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THIRD MEETING OF THE STANDING COMMITTEE

04 - 05 July 2005, Bonn, Germany

PROPOSAL FOR GUIDANCE ON DEFINITION OF BIOGEOGRAPHICAL POPULATIONS OF WATERBIRD

AEWA's Second Meeting of Parties called upon *"… the Technical Committee of the Agreement to provide clarification on the procedures used to delimit bio-geographical populations of waterbirds, noting their significance as practical units for conservation management;"* (Resolution 2.1).

The Technical Committee at its 4th meeting decide to progress this task in association with analyses of ringing recoveries and movements contracted to the Avian Demography Unit, University of Cape Town as part of the development of African waterbird ringing programmes. However, this has not proved possible.

The definition of the term 'biogeographical population' adopted by the Ramsar Convention in 1999 (Annex 1) follows that provided by Scott & Rose (1996)[1] in their *Atlas of Anatidae populations in Africa and Western Eurasia.*

Technical Committee's approach to this task was to revisit Scott & Rose's 1996 definition, and to update their thorough summary in the light of developments since 1996. They also reviewed approaches for other waterbird taxa, notably the approaches adopted by the International Wader Study Group in their recent review of African and Western Eurasian wader populations (Stroud *et al.* 2004)[2].

The Technical Committee at its 6th meeting in May 2005 made a final review and agreed on the attached paper to be submitted to the MOP.

Action requested from the Standing Committee

The Standing Committee is requested to review the proposed guidance from its end and approve it for submission to MOP.

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[1] Scott, D.A. & Rose, P.M. 1996. *Atlas of Anatidae populations in Africa and Western Eurasia.* Wetlands International Publication 41, Wageningen, The Netherlands.

[2] Stroud, D.A., Davidson, N.C., West, R., Scott, D.A., Haanstra, L., Thorup, O., Ganter, B. & Delany, S. (compilers) on behalf of the International Wader Study Group 2004. Status of migratory wader populations in Africa and Western Eurasia in the 1990s. *International Wader Studies* 15: 1-259. {www.waderstudygroup.org}

GUIDANCE ON DEFINITION OF WATERBIRD BIOGEOGRAPHICAL POPULATIONS[3]

Conclusions and recommendations

The international approaches to defining waterbird biogeographical populations adopted over the last three decades have provided a valuable means to guide waterbird conservation through the definition of practical population units.

As a basic unit for waterbird conservation management, the biogeographic population has proved an effective approach, especially through its conceptual underpinning of Criterion 6 of the Ramsar Convention. Indeed, in early 2005, a high proportion (35%) of all the 1,421 Ramsar sites world-wide have been designated on the basis (in whole or part) of this "1%" Criterion.

However, the *process* (= timetable, responsibilities and standards) for defining waterbird biogeographical populations — as major units of international conservation policy — is confused or lacking. (In a slightly different context, this is analogous to the situation prior to Ramsar's CoP6 in 1996 which established an international process and responsibility for the regular update of waterbird population estimates — through its Resolution VI.4[4] (Stroud 1996)).

Although the biogeographical populations of Anatidae and waders are generally well defined, there are a range of issues that should be addressed:

1. Assigning responsibility for the definition of biogeographical populations and their revision in the context of AEWA;
2. the key need for transparency regarding assumptions underlying population definitions (audit trails);
3. the value of integrated analyses of count data (waterbird presence and abundance) and ringing data (waterbirds movements);
4. scope for use of new technologies; and
5. providing resources for this activity.

These issues are summarised below.

1. Responsibility for responsibility for defining biogeographical populations

The waterbird Specialist Groups of Wetlands International and IUCN-SSC should have the central role in defining population limits as part of their overall advisory role to Wetlands International and IUCN-SSC. This work should be co-ordinated by Wetlands International. In a similar fashion to the request from Ramsar CoP6 regarding update of 1% thresholds (above), there would be benefit in the AEWA MoP formally requesting this work from Wetlands International and its Specialist Groups for the AEWA region (but see issues on resourcing below).

- AEWA MoP3 should establish responsibilities and a process for the review and update of limits of waterbird biogeographic populations.

[3] Much of this text is based on Chapter 2 of Wetland International's *Atlas of Anatidae populations in Africa and Western Eurasia* (1996) by Derek Scott & Paul Rose, taxonomically expanded, updated and modified.

[4] In which, essentially, Wetlands International was requested to bring to each triennial CoP an update of waterbird population estimates and at each third CoP to revise relevant 1% thresholds.

2. Audit trails

It is important, however, that biogeographical populations are defined explicitly, with any underlying assumptions clearly described. This is for the same reason as the need for explicit documentation of the assumptions underlying published population sizes and trends (Brouwer *et al.* 2003). In particular, it is important that there is a clear and published description of the geographical extent of each waterbird population based on best available knowledge. This is especially important where knowledge is poor and there is limited hard data to support decisions as to the limits of populations.

However, such transparency is currently lacking for the definitions of many waterbird populations.

- Clear transparency of the rationale for decisions will facilitate the future revision of the extent (and size) of such populations in the light of new scientific findings, and accordingly, transparent approaches should be required in relevant future publications.

3. Integrated analyses of count and ringing data

There have been few systematic reviews of waterbird population limits in recent years, despite the existence of a range of new methodologies that might be informative (above). Whilst some of these involve expensive technologies that are unlikely to be widely applied to large samples of birds, there are other approaches that could be readily applied and would be highly instructive with relatively limited investment.

3a. Analysis of available data on waterbird ringing recoveries

Simple consideration of existing, but un-analysed, data relating to waterbird ringing recoveries is capable of giving major new insights.

Good examples are the review of Southern African waterbird ringing recoveries of Underhill *et al.* (1999), distributional ranges of birds ringed or recovered in Greenland (Lyngs 2003), single species analyses such as those undertaken for Dutch-ringed Golden Plover *Pluvialis apricaria* by Jukema *et al.* (2001), and the more ambitious summarisation of results from the national ringing schemes in Belgium (Roggeman *et al.* 1995), Norway (Bakken *et al.* 2003), Sweden (Fransson & Pettersson 2001), and Britain and Ireland (Wernham *et al.* 2002).

Previous analyses of movements of waterbirds shown by ringing have generally not been undertaken in the context of reviewing population limits. There would be great advantage in integrating ringing analyses with review of waterbird count and survey information.

Existing relevant activities by other organisations such as OMPO have potential to assist in developing understanding of waterbird populations through support of analyses of waterbird ringing data.

- Systematic analysis of data on waterbird ringing recoveries should continue to be a priority for AEWA so as to give a better assessment of distributional limits of biogeographic populations. This work should be encouraged on a co-operative, international basis, and integrated with reviews of waterbird survey and census information (below).

3b. Flyway Atlases

The mapped depiction of the geographic limits of different biogeographic populations has long been seen as a conservation priority. Indeed, IWRB organised a whole international symposium in 1976 on the subject of mapping waterbird distributions (Matthews & Isakov 1981), at which was discussed a proposal for an atlas of wetlands and waterfowl so as to map flyways and key sites for ducks, geese and swans (Isakov 1981). This project was eventually realised fifteen years later by Scott & Rose with their 1996 *Atlas of the distribution of African and West Eurasian Anatidae* — a land-mark publication by Wetlands International summarising existing knowledge. However, since then there has been slow progress in developing population atlases for other waterbird taxa, although a major publication on waders is currently in preparation.

- AEWA should give high priority to the development of further flyway atlases, and consideration be given as to how new web-based technologies can be used to integrate and disseminate information, not only on population limits, but also on the locations and importance of key sites. More interactive, GIS-based systems, internationally accessible through the internet might prove to be easier and more cost-effective to keep up-to-date in the light of development of knowledge of waterbird populations (below).

4. Use of new technologies

Recent years have seen the development of a range of new technologies, described above, that can provide information on waterbird population limits. Cost and logistic considerations means that the use of these will generally be limited to individual species or populations, but where such studies are undertaken, results should be integrated with other relevant information.

- New technologies have the potential to help refine knowledge of waterbird biogeographical populations, and AEWA should encourage these approaches, especially in remote areas where conventional fieldwork is difficult.

5. Resources for assessment of biogeographical populations

It is important that AEWA Contracting Parties realise that if there is a need for better quality information on waterbird biogeographical populations, this work will require the provision of resources.

It is notable however, that many of the needs outlined above are already identified as priorities for the implementation of AEWA[5]:

AEWA priorities of major relevance:

17. Publication of an Atlas of Wader Populations
18. Publication of flyway atlases for gulls, terns, herons, ibises, storks and rallidae
19. Pilot study of potential from waterbird ringing analyses for the Agreement area
20. Ringing recoveries in atlases
23. Telemetry in migratory waterbirds
31. Compiling flyway information (in digital format) for use in conjunction with existing waterbird count data and site information

AEWA priorities also of relevance:

15. Survey work in poorly-known areas
16. International Waterbird Census - special gap-filling survey
22. Guideline on the use of satellite tracking for migratory waterbirds
29. Flyway population catalogue (or register)

AEWA Project 20 (Ringing recoveries in atlases) already highlights some of the main conclusions of this review:

> "Ringing recoveries provide the physical evidence for an individual bird to have travelled from one point to another. Since in many cases the flyway population to which an individual belongs is known, this contributes greatly to visualising and understanding the concept and delimitation of

[5] AEWA Resolution 2.4: Implementation priorities for 2004-2007; numbers follow the listing of identified projects

flyway populations. Mapping ringing recoveries and providing background statistics with them, are a very valuable addition to census information presented in flyway atlases. Ideally therefore the publication of these data should be combined. …."

- A significant improvement in current knowledge of waterbird biogeographical populations will require the provision of resources. AEWA's Implementation Priorities for 2004-2007 already broadly outlines the necessary technical and financial requirements.

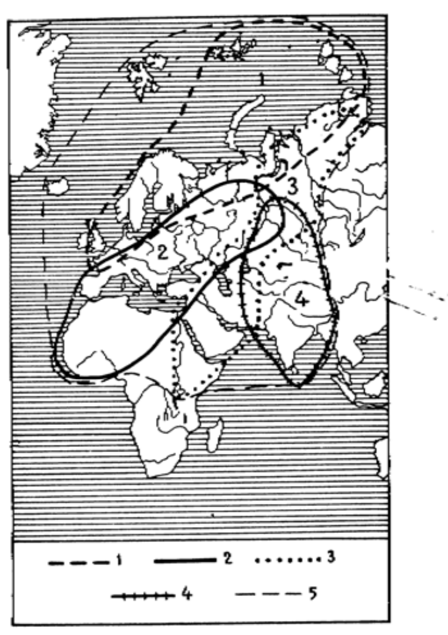
History of waterbird population delineation in Western Eurasia and Africa

Pioneering work by Russian ornithologists in the 1960s identified the main 'geographical' populations' of Anatidae in the western part of the former USSR and Europe. Isakov (1967) recognised four major flyways for Anatidae in western Eurasia, and provided a preliminary list of 44 wetlands in the former USSR which were of great significance as breeding, moulting, staging and/or wintering grounds. Isakov's four populations were:

1. Northern White Sea/North Sea population;
2. European Siberia/Black Sea-Mediterranean population;
3. West Siberian/Caspian/Nile population; and
4. Siberian-Kazakhstan/Pakistan-India population (Figure 1).

Isakov (1970) attempted to define the breeding grounds of these populations in greater detail, and demonstrated that there was extensive overlap between the various regions.

Figure 1. Isakov's main geographical populations of Anatidae in western Eurasia. Flyway coding as above.



Shevareva (1970) analysed 10,600 recoveries of ducks ringed in the former USSR and confirmed the basic geographical populations outlined by Isakov (1967) for Mallard *Anas platyrhynchos*, Teal *A. crecca*, Pintail *A. acuta*, Wigeon *A. penelope* and Garganey *A. querquedula*.

The concept of 'biogeographical populations' was elaborated in some detail by Atkinson-Willes *et al.* (1982), and the following account is based largely on these authors. In its simplest form, a population comprises a discrete unit with a clearly defined 'flyway' linking the breeding and moulting grounds to the terminal winter quarters. In some cases, the unit will comprise the entire population of a species, as in Red-breasted Goose *Branta ruficollis*, or the entire population of a sub-species, as in Greenland White-fronted Goose *Anser albifrons flavirostris*, or the six separate populations of Red Knot *Calidris canutus* (*canutus, rogersi, piersmai, roselaari, islandica* and *rufa*). But note that in North America, the term 'flyway' is used in a rather different manner to refer to an administrative unit for the management of waterfowl populations, and is identical for virtually all duck species.

A number of other species and sub-species are known, from ringing and migration studies, to have two or more distinct populations which seldom if ever mix at any stage in their annual cycles, and therefore should be treated separately. The conditions which these populations experience are likely to be quite different: it is therefore reasonable to suppose that each of them, in isolation, have evolved its own particular adaptations. The Western Palearctic provides several examples of these discrete units, notably the two populations of Pink-footed Geese *Anser brachyrhynchus,* the three populations of Barnacle Geese *Branta leucopsis* and the isolated west Mediterranean population of Marbled Teal *Marmaronetta angustirostris.* The recent taxonomic Phylogenetic Species Concept recognises such separate units of evolution as worthy of full species status ("clusters of individuals with a pattern of ancestry and decent" — Cracraft 1983; Helbig *et al*. 2002; Parkin 2003; Newton 2003). Indeed, some taxonomists now recognise many of these discrete waterbird populations and races as full species (*e.g.* Sangster *et al.* 1999). For example, Sangster *et al.* regard three races of Brent Goose (*Branta bernicla bernicla, B. b. hrota and B. b. nigricans*) as full species (respectively *B. bernicla, B. hrota* and *B. nigricans*).

Such a diversion of species into discrete population units is, however, usually impossible, especially amongst the common and widespread species. For most species of Anatidae, and many species of waders, which have been the subject of intensive ringing studies, it is clear that no such biogeographically discrete populations exist. Thus, in most of the Palearctic ducks, there is no clear cut relationship between the various breeding and wintering rounds. The flocks wintering in any given area are likely to contain individuals from several of the main breeding grounds, and similarly birds from the same breeding areas may often occur in a number of widely separately breeding quarters (see Wernham *et al.* 2002 for examples). In most species, there is a great deal of mixing across huge longitudinal ranges, and clear dividing lines are seldom present. An alternative method of subdividing species into convenient units for conservation and management action must therefore be devised. Otherwise the total numbers would be so large that the 1% criterion would cease to be relevant and priorities for conservation and management would be difficult to define from a quantitative basis.

Practical versus biogeographic units of population

Atkinson-Willes (1976) and Atkinson-Willes *et al.* (1982) recommended that the flyway concept be abandoned for common and widespread species in the western Palearctic, and that population 'units' be based on the main wintering regions. On this basis, the individuals wintering in a given region are treated as a single population, regardless of their distribution at other times of the year.

This concept was applied to the Palearctic ducks wintering in western Eurasia and the northern half of Africa. Within this area, five biogeographic regions were defined: Northwest Europe, Black Sea/Mediterranean, Caspian/Gulf, Turkestan/Pakistan, and Tropical West Africa (Atkinson-Willes 1976). Atkinson-Willes set the line between northwest European and the Black Sea/Mediterranean regions north of the Alps, and included central Europe in the Black Sea/Mediterranean region. He included the Nile Delta (Egypt) and Azraq Oasis (Jordan) in the Black Sea/Mediterranean region, and remained undecided as to the location of the important wetlands of the Seistan Basin on the border between Iran and Afghanistan.

The principles involved in defining these particular wintering areas were as follows:

- a region must be large enough and have a sufficiently wide range of habitat and climate for birds to remain within its boundaries in all normal winters;
- it should, as far as possible, be bounded by physical barriers sufficiently to prevent the easy movement of birds from one region to another, or by zones in which the species under review is either scarce or absent;
- the boundaries of the region should preferably be uniform for all species; the alignment may, however, be varied to take into account specific peculiarities in distribution; and
- the boundaries of the wintering regions should include the migration routes leading to them.

In support of the boundaries chosen by Atkinson-Willes (1976), there is a considerable body of evidence, mostly from ringing studies such as those by Shevareva (1970), and Perdeck & Clason (1980), that most Anatidae in western Eurasia follow a south-westerly course from their breeding grounds to their winter quarters. For species with a relatively continuous breeding range across northern Eurasia and a relatively continuous wintering range across southern Eurasia (to Africa, India and southeast Asia), there is a very strong tendency for birds in the west to winter in the west, and birds in the east to winter on the east. For many species of Anatidae, ringing recoveries have demonstrated that the majority of birds breeding in northwest Europe (including Scandinavia) winter from western Europe south in varying degrees to the west Mediterranean and northwest Africa. The majority of birds breeding in northeast and central Europe (in the east up to the Urals)generally follow a more easterly route to winter from the Black Sea and southeast Europe through the Mediterranean basin to West Africa and the central Sahel zone. Birds breeding in western Siberia (notably in the basin of the Ob and Irtysh rivers) generally migrate southwest through the Caspian region to the Middle East, and in some cases also to northeast and eastern Africa.

Atkinson-Willes (1982) discussed some of the problems arising form this rather arbitrary approach to the selection of geographical units of populations. The main problem arises in cases where a species is abundant in one region, but scarce and at the edge of its range in the next. If the populations in the two regions are treated separately, the 1% criterion will place undue emphasis on sites in the region where the species is scarce (*i.e.* the region of least importance for the species). The obvious solution is to combine the two regions, or to amend the boundary between them, so that the marginal overspill is included in the main population. However, it is important to distinguish between small relict populations, which are genetically and geographically isolated from other populations of the species, and those which comprise no more than a minor extension of the normal distribution. The former should be treated separately, the latter as part of the main population.

Another problem arises where the number of individuals wintering in a region is very much smaller than the number passing trough on migration. It has been suggested that two 1% thresholds should be adopted in this situation, one based on the number occurring on passage — for use in autumn and spring — the other for the number remaining in winter. Atkinson-Willes *et al.* (1982) regarded this as an unnecessary complication, and recommended that the small winter remnant be lumped with the main population with which it is associated; the same 1% thresholds should then be used throughout. For example, the small numbers of Garganey *Anas querquedula* which remain throughout the winter in the Mediterranean Basin and Middle East should be regarded as part of the main populations wintering in West Africa and eastern Africa respectively. An exception to this should, however, be made in those instances in which two populations from distinct breeding areas are involved. In this situation, separate criteria might be justifiable. Examples might occur in Pintail *Anas acuta* and Shoveler *A. clypeata* in northwest Europe. The rather small wintering populations in this region consist of birds from Fennoscandia, the Baltic States and northwest Russia, while many of the birds occurring on migration originate from breeding areas further to the east and winter in the Mediterranean basin and West Africa.

Meininger *et al.* (1995) have suggested that when two or more populations use a site during the course of a year, the 1% threshold used at a particular time of year should be the 1% threshold of that population which is most abundant at that time of year. When it is unclear which population dominates, the highest level should be applied[6].

In most cases, there should be no difficultly in separating recognised sub-species as discrete populations of the species considered. The recognised subspecies of Anatidae considered by Scott & Rose (1996) are either:

(a) totally discrete, *e.g.* the African and Madagascar subspecies of White-backed Duck *Thalassornis leuconotus*;

(b) show only a narrow zone of intergradation or secondary contact zone where they come together, *e.g.* the two subspecies of Bean Goose *Anser fabalis* and the two subspecies of Spur-winged Goose *Plectropterus gambensis*; or

(c) are separated from other populations during the breeding season by unsuitable terrain *e.g.* the three subspecies of Common Eider *Somateria mollissima.*

Reviews of Anatidae populations in the Western Palearctic

Atkinson-Willes (1976) described the main wintering regions for 12 species of Anatidae in the Western Palearctic as well as discussing the numbers and distribution of five species of European seaduck. He defined northwest European 'populations' for these , but noted that the Common Eider *Somateria mollissima* (with several isolated and relatively sedentary populations and Long-tailed Duck *Clangula hyemalis* (still at that time relatively poorly known) did not fit so neatly into the system of 'wintering regions' (Atkinson-Willes 1978). Finally, he examined the winter distribution of three swans *Cygnus* spp. in northwest Europe, and identified the main wintering groups of these species (Atkinson-Willes 1981).

Detailed accounts of the populations of geese (*Anser* and *Branta* spp.) occurring in the Western Palearctic were given by Timmerman (1976, 1981) and Ogilvie (1978). Madsen (1991) and, more recently, Madsen *et al.* (1999) reviewed the status and trends of goose populations wintering and/or breeding in the Western Palearctic. Madsen *et al.* (1999) recognised 21 populations of eight species of geese occurring in the wild in substantial numbers, as well as two populations of the introduced Canada Goose *Branta canadensis*.

Rüger *et al.* (1986) adopted the by now traditional approach for the purposes of analysis of trends but acknowledge that this did not necessarily reflect true biogeographical populations. They repeated the rationale of Atkinson-Willes (1976) and followed many of his 'wintering regions', adding further justification for some of the regional boundaries. The division of France, Germany and Spain between northwest European and Black Sea/Mediterranean regions followed Atkinson-Willes (1976). However, these authors described more exceptions for species for which better information was then available, *e.g.* these authors split off the western Mediterranean population of Shelduck *Tadorna tadorna* from the rest of the Black Sea/ Mediterranean group on the basis of a paper by Walmsley (1984). Rüger *et al.* (1986) concluded that "the mid-winter waterfowl census data provide further support for the use of the biogeographical regions. Whilst there is evidence of substantial internal redistribution of some northwest European waterfowl populations from year to year depending on weather conditions, large-scale movements out of the region apparently occur only in severe winters (*e.g.* 1978-79), when certain species , such as Wigeon *A. penelope* and Teal *A. crecca*, move to southern Spain and probably northwest Africa".

[6] Note however, that the Scientific and Technical Review Panel of the Ramsar Convention is proposing to the Convention's ninth Conference of the Parties (November 1999) that "Where such mixed populations occur (and these are inseparable in the field) it is suggested that the larger 1% threshold is used in the evaluation of sites. However, particularly where one of the populations concerned is of high conservation status, this guidance should be applied flexibly and Parties should consider recognising the overall importance of the wetland for both populations through the application of Criterion 4, as the basis of ensuring that their management planning for the site fully recognizes this importance. This guidance should not be applied to the detriment of smaller, high conservation status populations."

Monval & Pirot (1989) also adopted the wintering regions as defined by Atkinson-Willes (1976), and defined the northwest European and Black Sea/Mediterranean regions rather precisely, including central Europe (southwest Germany, Switzerland, Hungary, Czech Republic, Slovakia and Austria) within the Black Sea-Mediterranean region. Both Rüger *et al.* (1986) and Monval & Pirot (1989) divided the Black Sea-Mediterranean region into two sub-regions, east and west, because of differences in the quality of data between these two regions, and not because they thought that the birds in these two sub-regions belonged to different populations.

In their summary of waterbird population estimates, Rose & Scott (1994) also followed the traditional approach, but made further adjustments to the limits of some populations in the light of recent information, and also made a first attempt at identifying population units in the Afrotropical species.

A first assessment of population limits of Anatidae occurring in the western parts of Asia was made by Perennou *et al.* (1994) in their first reporting on Asian Waterbird Census results.

The most comprehensive review to date was undertaken by Scott & Rose (1996) who reviewed 167 populations of 61 species of Anatidae in Africa and Western Eurasia. Many of these populations, especially for Afrotropical species, had not been previously described.

Reviews of wader populations in the Africa and Western Eurasia

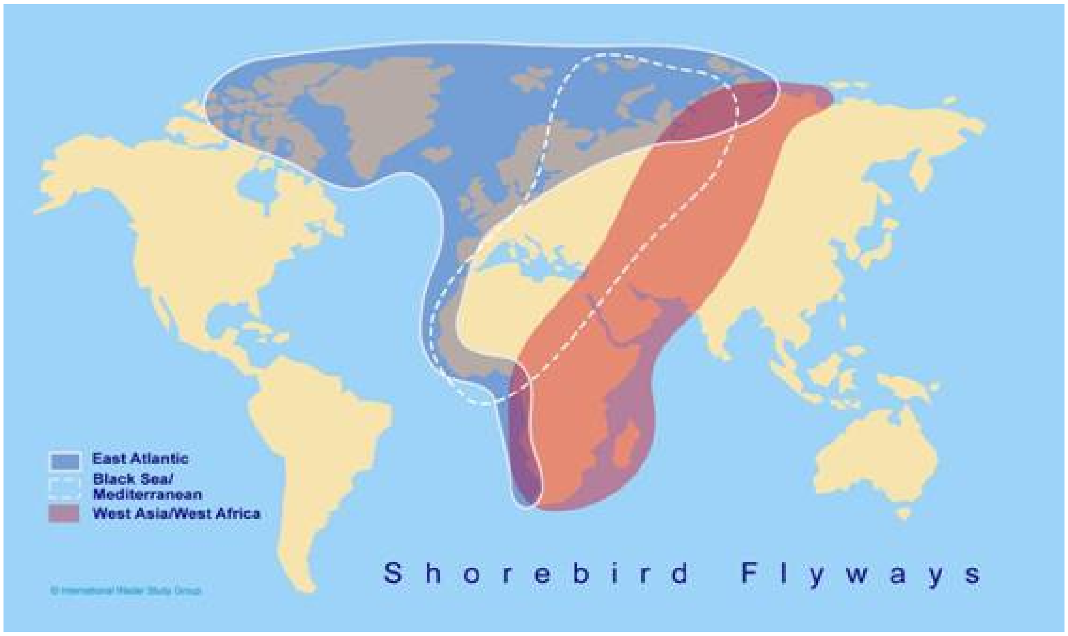
Generally knowledge of international distributions and definition of biogeographic populations has developed more recently for waders than for Anatidae. A first attempt to estimate the size of wader populations wintering along the eastern seaboard of the Atlantic Ocean in western Europe, and in North and West Africa was made in the mid 1970s by Prater (1976). Birds using this 'East Atlantic Flyway' (Figure 2) breed over a large area of the arctic, boreal and temperate northern hemisphere from Canada in the west, to mid-northern Siberia in the east. At the same time, information from the development of extensive ringing programmes was allowing determination of racial characteristics of waders as this related to distributions (Harrison 1974), and elaborated by Boere (1976).

Major reviews of the populations of waders using this flyway and their migration systems were made by Piersma *et al.* (1987) and Smit & Piersma (1989) which confirmed that many subspecies and biogeographical populations using this flyway over-wintered on the estuaries and open coasts of western Europe. Others pass through this region during spring and autumn to reach overwintering sites in western Africa, some reaching as far south as South Africa. Smit & Piersma's 1989 review was the first to attempt a more or less compressive overview of wader populations and their migration systems on the East Atlantic Flyway and they presented information on 29 populations of 21 species.

Two other flyways within the African-West Eurasian region are less well known than that of the East Atlantic coast. The Black-Sea/Mediterranean Flyway joins arctic and boreal breeding areas with final destinations in the Mediterranean Basin and west Africa (Kube *et al.* 1998; Summers *et al.* 1987; van der Have 1988).

The West Asian/East African Flyway links the central Siberia tundra with the Caspian Sea, the Middle East (especially the Gulf Region) and eastern and southern African (Summers *et al.* 1987). The waders of the latter flyway/region are particular poorly known :a first assessment of population limits of some waders (and other waterbird species) occurring in the eastern parts of the flyway was made by Perennou *et al.* (1994), with more recent reviews published by Scott (2002) and compiled by Dodman (2002). These latter reviews also covered other African areas.

Figure 2. The East Atlantic Flyway, the Black-Sea/Mediterranean, and West Asian/East African Flyways for waders.



In the late 1990s, the International Wader Study Group (Stroud *et al.* 2004) undertook a major collation exercise and reanalysis of 1990s migratory wader population data for all countries in Africa and Western Eurasia, updating previous estimates dating from the mid-1980s (Smit & Piersma 1989). Status information was presented on 131 populations of 55 species that have at least one migratory population. A major emphasis of this review was to fully document the best-knowledge of the distribution of wader populations so as to provide a clear baseline for future assessment of status.

For some species, the separation of biogeographic populations was based on recent improvements in knowledge and differed from those defined by Smit & Piersma (1989) and other sources used by Rose & Scott (1997). All such differences in treatment were identified and documented, since such differences are important in interpreting observed differences in population size.

Engelmoer & Roselaar (1998) reviewed the taxonomy and characteristic of 14 species of mainly NW European wintering waders. Where possible the WSG assessment considered the results of their review, noting where conclusions differed – typically where there remained taxonomic uncertainty at sub-specific level. In such cases, Stroud *et al.* (2001) recommended further review of certain population limits.

As with Anatidae, waders show several types of populations, from the biologically discrete (*e.g.* Red Knot *Calidris canutus*), to species that have more or less continuous distributions across boreal Eurasia, and where, for reasons outline above, population units are more arbitrary. Where population estimates were derived from the aggregation of national breeding totals, Stroud *et al.* (2004) documented which countries (or parts of countries) were included within each population and the reasons behind any assumptions made. A similar approach was taken where estimates derive from totals of wintering birds. This results in a higher degree of transparency as to the assumptions underlying each estimate (or limits to proposed biogeographical population) than had been available before. Table 1 presents a summary of the types of biogeographical populations is given for 131 populations the 55 wader species treated in WSG's review.

Table 1. The nature of populations of migratory waders found in the AEWA Agreement area. Populations as described by Stroud *et al.* (2004), and population definitions following Scott & Rose (1996).

	Entire popn of a monotypic species	Entire popn. of a sub-species	Discrete popn of a species or sub-species at all times of year	A discrete popn. in one season but not in another	A regional group of species with a continuous distribution	Non migratory discrete popn.	**Total no of popns. in AEWA area**
Crab Plover *Dromas ardeola*	1						**1**
Oystercatcher *Haematopus ostralegus*		2					**2**
Black-winged Stilt *Himantopus himantopus*		1	4			1	**6**
Avocet *Recurvirostra avosetta*			3			2	**5**
Stone Curlew *Burhinus oedicnemus*		3		2			**5**
Cream-coloured Courser *Cursorius cursor*		6					**6**
Collared Pratincole *Glareola pratincola*			3				**3**
Black-winged Pratincole *Glareola nordmanni*	1						**1**
Madagascar Practincole *Glareola ocularis*	1						**1**
Eurasian Golden Plover *Puvialis apricaria*				3			**3**
Pacific Golden Plover *Pluvialis fulva*		1		1			**2**
Grey Plover *Pluvialis squatarola*					2		**2**
Great Ringed Plover *Charadrius hiaticula*		3					**3**
Little Ringed Plover *Charadrius dubius*			2				**2**
Forbes Plover *Charadrius forbesi*			1				**1**
Kentish Plover *Charadrius alexandrinus*			3				**3**
Lesser Sand Plover *Charadrius mongolus*		1					**1**
Greater Sand Plover *Charadrius leschenaultii*		3					**3**
Caspian Plover *Charadrius asiaticus*			1				**1**
Eurasian Dotterel *Eudromias morinellus*			2				**2**
Northern Lapwing *Vanellus vanellus*					2		**2**
Spur-winged Plover *Vanellus spinosus*			1			1	**2**
Brown-chested Lapwing *Vanellus superciliosus*			1				**1**
Sociable Plover *Vanellus gregrarius*				2			**2**
White-tailed Lapwing *Vanellus leucurus*			2				**2**
Eurasian Woodcock *Scolopax rusticola*				2			**2**
Common Snipe *Gallinago gallinago*		1		2			**3**
Great Snipe *Gallinago media*			2				**2**
Jack Snipe *Lymnocryptes minimus*			2				**2**
Black-tailed Godwit *Limosa limosa*		1		3			**4**
Bar-tailed Godwit *Limosa lapponica*		3					**3**
Whimbrel *Numenius phaeopus*		2		2			**4**
Slender-billed Curlew *Numenius tenuirostris*	1						**1**
Eurasian Curlew *Numenius arquata*		3					**3**
Spotted Redshank *Tringa erythropus*					2		**2**
Common Redshank *Tringa totanus*		3		2			**5**
Marsh Sandpiper *Tringa stagnatilis*					2		**2**
Common Greenshank *Tringa nebularia*					2		**2**
Green Sandpiper *Tringa ochropus*			2				**2**

	Entire popn of a monotypic species	Entire popn. of a sub-species	Discrete popn of a species or sub-species at all times of year	A discrete popn. in one season but not in another	A regional group of species with a continuous distribution	Non migratory discrete popn.	**Total no of popns. in AEWA area**
Wood Sandpiper *Tringa glareola*				2			**2**
Terek Sandpiper *Tringa terek*			1				**1**
Common Sandpiper *Tringa hypoleucos*					2		**2**
Ruddy Turnstone *Arenaria interpres*			3				**3**
Great Knot *Calidris tenuirostris*			1				**1**
Red Knot *Calidris canutus*		2					**2**
Sanderling *Calidris alba*			2				**2**
Little Stint *Calidris minuta*					2		**2**
Temminck's Stint *Calidris temminckii*			2				**2**
Purple Sandpiper *Calidris maritima*		2					**2**
Dunlin *Calidris alpina*		3		3			**6**
Curlew Sandpiper *Calidris ferruginea*				2			**2**
Broad-billed Sandpiper *Limicola falcinellus*			1				**1**
Ruff *Philomachus pugnax*				2			**2**
Red-necked Phalarope *Phalaropus lobatus*					1		**1**
Grey Phalarope *Phalaropus fulicaria*					1		**1**
TOTALS	4	40	39	28	16	4	**131**

Stroud *et al.* (2004) also reviewed how well wader populations fit within the broad outline of flyway systems currently recognised in Africa-Western Eurasia: (Figure 2). Although most populations had migration patterns that fell within one or other of these flyways, a small number (14) of populations did not, however, fit precisely into these pre-determined flyways. These are largely wader populations that breed broadly across north-west and northern Europe, the majority of which migrate on a broad front south through Europe but some of which overwinter on the coastlines of western and eastern Africa. In all, seven Black Sea/ Mediterranean flyway populations also occur on parts of the East Atlantic Flyway, and two on the West Asian/East African Flyway. A smaller number of populations occur chiefly on the two predominantly coastal flyways but parts of which spread inland across Europe and Africa. It should be noted however that for the West Asian/East African Flyway, some populations also occur, sometimes predominantly, on the Central Asian Flyway but this has not been included in the analyses.

They concluded that the broad delimitation of flyways fits well with more detailed assessment of how each population migrates, but there may be a case for considering the species/ populations that breed and migrate over a broad front across temperate and boreal Europe, including north-western Europe as forming a distinct flyway population group. Nevertheless whatever flyway separations are distinguished, Stroud *et al.* (2004) stressed that each individual of each population migrates according to its own history and survival priorities. Thus, the observed commonality of individuals and populations on similar flyways is largely a human interpretation, chiefly for conservation management purposes, of the general similarity of purpose of each of the millions of individual waders migrating through the region.

Reviews of other waterbird populations in the Africa and Western Eurasia

Lloyd *et al.* (1991) summarised population data, not only for Britain and Ireland, but also for other countries within the distribution of each species (although these were often just estimates). These have allowed the production of estimates of biogeographic populations (*e.g.* Stroud *et al.* 2001). Mitchell *et al.* (2004) updated international estimates for 25 species of British and Irish seabird and derived new totals for populations, generally at racial scales. The national data for these new international totals were drawn largely from the collations of Hagemeijer & Blair (1997) and Heath *et al.* (2000). As these sources are themselves secondary compilations, the 'best available' estimates presented by Mitchell *et al.* (2004) actually derive from a period of a decade or more.

For seabirds there have typically been few attempts to define separate populations through analysis of movements of ringed birds, and populations presented by Lloyd *et al.* (1991) and Mitchell *et al.* (2004) generally relate to whole sub-species, or wide but discrete geographical areas (*e.g.* north-east Atlantic).

Most of available information on populations of crakes and rails is drawn from the monograph of Taylor & van Perlo (1998), although generally this is a very poorly known group of waterbirds.

Population divisions of most other waterbird species in Africa and western Eurasia derive mainly from either Perennou *et al.* (1994) for Asian parts of the region, or were established by Rose & Scott (1994) in their first collation of *Waterbird Population Estimates*. These population divisions generally followed principles established earlier for Anatidae.

The role of new technologies and methodologies

A range of new research methodologies have been developed in recent years which have potential to inform the identification of waterbird biogeographic populations. These are briefly summarised below.

Telemetry

Remote sensing, using radio or satellite telemetry, offers the great advantage of yielding detailed and precise information about the location (and sometimes also behaviour) of the individuals carrying transmitters. Miniature data loggers, for recording the behaviour of individuals, are also likely to become more widely used in the future. Radio-telemetry has been used very successfully for interpreting long distance migrations of even small waterbirds, notably Western Sandpipers *Calidris mauri* (Iverson *et al.* 1996). There are currently some limitations to the technique, notably high costs, the high time cost of locating birds carrying transmitters, weight limitations for satellite transmitters (constraining their use on the smallest waterbirds, especially waders), and that generally results come from a few individuals that may not represent the behaviour of the population as a whole. However, costs and minimum size of transmitters are falling – increasing the number of individuals and species that can carry them. This will greatly increase the value of the technique.

Satellite telemetry involves larger transmitters and more powerful batteries and to date its use has been restricted to migratory geese and swans, typically to investigate the detailed migration ecology of populations using well known flyways. Recent examples have included Bewick's Swans *Cygnus bewickii* (Beekman *et al.* 1996), Icelandic Whooper Swans *Cygnus cygnus* (Pennycuick *et al.* 1996), Pink-footed Geese *Anser brachyrhynchus* (Gladher unpubl.) Greenland White-fronted Geese *Anser albifrons flavirostris* (Gladher *et al.* 1999; Fox *et al.* 2003); Lesser White-fronted Goose *Anser erythropus* (Lorentsen *et al.* 1998; Aarvak & Øien 2003) and Light-bellied Brent Geese *Branta bernicla hrota* (Colhoun *et al.* 2005) and Dark-bellied Brent Geese *Branta bernicla bernicla* (Green *et al.* 2002a,b). Clausen & Bustnes (1998) reported satellite telemetered data of the spring movements of Svalbard Light-bellied Brent Geese which, unexpectedly, showed that those geese known to breed in NE Greenland were of the Svalbard rather than NE Canadian population.

The high costs of satellite telemetry will restrict its used for the foreseeable future. However, even though one consequence of this is its restriction to a small number of individuals, its use may be the only realistic means of obtaining information on migratory flyways (and hence limits to populations) for birds migrating through regions with few birdwatchers, or which political instability restricts the potential for other forms of field studies. In particular it may be valuable in defining waterbird flyways commencing in the central Siberian arctic and extending south to the Indian sub-continent, and/or south-west to eastern Africa.

Given the increasing evidence of great individual variation in migration strategy within populations, the most biologically appropriate approach to the analysis and interpretation of ringing-recovery data now seems to be the use of telemetry to establish in detail the range and types of individual strategies within a biogeographic population (*e.g.* Scott *et al.* 2004). This information can then be used to guide and inform the interpretation of the other general ringing-recovery data. Neither telemetry nor ringing should be seen as the only or best approach; rather each will add value to the interpretation and understanding of waterbird flyways if used in combination.

Genetic studies

Some populations may be distinguishable using plumage characters or morphometrics, but others are not. Genetic 'fingerprinting' has proved effective in differentiating between populations (*e.g.* Wennerberg *et al.* 1999, 2002; Wennerberg 2001; Wennerberg & Bensch 2001), and the use of such techniques is likely to increase in future.

Genetic studies have important potential to supplement traditional taxonomic approaches: thus, in their genetic study of Dunlin *Calidris alpina*, Wenink *et al.* (1993, 1996) found that some of the most recognisable sub-species were genetically indistinguishable, whilst the most genetically distinct group is very similar to its nearest relative.

Chemical profiles of feathers

The use of chemical markers within feathers to identify the breeding/moulting areas where feathers were laid down was pioneered in North America in the 1970s (Kelsall *et al.* 1975; Kelsall & Burton 1977). The approach was not widely adopted as a methodology to differentiate populations — probably owing to cost and methodological considerations (Kelsall & Burton 1979).

More recently, however, stable isotope ratios in feathers have been used to identify migration patterns and habitat use — a consequence of differential occurrence of some elemental isotopes in different habitats or ecosystems (Alisauskas & Hobson 1993; Chamberlain *et al.* 1997; Cherel *et al.* 2000; Wennerberg *et al.* 2002; Farmer *et al.* 2003). To date the technique has been rarely used to define distributional limits of population since like telemetry, costs will probably constrain its widespread use. Published studies do, however give examples of successful application to determine migration paths and distributional extent, suggesting that it may be valuable in specific research applications.

Detailed taxonomic studies

Detailed biometric studies, such as the massive review by Engelmoer & Roselaar (1998) of Eurasian wader taxonomy, have significant potential to inform about the distribution limits of forms of species.

Multivariate, cluster analyses of detailed measurements of 4,321 museum skins of 15 wader species all taken from their breeding areas, allowed Engelmoer & Roselaar to present distribution maps of the breeding areas of different populations and significant new understanding of wader population limits. Many of these findings have been adopted in the most recent update of Western Eurasian wader populations (Stroud *et al.* 2004).

Such approaches can be used to identify biogeographical populations, especially when used in combination with other datasets and approaches.

Summary of different types of biogeographical populations

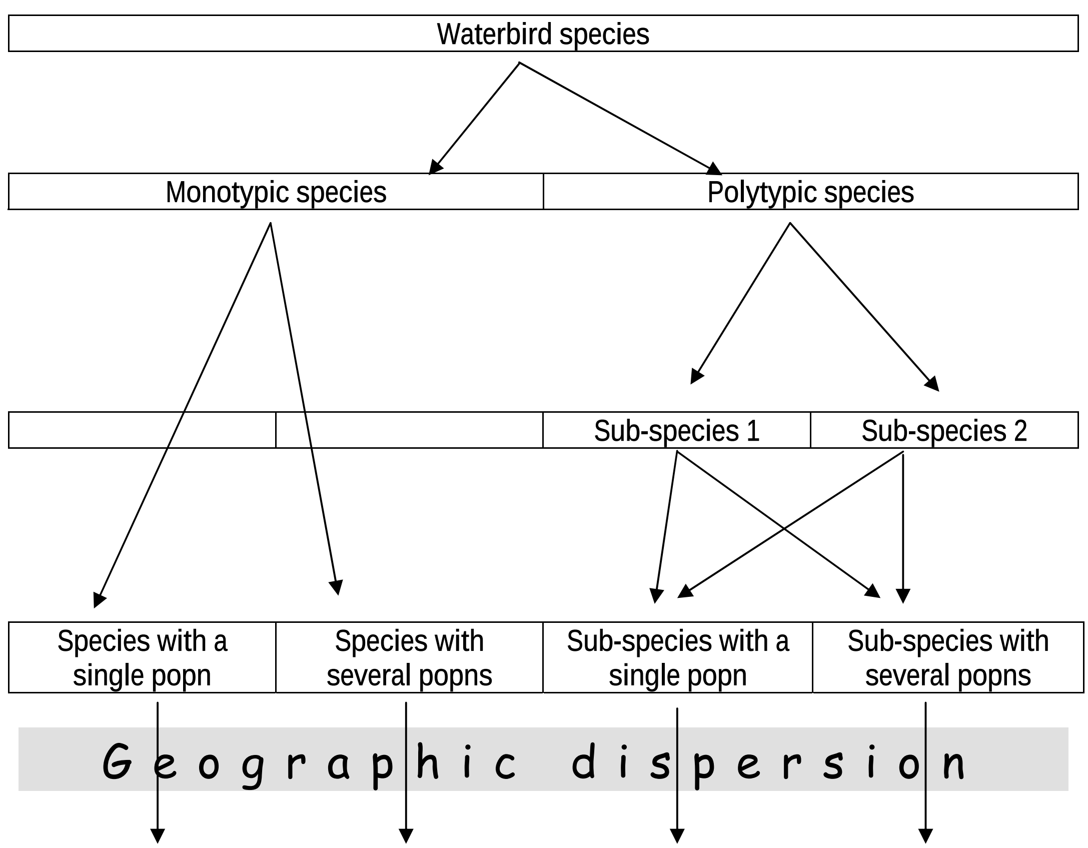
Several types of ‘populations’ of waterbirds were recognized by Scott & Rose (1996):

1. the entire population of a monotypic species;
2. the entire population of a recognized subspecies;
3. a discrete migratory population of a species or subspecies, i.e., a population which rarely if ever mixes with other populations of the same species or subspecies;
4. that ‘population’ of birds from one hemisphere which spend the non-breeding season in a relatively discrete portion of another hemisphere or region. In many cases, these ‘populations’ may mix extensively with other populations on the breeding grounds, or mix with sedentary populations of the same species during the migration seasons and/or on the non-breeding grounds;
5. a regional group of sedentary, nomadic or dispersive birds with an apparently rather continuous distribution and no major gaps between breeding units sufficient to prohibit interchange of individuals during their normal nomadic wanderings and/or post-breeding dispersal.

These definitions were adopted by Ramsar CoP7 in the glossary of terms of the *Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance* (Resolution 7.11).

However, these definitions mix concepts of taxonomy (species/sub-species/populations); and dispersion (populations separate all the year/part of the year/arbitrary splits of continuously distributed waterbirds).

Figure 3. The basis for defining different types of biogeographical populations.



Popns discrete year round	✓	✓	✓	✓
Popns separate part of the year only	Not possible	✓	Not possible	✓
Regional group of a continuous distribution	Not possible	✓	Not possible	✓

Considering taxonomy and dispersion as axes of a matrix results theoretically in 12 combinations, however, only eight are logically possible.

Table 2 gives some examples for each category.

Table 2. A taxonomic and dispersion matrix for the classification of biogeographical populations.

		DISPERSION		
		Geographically discrete population at all times of year	Population discrete in one season but not in another from the same species/sub-species	A regional group of a species or sub-species with a continuous distribution
TAXONOMY	Entirety of a monotypic species	✓	Not logically possible	Not logically possible
	Separate population of a monotypic species	✓	✓	✓
	Entire population of a sub-species	✓	Not logically possible	Not logically possible
	Separate population of a sub-species	✓	✓	✓

		DISPERSION		
		Geographically discrete population at all times of year	Population discrete in one season but not in another from the same species/sub-species	A regional group of a species or sub-species with a continuous distribution
TAXONOMY	Entirety of a monotypic species	Slender-billed Curlew *Numenius tenuirostris*		
	Separate population of a monotypic species	Barnacle Goose *Branta leucopsis* populations	Black-winged Pratincole *Glareola pratincola*	European Mallard *Anser platyrhynchos* populations
	Entire population of a sub-species	Greenland White-fronted Goose *Anser albifrons flavirostris*		
	Separate population of a sub-species	Populations of Greylag Goose *Anser anser anser*	European White-fronted Goose *Anser albifrons albifrons* populations	E & W European populations of Stone-Curlew *Burhinus oedicnemus oedicnemus*

A simplified definition, drawn from the approach above is:

"A waterbird biogeographical population is a population of a species or a sub-species that is either geographically discrete from other populations at all times of the year, or at some times of the year only, or is a specified part of a continuous distribution so defined for the purposes of conservation management."

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