WADER MIGRATION SYSTEMS IN THE NEW WORLD

R.I.G.Morrison and J.P.Myers

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Knowledge of flyways used by shorebirds in the New World has increased considerably over the past 10-15 years through international research programs designed to identify the key areas used by the birds throughout their ranges. These programs have included volunteer survey networks, specific ground investigations and aerial surveys of remote areas. Some species breeding in the far northeast and northwest of the North American arctic migrate to wintering areas in Europe and the Pacific/Asia, respectively, while the bulk of species breeding across the rest of the arctic winter in the New World, some as far south as Tierra del Fuego. Major migration flyways in North America are found through James Bay and Hudson Bay, through the eastern seaboard, through the interior of the continent, through the western Gulf of Mexico and along the Pacific coast. In South America, flyways pass along the northern coast, across Amazonia by various routes following the major river systems, along the Atlantic coast, down the Andes chain and along the Pacific coast. Species often follow an elliptical route, with their southward path east of their northward one. Aerial surveys conducted between 1981 and 1986 identified major wintering areas on the coast of South America. Shorebirds concentrate markedly during migration and on the wintering grounds, with a restricted number of sites holding large percentages of populations. The results have enabled key sites used by the birds to be identified throughout their ranges, and have demonstrated the conservation importance of such areas.

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INTRODUCTION

The last 10-15 years have seen many advances in our knowledge of the distribution, abundance and migration routes of the shorebirds breeding in arctic and subarctic areas of the New World (for scientific names of species mentioned in the text see Appendix 1). Their wintering areas are found not only in the New World, but also in various parts of the Pacific and on the European seaboard (Morrison 1984). This paper provides an overview of present knowledge of flyways used by New World populations of shorebirds and indicates some areas and topics on which further information is required.

NEW WORLD FLYWAY STUDIES: HISTORY AND METHODS

Only recently have comprehensive attempts been made to gather integrated information on shorebird populations in the New World throughout their migration ranges. Early summaries, such as those of Cooke (1910), Bent (1927, 1929), and Wetmore (1926, 1927), rarely provided data which enabled a quantitative assessment to be made of the relative importance of various locations over a wide geographical area. Prior to the widespread use of aerial surveys, difficulties of access to, and travel in, many remote areas used by shorebirds precluded wide scale coverage of key areas.

Lincoln (1950) introduced the concept 'flyway' to describe the main migration corridors used by different populations of waterfowl moving between breeding and wintering areas in North America. The concept may also be applied broadly to the movements of shorebird populations. Two basic types of information are needed to identify shorebird flyways: first, identification of the key sites they are using at different times of the year, and second, migration studies involving banding/marking, to reveal links between the various sites.

Only in early 1970's did large-scale investigations begin to determine distribution patterns and identify key sites over wide geographical areas. Two main approaches have been used. The first involved the organisation of networks of volunteer observers, whose members undertake shorebird counts at regular intervals in a standardised fashion. For example, the International Shorebird Survey (I.S.S.) scheme was set up in 1974 in eastern North America, with independent but collaborative operations being coordinated in Canada by the Canadian Wildlife Service and in the U.S.A. and points south by the Manomet Bird Observatory, Massachusetts. This type of operation is well suited to areas

where there are enough volunteers, adequate ground access and local knowledge to maximise the likelihood of major areas being discovered and/or covered. Advantages of this type of operation include being able to collect data on the phenology of migration and on the details of the species present more readily than is possible from aerial surveys. Since 1974, some 387 sites have been covered on I.S.S. surveys in Canada in the autumn, and in the U.S.A. some 210 in spring and 454 in autumn (MBO 1986). A similar scheme was run in California from 1969-1974 (Jurek 1974). Single-species efforts along the US Pacific Coast since then have focussed on Snowy Plovers and Sanderlings. Data on particular areas have also been gathered through specific investigations (*e.g.* St. Lawrence River, Broussard 1981; coast of Argentina, Harrington and Morrison 1980). Information from these surveys has provided much of the data base for identification of critical sites for shorebirds in North America (Senner and Howe 1984, MBO 1986).

The Alaska version of the Outer Continental Assessment Program, begun in 1975, focussed the efforts of many research groups on bird use of coastal areas throughout that state. Over the subsequent decade, university and agency researchers accumulated a vast collection of data relating bird densities to season, habitat and location for much of Alaska's extensive shoreline. These data derive from the complementary approaches of large area surveys by airplane, boat and foot coupled with site-specific intensive studies of seasonality and habitat use in coastal bird populations. For example, Woodby and Divoky (1983) reported results of over 2 000 km of aerial censuses covering the Norton Sound section of the Alaska Bering Sea coast. These are complemented within the same area by intensive site studies such as those reported by Shields and Peyton (1979).

For more remote areas, aerial surveys often provide the only effective way of assessing use by shorebirds. The most extensive aerial survey operation to date has been the South American Shorebird Atlas Project, carried out under the Latin American Program of the Canadian Wildlife Service, in which most of the coastline of South America thought to contain potential shorebird habitat was surveyed between 1981 and 1986. This has led to the identification of major wintering areas for a number of species (Morrison 1984, Morrison and Ross 1987). Aerial surveys have also been used to identify and document major staging areas in James Bay (Morrison 1984) and in Delaware Bay (Dunne *et al.* 1982).

Banding studies not only provide essential information on the movements of birds between critically important areas, but also provide much valuable data on the purposes for which birds are using the areas and on their general biology - *e.g.* weight gain, moult, morphometrics, turnover rates. Band recovery rates are generally very low for shorebirds and colour-marking is usually employed to provide more information. Most major banding operations have taken place mostly within the last twenty years and have included both large-scale operations, such as those in the Magdalen Islands (McNeil and Burton 1973, 1977), in James Bay (see Morrison 1984), and in Suriname (Spaans 1978, 1979), and projects directed more towards single species, such as the studies of Red Knot by Harrington (1982), of Semipalmated Sandpipers by Lank (1979, 1983) and of Sanderling by Myers and associates (*e.g.* Myers *et al.* 1984, 1985). Continent-wide marking schemes and projects have been coordinated under the Pan American Shorebird Program (Myers *et al.* 1983, 1984).

FLYWAYS IN THE NEW WORLD

Three main migration systems are found amongst New World shorebirds (Morrison 1984). The first involves species which breed in the north-eastern Canadian High Arctic and migrate to wintering areas on the European seaboard. Species such as the Knot and Turnstone reach their breeding grounds after a flight from the major European estuaries to staging grounds in Iceland, followed by a flight across the Greenland ice cap (Salomonsen 1950-51, Morrison 1975, 1977, Wilson 1981, Alerstam *et al.* 1986). Recent studies have indicated that some Knot may also reach the Canadian High Arctic via staging grounds in northern Norway (Davidson *et al.* 1986).

The second system, which includes the majority of species, involves shorebirds breeding across the North American Arctic and wintering in North, Central and South America. Major migration flyways occur along the Atlantic and Pacific coasts as well as through the interior of the continent in both North and South America. Some species, particularly those on the Pacific coast, tend to remain within one flyway, while others use two or more, their migration routes forming an elliptical pattern, with their southward path in autumn further east than the northward, spring journey (Morrison 1984, Myers *et al.* 1987a).

The third system involves species breeding in Alaska and migrating to wintering areas in the Pacific and Asia. Some species may winter on Pacific islands, some in Australasia, and some along the Asian coast, and for turnstones, at least, there is evidence of an elliptical pattern of migration southwards through the Pacific islands and northwards up the Asian coast (Thompson 1973).

BREEDING AREAS

Until the advent of air travel, the breeding distribution of shorebirds in the eastern Arctic remained poorly, or at least patchily, known. By the 1960s enough information was available from collecting and other expeditions

(*e.g.* Parmelee and Macdonald 1960, Parmelee *et al.* 1967) for Godfrey (1966) to outline the breeding ranges of shorebirds in the Canadian Arctic. Knowledge of Alaskan ornithology developed somewhat earlier (see Gabrielson and Lincoln 1959). Whereas many early investigations were concerned primarily with distributional/avifaunal studies, later work has been concerned more with quantitative studies or syntheses of information on breeding biology (*e.g.* Norton 1972, Pitelka *et al.* 1974, Ashkenazie and Safriel 1979a, 1979b). Although the breeding ranges of the birds are now known reasonably well in outline (Godfrey 1986), few estimates of breeding densities exist in relation to the enormous areas involved (*e.g.* Freedman and Svoboda 1982). Very little information exists on where the centres of species' populations may be, either in terms of densities or overall numbers, or to what extent breeding densities may vary from year to year, or on population levels over the long term. Some parts of the Arctic which appear to contain habitat highly suitable for breeding shorebirds remain poorly known, for instance the islands and coastal lowland tundra of the Foxe Basin.

Determination of the location of population centres in relation to factors such as habitat distribution and requirements, food availability, population structures, migration systems and breeding biology of the species concerned, remains a pressing need. Another gap in information concerns the manner in which shorebirds depart from the breeding grounds in different areas of the Arctic. Studies of changes in habitat use during and after the breeding season have been conducted in Alaska (Connors *et al.* 1979), but little is known of the resources used by shorebirds in the eastern Arctic prior to departure - are the birds dependent on tundra or littoral resources or both, are there major gathering areas used before an initial flight out to staging areas further south, do birds put on substantial energy reserves, or do they drift south more slowly during the initial stages of migration?

SOUTHWARD MIGRATION ROUTES

North America

The flyways used by North American shorebirds moving south from artic breeding grounds divide into three principal corridors.

The first moves south-eastward across the artic to the north-east Atlantic coast of Canada and the U.S., then south either by direct over-water flight to South America or dribbling south along the U.S. eastern seaboard. The second moves south through the central plains and mountain regions of Canada and the U.S. and then on to South America, with some numbers lingering along the U.S. Gulf Coast, in Mexico, and in Central America; and the third south from eastern Siberia and Alaska along the Pacific coast.

The following discussion adds detail for each of the corridors where data are available, using certain indicator species to depict major movement patterns.

Some shorebird populations from the eastern Arctic appear to cross the Ungava Peninsula to the east of Hudson Bay to reach staging areas on the eastern seaboard of North America (see Todd 1963), though little is known of these routes. White-rumped Sandpipers are reported to be the most common shorebird along the coast of Labrador (Austin 1932) and apparently migrate further north and east of most species, being uncommon in the New England states. Larger species, such as the Whimbrel, use upland habitats found in the region, are also rela tively common on this route.

The coastlines of James Bay and Hudson Bay form a migration route of major international importance for many shorebirds breeding in the eastern and central arctic (Morrison and Harrington 1979, Morrison and Gaston 1986). The most important habitats are found along the west coast of James Bay and south coast of Hudson Bay, between Moosonee, Ontario, and Churchill, Manitoba. The very flat topography (gradient 0.5 m/km) and moderate tidal ranges (1.2 - 3.3 m) have produced extensive intertidal flats and marshes, defining a migration corridor some 1 600 km long and several km in width. Along the corridor shorebirds concentrate heavily in a few key sites. In southern James Bay, for example, 71% of the Semipalmated Sandpipers occurr in 10% of the coastline surveyed, with the top three sectors holding some 88% of the birds in 18% of the coast (Morrison 1984). Many species use the resources of the coast of James Bay to accumulate fat reserves to fuel their subsequent flights to the major staging areas on the eastern seaboard. Dunlin undergo a full post-nuptial moult while on this coastline of James Bay. Most of the central arctic population of Red Knot probably uses the coast of James Bay, and Hudsonian Godwits appear to accumulate enough energy reserves during their stay in James Bay for a direct flight to South America (Morrison and Harrington 1979, Morrison 1984).

A limited number of east coast estuaries serve as refuelling sites where shorebirds put on fat reserves for the next stage of their migration. For many this involves awhich takes many species on a direct, trans-oceanic flight to South America. The upper Bay of Fundy is the most important area for Semipalmated Sandpipers, with individual sites, such as Mary's Point, N.B., supporting peak numbers of several hundred thousand birds every year. Major staging areas differ for other species. Red Knot, for example, concentrate at a restricted number of sites in Massachusetts and New Jersey. For many species, the top five sites support 50% and in some cases considerably more, of the populations concerned (MBO 1986).

The Interior Corridor

Other species or populations use interior flyways. Baird's Sandpiper migrates through the central High Plains of North America. Jehl (1979) concluded that it departed from such central staging areas on a non-stop flight of some 6 500 km to the Andes in northern South America. Semipalmated Sandpipers from the western parts of the breeding range appear to migrate south along a central route (Harrington and Morrison 1979): some move on to the north coast of South America (Lank 1979, 1983), while some may cross to the Pacific side, to winter along the Pacific coast.

Many Sanderlings moving southwards along the Atlantic coast and through the interior of North America cross to wintering areas along the Pacific coast in Peru and Chile (Myers *et al.* 1984).

Saline lakes scattered across the Great Basin of the United States are extremely important stopover points for phalaropes. Tens of thousands to hundreds of thousands, perhaps more, of Red-necked Phalaropes and Wilson's Phalaropes have been reported from Great Salt Lake, Utah, Mono Lake, California, and Abert Lake, Oregon (Senner and Howe 1984, Jehl 1986). Further investigations are likely to result in the discovery of other important staging areas.

The Pacific Corridor

The Western Sandpiper and Dunlin of the race *C. alpina pacifica*, breeding in western Alaska, migrate principally along the Pacific coast. There they make use of a series of estuaries, including the Lower Fraser River delta in British Columbia, the Gray's Harbour area in Washington and San Francisco Bay, California, where very large concentrations occur on migration. The Wandering Tattler and Surfbird also migrate along the Pacific coast.

While dividing the North American continient into three general corridors effectively conveys the broad patterns of flyway organisation, it oversimplifies the behaviour of particular species or populations, and even of individuals. For example, Western Sandpipers from Alaskan breeding grounds move south along both the Pacific and Interior corridors (Senner and Martinez 1982). Sanderling migrants headed toward the Pacific Coast of Chile and Peru can be observed on the north-eastern U.S. coast as well as in the interior (Myers *et al.* 1984). One individual Sanderling was even observed during the same migration in Massachusetts and subsequently in Texas (Myers, unpublished).

South America

Migration routes in South America are less well documented than those in North America. Many shorebirds arriving on the north coast of South America after a direct flight from the eastern seaboard of North America, or from an interior staging site, move eastwards along the north coast of the continent before reaching their wintering area or before heading further south (Spaans 1978). Antas (1983) has reviewed possible migration routes of shorebirds in Brasil.

An important migration route used by species such as Baird's Sandpiper and Wilson's Phalarope involves the series of high lakes in the Andes mountains, leading southwards along the mountain chain to inland lakes and wetlands, such as the Laguna Mar Chiquita in Argentina.

On the Pacific coast, estuaries such as those in Buenaventura Bay/southern Colombia, the Gulf of Guayaquil, Ecuador, and the Virrila Estuary in northern Peru, as well as isolated patches of habitat, such as those at Paracas, Peru, and coastal lagoon complexes, such as those at Mejia, Peru, provide stopover areas for shorebirds moving south along the Pacific coast.

WINTERING AREAS

North America

The National Audubon Society's Christmas Bird Counts span much of the relevant area and give a general guide to where shorebirds can be found in mid-winter in the U.S. and temperate Canada. They do not, however, provide solid quantitative information because of wide variation in effort and lack of standardization for censuses in tidal sites. More quantitative data come from less comprehensive studies either limited geographically (*e.g.* the California Shorebird Survey, Jurek 1974) or taxonomically (Haig and Oring 1985, 1986; Myers *et al.* 1975; Page *et al.* 1987).

Together, these various efforts reveal large concentrations of waders along the U.S. Pacific Coast, especially in the coastal and estuarine habitats in the vicinity of San Francisco Bay, which also has the most diverase community of wintering shorebirds in North America. Northern California's mild winter climate and rich mosaic of wader habitats are undoubtedly responsible for such abundant numbers.

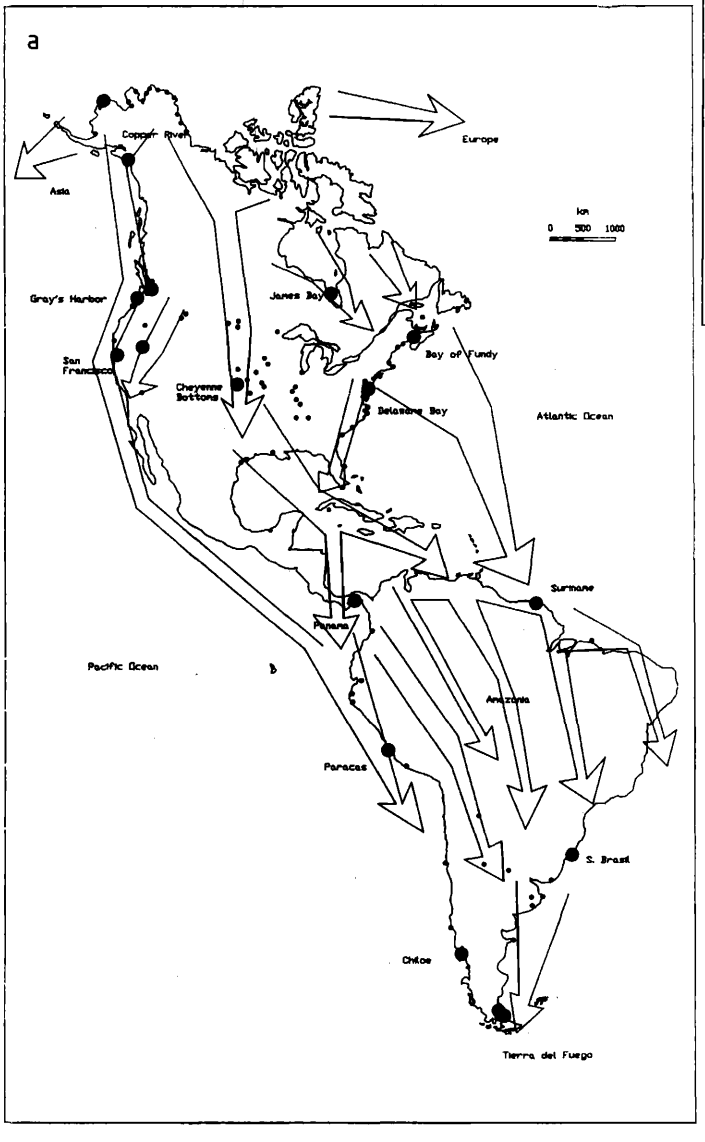
North of Northern California the wader community becomes less diverse. Both dowitcher species, Willets, Semipalmated Plover, and Marbled Godwits drop drop out by estuaries in Northern Washington. These sites, nonetheless, harbour many thousands of Dunlins (Wildrig 1980; Buchanan *et al.* 1986) and during some winters Sanderling numbers are higher in western Washington then anywhere else in North America (Schick and Myers, in prep.).

South of Central California, numbers also fall steadily through to Baja California (Schick *et al.* 1984). Many of the coastal lagoons and estuaries that might have supported major wader populations in Southern California have now disappeared under land-claim.

Compared to the Pacific, the East Coast is relatively depauperate. Dunlin is virtually the only species with totals exceeding the low thousands north of Virginia. Numbers of other species begin to pik up south of Cape Hatteras. By Florida, especially its south and Gulf coasts, estuaries and marshes are known that harbour tens of thousands (totalled across species) of Dunlin, Red Knots, Western Sandpipers, Black-bellied Plovers, Semipalmated Plovers, and other species (Below 1985).

Vast marshes and tide flats in coastal Alabama, Mississippi, Louisiana, and Texas could harbour large numbers of waders. Midwinter census data, however, are limited to a small number of the potential sites, principally around urban centres. Numbers reported from around these areas suggest that this coastline is of major significance to species preferring marsh, such as the yellow-legs and Least Sandpipers. Haig's surveys (Haig 1986) also document the importance of Gulf sandy beaches for the endangered Piping Plover.

The Mexican Gulf Coast is similarily unknown quantitatively other than through a few sorties focussed on Piping Plovers (Haig 1986) and Sanderling (Myers *et al.* 1984).



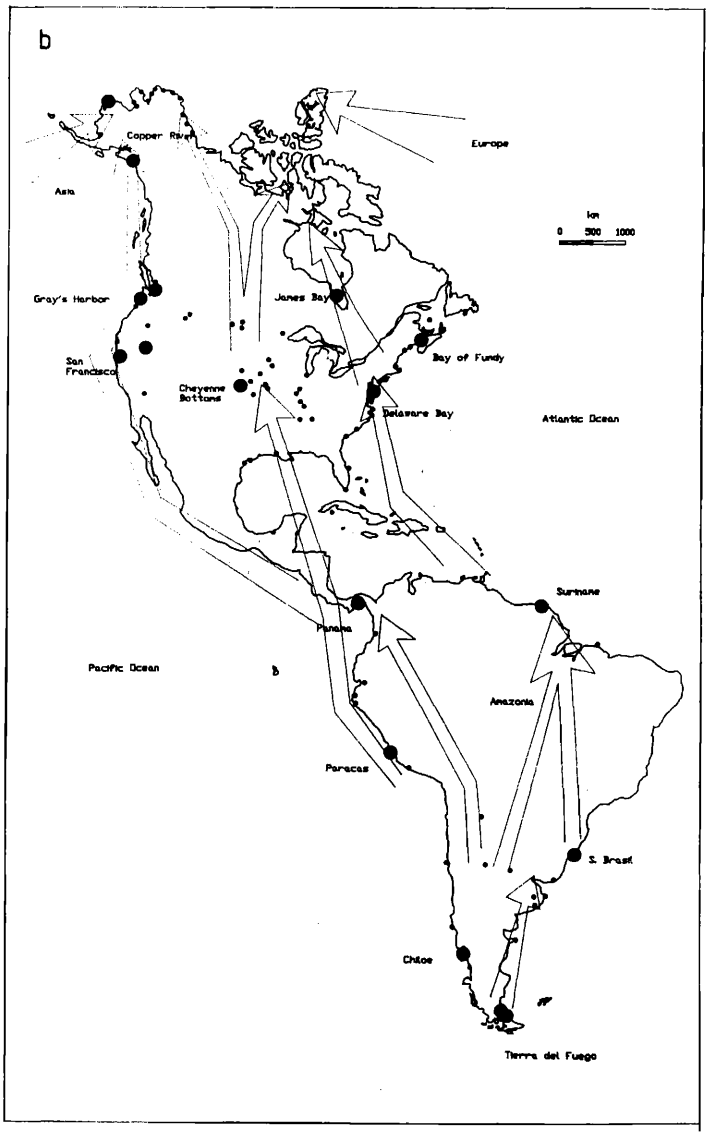


Figure 1. Shorebird flyways in the New World - (a) southward migration, (b) northward migration. Arrows show some of the principal flyways along which shorebirds move during their migrations between breeding areas in the arctic and subarctic and wintering areas in South America. Filled circles show locations of sites which support substantial numbers of shorebirds and which have been nominated for inclusion in the Western Hemisphere Shorebird Reserve Network (see Myers *et al.* 1987a, 1987b this volume). Large circles indicate sites of 'hemispheric' importance, supporting over 250 000 shorebirds or 30% or more of a species flyway population, and small circles indicate 'regional' sites, which support 20 000 shorebirds or 5% or more of a species flyway population.

Central America

This region remains a quantitative void on midwinter shorebird distributions. Anecdotal reports point to the Gulf of Panama as of likely great importance, particularly for Western Sandpipers, Willets, Short-billed Dowitchers, and Semipalmated Plovers. One flock of 10 000 Wilson's Plovers was only first discovered here in December 1986 (Castro and Myers, unpubl.).

South America

Information on the locations of wintering areas used by different species and groups of shorebirds on the coast of South America has come from the Canadian Wildlife Service Shorebird Atlas Project as well as from the work of Myers *et al.* on the Pacific. Some 2.92 million shorebirds were counted during low-level surveys of some 28 000 km of coastline between 1981 and 1986. Most species were highly concentrated into their preferred areas (Morrison and Ross 1987). Totals of shorebirds counted during the surveys are shown in Table 1 and overall distribution patterns summarised by size category are shown in Figure 2.

The principal wintering area for Semipalmated Sandpipers, which made up the bulk of the 2.08 million small sandpipers occurring on the north coast, was in the Guianas: 65% were found in Suriname alone, with a further 19% in French Guiana, so that these two small countries held nearly 84% of the total. The north-central coast of Brasil was also important, with 9% of the total (Morrison and Ross 1987).

The most important coastal wintering areas for Red Knot were in Tierra del Fuego. Some 55% of the South American total of 76 000 Red Knots occurred on the vast intertidal flats of Bahia Lomas, near the eastern mouth of the Straits of Magellan in the Chilean sector of Tierra del Fuego. Knots also were found along the Atlantic coast of Argentinian Tierra del Fuego, with concentrations in Bahia San Sebastian and near Rio Grande. Altogether, Tierra del Fuego held 70% of the South American total, with the remainder wintering on the eastern Atlantic coast between Tierra del Fuego and the Rio Colorado in Argentina.

Two centres of distribution of Hudsonian Godwits were evident. The single most important site was the Bahia San Sebastian on the Atlantic coast of Tierra del Fuego in Argentina, where 43% of the South American total of 46 000 were found. With other areas, particularly Bahia Lomas (23%), Tierra del Fuego altogether held 69% of the South American total. The Chiloe area in southern Chile held 28% of the total.

Most (88%) of the 112 000 Sanderling counted in South America occurred along the ocean beaches of the Pacific coast, with major concentrations occurring in northern Peru around Pacasmayo and on the huge ocean beach fronting the Sechura Desert; moderate to large numbers occurred south to Chiloe.

The north-central coast of Brasil between Belem and Sao Luis was of particular importance for Ruddy Turnstones, Black-bellied Plovers, Willets and Whimbrels (76%, 54%, 49%, and 44% of the South American species totals, respectively).

On the eastern Atlantic coast, other important areas were found in Rio Grande do Sul in southern Brasil, including both ocean beaches and nearshore, shallow, saline to brackish lagoons. The Lagoa do Peixe is the most important currently known, holding substantial numbers of small sandpipers, mostly White-rumped Sandpipers, and Lesser Golden Plovers. Coastal lagoons in Uruguay were also important for shorebirds, with the Laguna da Rocha supporting large numbers of Lesser Golden Plovers (Morrison and Ross 1987).

Independent of CWS surveys, a series of studies have higlighted the importance for wintering waders of central and northern Argentina, especially coastal Buenos Aires. White-rumped and Pectoral Sandpipers populate these marshes in considerable numbers, while Lesser Golden Plovers and Buff-breasted Sandpipers inhabit the uplands (Wetmore 1926,1927; Myers and Myers 1979). While these works do not allow total population estimates, they clearly identify some of the richest non-tidal shorebird habitats yet found in South America.

On the Pacific side, shorebird habitats other than ocean beaches are often restricted in area and separated by long distances, and they assume considerable importance both as wintering areas and as staging sites. In Peru, such habitats include isolated wetlands or lagoon systems, such as those at Mejia, the tidal flats at Paracas and nearby river mouth habitats associated with the Pisco River, and the extensive Virrila estuary in the north of the country.

The totals shown in Table 1 represent minimum possible population figures for shorebirds on wintering areas in coastal South America. Ground-truthing operations to determine accuracy of counts were not undertaken, as it was considered both impracticable from a logistical point of view, given the very remote coastlines and large distances involved, and doubtful whether appropriate correction factors could be developed which would be applicable to all of the extremely wide variety of conditions encountered during the surveys. The survey totals of 2.08 million small sandpipers for the north coast may be compared with Spaans' (1984) estimate of 2-5 million using the coast of Suriname at peak periods, and of some 76 000 Red Knots with Harrington's (1982) estimate of 150 000+ for this species.

Table 1. Totals of Nearctic shorebirds counted during aerial surveys of coastal "wintering" areas in South America in January and February between 1981 and 1986 (from Morrison and Ross 1987). For species in each size category see Morrison et al. (1985).

(a) Small Shorebirds

	Small Sized Shorebirds	Sanderling	Total Small Shorebirds
Venezuela	93 822	654	94 476
Trinidad	12 388	5	12 393
Guyana	9 778	30	9 808
Suriname	1 346 583	42	1 346 625
French Guiana	394 332	2	394 334
Brasil	241 830	10 982	252 812
Uruguay	3 132	5	3 137
Argentina	39 580	1 849	41 429
Chile	20 899	30 287	51 186
Peru	22 829	66 846	89 675
Ecuador	2 044	230	2 274
Colombia	28 790	883	29 673
Total	2 216 007	111 815	2 327 822

(b) Medium-sized Shorebirds

	Medium-sized Shorebirds	Lesser Golden-Plover	Black-bellied Plover	Ruddy Turnstone	Surfbird	Yellowlegs sp.	Red Knot	Dowitcher sp.	Total medium-sized shorebirds
Venezuela	18 699	0	403	261	0	2 377	520	10 213	32 473
Trinidad	80	0	173	6	0	518	0	209	986
Guyana	1 248	0	598	48	0	6 824	0	2 900	11 618
Suriname	55 392	0	3 940	619	0	66 377	0	21 840	148 168
French Guiana	24 148	0	640	601	0	5 117	0	2 400	32 906
Brasil	50 242	758	17 024	18 859	0	6 734	8 326	8 310	110 258
Uruguay	3 087	3 167	365	253	0	88	0	0	6 960
Argentina	4 250	115	10	321	0	715	24 784	0	30 195
Chile	1 133	15	28	150	120	224	42 762	0	44 432
Peru	18 035	0	1 344	1 908	77	1 899	0	0	23 367
Ecuador	1 334	0	1 082	109	0	135	0	825	3 485
Colombia	8 012	0	1 660	364	0	39	0	2 162	12 238
Total	185 660	4 055	27 267	23 499	197	91 047	76 392	48 859	457 086

(c) Large Shorebirds

	Large Shorebirds	Whimbrel	Willet	Hudsonian Godwit	Total Large Shorebirds
Venezuela	221	326	858	0	1 405
Trinidad	0	75	184	0	259
Guyana	0	57	283	0	340
Suriname	2 580	3 310	15 646	0	21 536
French Guiana	1 039	326	729	0	2 094
Brasil	1 939	11 203	21 996	4	35 147
Uruguay	94	2	0	326	422
Argentina	60	20	0	20 726	20 806
Chile	4	7 711	2	24 302	32 019
Peru	542	933	588	171	2 234
Ecuador	60	562	3 384	0	4 006
Colombia	0	349	700	0	1 049
Total	6 539	24 874	44 370	45 529	121 317

Table 1. (Cont'd)

(d) Summary by size category

	Length (km)	Total Small Shorebirds	Total Medium-sized Shorebirds	Total Large Shorebirds	Total Unclassified Shorebirds	TOTAL
Venezuela	1 939	94 476	32 473	1 405	1 411	129 765
Trinidad	484	12 393	986	259	0	13 638
Guyana	479	9 808	11 618	340	0	21 766
Suriname	370	1 346 625	148 168	21 536	10 000	1 526 329
French Guiana	388	394 334	32 906	2 094	1 500	430 834
Brasil	7 852	252 812	110 258	35 147	0	398 217
Uruguay	624	3 137	6 960	422	0	10 519
Argentina	4 548	41 429	30 195	20 806	194	92 624
Chile	5 488	51 186	44 432	32 019	0	127 637
Peru	2 775	89 675	23 367	2 234	0	115 276
Ecuador	1 385	2 274	3 485	4 006	0	9 765
Colombia	1 601	29 673	12 238	1 049	0	42 960
Total	27 933	2 327 822	457 086	121 317	13 105	2 919 330

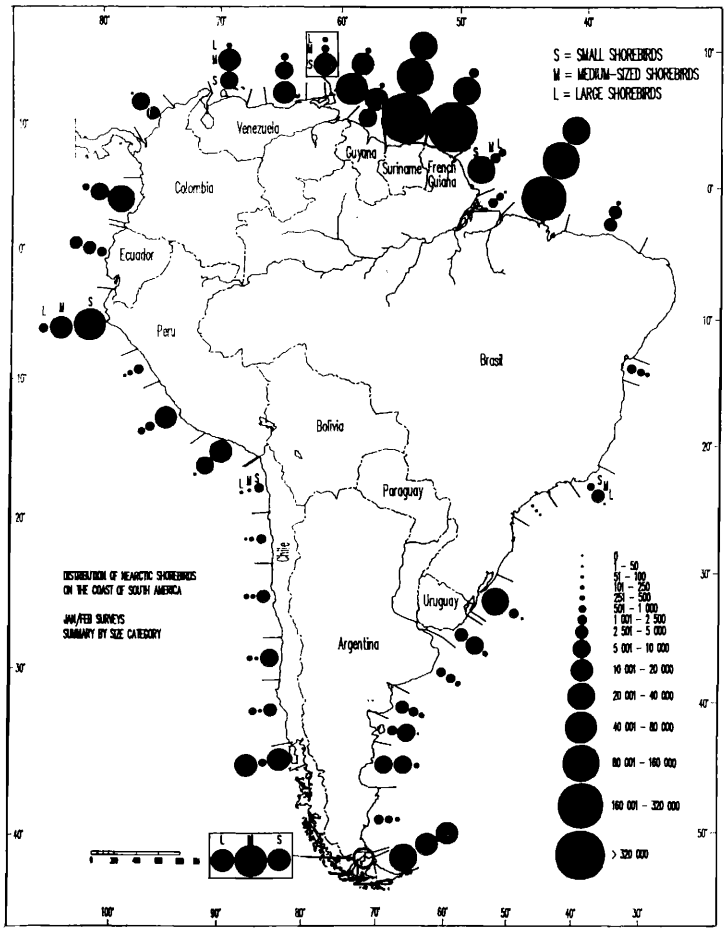


Figure 2. Summary by size category of the distribution of Nearctic shorebirds on the coast of South America observed during surveys conducted in January/February from 1981-1986 (for species in each size category see Morrison *et al.* 1985).

NORTHWARD MIGRATION

As on southward migration, birds travelling northwards to the breeding grounds often concentrate at a discrete series of stopover areas.

Red Knot are found in large numbers on the Valdes Peninsula on the coast of Argentina as they move northwards from Tierra del Fuego and Patagonia. The lagoons and coastline of southern Brasil, and probably northern Uruguay, make up the next important staging area for both Red Knots and Hudsonian Godwits, with concentrations of up to 11 000 and 3 000+, respectively, reported from the Lago do Peixe. The birds are very heavy, implying that they are about to make a long flight, which presumably takes them across Amazonia to, at least, the north coast of South America. (unpublished results, Harrington *et al.* 1986).

In North America, I.S.S. counts from central and eastern areas of the U.S.A. have shown that migrants concentrate even more heavily during northward migration than during the autumn. For 13 out of 20 species of shorebirds censused, more than 75% of the birds were at only five or fewer sites, and at just one site in the case of six species. The most spectacular concentrations on the Atlantic coast occur in Delaware Bay, where migration coincides with the peak of egg-laying by horseshoe crabs *Limulus polyphemus* (Myers 1986). The shores of Delaware Bay have been estimated to support 80% of the Ruddy Turnstones, 79% of Red Knots, 70% of Semipalmated Sandpipers and 62% of the Sanderling counted during spring migration in the U.S.A. (MBO 1986).

From Delaware Bay many birds fly inland towards arctic breeding grounds. Flyways along the coasts of James Bay and Hudson Bay are used by many species, particularly Dunlin, Red Knot and Semipalmated Sandpiper (R.I.G. Morrison, unpublished data).

I.S.S. results imply also that shorebirds are highly concentrated at inland staging sites. Cheyenne Bottoms, Kansas, supported over 90% of White-rumped Sandpipers, Baird's Sandpipers, Stilt Sandpipers, Long-billed Dowitchers and Wilson's Phalaropes, over 70% of Pectoral Sandpipers and Marbled Godwits and nearly 60% of the Hudsonian Godwits counted on the surveys (MBO 1986). Although discovery and coverage of other areas may alter these figures, it seems clear that substantial proportions of birds are found at a very limited number of locations. Cheyenne Bottoms (45%) and Delaware Bay (31%) together accounted for 76% of the shorebirds counted at 210 sites in eastern North America during spring migration (MBO 1986).

Interior sites serve as stopover points for birds coming from many different parts of the wintering range. Semipalmated Sandpipers breeding in the central part of the Arctic and wintering along the north coast of South America migrate northwards through interior sites such as Cheyenne Bottoms and return southwards via the eastern seaboard of North America (Harrington and Morrison 1979). White-rumped Sandpipers, which winter much further south, also appear to take a central route northwards, returning via the northeastern seaboard of North America, as shown both by counts and band recoveries (see Morrison 1984). Baird's Sandpipers, while wintering at southern latitudes comparable to White-rumped Sandpipers, migrate in both directions along the Andes in South America and via a central route in North America (Jehl 1979). Some Sanderlings wintering on the Pacific coast cross the central American isthmus and migrate northwards through the interior, returning to the Pacific coast either via the east coast or by a central route. Individual Sanderlings have been observed northbound on the Pacific coast of Oregon and southbound on the Atlantic coast near Massachusetts, thus describing a vast cir cumcontinental (Myers *et al.* 1984).

Major concentration areas also occur on the west coast. San Francisco Bay and Humboldt Bay in California both support over 100 000 shorebirds at one time, and over one million pass through Gray's Harbor, Washington en route northwards (Senner and Howe 1984). Major staging areas for Sanderlings occur in the Oregon Dunes National Recreation Area and on the beaches from northern Oregon to Gray's Harbor, with an estimated 30 000+ Sanderling passing through these areas (Myers *et al.* 1985). In Alaska, the Copper River Delta supports well over a million shorebirds during spring migration, some estimates running as high as 20 million (Isleib 1979). The bulk of the entire world population of Western Sandpipers and Dunlin of the subspecies *C. alpina \ pacifica* pass through the Copper River Delta (Senner et al. 1981, Senner and Howe 1984).

CONSERVATION INITIATIVES

The wide geographic perspective provided by the international survey operations, such as the I.S.S., the South American Shorebird Atlas Project and Pan American Shorebird Program, has led directly to the formulation of new conservation initiatives. The demonstration that large proportions of shorebird populations are often dependent on a limited number of key sites both on the wintering grounds and during migration implies that for conservation to be ultimately successful, all the key areas must be protected, since removal of one critical link in the chain would put the entire migration system at risk. The concept thus soon emerged of creating a system of linked reserves, or "Sister Reserves", which would protect the key sites used by the birds throughout the year (Morrison 1983, 1984), and the result has been the setting up of a 'Western Hemisphere Shorebird Reserve Network' with this objective, as described by Myers *et al.* (1987a, 1987b).

GAPS IN KNOWLEDGE

Although recent research has clarified many aspects of shorebird flyways in the New World, much information is still required for the formulation of soundly based conservation and management initiatives. Some of the main areas in which further information is required may be summarised as follows:

Much better information is needed on the locations of the main population centres on the breeding grounds. Better information is needed on breeding densities, in relation to habitat, food supply and other birds, and on year to year variability in densities, breeding success and productivity. More information is also required from arctic and subarctic areas on the location of gathering points and the resources used by the birds before their departure from the breeding grounds: this information is par ticularly needed from the eastern arctic.

On the Pacific coast, little information is available on species such as the Wandering Tattler and Surfbird. Better information is needed on the numbers and phenology of shorebirds using west coast estuaries.

Another major gap concerns knowledge of staging areas in the interior of North America, particularly on the Canadian Prairies, in the U.S. west and mid west and the lakes of the Great Basin. Similarly in South America, although considerable information now exists for coastal wintering areas, much more information is needed on numbers and phenology of birds using staging areas on the coast, and on major concentration areas in the interior at all times of the year: very little information at all, for instance, is available from inland poten tial stopover areas in the interior of Brasil or along the Andes chain. Another region for which much better information is required includes Mexico, Central America and the Caribbean.

Rather little information is available on species associated with upland habitats, such as the Lesser Golden Plover, the Buff- breasted Sandpiper, and the Upland Sandpiper. Another group of species for which more information is required includes those breeding within South America, such as Magellanic Plover.

More information is needed on shorebirds remaining in South America and south of the breeding grounds during the breeding season, and the importance of "summering areas" to subadult portions of the population.

Better information is needed on population trends in shorebird populations in the New World and on the factors affecting survival. Information on how mortality is divided between the various phases of the annual cycle and when shorebirds are most vulnerable to environmental pressures is also needed.

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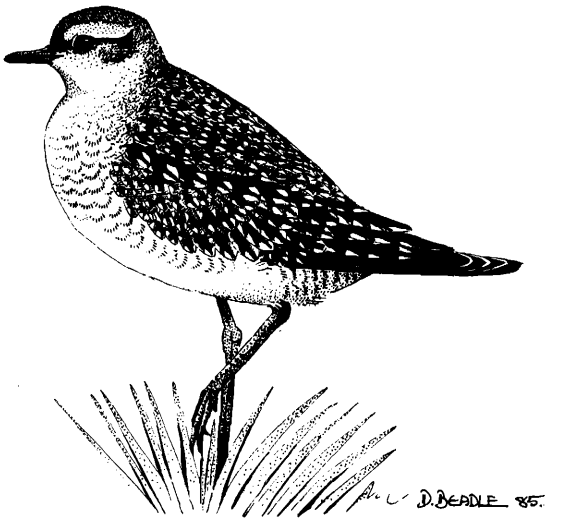

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Appendix 1. Scientific names of shorebird species mentioned in the text.

Black-bellied Plover	*Pluvialis squatarola*
Lesser Golden Plover	*Pluvialis dominica*
Magellanic Plover	*Pluvianellis socialis*
Piping Plover	*Charadrius melodus*
Snowy Plover	*Charadrius alexandrinus*
Upland Sandpiper	*Bartramia longicauda*
Whimbrel	*Numenius phaeopus*
Hudsonian Godwit	*Limosa haemastica*
Marbled Godwit	*Limosa fedoa*
yellowlegs sp.	*Tringa melanoleuca/T. flavipes*
Solitary Sandpiper	*Tringa solitaria*
Willet	*Catoptrophorus semipalmatus*
Wandering Tattler	*Heteroscelus incanus*
Ruddy Turnstone/Turnstone	*Arenaria interpres*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Short-billed Dowitcher	*Limnodromus griseus*
Surfbird	*Aphriza virgata*
Red Knot/Knot	*Calidris canutus*
Sanderling	*Calidris alba*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
White-rumped Sandpiper	*Calidris fuscicollis*
Baird's Sandpiper	*Calidris bairdii*
Pectoral Sandpiper	*Calidris melanotos*
Dunlin	*Calidris alpina*
Stilt Sandpiper	*Micropalama himantopus*
Buff-breasted Sandpiper	*Tryngites subruficollis*
Red-necked Phalarope	*Phalaropus lobatus*
Wilson's Phalarope	*Phalaropus tricolor*