

Wader Study Group Special Spring 2001 Conference, Virginia, USA

Overview of the Conference

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For the first time in its 31-year history, the Wader Study Group held a special meeting in North America. The venue was the field station at the Marine Science Consortium at Wallops Island in Virginia, ably organised by Barry Truitt of The Nature Conservancy in Virginia along with Tom Dick and several volunteer helpers. The meeting was held during May 11–13 to coincide with the annual gathering of international teams banding shorebirds in Delaware Bay, and to provide an opportunity for attendees to go birding in this internationally renowned stopover site. The principal objective of the meeting was to bring together the partners in the western hemisphere who are working throughout the flyway to better understand the migration of red knots, following on the pioneering research of Brian Harrington summarised in his book *The Flight of the Red Knot*. The meeting also provided a forum for shorebird biologists to present results of their work in the Americas on other species and related issues in ecology and conservation.

The first day of the meeting was devoted to a symposium on Red Knots in the Western Atlantic Flyway. In his welcoming address, WSG Vice-Chairman Theunis Piersma set the stage for ensuing papers by pointing out major contributions in the past, and noting that because of the current flurry of research throughout the flyway we are in need of an update in our understanding of Red Knot migrations. As in any active field of research, he predicted the papers in the symposium would show that a modern synthesis is required to integrate this new knowledge within the framework established in the past.

The first paper by Larry Niles, Ken Ross and Guy Morrison presented aerial and confirmatory ground census data on populations in the major over-wintering area for Red Knots in Tierra del Fuego. They showed that counts of about 52,000 birds in 2000 were essentially very similar to those made in the late 1980s, suggesting that these southern populations have remained stable over this period. When they repeated the census in February 2001, however, they counted only 32,000 birds in the same areas (though Bahia San Sebastian, which usually supports only a few thousand knots, was not censused). This points either to an alarming decline through some cataclysmic mortality event or to a major redistribution of over-wintering birds in other parts of the flyway. In the following paper Patricia Gonzalez presented results of work done with David Price and Guy Morrison at the first major stopover site 1,400 km to the north at San Antonio Oeste

(SAO) in central Patagonia. She showed that the arrival of individually colour-ringed birds in SAO coincided with departures from Rio Grande in Tierra del Fuego. Some of these birds arrived less than 48 hours after leaving Rio Grande. Based on the proportion of Rio Grande birds re-sighted in SAO, she obtained an estimate of the Tierra del Fuego population that was consistent with the census data in the previous paper. The 20,000 fewer knots in Tierra del Fuego in 2001 is therefore confirmed independently. The reduction occurred only in Bahia Lomas because the Rio Grande flock was the same size as in 2000. The third paper in the first session was by Ines do Nascimento from CEMAVE in Brazil. She summarized data collected over the past 15 years in Lagoa do Peixe and showed that birds can achieve mean weights of around 190g before departing to the north. During the spring migration she estimated that about 10,000 knots are present on passage in four major bays in Maranhao, though simultaneous counts in each bay will be required in future to determine the total number of knots that stopover there. One knot ringed in LDP was re-sighted in Delaware Bay 13 days later, suggesting it stopped in Maranhao for a few days en route.

In the second morning session Ted Below reported on the population of knots he has been studying in Florida over several decades. In the 1990s, the population has declined from 800 to around 100 birds, paralleling similar declines in knots counted at places like Delaware Bay. Despite using distinctive combinations of flags and colour rings he has had only three re-sightings of his ringed birds outside of Florida – two in Delaware Bay and one in Manitoba. The next paper by Brian Harrington and Brad Winn gave details of the flock of about 7,000 knots that now occurs on the coast of South Carolina and Georgia in Spring and Fall. This population contains birds ringed in Delaware Bay, but not birds that over-winter in Tierra del Fuego. The breeding grounds of these birds remain a mystery, but searches will be made this season in Alaska. Just prior to the conference, birds ringed in South Carolina and Georgia were observed foraging in the coastal marshes in Stone Harbor, New Jersey by our esteemed Editor, Humphrey Sitters.

After lunch our host Barry Truitt (along with Bryan Watts, Bonnie Brown and William Dunstan) documented the passage of knots through the barrier islands of Virginia. He pointed out that several hundred birds can be observed each day during the peak of migration, and they forage on mussels





Two photographs taken during the Virginia conference field trip to Metompkin Island. *Left:* Landing on Metompkin Island. *Right:* Waiting for the tide to recede, Metompkin Island. Both photos taken by Theunis Piersma.

during their brief stops. A later field trip to Metompkin Island allowed many of us to see them picking these mussels off exposed peat outcrops, although our host at one stage suffered an anxiety attack until the first knots put in a late appearance. The next paper was presented by Clive Minton on behalf of the international and state teams from New Jersey and Delaware that have caught and banded knots in Delaware Bay since 1997. Migratory fattening in which the birds approximately double their arrival weights coincides with major spawning peaks by horseshoe crabs. In the last two seasons for which complete data are available (1999 and 2000), a significant proportion of knots arriving in the last week of May have not achieved weights thought to be optimal for breeding. This raises the concern that increased harvesting of crabs since the late 1990s may be having a detrimental affect of the availability of crab eggs on which the birds normally gorge themselves. Research continues on this debated issue, but any reduction in the number of breeding adults must be considered a serious cause for concern in any risk-adverse management strategy. Supporting evidence for this scenario came from the next paper presented by Theunis Piersma and David Carter. They showed that in small samples of knots sampled in Delaware in 1998 and 1999 there was a statistically significant reduction in the amount of fat, muscle mass, gut size and liver mass in the "bad year" of 1999 when head winds delayed the arrival of some birds. However, this mass decline was also seen in early arriving birds. The final paper in the session by Graciela Escudero and Larry Niles reported on the density and availability of possible alternative prey to horseshoe crab eggs in Delaware Bay. Using Holling's resource model they showed that these alternatives are insufficient in themselves to refuel knots on the scale observed in Delaware Bay.

In the second afternoon session, Humphrey Sitters presented evidence from his field studies that the availability of horseshoe crab eggs may be insufficient to completely cover the energetic requirements of shorebirds fattening in Delaware Bay. He observed that in New Jersey the knots left the Bay at dusk and often foraged at night mostly on mussels in the marshes and bays in Avalon. Further support for this view comes this year. At the time of writing this report in mid-May, the lack of available horseshoe crab eggs on most New Jersey beaches has not only seen most knots desert the state but the few that have remained have been sighted feeding on mussels in the Stone Harbor area. Then Larry Niles (with co-

authors Mark Peck and Rick Lathrop) summarized the work they have been doing in delimiting the breeding grounds of red knots in the central Canadian arctic in the past two years. Larry described how birds fitted with radio-transmitters in Delaware Bay were located on Southampton Island and King William Island in Nunavut. Territories cover about 1 km² on gravel ridges 5–15 km inland from the coast. With hard work in the future it may be possible to study productivity if suitable densities of breeding birds can be found. Theunis Piersma then summarized the day's proceedings in the broad context of his expansive knowledge of knots in various parts of the world. He pointed out the remarkable biological attributes of these birds that enable them to live a life as long-distance marathoners. He also raised many questions about them that remain unanswered, such as migration of juveniles, recruitment rates, and annual mortality rates. Why do some knots migrate so far each year whereas others in the same flyway do not? Serious declines in numbers of many species of shorebirds in the last 30 years or more demand answers to these questions and suggest priorities for future work.

In the evening keynote address, Allan Baker and Patricia Gonzalez provided preliminary answers to some of the these questions. They stressed that the results obtained over the past five years were only possible because of international team-building along the flyway. In particular, the network of researchers, educators and the lay public, established under the umbrella of the Western Atlantic Shorebird Association (WASA), was critical in enabling people to work together as a strong team and report observations throughout the flyway. As a result, we now know when birds, individually identified with unique colour-ring combinations, leave Tierra del Fuego, when they arrive at stopovers such as San Antonio Oeste in central Patagonia and how long they stay there, as well as their progression northwards through Delaware Bay. By partnering with the Brazilian Government bird-banding agency CEMAVE, the fine details of the passage of knots through Brazil are emerging, building on their long tradition of banding shorebirds at Lagoa do Peixe. Conditions throughout the flyway are now known to be important in explaining annual variations in migratory timing and fattening cycles at various stopover sites, but Delaware Bay is a crucial site in the spring migration because it is the last chance for migrants to reach good departure weights that appear to be necessary for successful breeding and survival. Only a small proportion of juveniles migrate annually to Tierra del Fuego. Instead



they winter in North America, Brazil, and northern Argentina. In their second year and later, most birds undertake the full migration. The annual mortality rate of adults wintering in Rio Grande, Tierra del Fuego, was estimated at 25%, but the recruitment rate of immatures there was estimated at only 19%. The numbers of red knots in the flyway has declined by 30–40% since the early 1990s, and risk-adverse management is urgently required to aid the recovery of this threatened population.

On the second day of the conference, papers covered a broader range of shorebird topics. Melissa Rose and Erica Nol presented data on the winter feeding ecology of *Charadrius semipalmatus* in Georgia. Low return rates of adults to northern breeding sites seem likely to be attributable to high dispersal rates rather than high mortality, a common problem encountered in interpreting population parameters. Hugh Insley and Mark Rehfish then described the impressive scope of the work being done by the Highland Ringing Group on wintering waders in the Moray Basin in Scotland. Their large-scale ringing studies are providing fascinating details of local movements of waders in the Basin plus a host of new insights into the ecology and patterns of habitat use by different species. Mark Peck then presented a new molecular phylogeny of the plovers, and raised eyebrows by suggesting a radical new definition for which of these species should be called dotterels. The Magellanic Plover was shown not to be a plover, but is the sister group to the sheathbills.

Dick Veitch brought us up to date with data on red knots wintering in New Zealand. He also pointed out that bar-tailed godwits wintering there might be the ultimate long-distance champions for a single flight by shorebirds. If they go directly from Alaska to New Zealand during autumn migration, they would fly at least 10,500 km non-stop. He also

showed us data for other species of shorebirds in New Zealand. Kathleen Clark, Larry Niles and Alice Doolittle then presented a summary of aerial surveys of shorebirds made annually during spring passage in Delaware Bay over the past 15 years. These surveys clearly document the decline in shorebird numbers using the Bay during this period. Notably, red knots have shown a major decline that parallels increases in horseshoe crab harvesting in the late 1990s, though we now know that other changes in the flyway are also likely to be impacting population size. Theunis Piersma then impressed the audience with what can be done to study movements of shorebirds with automatic radio tracking stations (ARTS). This technology is ideal for studying movements within a site like Delaware Bay, and for obtaining estimates of population turnover and departure times of shorebirds bound for their arctic breeding sites. Garry Donaldson then concluded the conference with a description of new approaches to hemispheric conservation of shorebirds, focusing primarily on interagency co-operation throughout the flyway. This is an important step with much promise for the future.

Then followed a fine afternoon at Metompkin island watching shorebirds on this pristine and beautiful island. All the knot watchers were surprised to see the birds were mostly fat, suggesting they had not just arrived from South America on their arduous journey, but instead might belong to the beach-hoppers club. Are these the birds from the recently discovered South Carolina flock? If life is so easy in the north, why go to Tierra del Fuego? We all presume that the answer must lie in trade-offs between survival and migration strategies, but the theoretical foundations of competing hypotheses are now coming under increasing scrutiny as our growing knowledge of the biology of migrants adds to the mix.

Abstracts of talks

Survey of Red Knots in Terra del Fuego

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The decline in availability of horseshoe crabs eggs on the Delaware bay would ultimately affect the wintering population of new world red knots (*Canutus canutus rufa*). G. Morrison and K. Ross first conducted surveys of wintering areas in 1986–88. They reported 66,000 red knots, most of which occurred in Tierra del Fuego and most of them (42,762) in one bay, Bahia Lomas, Chile. In 2000, we surveyed shorebirds along in the Chilean and Argentine coasts of Tierra del Fuego while in 2001 we restricted our search to the Strait of Magellan focusing on Bahia Lomas. In the two years of our survey, numbers in Bahia Lomas fell from 45,705 to 29,745. This represents a decline of approximately 20% of the total flyway population currently estimated at 80,000 (A. Baker pers. comm.).

A decline of this magnitude can only be evaluated with continuing surveys, however, several alternate hypotheses are possible. Red knots may have moved to another winter-

ing site. A corresponding increase in hudsonian godwits in 2001 suggests significant movement of birds in the vicinity of Bahia Lomas. Moreover, we did not survey the Argentine coast of Tierra del Fuego in 2001, which is less than 60 km from Bahia Lomas. Alternatively, the decline may represent a real decline in the population of red knots. An estimate of southern Patagonian wintering knot population presented by Patricia González and Allan Baker in this session, and based on colour-band re-sightings, corroborates our wintering estimate.

In our 2001 groundwork at Bahia Lomas, we found 171 colour-banded birds in a scan of 4,700 knots, most from Delaware Bay (92%), the rest from Argentina and Brazil. Bird movement on the bay appeared to be most influenced by lunar tides that rise three meters higher than mean high tide. During lunar tides most of the suitable roosting habitat is restricted to relatively small areas of *salicornia* sp. marsh. As it accounts for as much as 60 percent of the entire population of *C. rufa*, Bahia Lomas qualifies as a site of Hemispheric Importance in the Western Hemisphere Shorebird Reserve Network. The chief threat to the bay appears to be accidental oil spills from offshore pumps and nearby oil storage facilities. In 2002, we plan a new survey of both the Chilean and Argentine coasts and an extensive trapping program.



Migration of Knots through Bahía de San Antonio, Río Negro, Argentina

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Because of concern about declining numbers of Red Knots (*Calidris canutus rufa*), the International Shorebird Banding Project (ISBP) is attempting to estimate population parameters and migration strategies. In early December 2000, an ISBP team caught and colour-banded 582 knots in Río Grande (RG), Tierra del Fuego, Argentina, of which 62 were marked individually, and 45 marked with standard combinations for juveniles and immatures. In the ensuing period to the end of April 2001, Western Atlantic Shorebird Association (WASA) observers along with ISBP and Canadian Wildlife Service researchers made counts and scans of colour-banded birds mostly in RG and Bahía de San Antonio (SAO), a key stopover site 1450 km north in Patagonia.

Northern migration of adults started in mid February when the first decline in numbers at RG was noted and 6000 birds arrived in SAO. From 20 February to 20 March, about 5000–7000 knots were counted at SAO. Re-sightings of birds individually colour-banded at RG showed that they were arriving in SAO during this period. A big drop in numbers at SAO occurred by March 21, when 700–1500 knots were present, but by March 31 numbers increased to 3000. Re-sightings of individually colour-banded birds during this second period showed that several birds present in SAO in mid-February were still in SAO in early April (5 of 44 adults resighted at SAO). The first sightings of immatures banded in RG were recorded during this second wave.

Scans of RG banded birds re-sighted in SAO gave an estimate of the total wintering population of knots south of SAO of 31,800 (26,850–37,850 95% CL) birds, while scans of SAO banded birds re-sighted both at SAO and RG gave an estimate of 37,600. These estimates are consistent with those obtained during an aerial census by Larry Niles (NJ Division of Fish and Wildlife's Endangered and Nongame Species Program), Guy Morrison (CWS), Ken Ross (CWS) in early February 2001 in the Tierra del Fuego expedition lead by NJDFW.

The wintering population size in RG was estimated as 5,500–6,500 birds (18 % of southern total) both from censuses and colour band scans. The migration through SAO was different from the pattern in 1998 and 1999 when bird turnover was more gradual. SAO population size declined from 20,000 (or more) in 1996, to 15,000 birds in 1997 and 1998, and then to 8,500 (± 500) birds in 2001. This figure for 2001 represents 24% of the total southern population on its northward migration.

Migration and other biological data of *Calidris canutus rufa* from Brazil

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Nearctic shorebirds have been monitored in Brazil since

1980 through CEMAVE/IBAMA. The main objective has been to furnish sound information for shorebird conservation. Recent population decreases detected in species such as the Red Knot (*Calidris canutus rufa*) have made the monitoring of population levels and migratory strategies fundamental to proper conservation policies.

CEMAVE has conducted aerial and terrestrial evaluation of potential areas while census and capture has been set up in key locations. For the Red Knot, Maranhão state coast (MA) and Lagoa do Peixe National Park (LP) have been monitored since 1987 (MA) and 1984 (LP).

From 1984 to 1999, 2,398 Red Knots have been banded in Brazil (LP = 2251 and MA = 47), 87% as adults and 13% as immatures. The recovery rate is 7%.

Southward migration shows a stopover in eastern US coast (Scituate, Massachusetts, August 10th) and Guianas (September 7th and 12th). MA is used from September although Central Brazil is overflowed. Quick stops take place in Pantanal (late September and early October 1989 at Rio Negro's salt lakes) where 8 of 10 still have breeding plumage. Birds arrive at LP as early as the second week of September, some still with breeding plumage. Numbers increase in October, decreasing afterwards when birds migrate to Argentina (where banded birds were observed on October 6th, 1997) and Chile.

During northward migration higher numbers occur on the coast of Rio Grande do Sul, with LP the major stopover. Main passage takes place from the second week of April to the first week May. Body moult occurs in April when breeding plumage is acquired. May average mass is 192g ($n=309$, $SD = 27$). A LP colour-banded knot was seen near Turiaçu, MA, two weeks after banding. May MA samples show masses between 115 g and 210 g ($SD = 29.7$). The average mass (153.6 g) suggests fattening for migration may take place there. An alternative hypothesis is that birds below minimum migratory mass may remain on the continent's northern coast, skipping breeding. Immatures must stay, being found in June and July as far south as LP.

The next major stopover for birds from LP is Delaware Bay, in U.S. (94 recoveries), perhaps the same is true for MA banded knots. Apart from a recovery in Presqu'île, Ontario, there is no further information on Brazilian-banded knots in Canada.

Data indicate 7,000 knots using LP in recent years. This follows a decline from 1997 to 1999 and again in 2001 (as also found in Argentina (P. Gonzalez, pers. comm.)). MA has 10,000 knots or more.

Future studies aim to establish the age composition of the population, particularly on the north coast. It is also important to identify all sites used by knots, either for stopovers or for wintering. Demographic aspects of the population will be cornerstones of conservation strategies, whether in a local or hemispheric perspective.

Red Knot monitoring in southwest Florida

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Red Knots (*Calidris canutus*) are present along the southwest Florida coast year round. In this paper, I describe population trends and site fidelity of Red Knots in the vicinity of Marco



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For the last 28 years in several on-going projects, I have censused coastal waterbirds along 77 km of beaches, sandbar and mangrove estuaries. During a banding project conducted from 1985 to 1990, shorebirds were mist-netted on several sandbars in an effort to learn not only where these birds summered, but also to collect information on winter distribution and site fidelity. The shorebirds were banded using the Pan American Shorebird Program's protocol. In this study, 211 Red Knots were individually colour-banded. Of these, 157 were subsequently observed at least once and are the subject of the site fidelity analysis.

Red Knots are present in the area year round, but more occur during the winter (August–April, mean = 325), than in summer (May–July, mean = 65). From 1973 to 1990, the population was reasonably stable, but some time during 1990–93 it dropped dramatically in the southern part of the study area. Since then, it has remained stable. 662 sightings of individually marked Red Knots have been recorded since the beginning of the project. Of the 157 individuals recorded at least once, 135 (86%) were observed in the study area, 19 (12%) were observed out of the area on the west coast of Florida and 3 (2%) were recorded outside the state. Although Red Knots were reported from almost the whole west coast of Florida, 84% of the sightings occurred in the vicinity of the banding sites. 66% of the colour-banded Knot sightings were of birds that were present in more than one year and 45% were of birds that occurred in at least two or more consecutive years. Three Red Knots have been recorded in the area 13 years after being banded. Little offsite information about Red Knots has been generated in this study but from the on-site sightings it appears that these birds often stay in the area for some time and return for several years.

Red Knots of the southeastern United States: A Preliminary Report of Recent Investigations into the Insular Qualities of the Population

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As early as 1978, questions began to arise involving the ecological uniqueness of Red Knots (*Calidris canutus*) found wintering annually on Florida's Gulf Coast. Movements of the birds based on colour-band re-sightings indicated that the birds exhibited seasonal activity that differed substantially from the western Atlantic population of knots (*C. c. rufa*) known to nest in eastern Canada and move to southern Argentina and Chile during the non-nesting season. In September 1996, a flock of 8,000 Red Knots was seen on the central coast of Georgia. Peak numbers of knots observed each September in 1996–2000 at the mouth of the Altamaha River, Georgia, averaged 7,180 birds (range 1,800–12,000). Knots arrive in Georgia beginning in late July and early August, moult from breeding plumage to basic plumage through September and, begin to disperse in late September and early October. Flocks of up to 6,000 birds have been found on the coast of South Carolina near Hunting Island in April. Renewed colour-banding efforts since 1999 have shown that knots banded in Georgia in September, and South Carolina in April, have been recorded throughout coastal

Georgia, northeast Florida, and the south Florida Gulf Coast during temperate winter months. The primary food resource for knots in Georgia is the dwarf surf clam (*Mulinia lateralis*) and in South Carolina in the spring the birds feed heavily on coquina clams (*Donax variabilis*).

Red Knot Densities and Invertebrate Prey Availability on the Virginia Barrier Islands

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Because the Virginia barrier islands have received relatively little attention from the community of shorebird scientists and available estimates of use by migrant shorebirds are relatively poor, we undertook weekly aerial surveys to estimate the numbers of shorebirds that migrate along the islands in the spring of 1995 and 1996 (Watts & Truitt, in press). More than 100,000 observations of migrant shorebirds on barrier beaches were made. These were dominated by Red Knots (38.4% of observations). Peak counts of Red Knots were 7,710 in 1995 and 8,955 in 1996. Total counts for Red Knots, accumulated over the respective year, were 14,808 in 1995 and 23,917 in 1996. Densities of Red Knots (birds/km of shoreline) calculated as the average density across all surveys (n=12) varied from a high of 74.80 on Metompkin Island to 63.10 on Parramore Island to a low of 0.11 on Fishermans Island. During May 2000, we completed a preliminary quantitative assessment of the invertebrate prey species available to Red Knots at the time of maximum bird densities on these three islands. The peat banks of Metompkin Island held both the highest density and highest diversity of invertebrate prey species and were dominated by *Mytilus edulis* (blue mussel) spat. The sandy beach of Parramore Island had the second highest density of invertebrates but the least amount of diversity. The Melitidae amphipods were by far the most dominant invertebrate prey species available to Red Knots on this island. Fishermans Island held the smallest density of invertebrate prey species, but was the second highest in diversity. Red Knot numbers peaked on May 21 on Metompkin Island with approximately 1,200 birds in the 1 km study area and on May 23 on Parramore Island with approximately 1,500 birds in the 1 km study area there. A total of 68 flagged birds (37 from Argentina, 27 from Delaware Bay, and 4 from Brazil) were observed during the 19 days spent on the islands.

Migratory Fattening of Red Knots in Delaware Bay, 1997–2000

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Red knots (*Calidris canutus rufa*) usually begin arriving in Delaware Bay in early May each year. For the past 5 years we have led teams that cannon-netted samples of knots in Delaware Bay to document the spring fattening cycle. There



have been marked year to year variations and also considerable differences from week to week throughout each May. The earliest catch of birds, made in New Jersey on May 2, 1998, had a mean mass of 109.4 ± 9.97 g ($n = 12$), but birds in another early catch made on May 7, 2000 had a mean mass of only 93.5 ± 2.84 g ($n = 10$). Low-mass migrants (89–110 g) continue to occur in samples taken throughout May each year, but most knots have arrived by May 21. These masses are at or below the fat-free masses of knots, and indicate that the birds are approaching their energetic limits on the arduous migratory leg from South America. Both lipids and protein reserves need to be replenished during the critical refuelling stop in Delaware Bay. Once in the Bay the birds achieve rapid mass gains that closely track major spawning events by Horseshoe Crabs, and that clearly depend upon the availability of crab eggs on the surface of the sand. When eggs are available in superabundance, knots average mass gains in excess of 5 g per day, but when eggs are scarcer, mass gains are reduced to about 1 g per day. The heaviest birds each year reach masses of 220–240 g. Departure weights average about 190 g suggesting that knots have to be in the Bay about 15 days or more under optimal feeding conditions to achieve this doubling in mass. In 1999 and 2000, late arrivals of low-mass migrants coincided with low availability of crab eggs, and these birds were unable to reach optimal departure weights. They were also unlikely to have bred successfully because they had insufficient lipid reserves for migration to the breeding grounds and for reproductive activities. These results underscore the importance of Delaware Bay as an essential stopover in spring migration, and also point to the interdependence of ecological conditions at key sites throughout the flyway. If knots arrive late and/or in poor condition from South America, then Delaware Bay is even more crucial in restoring their lipid and protein reserves, which in turn maximizes the number of adults that can attempt to breed. This study illustrates that long-term monitoring of mass changes in red knots is an extremely effective tool for assessing the conservation status of this subspecies throughout the flyway.

Red knots fattening on horseshoe crab eggs: body composition changes and energetics

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To determine the energetic repercussions of fuel storage of Red Knots *Calidris canutus rufa* in Delaware Bay, we measured details of the body composition changes in randomly selected samples of birds, in May 1998 and 1999. In addition, food type was verified on the basis of stomach content. The patterns of change in body mass, fat mass and fat-free (dry) mass, confirm that body mass changes during refueling are attributable not only to fat, but to lean components as well. There is continuous re-organization of the functional organs during a stopover period. At least in 1998, the patterns of change in various organs suggest that the samples were taken from a fairly synchronised migratory population.

Individual mass changes should thus resemble those of the population. Under this assumption, fueling rates and their energetic equivalents were calculated for the 1998 season. Over the first eight days, the Red Knots stored an average of 1.17 g/day. Fat contributed very little and the additional energy requirement for storage was therefore only 8 kJ/day. Over the subsequent nine days the average mass gain was 6.39 g/day, towards which fat contributed 4.16 g/day or 65%. The additional energy requirement during this period was thus 179 kJ/day. During the last five days with a mass increase of 5.58 g/day, a contribution of fat of 4.47 g/day (80%), the estimate of the additional energy requirement was 184 kJ/day. The rate of energy expenditure of Red Knots for activity, thermoregulation and maintenance can be estimated at 200–250 kJ/day. Therefore, during the last two weeks of refueling, Red Knots in Delaware Bay must almost double their energy intake rates. In 1999, Red Knots arrived lean and late, and fueling rates over the remaining time in May seemed higher than in 1998. High fueling rates were achieved with smaller guts and livers than in 1998, suggesting considerable additional organ flexibility when birds are time-stressed. The long-term consequences of such adaptive short-term adjustments requires further investigation. Stomach content analyses confirmed that horseshoe crab eggs were the main foods. New data on digestive efficiency enable us to calculate the number of eggs that Red Knots have to consume for each g of fuel stored.

Are there alternative food resources for knots in Delaware Bay?

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Red knots (*Calidris canutus rufa*) in Delaware Bay feed on Horseshoe crab eggs (*Limulus polyphemus*). A decline of the *Limulus* eggs has been reported for many years. If the main prey (eggs) is scarce the predators (knots) could follow any of the following alternatives: switch prey, move to a different area where the main prey is still abundant, or die of starvation. We evaluate the first of the hypotheses: Does Delaware Bay offer an alternative food resource for knots? Benthos surveys were carried out in different types of habitats in New Jersey State: including inland mudflats under tidal influence (Thompson and Stone Harbor mudflats), narrow beaches in the bay (Reeds and Moores), broad beaches with sandflats and mudflats in the bay (Villas and Norburys) and a beach on the Atlantic side (Stone Harbor Point). The information on the benthic food resources was compared with studies of knots feeding in other areas around the globe, where knots mainly feed on molluscs. There are only some mussel beds and clams in the mudflats that could be used as alternative prey, but the densities are the lowest found in literature, and only a few places (7.8% of the area) reach the minimum harvestable biomass required for a knot. These places cannot support the number of birds that stopover in the area. The knots cannot switch to alternative preys. Our conclusion is coincident with all the previous studies: *Limulus* eggs in Delaware Bay are of crucial importance for the survival and successful migration of red knots.



Behavioural evidence that shorebirds may suffer shortages of available horseshoe crabs' eggs in Delaware Bay

Humphrey Sitters

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This study was prompted by concern that stopover shorebirds in Delaware Bay may be suffering from an insufficiency of their prime food resource of horseshoe crabs' eggs. It focuses on those aspects of the behaviour of knots and turnstones that may be attributed to such shortages.

Crabs' eggs are eaten on the shores of Delaware Bay only during daylight hours. In the past, it has been thought that knots do not feed at night but roost. Behaviours that might indicate a shortage of horseshoe crabs eggs include feeding at night, feeding by day on alternative foods and, while feeding by day on crabs' eggs, showing high mobility as lack of sufficient eggs drives them to move in search of better feeding sites.

This is an ongoing study but already there is evidence of all these behaviours. It has been proved that knots do sometimes feed at night in the tidal wetlands behind the Atlantic coast in New Jersey. Likely prey are small mussels and buried bivalves. However, it seems that little or no night-feeding occurs over several consecutive days when there are only short periods of tidal exposure in darkness. The available evidence is that turnstones do not feed at night.

There is also evidence that some knots feed by day on mussels and buried bivalves in the Atlantic coast wetlands. The largest numbers occurred from 5 to 10 May 2001 when up to 1400 fed regularly on mud banks in Great Sound, near Stone Harbor. Ten per cent of these birds had been banded in previous years along the shores of Delaware Bay. Therefore it can be assumed that they knew of the existence of the crabs' eggs found there but nevertheless chose to feed on different prey. It is possible, however, that this is a regular occurrence in the early part of the season when few crabs' eggs are available in Delaware Bay.

Radio-tracking of knots by Sherry Meyer in 1997 and 1998 showed that 60% of the tagged birds made at least one crossing of Delaware Bay (about 40 km) during their stopover. Retraps of banded birds showed similar evidence of mobility in knots but much less mobility in turnstones. It is suggested that less mobility and no night-feeding in turnstones may arise because much greater numbers of eggs are available to turnstones than knots because knots only take surface eggs whereas turnstones dig holes and access buried eggs.

It is not clear whether current observations reflect a new situation resulting from a decline in horseshoe crabs' eggs or are a long-standing pattern of behaviour. Nevertheless they suggest that crabs' eggs are not always an abundant food supply.

For the future, monitoring these factors – the incidence of night-feeding, feeding by day on prey other than horseshoe crabs' eggs and mobility – will give a good indication as to whether the shorebirds in Delaware Bay are facing a deepening crisis.

Breeding Habitat of the Red Knot in Nunavut, Canada

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In order to assess the viability of the Delaware Bay stopover we began an investigation of red knots to 1) locate breeding sites of knots radio-tagged on Delaware Bay, and 2) to establish baseline surveys for long-term surveillance. Our larger goal is to develop a method to monitor red knot productivity and breeding density to help evaluate the impact of declining horseshoe crab egg availability on Delaware Bay.

Twenty radio-tagged red knots were relocated on and between Southampton Island and King William Island in Nunavut, Canada. In 1999, we found eight of 65 radio-tagged birds on Southampton Island. All used patches of low elevation barren tundra within 50 km of the ocean coast. Using these criteria we developed a map of suitable red knot habitat using Landsat and other thematic imagery. In 2000, we searched all identified suitable habitat north and west of Southampton Island and found 12 out of 100 tagged birds. We estimate the area of breeding habitat to be at least 300,000 km².

In 2000, we systematically ground-searched 20 km of potential red knot habitat, finding 11 nests. All nests were scrapes within small patches of dryad (average = 51 cm) in sparsely vegetated tundra (29% vegetated within 10 m). Nests were spaced approximately 1 km apart on two sparsely vegetated eskers or narrow ridges less than 10 m high. All nests occurred within 180 m of an isolated wetland. All adults were banded and six were tagged with transmitters. Radio-tagged birds stayed within 2 km of the nest area, appeared to defend a 0.5 km area surrounding the nest, and shared wetlands outside that area. Average body mass of 18 birds was 131.9 g, four of which fell below the fat-free body mass of 120 g. This relatively low mass points out the importance of Delaware Bay in preparing birds for the migratory flight to the Arctic, and providing the initial source of energy prior to and during incubation.

Red Knots in the Western Atlantic Flyway

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In the last five years, international teams have worked intensively to gather data on the migrations and population status of red knots (*Calidris canutus rufa*) in the Western Atlantic Flyway, following in the footsteps of earlier work done by Brian Harrington and Guy Morrison. By working across the broad sweep of the flyway from Tierra del Fuego to the Canadian arctic breeding grounds, the teams have obtained new insights into the biology of these marvellous flying



machines, particularly during the northwards migration. Together, we have learned that ecological conditions in the southern over-wintering sites and on key stopover sites are important in getting the birds into good breeding condition. Strong head winds can delay the northwards migration and cause late birds to drop out on the Atlantic coast from Florida to the Carolinas. Delaware Bay is even more crucial as a refuelling point for red knots when they arrive late because the normal abundance of horseshoe crab eggs provides mass gains of up to 12–15 g/day in exceptional years. Thus it is possible to refuel in 7–10 days in times of plenty, and to attain the masses that are thought to be necessary for breeding.

Teams led by Larry Niles of the NJ Endangered Species and Nongame program of the Division of Fish and Game have begun to unravel the details of the breeding distribution of red knots, and have found that about two-thirds of the average mass gain in Delaware Bay is exhausted in breeding birds soon after the clutch of four eggs is completed. This implies that birds with low departure masses from the Bay are unlikely to breed successfully. The southwards migration is less coordinated than the northwards trek to the breeding grounds. Birds pass through San Antonio Oeste in Patagonia in September and arrive in Tierra del Fuego in October. Only a small proportion of juveniles make the full migration, but second year birds and adults over-winter at this southern terminus of the flyway. Annual recruitment rates as reflected in the 2-year old cohort appear to be insufficient to offset annual mortality in adults estimated from band recoveries and re-sightings, although more long term data is required to document cyclic variations in reproductive success. Although an assessment of over-wintering population size in Brazil is a priority in plotting population trends, it seems that the hemispheric population of red knots is at best stable, and may be in serious decline.

Winter Feeding Ecology of Semipalmated Plover (*Charadrius semipalmatus*) in Cumberland Island, Georgia

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The winter foraging ecology of Semipalmated Plovers (*Charadrius semipalmatus*) was studied at seven sites on Cumberland Island, Georgia, in January 2001. We measured number of pecks per minute as a proxy for the quality of different feeding areas. The average number of pecks per minute significantly predicted the average number of fecal pellets produced by birds in a particular site ($R^2 = 0.79$). For every 62.8 pecks, approximately 1.4 defecations were observed. The number of invertebrates found in substrate samples also significantly predicted the number of pecks per minute ($R^2 = 0.84$), suggesting that variation in pecks reflects variation in the quality of the feeding areas. For every 48.2 pecks, 2.5 invertebrates were available per 120 mm³. Dissection of fecal packages and substrate analysis revealed that the most common invertebrates available to Semipalmated Plovers were Polychaete worms, Diptera species Gastropods and Bivalves. Soft bodied Oligochaete worms, Amphipods and Isopods were found in substrate samples, but were not present in fecal sample data due to digestion. These results suggest that Semipalmated Plovers are opportunistic feeders

that choose to feed in areas where invertebrate density is the highest. Preservation of intertidal zones and the maintenance of invertebrate productivity are integral to the conservation of shorebirds in winter habitats. Increased development on beaches and near salt marshes could have depletive effects on sensitive invertebrate populations that would directly affect shorebird densities.

Sequence and phenology of prebasic moult in the Western Sandpiper: patterns from the Upper Bay of Panama

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The Upper Bay of Panama is a significant staging and moulting area for several species of shorebirds during fall migration. Western Sandpipers are the most numerous migrants with an estimated 2 million individuals passing through this area between late August and early November. During the fall of 1997, Western Sandpipers were captured and examined to determine the sequence and timing of prebasic moult within this staging area. Complete moult scores were determined for more than 800 individuals. Moult is initiated by the simultaneous loss of 4–6 inner primaries and advances both distally and proximally. Moult within this location is very rapid. Feather growth peaks in late September when a large portion of the population has 50% of flight feathers in active growth. The majority of individuals observed complete moult by mid-October. This period coincides with the arrival of large numbers of falcons into the bay.

Inter firth movements by wintering waders in the Moray Basin, Scotland

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The Moray Basin is located in the north-east of Scotland. It is the most northerly estuary in Europe to hold internationally important wintering numbers of six wader species (Oystercatcher, Knot, Dunlin, Bar-tailed Godwit, Curlew and Redshank). WeBS counts indicate an average winter peak of 50,300 birds present and 17,075 ha of the estuary complex have been designated Special Protection Areas under the EEC Natura 2000 programme.

Between 1977/78 and 1998/99, the Highland Ringing Group trapped 63,000 waders at 49 roost sites. We have used recapture data from these to examine roost fidelity and the implications for the provision of artificial roosts following land claim and destruction of natural sites. Ringed Plovers, Dunlins, Purple Sandpipers, Curlews and Turnstones were found to be very site-faithful. Over 97% of Oystercatcher, Ringed Plover, Purple Sandpiper, Dunlin, Curlew, Redshank and Turnstone inter-roost movements in the Moray Basin were within the same section of the estuary. Bar-tailed Godwits were mobile, and Knots extremely mobile with 13% and 63% respectively of adults changing sections within a winter.

Comparisons with results from the Wash, England, showed similarities in dispersal for Redshank and adult Dunlin suggest-



ing a generic pattern to movements between roosts. Differences in the large-scale movements of Oystercatchers on the two estuaries were thought to be related to prey availability.

By modelling the inter-roost movements of the eight main species of wader wintering in the Moray Basin, we predict that roosts would have to be 3.6 km or 0.8 km apart to ensure that they are reached by 50% or 75% of the populations of each species respectively with the exception of the very site faithful Ringed Plovers (0.3 km and 0.1 km). On practical grounds we suggest that an inter-roost distance of 2.5–3 km would be adequate for most species.

A molecular phylogeny of the Plovers (Charadriidae): implications for systematics and nomenclature

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Previous studies of morphological, behavioural and ecological variation have not fully resolved the phylogenetic relationships within the plovers. To help resolve these relationships further we obtained sequences of mitochondrial cytochrome *b*, CO1, ATPase 6 and 12S from 28 species of plovers and 7 outgroup species. The resulting phylogeny places the oystercatchers, stilts and avocets as the sister group to the plovers, and removes the Magellanic Plover from the clade as the sister taxon to the sheathbills. The ingroup phylogeny produced with the concatenated sequences shows the Charadriidae to be monophyletic. The tree differs from traditional taxonomy in placing *Pluvialis* as the outgroup to the rest of the plovers and lapwings. The remaining taxa are grouped in three major clades; ringed plovers, lapwings and sand plovers with some of the South American aberrant species positioned in the basal branches. Current nomenclature needs to be revised to accurately reflect the phylogenetic relationships found within the family.

Red Knots in New Zealand, with a brief mention of a few other waders

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Some 59,000 Red Knots (*Calidris canutus rogersi*) are in New Zealand during their non-breeding season. This species is second in abundance to Eastern Bar-tailed Godwit (*Limosa lapponica baueri*) (102,000). All other Arctic migrants are far less abundant, with Turnstone (*Arenaria interpres*) (5,100) at the top of the list. In total, 45 species of Arctic migrants have been recorded among the estimated 166,500 shorebirds present each summer. Ten to fifteen percent of each of these species remain as non-breeders during the southern winter. A significant change of Red Knot distribution within New Zealand has been noted with numbers present on the Manukau Harbour increasing from near zero in 1962 to about 18,000 in 2000. A significant decrease in abundance has been noted at Farewell Spit and a small decrease on the Firth of Thames. The reasons for this move-

ment are not known. All these Arctic species migrate northwards along the East Asian Flyway and all but Bar-tailed Godwit are proven to return by this route. The Bar-tailed Godwit may return directly from Alaska, a 10,500 km flight aided by the regular strong wind pattern in the North Pacific, but this has yet to be proven.

There has been a significant increase in numbers of South Island Pied Oystercatchers (*Haematopus finschi*) that breed in southern New Zealand and migrate to northern New Zealand during their non-breeding season. Hunting during the 1940s reduced their numbers but they are now fully protected. Their choice of breeding habitat has changed from only braided riverbeds to include pasture and their breeding distribution has extended markedly. Numbers present on the Manukau Harbour and Firth of Thames, which are not the entire winter range but the only areas frequently counted, have risen from fewer than 5000 in 1960 to more than 50,000 in 2000. The endemic Wrybill (*Anarhynchus frontalis*) population declined between 1960 and 1980 but may now be steady at about 4,000 birds.

Fifteen Years of Spring Shorebird Surveys at Delaware Bay

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The beaches and marshes of Delaware Bay in New Jersey and Delaware provide habitat for hundreds of thousands of northbound-migrating shorebirds each spring. Many species of shorebirds stop over to feed and rest in Delaware Bay, the most abundant being red knot, ruddy turnstone, sanderling, semipalmated sandpiper, dunlin and short-billed dowitcher. In an effort to quantify the number of birds and their distribution, we conducted aerial surveys of Delaware Bay beaches each spring in 1986–2000. Surveys were conducted by fixed-wing airplane once a week for five or six weeks between approximately May 2 and June 12. The survey crew consisted of one person who counted birds, one person who identified species composition of flocks, and a third who recorded the information on topographic maps.

The number of shorebirds varied by species, week, and location within the bay. Between 1986 and 2000, maximum, single-day counts of red knots ranged from 20,000 to 95,500; ruddy turnstones ranged from 30,000 to 108,000; semipalmated sandpipers ranged from 42,000 to 285,000; sanderlings ranged from 5,300 to 28,000. Maximum counts of dunlin and dowitcher (mostly short-billed) increased in recent years to 40,000 and 11,000, respectively. Most species (knots, turnstones, sanderlings and semipalmated sandpipers) usually reached their maximum count on 24–27 May; dunlin and dowitchers usually peaked earlier, around 12–15 May. Distribution varied by species: knots and sanderlings were most often found in the southern half of the bay; semipalmated sandpipers were mostly in the northern half of the bay; turnstones were generally equally distributed. Differences in distribution were partially related to habitat preferences of each species. An Analysis of Variance showed that the variables year, week and area of the bay were significantly related to numbers of birds. The number of all shore-



birds declined in southern New Jersey portion of the bay, and numbers of semipalmated sandpipers declined in southern New Jersey and northern Delaware. The only increases were in dunlin and dowitcher numbers. For red knot, ruddy turnstone and sanderling, regression analysis found declining trends in each, but below statistically significant levels.

Annual surveys of the Delaware Bay migration have been valuable in determining habitat use and concentration of species populations that may reflect the overall condition of Delaware Bay as a stopover for migratory shorebirds. Most of the hemispheric red knot population (at least 64% and possibly 90%, depending on the population estimate referenced) uses Delaware Bay to refuel: the last stop that adds resources necessary for completing the migration and beginning nesting. Large proportions of the Eastern Flyway populations of the other species (especially ruddy turnstone and possibly dunlin) are also found here in the month of May. This survey has served to focus attention on the magnitude of the migration, and spurred habitat protection and acquisition. That protection may not be enough, however, in the face of the larger issue: ultimate dependence of the migration on the horseshoe crab population.

ARTS and science: the use of automated radio tracking stations to study the movements of shorebirds

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The use of tiny radiotransmitters weighing one or two percent of the birds that carry them has greatly helped us to map the movements of birds within their home range. Manual

collection of localisations using antenna and receiver, however effective the human ear may be, necessarily restricts the temporal and spatial resolution of plots of daily movements because of its labour-intensiveness. Automated registration of radio-contacts should be of great help, but few reliable devices have so far appeared on the market. Over the last few years, our team has employed Automated Radio Tracking Stations (ARTS) developed and built by Willem van der Veer and Kees van't Hoff, then at the institute Alterra, Wageningen. ARTS consist of an antenna connected to a radio-scanner interfaced to a palmtop computer. The computer is programmed to scan particular frequencies at particular intervals for particular durations and record the ratio between the signal strength and the background "noise" of the pulses received during the predetermined intervals. The system can be calibrated by varying the position of a test receiver with respect to the ARTS at known times and then plot the signal/noise ratios as a function of position. In our experience radiotagged shorebirds at groundlevel can be recorded within a radius of about one km from the stations, but shorebirds with radiotransmitters (glued to their lower back with an antenna emerging from beyond the tail) that migrate at altitudes of 1 km and more can be picked up at distances of 4–6 km (M. Green *et al.* unpubl. data). We have now successfully used arrays of up to 14 ARTS to map the movements of up to 50 different individual Red Knots *Calidris canutus* and/or Great Knots *Calidris tenuirostris* in the Dutch Wadden Sea and in Roebuck Bay, Australia. Depending on the movements of the birds relative to the lie of the land and the position of the ARTS, most individuals can be followed for at least 10% of the time, and for many birds coverages greater than 80% have been achieved. ARTS have also been successfully applied to study the timing of passage of Bar-tailed Godwits *Limosa lapponica* tagged on Texel in The Netherlands in May when they overfly southern Sweden on their way to the Siberian Arctic later that month or in early June.

Abstracts of posters

Red knot diet and prey size selection during northward migration at Punta Rasa, Buenos Aires, Argentina

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During March and April, after red knots (*Calidris canutus rufa*) have left their main wintering areas in southern Patagonia, they migrate northward along the coasts of Argentina. Part of the population relies on Punta Rasa, a brief stopover site lying in between Bahía de San Antonio and southern Brazil stopover sites.

This work examines the extent to which Punta Rasa is used by knots as a refueling station during northward migration. On the basis of fecal and gizzard analysis, diet is discussed and linked with migration routes. Data presented in this work are based on two studies at Punta Rasa carried out

in April 1995 and April 2000. In April 1997, an international expedition took place and birds were cannon-netted. We also used casualties that occasionally occurred during the catching operations. Prey identification was confirmed by examination of the prey remains in faeces collected where the birds had been feeding. Remains of prey occurred in all droppings and consisted entirely of shell fragments of the mudsnail *Heleobia australis*. A total of 295 droppings containing mudsnail fragments were analysed from which the size distribution of ingested *H. australis* could be reconstructed using a regression equation derived from a reference collection ($r = 0.87$, $n = 599$). For both years (1995 and 2000), the size distribution of ingested mudsnails differed from the size distribution of those available ($t = 2.58$, $p < 0.01$; $t = 2.57$, $p < 0.01$). In this study, knots tended to select prey that were approximately 1–3.5 mm in length (mean length approx. 2 mm), but took items ranging from 0.5 mm to greater than 6 mm. All except one of the stomachs analysed also contained mudsnails. The exception contained only insect materials identified as disticid Coleoptera, a very common



type of scarabird present in the area during spring and autumn. These results support the hypothesis that red knots have a specialized diet, at least while staging at Punta Rasa during the austral autumn. The next step is to measure intake rates during the pre-migration period to assess the relative importance of this northward migration stopover site. This study is contributing to a better understanding of the role of Punta Rasa as a stopover site for migratory shorebirds.

Use of two environments, marine and freshwater, by Western Sandpipers *Calidris mauri*, in relation to sex and age in southern Baja California Peninsula, Mexico

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Western sandpipers *Calidris mauri* are among the most abundant shorebirds of the American Continent. On migration, they occur commonly along the Baja California Peninsula using both marine and freshwater habitats. Due to their high energetic requirements, their feeding sites are particularly important. To evaluate the use of both habitats, simultaneous and biweekly censuses were carried out at a coastal site, Chametla beach (CHA), and at a freshwater one, the oxidation lagoons of La Paz City (LO) from August 2000 to February 2001. Additionally, in the same period, western sandpipers were captured using mist nets at both localities to determine the sex and age ratios. The birds captured (341) were measured, weighed and banded (noting also sex, age, and place of capture). *C. mauri* used LO mainly during fall migration and were absent after January. CHA maintained a more constant use with the greatest abundance occurring in January. Males predominated in both areas (LO: 2.6 males to 1 female; CHA: 4.5 to 1). There were as many juveniles as adults at CHA (1.3 juveniles to 1 adult), but juveniles predominated at LO (3.5 to 1). It therefore appears that many juveniles are excluded from the optimal habitat (CHA). In addition, the adults were invariably re-sighted at the same site at which they had been captured (CHA 100%), unlike juveniles (75%). This implies that juveniles are moving more frequently between feeding sites.

Size and sex ratio of Western Sandpipers *Calidris mauri* at La Ensenada de La Paz, Baja California Sur (1997–1998)

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Western sandpipers *Calidris mauri* are the most abundant shorebirds on the west coast of the America Continent. Their migration route includes the Ensenada de La Paz, Baja Cali-

fornia Sur. There, sex ratio and sizes were determined from 752 captured birds during an annual cycle. Males were more abundant than females (4:1). This supports the hypothesis proposed for wintering sites: that males winter further north than females, preferring sites closer to their reproduction areas. During migration, the proportion of females increased (August 3 males: 1 female, February 3.5:1). The largest proportion of males was in November with 96%. Weights showed considerable variation. This suggests two hypotheses: 1) birds visiting the study area belong to different populations, or 2) for some reason, weights vary throughout the year. Biometric studies (culmen, tarsus, and wing) showed no significant size variation over time so the first hypothesis was rejected. In order to study weight variation making allowance for size, weight was standardised by reference to mean culmen length. Both male and female exponential regressions were required in order to define the relationship between culmen and weight (males: calculated weight = 2.77 (culmen)^{0.71}; females: calculated weight = 2.06 (culmen)^{0.81}; $p < 0.01$, in both cases). The slopes from these relationships were used as the correction factor. Both sexes increased their weights after they arrived at the study area, presumably because they were replacing reserves depleted during migration. Weights then declined throughout the winter when energy demand is low. At the beginning of spring, the birds recovered their weights, as they laid down energetic reserves in preparation for migration and reproduction.

Molecular sexing of Semipalmated Sandpipers *Calidris pusilla* from the northern coast of Brazil

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Semipalmated Sandpipers *Calidris pusilla* breed along an extensive area of coastline of the Arctic from Alaska, across Canada to northern Québec, central Baffin island and northern Labrador, apparently in three separate populations. In addition to geographic variation, sex-related differences are found in biometric variables, both within and between populations. Specifically, the length of the wing and culmen in males is shorter than in females, which complicates the morphometric analysis of live birds of unknown sex, especially in wintering areas. In order to test the efficiency of the morphological sexing of *C. pusilla* in the field, blood samples were collected from the brachial vein of 55 individuals captured between 1997 and 2000 on the north coast of Brazil. Following whole DNA extraction, fragments of the genes CHD-Z and CHD-W were amplified through PCR using the P2/P8 oligonucleotide sets, separated in 3% agarose gel. Assessment of the sexing of live birds using molecular studies is rare, but has the advantage of avoiding the need to sacrifice individuals for sexing. The results of our molecular study corroborate the morphometric data, which show that male *C. pusilla* have significantly shorter ($p < 0.05$) culmens than females (mean culmen length: males = 19.96 ± 3.21 mm, n=41; females = 22.08 ± 1.33 mm, n=14).



Nearctic Shorebirds in the Bahía de Asunción, Paraguay

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The Bahía de Asunción is a 375 ha shallow bay located along the northern outskirts of Asunción, and separated from the Paraguay River by the Banco San Miguel, a narrow peninsula of low-lying land. During high water levels (primarily during the austral winter) most of the bay is under water, but as the water level drops in spring, mudflats and sandy beaches appear. As the water continues to recede, most of the mudflats dry out and become grasslands, some of which remain moist. Shorebirds were first studied in the Bahía de Asunción by Hayes & Fox (1991; *Wilson Bull.* 103: 637–649), who recorded 20 species during 47 censuses from 1987 to 1989 (including 15 species of Nearctic migrant). In September 2000, *Guyra Paraguay*, a Paraguayan bird conservation organization, began regular monitoring of shorebird populations in the bay. During the first 25 censuses, conducted from 12 September to 15 December 2000, a total of 19 shorebird species were recorded, including the first documented record of Ruddy Turnstone *Arenaria interpres* for Paraguay.

Of a total of 14 species of Nearctic shorebird recorded during the study period, nine were recorded in 67% or more of all censuses, while only one species, Sanderling *Calidris alba*, was recorded just once (the fifth record for Paraguay). Of these nine species, for seven the highest single-day count was markedly higher (an increase of \oplus 50%) than that recorded by Hayes & Fox (1991). A marked decrease in numbers was noted for just one species, Hudsonian Godwit *Limosa haemastica*. During 9 censuses in September to December 1988, Hayes & Fox (1991) recorded a total of 64 *L. haemastica*, whereas just 18 were recorded during 2000. However, Hayes & Fox (1991) did not record the species during surveys in 1987, and there may be considerable annual variation in their occurrence in the bay.

The Bahía de Asunción would appear to be a regionally important stopover site for the near-threatened Buff-breasted Sandpiper *Tryngites subruficollis*. The highest single count of 140 birds is just less than 1% of the global population, and a minimum of 539 individuals (or 3.6% of the global population) are estimated to have passed through the bay during the study period. Minimum totals for other species include 402 American Golden Plover *Pluvialis dominica* (0.27% of the global population), 1,526 White-rumped Sandpiper *Calidris fuscicollis* (0.38% of the global population) and 1,656 Pectoral Sandpiper *C. melanotos* (0.41% of the North American population).

Laguna Salada: a "New" Site of Regional Importance for Migrant Shorebirds in Paraguay

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The "Gran Chaco Americano" is a vast, relatively flat, alluvial plain occupying southeastern Bolivia, western Paraguay and northern Argentina. In Paraguay, the central Chaco is typified by xerophytic thorn-scrub forests, interspersed in

many areas by large, bare, saline depressions and riverbeds that often form shallow lakes after heavy rains. One such area is the Laguna Salada in Presidente Hayes department which, combined with the surrounding complex of meanders of the Yacare Sur River, forms an extensive area of saline wetland habitats, approximately 111 km² in extent.

In 2000, *Guyra Paraguay*, a Paraguayan bird conservation organization, initiated a migratory bird program, funded by NFWF, with the primary goal of identifying sites of regional importance for Nearctic migrant shorebirds. Previous visits to the Laguna Salada complex had suggested it could potentially be such a site, and censuses initiated in October 2000 demonstrated this to be so. During five censuses conducted between October 2000 and February 2001, 51,000 shorebirds of 21 species were recorded, 43,000 during just two counts in October–November 2000. Summing the highest counts for individual species gives an absolute minimum of 33,600 shorebirds recorded during the five censuses.

Particular highlights included a pre-roost gathering of 25,000 Wilson's Phalaropes *Phalaropus tricolor* at Laguna Salada on 18 November 2000 (intermixed with 2,000 of the near-threatened Chilean Flamingos *Phoenicopterus chilensis*), and records of Black-bellied Plover *Pluvialis squatarola*, Red Knot *Calidris canutus* and Sanderling *C. alba*. All three of these species have been considered as rare in the interior of South America, and were previously known from just two or three records in Paraguay. Surveys on 18 November 2000 recorded small flocks of both *Pluvialis squatarola* and *Calidris alba*, totaling a minimum of 51 and 34 individuals respectively. Both of these species and *Calidris canutus* were recorded in small numbers during other censuses, suggesting that they may be relatively frequent migrants through Paraguay.

Internationally important (\oplus 1% of the global population) congregations of two shorebird species were recorded: White-rumped Sandpiper *Calidris fuscicollis* (4,000 individuals or 1%) and *Phalaropus tricolor* (25,000 or 1.67%). Counts of presumed regional significance include 3,000 White-backed Stilts *Himantopus melanurus*, 1,000 Lesser Yellowlegs *Tringa flavipes* (0.2% of the global population) and 3,000 Pectoral Sandpipers *Calidris melanotos* (0.75% of the global population). Additional notable observations include the sixth and seventh records of Semipalmated Sandpiper *C. pusilla* and the third record of Least Sandpiper *C. minutilla* for Paraguay.

Habitat quality of sandy beaches in south-central Chile for migratory shorebirds: Analysis of its importance as stopovers areas

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The shoreline of Valdivia Province Chile (40°S) is recognized as one of the areas with the greatest density of wintering migratory shorebirds species along the Pacific coast of South America.

Stopover areas, used by migratory shorebirds as re-fueling sites, are links in a latitudinal chain that ensure the survival of the birds. Therefore the key importance of these sites is the food supply they provide.



South-central Chile (38°–42° S) has several sandy beaches rich in macroinfauna (crustaceans like *Excirolana braziliensis* and *Emerita analoga*, insects like *Phalerisida maculata*, bivalves like *Mesodesma donacidium* and polychaetes like *Nephtys impressa*). Peaks of macroinfauna abundance occur in both the austral spring and the fall. These coincide with the arrival of boreal shorebirds (spring) and austral shorebirds (fall). Therefore the sandy beaches of the Province of Valdivia could be stopovers for boreal shorebirds flying to wintering grounds in Tierra del Fuego and for austral shorebirds travelling north. However shorebirds are relatively scarce at these sites. The question therefore arises: why is there not a greater abundance of shorebirds on the sandy beaches of the Province of Valdivia if there is such a rich food supply?

To determine the importance of some areas, which might be stopovers to migratory shorebirds populations, I am evaluating the relationship between the shorebird assemblage and the habitat patterns at five sandy beaches in the Province of Valdivia. So far, I have made 46 bird censuses and have carried out spring and summer macroinfauna sampling (324 samples). I had hoped to find at least 10 shorebirds species, but I have only recorded eight.

Whimbrel *Numenius phaeopus* is the most common species. Their abundance has been constant at La Misión, San Ignacio and Chaihuín beaches but has fluctuated at Curiñanco and Calfuco beaches, where numbers peaked in January and November respectively.

The arrival of Surfbirds *Aphriza virgata* at the end of February, suggested that these beaches are used mainly by boreal migrants returning north and not in the season of southward migration (the fall migration).

Shorebirds of the Sanquianga Natural National Park, Colombia

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We report a preliminary study of the shorebird assemblage of the Sanquianga Natural National Park, a state natural reserve that protects mangroves, beaches and other coastal habitats in the south of the Colombian Pacific coast. 12 surveys along 19 km of coastline were carried out for beaches (sandy beaches and mudflats) and pasture grounds during June and July 2000. Fourteen shorebirds species were identified: 13 species of Nearctic migrant and one resident. The richest habitat was the beach with 12 species, while the pasture grounds supported 9 species. Ten species used the beach to forage and nine used this habitat to rest. On the other hand, the pasture grounds were used for at least five species to forage and two to rest. The relative importance of pasture grounds for shorebirds in this zone is emphasised. This is the first report of the relationship between shorebirds and pasture grounds on the Colombian Pacific coast. This habitat

supported 64% of the species reported by this study. Relative abundance was calculated independently for each habitat. The Ruddy Turnstone *Arenaria interpres* was the most abundant species on the beaches and pasture grounds. This short-time study almost coincided with the beginning of the migration season. The richness of shorebird species is the highest reported for a single locality on the Colombian Pacific coast.

To complement our knowledge about shorebirds in the Sanquianga reserve, more extensive investigations are recommended to include those localities in the coastal zone and those times of the year that were not covered in this study.

Diversity of Shorebirds during spring migration through the Bay of Bluefields and Laguna de Tisma, Nicaragua

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In February 2000, we initiated a survey of shorebirds at spring migration stopovers in Nicaragua. Nicaragua's wetlands are strategically important because they provide stopover opportunities for species that must store fat for a long trans-Gulf migration to North America. Our objectives for this effort are: 1) identify species that stop in Nicaragua during migration; 2) identify the relative abundance of shorebird species in different habitat types; and 3) identify important stopover sites for protection and conservation.

During this first year of study, we conducted surveys in two areas; Bluefields on the Caribbean coast, and Laguna de Tisma, located between Lakes Nicaragua and Managua. Surveys were conducted during each of three months, February, March and April. We observed 23 species of shorebirds; 19 in the Bay of Bluefields, and 16 at Laguna de Tisma. Four of these species, while not particularly rare in North America, have never been officially recorded in Nicaragua. Abundance was highest at both areas during the February and March census periods. Numbers dropped substantially during April.

In this first year of study, some patterns of habitat use were beginning to become apparent. There were no large numbers of shorebirds at any of the Bluefields sites; the largest number of individuals counted from any single point did not exceed 100. The sites in the Bay are typically small mudflats or sandflats, and shorebirds are dispersed among many such small sites. In contrast to the small estuarine sites in the Bay of Bluefields, the Laguna de Tisma is a large wetland complex that exists in a landscape containing other wetlands and flooded rice fields. Based on a count of shorebirds along about 500 m of lakeshore on 18 February (of around 5,000 individuals), we estimated that the number of shorebirds at this site on that date could approach 50,000. The differences between the two sites may reflect a combination of habitat quality, landscape, and geographic factors.



Proposal for the zonification of the Gallegos estuary (Santa Cruz Province, Argentina) for the conservation of the habitats used by migrant shorebirds

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This work was carried out between 1997 and 1999 on the estuary of the Río Gallegos, located in the southeast of southern Patagonia, Santa Cruz province, Argentina. It is an environment subject to multiple use. To the south lies the provincial capital city with approximately 85,000 inhabitants. The aims of the study were 1) to determine the importance of the area for migrant shorebirds; 2) to determine which species of migrant shorebirds use the area; 3) to analyse the potential problems generated by human activities; 4) to propose a zonification of the area leading to the protection of the shorebirds. We recorded 13 species, 7 of which breed in the north of the American continent. Maximum numbers of species and individuals were recorded in February and March. White-rumped Sandpiper *Calidris fuscicollis* was the most abundant species, with 6,500 in January and February. This was followed by Red Knot *Calidris canutus* and Hudsonian Godwit *Limosa haemastica*, with a maxima of 2,500 (February 1998) and 1,000 (March 1998) respectively. Among Patagonian species, the most abundant were Magellanic Oystercatcher *Haematopus leucopodus* and Two-banded Plover *Charadrius falklandicus*, which both nest on the Gallegos estuary. The endemic plover of southern Patagonia, Magellanic Plover *Pluvianellus socialis*, was found from March to May 1999 with numbers ranging between 15 and 145 individuals. Our results indicate that the Gallegos estuary is an important area for shorebirds.

The most serious impact detected in the zone was the extensive use of the tidal flats and salt marshes for urban purposes. This leads to modification or loss of habitat as well as increasing human disturbance due to walkers and pets on the beaches. We propose a zonification of the area using the technique of Inventory System and Planning of Resources (Robinette & Crozier 1976). We propose the creation of a protected area about 12 km long, another area for recreational use and a third for educational activities and ecotourism. This takes into account the sites used by the shorebirds, the capacity of the site for each activity and the distance from the city.

Distribution and abundance of migratory shorebirds along the coasts of the Buenos Aires Province, Argentina: towards a model of habitat use and conservation guidelines

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Information about shorebird distribution and abundance throughout their entire range (breeding, migrating and non-reproductive areas) is critical for their conservation and management. The coastal zone of the Buenos Aires province, in Argentina, includes a wide diversity of habitats that are

used by more than 15 nearctic shorebirds during annual migrations, including those species having their main non-reproductive quarters in southern Patagonia and Tierra del Fuego, like Hudsonian Godwit *Limosa haemastica*, Red Knot *Calidris canutus* and White-rumped Sandpiper *Calidris fuscicollis*. These coasts show the highest human population density and are the most economically developed of the whole Argentinean coastal zone, resulting in a serious threat to habitats and wildlife. The goal of this project is to model shorebird distribution and habitat use along the coasts of the Buenos Aires province, based on field surveys and satellite imagery. The resulting model will contribute to a better definition of those critical coastal areas needing protection. For this purpose, during December 2000–January 2001 we carried out 53 field line-transects and 6 aerial surveys sampling approximately 1,000 km of coastal habitats. We present some preliminary results, including the identification of habitat types and shorebird abundances in each habitat.

For the northern part of the study area (from Magdalena to Miramar), 17 shorebird species were identified, with abundances varying from zero to 654 birds/km at Samborombón bay. The more abundant species were *Calidris fuscicollis*, *Haematopus palliatus*, *Pluvialis dominica*, *Limosa haemastica* and *Calidris canutus*. Abundance and species diversity were higher at estuarine wetland habitats, while they were low at sandy beaches from San Clemente to Mar Chiquita. Sandy beaches south of Miramar, however, showed high abundances of *Calidris alba* associated with “restinga” areas. Shorebird distribution and abundance will be later analysed in relation to habitat features with the help of satellite images and GIS. A better understanding on how shorebirds make use of the Buenos Aires coastal zone during the non-reproductive period, will have significant consequences for their habitat management and conservation.

Changes in patterns of wetland utilisation by the red knot *Calidris canutus rufa* in Peninsula Valdes: a need or an approximation to the optimum?

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Red knot *Calidris canutus rufa* use Fracasso Beach (San Jose Gulf, Peninsula Valdes, Argentina) as a regular stop in their migration from Tierra del Fuego (South America) to the Canadian Arctic. In this wetland, they feed on intertidal invertebrates. Therefore their access to the trophic resource depends on the tidal cycles. From 1994 to 1997, these shorebirds fed in different tidal levels for the whole daytime, leaving the intertidal area only during high tide to roost nearby. In 1999 and 2000, the red knots limited their feeding activity to a half tidal cycle, from high to low tide. Then they abandoned the beach and came back on the next high tide. Based on the analysis of faeces, we concluded that the diet at the alternative feeding area was similar to that in Fracasso Beach. The only possible place where these prey items might be found is Nuevo Gulf, 20 km away, where tides occur half a cycle later. As far as we know, this is the first time that such a drastic change in the daily pattern of habitat use is described for red knot.



The importance of Fracasso beach, Valdes Peninsula, Argentina, as a stop-site used by migrating shorebirds: Report of census and ringed birds observed since 1994

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Every year, from February and April, Fracasso beach is used as a stop site by different species of migrating shorebirds, such as *Calidris canutus rufa*, *Calidris fuscicollis*, *Calidris alba* and *Limosa haemastica* (Scolopacidae); *Charadrius falklandicus* (Charadriidae) and *Pluvianellus socialis* (Pluvianellidae).

During the 1994 to 2000 migrating seasons, we carried out systematic censuses and ringed bird scans.

The most abundant species in all seasons was *C. canutus rufa* while *C. fuscicollis* and *Charadrius falklandicus* were second and third in order of importance.

All the ringed birds observed were red knots. The number of ringed birds annually increased: 7 birds in 1994, 8 in 1995, 29 in 1996, 62 in 1999 and 115 in 2000.

Shorebirds in Bahía Bustamante (Chubut, Argentina): seasonal variation and habitat use

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Bahía Bustamante, on the central Atlantic shore of Patagonia, is an important ornithological area, already known for two endemic species (*Tachieres leucocephalus* and *Larus belcheri*) and other big sea birds colonies. It is a wintering and stopover area for neotropical migratory shorebirds and breeding and permanent areas for Patagonian shorebirds, where even species such as *Pluvianellus socialis*, *Charadrius modestus* and *Tringa melanoleuca* can be found. During the three years of this study (1997–1999), the numbers of Arctic-breeding shorebirds (*Calidris alba*, *Calidris canutus*, *Arenaria interpres*, *Pluvialis dominica*, *Pluvialis squatarola*

and *Limosa haemastica*) were very variable. This indicates that it is an alternative stopover site, which can help small numbers of birds to refuel. *Calidris fuscicollis*, however, was present during the three austral summers, from November to February, indicating that this species is “wintering” in the area. *Numenius phaeopus* was present briefly during two of the three austral summers (63 individuals in 1997 and 258 in 1999). *Haematopus palliatus* and *Charadrius falklandicus* breed in the area during October and November. The highest numbers of *Charadrius falklandicus* and *Haematopus leucopodus* were always observed after February, which may indicate the return of those birds that have migrated to breed in other areas. The most important roosting place was “La Salina”, a salt-flat area inland used by birds coming from many different feeding areas. This intertidal area offers different types of feeding habitat: mud-sandy areas with small burrowing clams, restingas with mussels and arthropods and muddy areas with crabs; where every species seems to find their favourite prey.

“Attention! banded bird”

Pablo Luis Michelutti

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Colour poster for public awareness about re-sightings of banded birds in Laguna Mar Chiquita, Córdoba, Argentina, which is a Hemispheric Site of the Western Hemisphere Shorebird Reserve Network. In Spanish. Size: 30 × 42 cm.

“Hemispheric Site”

Ministerio de Agricultura Ganadería y
Recursos Renovables de la Provincia de Córdoba,
Argentina

Colour poster for public awareness made in March 1991 to commemorate the declaration of Mar Chiquita Natural Area Protected, Córdoba, Argentina as a Hemispheric Site of Western Hemisphere Shorebird Reserve Network. In Spanish. Size: 33 × 40.5 cm.

