 2006, Andres et al. 2012, Zöckler et al. 2013) and reductions in abundance were identified in a number of species monitored on autumn migration in the Midwest-US and Atlantic Canada (Bart et al. 2007). Species with presumed declining trends include American golden plover *Pluvialis dominica*, Semipalmated sandpiper *Calidris pusilla*, Ruddy turnstone *Arenaria interpres*, Sanderling *C. alba*, Whimbrel *Numenius phaeopus*, and Red knot *Calidris canutus rufa* (Morrison et al. 2004, Morrison et al. 2006, Kirby et al. 2008, Andres et al. 2012). The latter has shown continuing declines in numbers wintering in South America (Andres et al. 2012), which may be due to loss of staging habitat and/or food resources. Range shifts can also contribute to changes in abundance (Bart et al. 2007), and although some species in the data set appear to be recovering because of such shifts, reasons for increase were unknown for the majority of time-series in our data set, and we could thus not investigate this further.

Other taxonomic subgroups have increased compared to our 1970 baseline. For landbirds, this is in contrast to the declines reported for Nearctic-Neotropical migrants (Kirby et al. 2008), temperate-zone migrants (Kirby et al. 2008), Arctic landbirds (North American Bird Conservation Initiative 2009), and specific species such as Horned lark *Eeremophila alpestris*, Lapland longspur *Calcarius lapponicus*, Snowy owl *Bubo scandiacus*, Arctic redpoll *Carduelis hornemanni*, American tree sparrow *Spizella arborea* and Buff-bellied pipit *Anthus rubescens* (Butcher & Niven 2007, Downes et al. 2011). This incongruence may be attributable to the fact that abundance information for many of these species could not be obtained and incorporated for this region. This is true, for example, of the Snow bunting *Plectrophenax nivalis*, which has shown severe declines of 64% since 1965 (Butcher & Niven 2007) and 40% since 1970 (Downes et al. 2011). Although this reduction does not reach statistical significance (Downes et al. 2011), seeing declines across multiple flyway regions may be cause for concern, and more information is needed to establish exact trends for this species. Some declines should, however, be interpreted with caution as they might be caused by species wintering further north than the area covered by the Christmas Bird Count (CBC) from which these trends were derived, as is the case for Snow bunting, Arctic redpoll and Snowy owl (Downes et al. 2011).

Results suggest that seabirds have increased in our data set by over 50% due to recoveries in auks, gulls and skuas. Stable or increasing trends have indeed been reported for Thick-billed murre *Uria lomvia* in North America, but negative change has been occurring in Greenland (CAFF 2010) and in several widespread Arctic auk and gull species over recent decades such as Black-legged kittiwake *Rissa tridactyla* and Thayer's gull *Larus thayeri* (Gaston 2011, Ganter & Gaston 2013). Stable trends in loons, which are included in the seabird group following the ABA, and declines in Pelagic cormorant *Phalacrocorax pelagicus* are in line with the literature (Evers 2007, Sauer et al. 2012). More data are needed to fill the gaps in this data set, so that more reliable trend estimates can be produced.

In this study, waterfowl species in the Americas have increased in abundance, although there is some concern about the decline observed from 2005. Many geese have indeed shown substantial recoveries in the US and Canada (Canadian Wildlife Service Waterfowl Committee 2013, U.S. Fish and Wildlife Service 2013). However, reductions have been reported for Greater scaup *Aythya marila*, Northern pintail *Anas acuta*, American wigeon *Anas americana*, Long-tailed duck *Clangula hyemalis*, King eider *Somateria spectabilis* and Common eider *Somateria mollissima* (Butcher & Niven 2007, Canadian Wildlife Service Waterfowl Committee 2013, U.S. Fish and Wildlife Service 2013). Overall, long-distance migrant waterfowl are believed to have declined in all decades since 1976, although trends are showing signs of stabilising (Wetlands International 2010). However, it is also worth mentioning that many species of waterfowl have recovered to such an extent that they are now considered to be overabundant. In the Canadian Arctic, for example, a growth in population size in Lesser snow goose *Chen caerulescens caerulescens* has led to degradation in coastal breeding habitats due to their destructive foraging behaviours (Abraham et al. 2005). This has, in turn, had an effect on the abundance of plant, insect and avian species that depend on the same habitat (Milakovic & Jefferies 2003, Rockwell et al. 2003, Abraham et al. 2005). Increases in abundance are therefore not always desirable, especially in cases where a species is already considered to be overabundant.

Africa-Eurasia

In our data set, we found positive trends across taxonomic subgroups in Africa-Eurasia. Some studies do, however, suggest that Afro-Palaearctic migrant bird populations have declined in Europe in recent decades, often to a greater degree than resident or short-distance migrants, with different factors playing a role in the breeding and non-breeding areas (Vickery et al. 2014). It is important to keep in mind, however, that the species included in the Vickery study were mainly non-Arctic breeders and the studies may therefore not be comparable.

Seabird declines from 2002 are consistent with the literature, which reports reductions of 85% in Red-throated *Gavia stellata* and Arctic loon *G. arctica* abundance across the Baltic Sea between 1993 and 2007 (Skov et al. 2011) as well as recent declines in Thick-billed murre *Uria lomvia* in Greenland, Iceland, Svalbard and the Barents Sea (CAFF 2010). In addition, there have been marked declines in the number of breeding Horned lark *Eremophila alpestris* in the Arctic possibly caused by habitat loss in the wintering grounds in western Europe (Dierschke 1997). However, neither landbirds nor seabirds show good taxonomic coverage, so further data is needed to obtain more robust trends for comparison.

There have been conflicting reports regarding trends in African-Eurasian shorebirds, although most studies have described increases. For example, the majority of shorebird species in our data set (n = 11) have reportedly recovered since the 1980s in areas of the African-Eurasian Waterbird Agreement (AEWA 2009). In addition, the proportion of declining populations reduced between two studies in the late 1990s and 2013 (Stroud et al. 2004, Zöckler et al. 2013), with around half now considered to be stable (Zöckler et al. 2013). There are problems with this comparison, however, as some of the difference in proportion may be attributable to differences in species composition between the two studies. Declines in some species may also be masked by increases in others; it has been suggested, for example, that increases in coastal wintering populations of shorebirds in the East Atlantic between 1980s and late 1990s have gone hand-in-hand with substantial changes in species composition[6] (Davidson 1998). Evidence may indeed be starting to point to a reversal of the positive trend of African-Eurasian shorebirds. This is true, for example, of the Wadden Sea, an important staging, moulting and wintering site in the flyway region for many species (Blew et al. 2013), which has shown a decline of around 25% since 1987 (Figure 22) in line with recent figures (Blew et al. 2013). In addition, shifts in primary wintering area in response to climatic changes may lead to misleading population trends locally (Austin & Rehfisch 2005). In Greenland, Red phalarope *Phalaropus fulicarius* declined as a result of increased predation due to the disappearance of Arctic tern *Sterna paradisaea* colonies (Egevang et al. 2006).

In this report, waterfowl species have more than doubled in abundance between 1970 and 2009, which is broadly in line with the literature. For example, 13 species of swans, geese and ducks have expanded their populations over the past 50 years, with the greatest increases occurring between 1970 and 1990 (van Eerden et al. 2005). However, some geese have been showing decreasing trends since the 1990s, such as Red-breasted goose *Anser ruficollis*, Dark-bellied Brent goose *Branta bernicla bernicla*, Greenland Greater white-fronted goose *A. albifrons* and Lesser white-fronted goose *A. erythropus* (Fox et al. 2005, Martin 2009, Fox et al. 2010, Cranswick et al. 2012, Ebbinge et al. 2013). Declines in abundance have also been detected in some waterbird species in the Wadden Sea since the 1990s (van Roomen et al. 2012, Blew et al. 2013) – see also 'Case studies' – and in the Baltic Sea (Skov et al. 2011). While Baltic declines could in some cases be due to range shifts or individuals remaining in their breeding area for winter because of favourable conditions as is true for many ducks (Žydelis et al. 2006), this cannot fully explain all of the reductions in numbers seen, for example in Long-tailed duck (Skov et al. 2011).

Abundance monitoring has focused primarily on the European part of Africa-Eurasia, producing an incomplete picture for the region as a whole. Even within Europe, information about population sizes and trends is missing for many species, including shorebirds (Nagy et al. 2012). With the suggested recent decline, these knowledge gaps need to be filled to be able to address threats in a timely manner.

6 These include increases in Grey plover *Pluvialis squatarola* and Sanderling *Calidris alba*, and a presumed decrease in Dunlin *Calidris alpina*.

Central Asia

Despite concerns regarding the robustness of the Central Asian data set resulting from a small data set size and low coverage, the declines observed in the overall index and in waterfowl and shorebirds (not shown) are in line with those reported in the literature. Zöckler et al. found that although all shorebird species populations with reliable trends utilising the Central Asian Flyway are stable (15% of 20 species), there are concerns about the remaining 17 populations for which trends are unknown (Zöckler et al. 2013). Long-term monitoring in India has highlighted strong declines between 1980 and 2002 for a number of shorebird species such Little Stint *Calidris minuta* (-90%), Curlew sandpiper *C. ferruginea* (-75%) and Ruff *Philomachus pugnax* (-90%) (Zöckler et al. 2013, Balachandran in litt), and it is possible that other species and locations are also affected. There have also been marked declines in populations of Siberian crane *Leucogeranus leucogeranus*, primarily due to hunting and habitat degradation along the species' migration routes and in wintering areas as opposed to threats in the Arctic breeding region (Meine & Archibald 1996).

The Central Asian Flyway is the most poorly studied of all of the flyways – in spite of the fact that there is widespread agreement about populations of migratory birds being in decline here (BirdLife International 2010c, Nagy et al. 2012). An Action Plan has been agreed for waterfowl covering 182 species and calling for enhanced regional cooperation (CMS 2006), but much work remains to be done to curb the declines in abundance observed since the 1980s and improve the monitoring in this flyway.

East Asia

Within East Asia, interpretation is focused mostly on the Australasian part as more detailed trend information is available here. Despite this, limited data for waterfowl may be reducing the accuracy of this index, which is increasing for our data set. As many species of geese, ducks and swans have reportedly been decreasing in Australasia and the Russian Arctic (Miyabayashi & Mundkur 1999, Syroechkovskiy 2006), it would be prudent to enhance and improve this subset of data for future studies. Seabirds appear to have also declined, although there are signs of a more recent upward turn in the trend.

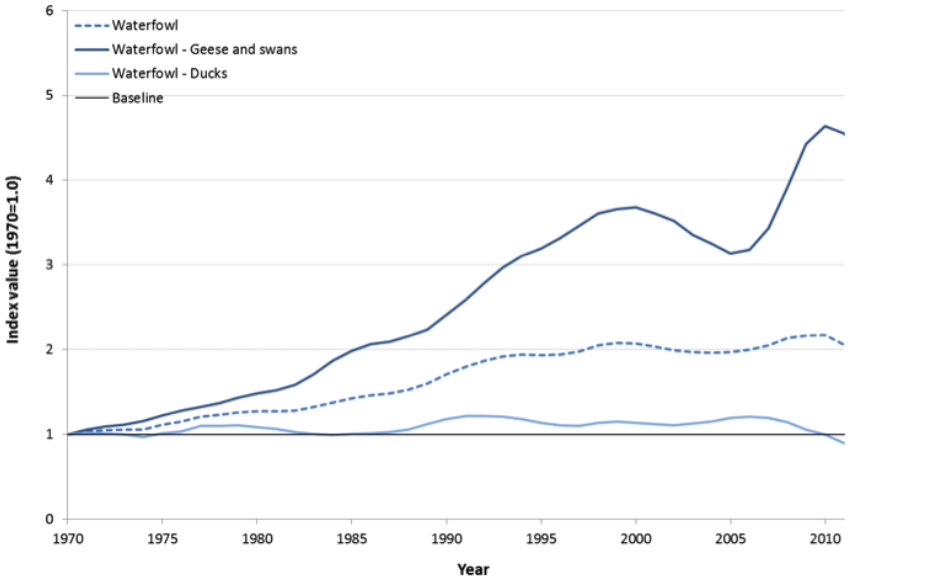
The most reliable trend within the East Asian flyway region in our data set is for shorebirds, which show a steady decline since 1987 leading to a 70% reduction overall. While migratory waders were not necessarily considered to be at significant risk in Australasia in the past (Milton 2003), recently emerging threats in East and Southeast Asia are leading to severe changes in abundance. The Spoon-billed sandpiper *Eurynorhynchus pygmeus*, for example, has been declining by 26% per annum at four breeding sites in the Russian Arctic between 2002 and 2009, or 88% overall; this is the equivalent of a decline from a total population of 1,000 breeding pairs in 2000 to 120-220 in 2009 (Zöckler et al. 2010b). The main threats to the population occur along the migration route or in the wintering areas, and include hunting and loss of intertidal habitats in the Yellow Sea (Amano et al. 2010, Zöckler et al. 2010b, Murray et al. 2014). It is believed that concerted international conservation action is essential if this species is to avoid extinction (Zöckler et al. 2010b, Murray et al. 2014). Its decline may possibly also herald that of many millions of waders and waterbirds utilising the same flyway. Declines have already occurred in other wading birds dependent on the same intertidal area, with 30-40% of species showing a significant reduction on both spring and autumn migration over the last 10-30 years (Amano et al. 2010). A recent study concluded that all 11 wader species populations with known trends using the East Asian-Australasian flyway are declining, while 13 have unknown status (Zöckler et al. 2013). The Curlew sandpiper *Calidris ferruginea* monitored at specific sites in Australia has declined from 84,000 individuals in 1993 to 20,000 in 2012 (Rogers & Gosbell 2006, Fuller 2013), and there has been a country-wide reduction of 43-79% in migrant abundance over the last 15 years (Zöckler et al. 2013). The overall decline in shorebirds of the Australasian region between 1983 and 2006 is believed to be around 73% (Nebel et al. 2008), with pronounced declines in Grey plover *Pluvialis squatarola*, Bar-tailed godwit *Limosa lapponica* and Red knot *Calidris canutus* (Garnett et al. 2011).

Case studies

Waterfowl

As one of the largest taxonomic data sets (Figure 11) showing high species coverage (Table 1), waterfowl represent an ideal group to examine abundance change since 1970 in more detail, both for different subgroups of species and for different regions. Such analysis reveals differences in the overall indices for ducks and for geese/swans (Figure 18).

Figure 18. Indices of abundance for geese/swans (dark blue line, 152 time-series, 14 species), and ducks (light blue line, 117 time-series, 15 species) across all flyways from 1970 to 2011.The dashed line is the overall waterfowl index.



Geese/swans

Geese/swans in our data set have more than quadrupled in abundance following larger increases and smaller declines (Figure 18). When separating geese and swans, trends are similar initially but diverge from 1994, with geese continuing a steep increase while the two swan species (Tundra swan *Cygnus columbianus*, Whooper swan *C. cygnus*) decrease (Figure 19). Significant declines exceeding the equivalent of one quarter in 25 years have been reported for swans from the 1980s in the Western Siberia and Northeast/Northwestern Europe population (AEWA 2009), and, specifically the Northwest European Tundra swan since 1990s (Rees & Beekman 2010).

At the flyway level, geese/swans show similar trajectories for the first 15 years, leading to more than a doubling in abundance in all regions despite a subsequent divergence in trends (Figure 20). Small increases have occurred from 2003-4 in all flyway regions except East Asia, which shows a decline from 2008 (Figure 20) due to Tundra swan in China and South Korea. This trend is, however, considered to be less robust due to the small size of the data set. Please note that the final flyway index values in Figure 20 are lower than the overall index – this is because the overall index also comprises the Central Asian data set, which is not shown but increases steeply.

The increases we observe here are consistent with the positive trends reported for most geese during the past two decades in the US and Canada (Canadian Wildlife Service Waterfowl Committee 2013, U.S. Fish and Wildlife Service 2013), particularly Snow *Chen caerulescens* and Ross's *C. rossii* goose (Canadian Wildlife Service Waterfowl Committee 2013). But there have also been marked increases in Europe: 86% of populations of seven Arctic breeding species in the Western Palearctic have shown annual growth rates between 1.1% and 7.8% since the late 1980s and early 1990s (Fox et al. 2010), particularly Barnacle goose *Branta leucopsis* (Fox et al. 2010) and the Svalbard Pink-footed goose *Anser brachyrhynchus* (Madsen & Williams 2012). It is believed that geese have benefitted from improved foraging opportunities resulting from changes in agricultural practices in staging and wintering areas along their migration routes in North America and Europe (Jefferies et al. 2004, Fox et al. 2005, Gauthier et al. 2005, van Eerden et al. 2005). But this is not true of all species; the Lesser white-fronted goose *Anser erythropus*, for example, has declined in northern Europe (Fox et al. 2010) and a number of species breeding in the Russian Arctic and wintering in in East Asia show long-term declines (Syroechkovskiy 2006).

Figure 19. Indices of abundance for geese/swans (dark blue line, 152 time-series, 14 species), and for geese only (small dashes, 131 time-series, 12 species) and swans only (large dashes, 21 time-series, 2 species) across all flyways from 1970 to 2011.

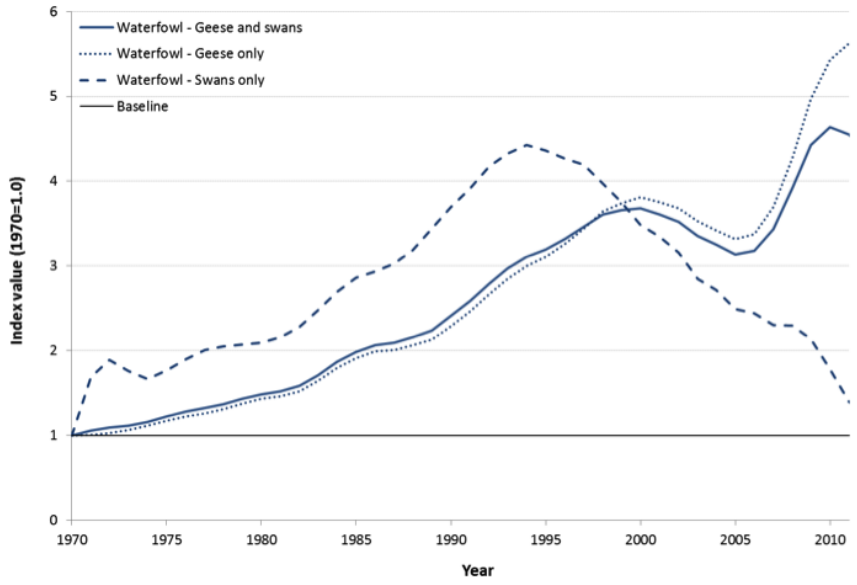
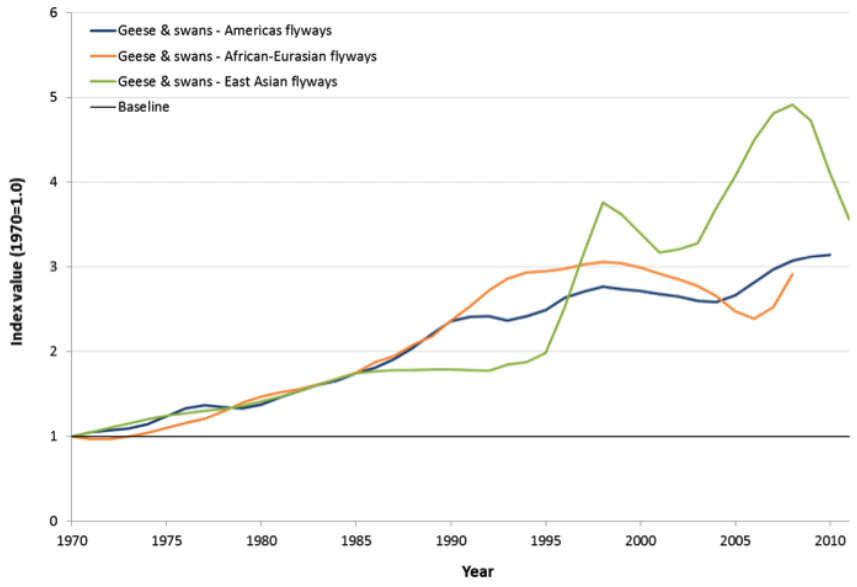


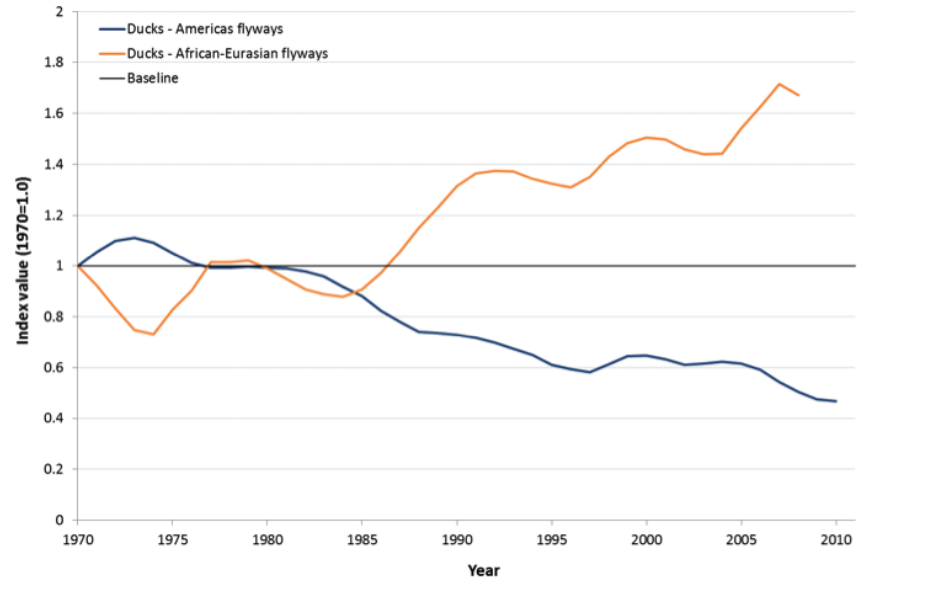
Figure 20. Indices of abundance for geese/swans within the Americas (blue line, 35 time-series, 8 species), Africa-Eurasia (orange line, 104 time-series, 9 species) and East Asia (green line, 12 time-series, 5 species) from 1970 to 2011. Please note that the Americas and African-Eurasian flyways indices end in 2010 and 2008 respectively due to data availability. No index could be calculated for the Central Asian Flyway due to the small size of this subset of data.



Ducks

Initially a steady trend, duck abundance across all flyways combined is 10% lower in 2011 than 1970 (Figure 18). Change patterns differ between the two flyway regions for which enough data are available (Figure 21). Duck populations in the African-Eurasian flyway region were steadily decreasing until the mid-1980s. Between 1984 and 2008 the population increased by 70%. The Americas show the opposite pattern, with a halving in population size by 2010. The trend for ducks in East Asia is not shown because we cannot be sure that the trend is reliable due to the small size of the data set. However, it does seem to point to a serious decline, which has been confirmed in other studies. For example, numbers of the Northern pintail in Chilika Lake in India have fallen by approximately 50% from 250,000 to 122,000 over the past ten years (Balachandran in litt).

Figure 21. Indices of abundance for ducks within the Americas (blue line, 27 time-series, 12 species) and African-Eurasian (orange line, 89 time-series, 10 species) flyways from 1970 to 2011. Please note that the Americas and African-Eurasian flyways indices end in 2010 and 2008 respectively due to data availability. No indices could be calculated for the Central Asian and East Asian flyways due to the small size of these subsets of data.



In line with results presented here, reductions have been reported for some species in the Americas including Greater scaup *Aythya marila*, Northern pintail, American wigeon *Anas americana*, Long-tailed duck *Clangula hyemalis*, King eider *Somateria spectabilis* and Common eider *S. mollissima* (Robertson & Gilchrist 1998, Butcher & Niven 2007, Canadian Wildlife Service Waterfowl Committee 2013, U.S. Fish and Wildlife Service 2013). Common eider are, however, now believed to be recovering due to improved harvest management (Chaulk et al. 2005).

Negative trends have also been reported in the African-Eurasian flyway region. Common eider in Greenland and Russia declined in the 1980s and 1990s due to unknown reasons that may have included human disturbance, overexploitation of eggs and birds, and climatic events (Suydam et al. 2000, Merkel 2004). The Greater scaup *Aythya marila* population has shrunk by over 2% per year since 1983 in Northern and Western Europe; the annual decrease has been double that in the Northern shoveler *Anas clypeata* since the late 1980s in the Western Siberian, Southwest Asian, Northeastern and Eastern African populations (AEWA 2009); and non-breeding Northern pintail *Anas acuta* declined by 33% in the UK between 1986 and 2011 (Austin et al. 2014). Steller's eider *Polysticta stelleri* reductions are estimated to amount to around 65% across Europe since the 1990s (Žydelis et al. 2006), with numbers in the Baltic Sea dropping by over two-thirds by 2007 thus reducing the proportion of the biogeographic population of the species wintering here from just under half to a quarter (Skov et al. 2011). In the same location, the Long-tailed duck *Clangula hyemalis* has declined by two-thirds over the past 20 years, while there have been reductions of between 42% and 60% in Velvet and Common scoter, Common eider, and Red-breasted merganser, and minor losses in Greater scaup since 1993 (Skov et al. 2011). It is possible that declines in species wintering in the Baltic may be due to several waterfowl species shifting their nonbreeding distribution northeast due to milder winters. This has been cited as a reason for Steller's eider and Long-tailed duck (Žydelis et al. 2006) but it cannot explain all of the declines in duck species in the Baltic. Skov et al. (Skov et al. 2011) found that declines in the concentration of nutrients has led to a decline in benthic productivity, which has coincided with reductions in bottom-feeding seaduck species. While correlations were generally weak because long-term offshore trends

are often unavailable for affected species, huge declines occurred in Common eider, Velvet scoter and Long-tailed duck without concomitant shifts in distribution. This suggests that the ranges of these species have contracted. Due to lack of information, we are unable to test these competing hypotheses with the current data set. In addition, some of these species appear to be showing reversals in trends such as Common eider in Greenland (Burnham et al. 2012).

Although information on trends from Africa is scarcer than from the European part of the flyway region, studies seem to indicate that declines are also occurring here. The Northern pintail population in the area surrounding Lake Chad, for example, declined by over 60% since the 1980s (Zwarts et al. 2009). The fact that the trend for the African-Eurasian region does not reflect these apparently negative developments may be attributable to the composition of the underlying data set, which is heavily dominated by time-series from Europe. To confirm that our results represent a genuine trend for Arctic breeding ducks in general, more data will have to be gathered for future studies. Expanding the data set would also be beneficial for assessing the accuracy of the divergence in duck trends between the different flyway regions, and allow for trend analysis in different subgroups such as sea and dabbling ducks.

Wadden Sea

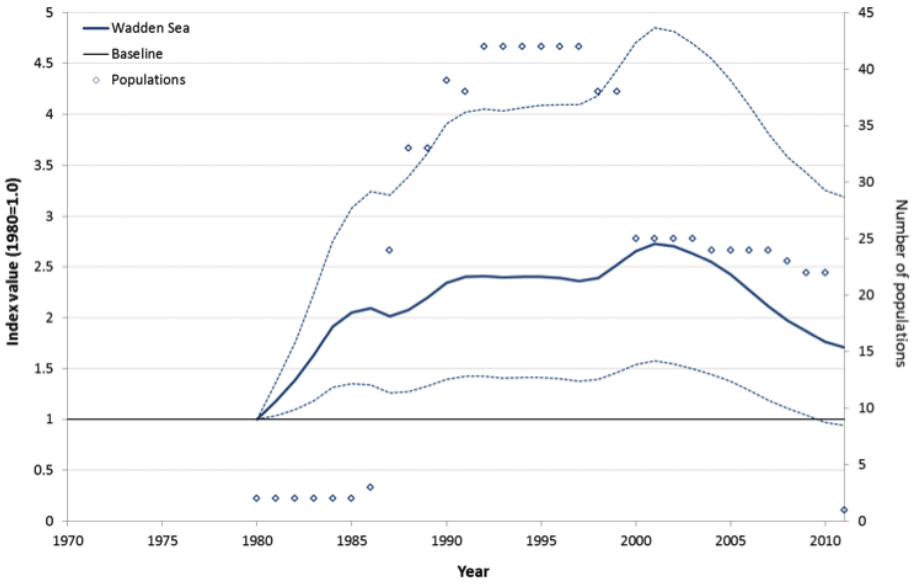
The Wadden Sea of the Netherlands, Germany and Denmark represents one of the important staging, moulting and wintering site for waterbirds and shorebirds travelling from their Arctic breeding grounds to their wintering range in the African subcontinent along the East Atlantic Flyway (Blew et al. 2013). It thus supports a large proportion of the flyway population for many species, e.g., Brent goose *Branta bernicla* (85%), Red knot *Calidris canutus* (subspecies *canutus* and *islandica*, 78%), Dunlin *Calidris alpina* (78%), Northern pintail *Anas acuta* (56%), Grey plover *Pluvialis apricaria* (55%) and Bar-tailed godwit *Limosa lapponica* (55%) (Blew et al. 2013).

To examine trends in this area, the data set was updated with additional trend information for 11 species for the period 2008-11[7] and the baseline set to 1980 as only one species contributed to the index before this point. Overall, Wadden Sea species increased by three-quarters between 1980 and 2011, following a mostly increasing trend until 2001 and a subsequent steep decline (Figure 22). The data set is dominated by shorebirds, and the decline towards the end of the study period can be attributed to a range of species from this group switching from positive to negative trends or continuing along a negative trajectory. This is in line with decreases reported in the literature, specifically in waders such as Eurasian golden plover *Pluvialis apricaria*, Dunlin *Calidris alpina*, and Ruff *Philomachus pugnax* (Blew et al. 2013). But declines in abundance have also been seen in many waterfowl (van Roomen et al. 2012), such as Brent goose and Tundra swan *Cygnus columbianus* (Zöckler 2007, Rees & Beekman 2010, Blew et al. 2013). Other species have been faring better between 1987 and 2010 according to research, with increases observed in Barnacle goose *Branta leucopsis* and Sanderling *Calidris alba*, and more stable trends in Northern pintail, Red knot, Curlew sandpiper *Calidris ferruginea*, Ruddy turnstone *Arenaria interpres*, and Whimbrel *Numenius phaeopus* (Blew et al. 2013).

The overall increasing trend observed in our Wadden Sea data set does not match the moderate decrease Blew et al. reported for populations of 13 Arctic-breeding species in the same area (Blew et al. 2013). However, when considering change in our data within the same time period as Blew et al., i.e. from 1987 to 2010, we obtain a more pronounced decline of around 25% across a larger number of species (n = 19). Overall, more data need to be added to our data set to develop a better understanding of how migratory bird populations are faring in the Wadden Sea.

7 *Arenaria interpres, Branta bernicla, B. leucopis, Calidris alba, C. alpina, C. canutus, C. ferruginea, Charadrius hiaticula, Limosa lapponica, Numenius phaeopus, Philomachus pugnax*

Figure 22. Index of abundance for 43 time-series of 19 Arctic migratory bird species monitored in locations within the Wadden Sea area from 1980 to 2011. Dashed lines are 95% confidence limits and diamonds the number of time-series contributing to the index in each year. Please note that the index ends in 2010 due to data availability.



Long tailed Duck. Photo: Slobrdr/Flickr, Creative Commons 2.0

Species trends

In the following section, we present abundance trends for selected species with sufficient data, including for flyway regions. For this purpose, the original data set was updated with additional trend information from the Wadden Sea for 2008-11 for Red knot *Calidris canutus* and Grey plover *Pluvialis squatarola*.

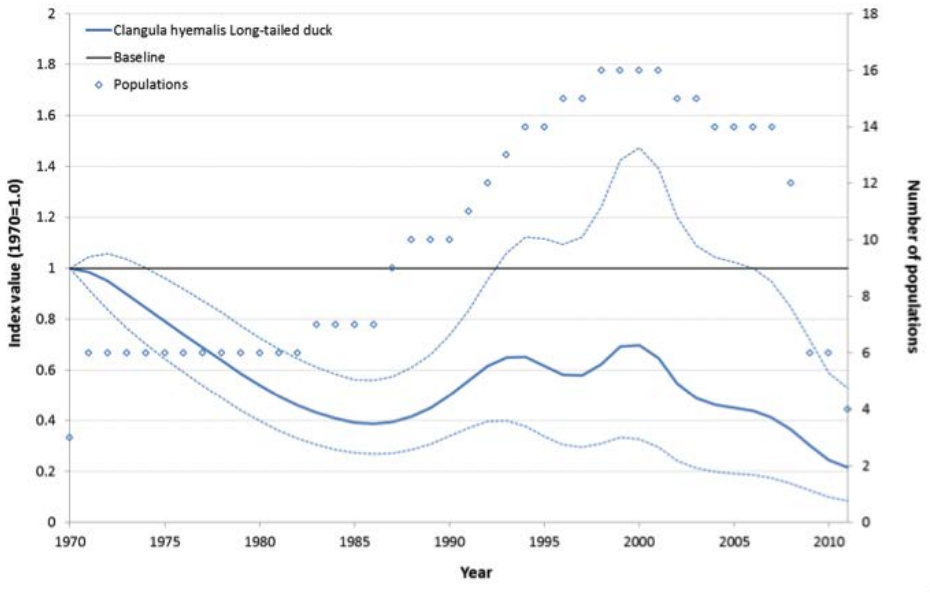
Long-tailed duck
Clangula hyemalis

The Long-tailed duck *Clangula hyemalis* has recently been listed as Vulnerable (VU) on the IUCN Red List because of dramatic reductions in the wintering Baltic Sea population since the 1990s (IUCN 2013). Experts suggest that this local decline will lead to a rapid decrease in the global population by 2020, even when taking into account uncertainty regarding the sizes and trends of other populations (IUCN 2013).

A decline of 75% in Long-tailed duck using the African-Eurasian Flyway was observed using our data between 1970 and 2011 (Figure 23), with time-series hailing from a range of countries including the Baltic Sea states, the UK, Slovakia and Greenland. This is in line with reports of a decline in the Baltic Sea (Skov et al. 2011) and the 65% reduction in the Western Siberian/Northern European population observed between 1993-95 and 2007-09 (AEWA 2014). A similar picture emerges in North America: population estimates based on aerial counts of breeding birds in Alaska and Canada's Yukon Territory are nearly 40% lower than the long-term mean in 2010 compared to 1957 (Mallek & Groves 2011). As in Europe, where decreases have accelerated over the past decade, North American declines are continuing, with an 11% reduction on the mean of the previous 10 years (Mallek & Groves 2011). While these data appear to be in congruence with previous findings and expert opinion, the proportion of individuals covered of the East Atlantic Flyway population is less than 5% (Figure 9), so results are likely to be incomplete. In addition, there is currently no information available on abundance trends from the Asian region.

As discussed previously, it is possible that apparent declines in species may be due to shifts in the wintering range (Žydelis et al. 2006). However, this does not seem to be the case with the Long-tailed duck, which has not shown such a shift in the Baltic Sea (Skov et al. 2011). This makes further research all the more important. Some countries have already developed objectives to address the lack of detailed knowledge of the multitude of factors driving the current rapid decline of the species in Europe (AEWA 2014), thus paving the way for a single species action plan for the Long-tailed duck (AEWA 2014). Better monitoring data are needed to construct a more detailed picture of how the Long-tailed duck is faring globally. If declining trends are established for areas outside the Baltic Sea, the species could be uplisted to Endangered (EN) in the near future (IUCN 2013).

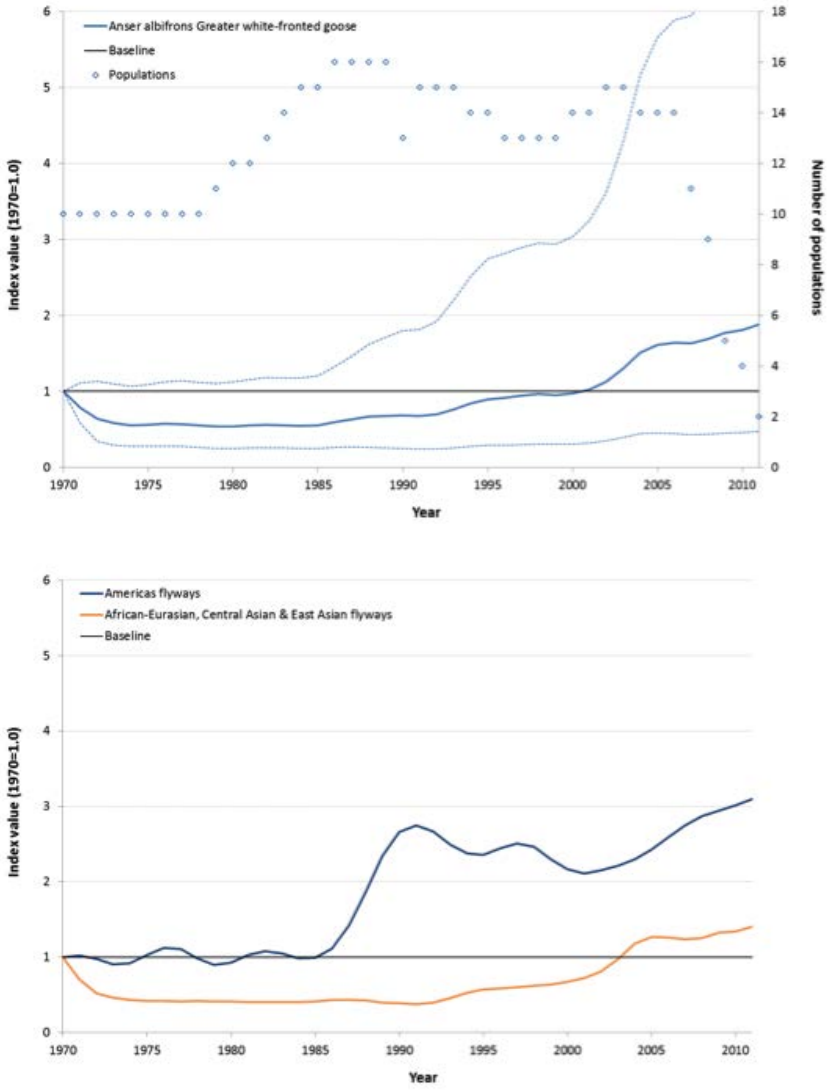
Figure 23. Index of abundance for 15 time-series of Long-tailed duck Clangula hyemalis *from the Europe region between 1970 and 2011.*



Greater white-fronted goose
Anser albifrons

The Greater white-fronted goose is the most widespread and numerous goose in the Western Palearctic (Wetlands International 2014). It occurs in several subspecies which breed in distinct regions of the North American and Russian Arctic. These subspecies are also segregated in their wintering areas: Siberian *A. a. albifrons* winter in the southern U.K. and Mediterranean, Greenland *A. a. flavirostris* in Ireland and Scotland, *A. a. gambelli* on the Gulf Coast and *A. a. frontalis* on the Pacific Coast from California to Mexico. At a global level the Greater white-fronted goose time-series in our data set have been thriving since 1985, showing a near doubling in abundance on 1970 (Figure 24). Like most other geese, the species has greatly benefitted in Europe from the introduction of hunting bans (Calvert & Gauthier 2005), which is especially true of the Greenland population (Fox & Francis 2008). Regulated hunting and other management strategies have also led to large increases in North America (Figure 24). In addition, eutrophication of grasslands and crops along the flyways through intensification of agriculture have supported a steady growth in numbers (van Eerden et al. 2005, Kruckenberg et al. 2008). However, it should be noted that sudden increases in some areas may be attributable to shifts in the range of populations. It is possible that such a shift has played a role in the numbers recorded for the Greater white-fronted goose, especially considering the very low numbers of juveniles recorded among wintering flocks in the past 15-20 years (Kruckenberg et al. 2011). Increases therefore need to be interpreted with caution, and care must be taken not to use such information for implementing potentially fatal changes in the management of populations or the species (Mooij 2009). So far, the actions taken have been beneficial for the development of the Greater white-fronted goose since the 1980s on both sides of the Atlantic, and it is hoped that continued population-wide monitoring will provide the basis for any decision-making regarding the future management of this and other goose populations.

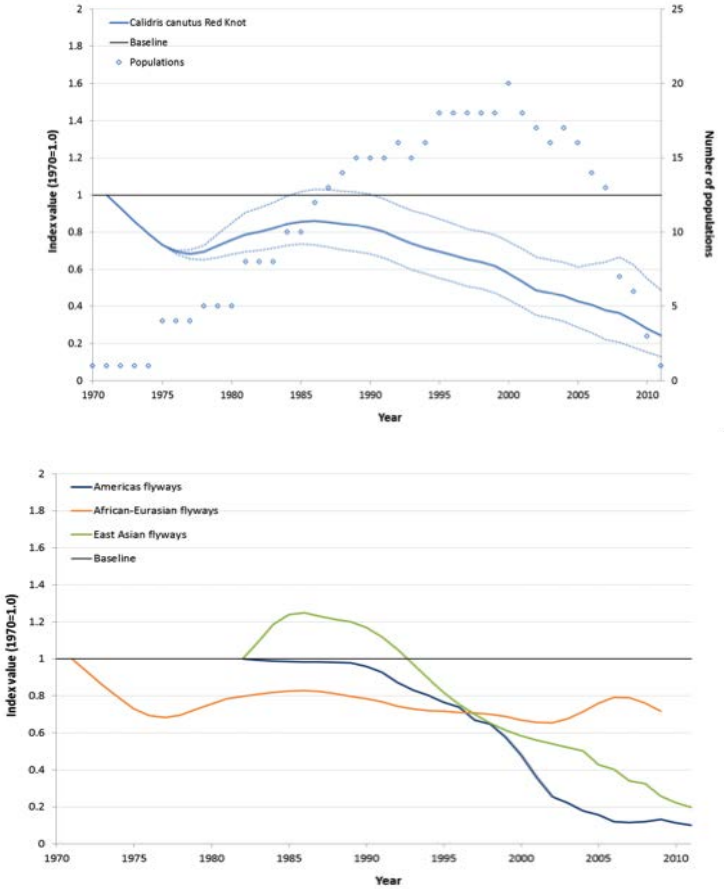
Figure 24. Index of abundance for 29 time-series of Greater white-fronted goose Anser albifrons *overall (left) and by flyway region (right; Americas: 6 time-series, rest: 23 time-series) between 1970 and 2011.*



Red knot
Calidris canutus

The Red knot *Calidris canutus* is a circumpolar-breeding shorebird species which occurs in five distinct populations (Piersma & Davidson 1992) encompassing all continents along the major flyways. It uses distinct stopovers sites which can be easily monitored, and for this reason the species is well-represented in this study, both in terms of the number of time-series available and the number of flyway regions covered (Figure 25). Our results suggest that the Red knot has declined by over 70% between 1970 and 2011, with comparable trends in all three flyway regions for which data were available (Figure 25). The data set for Africa-Eurasia shows a good spread geographically, including information from the Wadden Sea which supports an estimated 80% of the AEWA population (Blew et al. 2013) and receives individuals from populations breeding in Greenland and North America as well as those breeding in Central Siberia (Prokosch 1988). Our findings are consistent with a more recent assessment of the species' status in Northern Siberia/West & Southern Africa, which has a decreasing trend with a slight increase in the early 2000s (van Roomen et al. 2014). It is not entirely clear what the root causes of these declines are, but the fact that populations across flyways are showing negative trends may suggest problems within the Arctic itself. For example, Fraser et al. (Fraser et al. 2013) observed a correlation between an increase in juveniles in Delaware Bay and good lemming years in the Arctic dating back almost a century. These lemming cycles have been fading out recently (Ims et al. 2008), leading to greater predation on chicks and eggs, and this is ultimately impacting on the success rate of breeding birds rearing their young. However, different flyway regions do show divergent rates of declines, and this may point to the presence of a range of additional issues outside the breeding area. For example, the overharvesting of horseshoe crabs, the prime food of the Red knot at stop over sites in the Atlantic Americas, has had a significant impact on populations of the species (Morrison et al. 2004, Niles et al. 2008). In the Yellow Sea the few sites which are used for stop overs by individuals of the East Siberian and Alaskan populations of the species are affected by habitat loss and populations are therefore declining (Yang et al. 2011). This demonstrates how important the protection of all stop over sites is for the conservation of a circumpolar Arctic-breeding species. However, the declines observed in our data set have to be interpreted with caution. In many cases, it may be possible that local decreases are due to distributional shifts as opposed to actual declines in individuals, and further monitoring is needed to assess the contribution of this explanation to the decrease in number observed.

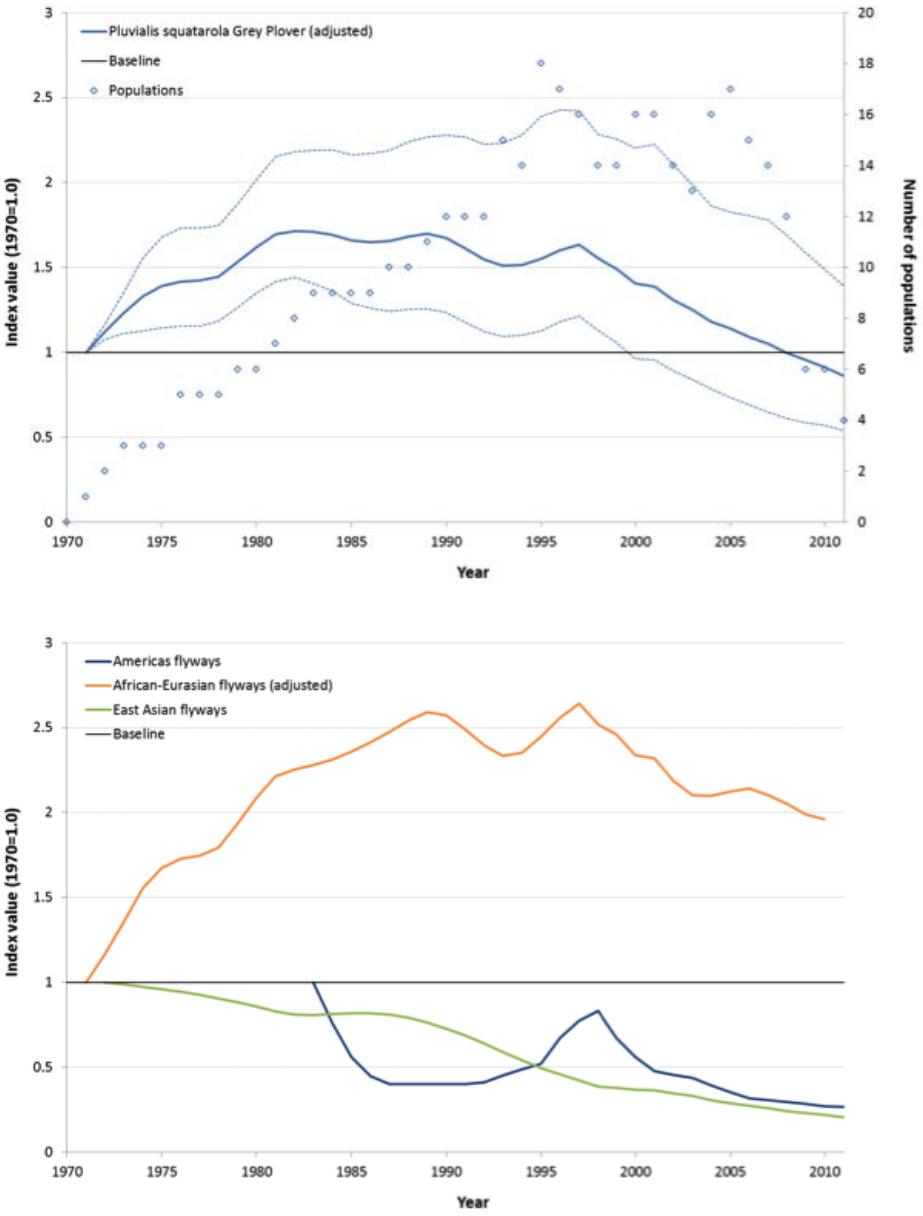
Figure 25. Index of abundance for 30 time-series of Red knot Calidris canutus *overall (left) and by flyway region (right; Americas: 9 time-series, African-Eurasian: 12 time-series, East Asian: 9 time-series) between 1970 and 2011. Please note that the African-Eurasian index ends in 2009 due to data availability.*



Grey plover
Pluvialis squatarola

Like many other shorebird species (Figure 11), the Grey plover *Pluvialis squatarola* has declined since 1970 (-15% globally), especially in East Asia (-80%) and the Americas (-75%, Figure 26) according to our data. Interestingly, the species appears to be thriving in the African-Eurasian region, where it more than tripled in abundance by 1993. From 1994, however, a steady decline is observed, which coincides with a slightly delayed peak in the Americas (Figure 26). This decline has primarily been reported for wintering populations in the African part of the East Atlantic Flyway, while trends in the European part have been described as stable (van Roomen et al. 2014). These latter changes in trajectory call for further research into whether factors within the Arctic are to blame. Hunting has likely contributed to the declines of some wader species such as the Spoon-billed sandpiper *Eurynorhynchus pygmeus* in East Asia (Zöckler et al. 2010a) and the Semipalmated sandpiper *Calidris pusilla* in the Americas (Morrison et al. 2012), while the loss of coastal wintering and stop over sites is impacting populations in East Asia (MacKinnon et al. 2012, Murray et al. 2014). Unlike the Red Knot or other species, the Grey Plover does not congregate in a small numbers of discrete sites during migration but spreads rather widely; hence, the decline in populations of this species occurs more slowly and may go almost unnoticed. It is therefore of utmost importance to increase our knowledge of the species and its regional trends to address potential fatal future declines.

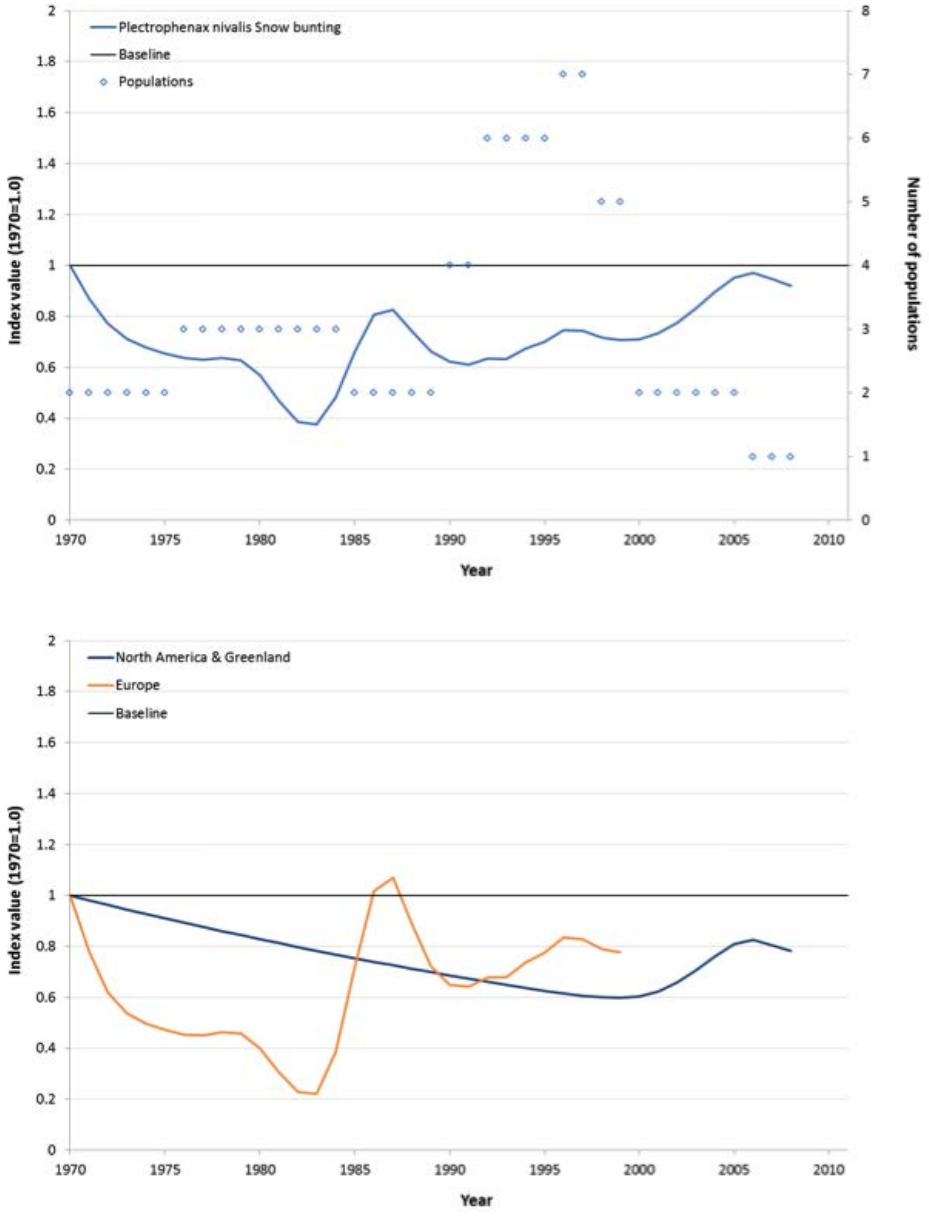
Figure 26. Index of abundance for 32 time-series of Grey plover Pluvialis squatarola *overall (left) and by flyway region (right; Americas: 8 time-series, African-Eurasian: 15 time-series, East Asian: 10 time-series) between 1970 and 2011. Please note that one time-series occurs in two flyway regions.*



Snow bunting
Plectrophenax nivalis

The trend for Snow bunting *Plectrophenax nivalis* depicted in Figure 27 suggests a 10% decline in the species between 1970 and 2008[8]. It is, however, possible that reductions are greater than shown. Data from the North American Christmas Counts, for example, reveal a reduction of 64% since 1965 (Butcher & Niven 2007) and 40% since 1970, although these changes are not statistically significant (Downes et al. 2011). Despite this, the fact that declines of varying magnitude are occurring across several of the flyway regions could be cause for concern. Trends from Sweden and Finland, for example, are also believed to be negative (BirdLife International 2004). Since our data set is small and is missing some vital information from, for example, the Americas, more information is needed. To obtain the best possible trends for the Snow bunting, as well as other landbirds in the data set, it is important to improve coverage for this taxonomic subgroup for future studies.

Figure 27. Index of abundance for 9 time-series of Snow bunting Plectrophenax nivalis *overall (left) and by region (right; North America & Greenland: 2 time-series; Europe: 7 time-series) between 1970 and 2011. Please note that confidence intervals are not displayed due to large variations in the underlying data set.*



8 based on time-series data from Canada, Greenland, Germany, and the United Kingdom

Conclusions

In this report, trends in 129 Arctic migratory bird species were examined between 1970 and 2011 using time-series information from locations inside and outside the Arctic. Overall, these selected species have increased in abundance, mostly influenced by recoveries in waterfowl (especially geese) and landbirds. Divergent trends are apparent at the flyway level, with increases in the Americas and the African-Eurasian region, while serious declines are observed in the Central Asia and East Asian flyways. Shorebirds are in decline across many regions, especially East Asia, but there may be some indication of a recent and continuing reduction in other groups since the 2000s. Within the waterfowl group, geese are faring well, some swans have been declining since 2009/2010, and duck abundance is lower than in 1970, especially in the Americas. Case studies showed that in the Wadden Sea, bird abundance is three-quarters higher in 2010 than in 1980, but the trend has been negative since 2002. A number of species are showing large declines across flyway regions, e.g. Long-tailed duck and Red knot, while others like the Grey plover show distinct differences between regions.

The indices presented here are an important first step towards building detailed knowledge of Arctic migratory bird populations over the past 40 years and their responses to a range of threats along flyway routes. As a barometer for the state of the flyways, our results have implications for policy makers and the wider conservation community both inside and outside the Arctic. However, it should be stressed that these trends represent changes compared to the chosen baseline year, and do not tell us explicitly about the current state of the species included. In addition, a number of gaps were identified which need to be addressed in order to improve the representation of the data underlying this indicator. Specifically, it is recommended to boost representation for landbird species, to update those time-series from long-term monitoring programmes within the Arctic, and to increase the overall number of species included in the index. Table 3 provides an overview of the species coverage for each taxonomic subgroup within each of the flyway regions based on the number of 160 ABA reference species (Ganter & Gaston 2013) currently covered by the data set, and thus provides a useful framework for future data collection. Some of the gaps identified, e.g. in Greenland and areas of Canada but also in Africa and India, were the result of time and resource constraints focusing collection on less well-covered regions. Others could be attributed to abundance trend information not having been generated or mobilised. We hope that this report will trigger interest and wider participation from the relevant stakeholders (ideally, all countries and organisations within each of the flyway regions). We therefore invite experts to contribute to the representation of this indicator by sharing their data with us, as this would also align our conclusions with expert opinion. Additional information would also allow us to make better judgments about whether declines are due to the disappearance of individuals, regional shifts in a species' seasonal distribution or other factors. Lastly, a larger data set would also enable us to examine geographic, taxonomic, life history, climate, anthropogenic activity and threat patterns in more detail, which can help identify the key issues in each flyway and directly inform conservation professionals and policy-makers about necessary further research and priority conservation action.

Empirical evidence of flyway structure is often lacking (Webster et al. 2002), despite the fact that it is vital for the implementation of effective and efficient conservation. A recent study demonstrated that strategies prioritising conservation investment based on spatially explicit knowledge of a flyway and its important sites always outperformed other approaches in maximising population flow (shorebirds in the East Asia-Australasia Flyway under sea-level rise scenarios) and this effect was particularly noticeable when the available budget was small (Iwamura et al. 2014). More intensive monitoring is therefore needed of species within the flyway regions they occupy, and this needs to be undertaken at all important sites within all countries along the migratory route. While this goes beyond the Circumpolar Biodiversity Monitoring Programme (CBMP) and the Circumpolar Seabird expert group (CBird) geographically, the Arctic Migratory Bird Initiative (AMBI) could be a good vehicle to encourage collaboration (see Box 2). The conservation of Arctic migrants is a truly global challenge covering virtually all ecosystems and requiring a high level of international cooperation (Scott 1998). If conservation efforts are to be effective, they will need to adopt a flyway-wide approach addressing all issues along the entire flyway, and aim to be as global in their participation and scope as the journey that the Arctic migratory birds that they aim to conserve undertake each year.

Table 3. Current data gaps of the data set with respect to flyway region and taxonomic group expressed as the proportion of reference species covered within each combination. Green = >70%, yellow = 50-70%, orange = 30-50%, red = <30%.

		Flyway Region			
		Americas	Africa-Eurasia	Central Asia	East Asia
Group	Landbirds				
	Seabirds				
	Shorebirds				
	Waterfowl				

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Appendices

Additional trend figures

Figure A1. The number of time-series (dark blue) and species (light blue) monitored in each of the eight flyways (top) and in the combined flyways (bottom). The Americas flyways are the Pacific Americas Flyway, Central Americas Flyway and Atlantic Americas Flyway; the African-Eurasian flyways are the East Atlantic Flyway and Mediterranean-Black Sea Flyway; and the East-Asian flyways are the East Asia-East Africa Flyway and East Asia-Australasia Flyway combined. The Central Asian Flyway remains separate.

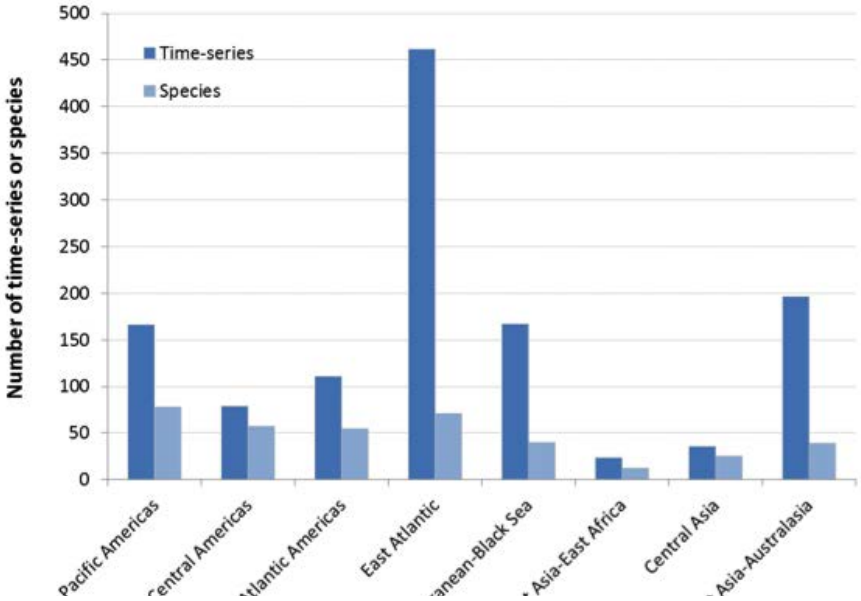


Figure A2. Species coverage by flyway, shown as the percentage of species in the final data set compared to the number of the same species expected to occur in each flyway. White numbers denote the number of species in the data set, and black numbers the total expected number for each flyway. Please note that a species can occur in more than one flyway.

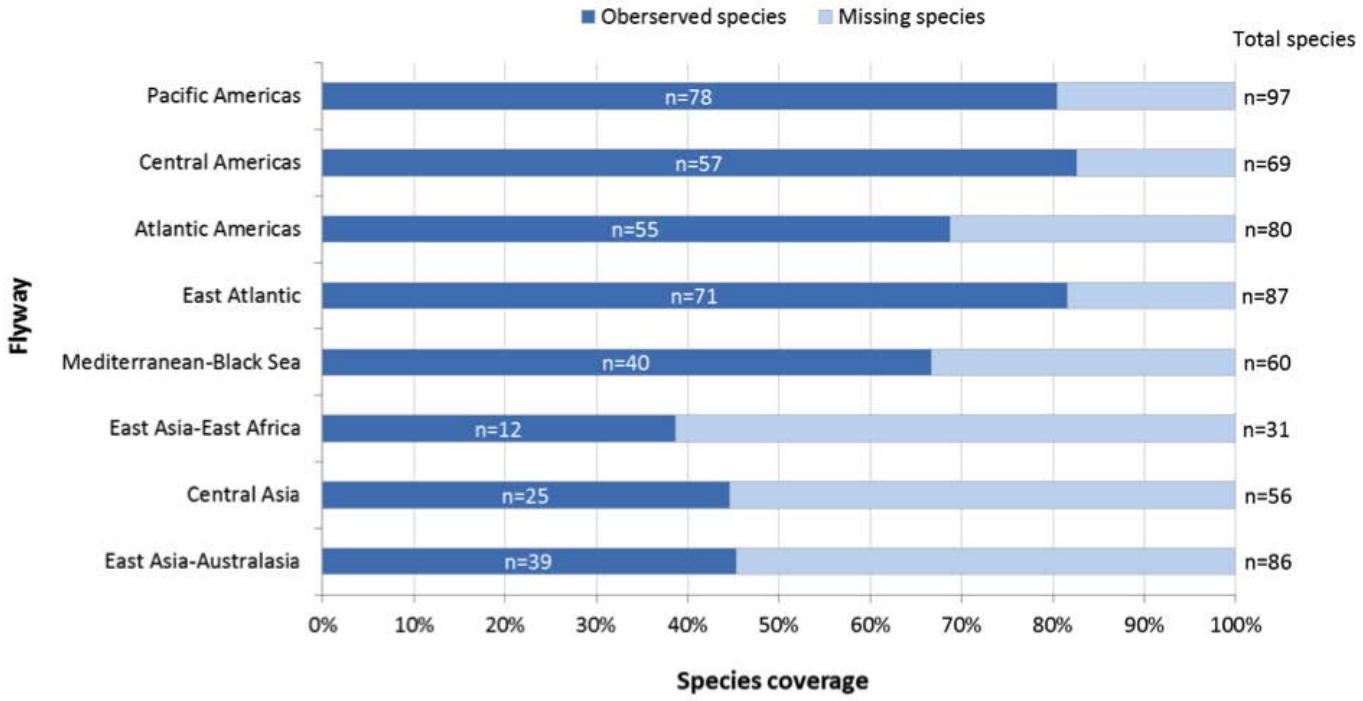
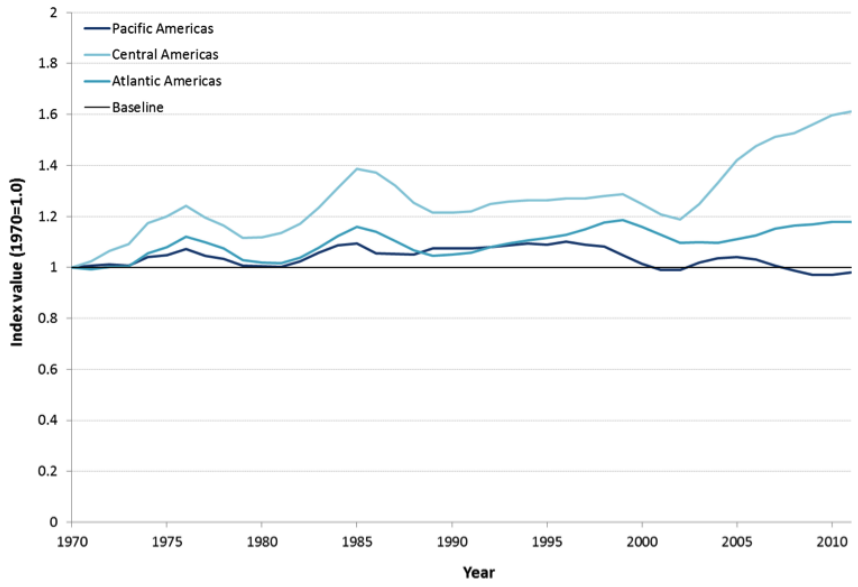


Figure A3. Indices of abundance for different flyways in the Americas (top) and Eurasia (bottom) for 966 time-series of 129 species from 1970 to 2011. Flyways are Pacific Americas (dark blue line; 166 time-series, 78 species), Central Americas (turquoise line; 79 time-series, 57 species), Atlantic Americas (light blue line; 111 time-series, 55 species), East Atlantic (purple line; 462 time-series, 71 species), Mediterranean-Black Sea (orange line; 167 time-series, 40 species), East Asia-East Africa (yellow line; 24 time-series, 12 species), Central Asia (olive green line; 36 time-series, 25 species) and East Asia-Australasia (light green line; 196 time-series, 36 species). Please note that due to data availability the index for the Mediterranean-Black Sea ends in 2009, East Asia-East Africa starts in 1976 and ends in 2008, and the index for Central Asia starts in 1980.



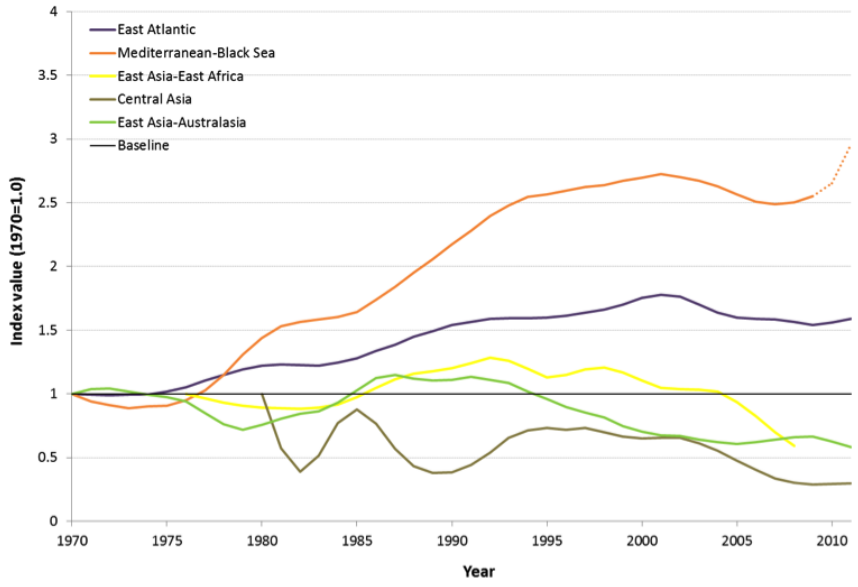


Figure A4. Final index end values for eight flyways for 966 time-series of 129 species from 1970 to 2011. Please note that due to data availability the index for East Asia-East Africa starts in 1976 and ends in 2008, the indices for the Mediterranean-Black Sea and combined African-Eurasian flyways end in 2009, and Central Asia starts in 1980.

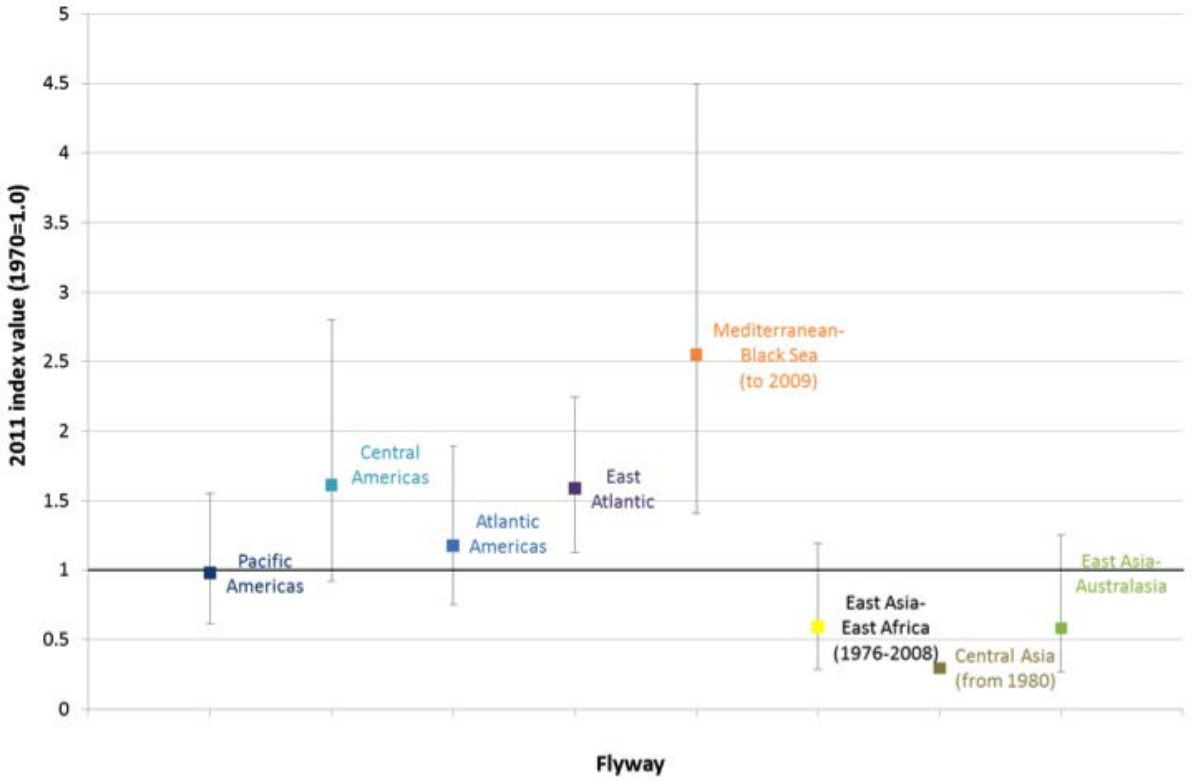
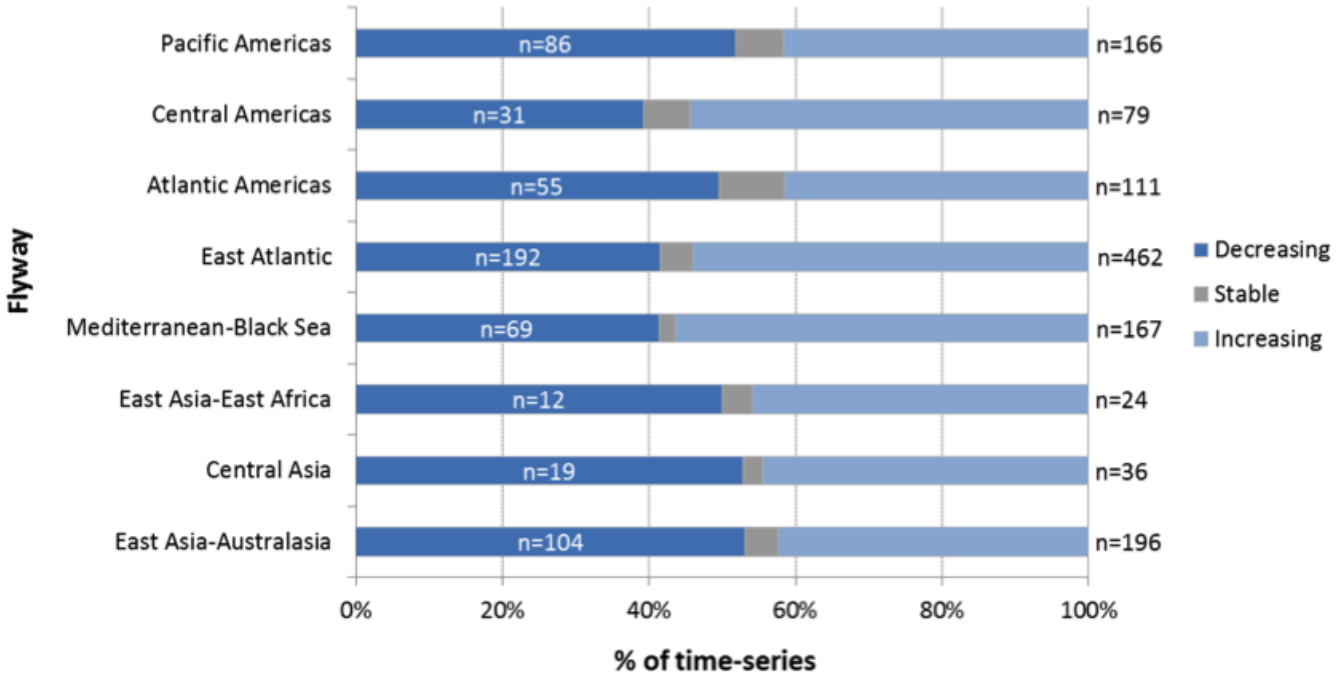


Figure A5. Proportion of decreasing (dark blue), stable (grey) and increasing (light blue) time-series for each of the eight flyways. A stable trend is defined as a 5% reduction or increase in abundance between 1970 and 2010. White numbers denote the number of decreasing time-series or species, black numbers the total number of time-series or species in that flyway.



Methods

Data collection

Species selection

To examine abundance trends in migratory birds, species were selected from the Arctic Biodiversity Assessment or ABA (Ganter & Gaston 2013) that breed within the Arctic as defined by CAFF (CAFF 2001) and migrate outside the Arctic region for the Northern Hemisphere winter. Species that are not recognised by BirdLife International (BirdLife International 2014), are considered resident in locations of occurrence, or whose non-breeding areas are within the Arctic (within the high, low or sub-Arctic regions or the CAFF boundary, as defined by CAFF) were excluded. A list of these reference species can be found in Table A1.

Range data

Species distribution information for selected species was collated from the 2012 release of bird species distribution maps of the world (BirdLife International and NatureServe 2012). Ranges were only included for those species where presence was listed as extant or probably extant, and where the species' status was native, introduced or reintroduced. The sourced maps were dissolved by season, producing separate breeding, non-breeding and passage ranges (where available).

Time-series data

Focusing primarily on those species with the highest proportion of migratory individuals according to the ABA, i.e. categories 1 and 2 (Ganter & Gaston 2013), time-series data were collated from the Living Planet Database (LPD) (WWF/ZSL 2014), which comprises information from published scientific literature, online databases, researchers and institutions and from grey literature. And established method was used (Loh et al. 2005, Collen et al. 2009), where data were included only if: a direct or proxy measure of population size was available for at least two years; there was information on how the data were collected and what the units of measurement were; the method was consistent and applied to the same subsection of the species population throughout the study period; and the data source was referenced and traceable. The length of these data sets, or time-series, varied according to the availability of information, meaning that the composition of the data set changed annually as time-series started and ended. Data were therefore not available for all species and time-series for every year between 1970 and 2011. Although targeted data collection was carried out before analysis, the final data set comprises data that could be easily obtained and entered within the timeframe of the project. It does not represent all data available. For any contributions to the data set, please contact the authors.

Time-series that were tagged as non-migratory, and all those explicitly breeding outside the Arctic boundary were excluded; for non-Arctic sites, time-series were included that were identified as overwintering or passing through monitoring locations, or where migratory activity was unknown. Further refinements included the removal of replicate time-series, of species in migratory status categories 3 and 4 (Ganter & Gaston 2013) that do not typically migrate to the Arctic to breed, and species that are present only within the Arctic. The final data set comprised a total of 966 time-series of 129 species (see Table A1 for a full species list).

Flyway information

The eight flyways were digitised in ArcGIS 9.3 (ESRI) following the delineation used by BirdLife International (BirdLife International 2010g, i, b, a, f, h, e, c, d): Pacific Americas, Central Americas, Atlantic Americas, East Atlantic, Mediterranean-Black Sea, East Asia-East Africa, Central Asia and East Asia-Australasia. Flyways were then combined into Americas (Pacific, Central, Atlantic Americas), Africa-Eurasia (East Atlantic, Mediterranean-Black Sea), Central Asia and East Asia (East Asia-East Africa, East Asia-Australasia).

Coverage was assessed for each flyway by relating the number of species for which data were available to the number of 160 reference species (Ganter & Gaston 2013) expected to occur here. In addition, the average number of individuals represented by each time-series was calculated for each species within each of the four flyway regions, and the highest of these values was then compared with the upper estimate of population size from the Waterbird Population Estimates Online Database (Wetlands International 2014). Because maximum population

size estimates were used and only those time-series based on counts of individuals and those that could easily be transformed into such counts (e.g. breeding pairs) were included, the resulting percentages represent the minimum coverage achieved in each flyway region.

Ancillary information

Additional information was compiled at the time-series and species level encompassing geographic and ecological themes. These data tags, presented in Table A2, were used to disaggregate the abundance trend data for further descriptive and statistical analyses.

Data analysis

Abundance change

Change in abundance was calculated between 1970 and 2011 using a Generalised Additive Modelling (GAM) framework, implemented using the mgcv package in R version 3.0.3 (R Development Core Team 2014), to obtain annual time-series level trends (Collen et al. 2009). These were aggregated geometrically following a standardised method to produce the final index (Collen et al. 2009) for each cut of the data. In addition to an overall index across all species, the data set was disaggregated into eight flyways or four flyway regions and then further using ancillary information described above to identify underlying change. Trends were also calculated at the species-level for selected example species (Long-tailed duck *Clangula hyemalis*, Greater white-fronted goose *Anser albifrons*, Red knot *Calidris canutus*, Grey plover *Pluvialis squatarola* and Snow bunting *Plectrophenax nivalis*) and these were also disaggregated them further into flyway regions. Because of its importance for a large number of Arctic migratory bird species (Blew et al. 2013) as well as good data availability, an index was produced for the Wadden Sea after supplementing the data set with up-to-date trend information for 14 species covering the years 2008-11 (Blew et al. 2013). All indices were smoothed over three years, and 95% confidence limits (CLs) were calculated using 10,000 bootstraps, although these were not shown on multi-line graphs for clarity. Five-yearly index values and their CLs are presented in Table A4.

Total change in abundance over time was calculated as the sum of all available annual change values between 1970 and 2010 for each time-series and for each species in the data set. 2010 was chosen as the end year because many of the time-series from locations within the Arctic boundaries finished at this point. Where abundance change was greater than ±5%, time-series and species were categorised as increasing or decreasing depending on the direction of change. All other time-series and species were deemed to be stable.

Spatial analysis

Richness maps were produced by overlaying a hexagonal grid[9] onto species' distributions following an established method (Schipper et al. 2008). To map global migratory bird species richness outside the breeding season, we used non-breeding and passage ranges from the IUCN Red List (BirdLife International and NatureServe 2012) of 155 reference species from the ABA (Ganter & Gaston 2013) (information was unavailable for 5 species[10]). Breeding species richness was based on the breeding ranges from the IUCN Red List (BirdLife International and NatureServe 2012) of 152 species[11]. In both cases, species richness was defined as the number of species polygons intersecting each grid cell. All resulting maps were clipped to the Arctic boundaries to eliminate overlap.

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9 The grid was defined on an icosahedron and projected to the sphere using the inverse Icosahedral Snyder Equal Area (ISEA) Projection, thus taking into account the Earth's spherical nature, and consisting of cells of approximately 2,597 km^2.

10 Non-breeding and/or passage range information was missing for the following species: Arctic redpoll *Carduelis hornemanni*, Northern fulmar *Fulmarus glacialis*, Wandering tattler *Heteroscelus incana*, European shag *Phalacrocorax aristotelis*, and Long-tailed jaeger *Stercorarius longicaudus*..

11 Breeding range information was missing for the following species: Arctic redpoll *Carduelis hornemanni*, White-throated dipper *Cinclus cinclus*, Northern fulmar *Fulmarus glacialis*, Wandering tattler *Heteroscelus incana*, Rock ptarmigan *Lagopus muta*, Slaty-backed gull *Larus schistisagus*, Asian rosy finch *Leucosticte arctoa*, and Long-tailed jaeger *Stercorarius longicaudus*.

Data tables

Table A1. List of reference species selected from the Arctic Biodiversity Assessment (Ganter & Gaston 2013).

Order	Family	Taxonomic name	Common name
Anseriformes	Anatidae	*Anas acuta*	Northern pintail
		Anas americana	American wigeon
		Anas clypeata	Northern shoveler
		Anas penelope	Eurasian wigeon
		Anser albifrons	Greater white-fronted goose
		Anser brachyrhynchus	Pink-footed goose
		Anser erythropus	Lesser white-fronted goose
		Anser fabalis	Tundra bean goose
		Aythya marila	Greater scaup
		Branta bernicla	Brent goose
		Branta canadensis	Canada goose
		Branta hutchinsii	Cackling goose
		Branta leucopsis	Barnacle goose
		Branta ruficollis	Red-breasted goose
		Bucephala clangula	Common goldeneye
		Bucephala islandica	Barrow's goldeneye
		Chen caerulescens	Snow goose
		Chen canagica	Emperor goose
		Chen rossii	Ross's goose
		Clangula hyemalis	Long-tailed duck
		Cygnus columbianus	Tundra swan
		Cygnus cygnus	Whooper swan
		Histrionicus histrionicus	Harlequin duck
		Melanitta americana	Black scoter
		Melanitta deglandi	White-winged scoter
		Melanitta fusca	Velvet scoter
		Melanitta nigra	Common scoter
		Melanitta perspicillata	Surf scoter
		Mergus serrator	Red-breasted merganser
		Polysticta stelleri	Steller's eider
		Somateria mollissima	Common eider
		Somateria spectabilis	King eider
Charadriiformes	Alcidae	*Aethia cristatella*	Crested auklet
		Aethia psittacula	Parakeet auklet
		Aethia pusilla	Least auklet
		Alle alle	Little auk
		Cepphus columba	Pigeon guillemot
		Cepphus grylle	Black guillemot
		Fratercula arctica	Atlantic puffin
		Fratercula cirrhata	Tufted puffin
		Fratercula corniculata	Horned puffin
		Uria lomvia	Thick-billed murre
	Charadriidae	*Charadrius hiaticula*	Common ringed plover
		Charadrius mongolus	Lesser sand plover
		Charadrius semipalmatus	Semi-palmated plover

Order	Family	Taxonomic name	Common name
		Eudromias morinellus	Eurasian dotterel
		Pluvialis apricaria	Eurasian golden plover
		Pluvialis dominica	American golden plover
		Pluvialis fulva	Pacific golden plover
		Pluvialis squatarola	Grey plover
	Laridae	*Larus argentatus*	European herring gull
		Larus canus	Mew gull
		Larus glaucoides	Iceland gull
		Larus hyperboreus	Glaucous gull
		Larus schistisagus	Slaty-backed gull
		Larus thayeri	Thayer's gull
		Rissa tridactyla	Black-legged kittiwake
		Sterna aleutica	Aleutian tern
		Sterna paradisaea	Arctic tern
		Xema sabini	Sabine's gull
	Scolopacidae	*Aphriza virgata*	Surfbird
		Arenaria interpres	Ruddy turnstone
		Arenaria melanocephala	Black turnstone
		Calidris acuminata	Sharp-tailed sandpiper
		Calidris alba	Sanderling
		Calidris alpina	Dunlin
		Calidris bairdii	Baird's sandpiper
		Calidris canutus	Red Knot
		Calidris ferruginea	Curlew sandpiper
		Calidris fuscicollis	White-rumped sandpiper
		Calidris himantopus	Stilt sandpiper
		Calidris maritima	Purple sandpiper
		Calidris mauri	Western sandpiper
		Calidris melanotos	Pectoral sandpiper
		Calidris minuta	Little stint
		Calidris minutilla	Least sandpiper
		Calidris ptilocnemis	Rock sandpiper
		Calidris pusilla	Semipalmated sandpiper
		Calidris ruficollis	Red-necked stint
		Calidris subminuta	Long-toed stint
		Calidris temminckii	Temminck's stint
		Calidris tenuirostris	Great knot
		Eurynorhynchus pygmeus	Spoon-billed sandpiper
		Gallinago gallinago	Common snipe
		Gallinago stenura	Pin-tailed snipe
		Heteroscelus brevipes	Grey-tailed tattler
		Heteroscelus incana	Wandering tattler
		Limicola falcinellus	Broad-billed sandpiper
		Limnodromus scolopaceus	Long-billed dowitcher
		Limosa haemastica	Hudsonian godwit
		Limosa lapponica	Bar-tailed godwit
		Limosa limosa	Black-tailed godwit
		Lymnocryptes minimus	Jack snipe

Order	Family	Taxonomic name	Common name
		Numenius phaeopus	Whimbrel
		Numenius tahitiensis	Bristle-thighed curlew
		Phalaropus fulicarius	Red phalarope
		Phalaropus lobatus	Red-necked phalarope
		Philomachus pugnax	Ruff
		Tringa erythropus	Spotted redshank
		Tringa flavipes	Lesser yellowlegs
		Tringa glareola	Wood sandpiper
		Tringa solitaria	Solitary sandpiper
		Tringa totanus	Common redshank
		Tryngites subruficollis	Buff-breasted sandpiper
		Xenus cinereus	Terek sandpiper
	Stercorariidae	*Stercorarius longicaudus*	Long-tailed jaeger
		Stercorarius parasiticus	Arctic skua
		Stercorarius pomarinus	Pomarine skua
		Stercorarius skua	Great skua
Falconiformes	Accipitridae	*Buteo lagopus*	Rough-legged buzzard
		Circus cyaneus	Hen harrier
	Falconidae	*Falco columbarius*	Merlin
		Falco peregrinus	Peregrine falcon
		Falco rusticolus	Gyrfalcon
Galliformes	Phasianidae	*Lagopus muta*	Rock ptarmigan
Gaviiformes	Gaviidae	*Gavia adamsii*	Yellow-billed loon
		Gavia arctica	Black-throated loon
		Gavia immer	Great Northern loon
		Gavia pacifica	Pacific loon
		Gavia stellata	Red-throated loon
Gruiformes	Gruidae	*Grus canadensis*	Sandhill crane
		Leucogeranus leucogeranus	Siberian crane
Passeriformes	Alaudidae	*Eremophila alpestris*	Horned lark
	Cinclidae	*Cinclus cinclus*	White-throated dipper
	Emberizidae	*Calcarius lapponicus*	Lapland longspur
		Calcarius pictus	Smith's longspur
		Emberiza pusilla	Little bunting
		Emberiza schoeniclus	Reed bunting
		Passerculus sandwichensis	Savannah sparrow
		Passerella iliaca	Fox sparrow
		Plectrophenax nivalis	Snow bunting
		Spizella arborea	American tree sparrow
		Zonotrichia leucophrys	White-crowned sparrow
	Fringillidae	*Carduelis flammea*	Common redpoll
		Carduelis hornemanni	Arctic redpoll
		Leucosticte arctoa	Asian rosy finch
		Leucosticte tephrocotis	Grey-crowned rosy finch
	Hirundinidae	*Petrochelidon pyrrhonota*	American cliff swallow
		Riparia riparia	Sand martin
	Laniidae	*Lanius excubitor*	Great grey shrike

Order	Family	Taxonomic name	Common name
	Motacillidae	*Anthus cervinus*	Red-throated pipit
		Anthus gustavi	Pechora pipit
		Anthus petrosus	Rock pipit
		Anthus rubescens	Buff-bellied Pipit
		Motacilla citreola	Citrine wagtail
	Muscicapidae	*Luscinia svecica*	Bluethroat
		Oenanthe oenanthe	Northern wheatear
	Parulidae	*Dendroica petechia*	American yellow warbler
		Wilsonia pusilla	Wilson's warbler
	Prunellidae	*Prunella montanella*	Siberian accentor
	Sylviidae	*Phylloscopus borealis*	Arctic warbler
		Phylloscopus trochilus	Willow warbler
	Turdidae	*Catharus minimus*	Grey-cheeked thrush
		Turdus iliacus	Redwing
		Turdus migratorius	American robin
		Turdus pilaris	Fieldfare
Pelecaniformes	Phalacrocoracidae	*Phalacrocorax aristotelis*	European shag
		Phalacrocorax pelagicus	Pelagic cormorant
Procellariiformes	Procellariidae	*Fulmarus glacialis*	Northern fulmar
Strigiformes	Strigidae	*Bubo scandiaca*	Snowy owl

Table A2. Additional information compiled at the species and time-series level.

	Data tag	Details
Time-series level	*Flyway*	Each time-series was assigned to a flyway by one of the authors (CZ) based on detailed knowledge of the selected species and their populations. We followed BirdLife International's delineation into eight flyways (BirdLife International 2010g, i, b, a, f, h, e, c, d). Flyways were then combined into broader flyway regions: Americas (Pacific, Central and Atlantic Americas), Africa-Eurasia (East Atlantic and Mediterranean-Black Sea), and East Asia (East Asia-East Africa and East Asia-Australasia). The Central Asian Flyway remained separate.
	Time-series length	Time-series length was defined as short (less than 10 years), medium (10 to 20 years) or long (more than 20 years).
Species level	*Taxonomic group*	Each species was assigned to one of the following groups: landbirds, seabirds (including loons), shorebirds (plovers and sandpipers) and waterfowl (geese, swans and ducks).
	Number of flyways	The number of flyways in which a species is expected to occur was assigned according to range information obtained from the IUCN Red List (BirdLife International and NatureServe 2012), using the flyway delineation from BirdLife (BirdLife International 2010g, i, b, a, f, h, e, c, d).

Table A3. List of monitored time-series in this analysis.

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
Accipitridae	*Buteo lagopus*	Rough-legged hawk / Rough-legged buzzard	Canada	South and North Arctic ecozone, Northern Canada	1966	2005	Confidential data source
			Finland	Inari-Utsjoki region, E Lapland, Finland	1973	1992	(NERC Centre for Population Biology 1999) with data taken from {Heikkila, 1994 #962)
				Western Finnish Lapland	1973	1992	(NERC Centre for Population Biology 1999) with data taken from {Heikkila, 1994 #962)
			Poland	Narew, Supraśl and Biała rivers	2000	2010	(Jankowiak et al. 2013)
			Romania	Pricopan Highs in Măcin Mountains	2002	2007	(Milvus Group 2007)
			Russian Federation	Agapa River Valley, Taimyr	2004	2007	(Kharitonov et al. 2007)
				Konkovaya river basin, Russia	1982	1992	(Potapov 1997)
				Taimyr Peninsula	1993	2005	(Ebbinge et al. 2006)
			United States	Colville river area, Alaska, USA	1952	1985	(Mindell et al. 1987) sourced from {NERC Centre for Population Biology, 1999 #524)
	Circus cyaneus	Northern harrier / Hen harrier	Spain	Delta del Ebro, Spain	1991	2008	(Galewski 2008)
				S'Albufera, Mallorca, Spain	1989	2012	(Galewski 2008) updated with (Govern de les Illes Balears - Espais de Natura Balear 2012)
			United States, Canada	United States and Canada	1966	2011	(Sauer et al. 2012)
Alaudidae	*Eremophila alpestris*	Horned lark / Shore lark	Germany	Dithmarscher Speicherkoog, Rickelsbüller Koog and Beltringharder Koog, Schleswig-Holstein	1990	1999	(Dierschke 2001)
				Helgoland	1990	1999	(Dierschke 2001)
				Wadden Sea islands, Niedersachsen	1992	1997	(Dierschke 2001)
				Wadden Sea mainland coast, Niedersachsen	1992	1997	(Dierschke 2001)
				Wadden Sea mainland coast, Schleswig-Holstein	1990	1999	(Dierschke 2001)
			Poland	Narew, Supraśl and Biała rivers	2000	2010	(Jankowiak, Polakowski et al. 2013)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
Alcidae	*Cepphus columba*	Pigeon guillemot	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe et al. 2012)
			United States	Buldir Island, Alaska	1972	2002	(Dragoo et al. 2008)
				Kasatochi Island, Alaska	1996	2005	(Dragoo, Byrd et al. 2008)
				Prince William Sound, Alaska	1972	2005	(Dragoo, Byrd et al. 2008)
				St Lazaria Island, Alaska	1994	2005	(Dragoo, Byrd et al. 2008)
	Cepphus grylle	Black guillemot	Iceland	Flatey Island, Breioafjorour Bay, Northwest Iceland	1974	1999	(CAFF International Secretariat 2005)
				Strandasysla Coastline, NW Iceland	1997	2005	(Johannsson et al. 2006)
			Norway	Norway	1970	2000	(Birdlife International 2005)
			United States	Cooper Island, Alaska	1975	2002	(Divoky et al. 2003)
	Fratercula arctica	Atlantic puffin	Canada	NE coast of Newfoundland	2000	2003	(Davoren 2007)
			Norway	Hernyken, Røst, Nordland	1979	2004	(Lorentsen 2004)
				Hornøy, Vardø, Finnmark	1980	2008	(Lorentsen et al. 2009)
			Russian Federation	Aynov Island, Murmansk, Russia	1928	1989	(Krasnov et al. 1995)
				Bol'shoy Aynov Island	1959	1995	(Anker-Nilssen et al. 2000)
				Gavriloski island	1960	1995	(Anker-Nilssen, Bakken et al. 2000)
				Maly Aynov Island	1961	1995	(Anker-Nilssen, Bakken et al. 2000)
				Seven islands	1938	1995	(Anker-Nilssen, Bakken et al. 2000)
	Fratercula cirrhata	Tufted puffin	United States	Aiktak Island, Alaska	1989	2005	(Dragoo, Byrd et al. 2008)
				Bogoslof Island, Alaska	1973	2004	(Dragoo, Byrd et al. 2008)
				E. Amatuli Island, Alaska	1995	2005	(Dragoo, Byrd et al. 2008)
				St Lazaria Island, Alaska	1996	2005	(Dragoo, Byrd et al. 2008)
	Uria lomvia	Thick-billed murre / Guillemot	Canada	Coats Island, Nunavut	1985	2007	Confidential data source
				Prince Leopold Island, Nunavut	1976	2008	Confidential data source
			Greenland	Kap Brewster	1974	1995	(Falk et al. 1997)
			Iceland	Hafnaberg, South-West Iceland	1982	2005	(Garoarsson et al. 2006)
				Krisuvikurberg (Krisuvik), SW Iceland	1985	2005	(Garoarsson and Zocker 2006)
				Skoruvik, NE Iceland	1986	2005	(Garoarsson and Zocker 2006)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
Anatidae	*Anas acuta*	Common pintail / Northern pintail	Austria, Czech Republic, Estonia, Hungary, Poland	Central Europe	1974	2002	(Wetlands International 2002)
			Ethiopia	Lake Ashenghe, Ethiopia	1993	1997	(Dodman et al. 1997)
			France, United Kingdom, Norway, Germany, Iceland	North West Europe	1974	2002	(Wetlands International 2002)
			India	Deepor Beel Wildlife Sanctuary, Assam, India	1989	1993	(Barman et al. 1995)
			Mali	Inner Niger Delta, Mali	1999	2001	(Girard et al. 2004)
			Mexico	Mexican Wetlands: The interior Highlands, Pacific Coast, Gulf of Mexico Coast	1961	2000	(Perez-Arteaga et al. 2004)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Nigeria	Hadejia-Nguru Wetlands, Nigeria	1992	1998	(Perennou 1992), (Dodman et al. 1996), (Dodman et al. 1998) and (Dodman, de Vaan et al. 1997)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Senegal	Parc National aux Oiseaux du Djoudj, Senegal	1996	1998	(Dodman and Taylor 1996), (Dodman, Beibro et al. 1998) and (Dodman, de Vaan et al. 1997)
			Spain	Delta del Ebro, Spain	1972	2008	(Galewski 2008)
				Doñana, Spain	1999	2008	(Reserva Biológica de Doñana 2008)
				S'Albufera, Mallorca, Spain	1986	2012	(Galewski 2008) updated with (Govern de les Illes Balears - Espais de Natura Balear 2012)
			Turkey	Kizilirmak delta	1970	1990	(Galewski 2008)
				Tuzla, Akyatan and Agyatan lakes; Seyhan delta	1970	1990	(Galewski 2008)
			Turkey, Greece, Ukraine, Bulgaria, Romania	Black Sea / East Mediterranean	1991	2000	(Wetlands International 2002)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Anas americana	American wigeon	Mexico	Mexican Wetlands: The interior Highlands, Pacific Coast, Gulf of Mexico Coast	1961	2000	(Perez-Arteaga and Gaston 2004)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Anas clypeata	Northern shoveler	Mexico	Mexican Wetlands: The interior Highlands, Pacific Coast, Gulf of Mexico Coast	1961	2000	(Perez-Arteaga and Gaston 2004)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Anser albifrons	Greater white-fronted goose / White-fronted goose	Austria, Hungary	Neusiedler-See area	1984	2006	(Laber et al. 2008)
			Belgium	Oostkustpolders, Flanders	1960	2003	(Kuijken et al. 2006)
			Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok et al. 2012)
			China	Key sites in Dongting Lake, Hunan province	2006	2008	(Zhao et al. 2012)
			Denmark	Bornholm	2000	2006	(Dansk Ornitologisk Forening 2007)
			Germany	Germany	1982	1994	(Mooij 2000)
				State of Nordrhein-Westfalen	1997	2003	(Wille et al. 2007)
			Hungary	Hungary	1986	2008	(Faragó 2010)
			Japan	Northern Miyagi Prefecture (mainly around Lake Izunuma-Uchinuma and Lake Kabukurinuma), Honshu	1987	2006	(Shimada 2009)
			Korea, Republic Of	Selected monitoring sites on the South Coast, West Coast and Inland Korea	2001	2012	(Birds Korea 2013)
			Mexico	Mexican Wetlands: The interior Highlands, Pacific Coast, Gulf of Mexico Coast	1961	2000	(Perez-Arteaga and Gaston 2004)
			Netherlands	The Netherlands	1980	1984	(Ebbinge et al. 1986)
				The Netherlands	1985	1989	(Lok et al. 1992)
			Poland	Poland	1991	1996	(Wuczyński et al. 2012)
			Poland	Western Pomerania	2002	2008	(Ławicki et al. 2008)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Russian Federation	Agapa River Valley, Taimyr	2004	2007	(Kharitonov, Egerova et al. 2007)
				Kolguev Island, Russia	1995	2008	(Kondratiev 2008)
				Taimyr Peninsula	1993	2005	(Ebbinge and Mazurov 2006)
			Slovakia	Slovakia	1991	2010	(Slabeyová et al. 2011)
			Turkey	Burdur Lake	1968	1995	(Green et al. 1996)
				Düden lake or Kulu lake	1970	1992	WIWO reports + (Magnin et al. 2000)
				Eregli marshes	1970	1989	(Galewski 2008)
				Seyfe lake	1970	1989	(Galewski 2008)
				Tuz, Tersakan and Bolluk lakes	1970	1993	(Galewski 2008)
			United Kingdom, Ireland	Britain, Ireland	1959	2007	(Mitchell et al. 2010)
			United States	Fall population along the US Pacific flyway	1979	2012	(U.S. Fish and Wildlife Service 2013)
				Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1994	2009	(Fischer et al. 2009)
				Wintering population of the Central and Mississippi flyways (Gulf of Mexico)	1969	2010	(Canadian Wildlife Service Waterfowl Committee 2013)
				Yukon-Kuskokwim Delta, Alaska, USA	1965	1993	(Hupp et al. 1995)
	Anser brachyrhynchus	Pink-footed goose	Belgium	Oostkustpolders, Flanders	1960	2003	(Kuijken, Verscheure et al. 2006)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1988	2010	(Laursen et al. 2013)
				Skjern River Valley restoration area, Central Jutland Region	2002	2005	(Bregnballe et al. 2009)
				Western Denmark	1932	1981	(Madsen 1982)
			Greenland	BioBasis programme, Zackenberg Research Station, Wollaston Forland, Northeast Greenland	1996	2007	(Meltofte et al. 2007)
				E Greenland/Iceland	1950	1994	(Scott et al. 1996)
			Netherlands	Netherlands	1960	1997	(Madsen et al. 1999)
			Norway	Sandfærhus, Stjørdal, Nord-Trøndelag	1993	1999	(Husby 1997) and (Husby 2000)
			Poland	Wielkopolska region	2002	2009	(Wylegała et al. 2010)
			Svalbard And Jan Mayen	Svalbard	1965	2006	Confidential data source

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United Kingdom, Ireland	Britain, Ireland	1959	2008	(Mitchell, Colhoun et al. 2010)
	Anser erythropus	Lesser white-fronted goose	Azerbaijan, Ukraine, Russian Federation, Kazakhstan, Estonia	Total population	1960	1995	(Scott and Rose 1996)
			China	East Dongting lake	1993	2001	(Fang et al. 2006)
			Greece	Evros delta	1965	2007	Confidential data source
			Hungary	Hungary	1986	2008	(Faragó 2010)
			Netherlands	The Netherlands	1989	2004	(Koffijberg 2007)
			Norway	Finnmark, North Norway	1985	2004	Confidential data source
			Turkmenistan	South-eastern Caspian region of Turkmenistan	1980	2002	(Vasiliev et al. 2006)
	Anser fabalis	Bean goose	Austria, Hungary	Neusiedler-See area	1984	2005	(Laber and Pellinger 2008)
			Germany	Germany	1982	1994	(Mooij 2000)
				State of Nordrhein-Westfalen	1997	2003	(Wille, Doer et al. 2007)
			Hungary	Hungary	1986	2008	(Faragó 2010)
			Japan	Japan	1970	2006	(Amano 2009)
			Netherlands	The Netherlands	1985	1988	(Lok, van den Bergh et al. 1992)
				The Netherlands	1979	1983	(Ebbinge, van der Bergh et al. 1986)
			Norway	Pasvik naturreservat, Sør-Varanger, Finnmark	1996	2005	(Günther 2003) updated with (Günther 2006)
			Poland	Poland	1991	1996	(Wuczyński, Smyk et al. 2012)
				Western Pomerania	2002	2008	(Ławicki, Czeraszkiewicz et al. 2008)
			Russian Federation	Kolguev Island, Russia	1995	2008	(Kondratiev 2008)
			Slovakia	Slovakia	1991	2010	(Slabeyová, Ridzoň et al. 2011)
			Slovenia	Ormoz Reservoir	1991	2002	(Vogrin 2004)
			Spain	Villafafila lagoon, Spain	1969	1992	(Palacios Alberti et al. 1999)
			Sweden	South West Sweden	1977	1986	(Nilsson 1988)
			United Kingdom, Ireland	Britain, Ireland	1959	2008	(Mitchell, Colhoun et al. 2010)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
	Aythya marila	Greater scaup	Austria	Austria	1970	1995	(Aubrecht et al. 1997)
			Canada	North America	1955	2002	(Jamieson et al. 2004)
				Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			Estonia	Estonian Baltic Coast	1993	2008	(Skov et al. 2011)
			Germany	German Central Baltic Coast	1987	2008	(Skov, Heinänen et al. 2011)
				German part of the Danish Straits	1987	2008	(Skov, Heinänen et al. 2011)
			Japan	Japan	1996	2009	(Kasahara et al. 2010)
			Korea, Republic Of	Selected monitoring sites on the South Coast and West Coast	2000	2012	(Birds Korea 2013)
			Poland	Polish Central Baltic Coast	1987	2008	(Skov, Heinänen et al. 2011)
			Slovakia	Slovakia	1991	2010	(Slabeyová, Ridzoň et al. 2011)
			Sweden	Blekinge archipelago, southeast Sweden	1971	2006	(Nilsson 2008)
				Landskrona to Falsterbo, southeast Sweden	1971	2006	(Nilsson 2008)
				Northern Gotland	1971	2005	(Nilsson 2008)
				Swedish Kattegat coast	1987	2008	(Skov, Heinänen et al. 2011)
			Ukraine	Molochnyi Liman	1991	2010	(Kostiushyn et al. 2011)
			United Kingdom	Moray Firth, Scotland	1998	2003	(Kalejta-Summers et al. 2006)
	Branta bernicla	Light-bellied brent goose / Dark-bellied brent goose	Canada	Campbell Island, Smoke-Moose delta	1995	1998	(Wiebe Robertson et al. 2006)
				Tuktoyaktuk peninsula, Mackenzie river delta	1995	1998	(Wiebe Robertson and Hines 2006)
			Canada, Greenland	Canada/Greenland popn	1965	1991	(Scott and Rose 1996)
			Denmark	Agero area	1980	1995	(Madsen, Cracknell et al. 1999)
				Denmark	1960	1975	(Ogilvie et al. 1976) sourced from (NERC Centre for Population Biology 1999)
				Mariager & Randers Fjords	1980	1995	(Madsen, Cracknell et al. 1999)
				Nissum Bredning	1980	1995	(Madsen, Cracknell et al. 1999)
				Nissum Fjord	1980	1995	(Madsen, Cracknell et al. 1999)
			Germany	West Germany	1963	1975	(Ogilvie and Joseph 1976) sourced from (NERC Centre for Population Biology 1999)
				Western Greifswalder Bodden	1979	2003	(Bendt et al. 2003)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Mexico	Mexican Wetlands: The interior Highlands, Gulf of Mexico Coast	1962	2000	(Perez-Arteaga and Gaston 2004)
			Netherlands	Netherlands	1960	1975	(Ogilvie and Joseph 1976) sourced from (NERC Centre for Population Biology 1999)
			Russian Federation	Taimyr peninsula, Russian Federation	1955	2006	Confidential data source
			Svalbard And Jan Mayen	Svalbard breeding population	1981	1995	(Clausen et al. 1998)
			United States	Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1994	2009	(Fischer, Stehn et al. 2009)
				Yukon-Kuskokwim Delta, Alaska, USA	1964	1993	(Hupp, Stehn et al. 1995)
	Branta bernicla	Light-bellied brent goose / Dark-bellied brent goose	Canada	Fraser river delta, British Columbia	1999	2000	(Hagmeier et al. 2008)
				Qualicum Bay and Parksville area, British Columbia	1999	2000	(Hagmeier, Smith et al. 2008)
			Denmark	Danish Wadden Sea between Blåvand and the German border (Dark-bellied brent goose population)	1987	2009	(Laursen and Frikke 2013)
				Danish Wadden Sea between Blåvand and the German border (Light-bellied brent goose population)	1986	2008	(Laursen and Frikke 2013)
			Germany	Wadden Sea in Niedersachsen and Hamburg	1987	2007	(Laursen et al. 2010)
				Wadden Sea in Schleswig-Holstein	1987	2007	(Laursen, Blew et al. 2010)
			Japan	Japan	1970	1995	(Lane et al. 1997)
			Netherlands	The Netherlands	1976	2010	(Hornman et al. 2012)
			United Kingdom, Ireland	Britain, Ireland (Dark-bellied brent goose population)	1959	2007	(Mitchell, Colhoun et al. 2010)
				Britain, Ireland (Light-bellied brent goose, East Canadian High Arctic population)	1960	2008	(Mitchell, Colhoun et al. 2010)
				Britain, Ireland (Light-bellied brent goose, Svalbard population)	1959	2007	(Mitchell, Colhoun et al. 2010)
			United States	Atlantic flyway population wintering along the US coast from Massachusetts to North Carolina	1961	2013	(Canadian Wildlife Service Waterfowl Committee 2013)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United States, Mexico	Winter population along the US Pacific flyway and Mexico	1972	2010	(U.S. Fish and Wildlife Service 2013)
	Branta canadensis	Canada goose	Mexico	Mexican Wetlands: The interior Highlands, Gulf of Mexico Coast	1961	2000	(Perez-Arteaga and Gaston 2004)
			United States, Canada	Pacific Flyway	1953	1993	(Hupp, Stehn et al. 1995)
	Branta hutchinsii	Cackling goose	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			United States	Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1985	2009	(Fischer, Stehn et al. 2009)
	Branta leucopsis	Barnacle goose / Greenland barnacle goose	Denmark	Denmark, Wadden Sea	1987	2008	(JMMB 2010)
				Skjern River Valley restoration area, Central Jutland Region	2002	2005	(Bregnballe, Amstrup et al. 2009)
			Estonia	Estonia	1970	1996	(Madsen, Cracknell et al. 1999)
			Finland	Finland	1985	1995	(Väisänen et al. 1998)
			Germany	Niedersachsen/Hamburg, Wadden Sea	1987	2008	(JMMB 2010)
				State of Nordrhein-Westfalen	1997	2003	(Wille, Doer et al. 2007)
				Wadden Sea in Schleswig-Holstein	1987	2007	(Laursen, Blew et al. 2010)
			Greenland	East Greenland	1959	1996	(Scott and Rose 1996)
			Ireland	Ireland	1959	2007	(Mitchell et al. 2008)
			Netherlands	The Netherlands	1981	1984	(Ebbinge, van der Bergh et al. 1986)
				Wadden sea, Netherlands	1987	2008	(JMMB 2010)
			Norway	Lånan/Flovær archipelago in the Helgeland region	1976	1983	(Gullestad et al. 1983)
			Poland	Wielkopolska region	2000	2009	(Wylegała and Krąkowski 2010)
			Russian Federation	Kolguev Island, Russia	1995	2008	(Kondratiev 2008)
				Russian and Baltic	1972	1996	(Ebbinge 1987)
			Svalbard And Jan Mayen	Svalbard	1950	1993	(Scott and Rose 1996)
			United Kingdom	Islay, Scotland	1987	2010	(Crabtree et al. 2010) (Wildfowl & Wetlands Trust 2011)
				Solway Firth, UK	1959	2010	(Crabtree, Humphreys et al. 2010)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
	Branta ruficollis	Red-breasted goose	Bulgaria	Shabla Lake and Lake Durankulak	1939	2006	(Hunter et al. 1996)
			Romania	Romania	1994	2009	(Barov et al. 2011)
				Romania (primarily the Black Sea coast)	1967	1996	(Madsen, Cracknell et al. 1999)
			Russian Federation	Taimyr Peninsula	1956	2007	Confidential data source
			Ukraine	Ukraine	1994	2009	(Barov and Derhé 2011)
				Ukraine (primarily the Black Sea coast)	1988	1996	(Madsen, Cracknell et al. 1999)
	Bucephala clangula	Common goldeneye	Denmark, Norway, Sweden, Germany, Poland	Baltic / Nordic	1974	2002	(Wetlands International 2002)
			Spain, France, Italy, Morocco, Tunisia	West Mediterranean	1975	1995	(Wetlands International 2002)
			Turkey, Greece, Ukraine, Bulgaria, Romania	Black Sea / East Mediterranean	1990	1995	(Wetlands International 2002)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Bucephala islandica	Barrow's goldeneye	Iceland	Lake Myvatn, Iceland	1962	2004	(Einersson 2004)
			United States, Canada	United States and Canada	1968	2011	(Sauer, Hines et al. 2012)
	Chen caerulescens	Greater snow goose / Lesser snow goose	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Hudson Bay	1964	1979	(Boyd et al. 1982) sourced from (NERC Centre for Population Biology 1999)
				La Perouse Bay, Manitoba	1970	1987	(Cooch et al. 1991) sourced from (NERC Centre for Population Biology 1999)
				St. Lawrence River Valley spring staging area, Quebec	1965	2013	(Canadian Wildlife Service Waterfowl Committee 2013)
			Russian Federation	Wrangel Island	1969	2005	(Kraege et al. 2008)
			United States	Central and South US (Texas, Oklahoma, Kansas, Nebraska, Iowa, Missouri, Arkansas, and Louisiana)	1950	1994	(Alisauskas 1998)
	Chen canagica	Emperor goose	United States	Jacksmith Bay to Canoe Bay, southwest Alaska	1981	2010	(Mallek et al. 2011)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
	Branta ruficollis	Red-breasted goose	Bulgaria	Shabla Lake and Lake Durankulak	1939	2006	(Hunter et al. 1996)
			Romania	Romania	1994	2009	(Barov et al. 2011)
				Romania (primarily the Black Sea coast)	1967	1996	(Madsen, Cracknell et al. 1999)
			Russian Federation	Taimyr Peninsula	1956	2007	Confidential data source
			Ukraine	Ukraine	1994	2009	(Barov and Derhé 2011)
				Ukraine (primarily the Black Sea coast)	1988	1996	(Madsen, Cracknell et al. 1999)
	Bucephala clangula	Common goldeneye	Denmark, Norway, Sweden, Germany, Poland	Baltic / Nordic	1974	2002	(Wetlands International 2002)
			Spain, France, Italy, Morocco, Tunisia	West Mediterranean	1975	1995	(Wetlands International 2002)
			Turkey, Greece, Ukraine, Bulgaria, Romania	Black Sea / East Mediterranean	1990	1995	(Wetlands International 2002)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Bucephala islandica	Barrow's goldeneye	Iceland	Lake Myvatn, Iceland	1962	2004	(Einersson 2004)
			United States, Canada	United States and Canada	1968	2011	(Sauer, Hines et al. 2012)
	Chen caerulescens	Greater snow goose / Lesser snow goose	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Hudson Bay	1964	1979	(Boyd et al. 1982) sourced from (NERC Centre for Population Biology 1999)
				La Perouse Bay, Manitoba	1970	1987	(Cooch et al. 1991) sourced from (NERC Centre for Population Biology 1999)
				St. Lawrence River Valley spring staging area, Quebec	1965	2013	(Canadian Wildlife Service Waterfowl Committee 2013)
			Russian Federation	Wrangel Island	1969	2005	(Kraege et al. 2008)
			United States	Central and South US (Texas, Oklahoma, Kansas, Nebraska, Iowa, Missouri, Arkansas, and Louisiana)	1950	1994	(Alisauskas 1998)
	Chen canagica	Emperor goose	United States	Jacksmith Bay to Canoe Bay, southwest Alaska	1981	2010	(Mallek et al. 2011)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
	Branta ruficollis	Red-breasted goose	Bulgaria	Shabla Lake and Lake Durankulak	1939	2006	(Hunter et al. 1996)
			Romania	Romania	1994	2009	(Barov et al. 2011)
				Romania (primarily the Black Sea coast)	1967	1996	(Madsen, Cracknell et al. 1999)
			Russian Federation	Taimyr Peninsula	1956	2007	Confidential data source
			Ukraine	Ukraine	1994	2009	(Barov and Derhé 2011)
				Ukraine (primarily the Black Sea coast)	1988	1996	(Madsen, Cracknell et al. 1999)
	Bucephala clangula	Common goldeneye	Denmark, Norway, Sweden, Germany, Poland	Baltic / Nordic	1974	2002	(Wetlands International 2002)
			Spain, France, Italy, Morocco, Tunisia	West Mediterranean	1975	1995	(Wetlands International 2002)
			Turkey, Greece, Ukraine, Bulgaria, Romania	Black Sea / East Mediterranean	1990	1995	(Wetlands International 2002)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Bucephala islandica	Barrow's goldeneye	Iceland	Lake Myvatn, Iceland	1962	2004	(Einersson 2004)
			United States, Canada	United States and Canada	1968	2011	(Sauer, Hines et al. 2012)
	Chen caerulescens	Greater snow goose / Lesser snow goose	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Hudson Bay	1964	1979	(Boyd et al. 1982) sourced from (NERC Centre for Population Biology 1999)
				La Perouse Bay, Manitoba	1970	1987	(Cooch et al. 1991) sourced from (NERC Centre for Population Biology 1999)
				St. Lawrence River Valley spring staging area, Quebec	1965	2013	(Canadian Wildlife Service Waterfowl Committee 2013)
			Russian Federation	Wrangel Island	1969	2005	(Kraege et al. 2008)
			United States	Central and South US (Texas, Oklahoma, Kansas, Nebraska, Iowa, Missouri, Arkansas, and Louisiana)	1950	1994	(Alisauskas 1998)
	Chen canagica	Emperor goose	United States	Jacksmith Bay to Canoe Bay, southwest Alaska	1981	2010	(Mallek et al. 2011)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Yukon-Kuskokwim Delta, Alaska, USA	1979	1993	(Hupp, Stehn et al. 1995)
	Chen rossii	Ross's goose	Mexico	Mexican Interior Highlands	1998	1999	(Drewien et al. 2003)
			United States	7 sites along the Texan coast	1968	1970	(Prevett et al. 1972)
				Kansas, Missouri, Oklahoma, Iowa, Illinois, Indiana, Kentucky, Alabama and New Mexico	1968	1970	(Prevett and C.D. 1972)
	Clangula hyemalis	Long-tailed duck	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	1998	2007	(Cadieux et al. 2008)
				Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			Estonia	Estonian Baltic Coast	1993	2008	(Skov, Heinänen et al. 2011)
			Finland	Söderskär Island, Gulf of Finland	1968	2008	(Aunins et al. 2013)
			Germany	Mecklenburg-Vorpommern	1992	2001	(Garthe et al. 2003)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Latvia	Latvian coast	1968	1997	(Pihl et al. 1999)
			Lithuania	Curonian Lagoon	1987	1999	(Švažas et al. 2001)
			Poland	Polish Central Baltic Coast	1987	2008	(Skov, Heinänen et al. 2011)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Slovakia	Slovakia	1991	2010	(Slabeyová, Ridzoň et al. 2011)
			Sweden	Blekinge archipelago, southeast Sweden	1971	2011	(Nilsson 2012)
				North Öland	1970	2011	(Nilsson 2012)
				South coast of Scania	1971	2011	(Nilsson 2012)
				Swedish Kattegat coast	1987	2008	(Skov, Heinänen et al. 2011)
				Väddö, Stockholm County	1971	2010	(Nilsson 2012)
			United Kingdom	Moray Firth, Scotland	1998	2003	(Kalejta-Summers and Butterfield 2006)
	Cygnus columbianus	Tundra swan / Bewick's swan	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Long Point, Lake Eerie, Ontario	1971	1999	(Petrie et al. 2002)
			China	Dongting Lake, Hunan province	2004	2010	(Cong et al. 2011)
				Yangtze estuary	1986	2008	Confidential data source
				Yangtze River floodplain in Anhui province	2004	2010	(Cong, Cao et al. 2011)
				Yangtze River floodplain in Jianxi province	2004	2010	(Cong, Cao et al. 2011)
			Denmark	Bornholm	1993	2006	(Dansk Ornitologisk Forening 2007)
				Tipperne	1976	2005	(Meltofte et al. 2011)
			France, United Kingdom, Norway, Germany, Iceland	North West Europe (formerly Europe in old record)	1974	2002	(Wetlands International 2002)
			Iran, Islamic Republic Of	Iran	1968	2006	(Amini et al. 2007)
			Ireland	Republic of Ireland	1984	2005	(Worden et al. 2006)
			Japan	Japan	1986	1999	(Albertsen et al. 2002)
			Korea, Republic Of	Selected monitoring sites on the South Coast, West Coast and Inland Korea	2001	2012	(Birds Korea 2013)
			Netherlands	The Netherlands	1976	2010	(Hornman, van Roomen et al. 2012)
			Russian Federation	Kolguev Island, Russia	1995	2008	(Kondratiev 2008)
				Russian Arctic between Kanin and West Taimyr	1973	2004	Confidential data source
			United States	Eastern population wintering along the Atlantic and Mississippi flyway	1957	2006	(Ad Hoc Eastern Population Tundra Swan Committee 2007)
				Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1985	2009	(Fischer, Stehn et al. 2009)
	Cygnus cygnus	Whooper swan	Austria, Czech Republic, Estonia, Hungary, Poland	Central Europe (Continental Europe in old record)	1974	2002	(Wetlands International 2002)
			Russian Federation, Norway, Sweden, Finland	Scandinavia and European Russia	1973	2000	Confidential data source

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United Kingdom	Northwest Europe (formerly UK and Ireland in old record)	1974	2002	(Wetlands International 2002)
	Histrionicus histrionicus	Harlequin duck	Canada	Hornby Island, northern Strait of Georgia, British Columbia	1996	2001	(Rodway et al. 2003)
	Melanitta americana	Black scoter / American scoter	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
	Melanitta fusca	Velvet scoter	Germany	Mecklenburg-Vorpommern	1992	2001	(Garthe, Ullrich et al. 2003)
	Melanitta nigra	Common scoter / Black scoter	Belgium	Coast of Belgium	1987	1995	(Pihl and Fox 1999)
			Estonia	Estonian Baltic Coast	1993	2008	(Skov, Heinänen et al. 2011)
			Germany	Mecklenburg-Vorpommern	1993	2001	(Garthe, Ullrich et al. 2003)
			Poland	Polish Baltic Coast	2009	2011	(Kajzer et al. 2012)
				Polish Central Baltic Coast	1987	2008	(Skov, Heinänen et al. 2011)
			Spain	Delta del Ebro, Spain	1974	2008	(Galewski 2008)
				Doñana, Spain	2002	2008	(Reserva Biológica de Doñana 2008)
			Sweden	Swedish Central Baltic Coast	1987	2008	(Skov, Heinänen et al. 2011)
				Swedish Kattegat coast	1987	2008	(Skov, Heinänen et al. 2011)
	Mergus serrator	Red-breasted merganser	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			Denmark, Norway, Sweden, Germany, Poland	Baltic / Nordic	1974	2002	(Wetlands International 2002)
			Estonia	Estonian Baltic Coast	1987	2008	(Skov, Heinänen et al. 2011)
			France, United Kingdom, Norway, Germany, Iceland	North West Europe	1974	2002	(Wetlands International 2002)
			Ireland	Republic of Ireland	1995	2001	(Colhoun 2001)
			Korea, Republic Of	Selected monitoring sites on the East Coast, South Coast, West Coast and Jeju Island	2001	2012	(Birds Korea 2013)
			Netherlands	The Netherlands	1976	2010	(Hornman, van Roomen et al. 2012)
			Russian Federation	Northern archipelago, Kandalaksha	1969	2001	(Bianki et al. 2004)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				White Sea	1958	1989	(Anker-Nilssen, Bakken et al. 2000)
			Spain, France, Italy, Morocco, Tunisia	West Mediterranean	1979	2002	(Wetlands International 2002)
			Turkey, Greece, Ukraine, Bulgaria, Romania	Black Sea / East Mediterranean	1990	1995	(Wetlands International 2002)
	Polysticta stelleri	Steller's eider	Åland Islands	Lågskär, Åland Islands	1968	2003	(Nygård et al. 1995) updated with (Žydelis et al. 2006)
			Estonia	Estonian coast (primarily Saaremaa Island)	1983	2003	(Nygård, Frantzen et al. 1995) updated with (Žydelis, Lorentsen et al. 2006)
			Lithuania	Coastal wetlands near Palanga	1987	2003	(Švažas, Dagys et al. 2001) updated with (Žydelis, Lorentsen et al. 2006)
			Russian Federation	Taimyr Peninsula	1993	2005	(Ebbinge and Mazurov 2006)
	Somateria mollissima	Common eider	Estonia	Estonian Baltic Coast	1993	2008	(Skov, Heinänen et al. 2011)
			Germany	Mecklenburg-Vorpommern	1992	2001	(Garthe, Ullrich et al. 2003)
			Greenland	15 colonies in Ilulissat and Upernavik	1963	2000	(Merkel 2004)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Netherlands	The Netherlands	1987	2002	(Desholm et al. 2002)
			Norway	Glomsteinskjær, Nøtterøy, Vestfold	1990	1998	(Fylkesmannen i Vestfold 2004)
				Hellesholmen m. Kråkene, Nøtterøy, Vestfold	1992	2000	(Fylkesmannen i Vestfold 2004)
				Hoftøya, Tjøme, Vestfold	1991	2000	(Fylkesmannen i Vestfold 2004)
				Knappen, Tjøme, Vestfold	1993	2000	(Fylkesmannen i Vestfold 2004)
				Kvitskjærene, Tjøme, Vestfold	1992	2000	(Fylkesmannen i Vestfold 2004)
				Langøya, Tjøme, Vestfold	1992	1999	(Fylkesmannen i Vestfold 2004)
				Leistein, Tjøme, Vestfold	1992	2000	(Fylkesmannen i Vestfold 2004)
				Rønneskjærene, Nøtterøy, Vestfold	1992	1999	(Fylkesmannen i Vestfold 2004)
				Saltbuskjær, Tjøme, Vestfold	1991	1997	(Fylkesmannen i Vestfold 2004)
				Selskjærene, Nøtterøy, Vestfold	1992	1999	(Fylkesmannen i Vestfold 2004)
				Store Rauer, Nøtterøy, Vestfold	1990	2000	(Fylkesmannen i Vestfold 2004)
				Tangenkilen, Tjøme, Vestfold	1990	2000	(Fylkesmannen i Vestfold 2004)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Tova, Nøtterøy, Vestfold	1995	2000	(Fylkesmannen i Vestfold 2004)
			Sweden	Kåseberga, Skåne County	1992	2000	(Desholm, Christensen et al. 2002)
			United States	Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1985	2009	(Fischer, Stehn et al. 2009)
	Somateria spectabilis	King eider	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	1998	2007	(Cadieux, Gauthier et al. 2008)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
Charadriidae	*Charadrius hiaticula*	Common ringed plover / Ringed plover	Belgium	The Belgian North Sea coastline	1976	2000	(Devos 2008)
			Canada	Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	2006	2007	(Cadieux, Gauthier et al. 2008)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2008	(Laursen and Frikke 2013)
			France	Granville to Cancale, Mont Saint-Michel Bay	1992	1993	(Le Drean-Quenec'hdu et al. 1995)
			Ghana	Keta Lagoon Complex, Salt Pans, Ghana	1997	1998	(Dodman, Beibro et al. 1998) and (Dodman, de Vaan et al. 1997)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman et al. 2005)
			Ireland	Republic of Ireland	1995	2001	(Colhoun 2001)
			Jordan	Jordan	2002	2012	(Qaneer et al. 2013)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts et al. 1997)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Netherlands	The Netherlands	1976	2010	(Hornman, van Roomen et al. 2012)
			Portugal	Aveiro, Tejo, Sado and Faro estuaries	1976	1989	(Rufino 1990)
			Russian Federation	Taimyr Peninsula	1993	2005	(Ebbinge and Mazurov 2006)
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet et al. 1998)
			Spain	Delta del Ebro, Spain	1973	2008	(Galewski 2008)
				Paisaje Protegido del Humedal del Ajauque y Rambla Salada, Murcia, Spain	1994	1997	(Herrero 2006)
	Charadrius mongolus	Lesser sand plover	Australia	Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton et al. 2012)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
	Charadrius semipalmatus	Semipalmated plover	Brazil	Coroa do Avião, Igarassu, Pernambuco State	1993	1996	(Telino-Júnior et al. 2003)
				Piaçabuçu Protection Area, Alagoas, Brazil	2004	2005	(Cabral et al. 2006)
				Saco da Fazenda, Rio Itajaí-Açú estuary, Santa Catarina state, Southern Brazil	1996	2005	(Branco 2007)
			Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			United States	Western portion of Isla Vista, Santa Barbara County, California	1995	2000	(Hubbard et al. 2002)
				Willapa Bay, Washington	1991	1994	(Buchanan et al. 1997)
	Eudromias morinellus	Eurasian dotterel / dotterel	Denmark	Denmark	1981	1999	(Østergaard 2001)
			Germany	Schleswig-Holstein	1960	2000	(Busche 2007)
			Russian Federation	Taimyr Peninsula	1993	2005	(Ebbinge and Mazurov 2006)
	Pluvialis apricaria	Eurasian golden plover	Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Skjern River restoration area, Central Jutland Region	2002	2005	(Bregnballe, Amstrup et al. 2009)
			Germany	Schleswig-Holstein, Wadden Sea	1988	1999	(Günther et al. 2000)
			Greece	Messolonghi Lagoons wetland complex, Aitoloakarnania Prefecture	1982	2012	(Liordos et al. 2014)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
			Norway, Finland, Sweden	Europe- FI, NO, SE	1981	2011	Confidential data source
			Spain	Delta del Ebro, Spain	1973	2008	(Galewski 2008)
				Delta del Llobregat, Catalunya, Spain	1999	2006	(Galewski 2008)
	Pluvialis dominica	Lesser golden plover / American golden plover	Argentina	Around 110 sites across Argentina	1995	1999	(Blanco et al. 2001)
				Around 60 sites across Argentina	2000	2004	(López-Lanús et al. 2005)
			Brazil	Saco da Fazenda, Rio Itajaí-Açú estuary, Santa Catarina state, Southern Brazil	2000	2005	(Branco 2007)
			Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	2005	2007	(Cadieux, Gauthier et al. 2008)
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
	Pluvialis fulva	Pacific golden plover	Australia	200km of coast between Airlie Beach and Cape Palmerston, Mackay region, Queensland	2002	2010	(QWSG 2011)
				Bush Point, Roebuck Bay, Western Australia	2004	2010	(Singor 2012)
				Cape Portland, north-east Tasmania	1981	2011	(Cooper et al. 2012)
				Eighty Mile Beach, Western Australia	2004	2010	(Singor 2012)
				Five sites in the south of Victoria	1981	1999	(Wilson 2001)
				George Town Reserve, George Town, north-east Tasmania	1974	2011	(Cooper, Clemens et al. 2012)
				Port Stephens, New South Wales	2004	2011	(Stuart 2011)
				Roebuck Bay, Western Australia	2004	2010	(Singor 2012)
				The Coorong, South Australia	1981	2008	(Wainwright et al. 2008)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Tweed River Estuary, New South Wales	1987	2003	(Rohweder 2007)
			India	Chilika lagoon, east coast of Orissa	2001	2003	(Nayak 2006)
			Japan	Okubo rice field, Saitama Prefecture	1984	1988	(Watanabe 1991)
			Malaysia	Intertidal mudflat at Kapar	2001	2002	(Riak et al. 2003)
			New Zealand	Numerous coastal locations in New Zealand	1994	2003	(Southey 2009)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Singapore	Sungei Buloh Wetland Reserve, northwest sector of Singapore	2000	2012	(NPARKS 2014)
			United States	Yukon Delta National Wildlife Refuge, Alaska	1988	1991	(McCaffery 1996)
	Pluvialis squatarola	Grey plover / Black-bellied plover	Australia	Bush Point, Roebuck Bay, Western Australia	2004	2008	(Rogers et al. 2009)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Eighty Mile Beach, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Northern beaches in Roebuck Bay, Western Australia	2001	2008	(Rogers, Hassell et al. 2009)
				Pelican Point, Matilda Bay Reserve, Western Australia	1972	2007	(Creed et al. 2009)
			Brazil	Coroa do Avião, Igarassu, Pernambuco State	1993	1996	(Telino-Júnior, de Azevedo-Júnior et al. 2003)
				Piaçabuçu Protection Area, Alagoas, Brazil	2004	2005	(Cabral, Azevedo Júnior et al. 2006)
			Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	2005	2007	(Cadieux, Gauthier et al. 2008)
				Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			China	Yalu Jiang National Nature Reserve, northeast coast of the Yellow Sea	1999	2006	(Riegen et al. 2006)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			France	Granville to Cancale, Mont Saint-Michel Bay	1981	1993	(Le Drean-Quenec'hdu, Mahéo et al. 1995)
			Greece	Messolonghi Lagoons wetland complex, Aitoloakarnania Prefecture	1982	2012	(Liordos, Pergantis et al. 2014)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			Ireland	Republic of Ireland	1995	2001	(Colhoun 2001)
			Japan	1000 sites around Japan	2004	2013	(Zöckler 2013)
			Korea, Republic Of	Selected monitoring sites on the West Coast	2000	2012	(Birds Korea 2013)
			Malaysia	Intertidal mudflat at Kapar	2001	2002	(Riak, Ismail et al. 2003)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Mozambique	Inhaca Island	1995	1997	(Oschadleus et al. 2004)
			Netherlands	The Netherlands	1976	2010	(Hornman, van Roomen et al. 2012)
			Portugal	Aveiro, Tejo, Sado and Faro estuaries	1976	1989	(Rufino 1990)
			Russian Federation	Kolguev Island, Russia	1995	2008	(Kondratiev 2008)
				Taimyr Peninsula	1994	2008	Confidential data source
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			South Africa	Knysna Estuary between The Heads and Red Bridge, Western Cape	1993	1998	(Martin et al. 2000)
				Langebaan Lagoon	1976	2003	(Harebottle et al. 2006)
			Spain	Delta del Ebro, Spain	1973	2008	(Galewski 2008)
			Turkey, Greece, Ukraine, Bulgaria, Romania	East Mediterranean	1989	2000	(Galewski 2008)
			United Kingdom	British coastline	1971	1991	(Prys-Jones et al. 1994) sourced from (NERC Centre for Population Biology 1999)
			United States	The Central Valley, California	1993	1995	(Shuford et al. 1998)
				The Outer Banks, North Carolina	1992	1993	(Dinsmore et al. 1998)
				Western portion of Isla Vista, Santa Barbara County, California	1995	2000	(Hubbard and Dugan 2002)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
Emberizidae	*Calcarius lapponicus*	Lapland longspur / Lapland bunting	Canada	South and North Arctic ecozone, Northern Canada	1966	2005	Confidential data source
			Korea, Republic Of	Selected monitoring sites on the South Coast and West Coast	2001	2012	(Birds Korea 2013)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
	Emberiza pusilla	Little bunting	Korea, Republic Of	West Coast	2000	2013	(Birds Korea 2013)
	Emberiza schoeniclus	Reed bunting	Sweden	Sweden	1960	1980	(Österlöf et al. 1982) sourced from (NERC Centre for Population Biology 1999)
	Passerculus sandwichensis	Savannah sparrow	United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Passerella iliaca	Fox sparrow	United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Plectrophenax nivalis	Snow bunting	Canada	South and North Arctic ecozone, Northern Canada	1966	2005	Confidential data source
			Germany	Helgoland	1990	1999	(Dierschke 2001)
				Rickelsbüller and Beltringharder Koog, Schleswig-Holstein	1990	1999	(Dierschke 2001)
				Wadden Sea islands, Niedersachsen	1992	1997	(Dierschke 2001)
				Wadden Sea mainland coast, Niedersachsen	1992	1997	(Dierschke 2001)
				Wadden Sea mainland coast, Schleswig-Holstein	1990	1999	(Dierschke 2001)
			Greenland	Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			United Kingdom	Caithness, Scotland	1976	1989	(Banks et al. 1991)
				Leicestershire	1959	1984	(Mason 1989)
	Spizella arborea	American tree sparrow	Canada	Canada	1975	2011	(Environment Canada 2013)
	Zonotrichia leucophrys	White-crowned sparrow	United States, Canada	United States and Canada	1967	2011	(Sauer, Hines et al. 2012)
Falconidae	*Falco columbarius*	Merlin	Spain	Delta del Ebro, Spain	1994	2008	(Galewski 2008)
	Falco peregrinus	Peregrine falcon	Canada	North Yukon (coastal plain)	1973	2005	(Mossop 2005)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Northern Alberta, Canada	1970	2000	(Banasch et al. 2004) updated with (Holroyd et al. 2003)
				Ontario, Canada	1965	2000	(Banasch and Holroyd 2004) updated with (Holroyd and Banasch 2003)
				Peel River, Yukon Territory, Canada	1990	2000	(Banasch and Holroyd 2004) updated with (Holroyd and Banasch 2003)
				Porcupine River, Yukon Territory, Canada	1990	2000	(Banasch and Holroyd 2004) updated with (Holroyd and Banasch 2003)
			Russian Federation	Agapa River Valley, Taimyr	2000	2007	(Kharitonov, Egerova et al. 2007)
			Spain	Delta del Ebro, Spain	1992	2008	(Galewski 2008)
			United States	Colville River area, Alaska	1951	1985	(Mindell, Albuquerque et al. 1987) sourced from (NERC Centre for Population Biology 1999)
				Upper Yukon River area, Alaska	1951	1985	(Mindell, Albuquerque et al. 1987) sourced from (NERC Centre for Population Biology 1999)
	Falco rusticolus	Gyrfalcon	Canada	Yukon North Slope	1976	1990	(Yukon Government 2009)
			Sweden	Padjelanta, Sarek and Stora Sjöfallet National Parks in Norrbotten County, Northern Sweden	1996	2002	(Nyström et al. 2005)
			United States	Colville River area, Alaska	1959	1985	(Mindell, Albuquerque et al. 1987) sourced from (NERC Centre for Population Biology 1999)
Fringillidae	*Carduelis flammea*	Hoary redpoll / Arctic redpoll / Common redpoll	Canada	South and North Arctic ecozone, Northern Canada	1966	2005	Confidential data source
			Greenland	Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Russian Federation	Europe - AT, BE, DK, CZ, FI, FR, DE, HU, IE, IT, LV, NL, PL, ES, SE, GB, NO, CH	1980	2011	Confidential data source
Gaviidae	*Gavia adamsii*	Yellow-billed loon	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			United States	Late survey area (inside early study area), north slope of Alaska north of Brooks range, between Point Lay and Kaktovik	1992	2003	(Earnst et al. 2005)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Late survey area (outside early study area), north slope of Alaska north of Brooks range, between Point Lay and Kaktovik	1992	2003	(Earnst, Stehn et al. 2005)
	Gavia arctica	Arctic loon / Black-throated diver	Austria	Austria	1970	1995	(Aubrecht and Winkler 1997)
			Denmark	Bornholm	2003	2006	(Dansk Ornitologisk Forening 2007)
			Italy	Circeo National Park, Laghi Pontini, Central Italy	1981	2000	(Corbi 2003)
			Korea, Republic Of	Selected monitoring sites on the East Coast and Jeju	2000	2013	(Birds Korea 2013)
			Norway	Pasvik naturreservat, Sør-Varanger, Finnmark	1996	2005	(Günther 2003) updated with (Günther 2006)
	Gavia immer	Common loon / Great northern diver	Ireland	Blacksod Bay, County Mayo	2002	2010	(Suddaby 2010)
				Broadhaven Bay, County Mayo	2005	2010	(Suddaby 2010)
			Spain	Coast of Galicia	1994	2010	(De Souza et al. 2010)
				Delta del Ebro, Spain	1987	2008	(Galewski 2008)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Gavia pacifica	Pacific loon	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			Korea, Republic Of	Selected monitoring sites on the East Coast, Jeju and the South Coast	2000	2013	(Birds Korea 2013)
			United States	Alaska-Yukon Delta, Alaska	1971	1993	(Groves et al. 1996)
				Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1994	2009	(Fischer, Stehn et al. 2009)
				Shelf-slope between Point Conception and San Diego, southern California	1975	1977	(Briggs et al. 1987)
				Shelf-slope between Santa Rosa and Point Conception, central California	1980	1982	(Briggs, Tyler et al. 1987)
				Shelf-slope between the Canadian border and Santa Rosa, northern California	1980	1982	(Briggs, Tyler et al. 1987)
	Gavia stellata	Red-throated loon	Austria	Austria	1970	1995	(Aubrecht and Winkler 1997)
			Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Denmark	Bornholm	1997	2006	(Dansk Ornitologisk Forening 2007)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Korea, Republic Of	Selected monitoring sites on the East Coast, Jeju and the South Coast	2000	2013	(Birds Korea 2013)
			Sweden	Scania coast, southern Sweden	1974	2003	(Nilsson 2005)
			United Kingdom	Cardigan Bay	2002	2004	(O'Brian et al. 2008)
				Survey block TH1 (Clacton-on-Sea to Herne Bay), Greater Thames	2002	2006	(O'Brian, Wilson et al. 2008)
				Survey blocks GW3 to GW6 (Maplethorpe to Great Yarmouth), Greater Wash	2002	2006	(O'Brian, Wilson et al. 2008)
				Survey blocks NW4 to NW6 (Barrow-in-Furness to Anglesey), northern England and Wales	2002	2006	(O'Brian, Wilson et al. 2008)
			United States	Alaska-Yukon Delta, Alaska	1971	1993	(Groves, Conant et al. 1996)
				Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1994	2009	(Fischer, Stehn et al. 2009)
Gruidae	*Grus canadensis*	Sandhill crane	United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Leucogeranus leucogeranus	Siberian crane	China	Poyang Lake	1984	2001	(Fang, Wang et al. 2006)
			China	Poyang Lakes	2000	2010	(Shan et al. 2012)
Hirundinidae	*Petrochelidon pyrrhonota*	Cliff swallow	United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Riparia riparia	Sand martin	United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
Laridae	*Larus argentatus*	Herring gull	Russian Federation	Agapa River Valley, Taimyr	2004	2007	(Kharitonov, Egerova et al. 2007)
				Seven islands, Murmansk	1929	1993	(Krasnov, Matishov et al. 1995)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Larus canus	Mew gull	Iceland	Eyjafjorour fjord area, North Iceland	1980	2000	(Petersen et al. 2004)
			Norway	Pasvik naturreservat, Sør-Varanger, Finnmark	1996	2003	(Günther 2003)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Russian Federation	Bolshoi Ainov, Murmansk	1928	1989	(Krasnov, Matishov et al. 1995)
				Seven Islands, Murmansk	1929	1993	(Krasnov, Matishov et al. 1995)
			United States	Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1985	2009	(Fischer, Stehn et al. 2009)
	Larus hyperboreus	Glaucous gull	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	1997	2007	(Cadieux, Gauthier et al. 2008)
			Korea, Republic Of	East coast of Korea	2001	2013	(Birds Korea 2013)
			Russian Federation	Kolguev Island, Russia	1995	2008	(Kondratiev 2008)
				Vaygach Island	1967	1992	(Anker-Nilssen, Bakken et al. 2000)
			United States	Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1985	2009	(Fischer, Stehn et al. 2009)
	Larus thayeri	Thayer's gull	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Continental shelf off the coast of Vancouver Island	1986	1987	(Vermeer et al. 1989)
				Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
	Rissa tridactyla	Black-legged kittiwake	Canada	NE coast of Newfoundland	2000	2003	(Davoren 2007)
				Prince Leopold Island, Nunavut	1975	2008	Confidential data source
			Iceland	Hafnaberg, South-West Iceland	1982	2005	(Garoarsson and Zocker 2006)
				Krisuvikurberg (Krisuvik), SW Iceland	1985	2005	(Garoarsson and Zocker 2006)
				Skoruvik, NE Iceland	1986	2005	(Garoarsson and Zocker 2006)
			Norway	Hjelmsøy, Måsøy, Finnmark	1991	2008	(Lorentsen and Christensen-Dalsgaard 2009)
				Hornøy, Vardø, Finnmark	1980	2008	(Lorentsen and Christensen-Dalsgaard 2009)
				Røst, Røst, Nordland	1979	2008	(Lorentsen and Christensen-Dalsgaard 2009)
				Sør-Varanger, Sør-Varanger, Finnmark	1989	2002	(Barrett 2001)
			Russian Federation	Arkhangelskaya Bay, Novaya Zemya	1967	1996	(Anker-Nilssen, Bakken et al. 2000)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Bezymyannaya bay, Novaya Zemya	1932	1992	(Anker-Nilssen, Bakken et al. 2000)
				Kharlov, Murman coast, North-West Russia	1958	1999	(Krasnov et al. 2007)
				Rubini Rock, Hooker Island, Franz Josef Land	1932	1991	(Anker-Nilssen, Bakken et al. 2000)
				Vilkitski Bay, Novaya Zemlya	1967	1992	(Anker-Nilssen, Bakken et al. 2000)
			Svalbard And Jan Mayen	Bear Island, Svalbard	1932	2000	(Anker-Nilssen, Bakken et al. 2000)
			United States	Agattu Island, Alaska	1970	2003	(Dragoo, Byrd et al. 2008)
				Bluff, Alaska	1979	2006	(Dragoo, Byrd et al. 2008), Updated with (Dragoo et al. 2009)
				Buldir Island, Alaska	1974	2005	(Dragoo, Byrd et al. 2008)
				Cape Lisburne, Alaska	1987	2006	(Dragoo, Byrd et al. 2008), Updated with (Dragoo, Byrd et al. 2009)
				Cape Peirce, Alaska	1990	2006	(Dragoo, Byrd et al. 2008), Updated with (Dragoo, Byrd et al. 2009)
				Chiniak Bay, Alaska	1975	2004	(Dragoo, Byrd et al. 2008)
				Chowiet Island, Alaska	1977	2005	(Dragoo, Byrd et al. 2008)
				Hall Island, Alaska	1983	2005	(Dragoo, Byrd et al. 2008)
				Koniuji Island, Alaska	1982	2004	(Dragoo, Byrd et al. 2008)
				Puale Bay, Alaska	1976	2002	(Dragoo, Byrd et al. 2008)
				Round Island, Alaska	1999	2003	(Dragoo, Byrd et al. 2008)
				St George Island, Alaska	1976	2005	(Dragoo, Byrd et al. 2008)
				St. Paul Island, Alaska	1976	2005	(Dragoo, Byrd et al. 2008)
	Sterna paradisaea	Arctic tern	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			Greenland	The 4 islands of Gronne Ejland	1980	2003	(Egevang et al. 2006)
			Norway	Pasvik naturreservat, Sør-Varanger, Finnmark	1996	2005	(Günther 2003) updated with (Günther 2006)
			Russian Federation	Oneshski Bay, White Sea, Russia	1960	1992	(Anker-Nilssen, Bakken et al. 2000)
				Seven Islands, Murmansk Coast, Russia	1936	1992	(Krasnov, Matishov et al. 1995)
				Taimyr Peninsula	1994	2008	Confidential data source

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United States	Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1985	2009	(Fischer, Stehn et al. 2009)
	Xema sabini	Sabine's gull	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Continental shelf off southwestern Vancouver Island	1986	1987	(Vermeer, Morgan et al. 1989)
			Senegal	Pointe des Almadies, Dakar	1995	2008	(Dubois et al. 2009)
			United States	Hazen Bay in the Yukon-Kuskokwim delta, Alaska	1985	2009	(Fischer, Stehn et al. 2009)
Motacillidae	*Anthus cervinus*	Red-throated pipit	Sweden	Rautas mountain area, northern Sweden	1978	2001	(Berg et al. 2004)
	Anthus rubescens	American pipit / Buff-bellied pipit	Canada	South and North Arctic ecozone, Northern Canada	1966	2005	Confidential data source
Muscicapidae	*Luscinia svecica*	Bluethroat	Spain	Anillamiento Station (PN Doñana)	1994	2006	(Reserva Biológica de Doñana 2008)
				Delta del Llobregat, Catalunya, Spain	1999	2006	(Galewski 2008)
			Sweden	Ammarnas, Nr Lake Stor-Tjultrasket, Swedish Lapland	1963	1982	(Enemar et al. 1984) sourced from (NERC Centre for Population Biology 1999)
	Oenanthe oenanthe	Northern wheatear	Sweden	Sweden	1975	1998	(Svensson et al. 1999)
Phalacrocoracidae	*Phalacrocorax pelagicus*	Pelagic cormorant	United States, Canada	United States and Canada	1968	2011	(Sauer, Hines et al. 2012)
Procellariidae	*Fulmarus glacialis*	Fulmar / Northern fulmar	Canada	NE coast of Newfoundland	2000	2003	(Davoren 2007)
				Prince Leopold Island, Nunavut	1980	2008	Confidential data source
			Iceland	Hafnaberg, South-West Iceland	1982	2005	(Garoarsson and Zocker 2006)
				Krisuvikurberg (Krisuvik), SW Iceland	1985	2005	(Garoarsson and Zocker 2006)
				Skoruvik, NE Iceland	1986	2005	(Garoarsson and Zocker 2006)
			Norway	Norway	1970	2000	(Birdlife International 2005)
			United States	Chowiet Island, Alaska	1976	2005	(Dragoo, Byrd et al. 2008)
				Hall Island, Alaska	1983	2005	(Dragoo, Byrd et al. 2008)
				St George Island, Alaska	1976	2005	(Dragoo, Byrd et al. 2008)
				St. Paul Island, Alaska	1976	2005	(Dragoo, Byrd et al. 2008)
Scolopacidae	*Aphriza virgata*	Surfbird	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
	Arenaria interpres	Ruddy turnstone / Turnstone	Australia	Bush Point, Roebuck Bay, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Cape Portland, north-east Tasmania	1981	2011	(Cooper, Clemens et al. 2012)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Eighty Mile Beach, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				George Town Reserve, George Town, north-east Tasmania	1974	2011	(Cooper, Clemens et al. 2012)
				Northern beaches in Roebuck Bay, Western Australia	2001	2008	(Rogers, Hassell et al. 2009)
			Brazil	Coroa do Avião, Igarassu, Pernambuco State	1993	1996	(Telino-Júnior, de Azevedo-Júnior et al. 2003)
				Piaçabuçu Protection Area, Alagoas, Brazil	2004	2005	(Cabral, Azevedo Júnior et al. 2006)
			Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)
			Germany	Schleswig-Holstein, Wadden Sea	1988	1999	(Günther and Rösner 2000)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			Ireland	Republic of Ireland	1995	2001	(Colhoun 2001)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			Mozambique	Inhaca Island	1995	1997	(Oschadleus and Lotz 2004)
			Namibia	Walvis Bay Ramsar site	1992	1998	(Dodman and Taylor 1996), (Dodman, Beibro et al. 1998), (Dodman, de Vaan et al. 1997) and (Perennou 1992)
			Netherlands	The Netherlands	1976	2010	(Hornman, van Roomen et al. 2012)
			New Zealand	Numerous coastal locations in New Zealand	1994	2003	(Southey 2009)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Portugal	Portuguese coast	2000	2010	(Lecoq et al. 2013)
			Russian Federation	Kolgeuv Island, Russia	1995	2008	(Kondratiev 2008)
				Taimyr Peninsula	1993	2005	(Ebbinge and Mazurov 2006)
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			South Africa	Langebaan Lagoon, South Africa	1976	2003	(Summers et al. 1989) updated with (Harebottle, Navarro et al. 2006)
			Spain	Delta del Ebro, Spain	1974	2008	(Galewski 2008)
			United Kingdom	British coastline	1971	1991	(Prys-Jones, Underhill et al. 1994) sourced from (NERC Centre for Population Biology 1999)
			United States	The Outer Banks, North Carolina	1992	1993	(Dinsmore, Collazo et al. 1998)
	Arenaria melanocephala	Black turnstone	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			United States	Willapa Bay, Washington	1993	1995	(Buchanan and Evenson 1997)
	Calidris acuminata	Sharp-tailed sandpiper	Australia	200km of coast between Airlie Beach and Cape Palmerston, Mackay region, Queensland	2003	2010	(QWSG 2011)
				Cape Portland, north-east Tasmania	1981	2011	(Cooper, Clemens et al. 2012)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Edithvale wetlands, Melbourne, Victoria	1990	2007	(Olsen 2008)
				Lake Bathurst and the Morass, New South Wales, Australia	1981	2003	(Olsen 2008)
				Lake McLarty, Western Australia	1982	1999	(Craig et al. 2001)
				Seaford wetlands, Melbourne, Victoria	1994	2008	(Olsen 2008)
				The Coorong, South Australia	2000	2008	(Olsen 2008)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			New Zealand	Numerous coastal locations in New Zealand	1994	2003	(Southey 2009)
	Calidris alba	Sanderling	Australia	Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Murray estuary, North lagoon, and South lagoon (The Coorong, South Australia)	2002	2008	(Murray-Darling Basin Commission 2008)
			Brazil	Coroa do Avião, Igarassu, Pernambuco State	1994	1996	(Telino-Júnior, de Azevedo-Júnior et al. 2003)
				Piaçabuçu Protection Area, Alagoas, Brazil	2004	2005	(Cabral, Azevedo Júnior et al. 2006)
			Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)
			Germany	Schleswig-Holstein, Wadden Sea	1988	1999	(Günther and Rösner 2000)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			Indonesia	Pantai Trisik, Yogyakarta	2008	2010	(Taufiqurrahman et al. 2010)
			Korea, Republic Of	Selected monitoring sites on the South Coast	1999	2012	(Birds Korea 2013)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Mozambique	Inhaca Island	1995	1997	(Oschadleus and Lotz 2004)
			Namibia	Walvis Bay Ramsar site	1992	1998	(Dodman and Taylor 1996), (Dodman, Beibro et al. 1998), (Dodman, de Vaan et al. 1997) and (Perennou 1992)
			Portugal	Portuguese coast	2000	2010	(Lecoq, Lourenço et al. 2013)
			Russian Federation	Chayvo Gulf, northeast Sakhalin	2005	2009	(Tiunov et al. 2010)
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			South Africa	Langebaan Lagoon	1976	2003	(Harebottle, Navarro et al. 2006)
			Spain	Delta del Ebro, Spain	1973	2008	(Galewski 2008)
				Doñana, Spain	2002	2008	(Reserva Biológica de Doñana 2008)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United Kingdom	British coastline	1971	1991	(Prys-Jones, Underhill et al. 1994) sourced from (NERC Centre for Population Biology 1999)
			United States	The Outer Banks, North Carolina	1992	1993	(Dinsmore, Collazo et al. 1998)
				Western portion of Isla Vista, Santa Barbara County, California	1995	2000	(Hubbard and Dugan 2002)
	Calidris alpina	Dunlin	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe, Barry et al. 2012)
			China	Yalu Jiang National Nature Reserve, northeast coast of the Yellow Sea	1999	2006	(Riegen, Vaughan et al. 2006)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)
				Skjern River Valley restoration area, Central Jutland Region	2002	2005	(Bregnballe, Amstrup et al. 2009)
			France	Granville to Cancale, Mont Saint-Michel Bay	1981	1993	(Le Drean-Quenec'hdu, Mahéo et al. 1995)
			Germany	Schleswig-Holstein, Wadden Sea	1988	1999	(Günther and Rösner 2000)
			Greece	Messolonghi Lagoons wetland complex, Aitoloakarnania Prefecture	1982	2012	(Liordos, Pergantis et al. 2014)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			India	Chilika lagoon, east coast of Orissa	2001	2003	(Nayak 2006)
			Ireland	Republic of Ireland	1995	2001	(Colhoun 2001)
			Japan	1000 sites around Japan	2004	2013	(Zöckler 2013)
			Korea, Republic Of	Selected monitoring sites on the West Coast, South Coast, Inland and Jeju Island	2000	2012	(Birds Korea 2013)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Netherlands	The Netherlands	1976	2010	(Hornman, van Roomen et al. 2012)
			Norway	Slettnes,Gamvik, Finnmark	1989	1996	(Strann 1996)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Poland	Mouth of the River Reda, Puck Bay, Gulf of Gdańsk	1996	2000	(Meissner et al. 2006)
			Portugal	Aveiro, Tejo, Sado and Faro estuaries	1976	1989	(Rufino 1990)
			Russian Federation	Kolguev Island, Russia	1995	2008	(Kondratiev 2008)
				Taimyr Peninsula	1994	2008	Confidential data source
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			Spain	Delta del Ebro, Spain	1973	2008	(Galewski 2008)
				Paisaje Protegido del Humedal del Ajauque y Rambla Salada, Murcia, Spain	1994	2002	(Herrero 2006)
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
				Willapa Bay, Washington	1992	1994	(Buchanan and Evenson 1997)
	Calidris bairdii	Baird's sandpiper	Canada	Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	2004	2007	(Cadieux, Gauthier et al. 2008)
	Calidris canutus	Knot / Red knot	Argentina	Bahía San Antonio, Río Negro	1990	2005	(Niles et al. 2007)
			Argentina, Chile	Tierra del Fuego	2005	2011	(Dey et al. 2011)
			Australia	Bush Point, Roebuck Bay, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Eighty Mile Beach, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Gulf St Vincent, South Australia	1982	2004	(Close 2008)
				Northern beaches in Roebuck Bay, Western Australia	2001	2008	(Rogers, Hassell et al. 2009)
			Brazil	Lagoa do Peixe	1995	2003	(Niles, Sitters et al. 2007)
				Saco da Fazenda, Rio Itajaí-Açú estuary, Santa Catarina state, Southern Brazil	2000	2005	(Branco 2007)
			Chile	Bahía Lomas, Tierra del Fuego	1985	2006	(Niles, Sitters et al. 2007)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)
			France	Atlantic Coast between Brest and the Spanish border	1976	2010	(Bocher et al. 2012)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				Channel Coast between Dunkirk and the Molène Archipelago	1976	2010	(Bocher, Quaintenne et al. 2012)
			Germany	Schleswig-Holstein, Wadden Sea	1988	1999	(Günther and Rösner 2000)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			India	Manali Island, Hare Island, Pillaimadam Lagoon and Dhanushkodi Lagoon in the Gulf of Mannar	1985	1987	(Balachandran 1998)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			New Zealand	Various coastal locations, including Manukau Harbour, Kaipara Harbour, Farewell Spit and Tasman Bay	1993	2012	Confidential data source
			South Africa	Langebaan Lagoon	1976	2003	(Harebottle, Navarro et al. 2006)
			Spain, Morocco, Algeria, Tunisia, France	West Mediterranean	1989	2002	(Galewski 2008)
			Turkey, Greece, Ukraine, Bulgaria, Romania	East Mediterranean	1996	2001	(Galewski 2008)
			United Kingdom	British coastline	1971	1991	(Prys-Jones, Underhill et al. 1994) sourced from (NERC Centre for Population Biology 1999)
				Burry Inlet Special Protection Area, south Wales	1991	2007	(Stillman et al. 2010)
			United States	Cape Romain National Wildlife Refuge, South Carolina	2001	2003	(Niles, Sitters et al. 2007)
				Delaware Bay	1982	2006	(Dey, Niles et al. 2011) updated with (Niles, Sitters et al. 2007)
				The Outer Banks, North Carolina	1992	1993	(Dinsmore, Collazo et al. 1998)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				West coast of Florida	2005	2009	(Dey, Niles et al. 2011)
	Calidris ferruginea	Curlew sandpiper	Australia	22 Shorebird 2020 sites across New South Wales	1981	2009	(Dawes 2011)
				Bush Point, Roebuck Bay, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Cape Portland, north-east Tasmania	1981	2011	(Cooper, Clemens et al. 2012)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Eighty Mile Beach, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				George Town Reserve, George Town, north-east Tasmania	1975	2012	(Cooper, Clemens et al. 2012)
				Lake MacLeod, Western Australia	1999	2006	(George 2009)
				Lake McLarty, Western Australia	1982	2000	(Craig, Darnell et al. 2001)
				Northern beaches in Roebuck Bay, Western Australia	2001	2008	(Rogers, Hassell et al. 2009)
				The Coorong, South Australia	2000	2008	(Olsen 2008)
				The Hobart area, Tasmania, Australia	1965	2007	(Olsen 2008)
				Western Port, Victoria, Australia	1974	2008	(Olsen 2008)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)
			Germany	Schleswig-Holstein, Wadden Sea	1988	1999	(Günther and Rösner 2000)
			Ghana	Keta Lagoon Complex, Salt Pans, Ghana	1997	1998	(Dodman, Beibro et al. 1998) and (Dodman, de Vaan et al. 1997)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			India	Chilika lagoon, east coast of Orissa	2001	2003	(Nayak 2006)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
			Mozambique	Inhaca Island	1995	1997	(Oschadleus and Lotz 2004)
			Namibia	Walvis Bay Ramsar site	1992	1998	(Dodman and Taylor 1996), (Dodman, Beibro et al. 1998), (Dodman, de Vaan et al. 1997) and (Perennou 1992)
			New Zealand	Numerous coastal locations in New Zealand	1994	2003	(Southey 2009)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			Singapore	Sungei Buloh Wetland Reserve, northwest sector of Singapore	2000	2012	(NPARKS 2014)
			South Africa	Knysna Estuary between The Heads and Red Bridge, Western Cape	1993	1998	(Martin, von Korff et al. 2000)
				Langebaan Lagoon	1976	2003	(Harebottle et al. 2006)
	Calidris fuscicollis	White-rumped sandpiper	Argentina	110 sites across Argentina	1995	2009	(Blanco and Carbonell 2001) updated with (López-Lanús and Blanco 2005) and (Serra 2010)
			Canada	Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	2005	2007	(Cadieux, Gauthier et al. 2008)
	Calidris himantopus	Stilt sandpiper	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
	Calidris maritima	Purple sandpiper	Finland	Finland	1980	1991	(Väisänen, Lammi et al. 1998)
			Germany, Netherlands, Denmark	Wadden Sea	1980	1990	(Meltofte et al. 1994)
			United Kingdom	Moray Firth, Scotland	1987	2009	(Summers et al. 2012)
	Calidris mauri	Western sandpiper	United States	The Central Valley, California	1992	1994	(Shuford, Page et al. 1998)
				Western portion of Isla Vista, Santa Barbara County, California	1995	2000	(Hubbard and Dugan 2002)
				Willapa Bay, Washington	1991	1994	(Buchanan and Evenson 1997)
	Calidris melanotos	Pectoral sandpiper	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Rasmussen Lowlands at the eastern side of Rasmussen Basin, central Canadian Arctic	1975	1995	(Gratto-Trevor et al. 1998)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	2006	2007	(Cadieux, Gauthier et al. 2008)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United States	Bald Knob National Wildlife Refuge, eastern Arkansas	2001	2002	(Lehnen et al. 2005)
				Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
	Calidris minuta	Little stint / Lesser stint	Cameroon	Fleuve Benoue, Kysmatary, Lac Ndekeha & Parc National de Waza logone, Cameroon	1996	1997	(Dodman, de Vaan et al. 1997)
			Denmark	Blåvandshuk, southern Denmark	1964	2003	(Meltofte et al. 2006)
			Egypt	Burullus lake	1979	1990	(Galewski 2008)
			Ghana	Keta Lagoon Complex, Salt Pans, Ghana	1997	1998	(Dodman, Beibro et al. 1998) and (Dodman, de Vaan et al. 1997)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			India	Chilika lagoon, east coast of Orissa	2001	2003	(Nayak 2006)
				Deepor Beel Wildlife Sanctuary, Assam, India	1989	1993	(Barman, Saikia et al. 1995)
			Israel	Israel	2009	2013	(Wetlands International 2013) updated with (Wetlands International 2013)
			Jordan	Jordan	2001	2013	(Qaneer, El Moghrabi et al. 2013)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			Morocco	Merja Zerga, Morocco	1992	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Namibia	Walvis Bay Ramsar site	1992	1998	(Dodman and Taylor 1996), (Dodman, Beibro et al. 1998) and (Perennou 1992)
			Norway	Sandfærhus, Stjørdal, Nord-Trøndelag	1993	1999	(Husby 2000)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			South Africa	Knysna Estuary between The Heads and Red Bridge, Western Cape	1993	1998	(Martin, von Korff et al. 2000)
			Spain	Delta del Ebro, Spain	1974	2008	(Galewski 2008)
				Paisaje Protegido del Humedal del Ajauque y Rambla Salada, Murcia, Spain	1994	2003	(Herrero 2006)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Turkey, Greece, Ukraine, Bulgaria, Romania	East Mediterranean	1989	2002	(Galewski 2008)
	Calidris minutilla	Least sandpiper	United States	The Central Valley, California	1993	1995	(Shuford, Page et al. 1998)
	Calidris pusilla	Semipalmated sandpiper	Brazil	Coroa do Avião, Igarassu, Pernambuco State	1994	1997	(Telino-Júnior, de Azevedo-Júnior et al. 2003)
				Piaçabuçu Protection Area, Alagoas, Brazil	2004	2005	(Cabral, Azevedo Júnior et al. 2006)
				Saco da Fazenda, Rio Itajaí-Açú estuary, Santa Catarina state, Southern Brazil	2003	2004	(Branco 2007)
			Canada	La Pérouse Bay, Hudson Bay, Churchill, Manitoba	1980	1993	(Hitchcock et al. 1997)
			French Guiana	French Guiana	1982	2010	(Morrison et al. 2012)
			Guyana	Guyana	1982	2010	(Morrison, Mizrahi et al. 2012)
			Suriname	Suriname	1982	2011	(Morrison, Mizrahi et al. 2012)
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
	Calidris ruficollis	Red-necked stint	Australia	200km of coast between Airlie Beach and Cape Palmerston, Mackay region, Queensland	2003	2010	(QWSG 2011)
				Bush Point, Roebuck Bay, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Cape Portland, north-east Tasmania	1981	2011	(Cooper, Clemens et al. 2012)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Eighty Mile Beach, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Lake MacLeod, Western Australia	1999	2006	(George 2009)
				Lake McLarty, Western Australia	1983	2000	(Craig, Darnell et al. 2001)
				Northern beaches in Roebuck Bay, Western Australia	2001	2008	(Rogers, Hassell et al. 2009)
				Pelican Point, Matilda Bay Reserve, Western Australia	1972	2007	(Creed and Bailey 2009)
				The Coorong, South Australia	2000	2008	(Olsen 2008)
				The Hobart area, Tasmania, Australia	1965	2008	(Olsen 2008)
				Western Port, Victoria, Australia	1974	2008	(Olsen 2008)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Japan	1000 sites around Japan	2004	2013	(Zöckler 2013)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			New Zealand	Numerous coastal locations in New Zealand	1994	2003	(Southey 2009)
	Calidris temminckii	Temminck's stint	India	Chilika lagoon, east coast of Orissa	2001	2003	(Nayak 2006)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Spain	Delta del Ebro, Spain	2001	2008	(Galewski 2008)
	Calidris tenuirostris	Great knot	Australia	200km of coast between Airlie Beach and Cape Palmerston, Mackay region, Queensland	2002	2010	(QWSG 2011)
				Bush Point, Roebuck Bay, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Darwin area, Northern Territories	1970	1971	(Crawford 1997)
				Eighty Mile Beach, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Gulf St Vincent, South Australia	1982	2004	(Close 2008)
				Moreton Bay, Queensland	1993	2008	(Wilson et al. 2011)
				Northern beaches in Roebuck Bay, Western Australia	2001	2008	(Rogers, Hassell et al. 2009)
			China	Yalu Jiang National Nature Reserve, northeast coast of the Yellow Sea	1999	2006	(Riegen, Vaughan et al. 2006)
			India	Mandapam, Gulf of Mannar, South India	1985	1987	(Balachandran 1997)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			Malaysia	Intertidal mudflat at Kapar	2001	2002	(Riak, Ismail et al. 2003)
	Eurynorhynchus pygmeus	Spoon-billed sandpiper	Korea, Republic Of	Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Russian Federation	Belyaka Spit & Yuzhny Island, Chukotka	1974	2009	Confidential data source updated with (Zockler et al. 2010)
				Beringovski, Chukotka	2003	2008	Confidential data source updated with (Zockler, Syroechkovskiy et al. 2010)
				Egvekinot, Chukotka	1975	2002	Confidential data source
				Einenekvyn Lagoon, Chukotka	1979	2002	Confidential data source
				Enurmino, Chukotka	1913	2002	Confidential data source
				Geka Spit, Chukotka	1933	2000	Confidential data source
				Kainupilgyno, Chukotka	2000	2007	Confidential data source
				Khatyrka, Chukotka	1976	2005	Confidential data source
				Kivak, Chukotka	1976	2004	Confidential data source
				Meinypilgyno, Chukotka	2003	2009	Confidential data source updated with (Zockler, Syroechkovskiy et al. 2010)
				Nikitikha River, Chukotka	1993	2000	Confidential data source
				Plover Spit, Chukotka	1993	2004	Confidential data source
				Russkaya Koshka, Chukotka	2000	2008	Confidential data source updated with (Zockler, Syroechkovskiy et al. 2010)
				Uelkal, Chukotka	1961	2006	Confidential data source
				Zhilova Koshka, Chukotka	1990	2001	Confidential data source
	Gallinago gallinago	Snipe / Common snipe	Norway	Norway	1997	2003	(Husby et al. 2004)
			Sweden	Sweden	1975	1998	(Svensson, Svensson et al. 1999)
			United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Gallinago stenura	Pintail snipe	India	Deepor Beel Wildlife Sanctuary, Assam, India	1989	1992	(Barman, Saikia et al. 1995)
	Heteroscelus brevipes	Grey-tailed tattler	Australia	Tweed River Estuary, New South Wales	1987	2003	(Rohweder 2007)
				Western Port, Victoria, Australia	1972	2006	(Olsen 2008)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
	Limicola falcinellus	Broad-billed sandpiper	China	Yalu Jiang National Nature Reserve, northeast coast of the Yellow Sea, Liaoning Province	1999	2005	(Riegen, Vaughan et al. 2006)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
	Limnodromus scolopaceus	Long-billed dowitcher	Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			United States	The Central Valley, California	1993	1995	(Shuford, Page et al. 1998)
	Limosa haemastica	Hudsonian godwit	Chile	Chiloé Island and Puerto Montt region, Chiloé and Llanquihue provinces	1993	2005	(Espinosa et al. 2006)
				Bahía Lomas, Tierra del Fuego	2002	2005	(Espinosa, von Meyer et al. 2006)
			United States	Chatham region, Massachusetts	1960	2009	(Harrington et al. 2012)
				Newburyport region, Massachusetts	1964	2009	(Harrington, Nikula et al. 2012)
	Limosa lapponica	Bar-tailed godwit	Australia	200km of coast between Airlie Beach and Cape Palmerston, Mackay region, Queensland	2002	2010	(QWSG 2011)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Eighty Mile Beach, Roebuck Bay, Milingimbi coast and Elcho Island	1995	2012	Confidential data source
				George Town Reserve, George Town, north-east Tasmania	1974	2011	(Cooper, Clemens et al. 2012)
				Port Stephens, New South Wales	2004	2011	(Stuart 2011)
				The Coorong, South Australia	1981	2008	(Wainwright and Christie 2008)
				The Hobart area, Tasmania, Australia	1965	2008	(Olsen 2008)
				Tweed River Estuary, New South Wales	1987	2003	(Rohweder 2007)
				Western Port, Victoria, Australia	1974	2008	(Olsen 2008)
			China	Yalu Jiang National Nature Reserve, northeast coast of the Yellow Sea	1999	2006	(Riegen, Vaughan et al. 2006)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2007	(Laursen, Blew et al. 2010)
			France	Granville to Cancale, Mont Saint-Michel Bay	1981	1993	(Le Drean-Quenec'hdu, Mahéo et al. 1995)
			Germany	Wadden Sea in Niedersachsen and Hamburg	1987	2007	(Laursen, Blew et al. 2010)
				Wadden Sea in Schleswig-Holstein	1987	2007	(Laursen, Blew et al. 2010)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			Ireland	Republic of Ireland	1995	2001	(Colhoun 2001)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			Mauritania	Sections A, C, D and K in Banc d'Arguin	1979	1997	(Zwarts, van der Kamp et al. 1997)
			Morocco	Merja Zerga, Morocco	1991	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Netherlands	Dutch Wadden Sea	1987	2007	(Laursen, Blew et al. 2010)
			New Zealand	Various coastal locations, including Manukau Harbour, Kaipara Harbour, Farewell Spit and Tasman Bay	1995	2012	Confidential data source
			Poland	Jastarnia, Hel peninsula, Gulf of Gdańsk	1984	1989	(Meissner et al. 2002)
				Rewa peninsula, Gulf of Gdańsk	1988	1995	(Meissner and Ściborski 2002)
			Portugal	Aveiro, Tejo, Sado and Faro estuaries	1976	1989	(Rufino 1990)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			South Africa	Langebaan Lagoon	1976	2003	(Harebottle, Navarro et al. 2006)
			Spain, Morocco, Algeria, Tunisia, France	West Mediterranean (Spain, Morocco, Algeria, Tunisia, southern France, Italy)	1989	2002	(Galewski 2008)
			United Kingdom	UK	1975	2005	(Eaton et al. 2007)
	Limosa limosa	Black-tailed godwit	Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
				Souss-Massa, Morocco	1983	2000	(Ramsar Sites Information Service 2003)
			Netherlands	Europe - AT, BE, DK, CZ, FI, FR, DE, HU, IE, IT, LV, NL, PL, ES, SE, GB, NO, CH	1984	2011	Confidential data source
	Lymnocryptes minimus	Jack snipe	Finland	Finland	1984	1987	(Väisänen, Lammi et al. 1998)
			Italy	Coastal wetland of Lazio, Italy	1980	1998	(Guerrieri et al. 1999)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
	Numenius phaeopus	Whimbrel	Australia	200km of coast between Airlie Beach and Cape Palmerston, Mackay region, Queensland	2002	2010	(QWSG 2011)
				Bush Point, Roebuck Bay, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Corner Inlet, South Gippsland, Victoria	1982	2011	(Minton, Dann et al. 2012)
				Eighty Mile Beach, Western Australia	2004	2008	(Rogers, Hassell et al. 2009)
				Northern beaches in Roebuck Bay, Western Australia	2001	2008	(Rogers, Hassell et al. 2009)
				Port Stephens, New South Wales	2004	2011	(Stuart 2011)
				Tweed River Estuary, New South Wales	1987	2003	(Rohweder 2007)
			Chile	Several sites across Chile	1995	2010	(Blanco and Carbonell 2001) updated with (López-Lanús and Blanco 2005) and (Schmitt et al. 2011)
			China	Yalu Jiang National Nature Reserve, northeast coast of the Yellow Sea, Liaoning Province	1999	2006	(Riegen, Vaughan et al. 2006)
			Denmark	Danish Wadden Sea between Blåvand and the German border	1988	2010	(Laursen and Frikke 2013)
			Finland	Finland	1983	1995	(Väisänen, Lammi et al. 1998)
			Guinea-Bissau	Bissagos Islands	1987	2001	(Dodman and Sá 2005)
			Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			Malaysia	Intertidal mudflat at Kapar	2000	2001	(Riak, Ismail et al. 2003)
			Mozambique	Bazaruto Island West Coast, 80 kilometers (50 miles) southeast of the mouth of the Save River	1996	1997	(Dodman and Taylor 1996) and (Dodman, de Vaan et al. 1997)
				Inhaca Island	1995	1997	(Oschadleus and Lotz 2004)
			New Zealand	Numerous coastal locations in New Zealand	1994	2003	(Southey 2009)
			Singapore	Sungei Buloh Wetland Reserve, northwest sector of Singapore	2000	2012	(NPARKS 2014)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			South Africa	Knysna Estuary between The Heads and Red Bridge, Western Cape	1993	1998	(Martin, von Korff et al. 2000)
				Langebaan Lagoon	1976	2003	(Harebottle, Navarro et al. 2006)
			United States	The Outer Banks, North Carolina	1992	1993	(Dinsmore, Collazo et al. 1998)
				Western portion of Isla Vista, Santa Barbara County, California	1995	2000	(Hubbard and Dugan 2002)
				Yukon Delta National Wildlife Refuge, Alaska	1988	1991	(McCaffery 1996)
	Numenius tahitiensis	Bristle-thighed curlew	United States	Laysan Island, Northwestern Hawaiin Islands	1988	1990	(Marks et al. 1996)
				Yukon Delta National Wildlife Refuge, Alaska	1988	1991	(McCaffery 1996)
			United States Minor Outlying Islands	Baker Island and Howland Island, northern Phoenix Islands	1963	1990	(Marks et al. 1994)
	Phalaropus fulicarius	Red phalarope / Grey phalarope	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	2005	2007	(Cadieux, Gauthier et al. 2008)
			Greenland	The 4 islands of Gronne Ejland	1979	2003	(Egevang, Kampp et al. 2006)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Senegal	Pointe des Almadies, Dakar	1995	2008	(Dubois, Holmström et al. 2009)
			Svalbard And Jan Mayen	Bear Island, Svalbard	1965	1996	(Anker-Nilssen, Bakken et al. 2000)
				Ny Alesund, Svalbard	1980	1999	(Anker-Nilssen, Bakken et al. 2000)
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
	Phalaropus lobatus	Red-necked phalarope	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			Greenland	Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			United States	Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
				The Central Valley, California	1993	1995	(Shuford, Page et al. 1998)
	Philomachus pugnax	Ruff	Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)
				Skjern River Valley restoration area, Central Jutland Region	2002	2005	(Bregnballe, Amstrup et al. 2009)
			Mali	Mali	1999	2001	(Trolliet et al. 2001)
			Morocco	Merja Zerga, Morocco	1990	2005	Abdelaziz et al. 2006
			Nigeria	Hadejia-Nguru Wetlands, Nigeria	1997	1998	(Dodman, Beibro et al. 1998) and (Dodman, de Vaan et al. 1997)
			Norway	Pasvik naturreservat, Sør-Varanger, Finnmark	1996	2001	(Günther 2003)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			Spain	Delta del Ebro, Spain	1977	2008	(Galewski 2008)
	Tringa erythropus	Spotted redshank	Denmark	Danish Wadden Sea between Blåvand and the German border	1987	2009	(Laursen and Frikke 2013)
			Germany	Schleswig-Holstein, Wadden Sea	1988	1999	(Günther and Rösner 2000)
			Ghana	Keta Lagoon Complex, Salt Pans, Ghana	1997	1998	(Dodman, Beibro et al. 1998) and (Dodman, de Vaan et al. 1997)
			India	Deepor Beel Wildlife Sanctuary, Assam, India	1990	1993	(Barman, Saikia et al. 1995)
			Korea, Republic Of	Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
			Netherlands	The Netherlands	1976	2010	(Hornman, van Roomen et al. 2012)
			Norway	Pasvik naturreservat, Sør-Varanger, Finnmark	1996	2003	(Günther 2003)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			Spain	Delta del Ebro, Spain	1973	2008	(Galewski 2008)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
				S'Albufera, Mallorca, Spain	1989	2012	(Galewski 2008) updated with (Govern de les Illes Balears - Espais de Natura Balear 2012)
	Tringa flavipes	Lesser yellowlegs	Brazil	Saco da Fazenda, Rio Itajaí-Açú estuary, Santa Catarina state, Southern Brazil	1996	2005	(Branco 2007)
			United States, Canada	United States and Canada	1967	2011	(Sauer, Hines et al. 2012)
	Tringa glareola	Wood sandpiper	Australia	Lake McLarty, Western Australia	1982	2000	(Craig, Darnell et al. 2001)
			Finland, Sweden	Europe-FI, SE	1980	2011	Confidential data source
			India	Deepor Beel Wildlife Sanctuary, Assam, India	1989	1990	(Barman, Saikia et al. 1995)
			Norway	Pasvik naturreservat, Sør-Varanger, Finnmark	1996	2003	(Günther 2003)
			Senegal, Mauritania	Various sites across the Senegal river delta	1993	1997	(Triplet and Yesou 1998)
			Spain	Delta del Ebro, Spain	1987	2008	(Galewski 2008)
	Tringa totanus	Redshank / Common redshank	Iceland	Europe - AT, BE, DK, CZ, FI, FR, DE, HU, IE, IT, LV, NL, PL, ES, SE, GB, NO, CH	1980	2011	Confidential data source
	Tryngites subruficollis	Buff-breasted sandpiper	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			United States	Eastern Rainwater Basin, Nebraska	2004	2005	(Jorgensen 2007)
				Point McIntyre Reference Area, Prudhoe Bay, Alaska	1981	1991	(Troy 1996)
			Uruguay	Laguna de Castillos and Laguna de Rocha, Uruguay	1999	2001	(Lanctot et al. 2002)
	Xenus cinereus	Terek sandpiper	Korea, Republic Of	14 coastal sites, south and west coasts, Republic of Korea	1998	2008	(Moores, Rogers et al. 2008)
				Saemangeum Shorebird Monitoring site, Republic of Korea	2006	2008	(Moores, Rogers et al. 2008)
Stercorariidae	*Stercorarius longicaudus*	Long-tailed jaeger / Long-tailed skua	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
				Southern Plain, Sirmilik National Park, Bylot Island, (Qarlikturvik Valley /main goose nesting colony)	1997	2007	(Cadieux, Gauthier et al. 2008)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
			Finland	Finland	1985	1995	(Väisänen, Lammi et al. 1998)
			Greenland	The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
				Zackerbergdalen, Northeast Greenland	1996	2008	(Hansen 2009)
			Russian Federation	Taimyr Peninsula	1994	2008	Confidential data source
			United States	Yukon Delta National Wildlife Refuge, Alaska	1988	1991	(McCaffery 1996)
	Stercorarius parasiticus	Arctic jaeger / Parasitic jaeger / Arctic skua	Australia	Western Port, Victoria, Australia	1993	1994	(Dann et al. 2003)
			Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			Norway	Slettnes,Gamvik, Finnmark	1989	1996	(Strann 1996)
			Russian Federation	Kharlov Island, Murmansk Coast	1930	1995	(Anker-Nilssen, Bakken et al. 2000)
	Stercorarius pomarinus	Pomarine skua / Pomarine jaeger	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok and Vink 2012)
			Russian Federation	Taimyr Peninsula	1993	2005	(Ebbinge and Mazurov 2006)
Strigidae	*Bubo scandiaca*	Snowy owl	Canada	South and North Arctic ecozone, Northern Canada	1966	2005	Confidential data source
			Greenland	BioBasis programme, Zackenberg Research Station, Wollaston Forland, Northeast Greenland	1996	2007	(Meltofte, Sittler et al. 2007)
				The Karupelv Valley Project, Traill O, Kong Oscars Fjord, North-East Greenland	1988	2007	(Meltofte, Sittler et al. 2007)
			Russian Federation	Taimyr Peninsula	1993	2005	(Ebbinge and Mazurov 2006)
Sylviidae	*Phylloscopus trochilus*	Willow warbler	Sweden	Sweden	1960	1977	(NERC Centre for Population Biology 1999) with data taken from {Österlöf, 1982 #1639)
Turdidae	*Catharus minimus*	Grey-cheeked thrush	Canada	Canada	1968	2007	(Downes 1999) updated with (Downes et al. 2008)
			Costa Rica	Tortuguero, Limón Province	1995	2002	(Ralph et al. 2005)

Family	Binomial	Common name	Country/ Countries	Location	Start year	End year	Reference
	Turdus iliacus	Redwing	Norway	Lista fuglestasjon, Farsund, Vest-Agder	1990	2003	(Norsk Ornitologisk Forenig 2004)
			Sweden	Ammarnas, Nr Lake Stor-Tjultrasket, Swedish Lapland	1963	1982	(NERC Centre for Population Biology 1999) with data taken from {Enemar, 1984 #964)
				Sweden	1960	1980	(NERC Centre for Population Biology 1999) with data taken from {Österlöf, 1982 #1639)
	Turdus migratorius	American robin	United States, Canada	United States and Canada	1966	2011	(Sauer, Hines et al. 2012)
	Turdus pilaris	Fieldfare	Russian Federation	Europe - AT, BE, DK, CZ, FI, FR, DE, HU, IE, IT, LV, NL, PL, ES, SE, GB, NO, CH	1980	2011	Confidential data source

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Table A4. Five-yearly index values, 95% confidence intervals and the number of time-series and species contributing to each index shown between 1970 and 2011. Start years that do not coincide with 5-yearly interval are marked as follows: A) starts 1971, B) starts 1972, C) starts 1976, D) starts 1982, E) starts 1983, F) ends 1999.

		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Global index and taxonomic groups	Migratory Arctic Bird Index	1.00	1.05	1.10	1.30	1.40	1.49	1.45	1.40	1.40	1.40	1.40	1.40	1.39	1.39
	LCL	1.00	0.92	0.92	1.06	1.12	1.18	1.14	1.08	1.07	1.07	1.07	1.06	1.04	1.03
	UCL	1.00	1.20	1.31	1.60	1.76	1.88	1.85	1.81	1.82	1.82	1.83	1.84	1.84	1.87
	Landbirds	1.00	1.10	1.03	1.00	0.89	0.96	1.06	1.24	1.30	1.36	1.39	1.40	1.38	1.37
	LCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	UCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Seabirds	1.00	1.00	1.08	1.40	1.59	1.73	1.66	1.48	1.46	1.46				
	LCL	1.00	0.90	0.93	1.13	1.16	1.23	1.17	1.01	0.98	0.97				
	UCL	1.00	1.11	1.24	1.75	2.16	2.37	2.34	2.18	2.16	2.18				
	Shorebirds	1.00	0.98	1.02	1.39	1.50	1.51	1.28	1.15	1.12	1.08	1.03	0.98	0.93	0.92
	LCL	1.00	0.78	0.73	0.92	0.97	0.96	0.80	0.70	0.68	0.65	0.61	0.59	0.54	0.52
	UCL	1.00	1.21	1.41	2.06	2.29	2.37	2.07	1.90	1.87	1.81	1.73	1.67	1.61	1.63
	Waterfowl	1.00	1.11	1.27	1.43	1.71	1.93	2.07	1.97	2.00	2.05	2.14	2.17	2.17	2.05
	LCL	1.00	0.92	0.97	1.03	1.19	1.32	1.39	1.30	1.31	1.32	1.36	1.35	1.33	1.20
	UCL	1.00	1.36	1.70	2.00	2.47	2.86	3.11	3.04	3.09	3.21	3.37	3.47	3.55	3.48
Flyway regions and taxonomic groups	Americas	1.00	1.09	1.06	1.26	1.20	1.25	1.25	1.23	1.22	1.20	1.17	1.16	1.16	
	LCL	1.00	0.90	0.83	0.94	0.86	0.89	0.86	0.83	0.83	0.81	0.79	0.79	0.78	
	UCL	1.00	1.33	1.36	1.69	1.67	1.78	1.81	1.79	1.79	1.77	1.74	1.73	1.73	
	Landbirds	1.00	1.13	1.04	1.17	0.96	1.07	1.11	1.10	1.12	1.14	1.15	1.15	1.16	
	LCL	1.00	0.73	0.59	0.62	0.47	0.51	0.54	0.52	0.52	0.54	0.54	0.54	0.54	
	UCL	1.00	1.75	1.80	2.19	1.93	2.19	2.29	2.29	2.32	2.37	2.39	2.40	2.42	
	Seabirds	1.00	0.96	1.02	1.29	1.35	1.36	1.34	1.48	1.55	1.60	1.63	1.62	1.59	
	LCL	1.00	0.82	0.82	0.97	0.89	0.89	0.86	0.93	0.97	1.00	1.01	1.01	0.98	
	UCL	1.00	1.12	1.26	1.75	2.02	2.07	2.06	2.32	2.44	2.53	2.59	2.59	2.56	
	Shorebirds	1.00	1.06	0.95	1.22	1.19	1.35	1.19	1.07	1.01	0.96	0.91	0.90	0.92	
	LCL	1.00	0.86	0.63	0.61	0.53	0.54	0.45	0.38	0.35	0.33	0.31	0.31	0.31	
	UCL	1.00	1.43	1.64	2.68	2.86	3.61	3.35	3.12	2.99	2.87	2.74	2.74	2.85	
	Waterfowl	1.00	1.12	1.14	1.18	1.22	1.14	1.23	1.17	1.16	1.12	1.08	1.05	1.04	

		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
	LCL	1.00	1.00	0.97	0.96	0.92	0.82	0.83	0.77	0.76	0.73	0.70	0.67	0.66	
	UCL	1.00	1.26	1.34	1.45	1.60	1.55	1.79	1.74	1.74	1.69	1.65	1.61	1.60	
	Africa-Eurasia	1.00	0.98	1.18	1.25	1.50	1.60	1.73	1.59	1.57	1.55	1.53	1.52	1.58	1.75
	LCL	1.00	0.83	0.97	1.01	1.19	1.26	1.35	1.21	1.18	1.16	1.14	1.11	1.13	1.21
	UCL	1.00	1.13	1.43	1.55	1.89	2.04	2.24	2.10	2.08	2.07	2.06	2.07	2.20	2.57
	Landbirds	1.00	0.92	0.94	0.86	0.77	0.74	0.85	1.02	1.06	1.08	1.07	1.03		
	LCL	1.00	0.75	0.75	0.58	0.46	0.43	0.48	0.56	0.57	0.57	0.57	0.54		
	UCL	1.00	1.11	1.18	1.34	1.38	1.33	1.58	1.99	2.08	2.15	2.17	2.09		
	Seabirds	1.00	1.04	1.17	1.37	1.77	2.01	2.21	1.47	1.31	1.20				
	LCL	1.00	0.92	0.99	1.07	1.31	1.41	1.44	0.77	0.65	0.58				
	UCL	1.00	1.18	1.38	1.73	2.42	2.94	3.49	2.73	2.55	2.40				
	Shorebirds	1.00	0.99	1.26	1.34	1.50	1.56	1.63	1.55	1.52	1.47	1.42	1.41		
	LCL	1.00	0.67	0.79	0.83	0.93	0.95	0.98	0.92	0.90	0.87	0.84	0.83		
	UCL	1.00	1.37	1.92	2.07	2.34	2.48	2.62	2.51	2.49	2.41	2.33	2.34		
	Waterfowl	1.00	0.97	1.24	1.32	1.84	2.05	2.21	2.02	2.04	2.15	2.31	2.39		
	LCL	1.00	0.70	0.82	0.84	1.13	1.23	1.31	1.17	1.16	1.21	1.28	1.28		
	UCL	1.00	1.33	1.89	2.08	2.98	3.37	3.67	3.47	3.52	3.77	4.13	4.42		
	Central Asia			1.00	0.88	0.39	0.73	0.65	0.48	0.40	0.34	0.30	0.29	0.29	
	LCL			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	UCL			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	East Asia	1.00	0.97	0.76	1.00	1.08	0.94	0.77	0.67	0.67	0.65	0.65	0.64	0.62	0.61
	LCL	1.00	0.86	0.53	0.65	0.66	0.54	0.42	0.35	0.35	0.34	0.33	0.32	0.31	0.30
	UCL	1.00	1.13	1.05	1.54	1.80	1.69	1.45	1.31	1.31	1.30	1.30	1.31	1.29	1.28
	Seabirds	1.00	0.76	0.60	0.48	0.38	0.55	0.45	0.23	0.21	0.21	0.26	0.34	0.45	0.57
	LCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	UCL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Shorebirds	1.00	0.94	0.68	0.94	0.99	0.71	0.50	0.45	0.43	0.40	0.36	0.33	0.29	0.28
	LCL	1.00	0.80	0.43	0.54	0.54	0.37	0.25	0.22	0.21	0.19	0.17	0.15	0.13	0.12
	UCL	1.00	1.14	1.04	1.64	1.89	1.43	1.03	0.95	0.92	0.86	0.80	0.74	0.68	0.66
	Waterfowl	1.00	1.24	1.41	1.74	2.09	2.95	4.40	4.66	5.23	5.82	6.27	6.21	5.51	4.57
	LCL	1.00	1.15	1.30	1.56	1.54	1.37	1.53	1.53	1.70	1.89	2.03	1.97	1.65	1.24
	UCL	1.00	1.35	1.53	1.96	3.12	6.89	15.29	16.54	18.86	21.07	22.67	23.07	21.49	19.11

		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Waterfowl	Geese and swans	1.00	1.22	1.48	1.98	2.41	3.20	3.68	3.14	3.18	3.43	3.92	4.43	4.64	4.55
	LCL	1.00	0.97	1.12	1.35	1.57	2.05	2.29	1.87	1.87	2.01	2.26	2.50	2.54	2.44
	UCL	1.00	1.54	2.01	2.97	3.74	5.08	5.93	5.24	5.37	5.86	6.81	7.92	8.44	8.41
	Americas	1.00	1.24	1.37	1.74	2.36	2.49	2.72	2.67	2.82	2.97	3.07	3.12	3.15	
	LCL	1.00	1.09	1.08	1.26	1.58	1.50	1.54	1.49	1.57	1.65	1.71	1.74	1.75	
	UCL	1.00	1.40	1.74	2.40	3.50	4.07	4.73	4.67	4.94	5.23	5.43	5.51	5.55	
	Africa-Eurasia	1.00	1.10	1.47	1.75	2.37	2.95	2.99	2.48	2.39	2.53	2.91			
	LCL	1.00	0.82	1.05	1.17	1.50	1.81	1.81	1.41	1.34	1.38	1.55			
	UCL	1.00	1.45	2.07	2.62	3.73	4.83	5.03	4.41	4.35	4.69	5.56			
	East Asia	1.00	1.24	1.41	1.74	1.79	1.99	3.40	4.07	4.50	4.81	4.92	4.72	4.11	
	LCL	1.00	1.15	1.29	1.56	1.47	1.40	1.45	1.43	1.55	1.65	1.69	1.61	1.38	
	UCL	1.00	1.35	1.54	1.97	2.19	2.87	9.82	13.72	15.62	16.87	17.27	16.56	14.38	
	Geese	1.00	1.17	1.43	1.91	2.29	3.11	3.81	3.32	3.38	3.69	4.28	4.97	5.43	5.63
	LCL	1.00	0.95	1.09	1.26	1.43	1.89	2.25	1.89	1.89	2.04	2.33	2.64	2.84	2.92
	UCL	1.00	1.43	1.93	2.94	3.71	5.18	6.49	5.93	6.08	6.71	7.89	9.37	10.41	10.87
	Swans	1.00	1.77	2.09	2.86	3.70	4.36	3.49	2.49	2.44	2.31	2.30	2.13	1.78	1.40
	LCL	1.00	1.70	1.86	2.46	3.00	3.41	2.55	1.81	1.77	1.68	1.67	1.55	1.30	1.02
	UCL	1.00	1.84	2.39	3.45	4.56	5.67	5.16	3.71	3.64	3.44	3.43	3.18	2.66	2.09
	Ducks	1.00	1.01	1.08	1.01	1.18	1.14	1.14	1.19	1.21	1.19	1.14	1.05	1.00	0.90
	LCL	1.00	0.75	0.68	0.61	0.66	0.63	0.61	0.62	0.63	0.61	0.58	0.52	0.48	0.38
	UCL	1.00	1.39	1.79	1.71	2.13	2.10	2.17	2.37	2.41	2.41	2.33	2.19	2.12	2.09
	Americas	1.00	1.05	0.99	0.88	0.73	0.61	0.65	0.61	0.59	0.54	0.50	0.48	0.47	
	LCL	1.00	0.90	0.82	0.70	0.49	0.40	0.38	0.35	0.33	0.30	0.28	0.26	0.25	
	UCL	1.00	1.24	1.20	1.13	1.03	0.88	1.08	1.07	1.03	0.96	0.90	0.86	0.85	
	Africa-Eurasia	1.00	0.83	0.99	0.91	1.31	1.32	1.51	1.54	1.63	1.72	1.67			
	LCL	1.00	0.44	0.44	0.39	0.55	0.53	0.59	0.57	0.60	0.62	0.60			
	UCL	1.00	1.52	2.19	2.11	3.16	3.28	3.85	4.11	4.42	4.75	4.66			
Wadden Sea	Wadden Sea			1.00	2.05	2.34	2.40	2.66	2.43	2.27	2.11	1.98	1.87	1.76	1.71
	LCL			1.00	1.35	1.40	1.41	1.54	1.37	1.28	1.19	1.11	1.04	0.97	0.94
	UCL			1.00	3.08	3.91	4.09	4.70	4.34	4.08	3.81	3.58	3.43	3.26	3.19

		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Species	*Clangula hyemalis* Long-tailed duck	1.00	0.79	0.54	0.41	0.53	0.66	0.73	0.45	0.44	0.43	0.38	0.31	0.24	0.21
	LCL	1.00	0.65	0.40	0.29	0.37	0.37	0.35	0.20	0.19	0.18	0.16	0.13	0.10	0.08
	UCL	1.00	0.96	0.72	0.58	0.78	1.19	1.57	1.04	1.02	0.98	0.89	0.74	0.59	0.51
	Anser albifrons Greater white-fronted goose	1.00	0.56	0.54	0.55	0.69	0.89	0.98	1.61	1.64	1.63	1.69	1.77	1.81	1.88
	LCL	1.00	0.28	0.25	0.25	0.25	0.29	0.31	0.45	0.45	0.43	0.44	0.45	0.46	0.47
	UCL	1.00	1.09	1.13	1.20	1.80	2.74	3.04	5.66	5.89	5.94	6.23	6.58	6.78	7.10
	Americas flyways	1.00	1.02	0.93	0.99	2.66	2.36	2.16	2.43	2.59	2.75	2.87	2.94	3.01	3.10
	Africa-Eurasia, Central Asia & East Asia	1.00	0.42	0.41	0.41	0.39	0.57	0.67	1.27	1.26	1.24	1.25	1.32	1.34	1.41
	Calidris canutus Red Knot		0.73A	0.76	0.86	0.82	0.87	0.69	0.50	0.49	0.45	0.44	0.40	0.35	0.30
	LCL		0.73	0.68	0.72	0.67	0.64	0.48	0.32	0.28	0.24	0.22	0.20	0.17	0.15
	UCL		0.73	0.86	1.02	0.99	1.24	1.04	0.81	0.81	0.80	0.82	0.79	0.70	0.61
	Americas				0.98D	0.96	0.77	0.48	0.16	0.12	0.12	0.12	0.13	0.11	0.10
	Africa-Eurasia		0.73A	0.76	0.83	0.79	0.72	0.67	0.76	0.79	0.79	0.76	0.72	0.69	
	East Asia				1.24D	1.17	0.82	0.58	0.43	0.40	0.34	0.33	0.26	0.22	0.20
	Pluvialis squatarola Grey Plover		1.39A	1.62	1.66	1.67	1.55	1.41	1.14	1.09	1.05	1.00	0.95	0.91	0.86
	LCL		1.14	1.35	1.29	1.23	1.13	0.96	0.74	0.69	0.65	0.61	0.59	0.57	0.54
	UCL		1.68	2.02	2.16	2.28	2.39	2.20	1.83	1.81	1.78	1.69	1.59	1.49	1.39
	Americas				0.56E	0.40	0.52	0.56	0.35	0.32	0.31	0.30	0.28	0.27	0.27
	Africa-Eurasia		1.67A	2.09	2.36	2.57	2.45	2.34	2.12	2.14	2.10	2.05	1.99	1.96	
	East Asia		0.96B	0.86	0.82	0.73	0.50	0.37	0.29	0.27	0.26	0.24	0.23	0.22	0.21
	Plectrophenax nivalis Snow bunting	1.00	0.66	0.57	0.66	0.62	0.70	0.71	0.95	0.97	0.95	0.92			
	LCL	1.00	0.50	0.37	0.24	0.21	0.23	0.21	0.27	0.28	0.27	0.27			
	UCL	1.00	0.86	0.81	1.76	2.12	2.71	2.83	4.23	4.41	4.30	4.18			
	North America & Greenland	1.00	0.91	0.83	0.75	0.69	0.62	0.60	0.81	0.83	0.80	0.78			
	Europe	1.00	0.47	0.40	0.72	0.65	0.77F								

		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
Flyways	Pacific Americas	1.00	1.05	1.00	1.09	1.08	1.09	1.01	1.04	1.03	1.01	0.99	0.97	0.97	0.98
	LCL	1.00	0.84	0.76	0.79	0.74	0.73	0.67	0.67	0.66	0.65	0.63	0.62	0.61	0.62
	UCL	1.00	1.31	1.33	1.54	1.58	1.65	1.55	1.62	1.61	1.59	1.56	1.54	1.54	1.56
	Central Americas	1.00	1.20	1.12	1.39	1.21	1.26	1.25	1.42	1.48	1.51	1.53	1.56	1.60	1.61
	LCL	1.00	0.90	0.77	0.93	0.78	0.79	0.76	0.83	0.86	0.87	0.88	0.89	0.91	0.92
	UCL	1.00	1.60	1.61	2.07	1.88	1.98	2.03	2.41	2.53	2.61	2.66	2.72	2.78	2.80
	Atlantic Americas	1.00	1.08	1.02	1.16	1.05	1.12	1.16	1.11	1.12	1.15	1.16	1.17	1.18	1.18
	LCL	1.00	0.85	0.75	0.83	0.73	0.76	0.78	0.73	0.74	0.75	0.75	0.76	0.76	0.75
	UCL	1.00	1.39	1.40	1.67	1.56	1.69	1.79	1.74	1.76	1.81	1.84	1.85	1.88	1.89
	East Atlantic	1.00	1.02	1.22	1.28	1.54	1.60	1.75	1.60	1.59	1.58	1.57	1.54	1.56	1.59
	LCL	1.00	0.88	1.01	1.04	1.23	1.26	1.36	1.21	1.20	1.19	1.17	1.14	1.13	1.13
	UCL	1.00	1.17	1.49	1.58	1.93	2.02	2.25	2.11	2.11	2.11	2.10	2.09	2.16	2.25
	Mediterranean-Black Sea	1.00	0.91	1.44	1.64	2.17	2.57	2.69	2.56	2.51	2.49	2.50	2.55	2.65	2.96
	LCL	1.00	0.59	0.89	1.00	1.30	1.52	1.57	1.47	1.43	1.40	1.40	1.41	1.45	1.58
	UCL	1.00	1.34	2.23	2.61	3.49	4.22	4.54	4.44	4.36	4.34	4.37	4.50	4.75	5.48
	East Asia-East Africa			0.89C	0.97	1.20	1.13	1.11	0.94	0.82	0.70	0.59			
	LCL			0.79	0.83	0.94	0.74	0.70	0.52	0.44	0.35	0.29			
	UCL			1.03	1.15	1.52	1.63	1.69	1.63	1.51	1.35	1.20			
	Central Asia			1.00	0.88	0.39	0.73	0.65	0.48	0.40	0.34	0.30	0.29	0.29	0.30
	LCL			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	UCL			NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	East Asia-Australasia	1.00	0.97	0.76	1.03	1.11	0.96	0.70	0.60	0.62	0.64	0.66	0.66	0.63	0.58
	LCL	1.00	0.86	0.52	0.65	0.66	0.53	0.36	0.30	0.31	0.31	0.32	0.32	0.29	0.27
	UCL	1.00	1.13	1.07	1.62	1.87	1.72	1.35	1.21	1.25	1.30	1.36	1.37	1.32	1.25

Addendum

Introduction

Background

This addendum provides additional information on two of the trends presented in the report "The Arctic Species Trend Index for migratory birds". In this report, abundance change was examined for selected Arctic breeding bird species, incorporating information from both inside and outside the Arctic region. Analysis of 966 time-series of 129 bird species that breed in the Arctic region and overwinter outside revealed an increase of 40% in abundance between 1970 and 2011 (Figure 1). This overall trend masked differences between taxa and flyway regions, with declines in East Asia and Central Asia (-40% and -70%), and increases in Africa-Eurasia and the Americas (50% and 15%, Figure 2).

Figure 1. Index of abundance for 966 time-series of 129 Arctic migratory bird species monitored in locations inside and outside the Arctic boundary from 1970 to 2011 (Migratory Arctic Bird Index). Dashed lines are 95% confidence limits, and diamonds are the number of time-series contributing to the index in each year.

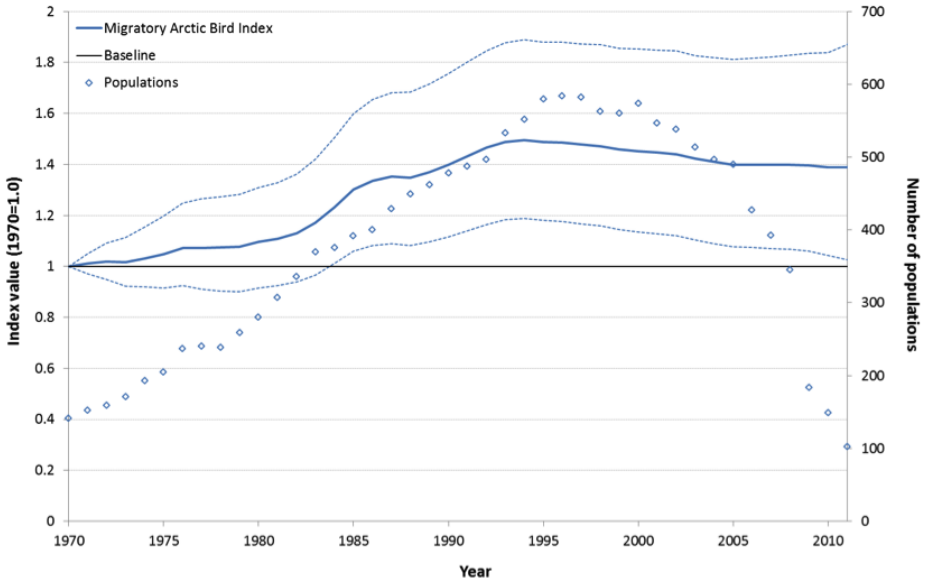
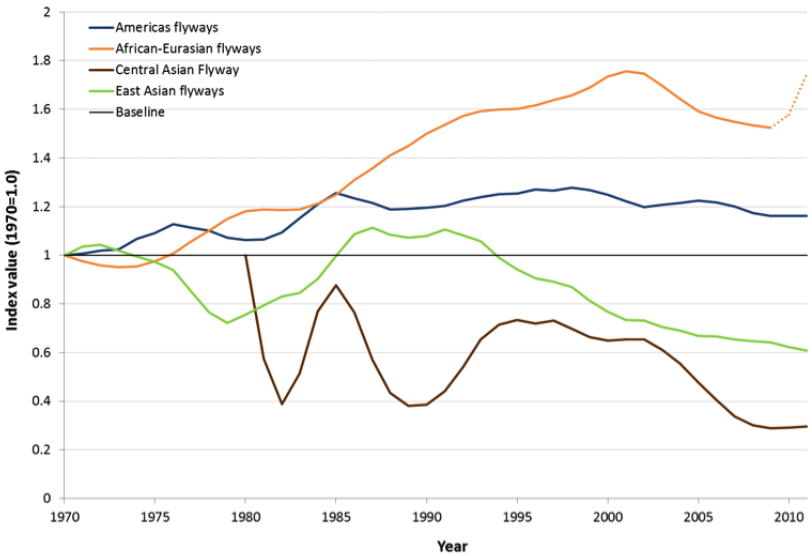


Figure 2. Indices of abundance for 966 time-series of 129 species in the four flyway regions from 1970 to 2011. Please note that due to data availability the index for Central Asia starts in 1980 and the index for the African-Eurasian flyways ends in 2009, although the trend is shown up to 2011 as a dashed line.



Additional data

The data used for the production of the original indices was extracted from the Living Planet Database (LPD, www.livingplanetindex.org). Data collection for this resource is usually opportunistic, focusing on filling geographical and taxonomic gaps. A number of long-term time-series from the North American regions could not be included due to time constraints (the data arrived after analysis had already started) and the particular way in which the data set evolved (the final data set does not allow any time-series which are from both Arctic and non-Arctic areas). Reviewers noted the absence of these time-series from the North American Breeding Bird Survey (BBS), the Christmas Bird Count (CBC), the Continental Migratory Shorebirds surveys (CMS) and the Seabird counts. This addendum integrates these time-series and examines the impact their inclusion has on the global Arctic Migratory Bird Index and the index for the Americas flyway region.

Results and Discussion

Data set

For this update, 27 time-series of 25 species were added to the original data set (Table 1). To avoid replication, 21 time-series of 12 species had to be removed from the original data set, and another one was excluded as new information revealed that it contained data for more than one species (Greater scaup *Aythya marila*; Table 2). The new data set comprised 970 time-series of 132 species, which represents an increase of 3 species on the original analysis (Smith's longspur *Calcarius pictus*, Iceland gull *Larus glaucoides* and Solitary sandpiper *Tringa solitaria*). In addition, population values for one time-series were adjusted because the data were entered incorrectly initially.

Table 1. The 27 time-series that were added to the Arctic migrants data set

Family	Binomial	Common name	Countries	Location	Start year	End year	Reference
Anatidae	*Anas penelope*	Eurasian wigeon	Canada	Canada	1989	2012	(Christmas Bird Count 2014)
	Branta canadensis	Canada goose	Canada	Northwest Territories	1989	2012	(Environment Canada 2014)
	Cygnus columbianus	Tundra swan / Bewick's swan	Canada	Canada	1970	2012	(Christmas Bird Count 2014)
Charadriidae	*Pluvialis dominica*	American golden plover	United States, Canada	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
Emberizidae	*Calcarius pictus*	Smith's longspur	Canada, United States	North America	1970	2012	(Christmas Bird Count 2014)
Gaviidae	*Gavia pacifica*	Pacific loon	Canada	Canada	1970	2012	(Christmas Bird Count 2014)
Laridae	*Larus glaucoides*	Iceland gull	Canada	Canada	1970	2012	(Christmas Bird Count 2014)
	Larus thayeri	Thayer's gull	Canada	Arctic Region, Canada	1985	2005	(State of Canada's Birds 2014)
				Canada	1970	2012	(Christmas Bird Count 2014)
Scolopacidae	*Aphriza virgata*	Surfbird	Canada	Canada	1970	2012	(Christmas Bird Count 2014)
	Arenaria interpres	Ruddy turnstone / Turnstone	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris alba	Sanderling	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris alpina	Dunlin	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris bairdii	Baird's sandpiper	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris canutus	Knot / Red knot	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris himantopus	Stilt sandpiper	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris maritima	Purple sandpiper	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris melanotos	Pectoral sandpiper	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris minutilla	Least sandpiper	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Calidris pusilla	Semipalmated sandpiper	United States, Canada	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Limnodromus scolopaceus	Long-billed dowitcher	United States, Canada	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Numenius phaeopus	Whimbrel	United States, Canada	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Phalaropus fulicarius	Red phalarope / Grey phalarope	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)

Family	Binomial	Common name	Countries	Location	Start year	End year	Reference
	Phalaropus lobatus	Red-necked phalarope	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Tringa solitaria	Solitary sandpiper	Canada	Northwest Territories	1989	2012	(Environment Canada 2014)
			Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)
	Tryngites subruficollis	Buff-breasted sandpiper	Canada, United States	North America	1974	2013	(Continental migrating shorebird annual indices 2014)

Table 2. The 22 time-series that were removed from the Arctic migrants data set to avoid replication.

Family	Binomial	Common name	Country	Location	Start year	End year	Reference
Anatidae	*Aythya marila*	Greater scaup	Canada	North America	1970	2002	(Jamieson & Brooks 2004)
Gaviidae	*Gavia pacifica*	Pacific loon	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe et al. 2012)
Laridae	*Larus thayeri*	Thayer's gull	Canada	Cambridge Bay, Victoria Island, Nunavut	1983	1986	(Lok & Vink 2012)
				Continental shelf off the coast of Vancouver Island	1986	1987	(Vermeer et al. 1989)
				Strait of Georgia, British Columbia	2000	2011	(Crewe et al. 2012)
Scolopacidae	*Arenaria interpres*	Ruddy turnstone	United States	The Outer Banks, North Carolina	1992	1993	(Dinsmore et al. 1998)
	Calidris alba	Sanderling	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe et al. 2012)
			United States	The Outer Banks, North Carolina	1992	1993	(Dinsmore et al. 1998)
				Western portion of Isla Vista, Santa Barbara County, California	1995	2000	(Hubbard & Dugan 2002)
	Calidris alpina	Dunlin	Canada	Strait of Georgia, British Columbia	2000	2011	(Crewe et al. 2012)
			United States	Willapa Bay, Washington	1992	1994	(Buchanan & Evenson 1997)

Family	Binomial	Common name	Country	Location	Start year	End year	Reference
	Calidris canutus	Knot / Red knot	United States	Cape Romain National Wildlife Refuge, South Carolina	2001	2003	(Niles et al. 2007)
				Delaware Bay	1982	2006	(Dey et al. 2011) updated with (Niles et al. 2007)
				The Outer Banks, North Carolina	1992	1993	(Dinsmore et al. 1998)
				West coast of Florida	2005	2009	(Dey et al. 2011)
	Calidris melanotos	Pectoral sandpiper	United States	Bald Knob National Wildlife Refuge, eastern Arkansas	2001	2002	(Lehnen & Krementz 2005)
	Calidris minutilla	Least sandpiper	United States	The Central Valley, California	1993	1995	(Shuford et al. 1998)
	Limnodromus scolopaceus	Long-billed dowitcher	United States	The Central Valley, California	1993	1995	(Shuford et al. 1998)
	Numenius phaeopus	Whimbrel	United States	The Outer Banks, North Carolina	1992	1993	(Dinsmore et al. 1998)
				Western portion of Isla Vista, Santa Barbara County, California	1995	2000	(Hubbard & Dugan 2002)
	Phalaropus lobatus	Red-necked phalarope	United States	The Central Valley, California	1993	1995	(Shuford et al. 1998)
	Tryngites subruficollis	Buff-breasted sandpiper	United States	Eastern Rainwater Basin, Nebraska	2004	2005	(Jorgensen 2007)

Index comparisons

The addition of data resulted in an overall Migratory Arctic Bird index that is slightly more positive throughout, leading to an overall change of 47% between 1970 and 2011 compared to the 39% that were obtained using the previous data set (Figure 3). The difference between the old and revised indices was slightly larger in the Americas flyway region (Figure 4); the initial version showed an estimated increase of 16% over the study period compared to 28% for the revised index. The inclusion of selected time-series from long-term monitoring programmes in North America thus appears to have limited impact on the overall shape of the indices although the 2011 value was higher in both cases, suggesting a greater increase in abundance overall since 1970 for this specific subset of species populations.

Figure 3. Index of abundance for 966 time-series of 129 Arctic migratory bird species monitored in locations inside and outside the Arctic boundary from 1970 to 2011 (Migratory Arctic Bird Index, blue line). Also shown is the index of abundance for an adjusted data set integrating long-term time-series from Canada and the US for which 27 time-series were added and 22 time-series were removed. The total revised data set comprised 970 time-series of 132 species. Dashed lines are 95% confidence limits.

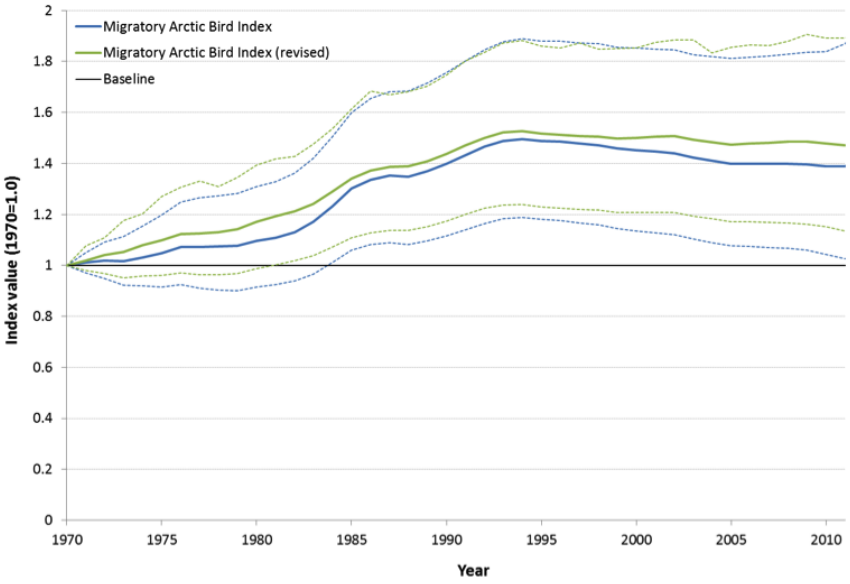
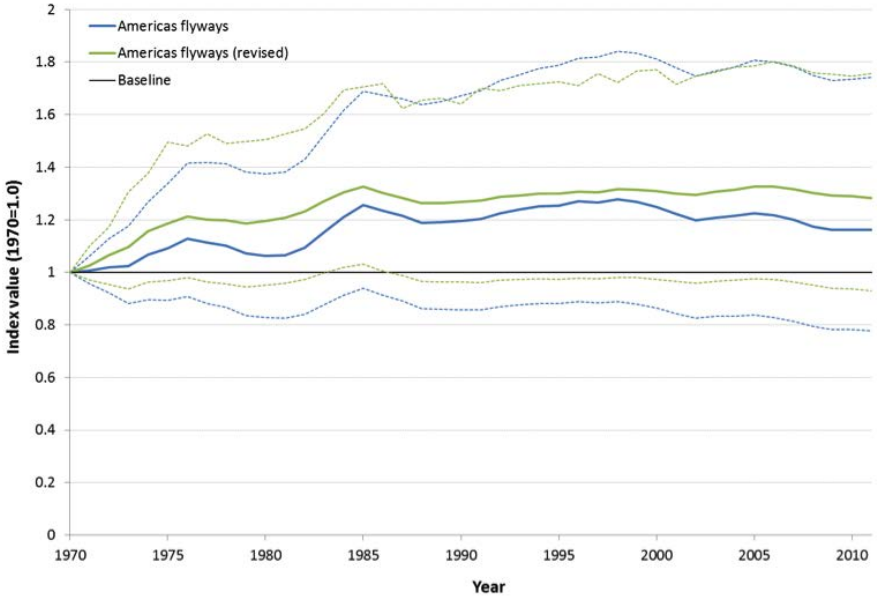


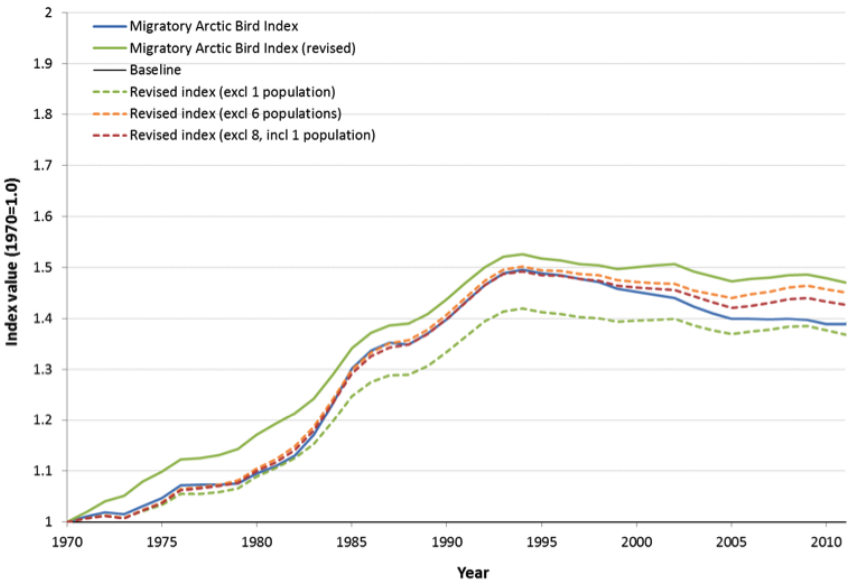
Figure 4. Index of abundance for 263 time-series of 84 Arctic migratory bird species monitored in locations inside and outside the Arctic boundary within the Americas flyway region from 1970 to 2011 (blue line). Also shown is the index of abundance for an adjusted data set integrating long-term time-series from Canada and the US for which 27 time-series were added and 22 time-series were removed. The total revised data set comprised 267 time-series of 88 bird species. Dashed lines are 95% confidence limits.



Because the new indices are a similar shape but of different magnitude, it follows that the trends may diverge due to the influence of a species or group of species early on in the study period – in this case, the influence would be positive since the new index is consistently higher throughout. The species responsible for the difference is the Thayer's gull Larus thayeri, for which time-series were added from Arctic Canada and the Canadian Christmas Bird Count region (Table 1), replacing records from Nunavut, Vancouver Island and the Strait of Georgia (Table 2). These changes result in data being available for the whole study period for this species, including the time prior to 1983 (the earliest available year in the original data set). However, it is specifically the time-series for Canada from the Christmas Bird Count (1970-2012) that causes this shift, as its removal results in an index that nearly matches the old index until 1983 (Figure 5). Unfortunately, there is no additional information recorded for this population which could provide a reason for why this population is increasing. This type of information is normally recorded in the LPI database if it is available in the original data source.

While removal of this additional population from the revised data set results in matching trajectories at the beginning of the study period, the new and old trends still diverge from the mid-1980s onwards. Exclusion of a further 5 populations of 5 species (Stilt sandpiper Calidris himantopus, Purple sandpiper C. maritima, Least sandpiper C. minutilla, American golden plover Pluvialis dominica and Buff-breasted sandpiper Tryngites subruficollis) from the Continental Migrating Shorebird monitoring programme closes this gap until the late 1990s (dashed orange line, Figure 5). Again, there is no additional information available that could provide an explanation for why these species populations are doing worse in the 1980s and 1990s than the existing populations in the original data set. The difference from 1998 until the end of the study period cannot be attributed to a single population or species, although it is reduced by excluding a further two populations of Red phalarope Phalaropus fulicarius and Surfbird Aphriza virgata, and including an old population of Buff-breasted sandpiper (dashed red line, Figure 5). The remaining difference is likely due to around 9 species showing higher increases or lower decreases over this period, caused by the addition of new population time-series, the removal of old time-series, or both. Overall, of the 26 time-series added, 8 appear to collectively have a noticeable effect on the magnitude of the trend (in addition to another which was removed from the data set), making abundance change in selected Arctic migrant species populations between 1970 and 2011 more positive.

Figure 5. The Migratory Arctic Bird Index (blue line), the revised index (green line), the revised index without 1 newly added population of Larus thayeri (dashed green line), the revised index without 6 new populations of L. thayeri, *Calidris himantopus, C. marititma, C. minutilla, Pluvialis dominica and Tryngites subruficollis (dashed orange line), and the revised index without 8 populations of L. thayeri, Calidris himantopus, C. marititma, C. minutilla, Pluvialis dominica, Tryngites subruficollis, Phalaropus fulicarius and Aphriza virgata and the addition of an old population of Tryngites subruficollis.*



Summary

The addition of 27 long-term time-series to the Arctic migrant bird species data set has had a minor effect on the two indices presented here, much of which can be ascribed to a small number of species. For both the pan-Arctic and the Americas indices, change is overall more positive, with the final index values in 2011 showing a difference of around 10 percent points. While this suggests that important information may indeed be missing, the fact that the global trend is slightly influenced by such a small number of populations further supports the assumption that the current data set would benefit from the addition of more time-series data to render it truly representative of trends in Arctic migrant species globally.

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