

Analysis of Red Knot *Calidris canutus rufa* banding data in Brazil

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Antas, P.T.Z. & Nascimento, I.L.S. 1996. Analysis of Red Knot *Calidris canutus rufa* banding data in Brazil. *International Wader Studies* 8: 63–70.

During the first two weeks in April, most Red Knots captured in Lagoa do Peixe in Brazil moulted their contour feathers to attain full breeding plumage; primaries and tail feathers were moulted in November, when the birds first arrived at the wintering grounds. Body masses increased over the first two weeks in April, although mean body masses varied considerably between years. Red Knots in Lagoa do Peixe originated from southern Argentina and Chile and migrated north to Punta Rasa and the coast of Rio Grande do Sul, to Maranhão state in northern Brazil and subsequently to Delaware Bay and Cape May, New Jersey. Southward migrants into Brazil originated from South Carolina and Massachusetts in July and August and Guyana in September.

Durante las dos primeras semanas de abril, la mayoría de los canutos rojos (también conocidos como 'correlimos gordo') capturados en Lagoa do Peixe en Brasil mudaron sus plumas de contorno para cambiar a un plumaje de reproducción; mudaron las plumas primarias y caudales en noviembre, cuando las aves llegan primero al territorio de invierno. La masa corporal aumentó en las primeras dos semanas en abril, si bien la masa corporal media varió considerablemente de un año a otro. Los canutos rojos en Lagoa do Peixe vienen del sur de Argentina y Chile y migran al norte a Punta Rasa y la costa de Rio Grande do Sul, al estado de Maranhão en el norte de Brasil y posteriormente a la bahía Delaware y Cabo May, Nueva Jersey. Las aves que migran hacia el sur a Brasil provienen de Carolina del Sur y Massachusetts en julio y agosto y de Guyana en septiembre.

Au cours des deux premières semaines d'avril, la plupart des bécasseaux maubèches capturés dans la Lagoa do Peixe au Brésil perdaient leurs plumes de contour pour acquérir leur plumage nuptial complet. Les rémiges primaires et les plumes de la queue étaient tombées en novembre lorsque les oiseaux sont arrivés aux aires d'hivernage. Leurs masses corporelles ont augmenté au cours des deux premières semaines d'avril, quoique les masses corporelles moyennes varient considérablement d'une année à l'autre. Les bécasseaux maubèches du Lagoa do Peixe proviennent du sud de l'Argentine et du Chili; au cours de leur migration vers le nord, ils sont passés par Punta Rasa et la côte du Rio Grande do Sul, ainsi que par l'État de Maranhão dans le nord du Brésil, avant d'arriver dans la baie du Delaware et au cap May, dans le New Jersey. Les oiseaux migrant vers le sud, vers le Brésil, sont partis de la Caroline du Sud et du Massachusetts en juillet et août, et de la Guyane en septembre.

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Introduction

The Red Knot *Calidris canutus rufa* is one of the Nearctic subspecies of knots breeding in the central Canadian Arctic. Its wintering grounds in the Western Hemisphere are scattered from western Florida in the United States to Tierra del Fuego and Patagonia in Argentina and Chile (Morrison & Harrington 1992). Morrison & Ross (1989) found the largest wintering concentration in the Chilean sector of Tierra del Fuego. In Brazil, wintering flocks occur along the northern coast, the delta of the Amazon River (Morrison & Ross 1989; Morrison, Ross & Antas 1989; Morrison & Harrington 1992) and at Lagoa do Peixe National Park (31°10'S, 51°00'W) in southern Brazil (Belton 1984). Staging areas utilized by knots during spring and fall migrations are located at Rio Grande do Sul

(Belton 1984; Harrington, Antas & Silva 1986) and along the Maranhão coastline in northern Brazil (R.I.G. Morrison & P.T.Z. Antas, unpubl. data). During the breeding season, small numbers of non-breeders remain in Rio Grande do Sul and Lagoa do Peixe National Park (Belton 1984).

Because of the importance of Lagoa do Peixe for the conservation of coastal birds, including high numbers of Nearctic and Patagonian shorebirds, the Brazilian government established it as a national park in November 1986. The area was also proposed by the Instituto Brasileiro do meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) as an International reserve in the Western Hemisphere Shorebird Reserve Network (WHSRN) in March 1990. The proposal was accepted by the WHSRN Council in April 1991.

This paper summarizes the recapture/recovery data obtained from Red Knots marked and banded in Brazil and also data collected on moult and body mass.

Materials and methods

From April 1984 through to April 1991, 1,087 Red Knots were banded in Lagoa do Peixe National Park plus 3 at the mouth of the Amazon River, for a total of 1,090 birds. The birds captured in the Amazon were netted on a small island (25 ha) surrounded by mudflats. The tidal amplitude in this portion of the Brazilian coastline reaches 6 m, and the birds foraged on the available mudflats and roosted on sandy beaches during high tide.

All the birds were captured at night with mist nets erected over shallow water. Each bird received a CEMAVE (Centre for Research and Conservation of Wild Birds) metal band, either stainless steel or aluminium, as well as colour bands. From 1986 to 1991, colour band combinations were assigned by the Pan-American Shorebird Program (PASP). In that same time period, the birds were also colour-marked with a picric acid solution. Volunteers throughout Brazil and North America provided details of sightings made of these birds, and recoveries of metal bands were also reported to CEMAVE.

Data on body mass were obtained by using 300-g Pesola scales, and the birds were also examined for moult during weighing. Based on the examination of the plumages (see Prater, Marchant & Vuorinen 1977; Hayman, Marchant & Prater 1986), each bird captured was classified as (1) young-of-the-year, (2) sub-adult, (3) adult–non-breeding, (4) adult–intermediate and (5) adult–full-breeding. The data collected were lumped by week (cohorts), such that all the birds captured in the same week were treated as a single unit. In the tables and figures included in this paper, the first weekday of each week is used to represent the full week's data.

Results

Moult schedule

Although there was variation between years in the percentage of birds that had completed the moult of contour feathers, a general pattern was found (Figure 1). Most birds captured in the first week of April (1987 and 1988) were actively undergoing the moult of the contour feathers; 21% of the birds were not moulting and were already in breeding plumage. As April progressed, the percentage of non-moulting knots increased, thus showing that full breeding plumage was attained during the first two weeks of April for most of the population. The new red feathers have a dull tip, and its wear

renders the plumage brilliant red at the belly, which is noticeable in some individuals by late April or early May.

However, within the same period, the moulting schedule varied from year to year, as was shown in our 1986 sample, when 84% of the birds were not moulting. In the third week in April, 42% of the birds in 1991, 59% in 1985 and 65% in 1990 were also not moulting. The only sample available from the southward migration (the first week of November in 1986) showed that some birds were still in the process of moulting the contour feathers to the eclipse or non-breeding plumage at that time of the year, although the majority had already moulted.

Outside of the first-year cohort, which was recognized in April by the birds' completely dull plumage, very worn primaries and greenish-yellow tarsus plus light body mass, no adult or sub-adult knots were moulting flight feathers or tail feathers. This moult occurs earlier, beginning around the time the birds arrive on their wintering grounds, as the November sample suggested; four of ten knots were then moulting primaries (numbers 3–7). A similar pattern of primary moult was found in the Semipalmated Sandpiper *Calidris pusilla* wintering in north-eastern Brazil, with the adults moulting the primaries from September until December/January (Antas & Nascimento 1990). The same was also true for Sanderling *Calidris alba* wintering in Pernambuco in north-eastern Brazil (Nascimento, Antas & Azevedo-Junior 1990). In west Africa, the wintering population of *C. c. canutus* begins to moult primaries soon after its arrival in Banc d'Arguin, Mauritania (Piersma, Prokosh & Bredin 1992).

Body mass

The average body mass of the samples also showed variable patterns between years (Figure 2). The average body masses ranged from 120 to 205 g. The second-week samples showed a slight increase in average body mass over the first-week birds, except in the 1987 sample.

When the maximum individual body masses in any week over all years were compared, the general pattern was the occurrence of a plateau, which varied annually, even when comparing the same months (Figure 3). The widest difference in maximum body masses between the first and second weeks occurred in 1988, when the maximum in week 1 was 145 g and the maximum for week 2 was 244 g (Figure 3). On the other hand, in 1986, the maximum body mass in week 2 was lower than the maximum mass recorded in week 1 (Figure 3). Over all years, the lowest body mass was 140 g.

Increases in maximum body masses between weeks 1 and 2 in 1988 (see Figure 3) were probably due to

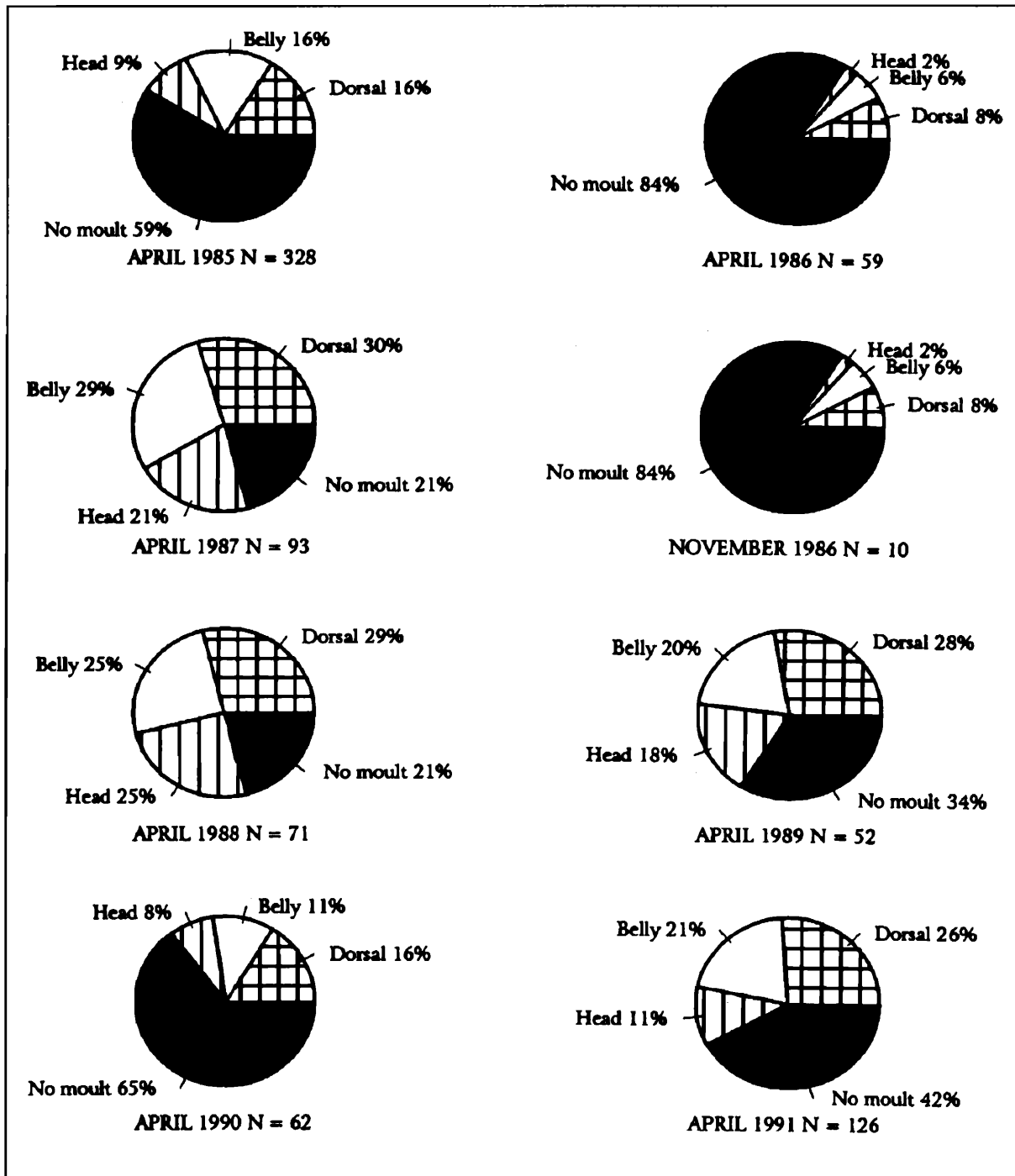


Figure 1. Body moult of *Calidris canutus* in Lagoa do Peixe National Park in Brazil.

birds coming from more southerly locations and thus arriving in Lagoa do Peixe with exceptionally high body masses. We interpreted the 1986 decrease as being due to the departure from the area by the birds with the highest body masses. The year 1986 was a year of severe drought, which was followed by very heavy rainfall. Hence, there was exceptional run-off of fresh water into the habitat, such that the lagoon contained primarily fresh and brackish water. Most of the birds that favoured a marine habitat moved from the lagoon to the seashore.

Band recoveries and sightings of colour-marked birds

To date, 144 bands and sightings of colour-marked knots that were banded or marked in Lagoa do Peixe have been reported. Only four bands were actually recovered. Of the sightings of colour-marked birds, 46 were of unknown individuals and 94 were resightings of the same birds. There were no retraps of banded birds. The annual recovery rates are shown in Table 1.

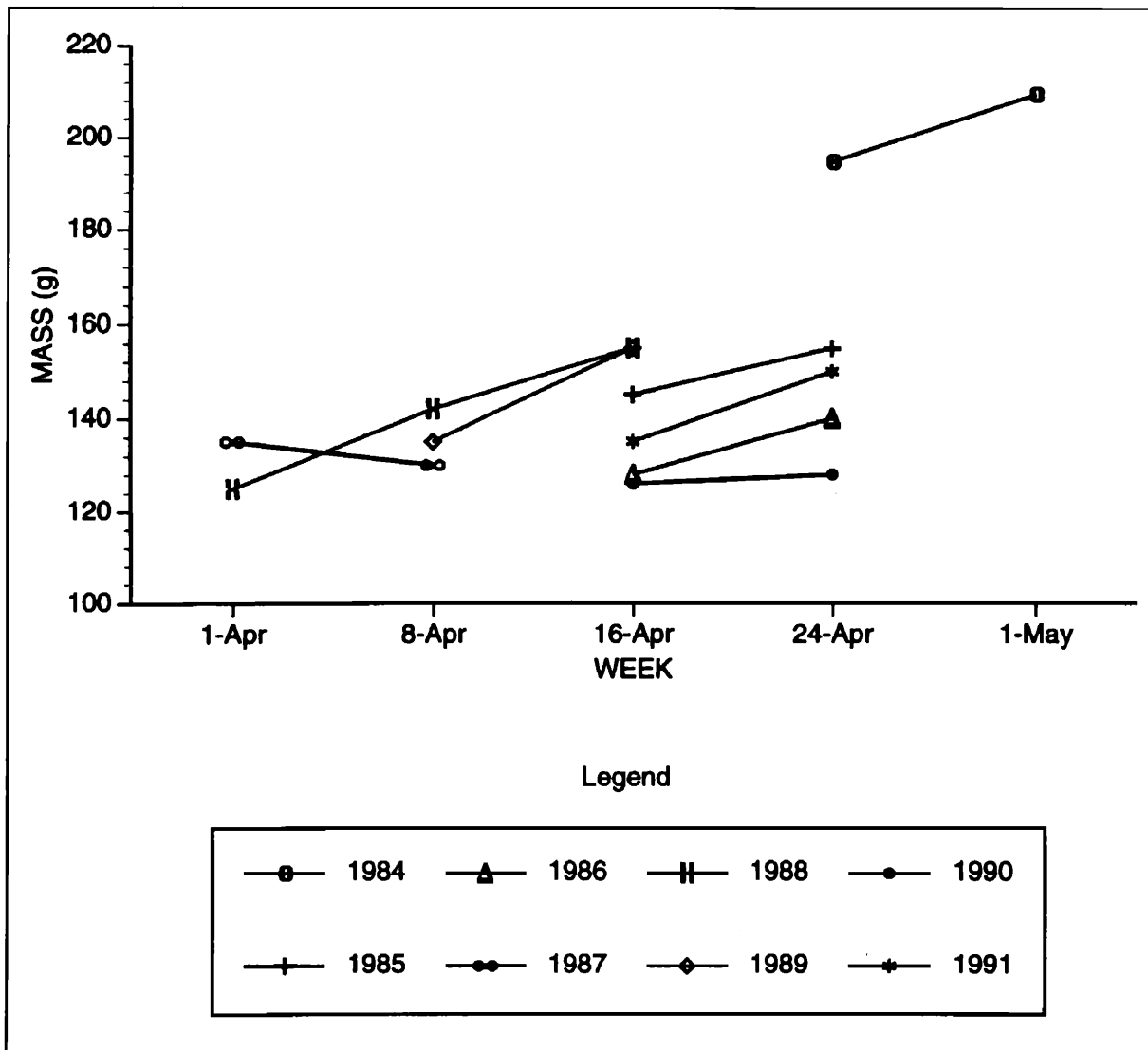


Figure 2. Average body masses of *Calidris canutus* in Lagoa do Peixe National Park, Brazil.

Northward migration

Most of the knots at Lagoa do Peixe in March, April and May originate from the southernmost portions of South America. Those birds banded and marked in Lagoa do Peixe were sighted in Punta Rasa, Buenos Aires Province, in Argentina and along the coast of Rio Grande do Sul. Knots banded in Lagoa do Peixe in April and May were subsequently seen in the northern parts of Rio Grande do Sul and south of Santa Catarina by mid-May (Figure 4). The next known stop is the Turiaçu beaches in Maranhão state in northern Brazil, again in mid-May. The time period from mid- to late May is when knots occur in Delaware Bay near Cape May. Beyond the eastern United States, there has been one sighting of our colour-marked knots, at Presqu'île Provincial Park on Lake Ontario, Canada (Figure 5).

Southward migration

The first post-breeding return came from South Carolina on 28 July 1986, when two birds were seen (Figure 6). Other birds recorded in the United States were in Massachusetts in mid-August, and two birds were seen in the Berbice area of Guyana in mid-September. There were no other records south of Lagoa do Peixe to allow us to trace the migratory path to the wintering grounds.

Discussion

The data suggest that most of the knots at Lagoa do Peixe National Park came from southerly wintering grounds in Argentina or Chile, although a small proportion overwintered there (Belton 1984).

Two lines of evidence suggest that the knots at Lagoa do Peixe moved slowly northward as April progressed. There were sightings of the previous year's colour-marked birds at Cassino beach near

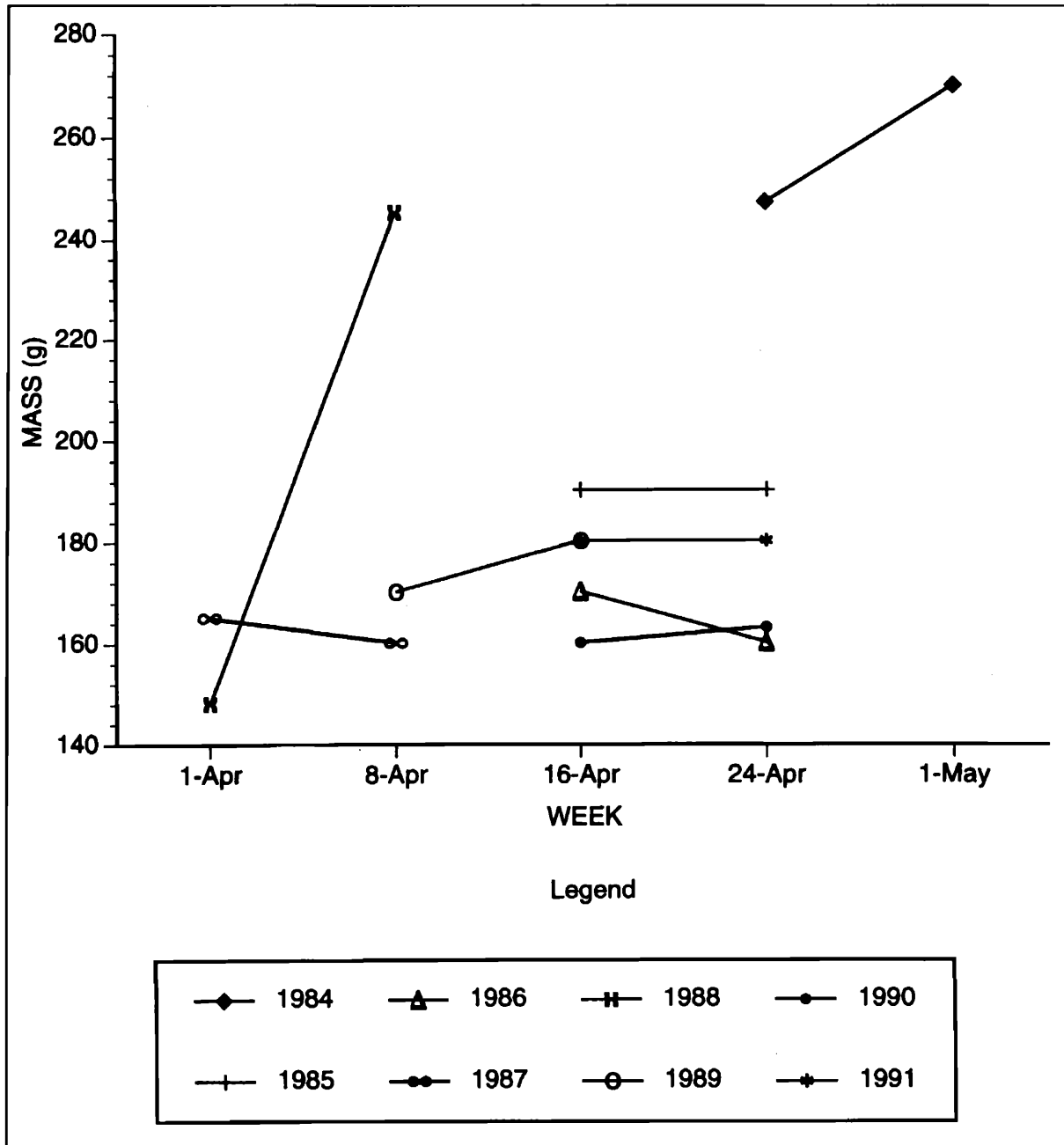


Figure 3. Maximum individual body masses of *Calidris canutus* in Lagoa do Peixe National Park, Brazil.

Rio Del Grande in mid-April. One of these birds was resighted the following year in Lagoa do Peixe. In 1991 and 1992, some birds were north of Rio Grande do Sul near Pinhal at the end of April. These last observations were significant, as the picric acid dye is lost when the birds moult their contour feathers. Those birds seen near Pinhal in 1991 and 1992 were certainly dyed earlier in those same years. The lack of retraps of marked birds in Lagoa do Peixe suggests a rapid turnover of knots.

At the end of April and in early May, the birds increased their fattening rates and departed on the long migratory flight; some birds stopped along the Maranhão state coastline, although most of the

birds likely continued on to Cape May. Table 2 shows the straight-line distances between stops, the minimum body masses required for each non-stop flight and the time necessary to fly these distances. The minimum body masses and the times shown in Table 2 are conservative applications of the formulae derived for shorebirds by McNeil (1970) and modified by us with hypothetical values for flight speeds estimated at 60 km/h. Theoretically, the average body mass of knots in Lagoa do Peixe in mid-April was sufficient only to reach the Maranhão coastline. The early May sample had too little fuel to accomplish the non-stop flight to the United States. The individual maximum body

Table 1. The numbers of knots banded at Lagoa do Peixe and sightings of colour-marked birds between 1984 and 1991, inclusive.

Year	Number banded	Number sighted	Recovery rate (%)
1984	281	10	3.6
1985	332	27	8.1
1986	69	20	29.0
1987	94	44	46.8
1988	70	14	20.0
1989	51	13	25.5
1990	64	16	25.0
1991	126	–	–
Total	1,087	144	13.2

Note: The number individually colour-marked under PASP was 474 (43.6%).

masses suggest that some knots could accomplish the flight with perhaps a quick stop at Maranhão.

The stop-over in Delaware Bay includes birds from Lagoa do Peixe; one of our colour-marked birds seen on the coast of Maranhão in 1987 was subsequently resighted in Delaware Bay in 1988 and 1990. The maximum stop-over interval confirmed by observations of colour-marked birds in Delaware Bay was seven days.

Coastal areas at Rio Grande do Sul must provide a rich source of food for knots. At Lagoa do Peixe, knots feed on polychaetes, the snail *Littorina*, *Emerita* spp., *Donax* spp. and adult mosquitoes. Food items may vary from year to year owing largely to differences in precipitation. In years when waters are brackish, salt-water invertebrates flourish. In years with heavy rains, these species do not occur in large numbers; they also become unavailable to the knots, as the birds cannot reach them because of the deeper waters. The abandonment of the lagoon by knots in 1986 is an example of such a situation.

Lagoa do Peixe is one of the major staging areas for knots in Rio Grande do Sul. When birds are present, there is a constant northward movement of knots through the area. Another major concentration of knots occurs at Pinhal in early May. The entire state coastline appears to be important, as it supplies knots with sufficient energy for moult and fat deposition in preparation for the long flight northwards.

This same coastline is also used by other species. However, like many other similar beaches in many parts of the world, the increasing human population uses these same beaches for recreational purposes. The creation of the Lagoa do Peixe National Park provided some control of human uses of the area, and its inclusion in the WHSRN gave further support to control disturbance.

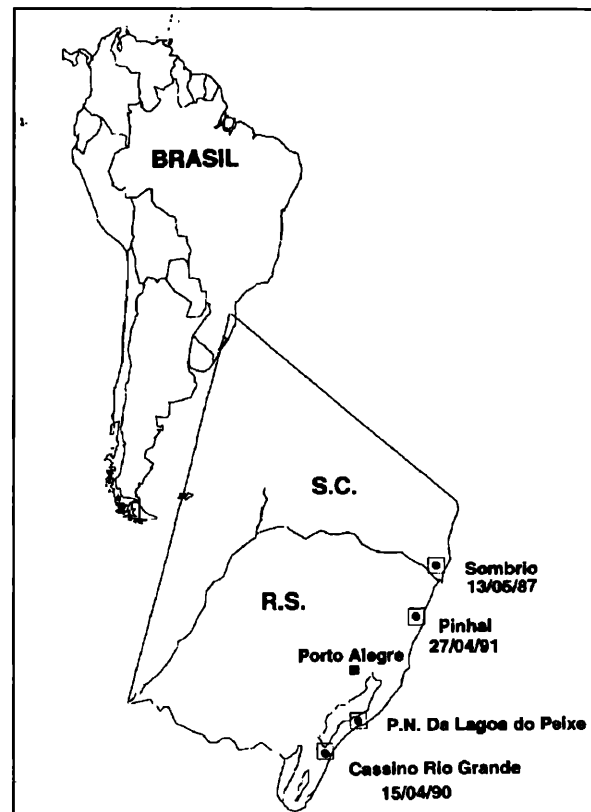


Figure 4. Recoveries of knots banded in Lagoa do Peixe and found in Rio Grande do Sul (R.S.) and Santa Catarina (S.C.) state coastlines.

However, the entire coast of the state needs attention.

Another significant threat to the area from human sources is oil spillage. This is unfortunately common in the northern portion of the state coast, where an oil terminal is located. A major oil spill in late April or early May could be catastrophic for migrating knots. The long distance from southern Brazil to the next two northern stops in the course of the birds' migration makes that coast crucial for the future of this subspecies.

Acknowledgements

This paper was only possible thanks to the interest and effort of many people who joined the CEMAVE's expeditions to Lagoa do Peixe or attended CEMAVE's workshops there. To all 80 participants, we extend our grateful thanks. The CEMAVE's expeditions and workshops were funded mainly by IBAMA, and complementary funds were provided by the Canadian Wildlife Service (Latin American Program), World Wildlife Fund (US), US Fish and Wildlife Service and Nature Conservancy. We wish to acknowledge their valuable contributions. Important support was furnished by the WHSRN, especially with regards to the provision of colour bands and forwarding to

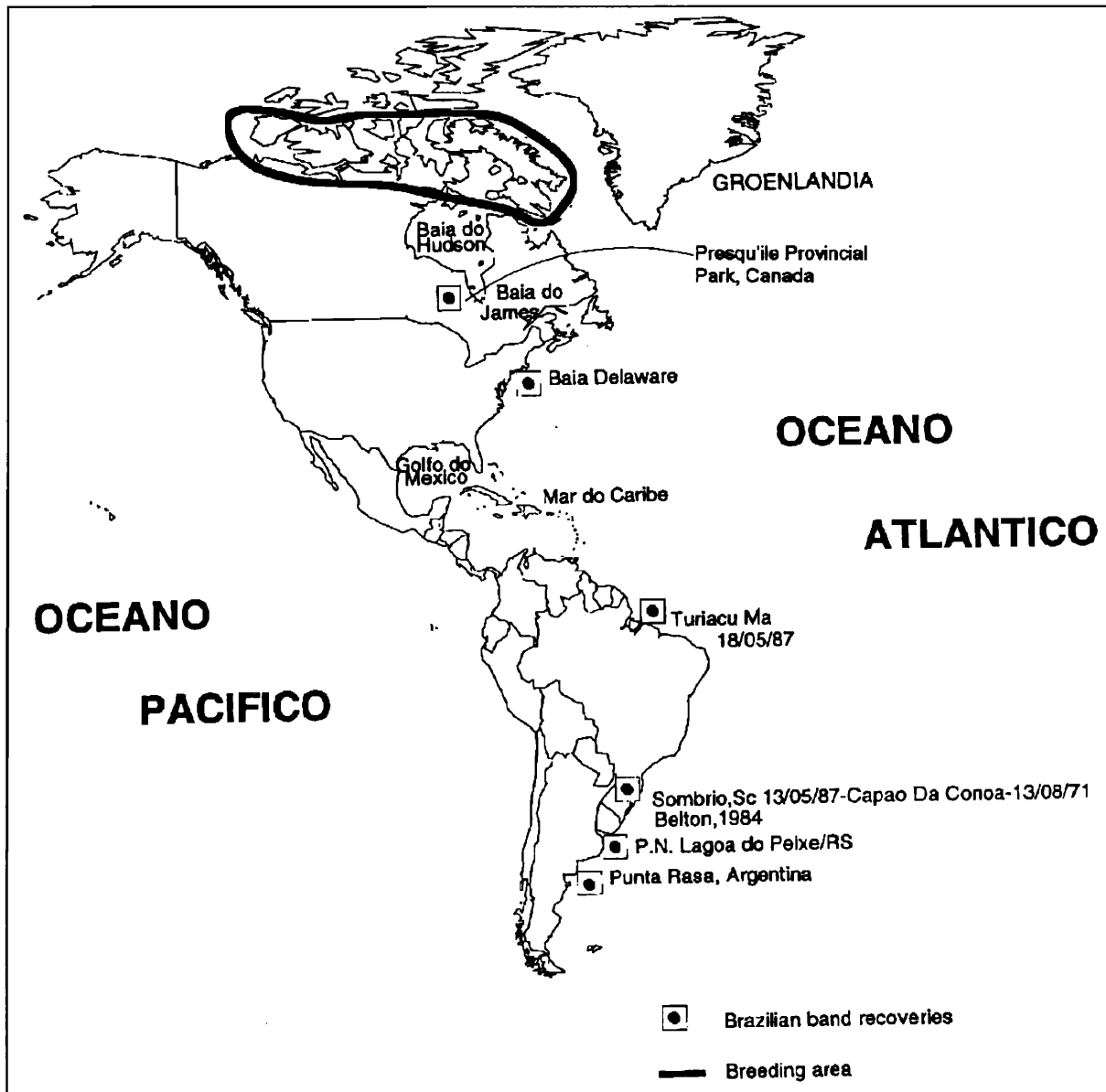


Figure 5. Northward migration of knots using Rio Grande do Sul, based on band recoveries and literature.

us observations of colour-marked birds. The WHSRN provided a grant to Inêz Nascimento to present this paper to the IV Congreso de Ornitologia Neotropical in Quito, Ecuador, in 1991.

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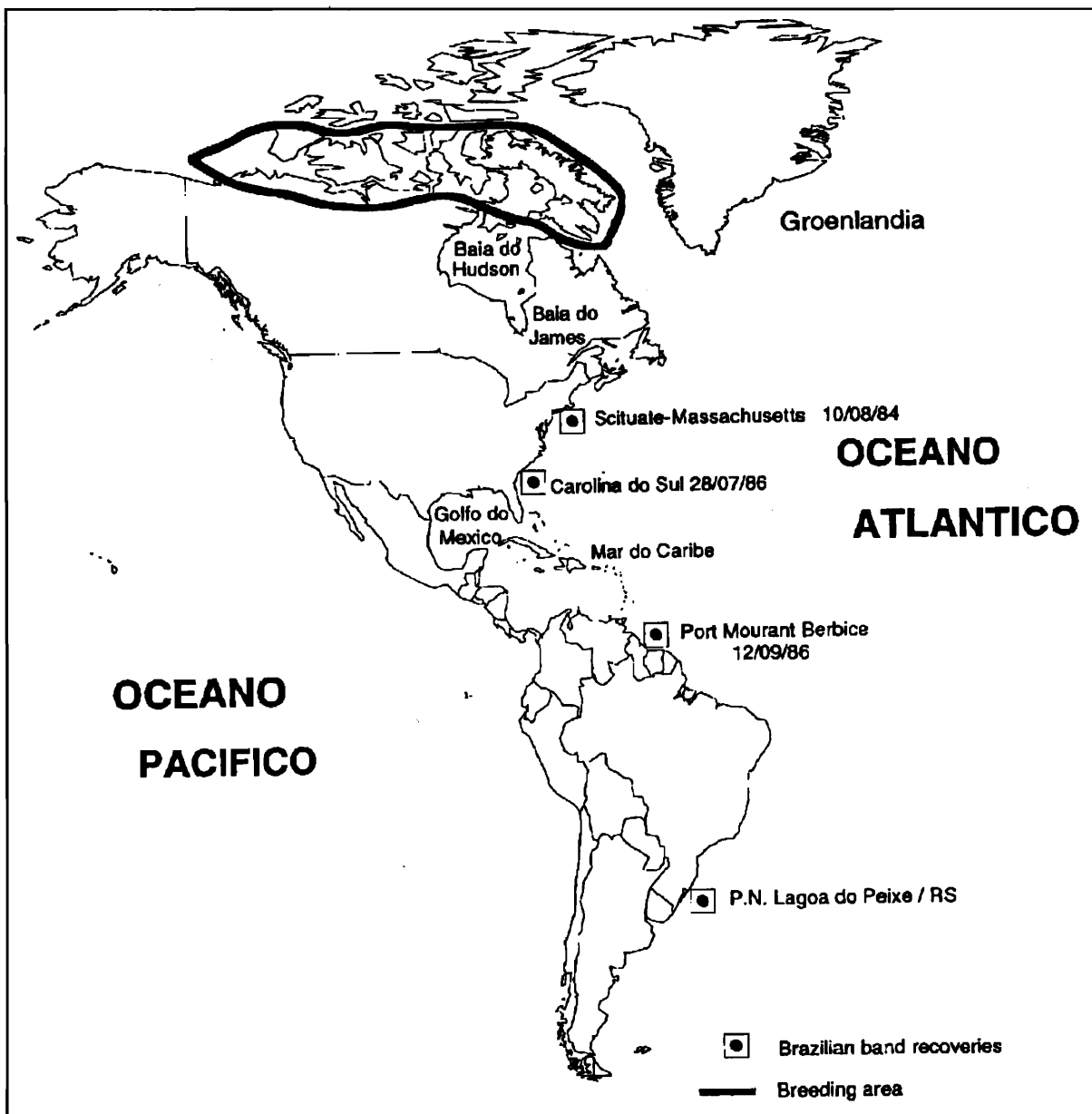


Figure 6. Southward migration of knots using Rio Grande do Sul coastline, based on recoveries.

Table 2. Hypothetical estimations of the minimum mass required for an individual knot to fly between known stop-over areas during the northward migration.

	Distance (km)	Minimum mass (g)	Estimation of flight time (h)
Lagoa do Peixe → Maranhão	3,200	145	42 ± 48
Maranhão → Delaware	5,000	200	66 ± 72
Delaware → Arctic	3,200	145	42 ± 48

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