Chapter 9

Brazil

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9.1. General geography

Brazil is the largest country in South America, in terms of both geography and population. It has a surface area of over 8.51×10^6 km^2, approximately half the area of the South American continent, and is the fifth largest country in the world. Brazil shares common borders with all but two countries in South America (Ecuador and Chile), and its population of some 135 million, the eighth largest in the world, is over half that of South America. Brazil is about 4320 km from north to south and 4330 km from east to west (Brooks 1985) and lies between 5°N and 34°S and between 35 and 74°W.

The coastline of Brazil is some 9200 km long and lies roughly between 4°N and 34°S. It contains a wide variety of morphologies, environments, and sediments, which are determined not only by the geological structure of the immediate coastal area, but also by that of the hinterland drainage areas, as well as oceanographic and climatic factors. The entire coastline, and indeed nearly all of Brazil, is underlain by the Precambrian rocks of the Brazilian Platform, the major geotectonic unit on which much of the continent between the Orinoco River and the Rio de la Plata is situated. The Brazilian Platform outcrops in three major shields, which form the major structural plateaus of northern South America (Harrington 1956) (Fig. 9.1): (1) the Guiana Shield, located to the north of the Amazon River and extending through northwestern Brazil along the borders with the Guianas and Venezuela; (2) the Central Brazilian Shield south of the Amazon River; and (3) the Coastal Brazilian (Atlantic) Shield, extending all along the eastern coastal margin of the country. These shields are composed of very old, hard crystalline rocks, dating back more than 1800 million years BP (Almeida *et al.* 1973), although they are partly overlain in some areas by later sedimentary rocks. Between the shields lie enormous basins containing the huge areas of the major river drainage systems. The two most important are the Amazon River system, occupying the vast Amazon Basin between the Guiana and Central Brazilian shields, and the Parana/Paraguay river system, which is situated between the Andes and the southern part of the Coastal Brazilian (Atlantic) Shield. Other principal geological basins include the Sao Francisco Basin, containing the third largest river system in Brazil, lying between the Central and Coastal Brazilian (Atlantic) shields, and the Parnaiba (or Maranhao) Basin to its north, extending towards the north coast (Fig. 9.1).

The Amazon is the largest river in the world, in terms of both drainage area and volume of water discharged (Gibbs 1967; Lisitzin 1972). The basin containing the vast network of tributaries making up the Amazon system is roughly bottle-shaped, trending in an east-northeasterly direction, being some 3000 km long, 600–800 km wide at its upper west end, and 300 km wide towards the narrow eastern end (Bigarella 1973). The entire area is very low-lying, most of it below 200 m in elevation. Rainfall is generally high, varying between 1500 and 3000 mm·yr^{-1}, with a rainy season occurring between October and May in the central and eastern sections. Peak river flow occurs in June, with tributaries to the north of the Amazon reaching peaks between June and August and those to the south between February and June (Junk 1983; Scott and Carbonell 1986). Together with the Tocantins, the Amazon and Parana/la Plata systems drain almost 80% of Brazil and, because of the aridity of the northeastern rivers, account for about 90% of the runoff and suspended load of sediments reaching the Brazilian coast (Milliman 1975).

Most of the sediment reaching the mouth of the Amazon is derived from the hard crystalline rocks of the Andes: some 84% of the discharged material derives from about 12% of the drainage area in the Andes, and the overall compositions of the sediments discharged at the mouth of the river and of those eroded from the mountainous environment differ only slightly (Gibbs 1967). Although the concentration of suspended material in the Amazon is not particularly high compared with those in other world rivers, the amount of material reaching the sea is very large: an estimated 500×10^6 tons·yr^{-1} from the 5500 km^3 of water discharged each year (Milliman 1975). Amazon sediments are carried northwestwards by the North Equatorial (Guiana) Current for some 2000 km in a belt averaging 60 km in width (Gibbs 1970*a*) and are deposited along the north coast of South America from northern Brazil and the Guianas to the Orinoco River in Venezuela. These coastlines are generally low and flat, with extensive mangrove forests and swamps and rather mobile intertidal mud- and sandflats.

In the mouth of the Amazon itself, discharge is so high that a saltwater wedge does not enter the river, resulting in an essentially freshwater environment, even during periods of low river discharge (Gibbs 1970*b*). Currents are strong and the tidal range high. Most intertidal areas consist of sandflats, and the low coast is backed by palm (*Euterpe oleracea* and *Mauritia flexuosa*) forests and open swamps.

East of the mouth of the Amazon River, the coastline between Belem and Sao Luis is highly indented. Shallow bays, which contain large areas of intertidal flats and are lined with extensive mangrove forests, alternate with sandy outer headlands fronted by ocean beaches. These

areas represent drowned river valleys being reinvaded by the sea and contain a wide variety of sediment and habitat types.

Beyond the Baia de Sanadi east of Sao Luis, the coastline becomes smoother and straighter. It is generally sandy, beach ridges and dunes alternating with occasional embayments and estuaries, which are restricted to the mouths of the larger (and some of the smaller) rivers. Although the larger rivers flow year-round, many of the smaller rivers in the arid northeast dry up. Much of the hinterland is arid and sparsely vegetated and consists of scrubland.

The eastern Atlantic coastline is backed by mountains of the Precambrian Coastal Brazilian (Atlantic) Shield, which reach heights of 500–1000 m. The coastal plain is generally fairly narrow, and parts of the shoreline are cliffed. Rainfall is high, usually exceeding 1000 $mm \cdot yr^{-1}$ and sometimes 2000 $mm \cdot yr^{-1}$, where the prevailing easterly and southeasterly winds deposit their moisture (Andrade 1964). The Rio Sao Francisco is the principal river; it is about 2700 km in length and provides the major source of sediment and freshwater input on the coast. Most of the sediment appears to remain within its own system, as with other rivers on the coast (Barretto and Summerhayes 1975; Summerhayes *et al.* 1975). The offshore waters are generally unproductive (Okada 1960; Hela and Laevastu 1962); even near the Rio Sao Francisco, which provides most of the nutrient and sediment input on this part of the coast, most organic matter (mainly diatoms) appears to be recycled within the water column, with only a small amount accumulating in the sediment (Barretto and Summerhayes 1975).

Much of the Atlantic coast is similar, with a coastal plain of variable width interrupted by occasional river deltas or outcroppings of the underlying Precambrian rocks. Parts of the coast are lined with reefs of beachrock, and barrier beaches develop under the influence of waves produced by the prevailing southeasterly trade winds. Rivers are generally short, owing to the proximity of the mountains of the Coastal Brazilian (Atlantic) Shield. Mangroves may develop in embayments (e.g., in the area of Salvador) or behind protective barrier beaches.

The crystalline basement rocks continue southwards into Rio Grande do Sul, nearing the coast in the ranges of the Serra do Mar and Serra Geral formations, which reach heights of 1000 m and in some places over 1900 m (Fuck *et al.* 1969). With the mountain ranges close to the sea, most of the rivers in the southern part of the country flow westwards into the Parana River system.

In the south, the coastline of Rio Grande do Sul forms one of the longest uninterrupted beaches in the world, being some 620 km in length (Martins 1967; Pinto and Ornellas 1970). A number of major lagoons lie behind the coast, the largest being the Lagoa dos Patos and the Lagoa Mirim. These are separated from the ocean by several kilometres of marine and eolian sands, in which are found numerous smaller lagoons. Some of the lagoons are periodically connected to the sea and are hence partially brackish; such lagoons (e.g., the Lagoa do Peixe) form important habitats for wintering and migrant birds (Morrison *et al.* 1985; Harrington *et al.* 1986).

Offshore, the west-flowing South Equatorial Current reaches the coast of Brazil to the north of Recife (Defaut 1961). The current splits, with the North Brazilian Coastal Current flowing north past Natal and then west along the north coast as the North Equatorial (Guiana) Current at about 1 $m \cdot s^{-1}$ (Metcalf and Stalcup 1967), and the Brazil Current flowing southwards towards Rio de Janeiro at about 0.25–0.5 $m \cdot s^{-1}$. Surface temperatures range between 26 and 29°C in summer (March; Fuglister 1960) and between 25 and 27°C in winter (August; Cavalcanti *et al.* 1967). Salinities are around 36 ppt. The Brazil Current flows south to about 30°S, where it meets the colder and less saline Falkland (Malvinas) Current moving north from the southern ocean. The Falkland (Malvinas) Current extends progressively northwards in the autumn under the influence of southwesterly winds, reaching its maximum development during the southern winter, when cool waters invade north of Santa Catarina state, dipping below the surface before upwelling at Cabo Frio. In the spring, winds shift to northeast, and the Brazil Current again dominates the coastal circulation (Emilsson 1961). After meeting, the two currents turn east to flow back across the South Atlantic, thus completing the counter-clockwise circulation of the South Atlantic Ocean (King 1975). Cabo Frio (23°S) marks the northernmost limit reached by cooler waters from the south. Upwelling is strong in the Cabo Frio area, and, with the incursion of cold water, biological productivity is relatively high thereabouts (Okuda 1962). Bottom sediments in the area show slightly elevated levels of nitrogen, but the impact of upwelling is not clearly shown in the sediments, probably because the high wave and current energies and high oxygen levels occurring between Cabo Frio and Vitoria facilitate high levels of recycling of organic matter within the water column (da Rocha *et al.* 1975). Ocean productivity increases southwards beyond Cabo Frio (Peres 1982). In contrast, waters off the northern part of the coast are generally unproductive (Okada 1960; Hela and Laevastu 1962).

9.2. Shorebird distribution

Brazil supported the third highest overall total of Nearctic shorebirds recorded on the surveys: of the total of 398 000, 63.5% were small shorebirds, 27.2% were medium-sized birds, and 8.8% were large species. These totals represented highly significant proportions of the South American totals for each category: 13.6% of the total Nearctic shorebirds, and 10.9, 24.1, and 29.0% of the small, medium-sized, and large categories, respectively (Table 9.1).

Two regions of Brazil stood out clearly as being of special importance for shorebirds. The most spectacular area was the north-central coast of Brazil between Belem and the Sao Luis area, which held major proportions of the wintering populations of a number of species (Morrison *et al.* 1986*a*, 1986*b*). The shoreline and coastal lagoons of Rio Grande do Sul in the south were of special importance both as a wintering area and as a staging area for birds on migration (Morrison *et al.* 1985; Harrington *et al.* 1986).

9.2.1. North-central coast of Brazil

This section of coast is highly indented and hence very long; it contains a series of bays and headlands with a wide variety of habitats, from extensive muddy intertidal areas lined with mangroves in the inner parts of the bays, through tough mudbanks, sandy and muddy flats and marsh developments in the middle parts of the bays, to sandy outer headlands with ocean beaches and spits (Morrison *et al.* 1987). This highly productive area sup-

Table 9.1
Summary totals of Nearctic shorebirds in eco-units in Brazil

Eco-unit/Parameter	Eco-unit length (km)	Small shorebirds	Medium-sized shorebirds	Large shorebirds	Total shorebirds
North	464.3				
No. of birds		25 598	2 323	674	28 595
% of size-class total (Brazil)		10.13	2.11	1.92	7.18
% of size-class total (South America)		1.10	0.51	0.56	0.98
% of size-class total (North Coast)		1.23	0.69	1.11	1.14
% of grand total (North Coast)		1.02	0.09	0.03	1.14
Amazon	633.8				
No. of birds		2 080	621	7	2 708
% of size-class total (Brazil)		0.82	0.56	0.02	0.68
% of size-class total (South America)		0.09	0.14	0.01	0.09
% of size-class total (North Coast)		0.10	0.19	0.01	0.11
% of grand total (North Coast)		0.08	0.02	0.00	0.11
North-central	2 504.7				
No. of birds		195 531	97 227	34 133	326 891
% of size-class total (Brazil)		77.34	88.18	97.11	82.09
% of size-class total (South America)		8.40	21.27	28.14	11.20
% of size-class total (North Coast)		9.36	29.01	56.25	13.09
% of grand total (North Coast)		7.83	3.89	1.37	13.09
Northeast	1 248.4				
No. of birds		3 009	2 760	183	5 952
% of size-class total (Brazil)		1.19	2.50	0.52	1.49
% of size-class total (South America)		0.13	0.60	0.15	0.20
% of size-class total (North Coast)		0.14	0.82	0.30	0.24
% of grand total (North Coast)		0.12	0.11	0.01	0.24
East	939.0				
No. of birds		1 817	679	143	2 639
% of size-class total (Brazil)		0.72	0.62	0.41	0.66
% of size-class total (South America)		0.08	0.15	0.12	0.09
% of size-class total (Atlantic Coast)		2.21	0.77	0.43	1.30
% of grand total (Atlantic Coast)		0.89	0.33	0.07	1.30
Rio	394.9				
No. of birds		688	4 885	0	5 573
% of size-class total (Brazil)		0.27	4.43	0.00	1.40
% of size-class total (South America)		0.03	1.07	0.00	0.19
% of size-class total (Atlantic Coast)		0.84	5.57	0.00	2.74
% of grand total (Atlantic Coast)		0.34	2.40	0.00	2.74
Sao Paulo	784.5				
No. of birds		11	1	0	12
% of size-class total (Brazil)		0.00	0.00	0.00	0.00
% of size-class total (South America)		0.00	0.00	0.00	0.00
% of size-class total (Atlantic Coast)		0.01	0.00	0.00	0.01
% of grand total (Atlantic Coast)		0.01	0.00	0.00	0.01
Rio Grande do Sul	882.9				
No. of birds		24 078	1 762	7	25 847
% of size-class total (Brazil)		9.52	1.60	0.02	6.49
% of size-class total (South America)		1.03	0.39	0.01	0.89
% of size-class total (Atlantic Coast)		29.23	2.01	0.02	12.71
% of grand total (Atlantic Coast)		11.84	0.87	0.00	12.71
All Brazil	7 852.5				
No. of birds		252 812	110 258	35 147	398 217
% of size-class total (South America)		10.86	24.12	28.97	13.64
% of grand total (South America)		8.66	3.78	1.20	13.64

ported 327 000 shorebirds (82.1% of the Brazilian total), including 196 000 small, 97 200 medium-sized, and 34 100 large shorebirds (77.3, 88.2, and 97.1% of the respective Brazilian size-class totals) (Table 9.1). These North-central eco-unit size-class totals represented 8.4, 21.3, and 28.1% of the respective South American totals (9.4, 29.0, and 56.3% of the respective North Coast totals) (Table 9.1), identifying the area as being of major international importance. The small shorebird category included 192 000 peeps (9.2% of the North Coast total, 8.7% of the South American total) and consisted principally of Semipalmated Sandpipers *Calidris pusilla*, with smaller numbers of other *Calidris* sandpipers (e.g., Least Sandpipers *C. minutilla*) and small plovers in the genus *Charadrius*. The area was regionally important for Sanderlings *Calidris alba*, supporting 70.5% (3100, 2.8% of the South American total) of the birds on the North Coast (Table 9.2*a*).

The north-central coast contained the most important wintering areas discovered on the continent for Ruddy Turnstones *Arenaria interpres* and Black-bellied Plovers *Pluvialis squatarola*. Ruddy Turnstones were especially common on the tough mudbanks and mangrove coasts of the area, the total of 17 900 representing 76.2% of the South American total (88.5% of the North Coast total), making the area of major international importance for this species (Table 9.2*b*). The complexes of large intertidal flats and beaches, providing both plentiful feeding and roosting habitats, attracted large numbers of Black-bellied Plovers, the total of 14 700 being 54.0% of the South American total (61.9% of the North Coast total). The area was also notable for Red Knot *Calidris canutus*, supporting the only substantial concentration (8200) discovered outside the main wintering areas in Tierra del Fuego and Patagonia.

Table 9.2*a*
Totals of Nearctic shorebird species in eco-units in Brazil—small shorebirds

Eco-unit/Parameter	Eco-unit length (km)	Semi-palmated Plover	Spotted Sandpiper	Solitary Sandpiper	Pectoral Sandpiper	White-rumped Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds
North	464.3								
No. of birds		0	2	0	0	0	2	25 594	25 598
% of species total (North Coast)		0.00	0.56	0.00	0.00	0.00	0.05	1.23	1.23
% of species total (South America)		0.00	0.46	0.00	0.00	0.00	0.00	1.16	1.10
% of size-class total (North Coast)		0.00	0.00	0.00	0.00	0.00	0.00	1.23	1.23
% of grand total (North Coast)		0.00	0.00	0.00	0.00	0.00	0.00	1.02	1.02
Amazon	633.8								
No. of birds		470	4	0	0	0	117	1 489	2 080
% of species total (North Coast)		100.00	1.11	0.00	0.00	0.00	2.68	0.07	0.10
% of species total (South America)		100.00	0.93	0.00	0.00	0.00	0.10	0.07	0.09
% of size-class total (North Coast)		0.02	0.00	0.00	0.00	0.00	0.01	0.07	0.10
% of grand total (North Coast)		0.02	0.00	0.00	0.00	0.00	0.00	0.06	0.08
North-central	2 504.7								
No. of birds		0	246	1	0	0	3 080	192 204	195 531
% of species total (North Coast)		0.00	68.33	100.00	0.00	0.00	70.51	9.22	9.36
% of species total (South America)		0.00	57.08	50.00	0.00	0.00	2.75	8.69	8.40
% of size-class total (North Coast)		0.00	0.01	0.00	0.00	0.00	0.15	9.20	9.36
% of grand total (North Coast)		0.00	0.01	0.00	0.00	0.00	0.12	7.70	7.83
Northeast	1 248.4								
No. of birds		0	3	0	0	0	380	2 626	3 009
% of species total (North Coast)		0.00	0.83	0.00	0.00	0.00	8.70	0.13	0.14
% of species total (South America)		0.00	0.70	0.00	0.00	0.00	0.34	0.12	0.13
% of size-class total (North Coast)		0.00	0.00	0.00	0.00	0.00	0.02	0.13	0.14
% of grand total (North Coast)		0.00	0.00	0.00	0.00	0.00	0.02	0.11	0.12
East	939.0								
No. of birds		0	20	1	65	0	261	1 470	1 817
% of species total (Atlantic Coast)		0.00	80.00	100.00	98.48	0.00	2.81	2.08	2.21
% of species total (South America)		0.00	4.64	50.00	98.48	0.00	0.23	0.07	0.08
% of size-class total (Atlantic Coast)		0.00	0.02	0.00	0.08	0.00	0.32	1.78	2.21
% of grand total (Atlantic Coast)		0.00	0.01	0.00	0.03	0.00	0.13	0.72	0.89
Rio	394.9								
No. of birds		0	2	0	0	0	524	162	688
% of species total (Atlantic Coast)		0.00	8.00	0.00	0.00	0.00	5.65	0.23	0.84
% of species total (South America)		0.00	0.46	0.00	0.00	0.00	0.47	0.01	0.03
% of size-class total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.64	0.20	0.84
% of grand total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.26	0.08	0.34
Sao Paulo	784.5								
No. of birds		0	0	0	0	0	0	11	11
% of species total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01
% of species total (South America)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% of size-class total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
% of grand total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Rio Grande do Sul	882.9								
No. of birds		0	0	0	1	2 340	6 618	15 119	24 078
% of species total (Atlantic Coast)		0.00	0.00	0.00	1.52	99.96	71.30	21.40	29.23
% of species total (South America)		0.00	0.00	0.00	1.52	99.96	5.92	0.68	1.03
% of size-class total (Atlantic Coast)		0.00	0.00	0.00	0.00	2.84	8.03	18.35	29.23
% of grand total (Atlantic Coast)		0.00	0.00	0.00	0.00	1.15	3.25	7.43	11.84
All Brazil	7 852.5								
No. of birds		470	277	2	66	2 340	10 982	238 675	252 812
% of species total (South America)		100.00	64.27	100.0	100.0	99.96	9.82	10.79	10.86
% of size-class total (South America)		0.02	0.01	0.00	0.00	0.10	0.47	10.25	10.86
% of grand total (South America)		0.02	0.01	0.00	0.00	0.08	0.38	8.18	8.66

Dowitchers *Limnodromus* spp. were also numerous, with 16.6% (8100) of the South American total (17.1% of the North Coast total).

North-central Brazil was also the most important wintering area discovered in South America for two large species, Whimbrel *Numenius phaeopus* and Willet *Catoptrophorus semipalmatus*. Whimbrels were especially numerous, again favouring the tough mudbanks and flats of the area, the total of 10 900 representing 43.7% of the total for South America (71.3% of the North Coast total). Willets were also common along the mangrove coastlines, the total of 21 900 representing 49.3 and 55.2% of the South American and North Coast totals, respectively (Table 9.2*c*).

9.2.2. Rio Grande do Sul

The long, sandy ocean beaches of the coastline of Rio Grande do Sul in southern Brazil supported the highest numbers of Sanderlings (6600, 5.9% of the South American total) found on the Atlantic coast, with 71.3% of the regional Atlantic Coast total. This area and the north-central coast of Brazil supported the most significant concentrations of Sanderlings found outside the main wintering area of the species on the west coast of South America.

Nearshore brackish lagoons, such as the Lagoa do Peixe, were especially important as shorebird habitat. The Rio Grande do Sul eco-unit held 15 100 peeps, representing 21.4% of the Atlantic Coast total (Table 9.2*a*). The

Table 9.2*b*
Totals of Nearctic shorebird species in eco-units in Brazil—medium-sized shorebirds

Eco-unit/Parameter	Eco-unit length (km)	Lesser Golden-Plover	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Red Knot	Dowitcher species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds
North	464.3								
No. of birds		47	676	191	205	120	20	1 064	2 323
% of species total (North Coast)		36.43	2.84	0.94	0.25	1.36	0.04	0.70	0.69
% of species total (South America)		1.16	2.48	0.81	0.22	0.16	0.04	0.57	0.51
% of size-class total (North Coast)		0.01	0.20	0.06	0.06	0.04	0.01	0.32	0.69
% of grand total (North Coast)		0.00	0.03	0.01	0.01	0.00	0.00	0.04	0.09
Amazon	633.8								
No. of birds		0	101	4	227	0	150	139	621
% of species total (North Coast)		0.00	0.42	0.02	0.27	0.00	0.32	0.09	0.19
% of species total (South America)		0.00	0.37	0.02	0.25	0.00	0.31	0.07	0.14
% of size-class total (North Coast)		0.00	0.03	0.00	0.07	0.00	0.04	0.04	0.19
% of grand total (North Coast)		0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.02
North-central	2 304.7								
No. of birds		0	14 711	17 909	803	8 191	8 105	47 508	97 227
% of species total (North Coast)		0.00	61.88	88.45	0.97	92.60	17.09	31.26	29.01
% of species total (South America)		0.00	53.95	76.21	0.88	10.72	16.59	25.59	21.27
% of size-class total (North Coast)		0.00	4.39	5.34	0.24	2.44	2.42	14.18	29.01
% of grand total (North Coast)		0.00	0.59	0.72	0.03	0.33	0.32	1.90	3.89
Northeast	1 248.4								
No. of birds		82	1 289	433	218	15	35	688	2 760
% of species total (North Coast)		63.57	5.42	2.14	0.26	0.17	0.07	0.45	0.82
% of species total (South America)		2.02	4.73	1.84	0.24	0.02	0.07	0.37	0.60
% of size-class total (North Coast)		0.02	0.38	0.13	0.07	0.00	0.01	0.21	0.82
% of grand total (North Coast)		0.00	0.05	0.02	0.01	0.00	0.00	0.03	0.11
East	939.0								
No. of birds		0	168	321	59	0	0	131	679
% of species total (Atlantic Coast)		0.00	27.01	35.75	0.97	0.00	0.00	1.52	0.77
% of species total (South America)		0.00	0.62	1.37	0.06	0.00	0.00	0.07	0.15
% of size-class total (Atlantic Coast)		0.00	0.19	0.37	0.07	0.00	0.00	0.15	0.77
% of grand total (Atlantic Coast)		0.00	0.08	0.16	0.03	0.00	0.00	0.06	0.33
Rio	394.9								
No. of birds		0	76	1	4 808	0	0	0	4 885
% of species total (Atlantic Coast)		0.00	12.22	0.11	78.78	0.00	0.00	0.00	5.57
% of species total (South America)		0.00	0.28	0.00	5.27	0.00	0.00	0.00	1.07
% of size-class total (Atlantic Coast)		0.00	0.09	0.00	5.48	0.00	0.00	0.00	5.57
% of grand total (Atlantic Coast)		0.00	0.04	0.00	2.36	0.00	0.00	0.00	2.40
Sao Paulo	784.5								
No. of birds		0	0	0	0	0	0	1	1
% of species total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
% of species total (South America)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% of size-class total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% of grand total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rio Grande do Sul	882.9								
No. of birds		629	3	0	419	0	0	711	1 762
% of species total (Atlantic Coast)		16.08	0.48	0.00	6.87	0.00	0.00	8.26	2.01
% of species total (South America)		15.51	0.01	0.00	0.46	0.00	0.00	0.38	0.39
% of size-class total (Atlantic Coast)		0.72	0.00	0.00	0.48	0.00	0.00	0.81	2.01
% of grand total (Atlantic Coast)		0.31	0.00	0.00	0.21	0.00	0.00	0.35	0.87
All Brazil	7 852.5								
No. of birds		758	17 024	18 859	6 739	8 326	8 310	50 242	110 258
% of species total (South America)		18.69	62.43	80.25	7.39	10.90	17.01	27.06	24.12
% of size-class total (South America)		0.17	3.72	4.13	1.47	1.82	1.82	10.99	24.12
% of grand total (South America)		0.03	0.58	0.65	0.23	0.29	0.28	1.72	3.78

majority of peeps in this region are White-rumped Sandpipers *Calidris fuscicollis*; if the totals for these categories are combined, the Rio Grande do Sul coastline held 17 500, or 23.9% of the Atlantic Coast total, with 14 200 (81.6%) in lagoon habitats and 3200 (18.4%) on the coast. Lagoon and shoreline habitats in this area were also important for the Lesser Golden-Plover *Pluvialis dominica*; the total of 630 represented 16.1% of the Atlantic Coast total (Table 9.2*b*), although this species also makes widespread use of inland habitats. During ground surveys in February 1985, an estimated 6000–10 000 Lesser Golden-Plovers were found at the Lagoa do Peixe (unpubl. results). The area is also known to be of critical importance as a stopover site for Red Knots and Hudsonian Godwits *Limosa haemastica* during northward migration (unpubl. results; Harrington *et al.* 1986).

9.2.3. Other parts of the Brazilian coast

Numbers of shorebirds were smaller along other parts of the Brazilian coastline. In the north, the coast between the border with French Guiana and the mouth of the Amazon River contained moderate numbers of small shorebirds, mostly peeps (25 600, 10.1% of the Brazilian total, 1.2% of the North Coast total; Table 9.2*a*), and

Table 9.2c
Totals of Nearctic shorebird species in eco-units in Brazil—large shorebirds

Eco-unit/Parameter	Eco-unit length (km)	Whimbrel	Willet	Hudsonian Godwit	Unidentified large shorebird species	Total large shorebirds
North	464.3					
No. of birds		138	25	0	511	674
% of species total (North Coast)		0.90	0.06	0.00	8.85	1.11
% of species total (South America)		0.55	0.06	0.00	7.81	0.56
% of size-class total (North Coast)		0.23	0.04	0.00	0.84	1.11
% of grand total (North Coast)		0.01	0.00		0.02	0.03
Amazon	633.8					
No. of birds		0	0	0	2	2
% of species total (North Coast)		0.00	0.00	0.00	0.03	0.01
% of species total (South America)		0.00	0.00	0.00	0.03	0.01
% of size-class total (North Coast)		0.00	0.00	0.00	0.00	0.01
% of grand total (North Coast)		0.00	0.00		0.00	0.00
North-central	2 504.7					
No. of birds		10 879	21 868	4	1 382	34 133
% of species total (North Coast)		71.30	55.17	100.00	23.93	56.25
% of species total (South America)		43.74	49.29	0.01	21.13	28.14
% of size-class total (North Coast)		17.93	36.04	0.01	2.28	56.25
% of grand total (North Coast)		0.44	0.88	0.00	0.06	1.37
Northeast	1 248.4					
No. of birds		117	26	0	40	183
% of species total (North Coast)		0.77	0.07	0.00	0.69	0.30
% of species total (South America)		0.47	0.06	0.00	0.61	0.15
% of size-class total (North Coast)		0.19	0.04	0.00	0.07	0.30
% of grand total (North Coast)		0.00	0.00	0.00	0.00	0.01
East	939.0					
No. of birds		66	77	0	0	143
% of species total (Atlantic Coast)		31.43	100.00	0.00	0.00	0.43
% of species total (South America)		0.27	0.17	0.00	0.00	0.12
% of size-class total (Atlantic Coast)		0.20	0.23	0.00	0.00	0.43
% of grand total (Atlantic Coast)		0.03	0.04	0.00	0.00	0.07
Rio	394.9					
No. of birds		0	0	0	0	0
% of species total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00
% of species total (South America)		0.00	0.00	0.00	0.00	0.00
% of size-class total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00
% of grand total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00
Sao Paulo	784.5					
No. of birds		0	0	0	0	0
% of species total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00
% of species total (South America)		0.00	0.00	0.00	0.00	0.00
% of size-class total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00
% of grand total (Atlantic Coast)		0.00	0.00	0.00	0.00	0.00
Rio Grande do Sul	882.9					
No. of birds		3	0	0	4	7
% of species total (Atlantic Coast)		1.43	0.00	0.00	2.53	0.02
% of species total (South America)		0.01	0.00	0.00	0.06	0.01
% of size-class total (Atlantic Coast)		0.01	0.00	0.00	0.01	0.02
% of grand total (North Coast)		0.00	0.00	0.00	0.00	0.00
All Brazil	7 852.5					
No. of birds		11 203	21 996	4	1 939	35 147
% of species total (South America)		45.04	49.57	0.01	29.65	28.97
% of size-class total (South America)		9.23	18.13	0.00	1.60	28.97
% of grand total (South America)		0.38	0.75	0.00	0.07	1.20

small numbers but a good variety of medium-sized and large species (Table 9.2*b*, 9.2*c*). The mouth of the Amazon River was notable for the very small numbers of shorebirds occurring along its shores; it would appear that the almost freshwater environment and very turbulent currents result in unsuitable habitat or feeding conditions for shorebirds.

The Northeast eco-unit, stretching from the Lencois Maranhenses National Park east of Sao Luis to Aracati, consisted mostly of sandy beaches, many with beachrock. Apart from peeps, which were found in low numbers (2600), the most numerous species were Black-bellied Plovers (1300, 5.4% of the North Coast total), Ruddy Turnstones (430, 2.1% of the North Coast total), and Sanderlings (380, 8.7% of the North Coast total), which appeared to make regular use of such habitats (Table 9.2*a*, 9.2*b*).

Despite the presence of extensive intertidal flats and mangrove coasts near Salvador and in the estuaries south of Salvador near Valenca and Itubera, shorebird totals were small (2600) in the East eco-unit. Peep totals (1500) were low, as were numbers of Ruddy Turnstones (320) and Black-bellied Plovers (170), most being found on the intertidal flats in the Baia de Todos os Santos; the majority of the 260 Sanderlings occurred on the sandy beaches north of Salvador (Table 9.2*a*, 9.2*b*). The long tropical beaches stretching south to Ilheus were almost devoid of birds.

Very few shorebirds were encountered on the coastal beaches in the Rio eco-unit, apart from occasional flocks of

Sanderlings (total 520; Table 9.2*a*). The most notable find was a large concentration of yellowlegs (4500, 5.3% of the South American total) in a flooded area between the Lagoa Feia and coastline between the Rio Paraiba do Sul and Cabo de Sao Tome.

The beaches running south from Santos towards Paranagua and associated nearshore inlets in the Sao Paulo eco-unit were notably empty of shorebirds. Many of the specimens in the University Museum in Sao Paulo were collected along these shores, and it would appear that they are used regularly by Nearctic shorebirds during migration (unpubl. results).

9.3. North coast

Sectors 1–73; Maps 9.1 (Brazil-1) to 9.6 (Brazil-6)

In terms of shorebird distribution and sedimentary structure, the coastline of northern Brazil can be divided into four distinct zones: (1) the northern coastline, from the border with French Guiana to the mouth of the Amazon system itself (North eco-unit, Sectors 1–12, Map 9.1 [Brazil-1]); (2) the mouth of the Amazon River system between the western channel (Macapa) and the Baia do Marajo (Belem) (Amazon eco-unit, Sectors 13–29, Maps 9.1 [Brazil-1] and 9.2 [Brazil-2]); (3) the coast between Belem and the Baia de Sanadi east of Sao Luis (North-central eco-unit, Sectors 30–62, Maps 9.2 [Brazil-2] and 9.3 [Brazil-3]); and (4) the remainder of the northern coastline eastwards from the Baia de Sanadi to Aracati (Northeast eco-unit, Sectors 63–73, Maps 9.4 [Brazil-4] to 9.6 [Brazil-6]).

9.3.1. Environmental conditions

The northern section of the coastline of Brazil is dominated by the Amazon River and the sediments it discharges. The Amazon River flows for over 3000 km from the Andes mountains to the Atlantic Ocean, draining an area greater than 6×10^6 km^2 (Keller 1962) and discharging an estimated 5.5×10^{12} m^3 of water per year and 4.5×10^8 tons of suspended matter (Gibbs 1967; Oltman 1968; Lisitzin 1972). Discharge is greatest during the rainy season in May and June and lowest during the dry months of October through December (Oltman 1968). Owing to the enormous outflow of fresh water, salt water is never able to penetrate into the estuary at all, and the very thorough mixing that takes place results in salinities that are only about 1 ppt at the mouth of the main river, even during periods of low discharge (Gibbs 1970*b*). The massive water outflow, prevailing winds, and high tidal range at the mouth of the estuary (up to 10 m; Gibbs 1970*a*) produce extremely turbulent conditions and violent tidal bores, which are a considerable danger to navigation. Fluctuations in river height occur as far inland as Manaus, some 800 km from the mouth of the river (Diegues 1972; Marlier 1973; Barreto *et al.* 1975). In such a high-energy environment, intertidal areas consist mostly of sandflats, and riverbanks are lined with many palms (*Euterpe oleracea* and *Mauritia flexuosa*), reflecting the freshwater regime, which effectively spans most of the mouth of the Amazon River proper and its associated islands.

Offshore, the freshwater influence extends for a considerable distance, the 35 ppt isohaline not being reached for some 185 and 230 km from the river mouth during periods of low and high discharge, respectively (Gibbs 1970*b*). The 20 ppt isohaline stretches in a broad arc offshore as far as the Amapa coastline, and farther to the coasts of French Guiana during the same respective periods (Gibbs 1970*b*).

Rivers flowing into the Baia de Marajo on the east side of the Ilha de Marajo include the Rio Para system, forming a distributary channel from the Amazon, the Rio Tocantins, and various other rivers, such as the Rio Capim. The Rio Tocantins has been estimated to have a discharge of 3.4×10^{11} m$^3 \cdot$yr^{-1} (Oltman 1968), with that of the Amazon distributary lower, the whole system probably having a lower suspended sediment load compared with the Amazon itself (Barreto *et al.* 1975). The sediments carried by the Rio Tocantins also differ, because the river drains low-standing tropical rain forest.

The mud discharged from the Amazon system forms a turbid plume, which is carried northwestwards by the North Equatorial (Guiana) Current and by longshore currents generated by the prevailing northeasterly trade winds. The North Equatorial (Guiana) Current flows with average velocities exceeding 0.5–1 m$\cdot$s^{-1} (1–2 knots) (Barreto *et al.* 1975). The longshore current is particularly strong along the coast of Amapa state to the northwest of the main channel. This current slackens during the seasonal northerly shift in wind, especially during February and March, and waters from the Para system may be carried eastwards well past the Baia de Sao Marcos, although the effect is small (Barreto *et al.* 1975). The plume of turbid water from the Amazon extends far offshore, the 5 mg$\cdot$L^{-1} line running some 100 km out from the river mouth to around 10 km out along the coast of French Guiana during high-discharge periods (Gibbs 1970*a*). The plume averages 60 km in width and extends northwestwards for some 2000 km: Amazon muds have been detected as far north as the southern Caribbean (Jacobs and Ewing 1969).

Most of the sediment discharged from the Amazon does not escape the nearshore environment, being either deposited within the estuary or transported northwestwards (Milliman *et al.* 1975*a*). Offshore muddy deposits have a somewhat different texture and composition from modern Amazon sediments and are thought to be relict structures that were deposited during an earlier period of lower sea level. Formation of a mud delta would occur if levels were some 20 m less than at present, and a level of 80–100 m lower than today would lead to most discharged material being channelled directly into the deep sea via relict channels that represent Pleistocene fluvial systems (Milliman *et al.* 1975*b*). Tidal and landward currents within the salt wedge may also act to prevent escape of sediments from the nearshore environment (Diegues 1972; Barreto *et al.* 1975).

North of the Amazon, the coastline of Amapa state is generally smooth and straight, as a result of the rapid shoreline accretion/mud deposition taking place. The very near inshore clays on the Amapa coast are almost identical with Amazon material, and it would appear unlikely that local rivers contribute much to the mudbanks on the coast; the same situation occurs in the Guianas (Eisma and van der Marel 1971). Conditions along the Amapa coastline are influenced by the extent of the freshwater plume from the Amazon River, which extends northwards during the high-discharge period, by seasonally varying longshore currents, which reach a maximum in February/March, and by the local influence of river input.

Organic contents of shelf sediments are higher north of the Amazon River than southwards, although high carbon/nitrogen ratios indicate that much of the organic

material is derived from terrestrial input: the low carbonate content of sediments on the shelf reflects a fairly low level of colonization by epibenthic communities, possibly because of the bottom turbulence and sediment motion. Sediments off the Amazon mouth have considerably higher silt/clay ratios than those farther northwest along the Amapa coast, reflecting the differential transport of the lighter fraction and deposition of the heavier components. In the mouth of the river itself, the strong and turbulent currents resuspend much material, and coastal sandflats are common. Much of the infauna consists of molluscs; productivity is considered to be much less than off the eastern coast of North America (Barreto *et al.* 1975).

9.3.2. North eco-unit

Sectors 1–12; Map 9.1 (Brazil-1)

The northern part of the coastline from Cabo Cassipore to Amapa and the Ilha de Maraca is very low-lying. There are extensive mangrove forests, with *Rhizophora mangle*, *Avicennia germinans*, and *Laguncularia racemosa*, and swamps, with *Montrichardia arborescens* and *Mauritia flexuosa*; some parts of the coast are backed by open palm savannahs with *Euterpe oleracea*, *Chrysobalanus icaco*, and other species. Currents appeared to be strong, particularly in the channel between the Ilha de Maraca and the mainland, and narrow sand beaches or tough mud was found along many parts of the shoreline, most of which was surveyed at high tide. The most extensive development of flats appeared to be north and south of the Calcoene and Amapa rivers (Sectors 4–5), where many birds were found on stretches of sandy-looking mud in front of the mangroves (Table 9.4). Small shorebirds, especially peeps, were numerous along these stretches of coast, the total for Sectors 3–6 (21 800) representing some 85% of the eco-unit total (Sectors 1–12) of 25 600 for this category (Table 9.3). Although these numbers were moderate compared with those in Suriname, they represented some 10% of the total small shorebirds in Brazil in this category and were the highest concentrations found in the country outside the north-central coast, with densities comparable with those in the latter area. A variety of other species was found, including Black-bellied Plovers, yellowlegs *Tringa* spp., Ruddy Turnstones, and Whimbrel, the latter two species tending to be associated with tough mud habitats. Small numbers of Red Knot occurred on sandy coastlines. Fewer birds were found on coastlines where tall mangroves came to the edge of the water (Sector 2) or where eroding coastlines occurred, such as the outer coastline of the Ilha de Maraca (Sector 9) and the coast north of the Rio Araguari (Sector 12).

9.3.3. Amazon eco-unit

Sectors 13–29; Maps 9.1 (Brazil-1) and 9.2 (Brazil-2)

The delta of the Amazon River consists of a vast low-lying complex of broad river channels, islands, mangrove forests and swamps, salt marshes with *Spartina brasiliensis*, intertidal flats, brackish and freshwater lagoons and marshes, and seasonally flooded grassland, swamp forest, and palm swamps with *Euterpe oleracea*, *Raphia taedigera*, *Manicaria saccifera*, and *Mauritia flexuosa* (Tables 9.4 and 9.6). Surveys were carried out along the shores of the North Channel (Canal do Norte; Sectors 17–19) and along the outer shores of the islands in the mouth of the Amazon system, including Ilha Bailique, Ilha Curua, Ilha Janaucu, Ilha Caviana, Ilha Mexiana, and Ilha de Marajo.

Riverbanks along the North Channel consisted mostly of tough mud. Intertidal areas occurring off the islands, on the other hand, were principally sandflats, some with *Spartina brasiliensis* colonizing their upper parts. A tidal bore was observed flooding into the mouth of the North Channel, and damaged and uprooted trees and vegetation attested to the violence of the turbulent currents along the river channels.

The eco-unit comprising the mouth of the Amazon was notable for the small numbers of shorebirds it contained, in spite of the presence of what superficially appeared to be suitable habitat. It appears likely that the instability of the sediments resulting from the very strong currents, and possibly the freshwater environment, may preclude the development of invertebrate infauna, and that lack of suitable food resources may explain the low numbers of birds.

Only about 2600 shorebirds were found in the eco-unit (Tables 9.3 and 9.5), most of which (1600 or 60.4%) were in Sector 13 at the mouth of the North Channel, the remainder being spread in small numbers along the outer marshy coastlines of Ilha Janaucu and Ilha Caviana as well as along the sandy northeastern shores of Ilha de Marajo. All the Sanderlings found in the eco-unit were in the area around Ilha de Marajo.

9.4. North-central coast

9.4.1. Environmental conditions

The coastline between Belem and the Baia de Sanadi east of Sao Luis is different from the Amapa shoreline north of the Amazon, as well as from the remainder of the north coast of Brazil farther to the east. Whereas the shorelines on either side are generally fairly smooth, the section between Belem and the Sao Luis area is deeply indented, with a series of sandy headlands separating shallow bays. This coastal morphology has resulted from the invasion by the sea of former river valleys.

The most significant phenomenon affecting habitat distribution is a regular trend in sediment distribution observed in all the bay systems, involving a progressive transition from sandy outer coastlines, through mixtures of mud and sand, tough mud, and finally to soft mudflats made up of finer sediments in the inner recesses of the bays. This transition from coarse to fine sediments produces a wide variety of habitats, reflected in the impressive numbers and diversity of shorebirds using the coast (Morrison *et al.* 1985, 1986*a*, 1986*b*, 1987). The typical progression of habitats involved: (1) sandy outer coastlines backed by dunes or low cliffs; (2) sandy beaches along northeast-facing shorelines; (3) areas of sand invading tough mudbanks, characterized by stands of dead mangroves; (4) tough mudbanks and intertidal areas consisting of a mixture of sand and mud; (5) areas of new mangrove growth, often fronted by marsh development and muddy patches; and (6) progressively finer, softer mudflats backed by mangrove forests (Morrison *et al.* 1987). The mangrove forests are often very extensive, not merely forming a layer bordering the shore, but in some cases extending completely across the bases of the headlands from one bay to the next and running great distances inland, indicating an enormous zone of tidal flooding around the bay. The mangrove forests were the most impressive seen in Brazil and represent one of the best examples of this habitat in South America.

North-central coast of Brazil. The indented coastline of north-central Brazil between Sao Luis and Belem consists of wide bays containing a variety of habitat types, ranging from sandflats to soft mudflats backed by some of the most extensive stands of mangrove forest in South America. The area is of great importance to a wide range of Nearctic shorebirds.

The area under consideration lies geologically within the Sao Luis Basin, a small coastal basin situated on the northern part of the larger Maranhao, or Parnaiba, Basin. The Sao Luis Basin contains some 4000 m of sediments that are apparently younger than the Paleozoic and Mesozoic sediments of the Parnaiba Basin (Putzer 1968; Asmus and Ponte 1973; Bigarella 1973; Barreto *et al.* 1975), and outcroppings of Precambrian basement rocks also occur. The climate is much wetter than that of areas farther east, affecting the weathering and amount and characteristics of sediments discharged at the coast.

The entire nearshore platform is dominated by sandy sediments (Barreto *et al.* 1975), and the outer headlands and shores are fronted by sandy beaches. Many of the bays contain extensive sandy shoals, some of which have grown into low sandy islands. The coastal rivers carry sediments derived from late Mesozoic and Tertiary sedimentary strata, and because these have been exposed to extensive weathering typical of tropical rain forests, the grains are more mature or rounded than the material discharged from the Amazon (Barreto *et al.* 1975). Offshore sediments show a distinctive mineral composition, reflecting the source material, weathering, and transport histories of material on this section of coast, and are indicative of rain-forest sediments (Barreto *et al.* 1975). Most of the finer sediment brought down by the rivers does not appear to escape from the bays and is found deposited as mudbanks along the inner margins or recesses of the bays. Coastal waters are generally not turbid and carry little sediment load. Shelf sediments are very poor in organic matter, although increased carbon/nitrogen ratios around the outflow of the Para and Gurupi rivers and in the Baia de Sao Marcos reflect input from terrigenous sources. With most material apparently remaining within the bay systems, such areas are likely to develop the most productive shorelines. The major rivers, such as the Gurupi, Mearim, and Itapecuru, flow throughout the year (Barreto *et al.* 1975), although this may not be the case with the smaller rivers entering some of the bays.

Offshore, the North Equatorial (Guiana) Current flows northwestwards, probably moving bottom sandy sediments with it (Barreto *et al.* 1975). The wind-driven longshore current generally flows in the same direction, although a countercurrent carrying sediments from Baia de Marajo eastwards appears to develop in February and March. Tidal currents can be particularly strong, especially around areas off the mouths of Baia de Marajo and Baia de Sao Marcos (Barreto *et al.* 1975). Tidal ranges are considerable (approximately 5–8 m; Marinha do Brasil 1985; Scott and Carbonell 1986).

9.4.2. North-central eco-unit

Sectors 30–62; Maps 9.3 (Brazil-3) and 9.4 (Brazil-4)

9.4.2.1. Habitats

Nearly all the bays on the north-central coast of Brazil show the typical progression of habitats described above, with muddy inner areas and sandy outer coastlines (Tables 9.8 and 9.10). In the Baia de Sao Marcos (Sectors 54–58), for instance, such a pattern occurred on both the west and east coasts. On the west coast (Sector 54), extensive intertidal

Map 9.1 (Brazil-1)
Distribution of Nearctic shorebirds on the northern coast of Brazil

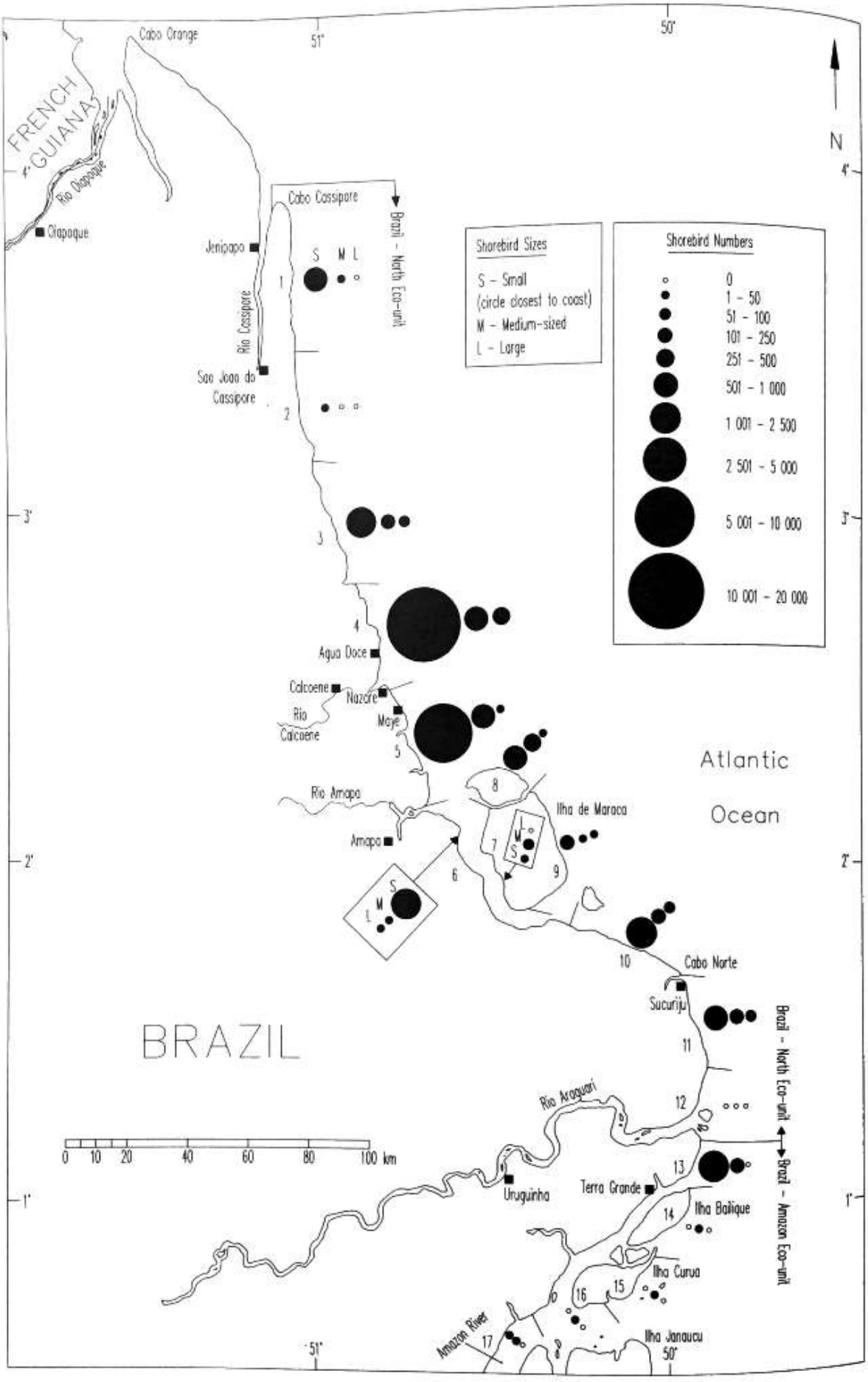


Table 9.3
Totals of Nearctic shorebirds in survey sectors in Map 9.1 (Brazil-1)

Sector no.	Sector length (km)	Semi-palmated Plover	Spotted Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Lesser Golden-Plover	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Red Knot	Dowitcher species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Whimbrel	Willet	Unidentified large shorebird species	Total large shorebirds	Total shorebirds
1	37.2	0	0	0	812	812	0	0	0	0	0	0	20	20	0	0	0	0	832
2	36.5	0	0	2	34	36	0	0	0	0	0	0	0	0	0	0	0	0	36
3	40.0	0	0	0	2 200	2 200	47	70	0	0	100	0	1	218	50	0	20	70	2 488
4	36.7	0	0	0	10 966	10 966	0	229	0	72	20	0	360	681	0	25	352	377	12 024
5	42.8	0	0	0	6 345	6 345	0	265	0	25	0	0	400	690	0	0	50	50	7 085
6	52.7	0	0	0	2 240	2 240	0	3	0	0	0	0	4	7	2	0	20	22	2 269
7	33.2	0	0	0	17	17	0	0	0	35	0	20	0	55	0	0	0	0	72
8	37.6	0	0	0	546	546	0	57	70	0	0	0	183	310	44	0	2	46	902
9	34.2	0	0	0	240	240	0	5	0	0	0	0	0	5	1	0	2	3	248
10	44.6	0	2	0	1 690	1 692	0	8	80	44	0	0	40	172	40	0	40	80	1 944
11	24.5	0	0	0	504	504	0	39	41	29	0	0	56	165	1	0	25	26	695
12	24.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	23.1	470	0	0	890	1 360	0	101	0	34	0	0	93	228	0	0	0	0	1 588
14	22.6	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1
15	17.4	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1
16	21.6	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1
17	38.3	0	1	0	0	1	0	0	0	3	0	0	0	3	0	0	0	0	4
Total	567.3	470	3	2	26 484	26 959	47	777	192	244	120	20	1 157	2 557	138	25	511	674	30 190

Table 9.4
Principal habitats in survey sectors in Map 9.1 (Brazil-1)

Sector no.	Habitat description
1	Some sand beach and tough mudbanks, mangroves / forest, marsh
2	Sand and mud shore, mangroves / forest, lagoons, open scrub
3	Sand and tough mud beach, mangroves / forest, scrub, wetlands
4	Sand beach, narrow mudbanks, mangroves / forest
5	Sandy mud beach, some mudflats, mangroves / forest, lagoons
6	Tough mud shore, some mudflats, mangroves / lagoons, forest
7	Steep narrow mud shore / grassland, open forest
8	Tough mudflats, mangroves (some dead) / marsh, forest
9	Narrow tough mudbanks, mangroves / forest
10	Narrow tough mudbanks, mangroves / forest
11	Sandy foreshore and mudflats, salt marsh / scrub
12	Tough mud, some sand beach, mangroves (stumps) / forest, marsh
13	Brackish estuary; broad sandflats, salt marsh, some mangroves / forest, marsh
14	Brackish estuary; broad mud- and sandflats, mangroves / forest / marsh
15	Brackish estuary; broad mud- and sandflats, mangroves / forest / marsh
16	Brackish estuary; broad mud- and sandflats, marsh, mangroves (many logs) / forest
17	Brackish estuary; broad sandflats and bars, mangroves / forest

areas are found, becoming progressively sandier towards the mouth of the bay. The outer coastline north of Alcantara towards the Baia do Cuma consists of sandy beaches backed by low, eroding cliffs. Soft mudflats occur in the inner parts of the bay and also in sheltered areas where creeks or rivers enter the bay, e.g., near Alcantara and in the channel on the southwest side of the Ilha dos Caranguejos (between it and the Ilha Verde; Sector 55). On the east side of the bay, soft flats are found in shallow embayments along the main channel of the Rio Mearim below the Ilha dos Caranguejos (Sector 57). Fierce currents occur along the channel between the Ilha dos Caranguejos and the mainland, producing a considerable tidal rip near the island. Much of the east coast of the island (Sector 56) consisted of relatively narrow, tough-looking eroded mudbanks, with many mangroves uprooted by the currents. Heavily eroded sections, with distinctive stepped terraces near the channel, also occurred on the mainland side (Sector 57), although flats were generally better developed. The coarsening trend in sediments towards the sea continued, with quite tough-looking intertidal flats south of Sao Luis (Sector 58) and sandier areas north of the city (Sector 59).

A broadly similar pattern occurs in the Baia de Sao Jose. The inner part, comprising the Baia do Arraial, contains well-developed mudflats lined with mangrove forests; large flats also develop around the mouths of rivers entering the bay. The west coast of the bay becomes increasingly sandy towards the sea: extensive sandy mudflats occur below sandy beaches and palm-covered hills below Ribamar, and a succession of sandflats and beaches occurs north of Ribamar. The east side of the bay is lined with mangroves. Sediments become increasingly coarser towards the outer part of the bay, with areas of dying mangroves appearing where sand has invaded muddier substrates. Offshore, extensive sandbars have developed, and large areas of sandflats are exposed at low tide. Mangrove forests cover much of the island between the Baia de Sao Jose and Baia do Tubarao. Habitat patterns are similar in the Baia do Tubarao and Baia de Sanadi.

9.4.2.2. Shorebirds

Nearly 327 000 Nearctic shorebirds were counted in the North-central eco-unit between Belem and the Baia de Sanadi, the total consisting of some 196 000 small shorebirds (59.8%), 97 000 medium-sized shorebirds (29.7%), and 34 000 large shorebirds (10.4%) (Tables 9.7 and 9.9). The small, medium-sized, and large size-class totals represented 9.4, 29.0, and 56.3% of the respective totals for the North Coast of South America, and 8.4, 21.3, and 28.1% of the respective continental totals, demonstrating that the coastline is of major international importance for shorebirds.

The most significant concentrations overall were found on the coastline north and west of the Baia de Sao Marcos between the Ilha Lencois and Baia do Cuma (Sec-

Map 9.2 (Brazil-2)
Distribution of Nearctic shorebirds along the Amazon delta coast of Brazil

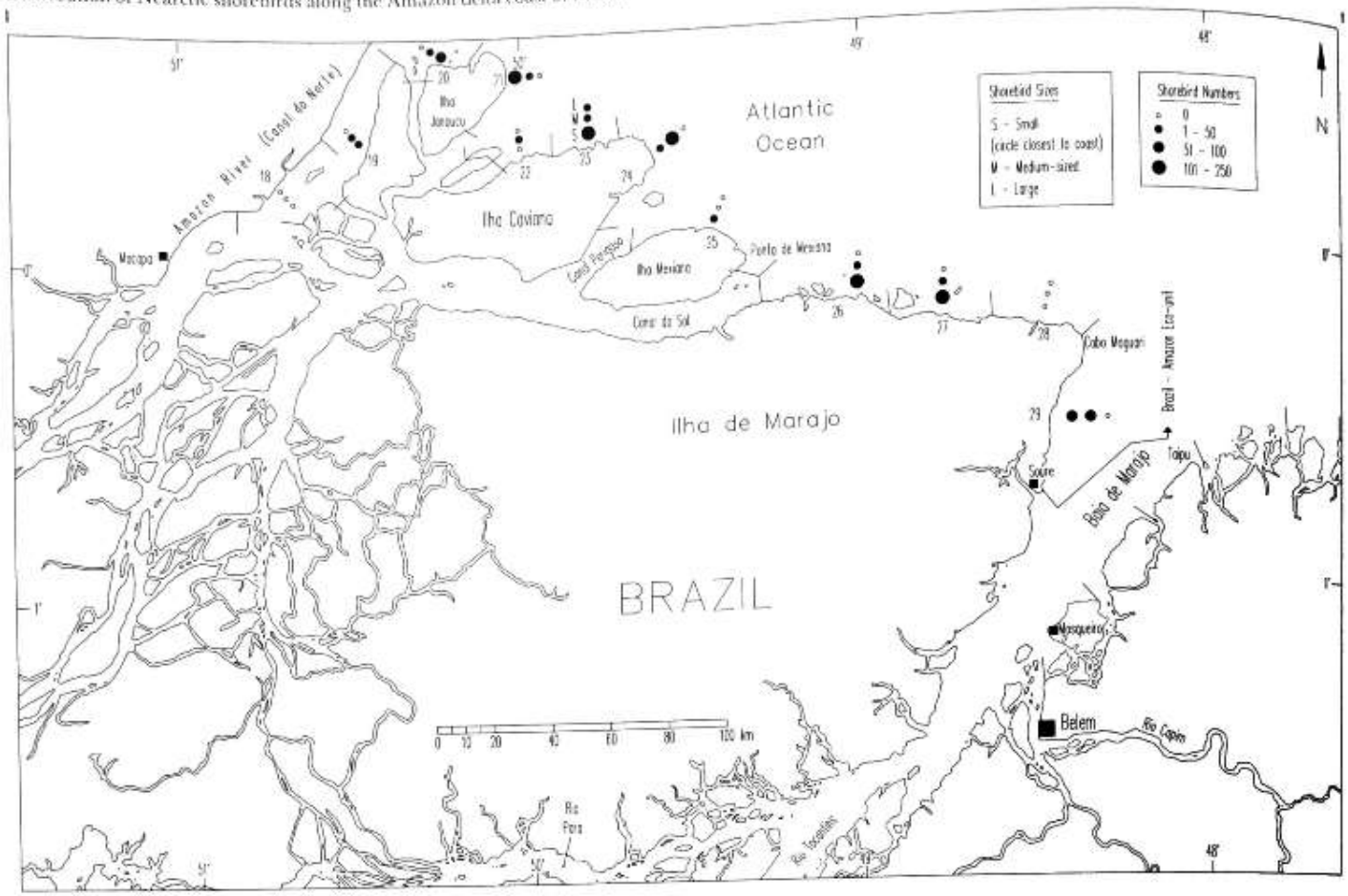


Table 9.5
Totals of Nearctic shorebirds in survey sectors in Map 9.2 (Brazil-2)

Sector no.	Sector length (km)	Spotted Sandpiper	Sanderling	Small shorebird species	Total small shorebirds	Ruddy Turnstone	Yellowlegs species	Dowitcher species	Medium-sized shorebird species	Total medium-sized shorebirds	Large shorebird species	Total large shorebirds	Total shorebirds
18	36.8	0	0	0	0	0	0	0	0	0	0	0	**0**
19	44.9	2	0	0	2	0	4	0	0	4	0	0	**6**
20	27.2	0	0	55	55	1	18	0	0	19	0	0	**74**
21	40.8	0	0	120	120	2	3	0	0	5	0	0	**125**
22	30.8	0	0	0	0	0	1	0	0	1	0	0	**1**
23	45.8	1	0	128	129	0	13	0	21	34	2	2	**165**
24	62.6	0	0	30	30	0	1	150	0	151	0	0	**181**
25	51.7	0	0	5	5	0	0	0	0	0	0	0	**5**
26	50.3	0	10	161	171	0	9	0	0	9	0	0	**180**
27	29.8	0	7	100	107	0	4	0	0	4	0	0	**111**
28	35.2	0	0	0	0	0	0	0	0	0	0	0	**0**
29	54.9	0	100	0	100	0	60	0	25	85	0	0	**185**
Total	510.8	3	117	599	719	3	113	150	46	312	2	2	**1 033**

Table 9.6
Principal habitats in survey sectors in Map 9.2 (Brazil-2)

Sector no.	Habitat description
18	Brackish estuary; broad sandflats and bars, mangroves (many dead) / scrub, wetlands, forest
19	Brackish estuary; broad sand- and mudflats, marsh, some mangroves (often dead) / scrub, wetland, forest
20	Brackish estuary; broad sandflats, some tough mudflats, few mangroves / forest, scrub
21	Brackish estuary; broad sand beach, marsh, some mangroves / forest
22	Brackish estuary; tough mudbanks, marsh, mostly dead mangroves / forest
23	Brackish estuary; tough mudbanks, marsh / scrubby forest, wetlands
24	Brackish estuary; some sand beach, marsh / scrubby forest, wetlands
25	Brackish estuary; tough mudbanks with mangrove debris, some sand beach / scrubby forest
26	Brackish estuary; sand beach / palms, mangroves, dunes / forest
27	Brackish estuary; sand beach, some mudbanks / some dunes, palms / scrubby forest
28	Brackish estuary; sand beach, some muddy sections / dunes / palms, scrubby forest
29	Brackish estuary; broad sandflats, some marsh / extensive flooded fields, scrubby forest

tors 48–52), with the highest sector total (Sector 50, 56 000; Table 9.9) occurring around the Baia Cabelo da Velha northeast of Cururupu. Important concentrations were also found around the Baia de Sao Marcos, especially around the inner channel of the Rio Mearim (Sector 57) and on the west coast of the bay (Sector 54). Further significant concentrations were found on the bays to the west and especially the east of the Rio Gurupi (Sectors 42–45). Moderate concentrations occurred in the western sectors towards Salinopolis (Sectors 36–38).

Distribution patterns of the different size categories or of individual species of shorebirds, while by no means identical, did show a number of general similarities, with particular sections of the coastline being favoured by a wide range of species (Morrison *et al.* 1986*a*, 1986*b*).

The majority of the 192 000 unidentified small shorebirds (peeps) consisted of Semipalmated Sandpipers *Calidris pusilla* (Tables 9.7 and 9.9). Moderate numbers were found in the bays to the east of Sao Luis, including the Baia de Sanadi (Sector 62), Baia de Tubarao (Sector 61), and Baia do Arraial/Baia de Sao Jose (Sector 60). Larger numbers were encountered on the soft flats on the lower part of the Rio Mearim (Sector 57), in the channel between the Ilha Verde and Ilha dos Caranguejos (Sector 55), and on the west side of the Baia de Sao Marcos (Sector 54). The largest concentrations of peeps were found in the bays to the north and west of the Baia de Sao Marcos, between the Baia do Cuma and the Baia Cabelo da Velha (Sectors 48–52). Large concentrations were also found in the bays around and to the east of the mouth of the Rio Gurupi (Sectors 42–45), and moderate concentrations were found in the western sectors up to Salinopolis (Sector 37).

The north-central coast of Brazil was regionally important for Sanderlings, holding 3100, or 70.5%, of the North Coast total. Most Sanderlings occurred on the outer coasts and beaches around Sao Luis (Sector 59) and on the coastline to the north and west of the Baia de Sao Marcos (Sectors 48 and 50–54); few were encountered on the central or western sectors of the coast (Tables 9.7 and 9.9).

The overall distribution of the 97 000 medium-sized shorebirds showed a clumped pattern, with significant concentrations on the northwest corner of Sao Luis Island (Ilha do Curupu; Sector 59), on the west side of the Baia de Sao Marcos (Sector 54), in the bays between Baia do Cuma and Ilha Lencois (Sectors 48–52), in the bays around the mouth and to the east of the Rio Gurupi (Sectors 42–45), and in the bays around and east of Salinopolis (Sectors 37–38). Distributions of individual species, however, varied considerably.

The north-central coast of Brazil was the most important area in South America for Black-bellied Plovers, the total of 14 700 representing 54.0 and 61.9% of the continental and North Coast totals, respectively (Tables 9.7 and 9.9). Black-bellied Plovers were common on the mainland shore of the Rio Mearim (Sector 57), on the west side of the Baia de Sao Marcos (Sector 54), around the Baia Cabelo da Velha (Sectors 50 and 51), and in the bays east of the mouth of the Rio Gurupi (Sectors 43 and 44); relatively few birds were seen in the western sectors of the coast.

The north-central coast of Brazil was also the most important wintering area discovered in South America for Ruddy Turnstones, the total of 17 900 representing 76.2 and 88.5% of the continental and North Coast totals, respectively (Tables 9.7 and 9.9). Ruddy Turnstones were fairly evenly spread along the coastline, being particularly common in areas with tough mudbanks; highest numbers occurred around the Rio Gurupi (Sectors 42–45).

Dowitchers were fairly evenly distributed along the north coast of South America, with north-central Brazil (total 8100, representing 16.6 and 17.1% of the continental and North Coast totals, respectively) second in importance after Suriname (Tables 9.7 and 9.9). Dowitchers were concentrated around the Baia dos Lencois (Sectors 46–51), with smaller numbers around the Rio Gurupi (Sectors 42–44) and scattered concentrations near Salinopolis (Sectors 33 and 36).

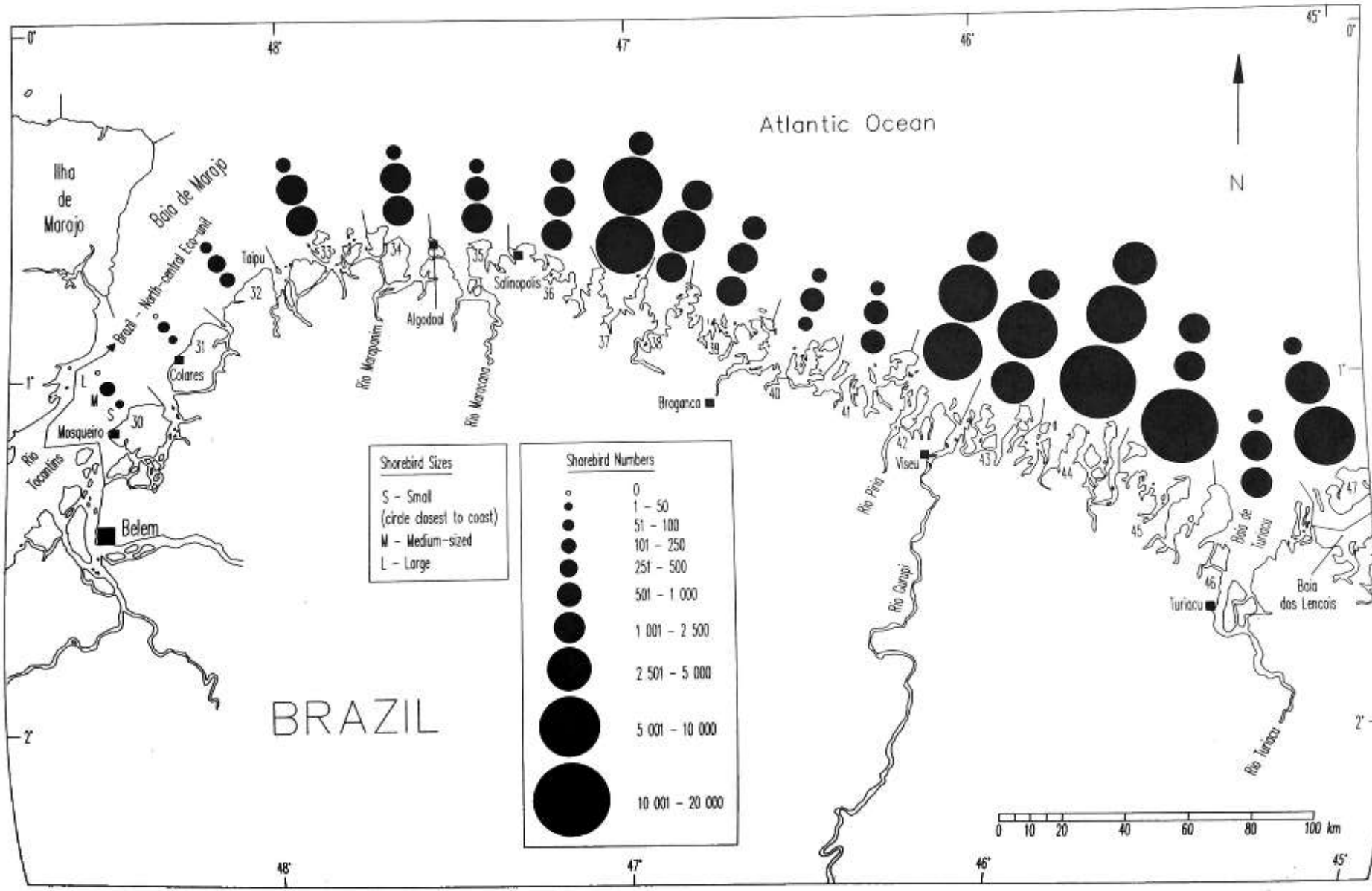
The flocks of Red Knot tentatively identified in Sectors 51 and 59 represent the only major concentrations discovered on the surveys outside the main wintering grounds in Patagonia and Tierra del Fuego (Table 9.9).

Yellowlegs were scattered in very low numbers along the north-central coast of Brazil, most being found east of the Rio Gurupi (Sector 44). Distribution of yellowlegs on the north coast of the continent was clearly centred on the Guianas, with by far the largest numbers in Suriname; the north-central coast of Brazil was of less relative importance for the two species involved.

Large shorebirds (total 34 000) showed a general pattern of distribution similar to those of the other size categories, largest numbers being recorded around the Baia dos Lencois and Baia do Capim (Sectors 48–51), the west side of Baia de Sao Marcos (Sector 54), the Rio Gurupi (Sectors 41–45), and towards Salinopolis (Sector 38).

The north-central coast of Brazil was the most important wintering area discovered on the coast of South America for Whimbrels (total 10 900, representing 43.7 and 71.3% of continental and North Coast totals, respectively) and for Willets (total 21 900, representing 49.3 and 55.2% of continental and North Coast totals, respectively) (Tables 9.7 and 9.9). Willets were found principally on the coast northwest of the Baia de Sao Marcos (Sectors 49–52), whereas Whimbrels were more evenly distributed.

In summary, the surveys clearly demonstrated that the north-central coast of Brazil is of major international importance as a wintering area for shorebirds and is of critical importance for several individual species.



Map 9.3 (Brazil-3)
Distribution of Nearctic shorebirds along the Belem coast of Brazil

Table 9.7
Totals of Nearctic shorebirds in survey sectors in Map 9.3 (Brazil-3)

Sector no.	Sector length (km)	Spotted Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Red Knot	Dowitcher species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Whimbrel	Willet	Unidentified large shorebird species	Total large shorebirds	Total shorebirds
30	39.9	5	0	0	5	0	130	0	0	20	0	150	0	0	0	0	155
31	39.1	2	0	47	49	6	10	29	0	0	6	51	0	0	0	0	100
32	33.9	0	0	220	220	8	144	14	0	0	151	317	21	43	0	64	601
33	81.1	35	0	995	1 030	71	298	23	0	335	883	1 610	74	76	0	150	2 790
34	74.0	94	0	1 633	1 727	44	705	11	0	40	378	1 178	78	62	0	140	3 045
35	76.4	2	60	1 605	1 667	134	335	6	0	2	467	944	70	108	0	178	2 789
36	90.1	1	0	1 187	1 188	401	314	25	0	350	1 266	2 356	364	385	0	749	4 293
37	46.5	5	0	5 332	5 337	465	290	0	0	20	4 885	5 660	381	447	0	828	11 825
38	40.0	6	0	1 650	1 656	468	1 228	0	40	0	844	2 580	745	663	410	1 818	6 054
39	55.1	0	5	1 062	1 067	786	654	2	0	0	321	1 763	440	201	10	651	3 481
40	99.8	0	0	240	240	115	323	36	0	0	82	556	115	68	0	183	979
41	70.1	0	0	740	740	93	136	64	0	20	548	861	119	123	0	242	1 843
42	64.0	0	0	8 480	8 480	393	1 348	16	0	300	5 581	7 638	914	622	442	1 978	18 096
43	92.7	2	27	4 697	4 726	1 684	2 179	4	0	150	3 015	7 032	669	396	0	1 065	12 823
44	137.7	2	0	19 659	19 661	1 531	1 098	349	0	400	4 127	7 505	1 301	1 899	200	3 400	30 566
45	123.8	4	1	10 050	10 055	142	1 289	20	0	82	925	2 458	523	503	0	1 026	13 539
46	104.3	1	44	2 100	2 145	92	138	5	1	1 107	143	1 486	82	131	0	213	3 844
47	65.6	0	0	9 600	9 600	187	51	13	0	3 000	428	3 679	40	352	0	392	13 671
Total	1 334.1	159	137	69 297	69 593	6 620	10 670	617	41	5 826	24 050	47 824	5 936	6 079	1 062	13 077	130 494

Table 9.8
Principal habitats in survey sectors in Map 9.3 (Brazil-3)

Sector no.	Habitat description
30	Brackish estuary; sandy beaches and flats, rocky outcrops / some mangroves / tropical forest
31	Brackish estuary; sandflats, marshes / mangroves
32	Brackish estuary; mudflats, marshes / mangroves
33	Bay systems; sandflats, some mudflats, mangroves, tough banks, marsh; rocky outcrops, sand beaches, points / dunes, river channel, forest
34	Bay systems; sandflats, some mudflats, mangroves, tough banks, marsh; rocky outcrops, sand beaches, points / dunes, river channel, forest
35	Bay systems; sandflats, some mudflats, mangroves, tough banks, marsh; rocky outcrops, sand beaches, points / dunes, river channel, forest
36	Bay systems; sandflats, some mudflats, mangroves, tough banks, marsh; rocky outcrops, sand beaches, points / dunes, river channel, forest
37	Bay systems; sandflats, mudflats, mangroves, marsh; sandy headlands, beaches, and points / forest, dunes
38	Bay systems; sandflats, mudflats, mangroves, marsh; sandy headlands, beaches, and points / forest, dunes
39	Bay systems; sandflats, mudflats, mangroves, marsh; sandy headlands, beaches, and points / forest, dunes
40	Bay systems; sandflats, mudflats, mangroves, marsh; sandy headlands, beaches, and points / forest, dunes
41	Bay systems; sandflats, mudflats, mangroves, marsh; sandy headlands, beaches, and points / forest, dunes
42	Bay systems; mud- and sandflats, mangroves, marsh; headlands with sand beaches and points / forest, dunes
43	Bay systems; mud- and sandflats, mangroves, marsh; headlands with sand beaches and points / forest, dunes
44	Bay systems; mud- and sandflats, mangroves, marsh; headlands with sand beaches and points / forest, dunes
45	Bay systems; mud- and sandflats, mangroves, marsh; headlands with sand beaches and points / forest, dunes
46	Bay systems; major river channel, mud- and sandflats, marsh, sand beaches, tough mudbanks, mangroves / forest
47	Broad sand beaches, small muddy inlets with mangroves / forest, dunes

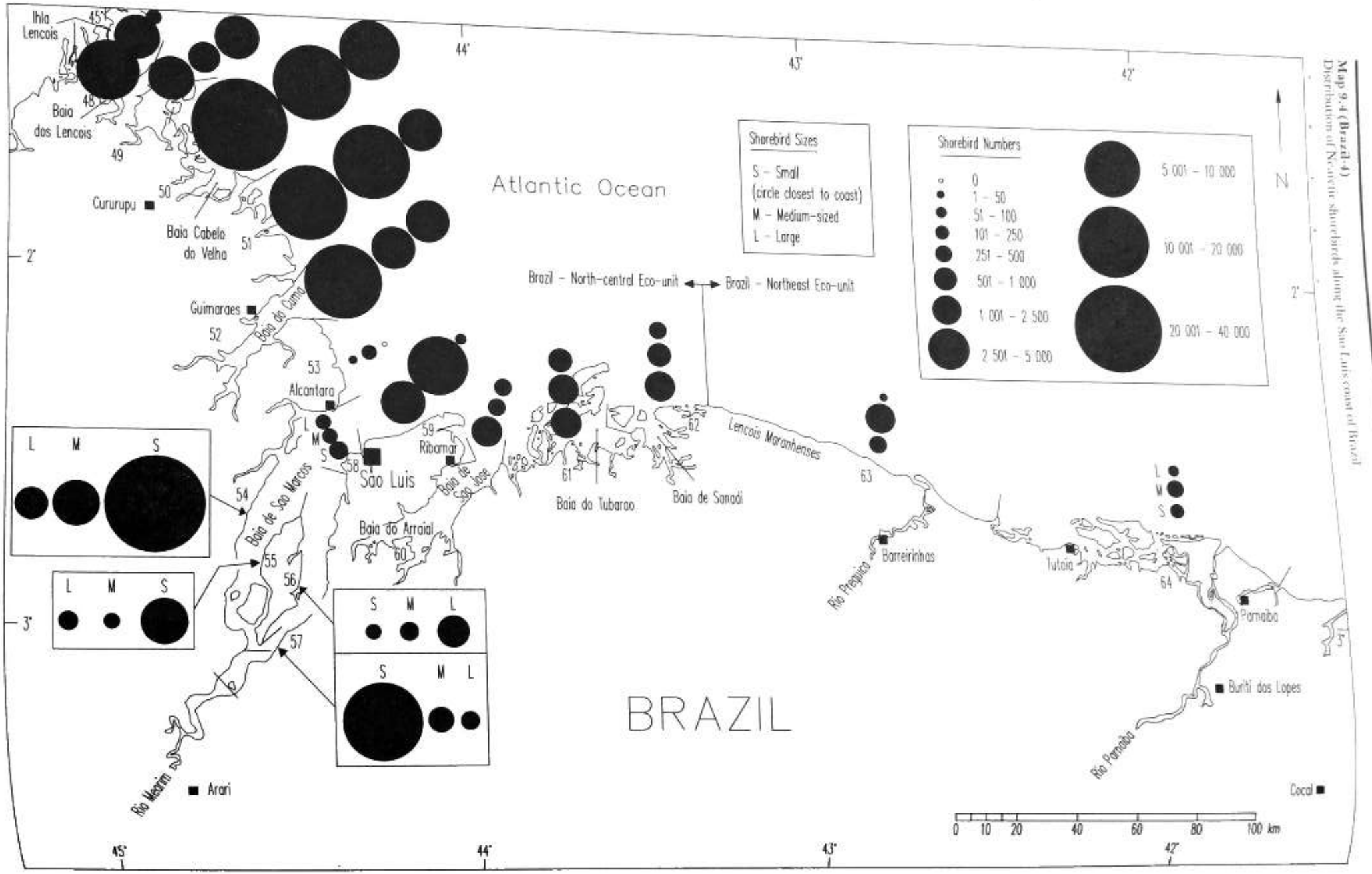
9.5. North coast: Sao Luis to Salvador

9.5.1. Environmental conditions

Much of the north coast of Brazil between Sao Luis and Natal is relatively low-lying, particularly between Sao Luis and Parnaiba, where relief is generally less than 100 m. Between Parnaiba and Fortaleza, the mountains of the Serra de Ibiapaba outcrop near the coast, rising to elevations exceeding 500 m. Farther east, the coastal plain widens again to more than 50 km between Fortaleza and Natal; inland, the mountains of the Precambrian Brazilian Coastal (Atlantic) Shield stretch southwards along the east coast of Brazil, reaching elevations of 500–1000 m.

The mountains exert a considerable influence on the climate. On the east coast, prevailing easterly or southeasterly winds deposit their moisture on the coastal ranges, where rainfall may exceed 1500 mm · yr^{-1} (Andrade 1964). To the west is found a "drought polygon," where conditions are arid to semiarid, with precipitation around 750 mm · yr^{-1} and in some places less than 500 mm · yr^{-1} (e.g., Ceara state, where it has recently averaged less than 100 mm · yr^{-1}) (Barreto *et al.* 1975; Summerhayes *et al.* 1975). This dry area reaches the coast between the Rio Parnaiba and Touros. Farther west towards Sao Luis, rainfall is generally higher and can reach 1000 mm · yr^{-1}. The climate is tropical, with temperatures ranging between 26 and 30°C throughout the year.

The two major drainage basins are those of the Parnaiba and Jaguaribe rivers. The Rio Parnaiba drains an area of about 300 000 km^2, involving the geological Parnaiba (Maranhao) Basin. The Rio Jaguaribe is about 450 km long and drains an area of some 80 000 km^2 (Milliman 1975; Summerhayes *et al.* 1975). Although the Rio Parnaiba flows year-round, the smaller rivers in the arid northeast dry up; the Rio Acarau, for instance, drains the Serra de Ibiapaba only during the rainy months (Barreto *et al.* 1975). In the northeast, rivers such as the Jaguaribe and the Acu drain part of the Precambrian Coastal Brazilian (Atlantic) Shield, which contains distinctive studded acid plutonic intrusive rocks (Summerhayes *et al.* 1975).



Map 9.4 (Brazil-4)
Distribution of Nearctic shorebirds along the Sao Luis coast of Brazil

Table 9.9
Totals of Nearctic shorebirds in survey sectors in Map 9.4 (Brazil-4)

Sector no.	Sector length (km)	Spotted Sandpiper	Solitary Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Lesser Golden-Plover	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Red Knot	Dowitcher species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Whimbrel	Willet	Hudsonian Godwit	Unidentified large shorebird species	Total large shorebirds	Total shorebirds
48	60.2	0	0	150	5 088	5 238	0	909	611	15	0	943	68	2 546	77	53	0	0	130	7 914
49	64.1	0	0	0	2 740	2 740	0	251	451	11	0	260	400	1 373	1 190	2 856	1	20	4 067	8 180
50	100.8	0	0	170	36 734	36 904	0	2 583	679	14	0	190	10 158	13 624	666	4 858	0	0	5 524	56 052
51	76.4	0	0	373	10 644	11 017	0	1 073	1 538	22	5 000	600	6 166	14 399	736	1 981	2	0	2 719	28 135
52	101.6	0	0	372	13 690	14 062	0	238	1 031	7	0	3	3 171	4 450	480	2 572	0	300	3 352	21 864
53	37.2	0	0	42	6	48	0	218	2	0	0	0	22	242	0	0	0	0	0	290
54	85.4	23	0	80	25 690	25 791	0	1 858	914	0	150	95	618	3 635	960	1 211	0	0	2 171	31 597
55	53.3	29	0	0	4 340	4 369	0	25	58	0	0	63	93	239	158	143	0	0	301	4 909
56	46.0	1	0	0	235	236	0	67	424	3	0	0	0	494	237	773	0	0	1 010	1 740
57	102.1	35	0	0	14 830	14 865	0	543	261	0	0	0	45	849	152	265	0	0	417	16 131
58	18.6	0	0	5	250	255	0	5	40	0	0	0	90	135	7	142	0	0	149	539
59	69.0	0	0	1 713	3 156	4 869	0	50	697	0	3 000	0	1 458	5 205	7	58	1	0	66	10 140
60	115.3	0	0	0	1 490	1 490	0	98	73	6	0	0	157	334	46	229	0	0	275	2 099
61	155.4	1	0	15	1 620	1 636	0	116	196	30	0	95	592	1 029	100	402	0	0	502	3 167
62	85.2	0	1	23	2 394	2 418	0	57	264	78	0	30	420	849	127	246	0	0	373	3 640
63	125.0	1	0	229	35	265	82	500	188	52	0	33	422	1 277	9	3	0	0	12	1 554
64	449.4	0	0	38	164	202	0	241	15	51	0	0	100	407	57	21	0	0	78	687
Total	1 745.0	88	1	3 210	123 106	126 405	82	8 832	7 442	289	8 150	2 312	23 980	51 087	5 009	15 813	4	320	21 146	198 638

Table 9.10
Principal habitats in survey sectors in Map 9.4 (Brazil-4)

Sector no.	Habitat description
48	Shallow bay with extensive mud- and sandflats, mangroves, marsh / forest with muddy pans
49	Bay with mud- and sandflats, mangroves, some sand beaches / forest
50	Bays with mudflats, mangroves; ocean coast with sand beaches and points / forest with muddy pans, dunes
51	Sand beaches, inlets with mudflats, mangroves / forest, dunes
52	Bay with mudflats, marsh, mangroves / forest, river exits
53	Sand beaches / cliffs / forest
54	Bay system; firm mudflats, sandflats, mangroves, marsh, sandbars / forest, river channels
55	Bay system; sandflats, mudflats, mangroves / forest, open grassy areas, creek channels
56	Major river channel with tough eroded mudbanks, mangroves / forest
57	Major river channel with tough eroded mudbanks, some soft mudflats, mangroves / forest, open grassy areas
58	Firm mudflats backed by mangroves / forested hills, industrial terminal
59	Sand beaches, points, some muddy inlets with mangroves / dunes, towns
60	Bay system; mudflats, sandflats, marsh, mangroves, river exits; outer sand beaches / forest, dunes, river channels
61	Bay system; mudflats, sandflats, marsh, mangroves, river exits; outer sand beaches / forest, dunes, river channels
62	Bay system; mudflats, sandflats, marsh, river exits, outer sand beaches / forest, dunes, river channels
63	Narrow sand beach, some tough mud sections / dunes, scrubby desert
64	Narrow sand beach with some broad mudflats and mangroves around islands and rivers / dunes in places / scrubby desert

Such factors are important in determining the amount and type of sediment reaching the coast.

The area between Sao Luis and Parnaiba lies within the Barreirinhas Basin, a coastal subbasin separated from the major Parnaiba (Maranhao) Basin by the Ferrer Arch (Mesner and Wooldridge 1964; Bigarella 1973; Asmus and Ponte 1973). This basin occupies a narrow belt 20–80 km wide and 300 km long, with an onshore area of some 13 000 km^2. The basin itself contains 10 000 m or more of sediments, mostly Cretaceous, and has good oil potential (Mesner and Wooldridge 1964).

The eastern part of the north coast from Aracati to around Natal lies on the Potiguar Basin, containing some 1500 m of Cretaceous and Tertiary sediments and covering an area of about 25 000 km^2 on its onshore portion; it is limited to both south and west by basement Precambrian crystalline rocks (Asmus and Ponte 1973).

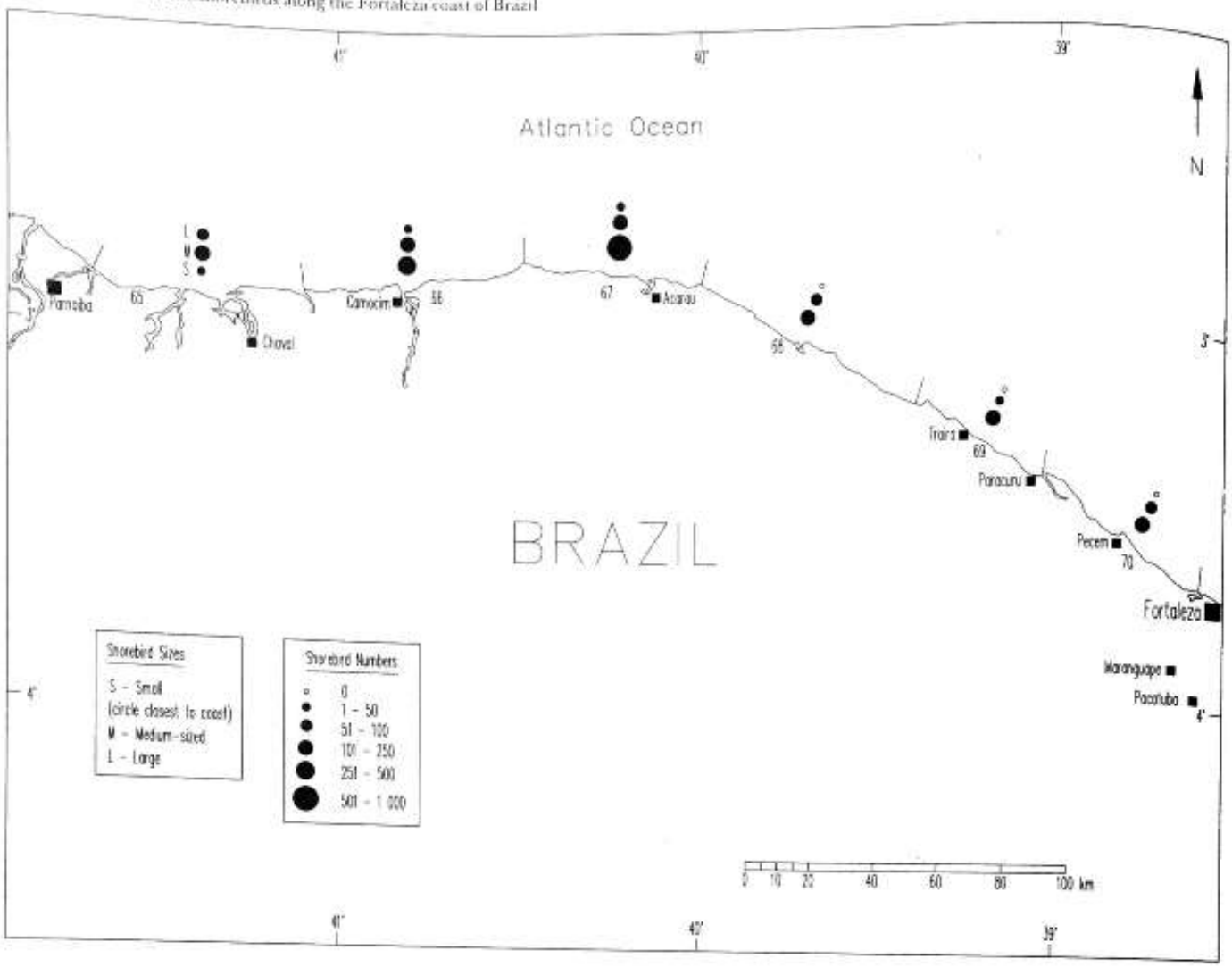
Offshore, the oceanic circulation is dominated by the North Brazilian Coastal Current, which flows north and west along the coast at 0.5–1 m·s^{-1} (1–2 knots) (Metcalf and Stalcup 1967), producing a strong northwestward longshore drift (Summerhayes *et al.* 1975).

In contrast to the muddy coastline north and west of the Amazon and the indented coastline between Belem and Sao Luis, the coastline east of Sao Luís is very sandy and generally smooth, embayments and estuaries being restricted to the mouths of the larger and some of the smaller rivers. Much of the shoreline consists of beaches and dunes.

Offshore, nearly the entire shelf consists of sand, which is essentially mud-free (Summerhayes *et al.* 1975). Organic contents of the sediments are very low, highest levels occurring off rivers such as the Jaguaribe, where there is a local source of nutrients (Summerhayes *et al.* 1975; cf. Barretto and Summerhayes 1975). Levels of suspended matter in the waters are very low (Barretto and Summerhayes 1975), probably because of their low productivity and nutrient levels (Okada 1960; Hela and Laevastu 1962), the tendency for fine material to remain trapped within estuaries in the region (Mabesoone and Coutinho 1970), and the low discharge of rivers from the drought polygon. One of the only rivers where sediments are known to be regularly discharged is at the cuspate delta of the Jaguaribe (Bacoccoli 1971). The mineral content of the sands reflects their history in terms of interaction of geological source, physiography, climate, and weathering, as well as transportation and deposition. The coastline is largely depositional, with sand dunes being blown inland from the coast. This has resulted in some areas of spectacular accumulation of sand, such as that along the coastline of the Lencois Maranhenses National Park west of Parnaiba.

Sandstone reefs are a feature of the northern and eastern Atlantic coasts of Brazil, occurring in both the littoral and nearshore zones in lines parallel to the shore.

Map 9.5 (Brazil-5)
Distribution of Nearctic shorebirds along the Fortaleza coast of Brazil



These beachrock formations are formed of cemented sands (Mabesoone 1964) and were reported by Darwin (1841), who knew they had not developed from coral. Two or three such reefs may be exposed at low tide, and there may be 10 or more submerged offshore. The reefs form along the beachline and are thus geologically recent; the lines of reefs reflect changes in the Holocene sea level, every line representing a temporary still-stand. The uppermost reefs are soft, with a hardened upper surface, and they become more consolidated offshore (Mabesoone 1964). Such outcroppings were observed along the extensive sandy section west of Parnaiba and have been reported between Fortaleza and the Rio Sao Francisco on the east coast (Mabesoone and Coutinho 1970). Similar formations have been reported on the coastal platforms of southern Brazil and Uruguay (Delaney, in Mabesoone 1964) and appeared to be present along the sandy southern coast of Buenos Aires province in Argentina (pers. obs.). These structures attract shorebirds on many beach areas where both are present.

9.5.2. Northeast eco-unit

Sectors 63–72; Maps 9.4 (Brazil-4) to 9.6 (Brazil-6)

Much of the coastline in the Northeast eco-unit was sandy, with only isolated inlets or lagoons (Tables 9.10, 9.12, and 9.14). Shorebird totals were moderate to low, the overall total of 6000 representing some 1.5% of the Brazilian total (Tables 9.9, 9.11, and 9.13).

Most of the small shorebirds (peeps) occurred in small lagoons or wet areas behind the ocean beach, such as those occurring in Sectors 67 and 72. Large numbers were not located during the surveys in the extensive complex of mangroves *Rhizophora mangle*, marshes, beaches, and dunes in the delta of the Rio Parnaiba between Tutoia and Parnaiba (Sector 64). Many of the areas of seasonally flooded wetlands that are found behind the coast, for instance near Aracati, were dry at the time of the surveys and contained relatively few birds.

Notable numbers of some shorebird species were found along the beaches of this eco-unit and appeared to be closely associated with patches of beachrock. Such habitats were observed regularly along the vast beaches and dune systems of the Lencois Maranhenses National Park (Sector 63) west of Parnaiba. Over half (230, or 60.5%) of the eco-unit total of 380 Sanderlings (8.7% of the North Coast total) occurred along this stretch of coast, which was also one of the few coastal localities in which Lesser Golden-Plovers (some 80) were observed. Ruddy Turnstones and Black-bellied Plovers were also associated with beachrock habitats. Of the total of 430 Ruddy Turnstones (2.1%

Table 9.11
Totals of Nearctic shorebirds in survey sectors in Map 9.5 (Brazil-5)

Sector no.	Sector length (km)	Spotted Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Dowitcher species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Whimbrel	Willet	Unidentified large shorebird species	Total large shorebirds	Total shorebirds
65	124.1	0	11	2	13	78	14	0	0	84	176	21	0	40	61	250
66	83.6	0	5	305	310	199	33	2	2	6	242	4	1	0	5	557
67	75.7	0	28	560	588	67	15	6	0	73	161	23	1	0	24	773
68	100.3	1	0	165	166	75	5	4	0	0	84	0	0	0	0	250
69	50.4	0	2	150	152	3	0	1	0	2	6	0	0	0	0	158
70	75.0	0	1	180	181	0	0	57	0	1	58	0	0	0	0	239
Total	509.1	1	47	1 362	1 410	422	67	70	2	166	727	48	2	40	90	2 227

Table 9.12
Principal habitats in survey sectors in Map 9.5 (Brazil-5)

Sector no.	Habitat description
65	Narrow sand beach, some mudflats by rivers, some rocky points / dunes, palms / sandy scrub, forest
66	Narrow sand beach, some mudflat with mangroves / dunes / scrubby desert lagoon, forest
67	Narrow sand beach, some mudflats / dunes / sandy scrub, forest, salt pans
68	Narrow sand outer beach, some small brackish muddy deltas / dunes / sandy scrub, palms, forest
69	Narrow sand beach, a few rocky outcrops / dunes / sandy scrub
70	Narrow sand beach, small brackish muddy estuary / dunes / sandy scrub, salt pans, small lagoons

of the North Coast total) counted in the eco-unit, 190 (43.4%) were found in Sector 63 and 160 (36.7%) in Sector 71, principally on the beaches. Black-bellied Plovers were most common in the eastern part of the eco-unit, with 740 (57.5%) of the total of 1300 (5.4% of the North Coast total) in Sectors 63 and 64 (Tables 9.9, 9.11, and 9.13).

9.6. Northeastern coast: Natal to Salvador

Shorebird surveys were not carried out in this sector, as logistical considerations precluded coverage of all of the very long Brazilian coastline, and extensive suitable habitat was not expected in this zone. Surveys of representative, fairly similar habitat were carried out to the north and south of the area, west of Aracati and from Salvador southwards, respectively.

The coastline is backed by mountains of the Precambrian Brazilian Coastal (Atlantic) Shield, which reach heights of 500–1000 m. There is a generally fairly narrow coastal plain, about 15 km in width between Joao Pessoa and Maceio and between Aracaju and Salvador, in which the coastline is steeply cliffed. The plain is wider, around 50 km, near Aracaju, and beaches and dunes with some lagoon developments occur in the area (Summerhayes *et al.* 1975).

The rainfall is high, usually exceeding 1000 mm · yr^{-1} and sometimes 2000 mm · yr^{-1} over the eastern coastal ranges, where the prevailing easterly and southeasterly winds deposit their moisture (Andrade 1964). The Rio Sao Francisco, the largest in the area, is some 2700 km in length; its upper drainage basin consists of Paleozoic metasediments, and it provides the major source of sediment and freshwater input on the coast. Even so, it appears that 90% of the sediment carried by the river is deposited within its own system, and the remaining 10% is deposited within 5–10 km of the river mouth (Barretto and Summerhayes 1975). Little or none of the suspended load of the other rivers in the region, which generally are short and drain a limited area because of the proximity of the coastal mountains, appears to reach the sea (Mabesoone and Coutinho 1970; Barretto and Summerhayes 1975; Summerhayes *et al.* 1975).

Organic contents of the submerged sediments are generally very low, being somewhat higher in the terrigenous muds off the Rio Sao Francisco and higher still in muds trapped behind reefs and in lagoons along the coast (Coutinho, in Summerhayes *et al.* 1975). Most of the river shelf sediments are sandy, although muddy sediments occur around the delta of the Rio Sao Francisco and are more plentiful farther offshore, especially south of Maceio. Although rainfall is high along the coast, the short river courses and luxuriant tropical vegetation until recently prevented extensive erosion of the heavily weathered soil (Gibbs 1967), so that little terrigenous detritus reached the sea. Erosion has increased considerably owing to the extensive removal of forest cover, especially since the middle of the present century. High wave energies along the coast (Coleman and Wright 1972) keep much of the sand in motion, precluding extensive organic growth on the inner shelf. Because of the lack of terrigenous input and the tropical climate, carbonate-producing organisms flourish, and biogenically produced carbonates predominate in the accumulated sediment offshore. The area is also unique in its almost total lack of coral and complete lack of ooids (Summerhayes *et al.* 1975). The offshore waters are generally unproductive (Okada 1960; Hela and Laevastu 1962), and, even near the Rio Sao Francisco, most organic matter (mainly diatoms) appears to be recycled within the water column, with only a small amount accumulating in the sediment (Barretto and Summerhayes 1975).

The west-flowing South Equatorial Current reaches the coast near Recife (Defaut 1961). The current splits, with the North Brazilian Coastal Current flowing north past Natal and then west along the north coast towards the Guianas at about 1 m · s^{-1} (Metcalf and Stalcup 1967), and the Brazil Current flowing southwards towards Rio de Janeiro at about 0.25–0.5 m · s^{-1}. In winter (June–August), a weak countercurrent flows north along the coast (US Naval Hydrographic Office 1967). Surface temperatures are in the range 26–29°C in summer (March; Fuglister 1960) and 25–27°C in winter (August; Cavalcanti *et al.* 1967). Salinities are around 36 ppt, although they are often

lower near major rivers during periods of high discharge (Fuglister 1960; Cavalcanti *et al.* 1967).

Two narrow sedimentary basins occur along the coastline at the margin of the Brazilian Coastal (Atlantic) Shield: the Recife – Joao Pessoa Basin, running between the cities of those names, and the Sergipe–Alagoas Basin, running for about 350 km from north of Maceio (9°S) southwards to south of Aracaju (11°30′S) (Asmus and Ponte 1973). Both are filled with Cretaceous and Tertiary sediments. Beach sands, eolian sediments, dunes, and alluvial deposits occur along the coast (Asmus and Ponte 1973).

9.7. East coast: Salvador to Vitoria

9.7.1. Environmental conditions

The east Atlantic coast of Brazil between Salvador and Vitoria is backed almost entirely by the Precambrian crystalline rocks of the Brazilian Coastal (Atlantic) Shield, which reach the coast in the vicinity of Ilheus. The hinterland is hilly, reaching 500–1000 m within 100 km of the sea; the highest elevations, up to 2884 m, are found inland from Vitoria. The coastal plain is very narrow and is set on three major geological basins: (1) the Reconcavo Basin, reaching the coast at Salvador and underlying the Baia de Todos os Santos; (2) the Jequitinhonha Basin, extending from south of Ilheus to north of Caravelas (15–17°S); and (3) the Espirito Santo Basin, extending from the mouth of the Rio Doce (19°45′S) to around Caravelas (17°30′S) (Asmus and Ponte 1973). A smaller basin, the Almada Basin, lies between the Reconcavo and Jequitinhonha basins north of Ilheus (Petri and Mendes 1983). The basins are filled with Cretaceous and Tertiary sediments, both of which occur north of Ilheus, the area south being cut into Tertiary sediments.

In the north, eolian fluviolacustrine sedimentation prevails (Asmus and Ponte 1973), and a number of extensive embayments and estuaries are found, including those at Salvador, comprising the Baia de Todos os Santos, and the two large systems south of Valenca and Itubera. The coastline north of Caravelas towards Ilheus, which is underlain by the Jequitinhonha Basin, is backed by low cliffs; similar shoreline is found towards Vitoria south of the Rio Doce. Between Caravelas and the Rio Doce, the Espirito Santo Basin is characterized by regression and the building of long sand bodies, so that beaches, bars, and spits, with some marshes and lagoons, are found (Asmus and Ponte 1973; de Melo *et al.* 1975). These areas were not covered on the surveys.

The climate of the area is hot and humid and has been termed "pseudo-equatorial" (Andrade 1964). Two rainy seasons occur, in March/April and in November/December. Precipitation falls mostly on the coastal ranges and principally in the northern section between Belmonte and Salvador, where it reaches 2000 mm·yr^{-1}. The hinterland is relatively dry, with rainfall in the range 500–1000 mm·yr^{-1}, the dry zone reaching the coast at the Rio Doce. Farther inland, the rainfall is again higher, exceeding 1000 mm·yr^{-1}. The principal rivers draining the area are the Jequitinhonha and Doce rivers, of which the Rio Doce is the larger: it is 630 km long, drains an area of 90 000 km^2, and discharges some 20 km^3 of water per year and an estimated 4 × 10^6 tons·yr^{-1} of sediment. The Jequitinhonha drains an estimated 70 000 km^2 and discharges some 8 km^3·yr^{-1} of water (de Melo *et al.* 1975; Milliman 1975). Both rivers discharge through cuspate deltas (Bacoccoli 1971), which effectively block the offshore movement of sand and gravel.

Map 9.6 (Brazil-6)
Distribution of Nearctic shorebirds along the Aracati coast of Brazil

Offshore, the Brazil Current moves south to southwestwards at about 0.3 m·s^{-1} (0.6 knots) (US Naval Hydrographic Office 1967), bringing warm saline water poor in nutrients. Several areas of upwelling are produced by the relatively complicated subsurface topography, particularly where the current diverges from the coast south of the Rio Doce and near the Royal Charlotte and Abrolhos banks.

Longshore drift may occur northwards between Ilheus and Salvador, and north and south on either side of Caravelas, where coastal outbuilding has occurred (de Melo *et al.* 1975).

Most of the inner shelf sediments are sandy, with muddy areas occurring off the major rivers (Rio Doce) or estuarine areas in the north (Valenca); these areas show the highest accumulation of organic matter (de Melo *et al.* 1975), the high carbon/nitrogen ratios probably reflecting the content of terrestrial plant material in these terrigenous sediments.

9.7.2. East eco-unit

Sectors 74–80; Map 9.7 (Brazil-7)

Surveys in the East eco-unit (Sectors 74–80) covered the bays and beaches from the vicinity of Salvador southwards to Ilheus. Much of the coastline is sandy, although fairly extensive mangrove development occurs around

Table 9.13
Totals of Nearctic shorebirds in survey sectors in Map 9.6 (Brazil-6)

Sector no.	Sector length (km)	Spotted Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Red Knot	Total medium-sized shorebirds	Whimbrel	Total large shorebirds	Total shorebirds
71	94.0	1	60	199	260	71	158	2	15	246	1	1	507
72	33.7	0	6	816	822	54	5	43	0	102	1	1	925
73	37.2	0	0	50	50	1	0	0	0	1	1	1	52
Total	164.9	1	66	1 065	1 132	126	163	45	15	349	3	3	1 484

Table 9.14
Principal habitats in survey sectors in Map 9.6 (Brazil-6)

Sector no.	Habitat description
71	Narrow sand beach, some small brackish muddy estuaries with mangroves, some rocky points / dunes, cliffs / scrubby desert, lagoon with palm forest
72	Narrow sand beach, some small brackish muddy estuaries with mangroves / dunes, palms / scrub, open forest, salt pans
73	Brackish estuary with mudbanks / forest, salt pans, lagoons

Salvador in the Baia de Todos os Santos (Sector 75) and around other major estuarine areas, including those near Valenca (Sector 77) and Itubera/Camamu (Sector 79) (Table 9.16). Despite the presence of suitable-looking habitat, however, few shorebirds were found in the latter areas (Table 9.15).

The Salvador Peninsula is a plateau made of Precambrian gneisses and granites of the Brazilian Coastal (Atlantic) Shield, generally covered with thick lateritic soils or coarse clastic late Tertiary rocks. It separates the Atlantic coast from the Baia de Todos os Santos, an enclosed embayment containing the estuary of the Rio Paraguacu. The bay is dotted with islands and fringed with mangrove stands. Alternating headlands and beaches are found around its shores, the cliffs being cut into bedded Cretaceous sandstones, siltstones, and shales. The sands are composed mostly of well-sorted quartz (Murphy and Schlanger 1962). Beaches tend to be larger and wider than on the outer Atlantic coast, with gentler slopes; extensive sandy and muddy flats are exposed at low tide and are well populated with pelecypods (Sestini 1967).

The Atlantic shoreline typically consists of a series of rocky headlands alternating with long stretches of gently curved or rectilinear beaches, or with coves and small bays. Most of the Atlantic beaches are narrow, 20–30 m at high tide and perhaps one-third wider at low tide, owing to the high angle of slope (3–5°), and are made up of quartz grains with a small percentage of skeletal fragments. Beach sands in the Bahia de Todos os Santos are finer grained and more calcareous than the outer beach sediments. Most quartz of the beach sands is derived from weathering of the basement gneisses, whereas that of the bay sands derives from breakdown of fine- and medium-grained Cretaceous sandstones. Outer beach areas are also exposed to ocean waves driven by the prevailing southeasterly trade winds, whereas those in the bay are in more sheltered waters.

Between the tip of the Salvador Peninsula and the harbour, the shore is mostly rocky, with small shingle and sand beaches. The southeast coast of Ilha de Itaparica consists of a long, wide, palm-lined beach, interrupted only in places by low cliffs of Cretaceous rocks.

South of Camamu and Itubera, there are extensive estuarine areas, with tidal mudflats, mangrove swamps dominated by *Rhizophora mangle*, brackish lagoons, and marshes. These areas are enclosed by low-lying islands fronted by long ocean beaches.

Totals of shorebirds observed on the surveys in the East eco-unit were surprisingly low, considering the extent of apparently suitable-looking habitat in the area. The eco-unit total of 2600 shorebirds represented only 0.7% of the Brazilian total (Table 9.15).

The majority of the shorebirds were found in bays and estuaries—most (2000, 76.0%) in the Baia de Todos os Santos, with smaller numbers in the estuaries south of Valenca (230) and Itubera (85). Small shorebirds were most numerous, with moderate to low numbers of Black-bellied Plovers, Ruddy Turnstones, yellowlegs, Whimbrels, and Willets. The estuary south of Itubera (Sector 79) was the farthest south that Willets were observed on the Atlantic coast during the present surveys.

Relatively few birds were found on the outer beaches, with the exception of the 230 Sanderlings in Sector 74 north of Salvador (Table 9.15), many of which were associated with the well-developed platforms of beachrock occurring along the shore. Fewer birds were seen on the beaches in the southern part of the eco-unit, where beachrock was less common. The picturesque sweep of tropical beach leading south to Ilheus (Sector 80) was spectacularly devoid of Nearctic shorebirds, only one Ruddy Turnstone being observed in some 36 km of shoreline.

9.8. Southern Brazil: Vitoria to Uruguayan border

Surveys were carried out in three areas of the southern coast of Brazil: (1) the Rio de Janeiro area, from Rio de Janeiro north to the Rio Paraiba do Sul/Cabo de Sao Tome (Rio eco-unit; Map 9.8 [Brazil-8], Sectors 81–89); (2) Sao Paulo area, from Santos south to Paranagua (Sao Paulo eco-unit; Map 9.9 [Brazil-9], Sectors 90–96); and (3) the Rio Grande do Sul coastline, from opposite Porto Alegre to near the Uruguayan border at the southern end of Lagoa Mirim (Rio Grande do Sul eco-unit; Map 9.10 [Brazil-10], Sectors 97–109, and Map 9.11 [Brazil-11], Sectors 110–120).

9.8.1. Environmental conditions

Much of the coastline in this region consists of sandy beaches, backed by a coastal plain of variable width. The mountains of the Precambrian Brazilian Coastal (Atlantic) Shield run along most of the coast, except in the Rio Grande do Sul eco-unit, and three sedimentary basins

Map 9.7 (Brazil-7)
Distribution of Nearctic shorebirds along the Salvador coast of Brazil

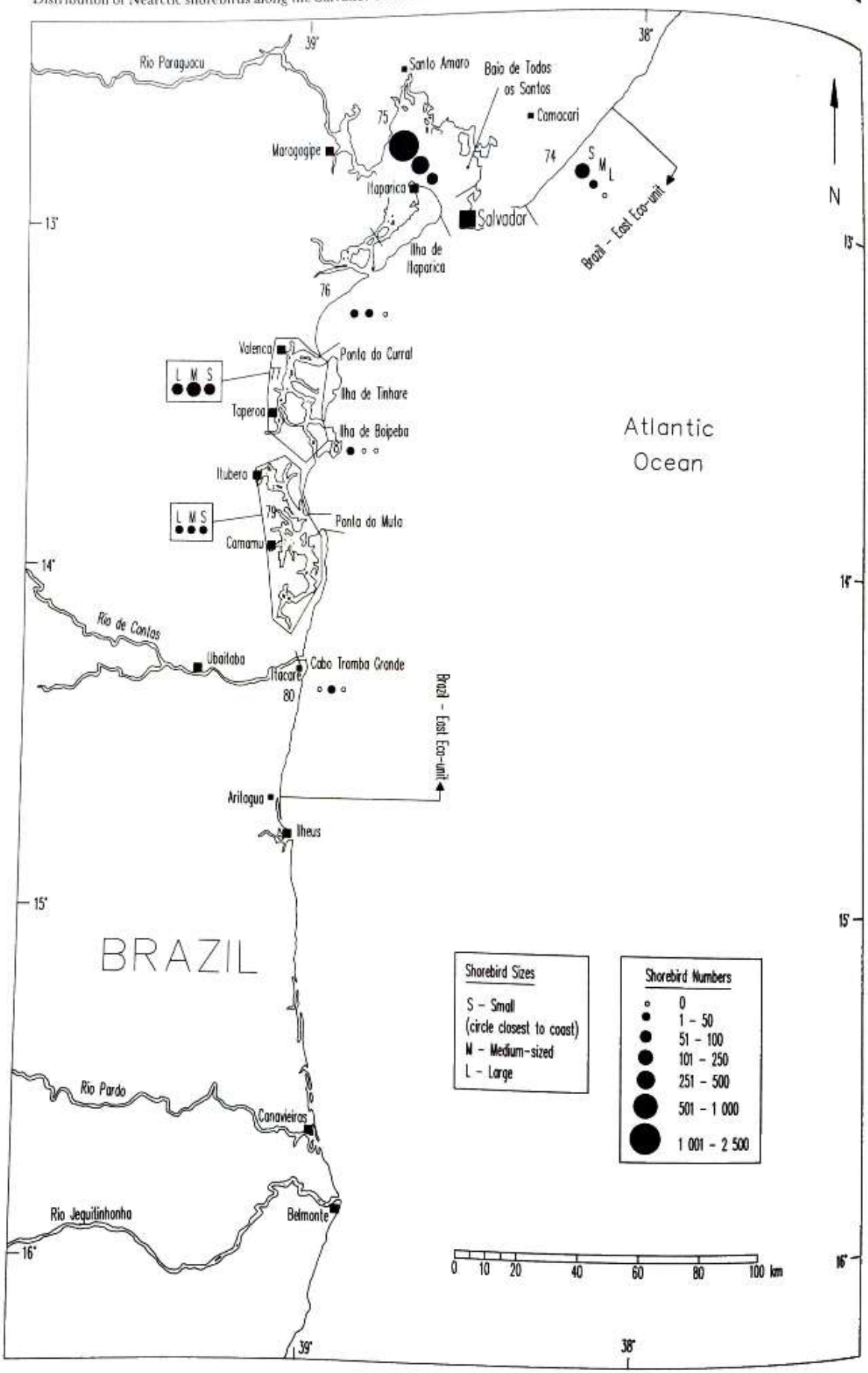


Table 9.15
Totals of Nearctic shorebirds in survey sectors in Map 9.7 (Brazil-7)

Sector no.	Sector length (km)	Spotted Sandpiper	Solitary Sandpiper	Pectoral Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Whimbrel	Willet	Total large shorebirds	Total shorebirds
74	43.1	0	0	0	232	3	235	0	9	0	0	9	0	0	0	244
75	261.0	5	1	20	23	1395	1 444	113	277	48	52	490	43	28	71	2 005
76	122.0	1	0	0	4	38	43	7	16	1	0	24	0	0	0	67
77	214.9	9	0	30	0	18	57	34	6	4	79	123	18	36	54	234
78	72.9	1	0	0	2	0	3	0	0	0	0	0	0	0	0	3
79	189.1	4	0	15	0	16	35	14	12	6	0	32	5	13	18	85
80	36.0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
Total	939.0	20	1	65	261	1 470	1 817	168	321	59	131	679	66	77	143	2 639

Table 9.16
Principal habitats in survey sectors in Map 9.7 (Brazil-7)

Sector no.	Habitat description
74	Narrow sand beach, rock outcrops / palms / habitations, lagoons
75	Broad mud- and sandflats, rocky shelves, mangroves / forested hills, industrial development
76	Sand beach, rocky shelves, some mangroves and mudflats / some palms, scrub / forest, habitations
77	Brackish estuary with large mudbanks, mangroves / forest
78	Sand beach, rocky reefs, some muddy bays and mangroves / palm plantations, forest
79	Brackish estuary with broad mudbanks, mangroves / forest
80	Narrow sand beach, steep rocky sections / palms / forested hills

are found—the Campos, Santos, and Pelotas basins (Asmus and Ponte 1973).

In the northern part of the region, north of Cabo Frio, the coastal plain opens to around 50 km at Campos, where the Rio Paraiba do Sul reaches the coast north of Cabo de Sao Tome. The extensive Lagoa Feia lies behind the coast in this area, although its well-vegetated freshwater borders do not provide a great deal of habitat for shorebirds. Numerous shallower small lagoons are found behind the outer barrier ocean beach; some containing more open habitat held large numbers of yellowlegs. Availability of such habitats depends on the specific topography of the individual lagoons/pools and the seasonally variable water levels. Some mangrove development occurred at the mouth of the Rio Paraiba do Sul.

The coastal strip is rather narrow between Cabo Frio and Rio de Janeiro. Several large brackish and saline lagoon systems are found behind the outer barrier beaches. Salt evaporation pans have been built in the lagoons immediately west of Cabo Frio, but the larger lagoons towards Rio de Janeiro are deeper and have less shoreline habitat. The area has become popular with holidaymakers: housing developments are found around many lagoons, and some beaches are crowded with people. Eutrophication has led to some lagoons becoming congested with vegetation, and increased disturbance through hunting and recreation has led to their deterioration as wildfowl or shorebird habitat. The shoreline of Baia de Guanabara at Rio de Janeiro, which once held extensive mangrove formations, has been extensively developed and polluted.

The mountains of the Serra do Mar run very close to the sea between Rio de Janeiro and Sao Paulo, rising to heights of up to 1000 m within 10 km of the sea; in some places, elevations exceed 2000 m. Surveys were not conducted along this precipitous coast.

The crystalline Precambrian rocks continue southwards into southeastern Rio Grande do Sul, in the high ranges of the Serra do Mar and Serra Geral; elevations reach 1000 m and in some places over 1900 m (Fuck *et al.* 1969). These mountains limit the coastal plain to a rather narrow strip for most of the distance, the Serra Geral coming close to the coast near Torres in Rio Grande do Sul. As a result, most rivers in the southern part of the area flow westwards into the Rio Parana system. The coast, in contrast, is drained by many short, small streams, which generally carry small amounts of sediment (da Rocha *et al.* 1975). Although rain-driven floods may bring large amounts of sediment to the coast, little of this material appears to reach the inner shelf offshore (Milliman and Santana, in da Rocha *et al.* 1975), and most is deposited within the coastal lagoons or estuaries or along the shoreline itself (da Rocha *et al.* 1975). The crystalline rocks constitute the source area for the sandy and argillaceous sediments on the coastal plain (Anon. 1975).

South of Santos, long sandy beaches run along the coast to the hilly outcrops at Peruibe. From Iguape to Ilha do Cardoso, the outer beach is backed by a large river channel running parallel to the shore. The estuaries at Paranagua and at Cananeia contain extensive mangrove developments. The southern limits of mangroves are reached at Florianopolis (27°30′S) for *Rhizophora mangle* and *Avicennia schaueriana*, and at the Rio Ararangua (29°S) for *Languncularia racemosa* (Lamberti 1969; Souza Sobrinho and Klein 1969; West 1977). In general, the coastal lowlands are poorly developed in the states of Parana and Santa Catarina. The coastal sediments consist of a relatively thick layer of marine and continental Quaternary/modern deposits (Fuck *et al.* 1969).

South of Laguna, the coastal plain contains a number of lakes and lagoons, but it is not until south of Tramandai that the coastal plain opens out extensively, elevations not exceeding 200 m westwards all the way to the Rio Uruguai, except for the Precambrian outcroppings west of the Lagoa dos Patos, which rise to some 600 m (Anon. 1975).

The coastal plain of Rio Grande do Sul comprises some 47 100 km^2 of lowlands; it is composed of Pleistocene and Recent sediments and contains many lakes and lagoons (Delaney 1965; Pinto 1966; Pinto and Ornellas 1970). The largest lagoon is the Lagoa dos Patos, which is 250 km

Ocean beaches, Rio Grande do Sul, southern Brazil. The very long ocean beaches fronting the sandy coastal plain in Rio Grande do Sul province in southern Brazil support some of the most significant concentrations of Sanderlings on the Atlantic coast of South America.

long, has an area of 9910 km^2, and is generally shallow, depths ranging from 6–8 m in the middle to 0.5–3 m at the margins (Closs and Madeira 1968; Anon. 1975). The Lagoa dos Patos receives water from the Rio Guaiba and its tributaries, the Camaqua River and the Lagoa Mirim. Salinity in the lower part of the lagoon near Rio Grande varies considerably, owing to seawater entering its channel; the remainder of the lagoon usually contains fresh water. The very low gradient of the lagoon floor (about 1 m in 120 km) results in wind direction and volume of runoff being the most important factors controlling water movements, and strong southeasterly winds occasionally bring saline water well north into the lagoon. Northeasterly winds predominate, although westerly continental winds occur in the fall and winter months (Closs and Madeira 1968). The lagoon is thought to have originated by development of a multiple sand barrier during up to four cycles of transgression and regression resulting from eustatic sea-level changes during Quaternary times (Villwock 1978). Bottom sediments are fine sand and silt, mostly derived from the Precambrian highlands (Closs 1963; Martins 1963; Villwock 1978). Biological activity is minor and related to a small mollusc assemblage (Villwock 1978).

Lagoa Mirim is the second largest lagoon, with an area of 3770 km^2 and depths up to 7 m (Delaney 1965).

Considerable numbers of smaller lagoons are found between the ocean beach and the larger lagoons inland, varying in size, depth, and salinity regime. The most important for shorebirds is the Lagoa do Peixe, situated between the Lagoa dos Patos and the ocean. It is some 40 km long, occupies an area of about 50 km^2, and is shallow, reaching depths of about 3 m, although much of the lagoon is less than 1 m deep. The lagoon is connected to the sea by a channel, near which saline to brackish conditions prevail, and there are extensive muddy, wet borders. The mouth of the lagoon is periodically blocked by moving sand and may be reopened by dredging (Delaney 1965) or by storm surges.

The coastline of Rio Grande do Sul forms one of the world's longest uninterrupted beaches: it is some 620 km in length (Martins 1967; Pinto and Ornellas 1970), and elevations reach 20 m at the crests of sand dunes. The major lagoons in the south are separated from the ocean by several kilometres of marine and eolian sands. The Pleistocene–Holocene–Recent sands extend westwards to the border of the Precambrian rock hills that outcrop in an arcuate belt from the Rio Guaiba to Pelotas (Closs and Madeira 1968), although the surface material consists of fluviatile clayey sediments between the lagoons and inland slopes (Anon. 1975).

Cabo Frio effectively marks the transition from a tropical environment farther north to a subtropical environment to the south. Mean annual temperatures range from 22 to 24°C from Rio de Janeiro northwards, from 20 to 22°C from about Sao Francisco do Sul to Rio de Janeiro, and from 18 to 20°C from Rio Grande to Sao Francisco do Sul (IBGE 1977). South of Rio de Janeiro, the climate can be classified as subtropical, and the southern Brazilian coastal climate can be classified as Cfa (subtropical humid without dry season and with warm summers [temperatures > 22°C]) on the Koppen system. The rainfall is heavy over the coastal regions, especially where polar air masses from the south meet the Serra do Mar range. Mean annual precipitation is generally 1500–2000 $mm \cdot yr^{-1}$ from Rio de Janeiro to Florianopolis, 1250–1500 $mm \cdot yr^{-1}$ southwards to Rio Grande do Sul, and 1000–1250 $mm \cdot yr^{-1}$ along the southern coast (IBGE 1977). The mountainous areas of the Serra do Mar and Serra Geral have some of the highest rainfall recorded in Brazil, with means of over 3500 $mm \cdot yr^{-1}$ and maximum values of over 6500 $mm \cdot yr^{-1}$ in Sao Paulo state (Anon. 1975). The prevailing winds are generally northeasterly (Andrade 1964; Santos 1965; Bigarella 1970–71).

In Rio Grande do Sul, mangroves do not occur, but beach areas may be colonized by *Sesuvium portulacastrum*,

Salicornia gaudichaudiana, and *Spartina* spp., and dunes with *S. portulacastrum*, *Cotula coronopifolia*, *Parricum reptans*, *Alternathera* spp., *Heliotropum reptans*, *Solanus sisymbrifolium*, and *Hyptio labiadas* (Delaney 1965).

Offshore, the most significant oceanographic features are the upwelling that occurs from Vitoria to Rio de Janeiro and the northward flow of cold waters into the southern areas. Upwelling is strongest in the north in the area of Cabo Frio, and biological productivity is relatively high thereabouts (Okuda 1962). Bottom sediments in the area show only slightly elevated levels of nitrogen, and the impact of upwelling is not clearly shown in these sediments, probably because the high wave and current energies and high oxygen levels that occur between Cabo Frio and Vitoria facilitate high rates of recycling of organic matter within the water column (da Rocha *et al.* 1975).

In the south, the Falkland (Malvinas) Current brings cool, less saline water northwards along the coast, especially in the autumn, when southwest winds push the Falkland (Malvinas) Current northeastwards and the Brazil Current farther offshore. The Falkland (Malvinas) Current reaches its maximum development during the winter, when cool waters invade north of Santa Catarina state, dipping below the surface before upwelling at Cabo Frio; in the spring, winds shift to northeasterly, and the Brazil Current again dominates the coastal circulation (Emilsson 1961).

Sand and gravel dominate the inner shelf sediments, especially along the southern coast. Belts of mud are found on the middle shelf, and some of these, especially in the Pelotas Basin, may represent old lagoonal structures now submerged, similar to those along the present coastline (da Rocha *et al.* 1975; Milliman 1978). The composition of the sediments off the southern part of the coast indicates that they are derived from material discharged from the Rio de la Plata and carried northwards by prevailing currents, perhaps during a period of earlier lower sea level (Urien 1972; da Rocha *et al.* 1975). In contrast, sediments off the northern part of this sector appear to consist principally of material from the Precambrian rocks of the coastal highlands carried down by the short east coast rivers. In the south, an area of mud is also found off the Rio Grande channel draining the Lagoa dos Patos, representing sediments derived from the lagoon (Martins *et al.* 1972; da Rocha *et al.* 1975).

9.8.2. Rio eco-unit

Sectors 81–89; Map 9.8 (Brazil-8)

The Rio eco-unit contained low numbers of shorebirds. The total of 5600 represented 1.4% of the Brazilian total and consisted mostly of yellowlegs (4800) and Sanderlings (520) (Table 9.17).

The Rio Paraiba do Sul marked the northern limit of the coastline surveyed for shorebirds. River levels were very high in January 1983, with extensive flooding occurring through the mangrove areas behind the outer barrier sand beach at the mouth of the river delta and in the adjacent open grassy fields surrounding the river channel farther inland.

The deltaic protrusion of the Rio Paraiba do Sul has been formed largely by Holocene beach ridge progradation (Dias 1981). The area is rather flat and contains a complex of relatively shallow lakes and marshes inland, mangrove swamps at the mouth of the river, and sandy beaches along the shoreline backed by a series of small, brackish lagoons (Table 9.18). Very few shorebirds were seen along the beaches between Atafona, at the mouth of the river, and Cabo de Sao Tome (Sector 84). Small numbers of Sanderlings (35) occurred along the beach between Cabo de Sao Tome and Macae (Sector 85), but the most significant shoreline habitat along this stretch appeared to be the shallow lagoons behind the beach, which contained most of the yellowlegs (330), Black-bellied Plovers (80), and small shorebirds (peeps) (10) (Table 9.17). The largest lake inland is the Lagoa Feia, of some 167 000 ha (in 1978, reduced from about 300 000 ha in 1933 through drainage schemes), which is an important area for resident and migratory waterfowl (Scott and Carbonell 1986). Much of the lagoon shoreline is well vegetated and surrounded by agricultural fields, with few muddy margins, and there was very little suitable shorebird habitat along its borders. With water levels in the lake controlled, it is unlikely that muddy margins would develop. Very few Nearctic shorebirds were observed around Lagoa Feia (Sector 83) or adjacent lagoons (Sector 84) (only a few yellowlegs), although South American species such as the Southern Lapwing *Vanellus chilensis* and jacanas were common in the surrounding areas.

The most significant numbers of shorebirds were found in shallow, flooded areas of open mud surrounded by fields with short vegetation; such areas were located to the north and east of the Lagoa Feia behind the coast between Cabo de Sao Tome and the Rio Paraiba do Sul. Very large numbers of yellowlegs used these areas: some 4500 were counted in Sector 82, in flocks of up to 1800 birds. These numbers were among the largest found in nearshore habitats along the Atlantic coast, the eco-unit total of 4800 representing 78.8% of the regional Atlantic Coast total and 5.3% of the South American total (Table 9.17).

Only a few Sanderlings were observed on the coast south of Macae (Sector 86), where a series of beaches and rocky points run south to Cabo Frio (Sector 87), a hilly promontory connected to the mainland by a broad sandy isthmus and bordered by curving beaches.

Between Rio de Janeiro and Cabo Frio, a series of lagoons has been formed by the sealing off of former embayments by Holocene barrier deposition; both an inner barrier, relating to a higher Holocene sea-level phase, and an outer barrier, relating to the present sea level, may generally be found. Barrier sediments are derived from the seafloor, whereas fluvial sediments are trapped within the lagoon systems (Muehe 1979). The lagoons vary from brackish to saline, the largest being the Lagoa de Araruama (15 000 ha). Some mangrove development occurs in brackish areas, although many of the lagoon shorelines are well vegetated and without muddy margins. Large areas of salt pans have been excavated from marshes or shallow lagoon areas towards Cabo Frio. Long sandy beaches run along the coast. Lagoon, salt pan, and shoreline habitats were all sampled in Sector 88. Sanderlings comprised nearly all of the shorebirds observed, most occurring in one large flock (400) on the outer beach towards the western end of the sector; the majority of the remaining birds were observed in the salt pans.

The heavily urbanized Baia de Guanabara at Rio de Janeiro, once an area of extensive mangrove development, was not surveyed, and no shorebirds were found on surveys of the coast west of the city (Sector 89).

Map 9.8 (Brazil-8)
Distribution of Nearctic shorebirds along the Rio de Janeiro coast of Brazil

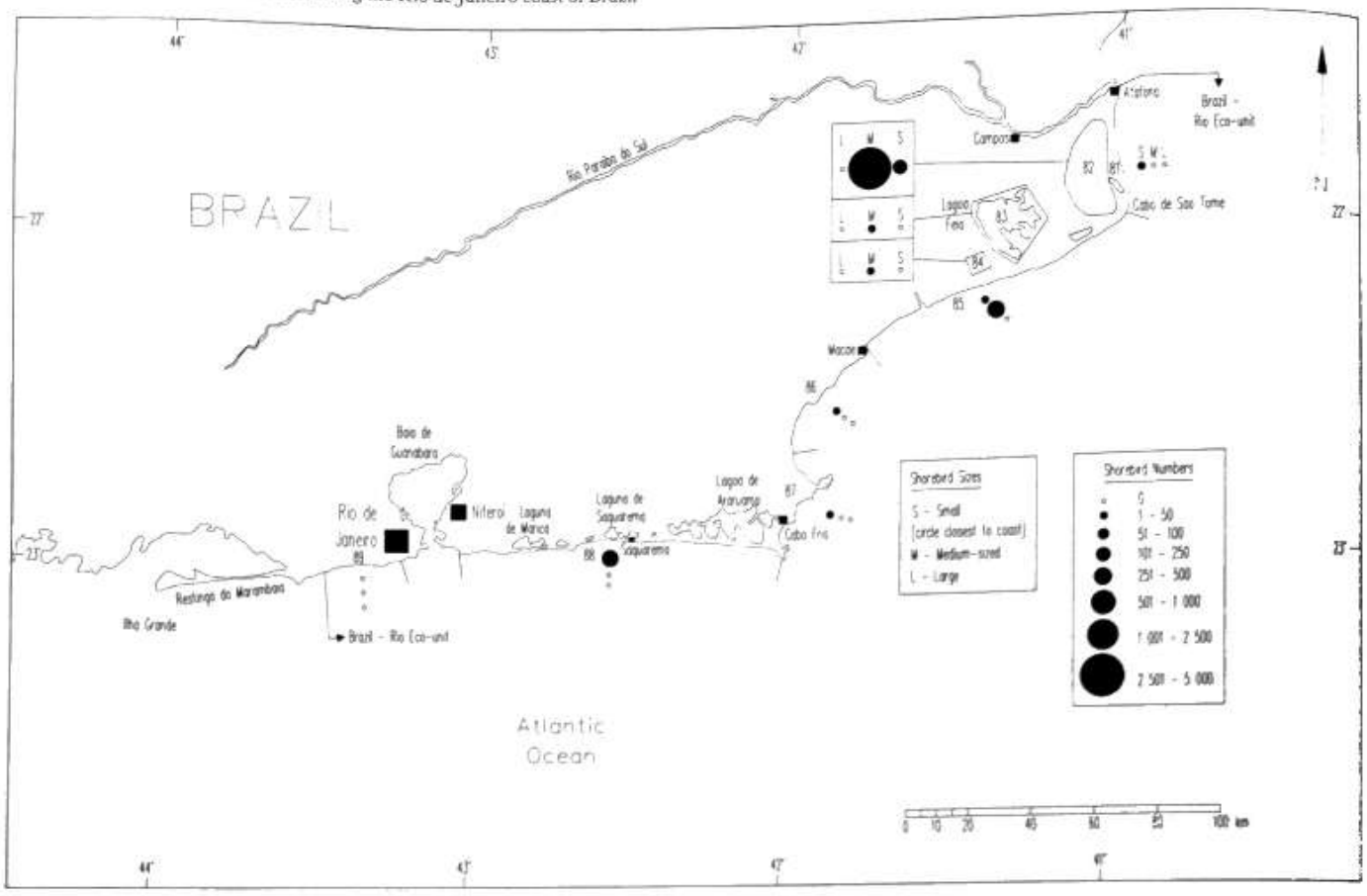


Table 9.17
Totals of Nearctic shorebirds in survey sectors in Map 9.8 (Brazil-8)

Sector no.	Sector length (km)	Spotted Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Black-bellied Plover	Ruddy Turnstone	Yellowlegs species	Total medium-sized shorebirds	Total large shorebirds	Total shorebirds
81	47.0	1	0	0	1	0	0	0	0	0	1
82	0.0	1	0	151	152	0	0	4 470	4 470	0	4 622
83	0.0	0	0	0	0	0	0	3	3	0	3
84	0.0	0	0	0	0	0	0	5	5	0	5
85	100.0	0	35	10	45	76	1	330	407	0	452
86	53.0	0	4	0	4	0	0	0	0	0	4
87	60.0	0	2	0	2	0	0	0	0	0	2
88	110.0	0	483	1	484	0	0	0	0	0	484
89	24.9	0	0	0	0	0	0	0	0	0	0
Total	394.9	2	524	162	688	76	1	4 808	4 885	0	5 573

Table 9.18
Principal habitats in survey sectors in Map 9.8 (Brazil-8)

Sector no.	Habitat description
81	Sand beach / farmland, scrub, marsh, lagoons
82	Inland; freshwater lagoons with marshy mudflats / farmland
83	Inland; freshwater lagoon with marshy edges / farmland
84	Inland; freshwater lagoon with marshy mudbanks / farmland
85	Narrow sand beach / farmland, small lagoons, marsh
86	Narrow sand beach, rocky points / forests, marsh / farmland
87	Narrow sand beach, rocky points / rocky, partly forested hills, habitations, farmland
88	Sand beach / habitation, farmland, salt pans, lagoons
89	Freshwater lagoon, marsh / urban area

9.8.3. Sao Paulo eco-unit

Sectors 90–96; Map 9.9 (Brazil-9)

The Sao Paulo eco-unit had the lowest overall total of Nearctic shorebirds found on the surveys—a mere 12, of which 10 occurred in one flock of peeps along the Praia da Jureia in Sector 92 (Table 9.19).

The northern end of the eco-unit is marked by a high mountainous promontory running out from the Serra do Mar to form the steep Ilha de Sao Sebastiao. Most of the coastline consists of long, straight, sandy beaches, whose outlines relate to the prevailing southeasterly wave action (Table 9.20). The beaches are interrupted periodically by residual outcroppings of coastal massif, as at

Lagoa do Peixe, southern Brazil. Shallow, brackish lagoons occurring near the coast in southern Brazil and in Uruguay provide important habitats for Nearctic shorebirds, both during the wintering period and on migration. A flock of Red Knots is pictured during northward migration in April.

Iguape, Jureia, Itatins, and Itanhaem. Ilha Comprida is an elongated, low, sandy barrier island; behind it a river leads to the mangrove-lined lagoons and swamps at Cananeia, which are enclosed by Pleistocene and Holocene barrier beaches and the hilly Ilha do Cardoso (Bigarella 1978). The Baia de Paranagua and Baia de Laraneiras, between Paranagua and Guaraquecaba, form a large sea bay with a complex indented coastline and many small islands; several small rivers enter the bay, and there are extensive marsh and mangrove formations around its borders. Tidal ranges are about 1–1.5 m.

Both the outer shoreline and the bays and channels were surveyed. Despite apparently suitable habitat along the ocean beaches and along some of the river channels and bays, shorebird numbers were exceptionally low. Extensive intertidal habitat was not observed in most of the larger bays during the flights, and vegetation generally bordered the water directly.

Even though few shorebirds were observed during the January surveys, it does appear that the beaches in this eco-unit are used heavily during migration periods, as suggested by the many specimens of shorebirds that have been collected in the area at such times (unpubl. results).

9.8.4. Rio Grande do Sul eco-unit

Sectors 97–120; Maps 9.10 (Brazil-10) and 9.11 (Brazil-11)

The coastline of Rio Grande do Sul in southern Brazil contains some of the most important shorebird habitats in the country. A total of 25 800 shorebirds was counted in the eco-unit, comprising some 6.5% of the regional total for the Atlantic Coast (Tables 9.21 and 9.23). Most (24 100 or 93.2%) consisted of small species, among which peeps (15 100) were most common: the majority of these consisted of White-rumped Sandpipers, of which a further 2300 were identified from the air. The inclusive total of 17 500 peeps/White-rumped Sandpipers represented 23.9% of the Atlantic Coast total of 73 000, making southern Brazil the second most important area discovered in the region after Tierra del Fuego. Moderate numbers of White-rumped Sandpipers/peeps occurred along the outer ocean beach (total 3200), especially in the northern part of the coast between Pinhal and Rio Grande (Sectors 97–103), with fewer occurring south of Rio Grande (Sectors 110–115). The majority (14 200, or 81.6% of the total) of shorebirds in this category were found in lagoon habitats, especially in the saline lagoons between the Lagoa dos Patos and the Atlantic Ocean: the Lagoa do Peixe (Sectors 106 and 107, total 11 900) was by far the most important location and contained large areas of exposed mudflats on which the birds were found (Table 9.22). Smaller numbers occurred on the sandy shorelines of the freshwater lagoons (e.g., Lagoa dos Patos, Sectors 104, 105, and 109; Lagoa Mangueira, Sectors 116–118; and Lagoa Mirim, Sector 120), or in marshy areas of wetland as found near Taim (Sector 119) (Table 9.24).

The ocean beaches of Rio Grande do Sul were the most important wintering area discovered for Sanderlings on the Atlantic coast of South America, the eco-unit total of 6600 representing 71.3% of the regional Atlantic Coast total (Tables 9.21 and 9.23). The species was again much more common north of Rio Grande than south of the city, particularly along the coastline in the vicinity of the Lagoa do Peixe (Sectors 99–101), where the majority of birds (5500) occurred (Table 9.21).

Important concentrations of Lesser Golden-Plovers were found in the eco-unit. The total of 630, representing 16.1% of the Atlantic Coast total of 3900, was the only significant number found in coastal or nearshore habitats outside Uruguay (Tables 9.21 and 9.23). Lesser Golden-Plovers were found along the ocean beaches (390, 62.6%), as well as in lagoon and nearby grassland habitats (240, 37.4%). Ground observations in February 1985 of an estimated 6000–10 000 birds confirmed the importance of the Lagoa do Peixe area for this species (unpubl. results).

Map 9.9 (Brazil-9)
Distribution of Nearctic shorebirds along the Santos coast of Brazil

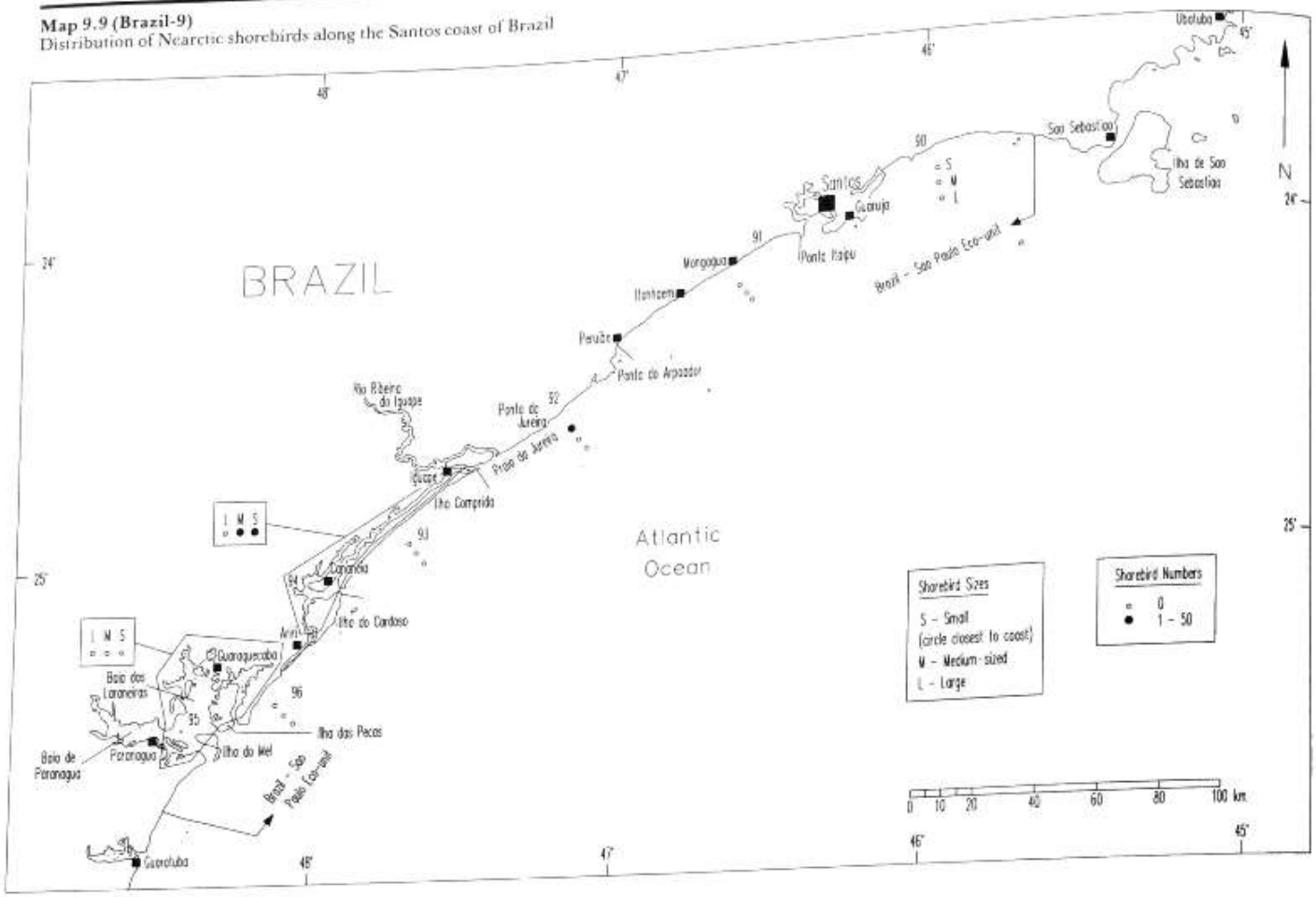


Table 9.19
Totals of Nearctic shorebirds in survey sectors in Map 9.9 (Brazil-9)

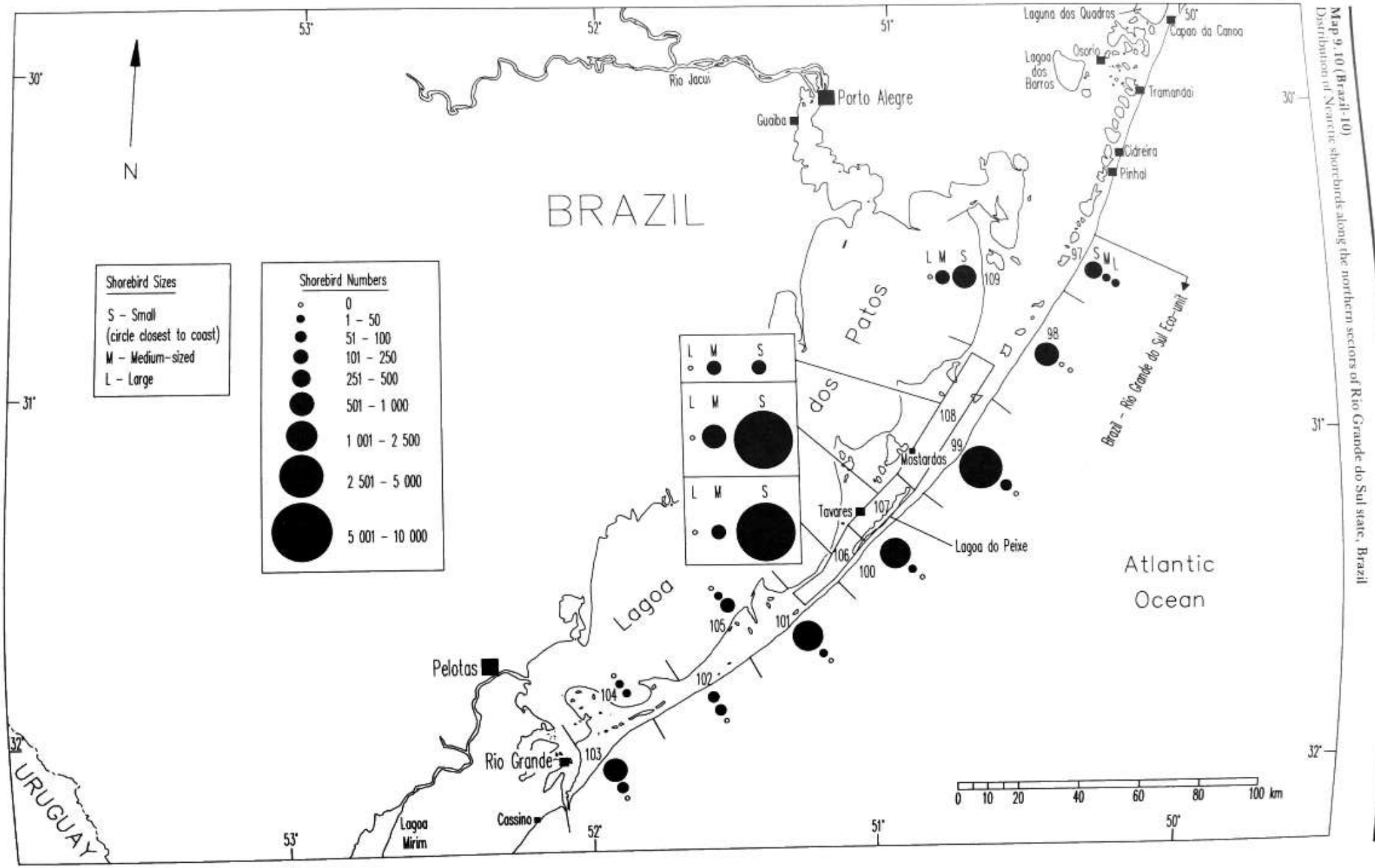
Sector no.	Sector length (km)	Unidentified small shorebird species	Total small shorebirds	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Total large shorebirds	Total shorebirds
90	96.5	0	0	0	0	0	0
91	82.0	0	0	0	0	0	0
92	73.0	10	10	0	0	0	10
93	61.0	0	0	0	0	0	0
94	62.0	1	1	1	1	0	2
95	325.0	0	0	0	0	0	0
96	85.0	0	0	0	0	0	0
Total	784.5	11	11	1	1	0	12

As well as being an important wintering area for Nearctic shorebirds, the Lagoa do Peixe is also of outstanding international importance as a stopover area, especially for shorebirds on northward migration. Over 10 000 Red Knots and 3000 Hudsonian Godwits have been observed during migration periods at the lagoon, many attaining high weight levels, indicating that the lagoon may be a critical area where birds put on the fat required to fuel long-distance flights across Amazonia en route to their breeding grounds in North America (unpubl. results; Harrington *et al.* 1986).

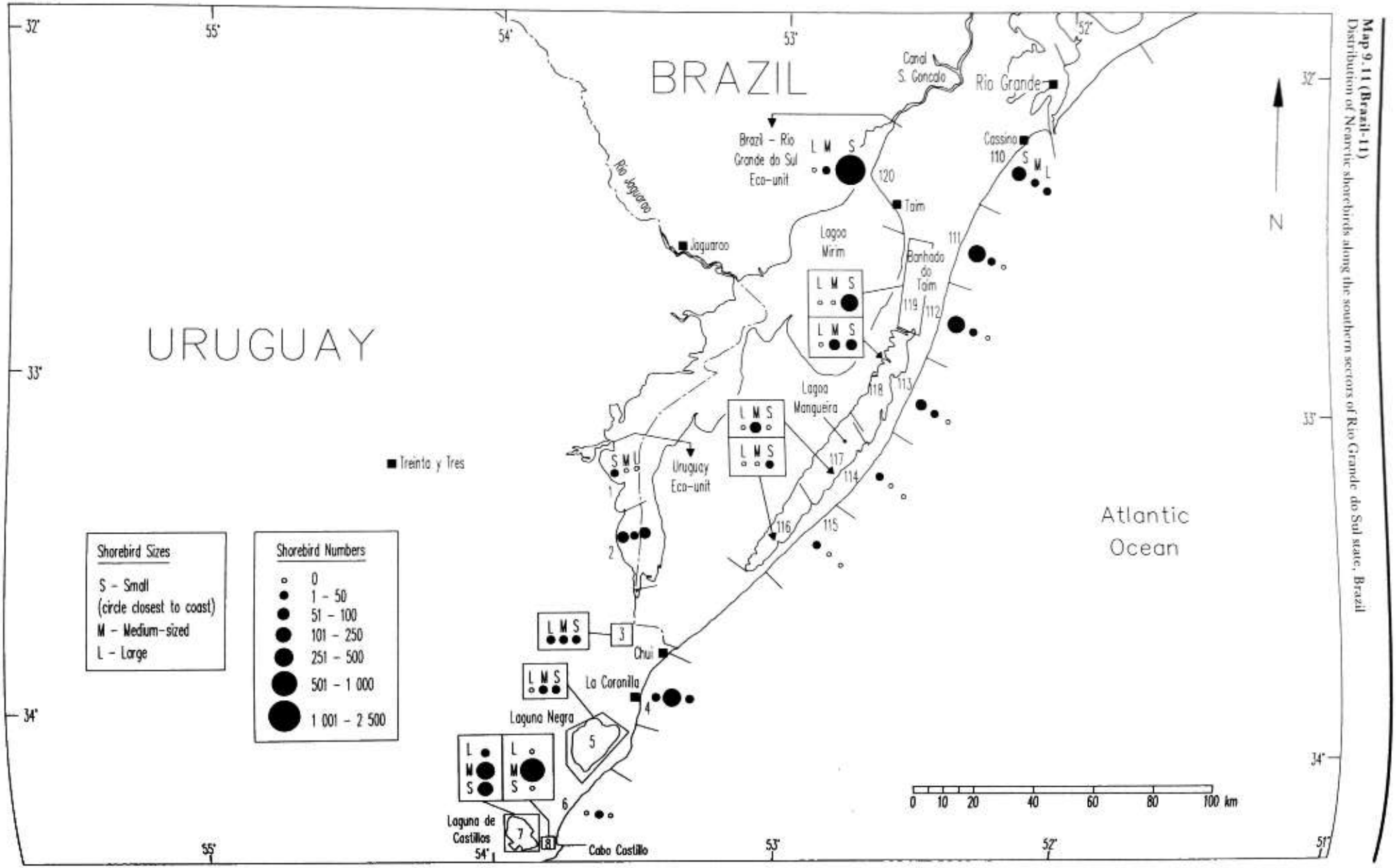
Lagoon shorelines, particularly those between Rio Grande and the Lagoa do Peixe area, held significant numbers of yellowlegs (420, 6.9% of the Atlantic Coast total; Tables 9.21 and 9.23).

Table 9.20
Principal habitats in survey sectors in Map 9.9 (Brazil-9)

Sector no.	Habitat description
90	Sand beach, some mangroves by river / scrubby forest, habitations
91	Sand beach / scrub, habitations
93	Sand beach / scrub, habitations
94	Brackish river channel; mudbanks and flats, mangroves / sandy scrub
95	Brackish lagoon; some mudflats edged by low mangroves / forest
96	Sand beach / sandy scrub



Map 9.10 (Brazil-10)
Distribution of Nearctic shorebirds along the northern sectors of Rio Grande do Sul state, Brazil



Map 9.11 (Brazil-11)
Distribution of Nearctic shorebirds along the southern sectors of Rio Grande do Sul state, Brazil

Table 9.21
Totals of Nearctic shorebirds in survey sectors in Map 9.10 (Brazil-10)

Sector no.	Sector length (km)	Pectoral Sandpiper	White-rumped Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Lesser Golden-Plover	Yellowlegs species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Whimbrel	Total large shorebirds	Total shorebirds
97	24.9	0	120	50	267	437	0	0	2	2	3	3	442
98	39.1	0	612	0	380	992	0	0	0	0	0	0	992
99	37.5	0	189	2 600	23	2 812	70	0	2	72	0	0	2 884
100	38.2	0	327	1 408	41	1 776	18	0	0	18	0	0	1 794
101	38.8	0	565	1 467	71	2 103	38	0	0	38	0	0	2 141
102	39.0	0	0	0	51	51	100	0	0	100	0	0	151
103	35.8	0	136	452	38	626	88	0	0	88	0	0	714
104	42.9	0	0	0	30	30	0	29	0	29	0	0	59
105	32.1	0	50	0	73	123	3	26	2	31	0	0	154
106	51.3	1	0	0	5 005	5 006	62	165	0	227	0	0	5 233
107	20.2	0	0	0	6 902	6 902	0	0	610	610	0	0	7 512
108	57.9	0	0	0	160	160	170	10	0	180	0	0	340
109	48.8	0	40	0	515	555	0	149	0	149	0	0	704
Total	506.5	1	2 039	5 977	13 556	21 573	549	379	616	1 544	3	3	23 120

Table 9.22
Principal habitats in survey sectors in Map 9.10 (Brazil-10)

Sector no.	Habitat description
97	Narrow sand beach / dunes / scrubby desert
98	Narrow sand beach / dunes / scrubby desert
99	Narrow sand beach / dunes / scrubby desert
100	Narrow sand beach / dunes / scrubby desert, lagoons
101	Narrow sand beach / dunes / scrubby desert
102	Narrow sand beach / dunes / scrubby desert
103	Narrow sand beach / dunes / scrubby desert, farmland
104	Freshwater wetland and lagoon shore; marsh / farmland
105	Freshwater lagoon shore; sandflats and bars, marsh / farmland
106	Inland; brackish wetland with broad mudflats / farmland, scrub, sand beach
107	Inland; brackish wetland with broad mudflats / farmland, scrub, sand beach
108	Inland; small freshwater lagoon with muddy margin and steep banks / grassland, farmland
109	Freshwater lagoon shore; sand beach and flats / pastures, marsh

Table 9.24
Principal habitats in survey sectors in Map 9.11 (Brazil-11)

Sector no.	Habitat description
110	Narrow sand beach / dunes / scrubby desert
111	Narrow sand beach / dunes / scrubby desert, forestry plantation
112	Narrow sand beach / partially vegetated dunes / scrubby desert
113	Narrow sand beach / partially vegetated dunes / scrubby desert
114	Narrow sand beach / dunes / scrubby desert
115	Narrow sand beach / dunes / scrubby desert
116	Freshwater lagoon shore; sand beach, marsh / scrubby desert
117	Freshwater lagoon shore; sand beach, marsh / scrubby desert
118	Freshwater lagoon shore; sand beach, marsh / farmland
119	Inland; freshwater wetlands and marsh / farmland
120	Freshwater lagoon shore; sandflats with pools, steep banks in places / marsh / farmland

Table 9.23
Totals of Nearctic shorebirds in survey sectors in Map 9.11 (Brazil-11)

Sector no.	Sector length (km)	White-rumped Sandpiper	Sanderling	Unidentified small shorebird species	Total small shorebirds	Lesser Golden-Plover	Black-bellied Plover	Yellowlegs species	Unidentified medium-sized shorebird species	Total medium-sized shorebirds	Unidentified large shorebird species	Total large shorebirds	Total shorebirds
110	38.5	65	165	0	230	20	0	0	0	20	4	4	254
111	28.4	80	158	35	273	31	0	0	0	31	0	0	304
112	37.2	115	303	33	451	29	3	0	0	32	0	0	483
113	36.1	25	15	11	51	0	0	2	0	2	0	0	53
114	27.6	15	0	20	35	0	0	0	0	0	0	0	35
115	26.3	1	0	0	1	0	0	0	0	0	0	0	1
116	36.0	0	0	32	32	0	0	0	0	0	0	0	32
117	29.1	0	0	0	0	0	0	2	50	52	0	0	52
118	35.9	0	0	61	61	0	0	35	30	65	0	0	126
119	34.0	0	0	350	350	0	0	0	0	0	0	0	350
120	47.3	0	0	1 021	1 021	0	0	1	15	16	0	0	1 037
Total	376.4	301	641	1 563	2 505	80	3	40	95	218	4	4	2 727

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