Final Report for The Convention on the Conservation of Migratory Species

The Living Planet Index for Migratory Species: an index of change in population abundance

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Executive Summary

The Living Planet Index (LPI) uses aggregated population trends among vertebrate species to indicate the rate of change in the status of vertebrate biodiversity. The LPI has been adopted by the Convention on Biological Diversity to address the question of whether the 2010 target, to achieve a significant reduction of the current rate of biodiversity loss, has been met. The methods for aggregating population trend information can be applied to any given subset of species, and in this case has been applied to CMS listed and Global Register of Migratory Species-defined species to provide global LPIs of CMS listed species (LPI-CMS) and migratory species (LPI-MS). Analyses revealed that migratory species have overall increased in global abundance between 1970 and 2006, although the index indicates little trend in this abundance in recent years. Interestingly, the global LPI-CMS showed that CMS-listed species are increasing in abundance at a faster rate than migratory species in total. Like the CMS appendices, bird species dominate the LPI-CMS dataset. As each species is given equal weight within the index, trends in CMS-listed birds are having the most influence on the global LPI-CMS trend. To address this, data was disaggregated by class to reveal trends at the taxonomic level that were not apparent within the global LPI-CMS. Mirroring the global LPI-CMS, the CMS listed bird species index increased in abundance between 1970 and 2006, however CMS-listed fish species abundance showed a steep decline in this time. CMS-listed mammal species abundance increased between 1970 and 2006; but on further analysis it was found that this increase was due to increases in marine species such as large whales, and in fact terrestrial mammal species abundance showed an overall pattern of decline over the 36 years. Further disaggregations revealed trends at a number of taxonomic and geographic sub-levels; such as for ACAP and AEWA-listed CMS species and for Afro-Palearctic and Neotropical-Nearctic migrant species. These indices illustrate how global indices can hide certain taxa and/or regions that are at risk, while conversely they highlight the risks of concentrating on analyses of small subsets of species which can ignore the global picture. Finally, the global LPI of migratory species was compared with that of non-migratory species. It was found that while migratory species abundance increased between 1970 and 2006; the LPI of non-migratory species showed a significantly different trend, with an overall pattern of decline during this time. Suggestions have been made to explain this finding, but further analyses would help to understand this difference in pattern. Indeed, given added time and resources the LPI dataset can be increased to further enhance global coverage of migratory species and present new avenues for analysis to explain trends. In this way the Living Planet Index can assist the Convention on Migratory Species with future policy decisions.

Biodiversity Monitoring

There is little prospect of effectively reducing global biodiversity loss unless trends in the state of biodiversity, and human impacts on it, can first be measured. One hundred and ninety nations are signed up to the Convention on Biological Diversity (CBD) 2010 target of "achieving…a significant reduction of the current rate of biodiversity loss" (UNEP 2002). One of the key tasks of the CBD is to devise measures of determining whether or not the 2010 target has been met. Monitoring changes in population abundance is one such measure.

At the 8th Convention of the Parties, the Living Planet Index (LPI) was adopted as one of the potential measures to address the CBD headline indicator: change in abundance of selected species (UNEP 2006). The LPI is based one of the largest time series databases on vertebrate population time series, and provides a broad range of vertebrate-population trend indicators. The LPI began life as a communications tool for a WWF campaign, and has since been developed into a versatile robust indicator that provides insight into trends of global vertebrate biodiversity. One of its biggest assets is that it is a simple yet powerful way of conveying information about changing trends in biodiversity to non-experts, including policy and decision makers, and the general public.

Aggregating species population trends

The Living Planet Index is an indicator of the status of vertebrate biodiversity and aggregates population trends across a large number of vertebrate species. The LPI is calculated using time series data on population and, for each year of the index and among all species with data for that year, calculates the average change in population compared with the previous year. A minimum of two data points are required for each species population. For time series with two to five data points, any missing population values from intermediate years are interpolated by assuming a constant annual rate of change between each data point. For time series with six or more data points, the population trend is fitted to the data using a general additive model. No values are extrapolated from the data. The average annual population change in each year is then chained to the previous one to make an index, starting with an initial value of 1 in 1970.

The Living Planet Index has been employed since 1998 to generate a global indicator of species population trends (Loh *et al.* 2005). This index shows that since 1970, a global decline in abundance of around 30% has been observed in monitored vertebrate populations. The same technique can be applied to any given subset of species, and a large body of work exists evaluating the best techniques to achieve this (e.g. see Fewster *et al.* 2000; van Strien *et al.* 2000; Loh *et al.* 2005; Collen *et al.* in press).

An LPI can be created to measure trends in the status of biodiversity at any geographic scale for any given set or group of species, provided that there are sufficient population trend data available. Living Planet Indices have been generated at the global level, for regions and countries, for biomes or biogeographic realms, or for particular taxonomic groups. The Living Planet Index for Migratory Species is the first LPI that has been calculated to illustrate trends among a particular set of species that is subject to an international agreement or convention.

Long term monitoring data provide essential information for effective conservation management. Understanding the direction, magnitude, and timing of changes in population abundance over time is vital to enable species of priority conservation concern to be identified, and reasons for the population changes to be understood and addressed. Aggregating population trends across a set of species gives a sensitive measure of their change in abundance, and allows the tracking of the impact of human pressures on that set of species.

Results

Global Analysis

The global Living Planet Index of CMS appendix species (LPI-CMS) is a measure of the global change in abundance of CMS-listed species based on trends from 1970 to 2006 in almost 2,000 populations of 378 species. The index shows an average pattern of increase, with abundance almost 30% higher in 2006 than 1970 (Figure 1) [1]. The LPI-CMS includes any species that is listed at the family level, for example in the CMS Appendix 2 the family Anatidae is listed and this family contains 163 species. Therefore any of these 163 species that occur in the LPI dataset are flagged as CMS appendix species. This means that some species may be included in the analysis as covered by the CMS agreement at the higher taxon level when they may not actually be migratory; however given the uncertainty of migratory status at the taxonomic level this is currently unavoidable. The Living Planet Index of CMS Appendix 1 species (LPI-CMS A1) is a measure of the global change in abundance of CMS Appendix 1 listed species only, based on trends from 1970-2006 of almost 260 populations of 62 species. The LPI-CMS A1 also shows an overall increase in species abundance, but at a higher rate than the LPI-CMS, with species abundance in 2006 60% higher than in 1970 (Figure 1).

These two LPI-CMS indices are based on populations that are considered migratory at the species or family level as defined by the CMS. In comparison, the Living Planet Index of Migratory Species (LPI-MS) indicates trends in abundance of species that are migratory at the population level, as defined by the Global Register of Migratory Species (GROMS). The LPI-MS is based on trends from 1970-2006 in almost 2,200 populations of 803 species, of which

[1] NB: for all indices produced confidence limits were calculated but are not always shown to avoid over-complication of figures. Confidence limits can be found in Table 2 in the Appendix.

300 species are listed on the CMS appendices. In contrast to the two LPI-CMS indices, the LPI-MS shows a general pattern of slow increase for the first 20 years, however since the early 1990s this pattern has reversed and by 2006 species abundance continues to decline (Figure 1).

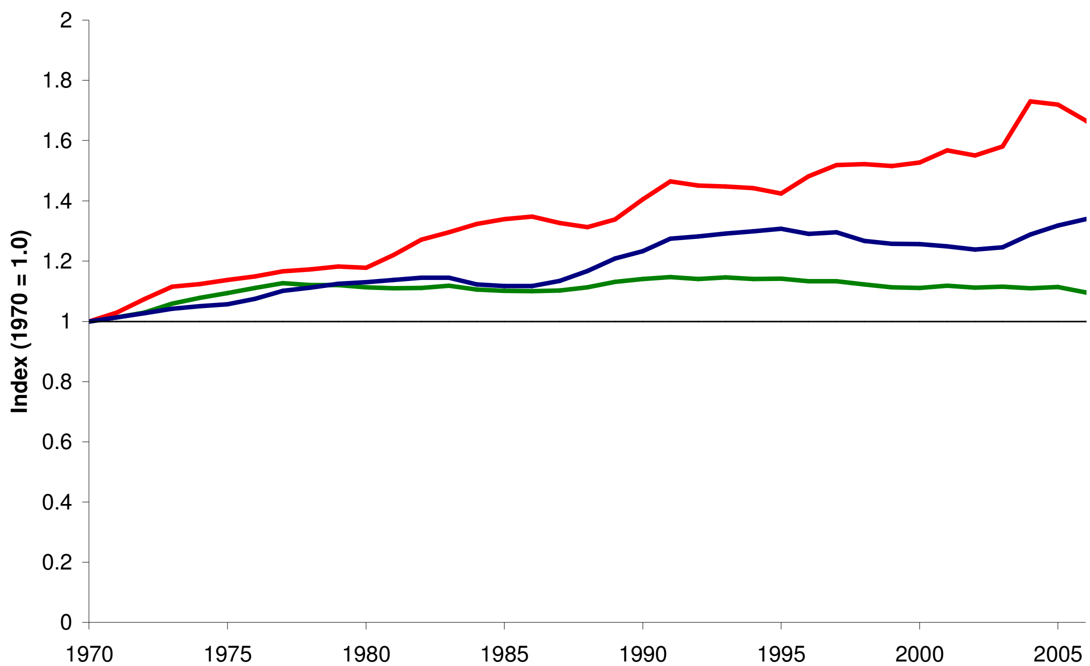

Figure 1. Global Living Planet Indices of CMS Appendix 1 listed species (red line) All CMS listed species (blue line), and all migratory species (green line) for the period 1970-2006 (CMS Appendix I: *n* = 62 species, 258 populations; All CMS: *n* = 378 species, 1814 populations; all migratory: *n* = 803 species, 2,818 populations).

The pattern of increase in CMS-listed species abundance exhibited in Figure 1 may illustrate the success of the convention since it's entry into force in 1979, and suggests that species covered by the convention are faring better than other migratory species. However, while these three indices reveal the average trends in CMS and migratory species globally, disaggregating the data reveals details that are not apparent from such broad scale analyses. Below we present a number of disaggregated CMS and migratory species indices to indicate trends at levels that are otherwise hidden at the global level. This can help identify regions and taxa of particular conservation concern.

Taxonomic analysis

All indices presented in this report are calculated so that each species is given equal weight (see technical appendix). Mirroring the CMS appendices, the LPI-CMS and migratory species dataset are dominated by bird species. Thus the global trends of CMS and migratory species abundance in Figure 1 are largely driven by trends in bird populations. By plotting data for birds, mammals and fish separately, the difference in trend trajectory between the three groups becomes apparent (Figure 2).

The LPI-CMS bird index mirrors the trend of the global LPI-CMS as this group dominates the overall dataset, and shows an overall increase in species abundance between 1970 and 2006 of about 40%. The LPI-CMS fish species index however shows a steep decline in abundance since the mid 1980s. The LPI-CMS mammal species index, while indicating an overall increase in species abundance of 30% between 1970 and 2006, shows a decrease in abundance over the last ten years and no net change over the 15 years before that.

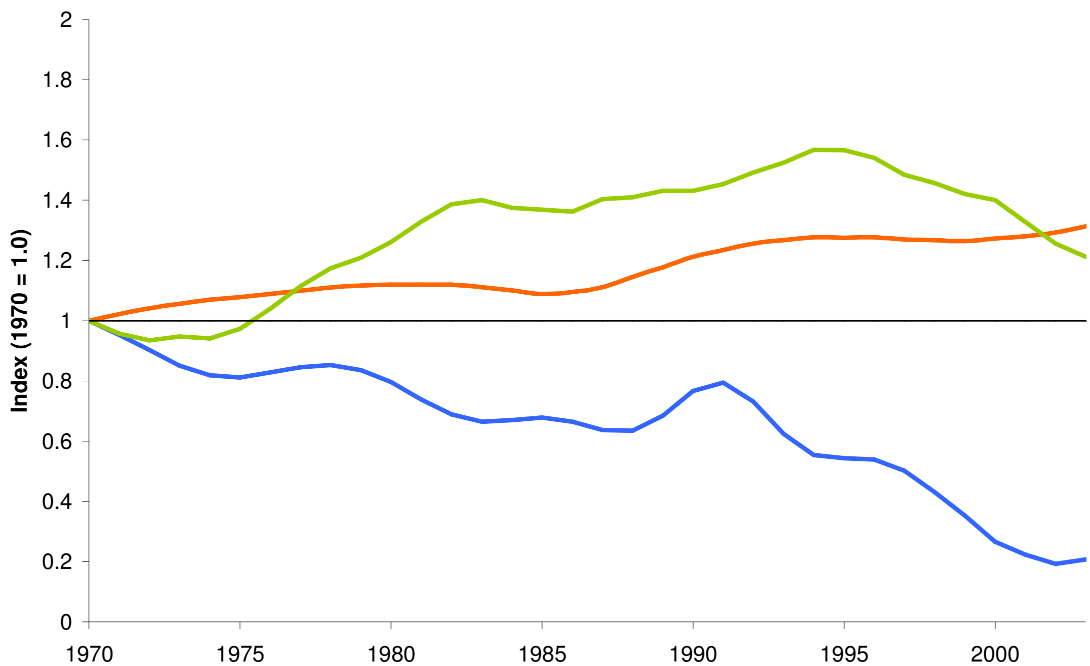

Figure 2. Index of all CMS-listed birds (orange line), mammals (green line) and fish (blue line) for the period 1970-2003 (birds: *n* = 297 species, 1,491 populations; mammals: *n* = 58 species, 213 populations; fish: *n* = 13 species, 21 populations). All three indices are presented with a 3 year running average.

Figure 2 indicates that globally, CMS-listed mammal species have increased in abundance between 1970 and 2006. This result must be interpreted with caution as it can mask downward trends at lower taxonomic or regional levels. Indeed, by disaggregating the mammal species LPI-CMS by system separately the cause for the large increase in the mammal index becomes apparent. While marine and freshwater migratory mammal species have increased overall, terrestrial migratory mammal species abundance declined by 10% from 1970 to 2002 (Figure 3). The increase in the marine species index can be explained by the recent well-documented recoveries of some large whale species, such as the humpback whale, which was down-listed from Vulnerable to Least Concern on The IUCN Red List (IUCN 2008).

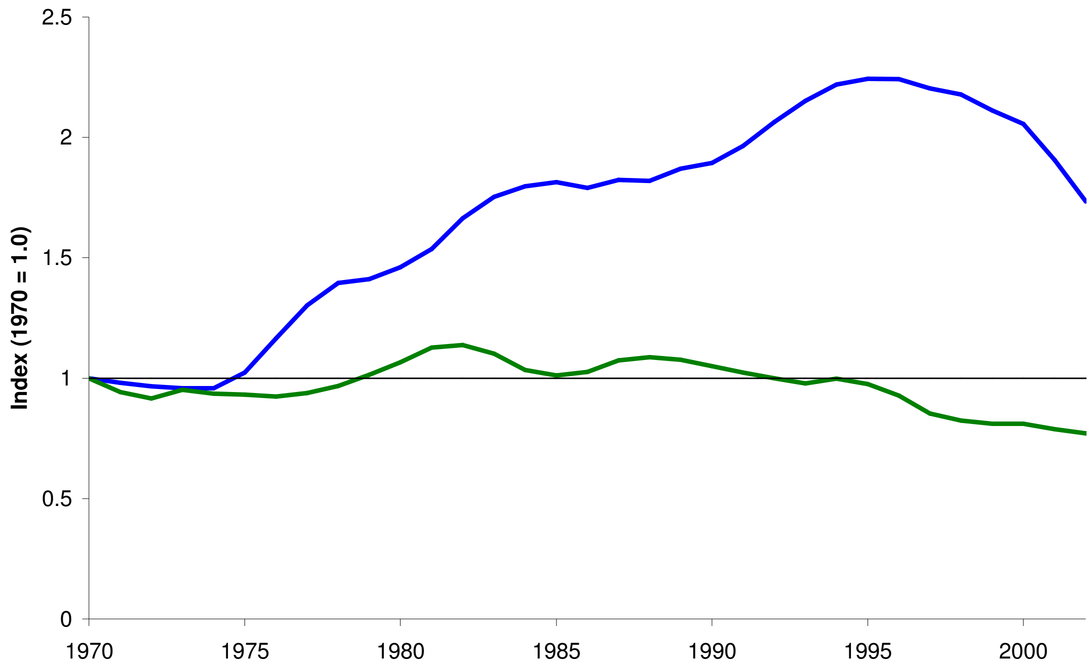

Figure 3. Index of all CMS listed terrestrial mammals (green line) and marine & freshwater mammals (blue line) for the period 1970-2002 (terrestrial mammals: *n* = 27 species, 132 populations; marine & freshwater mammals: *n* = 31 species, 81 populations). Both indices are presented with a 3 year running average.

Three species of chondrichthyan fish are listed in the CMS appendices; the whale shark (*Rhincodon typus*), basking shark (*Cetorhinus maximus*) and the great white shark (*Carcharodon carcharias*). The whale shark and the great white shark are represented in the LPI migratory database by two time series for each species. Box 1 displays the two populations of each shark (Figures 4 & 5) and also the Living Planet Index of these CMS-listed chondrichthyan fish combined (Figure 6). This box serves to illustrate the components of the LPI; in this case the four population time series that are used to calculate the index of average population abundance change for chondrichthyan species. The index illustrates a steep 90% decline in abundance of these species from 1970 to 1994 (Figure 6).

Box 1 - Chondrichthyan fish

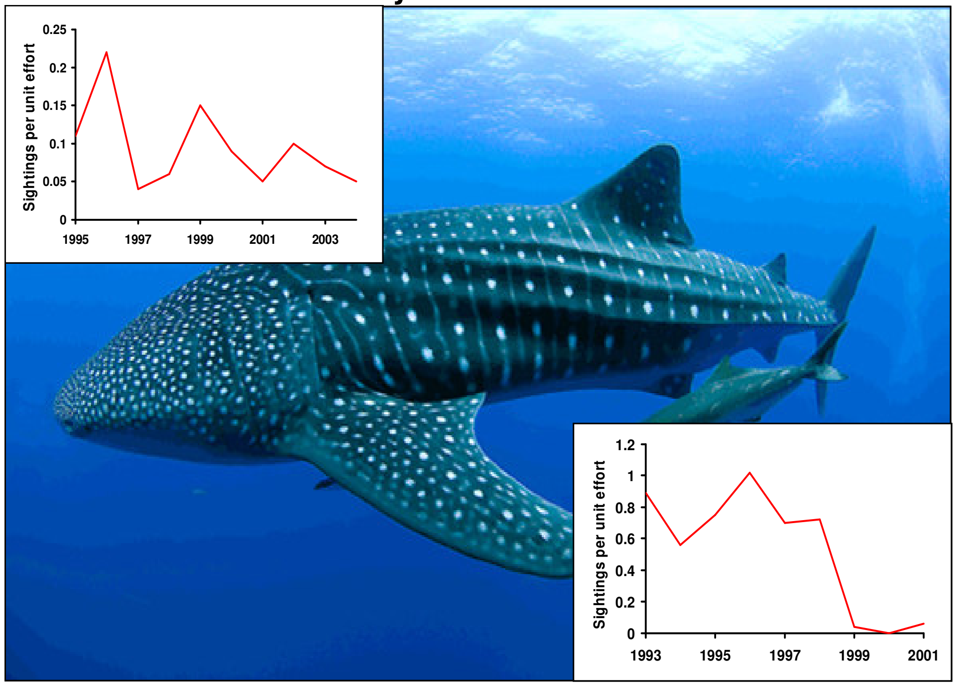

Figure 4. Two population time series for the Whale shark (*Rhincodon typus*) from different locations in the Indian Ocean

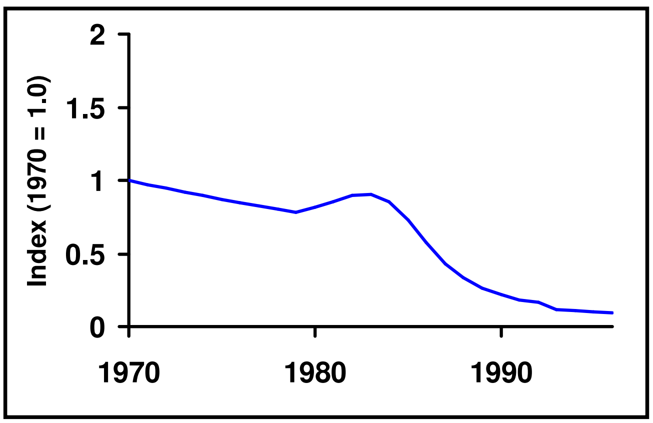

Figure 6. Index of two CMS listed chondrichthyan species for the period 1970-1996 (*n* = 4 populations). This index reveals the average of the four time series shown in figures 4 and 5.

Many chondrichthyan fishes are under threat from overfishing (both directly and through bycatch), pollution and habitat destruction. Slow growth, late maturity and low fecundity are common intrinsic factors that reduce this group's resistance to these threats.

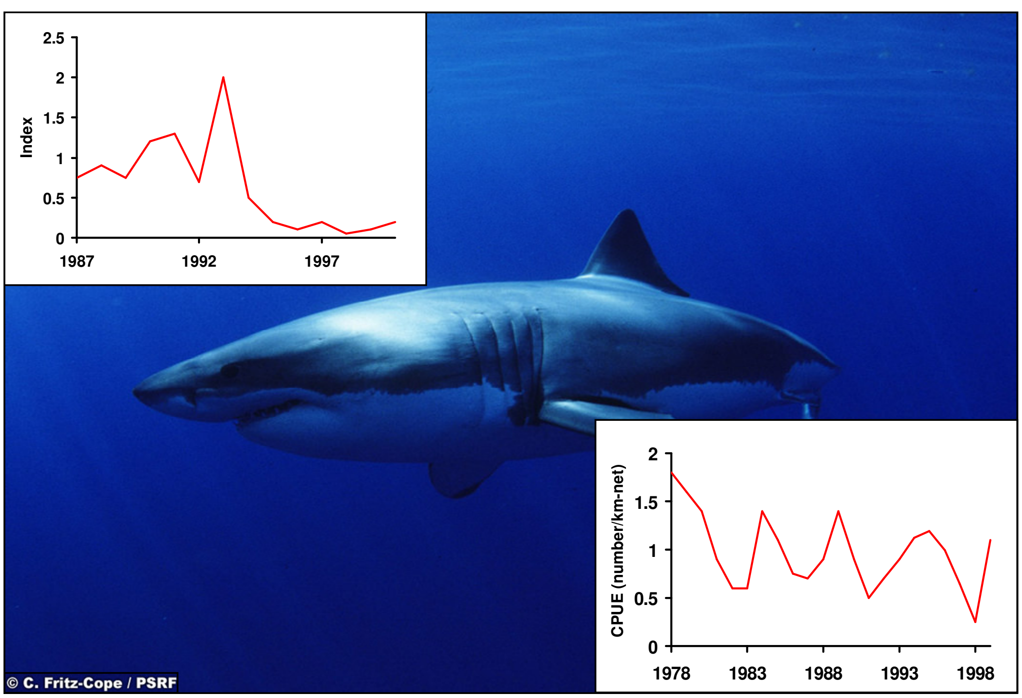

Figure 5. Two population time series for the Great white shark (*Carcharodon carcharias*) from the Northwest Atlantic ocean (top left) and the Indian ocean (bottom right)

The results shown in Figure 2 imply that bird species are not uniformly responding to human impacts in the same way as other taxa. However, not all bird species may be being affected equally; certain groups of birds are more at risk than others. Inter-continental migratory bird populations were divided according to the biogeographic realm they are monitored in to represent the Afro-Palearctic and Neotropical-Nearctic flyways. In this way we see differences in the trends in species abundance between two such groups (Figure 7). The index of Afro-Palearctic species indicates a 20% overall increase between 1970 and 2005 in abundance of inter-continental migratory bird species within this flyway, though abundance has been in decline since the mid-1990s. Conversely, the Neotropical-Nearctic index shows a steady decline in the abundance of birds migrating along this flyway, with species abundance almost 10% lower in 2006 than in 1970 (Figure 7). While the opposing trajectories are of interest the difference in trends between the two flyway indices is not significant, and so the global LPI-MS is not hiding any large discrepancy between Old world and New world migrants.

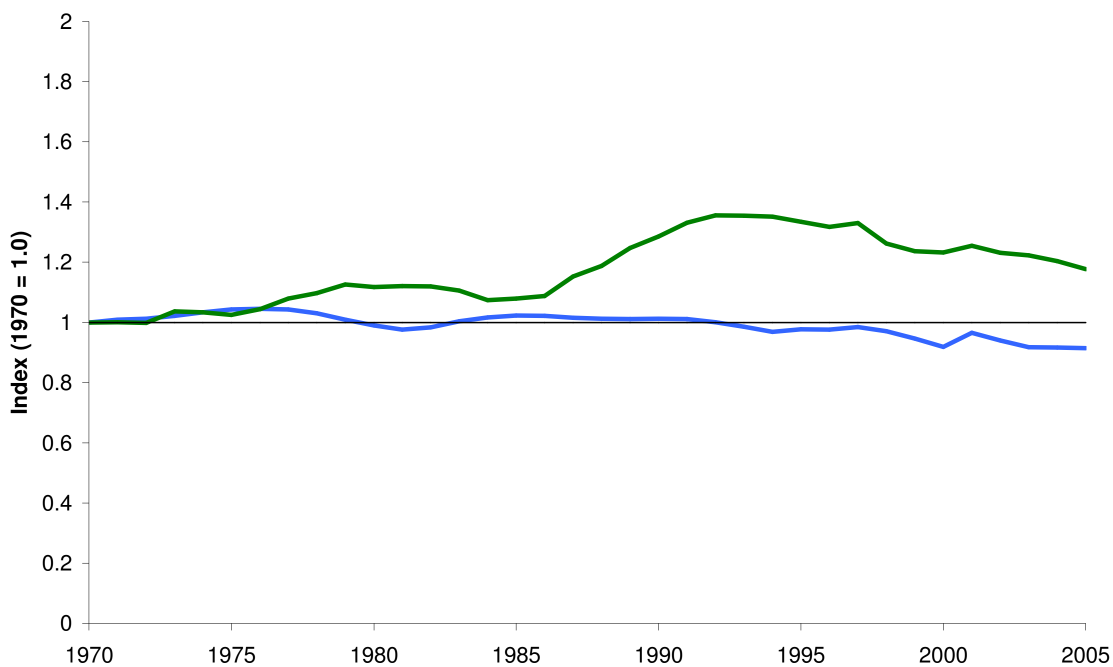

Figure 7. Index of Afro-Palearctic (green line) and Neotropical-Nearctic migratory bird species (blue line) for the period 1970-2005 (Afro-Palearctic migratory species: *n* = 139 species, 739 populations; Neotropical-Nearctic migratory species: *n* = 118 species, 137 populations).

Declines in species that follow particular migratory routes have previously been reported in the literature. For example, Sanderson *et al* (2006) concluded that Afro-Palearctic migrant birds have shown a pattern of sustained, often severe, decline based on population trends of 121 species. These findings are contradictory to those presented in Figure 7. However, when we select for and analyse those species used in the Sanderson *et al* analysis that are within our LPI migratory dataset, the selected Afro-Palearctic migratory species index is in agreement with the findings of Sanderson *et al.*, and shows a near 20% decline between 1970 and 2006 (Figure 8).

This example serves to highlight how trends in datasets aggregated at higher levels can mask trends within smaller sub-sets of data at lower levels, and so reveals certain species and/or regions at greater risk than others. This example also demonstrates the risk of concentrating on particular strata or restricted studies, as this can sometimes override the broader picture.

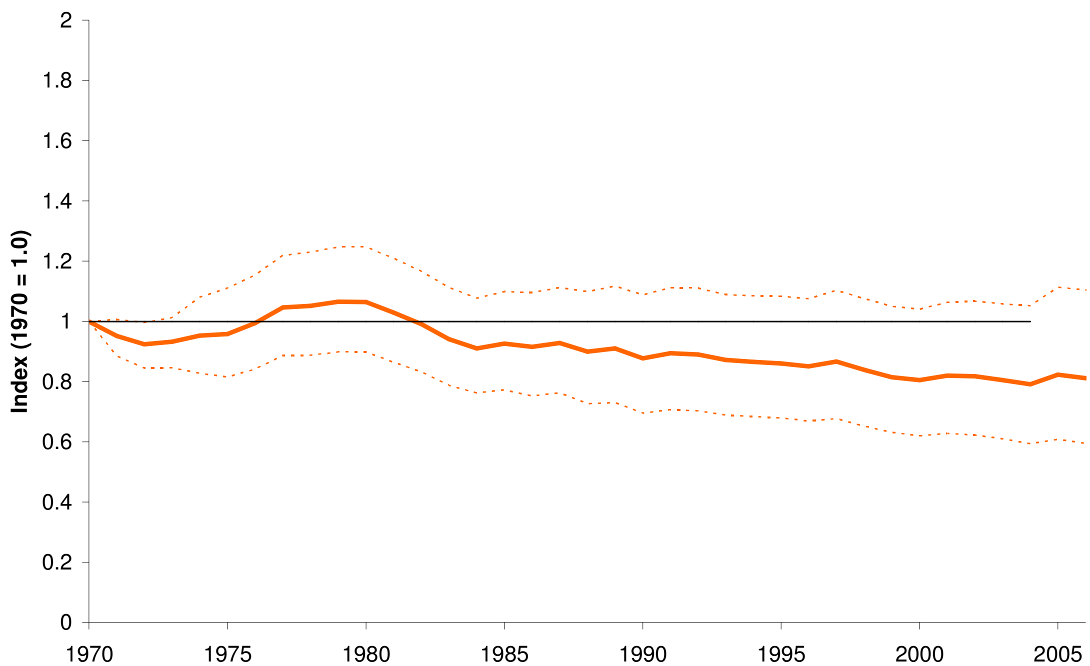

Figure 8. Index of selected Afro-Palearctic migrants for the period 1970-2006 (*n* = 72 species, 321 populations). Confidence limits (dotted lines) for the index are 95% values around the mean, generated using 10,000 bootstrap replicates (see technical appendix).

Monitoring of different sites along bird migration routes is also an important process so as to gauge trends in populations that congregate at staging posts between breeding and over-wintering areas. These locations provide vital stopovers for long distance migrants and changes in the quality or availability of resources could negatively affect the staging of large congregations of birds. Box 2 presents case studies illustrating trends in bird populations from staging posts on two different flyways.

Box 2 - Passage Migrants

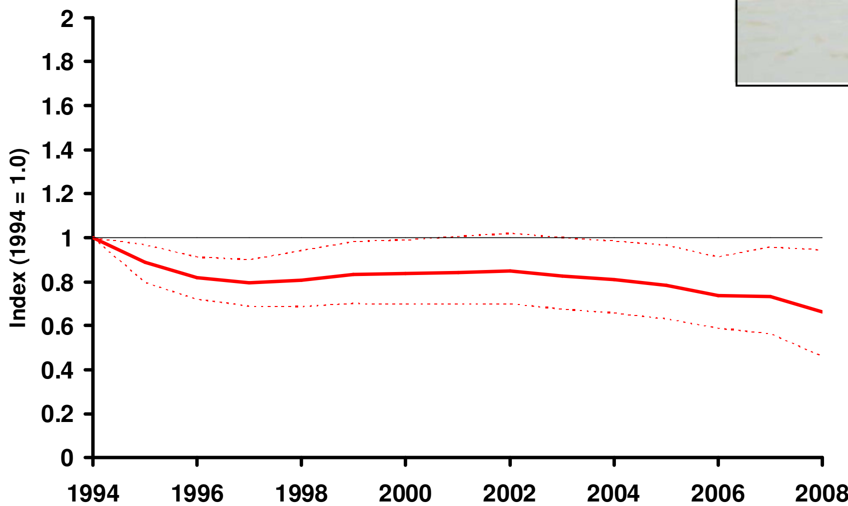

Figure 9. Index of passage migrants for the period 1994 – 2008 (*n* = 79 species, 101 populations). Confidence limits (dotted lines) for the index are 95% values around the mean, generated using 10,000 bootstrap replicates (see technical appendix).

Figure 9 above shows the average trend in abundance of bird species at staging posts from two different locations; Saemangeum in the Republic of Korea and Doñana National Park in Spain - situated in the East Asian/Australasian and the Western Palearctic flyways respectively. These passage migrants show a slow decline over the 14 year period primarily due to pollution and degradation of their wetland habitat. These studies concluded that such long-distance migrants may be less adaptable to habitat and resource variability, leaving them more prone to decline in numbers where these threats occur (Rendón et al., 2008; Moores et al., 2008). Here, declines in abundance of migratory birds could be attributed to a change in staging site where conditions are more favourable rather than a genuine loss of abundance. However, results from national monitoring of the surrounding areas of the Saemangeum site found that the birds had not relocated elsewhere but that there had been a sustained decline in many species of shorebirds. The Spoon-billed sandpiper (pictured above) occurred in the world's largest concentrations in Saemangeum from 1997-2005 but has since suffered considerable reduction in numbers and is now threatened with extinction (Moores et al., 2008).

Migratory distance analysis

With indices of Afro-Palearctic and Neotropical-Nearctic migratory species indicating different patterns of trend within bird species that migrate long distances, it is of interest to investigate any differences in species abundance trends between 'long', e.g. intercontinental or interoceanic species, and 'medium', e.g. intracontinental or intraoceanic species, distance migrants. Figure 10 shows trends in all migratory species according to the distance travelled during migration. The index of change in abundance of species that migrate 'long' distances shows a relatively flat trend. The index shows a slow increase for the first 20 years, however since the early 1990s this trend has become progressively more negative and by 2006 species abundance declined to the1970 level (Figure 10). The index of change in abundance of species that migrate 'medium' length distances indicates an overall decline of about 10% over 36 years, though this trend appears to be in reverse in more recent years (Figure 10). The trends of these two indices appear quite similar and any difference between them is not significant (see confidence limits in Table 2 in the Appendix).

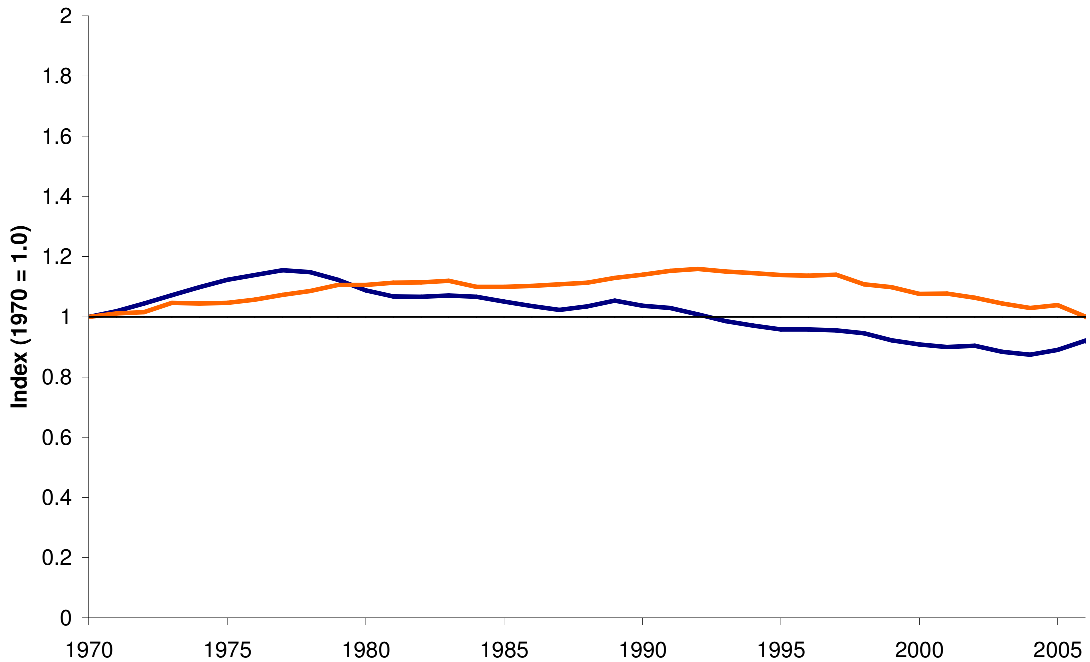

Figure 10. Index of 'long' distance (orange line) and 'medium' distance migratory species (blue line) for the period 1970-2006 (long distance migratory species: *n* = 302 species, 2,820 populations; medium distance migratory species: *n* = 156 species, 294 populations).

CMS Agreements analysis

In addition, indices have been disaggregated to investigate trends in species listed under particular CMS Agreements. The Living Planet Index for ACAP (The Agreement on the Conservation of Albatrosses and Petrels) species indicates a near 40% decline in species abundance between 1970 and 2004 (Figure 11). This index only includes populations of albatrosses and petrels from the French Southern Territories, South Georgia and the South Sandwich Islands and South Africa. The decline in albatrosses and petrels has also recently been documented globally (Gales, 1998), a trend attributed predominantly to commercial long-line fishing practices. The pelagic fishery for tuna has had one of the largest impacts on populations of Procellariiformes both in terms of fishing effort and the spatial scale covered. In contrast, The Living Planet Index of AEWA (The Agreement on the Conservation of Africa-Eurasian Migratory Waterbirds) listed species indicates a large increase in species abundance between 1970 and 2006, particularly since the mid-1980s (Figure 11).

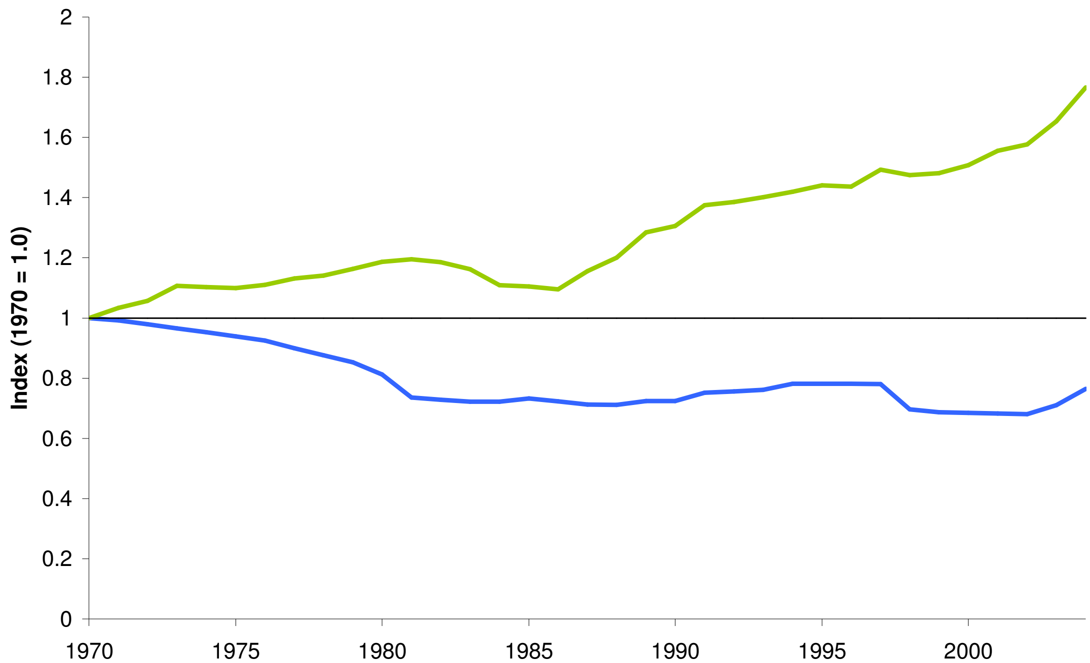

Figure 11. Index of ACAP (blue line) and AEWA (green line) listed migratory species for the period 1970-2004 (ACAP: *n* = 7 species, 11 populations; AEWA: *n* = 123 species, 1,017 populations).

Migratory vs. Non-migratory species

The final index shows global trends in non-migratory species, and is compared with the global Living Planet Index of Migratory Species (LPI-MS), as defined by GROMS. The Living Planet Index of non-migratory species indicates a steady decline over 35 years, with average abundance about 5% lower in 2005 than in 1970 (Figure 12), a significantly different trend to the LPI-MS. This figure indicates that on a global scale, migratory species are at less risk than non-migratory species. This may be due to the higher volume of bird species data in the LPI migratory species dataset than in the non-migratory dataset (see Table 1 in the Appendix). As previously discussed, bird species are influencing the positive trend of the LPI-MS, and so the difference in the two trends may just be indicative of birds being at less risk than other taxa. Alternatively, the difference in trend between the two indices may be due to the nature of migration itself, for example migratory species are able to migrate from areas suffering from human impact or degradation. Furthermore, migratory species may have broader tolerances to environmental conditions compared to non-migrants.

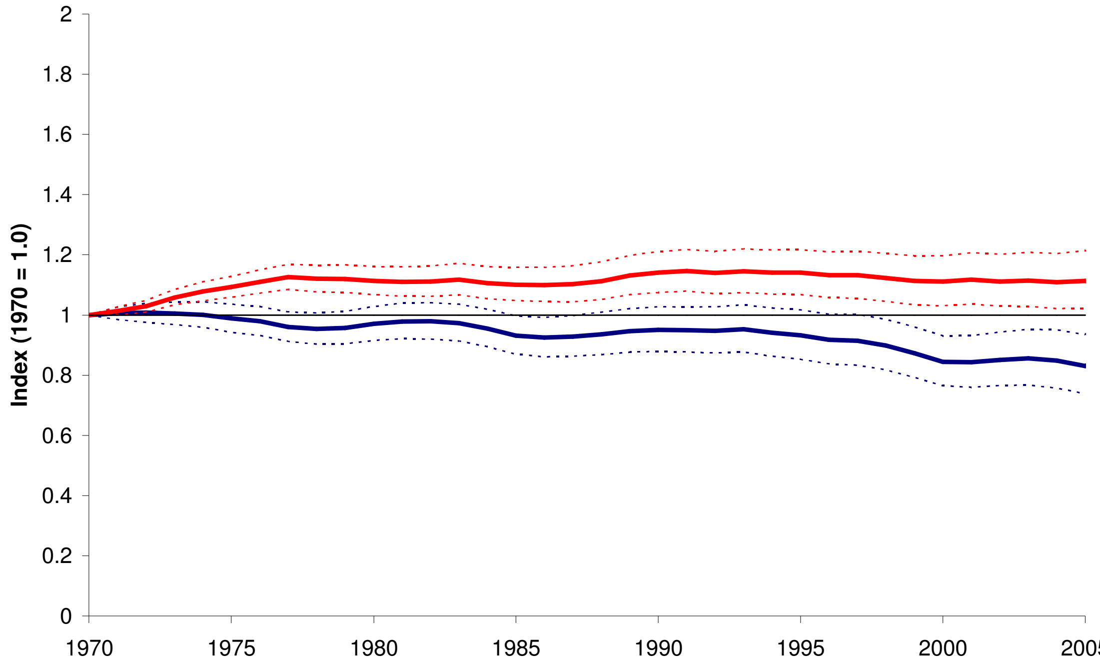

Figure 12. Global Living Planet Index of all migratory (red line) and non-migratory species (blue line) for the period 1970-2005 (all migratory species: *n* = 803 species, 2,818 populations; all non-migratory species: *n* = 1,047 species, 2,531 populations). Confidence limits (dotted lines) for the index are 95% values around the mean, generated using 10,000 bootstrap replicates (see technical appendix).

Conclusions and recommendations

The global Living Planet Index of migratory species shows an overall increase of about 10% in species abundance between 1970 and 2006. By disaggregating the global data, trends at the regional and taxonomic level become apparent. For example, further analyses found that migratory bird species are at less risk than migratory mammal or fish species and that Old world and New World migrant abundance trends are not significantly different from each other. In this way certain groups of species or populations within certain geographic areas that are under threat become apparent, such as the declines in ACAP species presented here that in the literature have been attributed to long-line fishing practices. Comparison with non-migratory species suggests that globally, migratory species are at less risk than non-migratory species. Suggestions have been made to explain this finding, but further analyses would help to understand this difference in pattern.

Recent data collection efforts have highlighted particular areas where available population trend data are lacking. In particular, 414 bat species are listed on the CMS appendices but these species are poorly represented in monitoring programmes, as illustrated by the disparity in terrestrial mammal species coverage indicated in Table1 in the Appendix. While current data coverage for bat species population trends is poor, BatLife – Europe, recently established by NGOs such as The Bat Conservation Trust, is working on a European Monitoring Project and they are looking to extend it to other regions with the help of global partners such as the Zoological Society of London.

Given the time and scope of this project the increase in migratory species data in the LPI dataset has been a major advance, however large population time series datasets for vertebrates remain to be collected. With added time and resources the LPI dataset can be increased further to continue to better-represent migratory species. Analyses presented in this report have introduced areas for discussion regarding migratory species and their vulnerability to human pressures in comparison to non-migratory species. Further analyses will allow better understanding of migratory species ecology and potentially the threats associated with observed declines. This report highlights trends in population abundance of taxonomic groups and/or geographic areas that are covered by existing CMS appendices and agreements in a simple yet informative matter, and so can assist the Convention on Migratory Species with future policy decisions.

Appendix I

Data coverage

The existing LPI database, which serves up data for the global Living Planet Index, held data on nearly 2000 populations of 674 migratory species at the beginning of this project, of which 265 species are listed on CMS appendices. A gap analysis was used to identify areas requiring additional data coverage and direct data collection to achieve a more accurate representation of migratory species. Three months of targeted data collection has resulted in a total of 2818 populations of 803 migratory species, of which 378 species are listed on all CMS appendices and 62 species are listed on CMS appendix 1. These are distributed as shown in Table 1. While poorly studied groups such as the bats remain under-represented in this dataset, the ratio of the number of each class of migratory species listed in the CMS appendices is broadly proportional to that of the number of species of each class in the LPI (Figure 13).

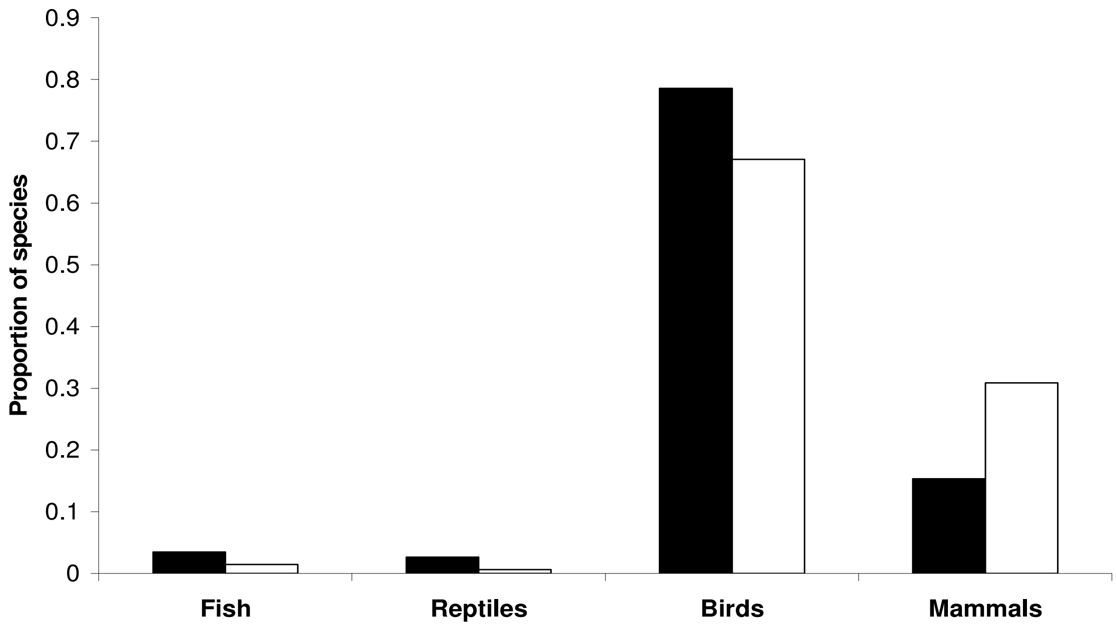

Figure 13. Species representation as a proportion of the total species listed in the CMS appendices (white bars) and LPI dataset (black bars) for each vertebrate class.

Like the species coverage on the CMS appendix, the data currently held in the LPI database are skewed towards birds (Table 1). Weighting an index can help reduce the dominance of certain data from a particular taxonomic group or region, but it should be done in such a way so as to avoid replacing one bias with another. The global LPI is weighted by temperate and tropical regions and by system (terrestrial, freshwater and marine) to account for the uneven ecological and geographical coverage of data (Loh et al., 2008). However, using the same global LPI tropical/temperate weighting system for any migratory index is not necessarily appropriate. By nature, many migratory populations may be representative of trends in both tropical and temperate regions, as a species is impacted by conditions at both wintering and breeding grounds for example. If a weighting system is to be applied in order to uncover the trends from an under-represented set of data, then that subset must be of sufficient size to be analysed separately and also be reflecting a different set of trends to the dominant subset. For these reasons all indices presented in this report are calculated so that each species is given equal weight within each index.

Table 1. Data coverage in the LPI and species listed on the CMS appendices by class.

		Fish	Reptiles	Birds	Mammals	Total
No. of species in the LPI dataset	CMS species (incl. those listed at family level)	13	10	297	58	378
	CMS species populations (incl. of those listed at family level)	21	89	1,491	213	1,814
	CMS Appendix 1 species	2	8	32	20	62
	CMS Appendix 1 species populations	2	75	117	63	258
	Migratory species (GROMS-listed species)	86	10	649	58	803
	Migratory species populations (GROMS-listed species populations)	448	84	2,075	211	2,818
	Non-migratory species	217	44	482	304	1,047
	Non-migratory species populations	493	96	971	971	2,531
Total no. of species listed on the CMS Appendices	CMS species (incl. those listed at family level)	23	10	1,073	494	1,600
	CMS Appendix 1 species	4	8	72	33	117

Technical appendix

Living Planet Indices of Migratory and CMS species

The species population data used to calculate the indices are gathered from a variety of sources primarily published in scientific journals, but also from grey literature where studies meet the appropriate standard. All data used in constructing the indices are time series of either population size, density, abundance or a proxy of abundance. The period covered by the data runs from 1960 to 2008. Annual data points were interpolated for time series with six or more data points using a generalized additive modeling framework (Collen *et al.* in press), or by assuming a constant annual rate of change for time series with less than six data points. The average rate of change in each year across all species was calculated (Loh *et al.* 2005). The average annual rates of change in successive years were chained together to make an index, with the index value in 1970 set to 1. We used a bootstrap resampling technique to generate confidence limits around the index values; these are not shown to avoid over-complicating the figure but are given in Table 2 below. Equal weighting was given to each species within the index. The global LPI-CMS, LPI-CMS A1, LPI-MS and disaggregated indices were aggregated according to the hierarchy of indices shown in Figure 14.

Disaggregated Indices

Separate indices were calculated for the following groups to show trends in CMS and migratory species by class, geographic divides and trends in passage migrants and non-migratory species:

- bird, fish and mammal CMS species
- terrestrial and marine & freshwater CMS listed mammal species
- chondrichthyan fish CMS species
- Afro-Palearctic and Neotropical-Nearctic migratory species
- selected Afro-Palearctic species
- Passage migrants
- ‘long’ and ‘medium’ distance migratory species
- ACAP and AEWA listed species and
- Non-migratory species

Indices were calculated in the same way as described for the global indices of migratory and CMS species. Confidence limits were generated for each index, but not always shown so as not to over-complicate the final figure (though are displayed in Table 2 below). A three-year moving average was applied to the CMS-listed bird, mammal and fish species indices and to the CMS-listed terrestrial and marine & freshwater mammal indices.

Figure 14. Hierarchy of indices within the Living Planet Indices of migratory species, CMS species, and disaggregated indices. Each population carries equal weight within each species and each species carries equal weight within the global indices and disaggregated indices.

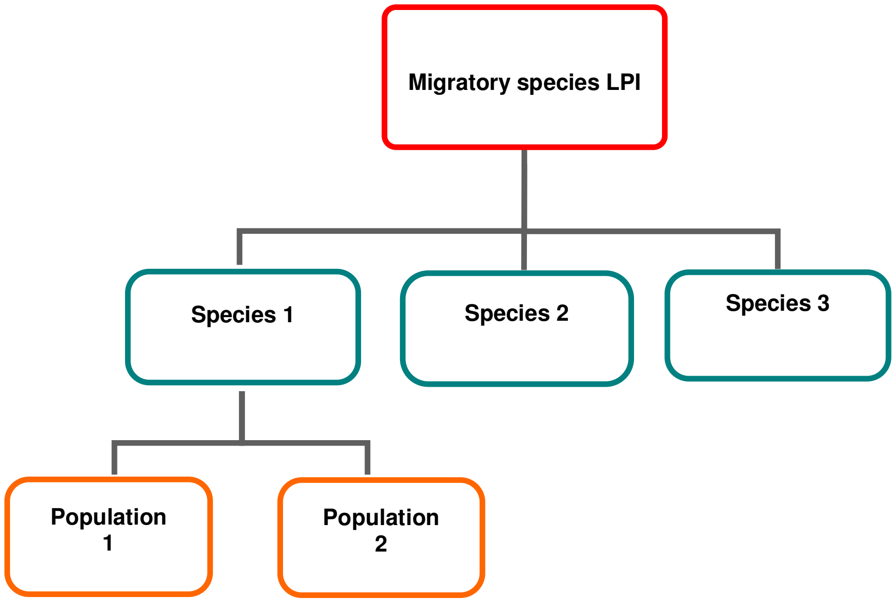

Table 2. Index values and 95% confidence limits (C. L's) for all indices presented at five-year intervals between 1970 – 2005.

Index		1970	1975	1980	1985	1990	1995	2000	2005
CMS Appendix 1	Index	1.00	1.14	1.18	1.34	1.40	1.42	1.53	1.72
	Lower C. L.	1.00	1.02	1.02	1.14	1.15	1.12	1.13	1.13
	Upper C. L.	1.00	1.27	1.36	1.58	1.72	1.82	2.06	2.64
All CMS	Index	1.00	1.06	1.13	1.12	1.23	1.31	1.26	1.32
	Lower C. L.	1.00	1.00	1.05	1.03	1.12	1.17	1.11	1.14
	Upper C. L.	1.00	1.11	1.21	1.21	1.36	1.46	1.42	1.52
Migratory	Index	1.00	1.09	1.11	1.10	1.14	1.14	1.11	1.11
	Lower C. L.	1.00	1.06	1.07	1.05	1.07	1.07	1.03	1.02
	Upper C. L.	1.00	1.13	1.16	1.16	1.21	1.22	1.20	1.21
CMS-birds	Index	1.00	1.08	1.12	1.09	1.21	1.28	1.27	1.35
	Lower C. L.	1.00	1.02	1.04	1.00	1.09	1.14	1.12	1.18
	Upper C. L.	1.00	1.14	1.20	1.18	1.33	1.43	1.44	1.55
CMS-mammals	Index	1.00	0.94	1.25	1.34	1.41	1.62	1.37	1.31
	Lower C. L.	1.00	0.75	0.91	0.93	0.94	1.04	0.85	0.76
	Upper C. L.	1.00	1.18	1.75	1.95	2.14	2.53	2.22	2.32
CMS-fish	Index	1.00	0.81	0.79	0.69	0.78	0.54	0.29	0.53
	Lower C. L.	1.00	0.74	0.68	0.54	0.47	0.28	0.12	0.09
	Upper C. L.	1.00	0.88	0.92	0.89	1.37	1.10	0.72	3.49
CMS-terrestrial mammals	Index	1.00	0.93	1.07	0.98	1.04	1.05	0.80	0.78
	Lower C. L.	1.00	0.59	0.66	0.56	0.57	0.49	0.34	0.33
	Upper C. L.	1.00	1.43	1.70	1.70	1.89	2.23	1.80	1.78
CMS -marine & freshwater mammals	Index	1.00	0.97	1.43	1.79	1.87	2.27	2.02	2.43
	Lower C. L.	1.00	0.91	1.00	1.20	1.14	1.35	1.14	0.88
	Upper C. L.	1.00	1.03	2.35	2.99	3.34	4.11	3.80	7.31
CMS-chondrichthyan fish	Index	1.00	0.87	0.81	0.73	0.22	0.10	-	-
	Lower C. L.	1.00	0.87	0.81	0.73	0.19	0.06	-	-
	Upper C. L.	1.00	0.87	0.81	0.73	0.26	0.17	-	-
Afro-Palearctic migratory species	Index	1.00	1.03	1.12	1.08	1.29	1.34	1.23	1.18
	Lower C. L.	1.00	0.92	0.97	0.93	1.06	1.10	1.00	0.92
	Upper C. L.	1.00	1.14	1.28	1.25	1.54	1.62	1.51	1.49
Neotropical-Nearctic migratory species	Index	1.00	1.04	0.99	1.02	1.01	0.98	0.92	0.91
	Lower C. L.	1.00	0.99	0.91	0.93	0.91	0.87	0.80	0.79
	Upper C. L.	1.00	1.11	1.07	1.13	1.13	1.10	1.05	1.07
Selected Afro-Palearctic migratory species	Index	1.00	0.96	1.06	0.93	0.88	0.86	0.80	0.82
	Lower C. L.	1.00	0.82	0.90	0.77	0.69	0.68	0.62	0.61
	Upper C. L.	1.00	1.11	1.25	1.10	1.09	1.08	1.04	1.11
Passage migrants	Index	-	-	-	-	-	0.89	0.84	0.78
	Lower C. L.	-	-	-	-	-	0.80	0.70	0.63
	Upper C. L.	-	-	-	-	-	0.97	0.99	0.97
Long' distance migrants	Index	1.00	1.05	1.11	1.10	1.14	1.14	1.08	1.04
	Lower C. L.	1.00	0.99	1.03	1.01	1.04	1.03	0.96	0.91
	Upper C. L.	1.00	1.11	1.19	1.19	1.26	1.26	1.21	1.19
Medium' distance migrants	Index	1.00	1.12	1.09	1.05	1.04	0.96	0.91	0.89
	Lower C. L.	1.00	1.05	0.98	0.93	0.90	0.83	0.77	0.74
	Upper C. L.	1.00	1.20	1.21	1.18	1.19	1.12	1.07	1.07
ACAP listed species	Index	1.00	0.94	0.81	0.73	0.72	0.78	0.68	-
	Lower C. L.	1.00	0.91	0.76	0.63	0.62	0.65	0.52	-
	Upper C. L.	1.00	0.97	0.86	0.83	0.83	0.92	0.88	-
AEWA listed species	Index	1.00	1.10	1.19	1.10	1.31	1.44	1.51	1.75
	Lower C. L.	1.00	0.98	1.04	0.95	1.08	1.17	1.19	1.35
	Upper C. L.	1.00	1.23	1.35	1.29	1.58	1.77	1.89	2.24
Non-migratory species	Index	1.00	0.99	0.97	0.93	0.95	0.93	0.85	0.83
	Lower C. L.	1.00	0.94	0.92	0.87	0.88	0.85	0.77	0.74
	Upper C. L.	1.00	1.04	1.03	1.00	1.03	1.02	0.93	0.94

References

Collen B, Loh J, Holbrook S, McRae L, Amin R *et al.* (in press) Monitoring change in vertebrate abundance: the Living Planet Index. Conservation Biology.

Fewster RM, Buckland ST, Siriwardena GM, Baillie SR, Wilson JD (2000) Analysis of population trends for farmland birds using generalized additive models. Ecology 81: 1970-1984.

Gales R (1998) Albatross populations: status and threats. In: Robertson G, Gales R (eds) Albatross biology and conservation. Surrey Beatty, Chipping Norton, pp 20-45

IUCN (2008) Humpback whale on road to recovery, reveals IUCN Red List. IUCN Press Release http://cms.iucn.org/index.cfm?uNewsID=1413 Accessed on 20th November 2008.

Loh J, Collen B, McRae L, Carranza TT, Pamplin FA, Amin R and Baillie JEM (2008) Living Planet Index in 'Living Planet Report 2008' (ed. C Hails) WWF International: Gland, Switzerland.

Loh J, Green RE, Ricketts T, Lamoreux JF, Jenkins M *et al.* (2005) The Living Planet Index: using species population time series to track trends in biodiversity. Philosophical Transactions of the Royal Society of London B 360: 289-295.

Moores, N., D. Rogers, et al. (2008). The 2006-2008 Saemangeum Shorebird Monitoring Program Report. B. Korea. Busan, Birds Korea.

Rendón MA, Green AJ, Aguilera E and Almaraz P (2008) Status, distribution and long-term changes in the waterbird community wintering in Doñana, south–west Spain. Biological Conservation 141 (5): 1371-1388

Sanderson F J, Donald P F, Pain D J, Burfield I J, van Bommel F P J (2006) Long-term population declines in Afro-Palearctic migrant birds. Biological Conservation 131: 93-105

UNEP (2002) Report on the sixth meeting of the Conference of the Parties to the Convention on Biological Diversity (UNEP/CBD/COP/20/Part 2) Strategic Plan Decision VI/26. In: CBD, editor.

UNEP (2006) Report on the eigth meeting of the Conference of the Parties to the Convention on Biological Diversity In: CBD, editor. pp. 374.

van Strien A, Pannekoek J, Hagemeijer W, Verstrael T (2000) A loglinear poisson regression method to analyse bird monitoring data. Bird Census News 13: 33-39.