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Author(s): Daniel E. Blanco, Pablo Yorio, Pablo F. Petracci, and Germán Pugnali
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Distribution and Abundance of Non-Breeding Shorebirds Along the Coasts of the Buenos Aires Province, Argentina

Daniel E. Blanco[1], Pablo Yorio[2], Pablo F. Petracci[3] and Germán Pugnali[1]

[1]Wetlands International, 25 de Mayo 758 10º I (1002) Buenos Aires, Argentina
Internet: deblanco@wamani.apc.org

[2]Centro Nacional Patagónico (CONICET) and Wildlife Conservation Society, Boulevard Brown s/n (9120)
Puerto Madryn, Chubut, Argentina

[3]Cátedra Zoología III Vertebrados. Facultad de Ciencias Naturales y Museo de la Plata
(1900) La Plata, Buenos Aires, Argentina

Abstract.—The coast of the Buenos Aires province, Argentina, includes a remarkable diversity of habitats and is used by more than fifteen Nearctic shorebird species during the austral summer months. We evaluated non-breeding shorebird distribution and abundance patterns along the Buenos Aires coastal zone and determined shorebird use of different coastal landscapes. Surveys were conducted in December 2000, and January and February 2001, using line-transect methods. The data were classified based on five previously defined coastal landscapes. Fifty four localities were surveyed covering 93 kilometers of coastline. A total of 44 waterbird species corresponding to 13 families were recorded. Shorebirds (Scolopacidae, Charadriidae, Haematopodidae and Recurvirostridae) accounted for approximately 45% of recorded waterbirds, including 14 nearctic species. Shorebird species recorded per locality varied from one to eleven, with 61% of the localities having one to four species. The most common were the American Oystercatcher (*Haematopus palliatus*), White-rumped Sandpiper (*Calidris fuscicollis*), Two-banded Plover (*Charadrius falklandicus*), American Golden-Plover (*Pluvialis dominica*) and the Sanderling (*Calidris alba*). Shorebird species richness and abundance varied significantly among coastal landscapes, with the highest values recorded in estuarine saltmarshes of Bahía Samborombón and Bahía Blanca. Among marine landscapes, the highest abundance and number of species were recorded in sandy beaches with "restinga" patches. This study confirms that shorebirds are an important component of the birdlife in the Buenos Aires coastal zone during the austral summer months, and that their distribution is not homogeneous along the coast, with species richness and abundances varying among localities depending on coastal landscapes. *Received 15 July 2005, accepted 10 May 2006.*

Key words.—Shorebirds, distribution, non-breeding ecology, coastal landscapes, Argentina.

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Non-reproductive shorebirds using coastal environments are known to forage in intertidal habitats with abundant invertebrate prey (Evans and Dugan 1984; Morrison 1984; Colwell and Landrum 1993). Because prey distribution and abundance vary with the physical features of the intertidal zone (Yates *et al.* 1993a; Danufsky and Colwell 2003), shorebirds are thought to distribute themselves so as to maximize food availability. This interdependency results in irregular patterns of shorebird distribution, which, at a regional scale, could be associated with the variability of the coastal landscape (Myers *et al.* 1987).

The coast of the Buenos Aires province, Argentina, includes a remarkable diversity of habitats (Schnack 1985). These coastal habitats are used by more than fifteen nearctic shorebirds (families Charadriidae and Scolopacidae) as staging areas during their southward and northward migration, and for some species as long-term resting sites during the austral summer months (Myers and Myers 1979; Martínez 1986; Blanco *et al.* 1988, 1992, 1995; Vila *et al.* 1994).

Several recent studies have indicated that particular sites within the Buenos Aires coastal zone are important to non-breeding shorebirds (e.g., Martinez 1986; Blanco *et al.* 1988; Morrison and Ross 1989; Vila *et al.* 1994). However, knowledge on shorebird distribution patterns at a larger geographic scale during the austral summer months is still very limited. Morrison and Ross (1989), using aerial surveys, were the first to provide a regional perspective about shorebird distribution and abundance. This methodology, however, did not allow for the complete identification of all shorebird species observed, especially the small ones. The aim of this study was to evaluate non-breeding shorebird distribution and abundance patterns along the Buenos Aires coastal zone, and to determine the use of coastal landscapes by the different species. In addition, this information was used to prioritize important coastal sectors for shorebirds and subsequently discuss the importance of conserving these areas. No other study has attempted to use regional landscape information to priories shorebird habitat needs in the Buenos Aires coast.

STUDY AREA AND METHODS

Our study area included the coast of Buenos Aires province from the city of Magdalena in the north (ca. 35°00'S 57°40'W) to Punta Laberinto in the south (ca. 39°40'S 62°07'W) (Fig. 1). The study area corresponds to the Pampas ecoregion (Administración Parques Nacionales 1999) and includes a remarkable diversity of coastal habitats such as sandy and pebble beaches, cliffs and vast intertidal coastal plains associated with estuarine ecosystems (Schnack 1985; Morrison and Ross 1989; SECYT 1997). Sandy beaches are of medium-fine grain and in general are backed by dunes, being wider in the southern part of this region. The area includes three major estuarine ecosystems that consist of, from north to south, Bahía Samborombón, Mar Chiquita coastal lagoon and the estuary of Bahía Blanca (Fig. 1). Tides range from micro-tidal (<2 m) in the north to meso-tidal (2-4 m) in the southern part (Schnack 1985). Urban development associated with tourism occurs in

Figure 1. Coastal zone of the Buenos Aires province, showing the study area and the coastal sectors defined for the analysis.

many marine coastal sectors from Punta Rasa to Bahía Blanca. This has resulted in the loss of dunes and beaches in the northern portion of the coast.

Coastal Landscapes

Intertidal habitats and their adjacent upland areas within the study area were classified following Cowardin *et al.* (1979), using information obtained in the field and from the literature (Milovich *et al.* 1992; Moscatelli *et al.* 1980; Schnack 1985). Five coastal landscapes were identified: (1) Estuarine-freshwater marshes, which includes mudflats and fresh-water marshes that are dominated by rushes. Upland areas are mainly woody lands, with "seibales" (*Erythrina crista-galli*) close to the intertidal zone and "tala" woods (*Celtis tala*) more inland. This landscape is characterized by very low salinity conditions. (2) Estuarine-saltmarshes, which includes saltmarshes and vast mudflats that are frequently covered by colonies of the Southwestern Atlantic burrowing crab *Chasmagnathus granulata*. Saltmarshes are usually crossed by many tidal channels and/or ponds with muddy intertidal areas that remain exposed during low tide. (3) Marine-cliffed shore, which includes a narrow intertidal zone dominated by "restingas" (wave-cut consolidated sediment platforms extending to the lower intertidal zone) and sectors of sandy substrates. This landscape is characterized by its pronounced slope, where the cliffs separate the intertidal zone from adjacent upland areas. (4) Marine-sandy beaches, which includes sandy substrates that are backed by dunes of varying height, vegetation coverage and level of disturbance. (5) Marine-sandy beaches with restinga patches, which includes sandy substrates with restinga patches of variable size emerging close to the low tide line. This landscape is backed by dunes of varying height, vegetation coverage and level of disturbance.

Survey Design and Census of Shorebirds

Surveys were conducted in the months of December 2000, and January and February 2001. Five additional surveys were carried out in January 2002 to improve the sample size. The time-frame for surveys was chosen to avoid counting shorebirds migrating either northward or southward.

A stratified sampling design was used and divided the study area in six sectors (Table 1 and Fig. 1), based on the previously defined coastal landscapes and on the subdivision developed by Secretaría de Ciencia, Tecnología e Innovación Productiva (1997). Along each coastal sector a minimum of seven surveys equally distributed were attempted. However, this was not always possible and survey localities were restricted to those areas that could be accessed by public roads or trails within private lands. With this constraint all the accessible localities within each coastal sector were sampled.

Fifty-four localities were surveyed, covering a total of 93 kilometers of coastline. Localities differed in landscape features, physical characteristics, and human use. Highly developed coastal sectors (i.e., towns and cities) were not included in the study.

Line-transect methods were used to census shorebirds (Bibby *et al.* 1992). Each transect was located parallel to the tide line and was at least 1000 m long (mean = 1.7 km, N = 54). In twelve cases however, the presence of tidal channel/river mouths prevented us from continuing the survey and reduced the length of the

Table 1. Subdivision of the study area into sectors based on dominant coastal landscapes: Freshwater marshes (FWM), Saltmarshes (SM), Sandy beaches (SB), Cliffed shore (CS) and Sandy beaches with "restinga" patches (SBR).

	Sectors and limits	Wetland system	Coastal landscape (dominant)
I	Magdalena to Punta Piedras	Estuarine	FWM
II	Punta Piedras to Punta Rasa—*Samborombón bay*	Estuarine	SM
III	Punta Rasa to Mar Chiquita coastal lagoon (mouth)	Marine	SB
IV	Mar Chiquita to Miramar south	Marine	CS
V	Miramar south to Punta Alta	Marine	SBR
VI	Punta Alta to Punta Laberinto—*Bahía Blanca estuary*	Estuarine	SM

transect. In nine cases, longer transects were completed. Surveys were conducted mostly by foot, although off-road vehicles were used on 13 occasions.

Geographical coordinates and the length of each transect were recorded using a handheld GPS (Garmin GPS 12). Transects encompassed the intertidal zone and adjacent supratidal habitats more inland, and their width varied depending on coastal topography. Counts were conducted mainly when intertidal areas were exposed and available for feeding shorebirds. In certain estuarine areas with vast intertidal plains surveys were timed to avoid very low tide conditions which would complicate the counts. During each survey, two observers recorded the number of shorebirds and other waterbirds on each side of the transect. Information on habitat features was also collected to later assign each transect to one of the defined landscapes.

Data Presentation and Analysis

Data are presented in a matrix of shorebird species abundance per kilometer (columns) by survey locality (rows). Within the matrix, species were organized in decreasing frequency of occurrence (left to right amongst the columns), while transects were ordered by latitude from top to bottom. To provide a community framework for the shorebird data, general information on other waterbird species are presented. Systematic and species names follow Mazar-Barnett and Pearman (2001).

To analyze shorebird distribution along the study area, transects were classified by landscape type and assigned to the six coastal sectors previously defined (Table 1, Fig. 1). The five most common species were selected to investigate how shorebird densities varied among sectors. These species were chosen based on their incidence (number of localities at which the species was present). Hudsonian Godwit (*Limosa haemastica*) was included because it is a species of particular interest in the Buenos Aires province. The Mann-Whitney and the Kruskal-Wallis tests, together with multiple comparisons, were used to evaluate differences in shorebird abundance and number of species among landscape types and coastal sectors.

RESULTS

A total of 44 waterbird species corresponding to 13 families were recorded during surveys (Table 2). The families with the highest percentage of species were Scolopacidae (25%), Laridae (23%), Charadriidae (14%) and Anatidae (14%). These families included eleven, ten, six and six species respectively. Shorebirds (Scolopacidae, Charadriidae, Haematopodidae and Recurvirostridae) accounted for approximately 45% of recorded species (Table 2), including 14 nearctic species that use the coasts of the Buenos Aires province during the austral summer months (December to February).

Shorebird Species and Abundance

Shorebird species recorded per locality varied from zero to eleven at Punta Rasa bay-1 (Locality 9), with 61% of the localities having between one and four species. Shorebirds were not recorded at 17% of localities (Appendix I). The most common species and number of localities were the American Oystercatcher (*Haematopus palliatus*, 28), White-rumped Sandpiper (*Calidris fuscicollis*, 23), Two-banded Plover (*Charadrius falklandicus*, 18), American Golden-Plover (*Pluvialis dominica*, 17), and Sanderling (*Calidris alba*, 14) (Appendix I). Species with the highest abundances were White-rumped Sandpiper ($X = 53.7 \pm 130.3$ indiv./km), American Golden-Plover ($X = 7.8 \pm 17.9$ indiv./km), American Oystercatcher ($X = 6.6 \pm 21.9$ indiv./km) and Sanderling ($X = 6.0 \pm 23.3$ indiv./km) (Appendix I). Some species were recorded only once, like the Semipalmated Plover (*Charadrius semipalmatus*), Rufous-chested Plover (*Charadrius modestus*), Blackish Oystercatcher (*Haematopus ater*), Baird's Sandpiper (*Calidris bairdii*), Spotted Sandpiper (*Actitis macularia*), and Buff-breasted Sandpiper (*Tryngites subruficollis*).

Table 2. Waterbird species recorded during surveys of the Buenos Aires coastal zone. For migratory species the status is included between brackets after the name (Mazar-Barnett and Pearman 2001): austral migrant (Ma), partial austral migrant (Mp) and nearctic migrant (Mn).

Family	Number of species	Species (migratory status)
Procellariidae	1	*Macronectes giganteus* (Mp)
Phalacrocoracidae	1	*Phalacrocorax brasilianus*
Ardeidae	1	*Ardea cocoi*
Threskiornithidae	1	*Plegadis chihi*
Ciconiidae	2	*Mycteria americana* (Ma), *Ciconia maguari*
Phoenicopteridae	1	*Phoenicopterus chilensis*
Anatidae	**6**	*Coscoroba coscoroba* (Mp), *Cygnus melanocorypha* (Mp), *Anas platalea* (Mp), *Anas flavirostris* (Mp), *Anas bahamensis, Anas georgica* (Mp)
Haematopodidae	2	*Haematopus palliatus, Haematopus ater*
Recurvirostridae	1	*Himantopus melanurus*
Charadriidae	**6**	*Vanellus chilensis, Pluvialis dominica* (Mn), *Pluvialis squatarola* (Mn), *Charadrius semipalmatus* (Mn), *Charadrius falklandicus* (Mp), *Charadrius modestus* (Mp)
Scolopacidae	**11**	*Limosa haemastica* (Mn), *Numenius phaeopus* (Mn), *Tringa melanoleuca* (Mn), *Tringa flavipes* (Mn), *Actitis macularia* (Mn), *Arenaria interpres* (Mn), *Calidris canutus* (Mn), *Calidris alba* (Mn), *Calidris fuscicollis* (Mn), *Calidris bairdii* (Mn), *Tryngites subruficollis* (Mn)
Chionidae	1	*Chionis alba* (Mp)
Laridae	**10**	*Stercorarius parasiticus* (Mn), *Larus maculipennis, Larus atlanticus* (Mp), *Larus dominicanus, Gelochelidon nilotica* (Mn), *Sterna maxima* (Mp), *Sterna eurygnatha* (Mn/Mp), *Sterna hirundo* (Mn), *Sterna trudeaui, Rynchops niger* (Mn/Mp)

Total shorebird abundances varied among localities, with highest values recorded at Canal 1 mouth (locality 7 = 647.2 indiv./km), Punta Rasa bay-2 (locality 10 = 626.3 indiv./km), Muelle Cuatreros (locality 49 = 514.7 indiv./km), Canal 1 inland (locality 8 = 395.0 indiv./km), and Punta Alta beach (locality 54 = 294.0 indiv./km) (Appendix I).

Shorebirds and Coastal Landscapes

Shorebird abundance and number of species varied significantly among coastal landscapes (Kruskall-Wallis test: H = 20.6370, P < 0.001, and H = 28.7482, P < 0.001 respectively), with the highest values recorded in the Estuarine-saltmarsh landscape (Table 3). Among marine landscapes, the highest abundance and number of species corresponded to the Sandy beaches with resting patches (Table 3).

Some species appeared to be associated with the Estuarine landscapes (with highest abundances recorded in Estuarine-saltmarshes), including the American Golden-Plover (Mann-Whitney test: U = 58, P < 0.001), Lesser Yellowlegs (U = 185, P < 0.01) and White-rumped Sandpiper (U = 156, P < 0.01) (Table 3). Some other species, such as the Hudsonian Godwit, Whimbrel, and Ruddy Turnstone, were exclusively observed in the Estuarine-saltmarshes landscape (Table 3).

Sanderlings were more abundant within the Marine landscapes, but no significant differences were found when comparing these with Estuarine landscapes (U = 225.5, n.s.). Highest abundances of this species corresponded to Sandy beaches with restinga patches (Table 3). Other species, such as the Black-bellied Plover (*Pluvialis squatarola*), Two-banded Plover, Southern Lapwing (*Vanellus chilensis*) and American Oystercatcher, showed similar abundances in both estuarine and marine landscapes (U > 264, n.s.; Table 3).

Shorebird Distribution

Shorebird abundance in our transect routes varied significantly among coastal sectors (Kruskall-Wallis: $\chi^2_5 = 24.79$, P < 0.001). Largest numbers of shorebirds were recorded in Sectors II and VI (Fig. 2), although sig-

Table 3. Shorebird average density (indiv./km) per coastal landscape. Species recorded only once were excluded from the analysis. N refers to the number of transects in each landscape and Np indicates a species was not present.

	Estuarine		Marine		
Species	Freshwater marshes	Saltmarshes	Cliffed shore	Sandy beaches	Sandy beaches with restinga patches
Pluvialis squatarola	Np	<1	Np	<1	<1
Pluvialis dominica	14.30	25.10	Np	<1	<1
Charadrius falklandicus	<1	3.20	<1	<1	1.60
Limosa haemastica	Np	9.20	Np	Np	Np
Numenius phaeopus	Np	3.50	Np	Np	Np
Tringa flavipes	<1	3.30	Np	Np	Np
Tringa melanoleuca	<1	<1	Np	Np	Np
Calidris canutus	Np	<1	Np	<1	3.00
Calidris alba	Np	<1	Np	1.00	29.80
Calidris fuscicollis	Np	183.50	2.00	5.20	2.80
Arenaria interpres	Np	2.00	Np	Np	Np
Vanellus chilensis	<1	<1	<1	<1	<1
Himantopus mexicanus	2.60	2.60	Np	<1	Np
Haematopus palliatus	Np	9.80	Np	8.90	2.20
Total shorebirds/km	20.80	246.60	2.90	16.20	40.00
Species/km	2.70	5.30	<1	1.80	3.70
N	3	15	5	21	10

nificant differences were only found between sector II and both sectors III ($P < 0.001$) and V ($P < 0.001$). Sector II also showed the highest number of species (Fig. 2), with significant differences found with sectors III ($P < 0.001$) and V ($P < 0.01$).

An examination of the abundance at the species level indicated that there were significant differences among coastal sectors for the White-rumped Sandpiper ($\chi^2_5 = 23.92$, $P < 0.001$), American Golden-Plover ($\chi^2_5 = 37.61$, $P < 0.001$) and Hudsonian Godwit ($\chi^2_5 = 45.70$, $P < 0.001$), with a notably restricted distribution for the last two species (Fig. 3). Abundances of American Oystercatcher, Two-banded Plover and Sanderling were less variable and not significant differences among sectors were found ($\chi^2_5 < 9.16$, n.s.). The former two species were more dispersed, being present in almost all coastal sectors with variable numbers, while Sanderling showed a notable higher use of beaches in Sector V and IV (Fig. 3).

DISCUSSION

Food density and local feeding conditions appear to be related to shorebird distribution in coastal environments. However, the quantification of the benthos fauna is not always possible, particularly in large-scale regional studies. In some studies, habitat and physical variables could be used as predictors of feeding conditions (Goss-Custard and Yates 1992; Yates *et al.* 1993a, b). Colwell and Sundeen (2000) reported that the main factors explaining shorebird distribution on coastal beaches of northern California were the proximity to main feeding areas and the variation in habitat features, which were thought to influence food availability and shorebird foraging activity. In our study, shorebird distribution was not homogeneous along the Buenos Aires coastal zone, with shorebird abundance and number of species varying among localities. When this variation was analyzed in relation to coastal landscapes, significant differences were observed. The Estuarine-saltmarsh landscape, characterized by wide tidal flats and a higher habitat heterogeneity (i.e., tidal flats, channelization, tidal pools), was used the most, suggesting these habitats provide better foraging conditions. In addition, inland sectors of saltmarshes may have provided alternative foraging sites and roosting places that could be used by shorebirds during high tides.

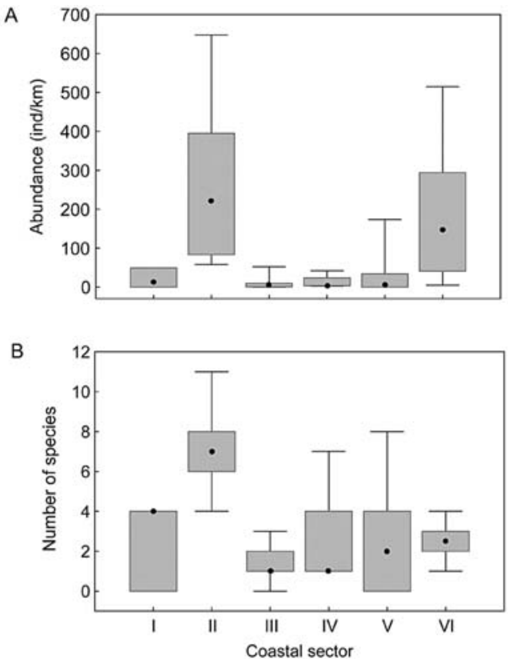

Figure 2. Total shorebird abundance (A) and number of species (B) per coastal sector. Boxplots with 25% quartiles, range (maximum-minimum) and median (●) are drawn.

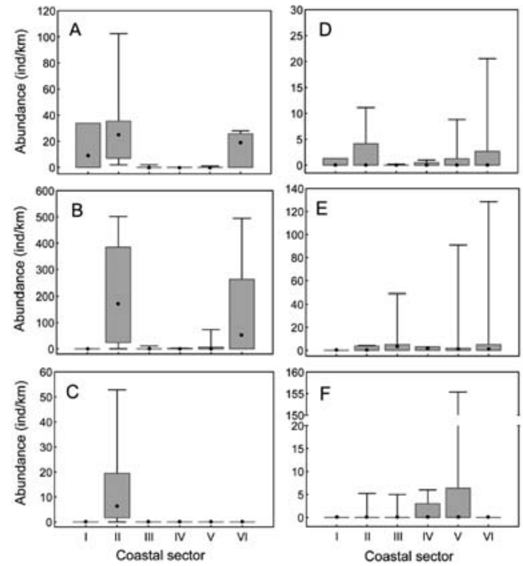

Figure 3. Abundance per coastal sector for (A) *Pluvialis dominica*, (B) *Calidris fuscicollis*, (C) *Limosa haemastica*, (D) *Charadrius falklandicus*, (E) *Haematopus palliatus* and (F) *Calidris alba*. Boxplots with 25% quartiles, range (maximum-minimum) and median (●) are drawn.

The sandy beaches with restinga patches were used mainly by small species, such as the Sanderling and the White-rumped Sandpiper. This pattern was also found in surveys conducted by Morrison and Ross (1989). The restinga patches are characterized by a high microhabitat heterogeneity, supporting a rich fauna of marine invertebrates (i.e., mussels, crustaceans) and algae, providing good feeding conditions. The other three coastal landscapes (Estuarine-freshwater marshes, Marine-cliffed shore and Marine-sandy beaches), were used by a lower number of shorebirds, suggesting poor feeding conditions. Shorelines with cliffs were avoided by almost all species, as was noted from this coastline by Morrison and Ross (1989), and as has been reported in the northern Hemisphere by Summers *et al.* (2002).

We identified three groups of shorebirds based on the use of coastal landscapes. These included: (1) species that concentrate mainly in estuarine ecosystems dominated by the Estuarine-saltmarsh landscape, (2) species that were restricted primarily to marine landscapes, and (3) species that used both estuarine and marine landscapes with similar intensity. The first group included the White-rumped Sandpiper, American Golden-Plover, Hudsonian Godwit, Whimbrel and the two yellowlegs. Within estuaries, the highest numbers of shorebirds were recorded at Bahía Samborombón followed by the Bahía Blanca estuary, suggesting slightly better habitat conditions in the former coastal sector. Iribarne *et al.* (2005) suggested that the low diversity of shorebirds in the Bahía Blanca estuary may be the result of high abundances of the Southwestern Atlantic burrowing crab (*Chasmagnathus granulata*). In addition, these differences in shorebird use might be explained by the salinity and substrate present in both areas. Additional studies are needed to determine the relationship among these variables, food availability, and shorebird use.

The most representative shorebird in the second group (i.e., marine landscapes) is the Sanderling, which was highly dispersed and patchily distributed along the coast. Sanderlings occurred in highest numbers along sandy beaches from Miramar to Punta Alta, as noted by Morrison and Ross (1989). The species preference for sandy substrates has been previously reported by other authors (Summers *et al.* 2002; Danufsky and Colwell 2003). Colwell and Sundeen (2000) indicated it was the most numerous species in sandy beaches near Humboldt Bay. Dispersed small groups of Sanderlings have also been reported in the surroundings of Lagoa do Peixe in Brazil (Harrington *et al.* 1986; Morrison and Ross 1989) and along the coasts of Chile and Peru (Castro and Myers 1987; Morrison and Ross 1989; Pulido *et al.* 1996). In southern Buenos Aires province, Sanderlings concentrated mainly in beaches that included restinga patches where they fed during the receding tide, as has been previously reported by Morrison and Ross (1989) and Petracci (2002).

This study confirms that shorebirds are an important component of the birdlife in the Buenos Aires province coastal zone during the austral summer months, accounting for approximately half of the recorded species. Our results also show that shorebirds concentrated at a few important coastal sectors. Bahía Samborombón, with an intertidal area estimated at 11,500 ha, appears to be the most important sector of the Buenos Aires coastal zone, offering good non-breeding habitat for White-rumped sandpipers, American Golden-Plovers and Hudsonian Godwits. The value of this bay has been previously highlighted (Myers and Myers 1979; Blanco *et al.* 1988; Morrison and Ross 1989; Vila *et al.* 1994), but this is the first time that the area has been evaluated on a detailed species basis in relation to shorebird numbers at a regional scale.

Currently, three Provincial reserves legally protect some sectors of Bahía Samborombón, which was designated as a Ramsar Site in 1987. Some private protected areas like the "Campos del Tuyú" Reserve (managed by the non-governmental organization Fundación Vida Silvestre Argentina) and ranch owners that care for wildlife also contribute to the preservation of particular sectors of the bay. Human disturbance on shorebirds along the bay is low due to the inaccessibility of the area. However, agrochemical pollution generated inland and flowing into the bay through water courses (FREPLATA 2004), is threatening the integrity of the ecosystem.

Our results also suggest that the Bahía Blanca Estuary, with an intertidal area estimated in around 110,000 ha, is another important coastal sector for shorebird species during the austral summer months. This area is frequented by White-rumped Sandpipers, American Golden-Plovers, American Oystercatchers and Two-banded Plovers. The use of the Estuary by migratory shorebirds along the annual cycle has also been described by Belenger *et al.* (1992) and Delhey and Petracci (2004), who recorded 20 different species, including both Nearctic and Patagonian shorebirds. Delhey and Petracci (2004) found that the area acts as an important stop-over site for Hudsonian Godwits during southward migration, when several thousands of birds may be recorded. At present the estuary is partially protected by the "Reserva Natural Integral con Acceso Restringido Bahía Samborombón" (Province of Buenos Aires), but a more detailed assessment on shorebird distribution within the area is needed to properly evaluate whether the reserve is adequately protecting the most important areas.

Marine beaches with restinga patches in southern Buenos Aires province, from Miramar to Punta Alta, were also used by significant numbers of shorebirds, especially Sanderlings. Some of these beaches are also used by a large number of people, as they are near important tourist centers like the city of Monte Hermoso. In these cases, shorebird conservation will depend more on the development and implementation of management guidelines and on raising awareness of tourists.

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LITERATURE CITED

Administración de Parques Nacionales. 1999. Eco-regiones de la Argentina. Componente de Política Ambiental. PRODIA-Secretaría de Recursos Naturales y Desarrollo Sustentable. Buenos Aires.

Belenger, C., K. Delhey, S. Di Martino, P. Petracci and A. Scorolli. 1992. Observaciones de Aves Playeras Migratorias de Bahía Blanca. Boletín Grupo Argentino de Limícolas 10: 2-4.

Bibby, C. J., N. D. Burgess and D. A. Hill. 1992. Bird census techniques. Academic Press, San Diego.

Blanco, D. E., G. D. Pugnali and H. Rodríguez Goñi. 1988. Punta Rasa: su importancia en la conservación de las aves migratorias. International Council for Bird Preservation, unpublished report, Buenos Aires.

Blanco, D.E., H. Rodríguez Goñi and G. Pugnali. 1992. La importancia de Punta Rasa, Buenos Aires, en la migración del Chorlo Rojizo *Calidris canutus*. Hornero 13: 203-206.

Blanco, D. E., P. González and M. M. Martínez. 1995. Migración de la Becasa de Mar, *Limosa haemastica* (Charadriiformes: Scolopacidae), en el sur de América del Sur. Vida Silvestre Neotropical 4: 119-124.

Castro, G. and J. P. Myers. 1987. Ecologia y conservación del playero blanco (*Calidris alba*) en el Peru. Boletín de Lima 52: 47-61.

Colwell, M. A. and S.L. Landrum. 1993. Nonrandom shorebird distribution and fine-scale variation in prey abundance. Condor 95: 94-103.

Colwell, M. A. and K. D. Sundeen. 2000. Shorebird distributions on ocean beaches of northern California. J. Field Ornithol. 71: 1-15.

Cowardin, L. M., V. Carter, F. C. Golet and E. T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Washington D.C. FWS/OBS-79/31.

Danufsky, T. and M. A. Colwell. 2003. Winter shorebird communities and tidal flat characteristics at Humboldt Bay, California. Condor 105: 117-129.

Delhey, K. and P. F. Petracci. 2004. Aves marinas y costeras del estuario de Bahía Blanca. *In* El ecosistema del estuario de Bahía Blanca (M. C. Píccolo and M. S. Hoffmeyer, Eds.). Instituto Argentino de Oceanografía (CONICET-UNS), Bahía Blanca.

Evans, P. R. and P. J. Dugan. 1984. Coastal birds. Numbers in relation to food resources. Pages 8-28 *in* Coastal waders and Wildfowl in winter (P. R. Evans, J. D. Goss-Custard and W. G. Hale, Eds.). Cambridge University Press, Cambridge.

FREPLATA. 2004. Análisis Diagnóstico Transfronterizo del Río de la Plata y su Frente Marítimo. Documento Técnico. Proyecto Protección Ambiental del Río de la Plata y su Frente Marítimo. Proyecto PNUD/GEF/RLA/99/G31. Montevideo.

Goss-Custard, J. D. and M. G. Yates. 1992. Towards predicting the effect of salt-marsh reclamation on feeding bird numbers on the Wash. Journal of Applied Ecology 29: 330-340.

Iribarne, O., M. Bruschetti, M. Escapa, J. Bava, F. Botto, J. Gutiérrez, G. Palomo, K. Delhey, P. Petracci and A. Gagliardini. 2005. Small and large-scale effect of the SW Atlantic burrowing crab *Chasmagnathus granulatus* on habitat use of migratory shorebirds. Journal of Experimental Marine Biology and Ecology 315: 87-101.

Harrington, B. A., P. de Tarso Zuquim Antas and F. Silva. 1986. Northward shorebird migration on the atlantic coast of southern Brazil. Vida Silvestre Neotropical 1: 45-54.

Martínez, M. M. 1986. Estudio faunístico y ecológico de las aves de la Albufera Mar Chiquita (prov. de Bs. As.). CONICET, Argentina (unpublished report). Mar del Plata.

Mazar-Barnett, J. and M. Pearman. 2001. Annotated checklist of the birds of Argentina. Lynx Edicions, Barcelona.

Milovich, J., C. Lasta, D. Gagliardini and B. Gillaumon. 1992. Initial study on the structure of the salt marsh in Samborombón Bay coastal area, Argentina, using LANDSMAT-MSS, SPOT-HVR data and field observations. Pages 869-882 *in* First Thematic Conference on Remote Sensing for Marine and Coastal Environments, New Orleans, Louisiana.

Morrison, R. I. G. 1984. Migration Systems of Some New World Shorebirds. Pages 125-201 *in* Shorebirds. Migration and Foraging Behavior (J. Burger and B. L. Olla, Eds.). Plenum Publishing Corporation, New York and London.

Morrison, R. I. G. and R. K. Ross. 1989. Atlas of Neartic Shorebirds on the Coast of South America. Canadian Wildlife Service Special Publication, Ottawa.

Moscatelli, G., J. C. Salazar Lea Plaza and C. Scoppa. 1980. El control geomorfológico y climático en la distribución de los suelos del litoral atlántico bonaerense. Simposio sobre Problemas Geológicos del Litoral Atlántico Bonaerense, Mar del Plata.

Myers, J. P. and L. P. Myers. 1979. Shorebirds of coastal Buenos Aires Province, Argentina. Ibis 121: 186-200.

Myers, J. P., R. I. G. Morrison, P. de Tarso Zuquim Antas, B. A. Harrington, T. E. Lovejoy, M. Sallaberry, S. E. Senner and A. Tarak. 1987. Conservation Strategy for Migratory Species. American Scientist 75: 19-26.

Petracci, P. F. 2002. Diet of Sanderling in Buenos Aires province, Argentina. Waterbirds 25(3): 366-370.

Pulido, V., J. Jahncke, P. Makamatsu and C. Flores. 1996. Conservation of Charadriiformes on the Peruvian coast. International Wader Studies 8: 55-61.

Schnack, E. J. 1985. Argentina. Pages 69-78 *in* The World's Coastline (E. C. F. Bird and M. L. Schwartz, Eds.). Van Nostrand Reinhold Co., New York.

Secretaría de Ciencia, Tecnología e Innovación Productiva. 1997. Evaluación de la vulnerabilidad de la costa argentina al ascenso del nivel del mar. Proyecto ARG/95/G/31-PNUD-SECYT. Buenos Aires.

Summers, R. W., L. G. Underhill and A. Simpson. 2002. Habitat preferences of waders (Charadrii) on the coast of the Orkney Islands. Bird Study 49(1): 60-66.

Vila, A. R., E. R. Bremer and M. S. Beade. 1994. Censos de chorlos y playeros migratorios en la Bahía de Samborombón, provincia de Buenos Aires, Argentina. FVSA Boletín Técnico No. 22. Buenos Aires.

Yates, M. G., A. R. Jones, J. D. Goss-Custard and S. McGrorty. 1993a. Satellite imagery to monitor ecological change in estuarine systems: example of the Wash, England. Pages 56-60 *in* Waterfowl and Wetland Conservation in the 1990s—A Global Perspective (M. R. C. Moser, R. C. Prentice and J. van Vessem, Eds.). Proceedings of the International Waterbird and Wetlands Research Bureau Symposium, St. Petersburg Beach, Florida, USA). IWRB Spec. Publ. No. 26, Slimbridge.

Yates, M. G., J. D. Goss-Custard, S. McGrorty, K. H. Lakhani, S. E. A. le V. dit Durell, R. T. Clarke and A. J. Frost. 1993b. Sediment characteristics, invertebrate densities and shorebird densities on the inner banks of the Wash. Journal of Applied Ecology 30: 599-614.

Appendix I. Matrix of shorebird species abundance (indiv./km) by survey locality along the Buenos Aires coastal zone. Species recorded only once were excluded from the table (see text). S refers to the number of species per locality. See acronyms for coastal landscapes in Table 1.

Coastal sector		Locality	Coastal land-scape	Transect length (km)	*Haema-topus palliatus*	*Calidris fuscicol-lis*	*Charadri us falk-landicus*	*Pluvia-lis do-minica*	*Calidris alba*	*Vanellus chilensis*	*Himanto-pus mela-nurus*	*Tringa flavipes*	*Limosa haemas-tica*	*Calidris canutus*	*Tringa melano-leuca*	*Pluvia-lis squa-tarola*	*Nume-nius phaeopus*	*Arenar-ia inter-pres*	Total shore-birds	S
I	1	Ea. El Destino	FWM	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	2	Punta Indio coast-1	FWM	0.8	0.0	0.0	1.3	33.8	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.4	4
	3	Punta Indio coast-2	FWM	1.0	0.0	0.0	0.0	9.0	0.0	2.0	0.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	13.0	4
II	4	Ea. La Monita	SM	1.2	0.0	0.0	0.0	53.3	0.0	3.3	11.7	2.5	1.7	0.0	0.8	0.0	0.0	0.0	73.3	6
	5	Pipinas north	SM	1.0	0.0	23.7	4.1	34.0	0.0	0.0	2.1	5.2	7.2	0.0	7.2	0.0	0.0	0.0	83.5	7
	6	Pipinas south	SM	0.7	0.0	172.6	0.0	19.2	0.0	0.0	2.7	1.4	0.0	1.4	4.1	0.0	0.0	0.0	202.7	7
	7	Canal 1 mouth	SM	0.5	3.8	498.1	1.9	1.9	0.0	0.0	7.5	32.1	52.8	0.0	0.0	0.0	49.1	0.0	647.2	8
	8	Canal 1 inland	SM	1.0	0.0	385.0	0.0	7.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	395.0	5
	9	Punta Rasa bay-1	SM	1.0	0.0	169.8	7.3	35.4	5.2	1.0	10.4	3.1	6.3	0.0	1.0	2.1	1.0	0.0	242.7	11
	10	Punta Rasa bay-2	SM	0.8	3.8	501.3	0.0	102.5	0.0	0.0	0.0	0.0	6.3	5.0	0.0	0.0	0.0	6.3	626.3	7
	11	Tapera de López	SM	0.7	4.2	131.9	11.1	25.0	0.0	0.0	2.8	0.0	19.4	1.4	0.0	0.0	2.8	23.6	222.2	9
	12	San Clemente stream	SM	0.8	0.0	6.2	0.0	6.2	0.0	0.0	2.5	0.0	43.2	0.0	0.0	0.0	0.0	0.0	58.0	4
III	13	Punta Rasa beach	SB	1.0	5.0	10.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0	3
	14	San Clemente north	SB	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	15	San Clemente south	SB	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	16	Las Toninas north	SB	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1
	17	Nueva Atlantis	SB	1.0	0.0	0.0	0.0	2.0	5.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	10.0	3
	18	Pta. Médanos light-house	SB	1.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1
	19	Punta Médanos camping	SB	1.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1
	20	Pinamar north	SB	10.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	1
	21	Cariló south	SB	5.0	6.2	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.4	2
	22	Villa Gesell north	SB	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	23	Mar Azul	SB	1.0	49.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.0	2
	24	Playa Querandí	SB	1.0	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	1
	25	Playa CELPA	SB	1.0	3.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	7.0	3
IV	26	Mar Chiquita south	SB	1.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1
	27	Mar de Cobo coast-1	SBR	1.0	3.0	3.0	1.0	0.0	6.0	0.0	0.0	0.0	0.0	24.0	0.0	4.0	0.0	0.0	42.0	7
	28	Mar de Cobo coast-2	SBR	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	5.0	1
	29	Las Brusquitas north	CS	1.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	1
V	30	Miramar coast-1	SB	5.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.8	2
	31	Miramar coast-2	SB	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

Appendix I. (Continued) Matrix of shorebird species abundance (indiv./km) by survey locality along the Buenos Aires coastal zone. Species recorded only once were excluded from the table (see text). S refers to the number of species per locality. See acronyms for coastal landscapes in Table 1.

Coastal sector		Locality	Coastal landscape	Transect length (km)	*Haematopus palliatus*	*Calidris fuscicollis*	*Charadrius falklandicus*	*Pluvialis dominica*	*Calidris alba*	*Vanellus chilensis*	*Himantopus melanurus*	*Tringa flavipes*	*Limosa haemastica*	*Calidris canutus*	*Tringa melanoleuca*	*Pluvialis squatarola*	*Numenius phaeopus*	*Arenaria interpres*	Total shorebirds	S
	32	Mar del Sud	CS	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	33	Arenas Verdes	SBR	3.0	7.3	0.0	0.7	0.0	155.3	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	164.0	4
	34	Costa Bonita	SBR	1.0	1.9	0.0	2.9	0.0	57.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.5	3
	35	Necochea coast-1	CS	3.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	1
	36	Necochea coast-2	CS	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	37	Los Angeles beach	CS	1.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	1
	38	San Cayetano beach	SBR	1.0	2.0	1.0	1.0	0.0	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.0	4
	39	Orense beach	SBR	1.0	0.0	2.0	2.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	4
	40	Claromecó north	SBR	1.0	1.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	2
	41	Dunamar	SBR	5.0	1.0	15.4	8.8	0.0	4.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	30.2	7
	42	Reta beach north	SB	4.0	1.0	5.0	1.3	0.0	0.5	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	5
	43	Reta beach south	SB	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	44	Marisol beach	SB	1.1	90.9	72.7	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	173.6	4
	45	Monte Hermoso south	SBR	7.0	4.3	0.1	0.0	0.0	51.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	55.6	4
	46	Monte Hermoso north	SB	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
	47	Sauce Grande beach	SB	7.3	0.7	22.1	3.0	0.0	5.1	0.3	1.8	0.5	0.0	0.0	0.4	0.0	0.0	0.0	33.9	8
	48	Pehuencó	SBR	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1
VI	49	Muelle Cuatreros	SM	1.1	0.9	494.5	0.0	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	514.7	3
	50	Villarino Viejo	SM	0.7	128.6	0.0	0.0	25.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	154.3	2
	51	Cabeza de Buey coast-1	SM	0.7	0.0	1.4	20.5	19.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.1	3
	52	Cabeza de Buey coast-2	SM	0.8	1.3	106.7	2.7	28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	138.7	4
	53	Villa del Mar	SM	1.2	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	1
	54	Punta Alta beach	SM	1.0	0.0	262.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	294.0	2
		Incidence			28.0	23.0	18.0	17.0	14.0	9.0	9.0	9.0	8.0	8.0	6.0	5.0	3.0	2.0		
		mean			6.6	53.7	1.3	7.8	6.0	0.3	0.9	1.0	2.6	0.7	0.3	0.2	1.0	0.6		
		SD			21.9	130.3	3.5	17.9	23.3	0.8	2.6	4.5	9.5	3.4	1.1	0.9	6.7	3.3		