TABLE 13. INVERTEBRATES RECORDED IN TRANSECT SAMPLING AT BAHÍA LOMAS, CHILE, AND THE RELATIVE ABUNDANCE OF EACH.

	N	%
Mollusca, Bivalvia		
Darina solenoides	1,815	51.3
Bivalvia (unidentified species)	3	0.1
Mollusca, Gastropoda		
Gastropoda (unidentified species 1)	4	0.1
Gastropoda (unidentified species 2)	3	0.1
Polychaeta		
Paraonidae		
Paraonidae (unidentified species)	875	24.8
Phyllocidae		
Eteone sp.	331	9.4
Nephtyidae		
Aglaophamus sp.	13	0.4
Opheliidae		
Travisia sp.	13	0.4
Euzonus sp.	29	0.8
Spionidae		
Scolelepis sp.	23	0.7
Scolecolepides sp.	165	4.7
Glyceridae		
Glycera sp.	1	0.03
Polychaeta (unidentified species)	11	0.3
Crustacea		
Isopoda 1	13	0.4
Amphipoda (unidentified species 1)	178	5.0
Amphipoda (unidentified species 2)	1	0.03
Others		
Insecta	3	0.1
Insect larvae	20	0.6
Nematoda	20	0.6
Nemertea	11	0.3
Unidentified	3	0.1

prey at Bahía Lomas, just as might be expected in view of the prey taken by Red Knots worldwide (Piersma 1994).

WINTER HABITAT—ARGENTINA

Wintering Red Knots in Argentina are now largely confined to Bahía San Sebastián and Río Grande in the Province of Tierra del Fuego. Knots feed mainly within the mudflats of Bahía San Sebastián and along sandy beaches, mudflats, and restingas in Río Grande (P. M. González, unpubl. data).

WINTER HABITAT—BRAZIL

The main wintering area of Red Knots in Brazil is on the coast of the state of Maranhão where they forage along sandy beaches, tidal mudflats, and mangroves (I. Serrano, unpubl. data).

WINTER HABITAT—PANAMA

A small number of Red Knots winter in the Upper Panama Bay where they utilize the soft, silty mud in the tidal mudflats near Panama City (Buehler 2002).

POPULATION SIZE AND TRENDS

In breeding habitats, Red Knots are thinly distributed across a huge area of the Arctic, where we have no comprehensive understanding

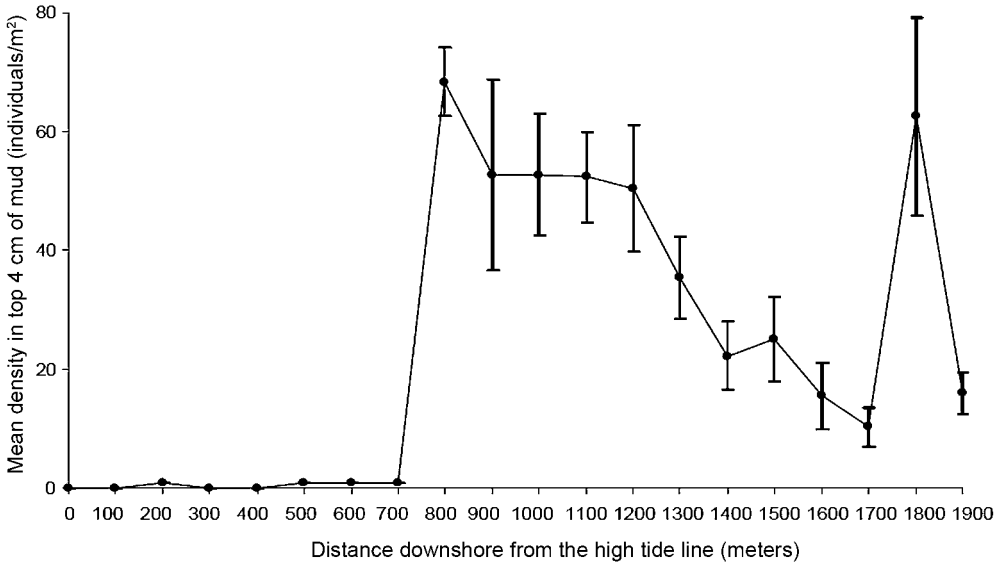

FIGURE 26. The intertidal distribution pattern of *Darina solenoides* at Bahía Lomas, Chile (Espoz et al. 2008).

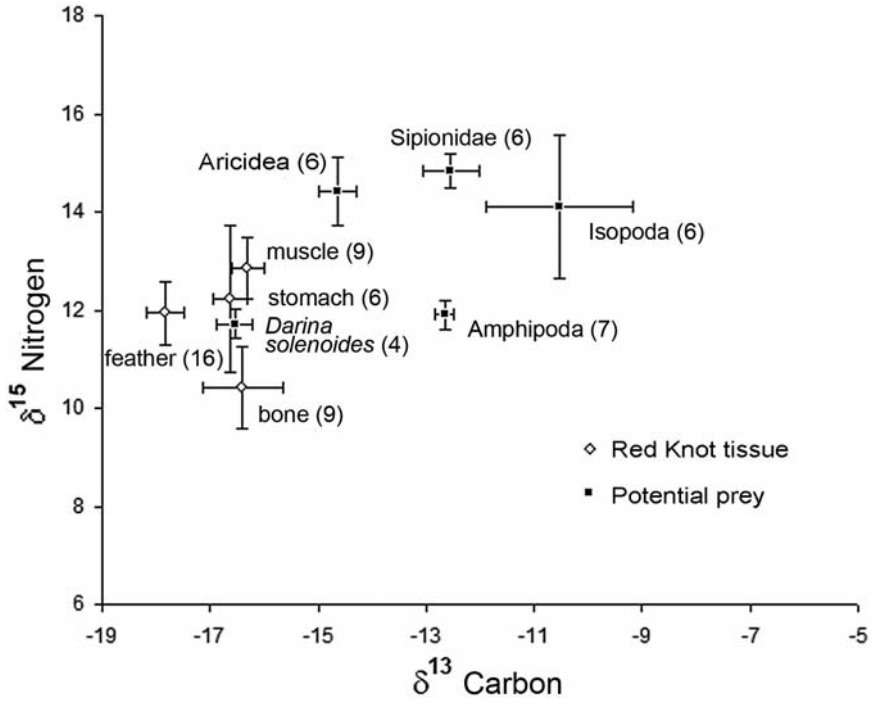

FIGURE 27. Isotopic signatures ($^{13}C/^{12}C$ and $^{15}N/^{14}N$) of tissue samples from Red Knots and benthic invertebrates from the tidal flats of Bahia Lomas, Tierra del Fuego, Chile. Sample size in parentheses (Espoz et al. 2008).

of breeding density or productivity. It is thus necessary instead to rely on surveys in primary wintering and stopover areas as the basis for monitoring population change. Fortunately the *C. c. rufa* population of the Red Knot is one of the best studied long-distance migrant shorebird populations in the world, with surveys taking place in nearly all of the key sites used along its 15,000 km flyway. These give us a reasonably complete picture of its critical habitat throughout the flyway. The surveys have also identified a number of problems in population structure that need to be taken into account in the assessment of population change.

Red Knot Populations of the Americas

The primary wintering area of the *C. c. rufa* subspecies of the Red Knot is now restricted to three sites on the main island of Tierra del Fuego (Morrison and Ross 1989, Morrison et al. 2004). In recent years, about 70% of the population has been found in just one bay, Bahía Lomas in the Chilean part of the island, with most of the remainder at Río Grande in the Argentinian part with smaller numbers at Bahía San Sebastián (Fig. 28). In the mid-1980s, this population numbered 67,000 and the wintering area extended northwards along the Argentinian coast from Tierra del Fuego to Río Negro province. Now, the population is not only confined to Tierra del Fuego but has decreased to only 17,211 in 2006.

During migration to its Arctic breeding grounds, *C. c. rufa* stop over in Delaware Bay in late May and numbers counted there have fallen in broad correlation with those in Tierra del Fuego. However, recent studies have shown that Red Knots from two other wintering areas also migrate through Delaware Bay. These are the populations that winter in the southeastern U.S. (mainly Florida) and Maranhão, northern Brazil (Atkinson et al. 2005), the subspecific status of which is uncertain.

The Red Knot population that winters mainly on the west coast of Florida was counted by aerial surveys in the 1980s, and was estimated at between 6,500 and 10,000 by Morrison and Harrington (1992), but counts in the 1993–1994 winter suggest a population of no more than about 4,000 (Sprandel et al. 1997). The most recent estimate is 7,500 birds based on a count of 7,000 Red Knots in South Carolina (April 2003) and 4,000–5,000 in one area in western Florida (November 2004; B. A. Harrington, unpubl. data). Recent evidence suggests that

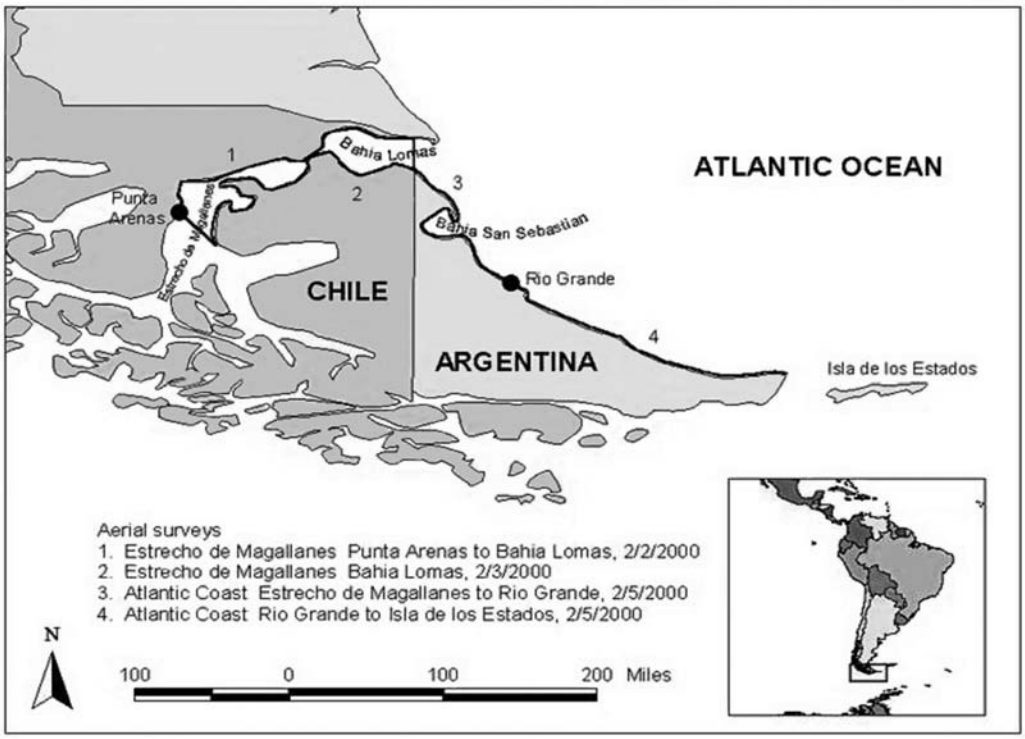

FIGURE 28. Tierra del Fuego and Bahía Lomas, Chile, the primary wintering grounds of *Calidris canutus rufa*.

this population may move with available resources as far north as the coast of Georgia and the winter population there can vary from hundreds in some years to a maximum of 5,000 in others (B. Winn, pers. comm.). There is no reliable evidence of a trend for the Florida wintering population. The count data are very erratic from year to year, probably because of the difficulty of finding Red Knots along Florida's greatly fragmented coastline. All that can be said is that no evidence suggests a major change in the size of the population and that it is probably still of the same order of magnitude as it was in the 1980s. Counts in Cape Romain NWR, South Carolina, indicate declines in the number of Red Knots on passage in both spring and late summer–fall (Fig. 29). It is not known to which wintering population or populations these birds belong. Possibly they are from the Tierra del Fuego population that has shown a clear decline, as described above.

The population wintering in the Maranhão region of Brazil was surveyed in February 2005 with a count of 7,575 (Baker et al. 2005a), which is only slightly below the 8,150 recorded by Morrison and Ross (1989) in the mid-1980s. However, the 20-yr gap between surveys means that there could have been trends that have not been detected.

In view of current uncertainties about the subspecific status of the northern wintering Red Knots, they are here treated as distinct biogeographic populations and considered separately so far as is possible. *C. c. rufa* breeds in the central and eastern Canadian Arctic, and birds wintering in southern South America are referable to this race. However, it is unclear where the Florida and Maranhão birds breed or whether they are referable to *C. c. rufa* or *roselaari* or even a hitherto undescribed subspecies. Color banding and the isotope signature of flight feathers show that substantial numbers (though probably not all) of the birds that winter in both Maranhão and the southeastern U.S. pass through Delaware Bay during spring migration along with the birds from Tierra del Fuego (Atkinson et al. 2005). Isotope signatures from Southampton Island (P. W. Atkinson, unpubl. data) suggest that some of the Red Knots nesting there are from the northern wintering group, but birds with the orange flags of the Argentinian (Tierra del Fuego) population have also been seen on the same island at East Bay (P. A. Smith, pers. comm.).

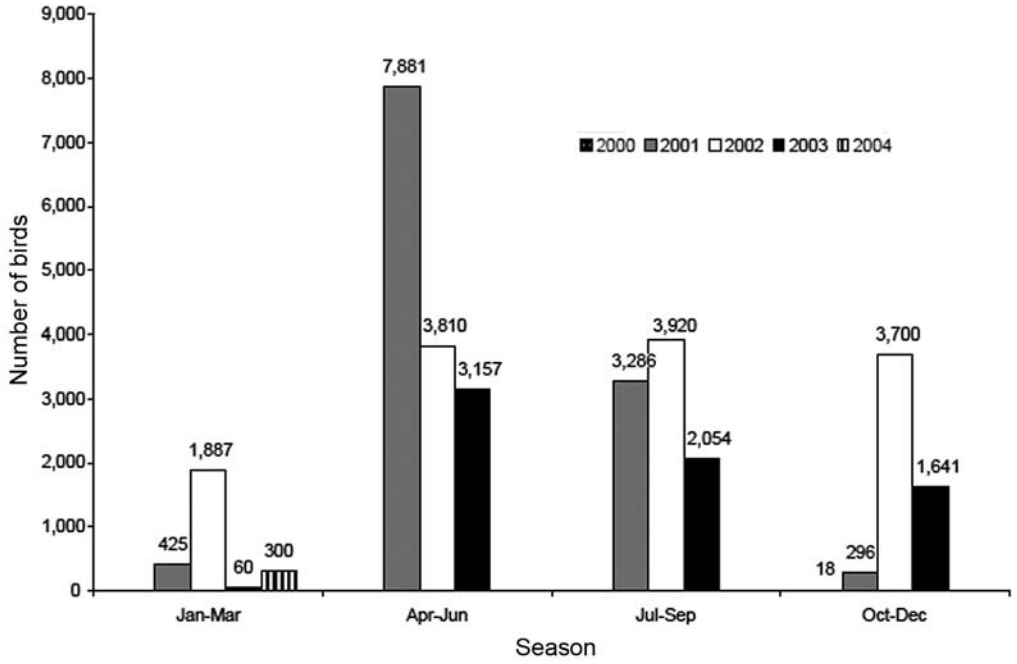

FIGURE 29. The number of Red Knots counted at Cape Romain National Wildlife Refuge, South Carolina, 2000–2004 (Cape Romain NWR, South Carolina DNR, unpubl. data).

If the southeastern U.S. and Maranhão birds are *C. c. roselaari*, the implication is that at least some of them migrate from their wintering areas to Delaware Bay and then to Alaska. Isotope signatures of Alaskan birds (N. Clark, unpubl. data; P. W. Atkinson, unpubl. data) do not support this view. Furthermore, this would seem to be an unlikely scenario because the distance between Florida and Alaska is almost the same as the distance between Delaware Bay and Alaska, but both are well within the capability of Red Knots for a non-stop flight (Weber and Houston 1997) and Delaware Bay is on an approximate great circle route between Maranhão and Alaska. Therefore, the flight from Florida to Delaware Bay would seem unnecessary. However, the possibility that Alaska-bound birds take such a circuitous migration route should not be discounted because it could have arisen in view of what is known about Red Knot evolution. Another factor that might have led to or maintained such a migration route is the existence of an abundant food resource in Delaware Bay in the form of horseshoe crabs' eggs. Therefore, the 5,000–6,000 km cross-continental flight might have been possible from Delaware Bay but not from Florida.

C. c. roselaari certainly use the Pacific coast flyway and at least some winter in California and Baja California (Tomkovich 1992; Page et al. 1997, 1999). However, it has also been suggested that Red Knots wintering in Florida conceivably may include *C. c. roselaari* and that they use a mid-continental route to reach breeding areas in Alaska (Harrington 2001). However, no good evidence supports or refutes this idea.

Color-banding shows little or no interchange between the Red Knots that winter in Maranhão and Tierra del Fuego or between Florida and Tierra del Fuego. No evidence exists for interchange between Florida and Maranhão, but observation rates are too low to accept this as verified (few Red Knots have been marked in Maranhão).

Isotope analysis of primaries from 16 Red Knots caught in Alaska in spring shows that almost certainly they did not molt in Florida (N. Clark, unpubl. data; P. W. Atkinson, unpubl. data). However, although this is inconsistent with C. c. *roselaari* molting and wintering in Florida, it is not proof that they do not because at 35,000–50,000 (Wetlands International 2006) the Alaska population is much greater than the 7,500 wintering in Florida. Therefore, because most of the Alaskan birds must winter elsewhere, a much greater sample than 16 will be necessary to exclude their movement to Florida.

Isotope analysis of primary coverts taken from Red Knots nesting in the main *C. c. rufa* breeding area on Southampton Island, Hudson Bay, showed a southeastern U.S. (or possibly northern Brazil) signature. This confirms that at least some birds wintering in that area are *C. c. rufa* (P. W. Atkinson, unpubl. data; M. Peck, unpubl. data).

Until the taxonomic uncertainties are resolved, the possibility remains that the Maranhão and Florida wintering populations include unknown numbers of *C. c. roselaari* as well as an unknown proportion of *C. c. rufa*. This complicates the assessment because the trend and population size of *C. c. roselaari* are uncertain. The estimate for *C. c. roselaari* in the U.S. Shorebird Conservation Plan (Brown et al. 2001) of 150,000 is based on counts in the 1970s and 1980s is probably a gross overestimate of the population at the time it was published. Current estimates at 35,000–50,000 are much lower (Wetlands International 2006). However, without systematic surveys it is uncertain whether a decline has occurred in the *C. c. roselaari* population. It is likely that all Red Knots using the Pacific flyway are *C. c. roselaari*. However, counts on the U.S. Pacific coast from California to Washington reported by Page et al. (1999) of 9,035 in spring, 7,981 in fall, and 4,813 in winter during 1988–1995 suggest that that flyway comprises no more than about 10,000 birds. It is therefore very difficult to account for even the current *C. c. roselaari* estimate of 35,000–50,000 birds in winter, if it is true that they all winter in the Americas. This is especially so if it were shown that the Florida and Maranhão wintering populations are all *C. c. rufa* as some of the evidence would seem to suggest.

In summary, five known major wintering sites were used by >1,000 Red Knots in the New World. These support a combined total of about 45,000 individuals (Table 14). To this figure a few small populations elsewhere can be added (e.g., 100 in the Upper Bay of Panama in Feb 2002 [Buehler 2002]) and possibly some in western Venezuela where 520 occurred in the mid-1980s (Morrison and Ross 1989). Allowing for some error in counts and estimates, and the fact that some counts are not recent, it would seem unlikely that the total is <40,000 or >50,000.

Assuming that the figures in Table 14 are accurate and discounting small numbers elsewhere, then, depending on whether the populations of uncertain subspecies are all *C. c. rufa* or all *C. c. roselaari*, the population of these two subspecies can range from a *C. c. rufa* population of 17,653–35,728 birds and a *C. c. roselaari* population of 9,035–27,110 birds. This does not take account of the fact that the Alaskan population, assumed to be *C. c. roselaari*, has been estimated at 35,000–50,000 (Wetlands International 2006). However, as discussed below, there is the possibility that many of the Alaskan birds are not *C. c. roselaari* but *C. c. rogersi*.

Wintering Population Trends in *Calidris canutus rufa*

The uncertainty about the numbers of *C. c. roselaari* and the areas in which it winters is in strong contrast to what is known about the *C. c. rufa* population of Tierra del Fuego. That population has been counted several times since the mid-1980s and (mixed with birds from Florida and Maranhão) every year from 1986–2005 as it passes through Delaware Bay as well as several sites in between. It is the decline in this distinct biogeographic population that is of primary concern.

Table 14. Recent population estimates of Red Knots wintering in the New World.

Location	Population	Recent trend	Date	Subspecies	Source
Tierra del Fuego	17,653	major decline	Jan 2005	*rufa*	R. I. G. Morrison (unpubl. data) R. K. Ross (pers. comm.)
Maranhão, northern Brazil	7,575	slight decline	Feb 2005	uncertain	Baker et al. (2005a)
Florida	7,500	not known	2004–2005 Winter	uncertain	B. A. Harrington (unpubl. data)
California, Mexico and possibly farther south	9,035 [a]	not known	Spring 1988–1995 [a]	*roselaari*	Page et al. (1999)
Texas coast	3,000	probable decline	1985–1996 (Jan 2003) [b]	uncertain	Skagen et al. (1999)
Total	44,763				

[a] The figure of 9,035 represents the maximum spring count along the main U.S. Pacific coast during 1988–1995 and probably includes both migrants and wintering birds. Winter counts alone produced 4,813 in the United States 1988–1995 (Page et al. 1999) and 1,082 in Baja California (Page et al. 1997). Presumably, the remaining 3,000 winter elsewhere in Mexico or farther south.

[b] Inquiries suggest that the Texas coast wintering population may now be as little as 300, but there has been no recent census.

Aerial counts during December to early February within the main *C. c. rufa* wintering area in southern South America have shown a catastrophic decline over the 20 yr interval, 1985–2005. The birds are thought to be relatively sedentary at this time of the year, so double counting or missing those that have not yet arrived or have already departed should not have occurred. Moreover, the same observers and survey techniques were used for all the aerial counts in South America. Surveys in the main non-breeding areas are the main method of population estimation for Red Knots recommended by the U.S. Shorebird Conservation Plan (Brown et al. 2001).

In the mid-1980s, the southern wintering *C. c. rufa* population numbered 67,546 and was found along 1,600 km of the Atlantic coast from Tierra del Fuego to Río Colorado in northern Patagonia (Morrison and Ross 1989). By 2006, numbers had fallen to 17,211 and almost the entire population was confined to Tierra del Fuego (Fig. 30). Within Tierra del Fuego, the largest numbers (at least 70% of the population) have always occurred at Bahía Lomas. There the count fell by about 50% (from over 45,000 to just over 20,000) between 2000 and 2002, remained stable in 2003 and 2004, but then fell again by a further 50% to <10,000 in 2005 (Fig. 30). In Tierra del Fuego as a whole, numbers fell from over 51,000 in 2000 (compared with 53,000 in the 1980s) to the 27,000–31,000 range between 2002 and 2004, and only 17,211 in 2006 (Fig. 30). By 2003, Bahía Lomas held 84% and the combined core areas 98% of all Red Knots counted over the entire wintering range in southern South America. The most recent decreases have occurred mainly in the numbers at Bahía Lomas. At Río Grande in the Argentinian part of Tierra del Fuego, aerial counts show that the population has remained relatively stable at 3,500–5,000 (Fig. 30), though ground counts in November have shown a drop from 6,000 in 2000 to 4,000 in 2004 (Baker et al. 2005a). Knots have almost disappeared from wintering sites outside of Tierra del Fuego on the Patagonian coast of Argentina, falling from over 14,300 in the 1980s to 790 in 2004 (Morrison et al. 2004; R. I. G. Morrison, unpubl. data)

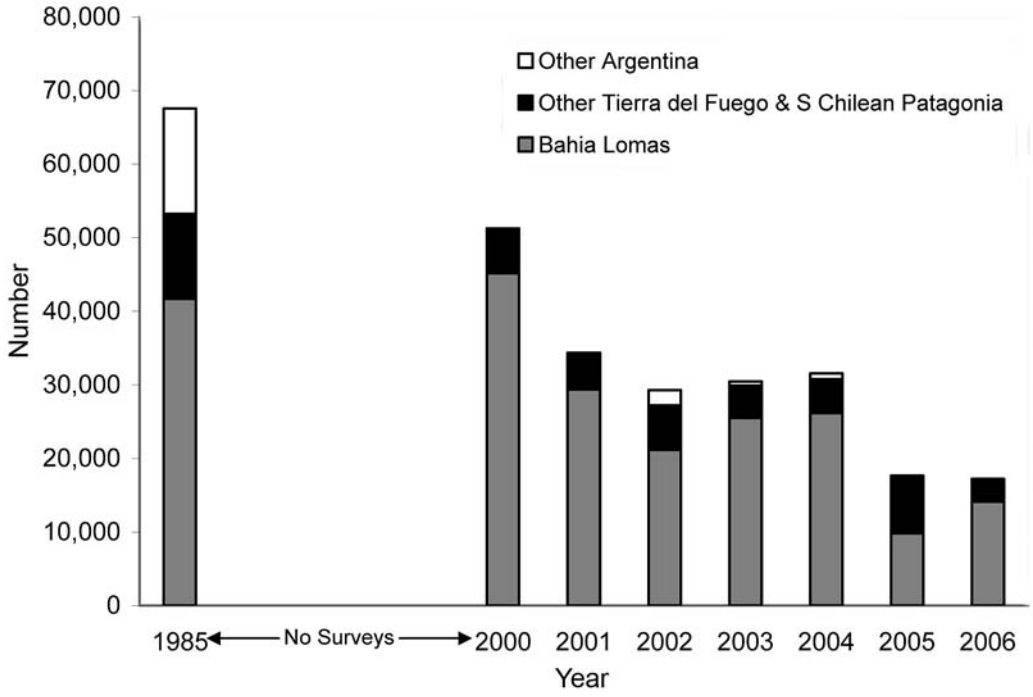

FIGURE 30. The number of Red Knots spending the austral summer in southern South America according to aerial counts made during the *Atlas of Nearctic shorebirds on the coast of South America* project (Morrison and Ross 1989) in 1985 and during 2000–2006. Grey sections are numbers at Bahía Lomas, black sections are other sites in Tierra del Fuego (mainly Río Grande) and southern Chilean Patagonia and white sections are other sites farther north along the coast of Argentina. No counts were made north of Tierra del Fuego in 2000, 2001, or 2005 because reports by ground observers (Ferrari et al. 2002, Escudero et al. 2003) showed that very few Red Knots wintered at any of the sites at which they had previously been reported.

(Fig. 30). This is reflected in surveys at all other sites in Patagonia where Red Knots have occurred during the past 20 yr with 14 out of the 18 sites occupied in 1985 having none in 2004–2005. In the same period, the population of Hudsonian Godwits (*Limosa haemastica*) which also spends the northern winter in Tierra del Fuego but takes the mid-continent flyway to breeding sites in Arctic Canada, remained stable (R. I. G. Morrison, unpubl. data; R. K. Ross, pers. comm.).

Banding studies in Tierra del Fuego invariably show a low proportion of juveniles and it is thought that most winter further north (Baker et al. 2005b). Therefore, the aerial counts of the Tierra del Fuego wintering population will underestimate its true size to the (probably marginal) extent that not all of the juveniles are included.

Passage Population Trends

The decline observed in wintering populations is also reflected in surveys of Red Knots at all major stopover sites along the coast of South America. At Bahía San Antonio, where surveys of passage birds are made during March and April, numbers have fallen from 15,000–20,000 in 1990–1997, to 7,000–12,000 in 1998–2002, to 5,000–6,500 in 2003–2005 (Fig. 31). Similar declines have been recorded at Península Valdés (Bala et al. 2001, 2002; Hernández et al. 2004). In Brazil, yearly counts at Lagoa do Peixe fell from a high of 10,000 in 1996 to 5,500–7,000 in 1996–1999, and 900–1,500 in 2001–2003 (Fig. 31). Taken together, these results support the conclusion that the Tierra del Fuego wintering population has declined significantly.

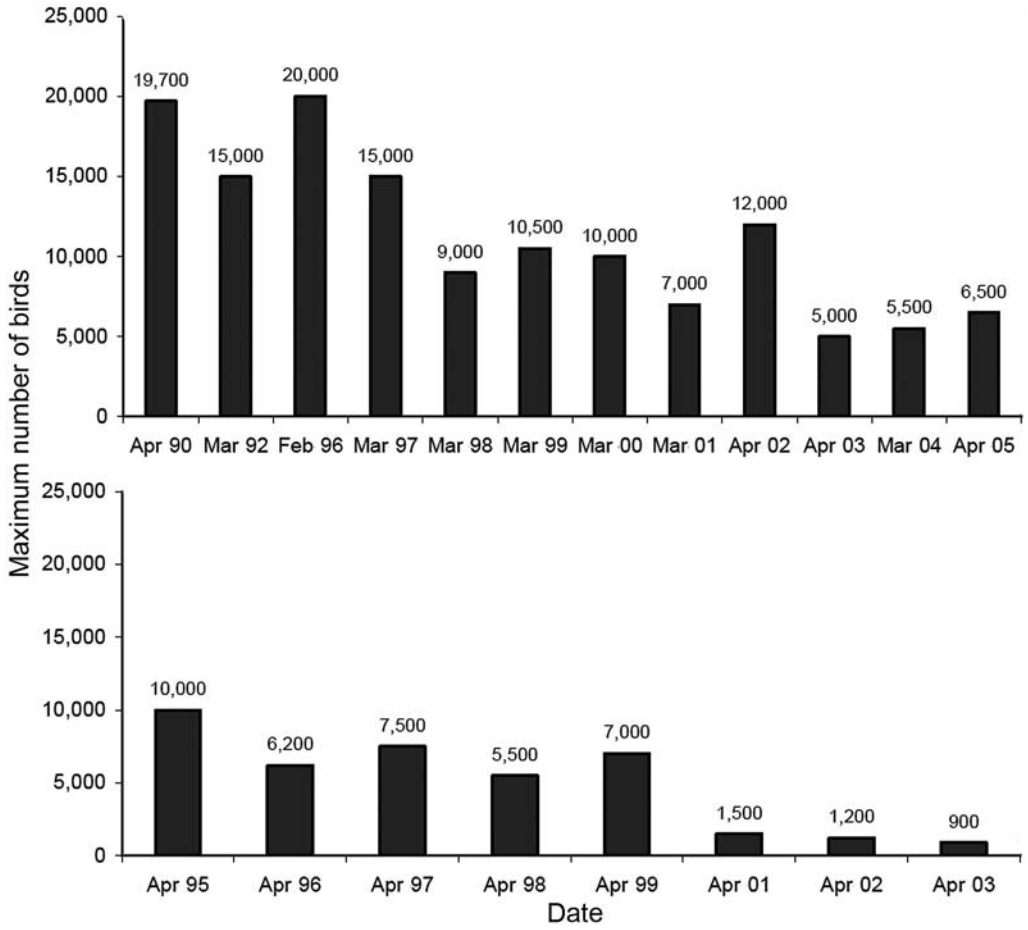

FIGURE 31. Peak numbers of Red Knots during northward passage at (upper) Bahía San Antonio, Argentina 1990–2005 (P. M. González, unpubl. data) and (lower) Lagoa do Peixe, Brazil 1995–2003 (I. Serrano, unpubl. data). Counts at Bahía San Antonio were mostly carried out on a weekly basis throughout February to April. Counts at Lagoa do Peixe were obtained during expeditions that covered the peak spring passage in April.

No regular systematic surveys of Red Knots have happened at any site further north in South America, either on passage or during the northern winter. Baker et al. (2005a) found no evidence of decline in Red Knots wintering in Maranhão, though this was based on just two counts 20 yr apart (1985 and 2005). In South Carolina, the USFWS carried out annual surveys in Cape Romain NWR during 2000–2004 (F. Sanders, pers. comm.; Fig. 29). These show a decline in passage birds similar to that seen in South America with numbers dropping from a March–April high of over 7,000 in 2000 to a low of 3,157 in 2004. Southbound Red Knots also declined from over 3,000 in 2001 and 2002 to 1,641 in 2003.

The longest running survey is the Delaware Bay Aerial Shorebird Survey that was started in 1982–1983 by the New Jersey Audubon Society (NJAS) and has been carried out from 1986 to the present by the NJENSP (Figs. 32 and 33; Clark et al. 1993; K. Clark, unpubl. data). The survey covers both shores of the bay and takes place under similar tidal conditions each week for the 6 wk of the stopover period. Every effort has been made to ensure even and consistent coverage. This has been achieved partly by keeping to the same methodology and partly by minimizing turnover of personnel. In fact the key role of counter has been fulfilled by the same person (K. Clark, NJENSP) since 1986.

The Delaware Bay Aerial Shorebird Survey is not a total census, because it does not cover the adjacent Atlantic coast of New Jersey or the intertidal marshes of Delaware Bay (Fig. 33). Moreover the peak count does not represent the total flyway population because of turnover—some birds may not have arrived, others may have departed. In 2004, for example, Gillings et al. (unpubl. data) estimated that, due to turnover, approximately 24,000 Red Knots passed through the Delaware Bay, despite the peak count being only 13,315 (Fig. 32). It is also likely that turnover rates have varied as the birds have responded to changes in the quantity of food. Overall, turnover rates were probably higher during 1986–1996 when horseshoe crab eggs were abundant than subsequently because of decreased egg availability. Higher turnover in the early years may be the reason for the greater volatility in peak numbers when compared with more recent years (Fig. 32).

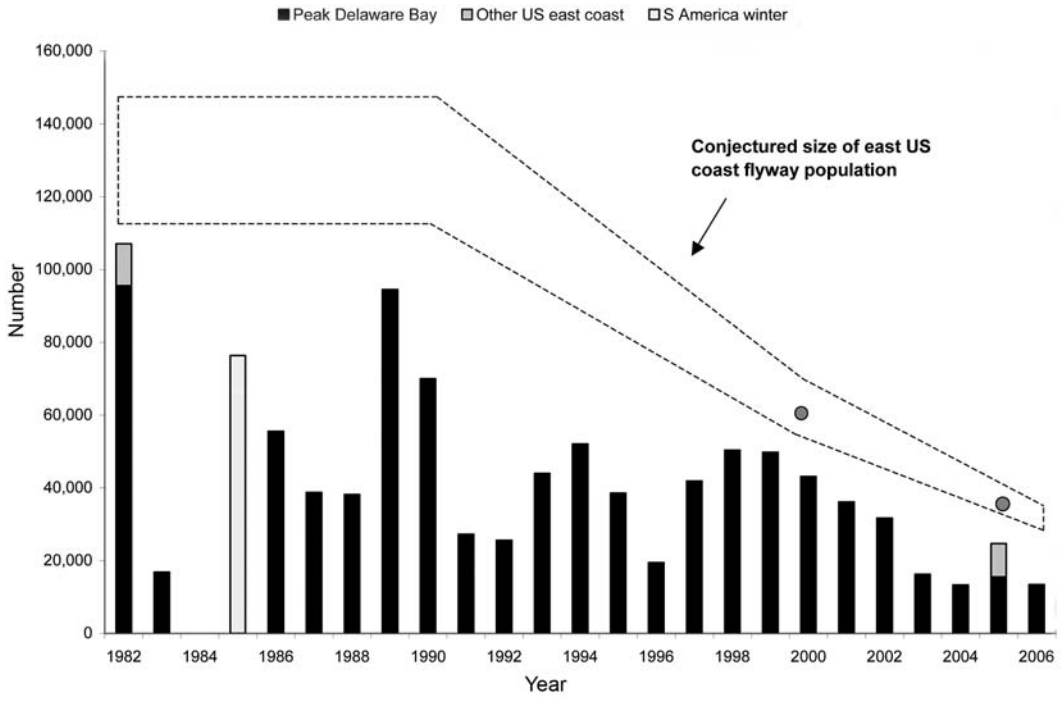

FIGURE 32. Peak counts of Red Knots in Delaware Bay May 1982–2006 as shown by weekly aerial counts. (NJAS (1982–1983), NJENSP (1986–2005). Also shown are simultaneous counts from other U.S. East Coast sites (mainly Virginia), the 1985 South America winter count (Morrison and Ross 1989), the authors' estimate of the total range over which the U.S. East Coast flyway population fluctuated (range enclosed by dashed lines) and the estimates of the flyway population in 1999 of 60,000 (Baker et al. 1999a) and in 2005 of 32,728 (Table 14) shown by gray dots.

FIGURE 33. Flight path of aerial surveys along the Delaware Bay conducted by the NJDFW.

In 1982 and 1989, the number of Red Knots in Delaware Bay reached peaks of 95,530 and 94,460, respectively. Although peak counts in the intervening years were lower and in some years surprisingly low, no reason exists to suppose that the population declined. In 1985 with no aerial survey in Delaware Bay, for example, the South America count (mainly the far south and Maranhão) was 76,373 to which can be added whatever population was then wintering in Florida. Since the early 1990s, however, the aerial survey has documented a steady decline with only 13,445 in 2006 (Fig. 32).

Figure 32 includes counts made simultaneously with the Delaware Bay peak elsewhere on the East Coast of the U.S. (mainly in Virginia). Included is the estimate of 60,000 for 1999 by Baker et al. (1999a) and the aggregate counts for the three main wintering populations (Tierra del Fuego, Maranhão and Florida) in 2005 of 32,728 (Table 14).

Until the late 1990s, the peak aerial counts in Delaware Bay were quite erratic from year to year (Fig. 32). Many of these changes are so big that they cannot have reflected changes in the total population because they are demographically impossible. Moreover, they are also far too large to be due to counting error. At this stage we can only speculate about the reasons. Possibly high availability of horseshoe crab eggs led to rapid turnover, leading to a reduction in the count; conversely bad weather may

have prevented birds from departing leading to a build-up. It is also possible that in some years many birds exploited food resources, such as *Donax* or mussel spat, elsewhere along the Atlantic coast and did not visit Delaware Bay.

Our conjectured estimate of the U.S. East Coast flyway population is based on the peak aerial counts in Delaware Bay, counts elsewhere along the U.S. East Coast, the 1985 and 2000–2005 aerial counts in Tierra del Fuego, and the counts in Florida and Maranhão referred to above. It also takes into account the fact that peak counts will almost invariably underestimate total stopover population because of turnover (S. Gillings et al., unpubl. data).

In the past it has been assumed that all the Red Knots stopping over in Delaware Bay in May are *C. c. rufa*. This is no longer certain, but the fact that a large proportion of the birds that pass through Delaware Bay are *C. c. rufa* from southern South America is suggested by the fact that the stopover population and the southern South America wintering populations have shown similar declines (Fig. 32). However, recent studies using carbon and nitrogen isotope ratios of feathers (Atkinson et al. 2005), and resightings of birds marked from other wintering areas have shown that approximately half the birds caught in Delaware Bay in 2004 and 2005 were from the Tierra del Fuego wintering population (Fig. 34). The remaining birds were from the more northerly wintering areas in Florida and Maranhão, Brazil.

The literature includes various estimates for the *C. c. rufa* population in the 1980s and early 1990s in the range of 100,000–150,000 (Harrington et al. 1988, Morrison and Harrington 1992). These estimates were all made on the assumption that *C. c. rufa* includes all birds passing through Delaware Bay, i.e., those wintering in Maranhão and Florida as well as Tierra del Fuego which are consistent with the information presented in Fig. 34. Later, however, Morrison et al. (2001) suggested that *C. c. rufa* numbered as many as 170,000 around the turn of the century by including 18,700

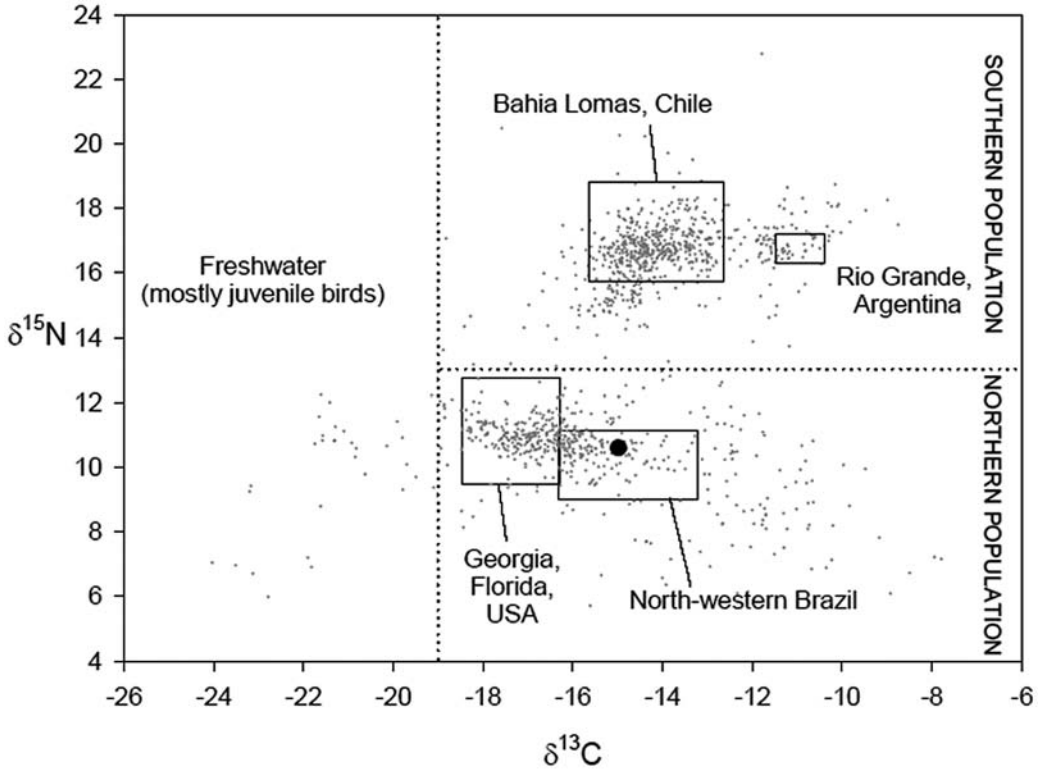

FIGURE 34. Stable isotope signatures of primary coverts taken from 1,150 Red Knots on spring migration through Delaware Bay in May and June 2004 (P. W. Atkinson, unpubl. data). Boxes mark the 90% confidence intervals of birds of known wintering origin. The large dot represents the signature of a tertial taken from a bird nesting on Southampton Island, Nunavut, Canada. Dotted lines show the approximate separation between juvenile birds (with freshwater Arctic signature) and the northern and southern wintering populations.

using the interior flyway. This is presumably why the same figure is mentioned in Brown et al. (2001). However, this figure appears to have been an over-estimation by a factor of almost three for two reasons—Baker et al. (1999a) had already published a much reduced estimate of only 60,000, and the figure of 18,700 is the sum of maximum counts for all sites along the interior flyway for January to June (Skagen et al. 1999), which might involve duplication.

Baker et al. (2004) showed that the reason the Tierra del Fuego population fell by almost 50% between 2000 and 2002 (Morrison et al. 2004) (Fig. 30) was because adult survival declined from an average of 85% in 1994–1998 to only 56% during 1999–2001. They also calculated trends in the population that could be expected if survival either recovered to 85% (Fig. 35a, the best-case scenario) or remained at 56% (Fig. 35b, the worst-case scenario). Subsequent counts during 2003–2005 (Fig. 35b) show that although the population held up in 2003–2004, the sudden drop to only 17,653 in 2005 brought it right back toward the track of the worst case scenario, indicating an increased risk of extinction within the next decade.

Since Fig. 35b was first published, it has been the subject of some misinterpretation. Therefore, we emphasize that its purpose was to demonstrate the consequences of adult survival remaining as low as 56% and not recovering. It assumes constant adult survival, but all studies show that adult survival actually varies from year to year. Thus there is no expectation that it will remain fixed at any particular value. The fact that the 2003 and 2004 counts were above the 95% confidence limits means that survival was more than 56%; the sudden drop in 2005 suggests that survival was much less than 56%. Therefore, although Fig. 35b predicts possible extinction as early as 2010, the year of extinction is unknowable, neither is extinction certain. The relevance and value of the model is that, combined with the recent counts, it shows that the current population trend is one that carries a considerably increased risk of extinction unless there is effective short term conservation action.

Breeding Area Population Trends

Although Red Knots can occur in huge flocks, during the breeding season they are spread out thinly across a vast area of the arctic tundra. From 2000–2004, NJENSP conducted regular annual surveys of the density of Red Knot nests in a 9.2 km^2 study area on Southampton Island, Hudson Bay. This showed a decline from 1.16 nests/km^2 in 2000 to 0.33 in 2003 followed by a slight increase to 0.55 in 2004 (Fig. 36). American Golden Plovers (*Pluvialis dominica*) nest commonly in the same study area but their numbers remained stable (Fig. 36). Golden Plovers take the mid-continent flyway to South American wintering areas and do not migrate through Delaware Bay.

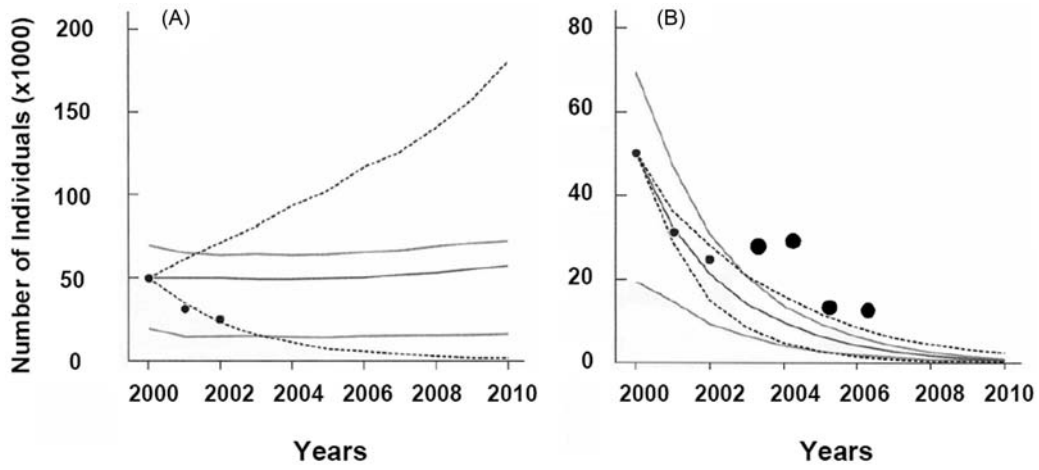

FIGURE 35. Predicted population trends and associated 95% confidence limits of adults (dashed lines), juveniles (lower gray line) and both combined (top gray line) for 10 yr from 2000, with (A) constant adult survival of 85% and juvenile survival being half that of adults ($\lambda = 1$) and (B) constant adult survival of 56% and juvenile survival being half that of adults ($\lambda = 0.66$). The small dots represent the aerial censuses of the over-wintering flock of adults in Tierra del Fuego during 2000–2002, and the large dots are the counts during 2003–2006. The 95% upper and lower confidence limits are based on 1,000 bootstrap iterations. Modified from Baker et al. (2004) and published in this form in Baker et al. (2005a).

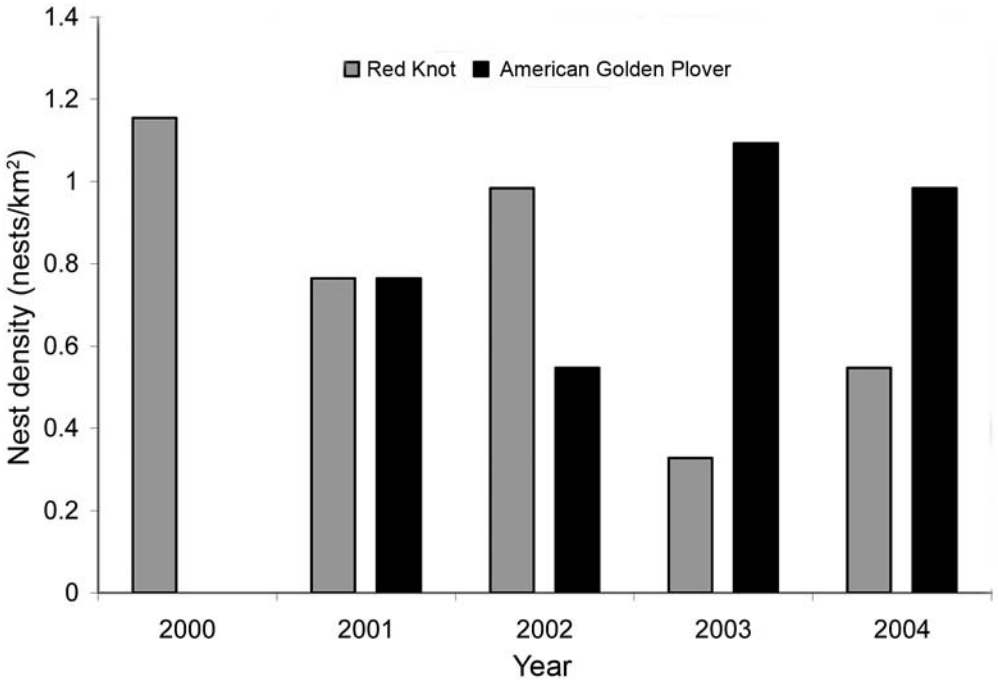

FIGURE 36. Density of the nests of Red Knots and American Golden Plovers in a 9.2 km^2 study site on Southampton Island, Nunavut, Hudson Bay, Canada, during 2000–2004. American Golden Plovers were not included in the survey until 2001.

Summary of Population Trends

Shorebird life-history traits are characterized by low fecundity (clutch size ≤4 eggs, high nest failure, only one brood per year), delayed maturity, and high annual survival (70–90%; Sandercock 2003). In these respects, the Red Knot is an exemplar of a shorebird. As with most arctic-breeding species, productivity is generally low and in some years can be virtually zero. Productivity depends on the weather, especially its effect on the chicks' thermoregulation requirements and the availability of their invertebrate food and predator abundance. The latter tends to be cyclic with a 3–4 yr period that is closely tied to the abundance of lemmings (Underhill et al. 1993). Years with few lemmings and many predators can be extremely unproductive for Red Knots. However, predator cycles are usually not uniform across all breeding areas so most years there is generally some production of young.

To some extent, periodic changes in the numbers of Red Knots may be related to arctic breeding conditions. However, other shorebird populations that breed in the same areas of the Arctic as Red Knots have experienced these conditions, but, at least during 2000–2004 in a small study area on Southampton Island, have not shown the same recent, sharp decline (Fig. 36) as have Red Knots. Therefore, although some changes in Red Knot populations can be ascribed to arctic breeding conditions, they are unlikely to be the primary cause of the recent declines.

Climate change is predicted to have adverse consequences for many arctic-breeding shorebirds (Rehfisch and Crick 2003). However, no study has yet shown an impact of climate change on Red Knot populations worldwide.

Intensive studies of *C. c. rufa* throughout the west Atlantic flyway only began in 1997 by which time the population had already dropped from the 100,000–150,000 reported in the 1970s and 1980s to close to the 60,000 estimated in 1999 (Baker et al. 1999a). Therefore, we have little information as to what caused this initial decline. Studies since 1997 have shown:

1. The majority of the populations that winters in Tierra del Fuego, Maranhão, and Florida passes through Delaware Bay during northward migration.
2. The Tierra del Fuego population has suffered major decline, but shows no discernible trend of decline in the birds from Florida or Maranhão.

3. A major reduction in the survival of the Tierra del Fuego population from an average of 85% during 1994–1998 to 56% during 1998–2001 coupled with lower rates of recruitment (Baker et al. 2004) was responsible for the decrease in the Tierra del Fuego population from >50,000 in 2000 to 30,000 in 2002–2004.
4. Continued low survival exacerbated by poor arctic productivity was likely responsible for the further fall in the Tierra del Fuego population from 30,778 in January 2004 to 17,653 in January 2005 (P. W. Atkinson, unpubl. data).
5. Birds caught in Delaware Bay in May with a low body mass during 1998–2002 had significantly lower survival than birds caught with a higher mass (after controlling for the general increase in weights that takes place during the stopover) (Baker et al. 2004).
6. Between 1997 and 2003, the proportion of well-conditioned Red Knots in Delaware Bay around the normal departure date at the end of May declined by 70% (Baker et al. 2004)
7. In recent years, especially in 2003 and 2005, substantial numbers of Tierra del Fuego birds have arrived in Delaware Bay later than usual.
8. Since about 1996 an order of magnitude decline has occurred in the availability of horseshoe crab eggs in Delaware Bay.

Worldwide, studies of arctic-breeding shorebirds show that declining populations are often associated with food supply problems at the final spring stopover (International Wader Study Group 2003). Although the precise reason or reasons for the decline in the Tierra del Fuego *C. c. rufa* population are not entirely clear, a major reduction in the availability of horseshoe crab eggs has occurred in Delaware Bay, a critical migration staging site used for refueling prior to the Red Knots' last leg of migration to the Arctic.

Population Size and Trends of Calidris canutus roselaari

C. c. roselaari is thought to breed in Alaska and on Wrangel Island and winter in the Americas, whereas *C. c. rogersi* breeds in northeast Siberia, mainly the Chukotski Peninsula and winters in Australasia (Tomkovich 1992). *C. c. roselaari* are slightly larger than *C. c. rogersi* and more intensely colored in breeding plumage on the belly and under-tail coverts.

In the 1980s, the number of Red Knots seen on spring migration in Alaska was reported to be of the order of 150,000 birds (Morrison et al. 2001). Analysis of the carbon and nitrogen isotope signatures of flight feathers from 16 adult specimens taken during this time indicated that birds molted in two very different regions and, compared to known wintering areas on the eastern seaboard of the Americas, were most similar to habitats found in Tierra del Fuego and northwestern Brazil, i.e., a temperate region and a tropical-subtropical region. However, without further data it is not possible to determine the location of those regions; e.g., the temperate region could be in Australasia (P. W. Atkinson, unpubl. data). More recently, numbers appeared to have dropped to 20,000 (COSEWIC 2006). Brown et al. (2001) states that *C. c. roselaari* numbers 150,000. As with *C. c. rufa*, this appears to be a major over-estimate of numbers at the time it was published in 2001.

If all Red Knots seen in Alaska are *C. c. roselaari* and if all *C. c. roselaari* winter in the Americas, then it is very difficult to account for them in winter—either in the 1980s, when there were 150,000, or today. In the mid-1980s, Morrison and Ross (1989) carried out an aerial count of shorebirds along the entire coast of South America. The only significant numbers of Red Knots recorded were the 67,500 *C. c. rufa* between Tierra del Fuego and Río Negro province, Argentina, and the 8,100 of uncertain status in Maranhão, Brazil. Farther north, no evidence suggests that numbers wintering along the Pacific coast of the U.S. and Mexico ever exceeded more than about 10,000, with another 10,000 in Florida and perhaps 5,000 in Texas. These figures total approximately 100,000. Subtract the definite *C. c. rufa* population and only about 33,000 Red Knots are left that could contribute to the 150,000 *C. c. roselaari* once thought to occur in Alaska. Similarly, if the present *C. c. roselaari* breeding population is 35,000–50,000, it is only possible to account for 9,000–27,000 in the Americas in winter (Table 14). It seems that any of the following hypotheses could explain this situation:

1. Many of the birds seen in Alaska in spring are not *C. c. roselaari* but *C. c. rogersi* (which migrate to Australasia). If so, the current *C. c. roselaari* population may be only the 9,000–27,000 suggested by winter counts. If the *C. c. roselaari* population numbers only 9,000, that subspecies may be even more threatened by the risks associated with small populations (such as extinction through stochastic events and the accumulation of harmful genetic mutation [International Wader Study Group 2003]) than *C. c. rufa*.

2. Part of the *C. c. roselaari* population winters outside the Americas; if so, no one knows where.
3. Major *C. c. roselaari* wintering grounds in the Americas remain to be discovered.

The resolution of which wintering populations are *C. c. roselaari* and which are *C. c. rufa* is important for the effective conservation of both subspecies, especially if one or the other turns out to far less numerous than has previously been supposed. Stable isotope analyses of feathers from Australasian wintering areas are a priority to determine whether staging Alaskan birds are likely to be *C. c. roselaari*, *C. c. rogersi* or a mix of both.

Geographic Area Summaries

The geographic area summaries in this section discuss location of, and factors affecting, important Red Knot non-breeding (wintering) and migratory stopover areas in South America, U.S., and Canada. These accounts include detailed maps of critical and suitable habitats for Red Knots (Appendix 1).

Identifying critical stopover and wintering sites for Red Knots is an important part of this status assessment. These maps represent current knowledge of areas known to be important migratory stopover and/or wintering habitats and will serve as a starting point for conservation action. These important habitats are classified as critical or suitable according to the following criteria:

Critical habitats:

1. Sites of known importance for Red Knots and are documented by survey.
2. Sites of known importance by expert opinion, and may or may not have survey data available.
3. Sites of known importance that are occupied intermittently (because of naturally fluctuating food resources, human disturbance, beach replenishment, etc.), and may or may not have survey data.

Suitable habitats:

1. Sites of known importance that are occupied intermittently, may or may not have survey data, and are deemed by expert opinion as secondary sites not critical to the persistence of the Red Knot population at its current population level—these sites may become critical if the Red Knot population increases.
2. Sites that were historically used by Red Knot but are now unused although the habitat has not been altered—these sites may become critical if the Red Knot population increases.

Chile

Red Knots visit the coast in the Southern Hemisphere from October to March and are often observed in flocks of over 2,000 birds (Morrison and Ross 1989, Harrington and Flowers 1996); however, since the main flyway is along the Atlantic coast, Red Knots are a rare visitor in most parts of Chile with just a few sightings at Arica (18º S), Río Huasco river mouth (29º S), Valparaiso (33º S), Río Maipo River mouth (33º S), Yali wetland (33º S), and Chiloe Island (42º S; Araya and Millie 1996, Couve and Vidal 2003). Although the flyway follows the Atlantic Ocean, the final destination for the majority of Red Knots is in Chile; specifically Bahía Lomas on the north coast of the main island of Tierra del Fuego (56º S) where 41,700 were recorded in 1985 (62% of the whole population of southern South American at the time; Morrison and Ross 1989). Since then, the total population and the numbers at Bahía Lomas have declined. By 2005, the site held only 9,827 or 56% of the southern population (R. I. G. Morrison, unpubl. data; R. K. Ross, pers. comm.; Fig. 37).

Argentina

In Argentina, *C. c. rufa* occur during migration and the austral summer in tidal wetlands distributed along the Atlantic shore. They spend more than 7 months of the year (September–April) in Argentina, but some individuals (mainly juveniles) can also remain during May and the austral winter. Counts at these sites mirror the severe decline of the population in recent years, and indicate that the birds have contracted into the main sites in Tierra del Fuego.

Aerial censuses conducted by the Canadian Wildlife Service (CWS) along the Patagonian coasts (January 1982) and in Tierra del Fuego (Chile—29 January 1985, Argentina—1 February 1985) reported a total of 67,496 Red Knots of which 24,734 were in Argentina: 10,470 in the Argentinian coast of Tierra del Fuego and 14,264 in the continental Patagonian coast (Morrison and Ross 1989). Small numbers (10–100) were reported to spend the austral summer in Bahía Samborombón, at Punta Rasa, and along the shores of Buenos Aires Province (Myers and Myers 1979, Morrison and Ross 1989, Blanco et al. 1992).

No aerial censuses were carried out in the 1990s, but in the 1994–1995 season a capture–recapture survey was conducted which estimated the total population that winters south of San Antonio Oeste at 74,193 Red Knots with a 95% confidence range of 51,398–111,573

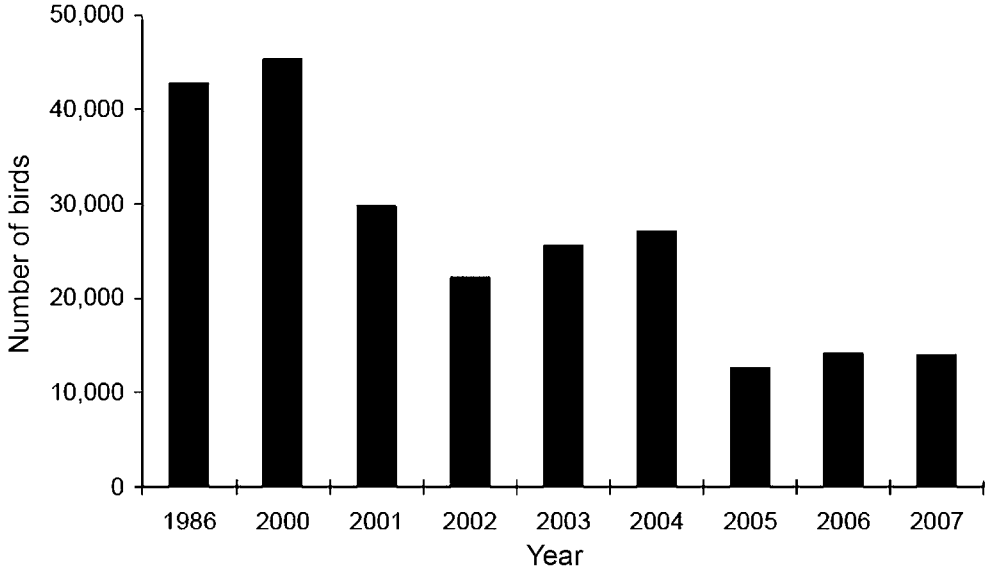

FIGURE 37. Total counts from aerial surveys of Red Knots done in Bahía Lomas, Tierra del Fuego, Chile.

(González et al. 2004). At least 5,000 of these birds were recorded by ground counts in Argentinian Tierra del Fuego (Minton et al. 1996). Although all sites included in 1980s aerial censuses were not visited, small numbers were reported along the shores of Buenos Aires Province (Vila et al. 1994) and at San Antonio Oeste (P. M. González, unpubl. data).

From 2000, aerial censuses showed a dramatic 40% reduction in the core areas of Tierra del Fuego (Morrison et al. 2004). Although not all Argentinian sites were covered by aerial censuses in 2000 and 2001, capture–recapture estimates for the total winter population south of San Antonio Oeste showed the same declining trend (González et al. 2004;

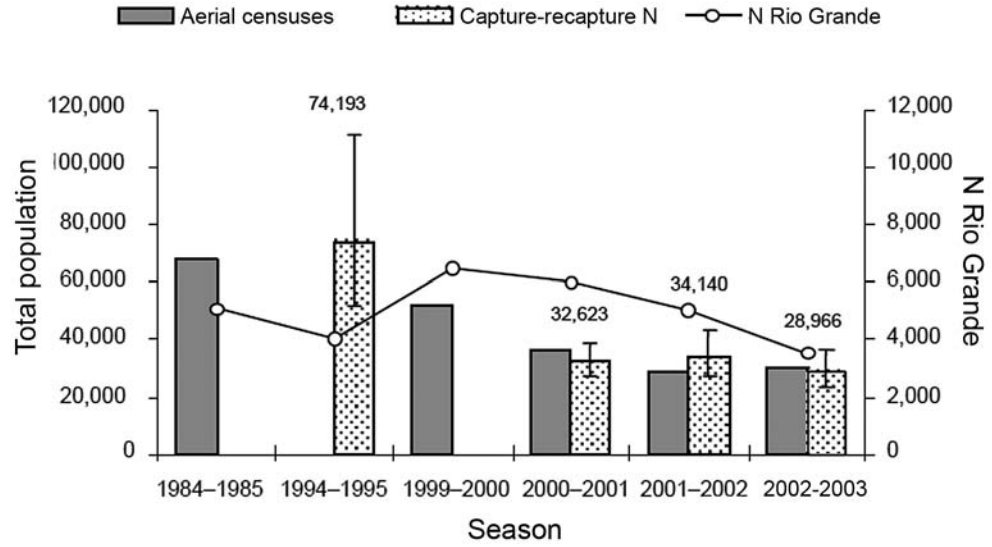

FIGURE 38. Total population estimates (± 95% confidence interval) of Red Knots spending the austral summer south of San Antonio Oeste, Río Negro, Argentina, from capture–recapture methods, compared with aerial census numbers (Morrison and Ross 1989, Morrison et al. 2004,) and number of Red Knots at Río Grande, Tierra del Fuego (González et al. 2004)

Fig. 38). Morrison and Ross (1989) reported important flocks of wintering Red Knots on the Patagonian coast at Península Valdés and Bahía Bustamante in the 1980s, but more recent studies have found none in these areas (L. Bala, pers. comm.; Escudero et al. 2003, Morrison et al. 2004; Table 15; Appendix 1, maps 4, 5, and 6). Therefore, a drastic decline in total numbers has occurred, and also a contraction in the range of the southern wintering population to core areas in Tierra del Fuego. That this change is not simply a redistribution of the birds but a true population decline is also supported by the following: (1) survival estimates and lower recruitment of immatures in this population (Baker et al. 2004), and (2) *C. c. rufa* wintering in northern Brazil are a different population from Tierra del Fuego; no Argentinian or Chilean color-marked Red Knots were found wintering there (Baker et al. 2005a). Moreover, a subsequent decline in Tierra del Fuego numbers to 17,653 was reported in the 2005 season of which 5,000 were seen at Río Grande, Argentina in February (R. I. G. Morrison, unpubl. data).

Based on records from Río Grande (Minton et al. 1996, González et al. 2003), Río Gallegos Estuary (Ferrari et al. 2002) and San Antonio Oeste (González et al. 2004), northward migration begins at the end of January or early February. By the end of April, most Red Knots have already left Argentina although a small number of birds may stay longer, even remaining through the austral winter (usually juveniles; Blanco et al. 1992, Blanco and Carbonell 2001, González et al. 2004).

In the 1980s, important known stopover places for Red Knots were Península Valdés, Chubut Province, where up to 20,000 Red Knots were estimated on passage (Morrison and Harrington 1992), and Bahía Samborombón with Punta Rasa, in Buenos Aires Province where up to 3,000 Red Knots were seen in a single flock (Blanco et al. 1992; Table 16). In the 1990s, San Antonio Oeste in San Matías Gulf was one of most important stopover sites during northward migration, hosting 25–50% of the wintering population from southern Patagonia where up to 20,000 Red Knots were seen at one time (González et al. 2003) (Table 16). Despite being so close to the main wintering areas in Tierra del Fuego (100–300 km away), Río Gallegos estuary was identified as an important stopover site during migration (Ferrari et al. 2002) with a high count of 2,500 Red Knots. Although Morrison et al. (2004) recorded 700 wintering Red Knots in this area in 2002, Ferrari et al. (2002) found no records in December or January from 1997 to 1999. Bahía Bustamante was another area censused regularly in the late 1990s with a highest count of 490 (Escudero et al. 2003; Table 16).

Long-term datasets of regular ground counts (>10 yr) only exist for San Antonio Oeste in San Matías Gulf (January–April, biweekly until 1999, daily to every 10 d from 2000–2005) and for Playa Fracasso (weekly from February–April), in the San José Gulf side of Península Valdés (Fig. 39). Although the highest counts (Table 16) are not necessarily correlated with either the actual number of Red Knots using stopover sites (because of turnover), or with wintering population size (e.g., because birds may bypass

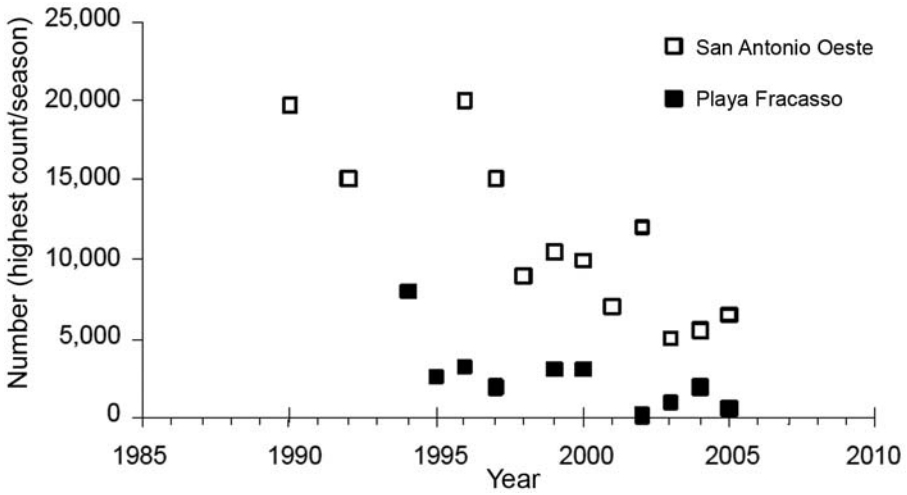

FIGURE 39. Maximum counts of Red Knots during northward migration at two stopover sites in Argentina: San Antonio Oeste and Playa Fracasso in Península Valdés (references in Table 16).

TABLE 15. WINTERING SITES OF RED KNOTS IN ARGENTINA (LOCATIONS GIVEN WITH PROVINCES IN PARENTHESES).

Location	Month	Year	Maximum count	Latitude	Longitude	Source
Río Grande	Jan	1976	3,000–5,000	53°45′ S	67°44.3′ W	Devillers and Terschuren (1976)
Tierra del Fuego	Nov–Dec	1979	5,000			Harrington and Flowers (1996)
	Feb	1985	5,100			Morrison and Ross (1989)
	Feb	1995	4,000			Minton et al. (1996)
	Jan	2000	6,500			G. Escudero (pers. comm.)
	Nov	2000	6,000			Baker et al.(2005b)
	Nov	2001	5,000			Baker et al.(2005b)
	Nov	2002	3,500			Baker et al.(2005b)
	Nov	2003	3,500			Baker et al.(2005b) Morrison and Ross (2004)
	Feb	2004	3,520			R. I. G. Morrison (unpubl. data)
	Feb	2005	5,000			R. I. G. Morrison (unpubl. data)
Bahía San Sebastián	Feb	1985	4,440	53°02.9′ S	68°22′ W	Morrison and Ross 1989
Tierra del Fuego	Feb	2000	2,250			Morrison et al. (2004)
	Feb	2002	50			Morrison et al. (2004)
	Feb	2003	900			Morrison et al. 2004
	Feb	2004	230			R. I. G. Morrison (unpubl. data)
	Feb	2005	100			R. I .G. Morrison (unpubl. data)
Estuario del Río Gallegos (Santa Cruz)	Jan	1998	0	51°30′ S	69°00′ W	Ferrari et al. (2002)
	Dec	2001	1,500			S. Ferrari (pers. comm.)
	Feb	2002	700			Morrison et al. (2004)
	Feb	2003	0			Morrison et al. (2004)
	Dec	2004	800			S. Ferrari (pers. comm.)
	Feb	2005	0			S. Ferrari (pers. comm.)
Bahía Bustamante (Chubut)	Jan	1982	7,400	45°06′ S	66°31′ W	Morrison and Ross (1989)
	Jan	1997	0			Escudero et al. (2003)
	Jan	1998	0			Escudero et al. (2003)
	Jan	1999	0			Escudero et al. (2003)
	Jan	2002	0			Morrison et al. (2004)
	Jan	2003	0			Morrison et al. (2004)
	Feb	2004	0			R. I. G. Morrison (unpubl. data)
	Feb	2005	Not surveyed			
Península Valdés (Chubut)	Jan	1982	3,800	42°30′ S	64°00′ W	Morrison and Ross (1989)
	Jan	2003	0			Morrison et al. (2004)
	Jan	2004	Not surveyed flight restriction			
	Jan.	2005	Not surveyed			R. I. G. Morrison (unpubl. data)
Península Valdés, Fracasso (Chubut)	Jan	1994	0	42º25′ S	64º04′ W	L. Bala et al. (pers. comm.)
	Jan	1995	0			L. Bala et al. (pers. comm.)
	Jan	1996	0			L. Bala et al. (pers. comm.)
	Jan	1997	0			L. Bala et al. (pers. comm.)
	Jan	1999	0			L. Bala et al. (pers. comm.)
	Jan	2000	0			L. Bala et al. (pers. comm.)
	Jan	2002	0			L. Bala et al. (pers. comm.)
	Jan	2003	0			L. Bala et al. (pers. comm.)
	Jan	2004	0			L. Bala et al. (pers. comm.)
	Jan	2005	0			L. Bala et al. (pers. comm.)

TABLE 16. STOPOVER SITES USED BY RED KNOTS IN ARGENTINA DURING NORTHWARD MIGRATION.

Location	Month	Year	Maximum count	Latitude	Longitude	Source
Estuario del						
Río Gallegos	Feb	1998	2,500	51°30′ S	69°00′ W	Ferrari et al. (2002)
(Santa Cruz)	Mar	1999	1,800			Ferrari et al. (2002)
	Mar	2005	1,000			S. Ferrari (pers. comm.)
Bahía Bustamante	Apr	1997	26	45°06′ S	66°31′ W	Escudero et al. (2003)
(Chubut)	Apr	1998	23			Escudero et al. (2003)
	Mar	1999	490			Escudero et al. (2003)
Península Valdés	Apr	1981	20,000	42°30′ S	64°00′ W	Morrison and Harrington (1992)
(Chubut)						
Península Valdés,						
Fracasso	Apr	1994	8,000	42°25′ S	64°04′ W	L. Bala et al. (pers. comm.)
(Chubut)	Mar	1995	2,625			L. Bala et al. (pers. comm.)
	Apr	1996	3,200			L. Bala et al. (pers. comm.)
	Mar	1999	3,020			Bala et al. (2001)
	Apr	2000	3,000			Bala et al. (2002)
	Mar	2002	80			M. Hernández et al. (2004)
	Apr	2003	1,000			L. Bala et al. (pers. comm.)
	Apr	2004	2,000			L. Bala et al. (pers. comm.)
	Apr	2005	500			L. Bala et al. (pers. comm.)
Península Valdés,						
Colombo	Apr	2002	1,500	42°38′ S	64°15′ W	Hernández et al. (2004)
(Chubut)	Apr	2003	250			Musmeci (2005
	Apr	2005	700			L. Bala et al. (pers. comm.)
San Antonio Oeste	Apr	1990	19,700	40°45′ S	64°55′ W	González (1991)
(Río Negro)	Mar	1992	15,000			González et al. (1996)
	Feb	1996	20,000			P.M. González et al. (unpubl. data)
	Mar	1997	15,000			Baker et al. (1999b)
	Mar	1998	9,000			P. M. González and T. Piersma (unpubl. data)
	Mar	1999	10,500			(unpubl. data)
	Mar	2000	10,000			González et al. (2003)
	Mar	2001	7,000			González et al. (2003)
	Apr	2002	12,000			González et al. (2003)
	Apr	2003	5,000			González et al. (2003)
	Mar	2004	5,500			P. M. González et al. (unpubl. data)
	Apr	2005	6,500			P. M. González et al. (unpubl. data)
Punta Rasa	Apr	1988	1,000	36°22′ S	56°45′ W	Blanco et al. 1992
(Buenos Aires)	Apr	1989	3,000			FVSA [a] banding workshop
	Mar	1997	200			Baker et al. (1999b)

[a] FSVA = Fundacion Vida Silvestre Argentina.

San Antonio Oeste after good wintering seasons [González et al. 2003]) or use other beaches at Península Valdés due to changes in sediments at Fracasso beach (V. D'Amico et al., pers. comm.), it is evident that counts in the 1990s were at least 60% higher than during 2000–2005 (Table 16).

In the 1981 season, Morrison and Harrington (1992) estimated that about 20,000 Red Knots occurred on passage in the entire Península Valdés area. However in 2005, thorough weekly ground, boat, and aerial counts from March to May revealed only 700 Red Knots at Colombo beach in the 5th week and 500 at Fracasso beach in the 7th week. Several individually marked birds were resighted more than once during the season, suggesting that the turnover rate was not very high (V. D'Amico, pers. comm.). Thus, counts at stopover sites are consistent with a declining trend in the wintering population.

Very few sites are known to host Red Knots during their southward migration. For example, at Península Valdés up to 3,800 birds were seen in early October 1980 (Harrington and Leddy 1982), but none have been recorded there during monthly surveys since 1994. At Bahía de San Antonio, 3,500 Red Knots were recorded in October 1992 and 2,500 in October 1997, but

only 1,000 in October 2001 (González et al. 2003). At the Río Gallegos estuary, Red Knots have been seen from October–November (Albrieu et al. 2004) with a record of 900 Red Knots in November 1997 (Ferrari et al. 2002). Small numbers have also been recorded in October at La Laguna in Puerto Madryn by Raúl Leon, and at Punta Rasa (Blanco et al. 1992), and Bahía Samborombón (Vila et al. 1994).

Austral winter counts of Red Knots in Argentina (i.e., June–August) are scarce because mainly juveniles occur there. However, a record of 600 exists during the austral winter of 1987 at Punta Rasa (Blanco et al. 1992) where it seems to have been common to see austral wintering Red Knots in the 1980s (Blanco et al. 1992). Small numbers have been at San Antonio Oeste (P. M. González, unpubl. data) as well as 179 at Claromecó (Blanco and Carbonell 2001).

Occasional records of Red Knots have been reported from other sites in Argentina (Table 17). However, because these have not been the subject of systematic surveys, their importance cannot be determined.

Brazil

With an Atlantic coastline of 7,347 km and vast inland wetlands such as the Pantanal, Brazil has a huge amount of shorebird habitat and supporting no less than 25 Nearctic shorebird migrants including Red Knots.

Although Red Knots can occur almost anywhere along the Brazilian shoreline, surveys show that two areas stand out as being of prime importance: the coast of the state of Maranhão in the north and the Lagoa do Peixe National Park in the state of Río Grande do Sul in the south (31º 10′ S, 51º 00′ S; Morrison et al. 1987, Morrison and Ross 1989, Morrison and Harrington 1992, Belton 1994, Nascimento 1995). Passage migrants especially use these

TABLE 17. TOWNS AND PROVINCES IN WHICH RED KNOTS HAVE BEEN OBSERVED IN ARGENTINA.

Place	Records	Date	Latitude, longitude	Source
Laguna Mar Chiquita, Buenos Aires	tens to hundreds	unknown	37º45′ S, 57º25′ W	C. Savigny (pers. comm.) L. Olveira (pers. comm.)
Mar de Cobo, Buenos Aires	tens–few hundreds	unknown	37º46′ S, 57º26′ W	J. Isaac (pers. comm.) D. Blanco et al. (unpubl. data),
Claromecó, Buenos Aires	tens – hundreds	unknown	38º51′ S, 60º05′ W	G. Francia (pers. comm.)
Punta Alta, Buenos Aires	hundreds	unknown	38º54′ S, 62º03′ W	Delhey and Petracci (2004)
Bahía Anegada, Buenos Aires	tens–hundreds	unknown	40º15′ S, 62º16′ W	J. Isaac (pers. comm.)
Caleta de Los Loros, Río Negro	presence	unknown	41º00′ S, 64º01′ W	Canevari et al. (1998) P. M. González (unpubl. data)
Complejo Islote Lobos, Río Negro	800; 3,000; hundreds	unknown	41º26′ S, 65º01′ W	J. P. Chillón (pers. comm.), Morrison et al. (2004)
South Golfo San Matías	1,200; hundreds	unknown	42º00′ S, 65º06′ W	Morrison and Ross (1989), Morrison et al. (2004)
Laguna Puerto Madryn, Chubut	tens	unknown	42º46′ S, 65º03′ W	R. León (pers. comm.)
Punta Tombo, Chubut	presence	unknown	44º02′ S, 65º11′ W	Canevari et al. (1998)
South Golfo Cabo San Jorge to Blanco, Santa Cruz	hundreds–1,300	unknown	47º12′ S, 65º45′ W	Pérez et al. (1995), Canevari et al. (1998), Morrison and Ross (1989), Morrison et al. (2004)
Ría Deseado (Pta.Foca), Santa Cruz	1,000	unknown	47º44′ S, 65º50′ W	Pérez et al. (1995)
Punta Medanosa, Santa Cruz	3,000	unknown	48º06′ S, 65º55′ W	Pérez et al. (1995), Morrison and Ross (1989)
Cabo Dañoso, Santa Cruz	150	unknown	48º50′ S, 67º13′ W.	Morrison and Ross (1989)
Bahía San Julián, Santa Cruz	tens, 350	unknown	49º21′ S, 67º42′ W.	Hernández (2004), C. Albrieu (pers. comm.)
Puerto Santa Cruz, Santa Cruz	400–500	unknown	50º08′ S, 68º20′ W	S. Imberti (pers. comm.)

areas during northward migration in April-May and during southward migration in September-October. Two factors suggest that passage Red Knots make a direct overland flight between the two: the general lack of records from the rest of the Brazilian coast, and an observation of 10 adults in September 1989 in the southern Pantanal in the state of Mato Grosso do Sul (19º30′ S, 56º10′ W; Centro Nacional de Pesquisa para Conservação das Aves Silvestres [CEMAVE], unpubl. data). Although it is not known whether Red Knots regularly stop over in the Pantanal or whether the 10 birds had been forced to land there as a result of weather conditions, it does indicate that they take the overland route.

The north coast of Maranhão also supports the largest wintering population in South America outside Tierra del Fuego (I. Serrano, unpubl. data; Morrison and Ross 1989, Baker et al. 2004, Baker et al. 2005a). During the breeding season small numbers of non-breeding birds (mainly juveniles) remain on the coast of Maranhão and Río Grande do Sul (Belton 1994), and in the Lagoa do Peixe National Park (Nascimento 1995). Other records of Red Knots along the Brazilian coast are insignificant.

It became clear during censuses carried out on the South American coast in 1982 and 1986 (Morrison and Ross 1989) that the regions of Salgado Paraense (State of Pará) and Reentrâncias Maranhenses (State of Maranhão) on the north coast are among the most important shorebird sites in Brazil. A total of 398,000 shorebirds were counted including 8,324 Red Knots.

Ground surveys were conducted by CEMAVE-IBAMA (Brazilian Institute of the Environment and Renewable Natural Resources) in 1990 and 1994 in October and November and from April to the second week of May along the coasts of the state of Amapá (Nascimento 1998) and in 1991 and 1995 on the coast of Maranhão (I. Serrano et al., unpubl. data). Activities included capture of migratory Nearctic shorebirds with mist-nets, banding (metal bands and color bands), and gathering of biometric data (molting, sex, age, weight, etc.).

In November 1992, 760 Red Knots were counted in Baía dos Lençóis near Campechá Island and in November 1993 1,398 were at the same site. Between 12 April and 5 May 1995, a ground survey was carried out along the north-northeast coast of the states of Ceará and Maranhão, including the mouth of the Gurupi River on the border between the states of Pará and Maranhão. Over 450 km were surveyed and several areas east of the Cabelo da Velha, including Lençóis Bay (Campechá Island) and Turiaçú Bay were found to hold large numbers of Red Knots (Table 18), particularly Coroa dos Ovos Island and Ingleses Island (I. Serrano et al., unpubl. data). In view of the dates of these observations, it is likely that the birds counted included both passage migrants that had overwintered in Argentina or Chile as well as birds that had wintered locally. In February 2005, an aerial census of the key coastal wetlands of Maranhão revealed a total of 7,575 Red Knots, the most (5,000) in Turiaçú Bay and on Coroa dos Ovos Island (Baker et al. 2005a). Therefore, only a slight (7%) decline had occurred in the population since the previous winter count in the mid-1980s, well within the likely counting error (Table 19). Although the 1995 and 2005 surveys were made using different methods and took place at different seasons, they both indicate that the Turiaçú Bay is the most important area for Red Knots.

TABLE 18. NUMBER OF RED KNOTS COUNTED ON THE NORTH COAST OF MARANHÃO, BRAZIL, IN APRIL AND MAY 1995 (I. SERRANO ET AL., UNPUBL. DATA).

Locality (bays)	Latitude, longitude	Estimated number
São Marcos	02º20′ S, 44º20′ W	50
Cumã	02º17′ S, 44º23′ W	0
Capim	01º29′ S, 44º49′ W	4
Cabelo da Velha	01º40′ S, 44º40′ W	90
Lençóis	01º22′ S, 44º56′ W	600
Turiaçú	01º25′ S, 45º06′ W	11,198
Total		11,942

TABLE 19. NUMBER OF RED KNOTS RECORDED ON THE COAST OF MARANHÃO, BRAZIL.

Source	Season	Count
Morrison and Ross (1989)	Winter	8,150
I. Serrano et al. (1995, unpubl. data)	Spring (Apr–May)	11,942
Baker et al. (2005a)	Winter (Feb)	7,575

CEMAVE records show that four Red Knots captured in Maranhão had been banded in Delaware Bay, U.S.—two in the Coroa dos Ovos Islands in November 1993, and two in Campechá Islanda in December 2003. Banding also shows that during northward migration, birds marked in Lagoa do Peixe may stop over on the Maranhão coast. One color-banded individual was seen at Lagoa do Peixe on northward passage in 1987 and again in Maranhão in May the same year. The same bird was observed in Delaware Bay in May 1988 and 1990 (Antas and Nascimento 1996). Another Red Knot was banded by CEMAVE on 10 May 2001 at Campechá weighing 165 g and recaptured only 11 d later at Slaughter Beach, Delaware. This is the shortest migration time recorded for an individual Red Knot between Maranhão and Delaware Bay. Based on theoretical estimates of flight capability, Red Knots weighing >160g can reach 5,000 km, the distance involved. Visual scaning for color-banded Red Knots in the Coroa dos Ovos and Campechá Islands in February 2005 (Baker et al. 2005a) showed that 12 out of 663 Red Knots had been marked in Delaware Bay.

Recent resightings of color-banded Red Knots in Maranhão and isotopic analysis of feathers shows that the Maranhão wintering population is distinct from that of Tierra del Fuego (Baker et al. 2005a). In May 2005, observations in Delaware Bay (NJENSP, unpubl. data) revealed at least three birds that had been banded in Maranhão (one in October 2004 and two in February 2005). Despite the low number of birds captured in the October 2004 and February 2005 expeditions (10 and 38, respectively), this is a strong indication of the importance of the Maranhão coast both for wintering and as a stopover location during northward migration of birds from Tierra del Fuego.

Lagoa do Peixe National Park is located in the southernmost region of Brazil, between the Atlantic Ocean and Lagoa dos Patos (Appendix 1, map 9). The park is one of the most important wintering grounds and stopover sites for North American migratory shorebirds.

The 35-km lagoon connects to the sea especially during winter during high wind, and when rain accumulates water in the lagoon. In summer, pumping sustains a constant influx of salt water. In this way, the lagoon has developed a rich invertebrate fauna all year round, making it an important source of food for migratory birds due to its high primary productivity. The major food resource for Red Knots at Lagoa do Peixe appears to be the mud snail.

Ground counts of Red Knots carried out in the Lagoa do Peixe National Park by CEMAVE (unpubl. data) during the month of April 1995–2003 show a decrease of numbers of Red Knots especially since 2001 of >90% (Fig. 40). Other

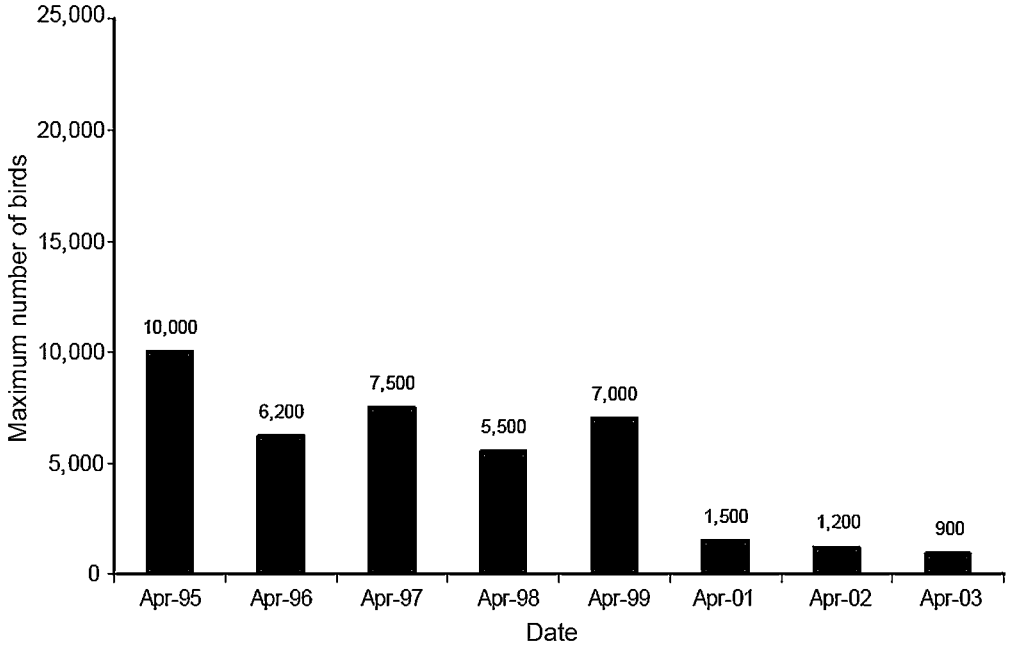

FIGURE 40. Peak numbers of Red Knots recorded in Lagoa do Peixe National Park, Brazil, 1995–2003 (CEMAVE/IBAMA).

published counts of Red Knots at Lagoa do Peixe include 7,000 in April 1984 (Harrington et al. 1986), 11,000 birds (Lara-Resende and Leuwemberg 1987) and 8,900 birds (Vooren and Chiaradia 1990). According to Belton (1994) 1,000 individuals were seen at the end of May. During the breeding season, a small number of non-breeding birds (probably 1-yr-olds) remain at Lagoa do Peixe (Belton 1994). Two birds color-banded at Lagoa do Peixe were later seen during southward migration on the coast of South Carolina on 28 July 1986.

During northward migration, most birds arrive at Lagoa do Peixe in March and the last birds are seen at the end of April, when birds occur on the northernmost beaches in the state of Río Grande do Sul. The last migrants are seen at Santa Catarina in mid-May (Antas and Nascimento 1996). After Lagoa do Peixe, the next stop is in Maranhão and then Delaware Bay, U.S. One color-banded bird from Lagoa do Peixe was encountered in the Presquile Provincial Park, Lake Ontario, Canada. Others have been seen in Florida in the second week of May (CEMAVE, unpubl. data).

About 8,900 migratory shorebirds have been banded by CEMAVE-IBAMA between 1984 and 2004 at the Lagoa do Peixe National Park, including 2,698 Red Knots, 1,871 White-rumped Sandpipers (*Calidris fuscicollis*), 745 Ruddy Turnstones (*Arenaria interpres*), and 658 Sanderlings. Red Knots have provided the most recaptures, especially in the U.S. (Delaware Bay) and Argentina (San Antonio Oeste and Río Grande); CEMAVE, unpubl. data).

Panama

Ten shorebird counts were made by Buehler (2002) between 5 January and 15 April 2002 in the upper Panama Bay: five close to Panama City, two at Río Pacora, and one at Chitré. These show that up to 200 Red Knots occurred during winter (January) and 300 during northward passage (March) (Table 20).

In the Costa del Este area of Panama City, where prime roosting sites were recently lost to housing development, flocks of up to 80,000 shorebirds were observed flying continuously for the duration of the high tide.

Two Red Knots were seen with orange color-marking flags on the tibia, indicating that they had been banded in Argentina. One, with the flag on the left tibia and no color bands, was seen on 20 February 2002 and had probably been banded at Río Grande, Tierra del Fuego, in February 1995. The other, with the flag on the right tibia and a red band on the left tarsus, was seen on 15 and 28 March 2002 and had been banded at San Antonio Oeste, Patagonia, in March 1998. Many of the Red Knots seen in January and February 2002 were identified as juveniles because they had yellowish legs.

The first Red Knots showing breeding plumage were observed on 15 March 2002 when the proportion was 20%. By 28 March, the proportion had increased to 70% with a similar figure on 7 April. By 15 April 2002, the majority of Red Knots had left the area and of the ten birds that remained, only one was in breeding plumage.

United States Fish and Wildlife Service Region 2 – Texas

During 1980–1996, flocks of Red Knots in excess of 1,000 were recorded from several sites on the Texas coast especially during winter (January) and spring passage (April–May), with over 2,800 on one occasion at Mustang Island Beach (Skagen et al. 1999; Table 21). Since that period, however, numbers have been much lower with the largest number recorded only 300, at Bolivar Flats, Galveston County, on 30–31 January 2003 (B. A. Harrington, unpubl. data). Bolivar Flats, which are managed by the Houston Audubon Society, is now the only site where small numbers of Red Knots (5–10) are seen regularly in winter with smaller numbers on the outer gulf beaches. Slightly greater numbers occur during migration (around 20). Christmas bird count (CBC) data from 1997–1998 (the only year for which data were available) shows a total of 36 Red Knots in the state.

The Gulf Coast Bird Observatory confirms that former estimates of 4,000 Red Knots on passage through Texas may now be high by as much as an order of magnitude. An important caveat to these figures is that there have been no systematic surveys for Red Knots in Texas

TABLE 20. COUNTS OF RED KNOTS AT THREE SITES IN PANAMA BETWEEN 5 JANUARY AND 15 APRIL 2002 (BUEHLER 2002).

	Date									
Location	5 Jan	19 Jan	2 Feb	21 Feb	24 Feb	28 Feb	15 Mar	28 Mar	7 Apr	15 Apr
Panama City	200	200				100	250	300	250	10
Río Pacora			20		5					
Chitré				100						

TABLE 21. RECORDS OF RED KNOTS ON THE TEXAS COAST DURING 1980–1996 (SKAGEN ET AL. 1999).

Maximum count	Latitude (°N)	Longitude (°W)	Location
January through June			
2,838	27.70	97.20	Mustang Island Beach, Texas
2,460	27.80	97.10	Airport, Port Aransas, Texas
900	26.00	97.10	Boca Chica Beach, Cameron County, Texas
800	28.20	96.60	Matagorda NWR, Texas
750	29.50	94.60	Bolivar Flats, Texas
575	26.30	97.40	Laguna Atascosa NWR, Texas
184	27.40	97.40	Padre Island National Seashore, Texas
81	26.20	97.20	South Padre Island, Texas
55	28.50	96.60	Magnolia Beach, Indianola Island, Calhoun County, Texas
48	27.60	97.30	Laguna Madre, Corpus Christi, Texas
48	28.90	95.10	San Luis Pass, Galveston Island, Texas
40	29.20	95.80	Big Reef, Galveston Island, Texas
40	29.40	94.60	Shore east of Bolivar Flats, Galveston Island, Texas
July through December			
1,443	27.70	97.20	Mustang Island Beach, Texas
1,439	27.40	97.40	Padre Island National Seashore, Texas
280	26.30	97.40	Laguna Atascosa NWR, Texas
250	28.20	96.60	Matagorda NWR, Texas
111	27.60	97.80	Beach on border of Nueces County and Kleberg County, Texas
88	27.80	97.10	Airport, Port Aransas, Texas
45	29.50	94.60	Bolivar Flats, Texas
30	26.10	97.20	South Padre Island, Texas
29	28.30	96.80	Burgentine Lake, Aransas NWR, Texas
28	26.00	97.10	Boca Chica Beach, Cameron County, Texas
27	27.60	97.30	Laguna Madre, Corpus Christi, Texas
12	27.70	97.60	Nueces County, Texas
10	29.20	95.80	Big Reef, Galveston Island, Texas

and there is nearly 1,000 km of outer coastline in the state from Port Arthur to Brownsville and 3,700 km of shoreline. Therefore, it is quite possible that substantial numbers of Red Knots occur in Texas and are undetected.

Three observations suggest that the Red Knots that occur in Texas belong to the *C. c. rufa* subspecies. First, Oberholser (1974) identified a winter specimen from Cameron County as *C. c. rufa*. Second, an orange-flagged bird from Argentina was seen on the Texas coast in May 2004. Third, an individually flagged bird that had been banded in Delaware Bay in May 2003 was seen on the Texas coast in August–September 2005 (B. Ortego, pers. comm.; W. Burkett, pers. comm.; J. Arvin, pers. comm.).

United States Fish and Wildlife Service Region 4 — Florida

Red Knots have been documented in Florida in all months of the year (Appendices 2, 3) but are seen most frequently from November–May. During November–February, they are most commonly observed on the west coast where the highest number of 6,500 was recorded at Casey Key Beach on 23 January 1979 (Appendix 3). However, the second highest count of 5,000 was on the east coast on 23 March 1978 at Anastasia Island, St. Johns County.

The number of Red Knots that currently winter in Florida is very uncertain and no recent count has been as high as the 6,500 recorded in 1979. ISS counts during 1993–1994, suggest a population of no more than about 4,000 (Sprandel et al. 1997). These were recorded at 27 of the 60 most important shorebird sites in Florida between 16 December 1993 and 1 March 1994 (Table 22; Appendix 1, maps 11, 12, and 13). Evidence from Florida Christmas bird counts obtained by averaging data for each circle during 1980–1989 suggests a minimum state population of 2,928. More recently, 4,000–5,000 were recorded at a single site in western Florida in November 2004 (B. A. Harrington, unpubl. data). Although the data are sparse, we conjecture that the state population may currently be in the region of 7,500. Our reasons are:

1. The 2004 observation was at just one site whereas in 1993–1994 Red Knots were found at 27 sites so it is likely that at least some of those sites would still support the species.
2. Knots are regularly recorded on the coast of South Carolina in early April. These include a flock of 7,000 in early April

TABLE 22. LOWEST AND HIGHEST NUMBER OF RED KNOTS COUNTED ON THE COAST OF FLORIDA IN FOUR COUNTS BETWEEN 16 DECEMBER 1993 AND 1 MARCH 1994, ORDERED ACCORDING TO THE MAXIMUM NUMBER RECORDED.

Site name	Count (lowest–highest)	Location (latitude, longitude)
Shell Key	113–775	27°40 5′, 82°44.0′
Caladesi Island, Hurricane Pass	6–300	28°03.0′, 82°49.3′
Passage Key	0–300	27°33.5v, 82°44.5′
Capri Pass (a.k.a. Key Island)	31–286	25°58.45′, 81°44.82′
Island north of Bunces Pass (now contiguous with Shell Key)	0–280	27°40.0′, 82°44.0′
Little Estero Island	0–241	26°25.0′, 81°54.0′
Palm Island Resort	51–223	26°53.5′, 82°20.5′
Caladesi Island, Dunedin Pass	0–165	28°01.0′, 82°49.45′
Merritt Island NWR, Black Point Drive	0–164	28°40.2′, 80°46.37′
Lanark Reef	1–147	29°52.4′, 84°35.3′
Honeymoon Island	31–122	28°04.0′, 82°49.5′
Lake Ingraham, SE End	0–122	25°08.67′, 81°05.2′
Yent Bayou	0–116	29°47.4′, 84°45.5′
Three Rooker Bar (N and S ends)	0–79	28°07.0′, 82°50.5′
Carrabelle Beach	0–69	29°50.0′, 84°40.5′
Anclote Key (N and S ends)	0–64	28°12.5′, 82°51.0′
Snake Bite Channel	0–60	25°08.13′, 80°53.79′
Courtney Campbell Causeway SE, (2 sites)	0–39	27°58.0′, 82°33.0′
Ding Darling NWR, tower stop	0–30	26°75.5′, 82°08.0′
Ft. DeSoto NW End	0–7	27°37.5′, 82°42.0′
Lido Beach	0–7	27°19.5′, 82°35.0′
Ft. DeSoto East End	0–2	27°38.0′, 82°44.5′
Kennedy Space Center, Pad 39B	0–2	28°37.48′, 80°36.7′

2003 (B. A. Harrington, unpubl. data). It is thought that it would be too early for these birds to have come from South America and that they had probably wintered in Florida. Extensive searches for color bands were made with 163 sightings of marked individuals, but no Red Knots marked in South America were found.

3. Calculations based on resightings of color-banded Red Knots wintering in Florida made between 1981 and 2004 consistently suggest that the population could be even larger than 7,500 (10,000 or more). The error associated with these calculations and the lack of reports of large numbers suggests that the estimates from band resightings may be too high (B. A. Harrington, unpubl. data), but they do suggest relatively consistent numbers through the years.

The evidence of the size of the population of Red Knots wintering in Florida is therefore far from satisfactory and although the figure of 7,500 is used throughout this review, it should be regarded with considerable caution. Systematic surveys to determine the exact size of this important population should be treated as a high priority.

United States Fish and Wildlife Service Region 4 — Georgia

The barrier coast of Georgia, approximately 160 km long, supports measurable numbers of Red Knots from about mid-July through May. During a 6-wk period in June and early July, only a few birds might be found in some remote locations. Clearly, the most significant documented event involving Red Knots in Georgia is the annual fall staging event that can include as many as 10,000 birds at one time. Less well-understood is the biology of the Red Knots that winter in Georgia, and those that migrate through Georgia in the spring (Table 23).

The fall staging phenomenon with large numbers of Red Knots was first discovered in September 1996. This area is remote, and it is very likely that Red Knots have been staging in this area prior to 1996. Knots in large but variable numbers have been recorded every September since 1996. The staging event appears to have a focal area at the mouth of the Altamaha River, where extensive river-generated shoals become exposed at lower tides creating vast areas of feeding habitat for the Red Knots (Fig. 41). The use area includes the south-

TABLE 23. IMPORTANT RED KNOT STOPOVER AND WINTER LOCATIONS IN GEORGIA.

Site name	Importance to fall staging (scale 1–20) N of birds	Importance to winter (scale 1–20) N of birds	Importance spring to migration (scale 1–20) N of birds
Little Tybee Island	none (1)	medium (10) 10–100	low (5) 10–1,000
Ogeechee River Bar	none (1)	low (5) 10s	high (15) 100s
Wassaw Island	none (1)	medium (10) 100–1,000	high (15) 100–1,000
Ossabaw Island	none (1)	high (15) 10–1,000	high (15) 10–1,000
St. Catherines Island	none (1)	high (15) 10–1,000	medium (15) 100
St. Catherines Bar	none (1)	medium (8) 10–100	medium (12) 10–100
Grass Island	none (1)	low (5) 10	high (18) 100–1,000
Blackbeard Island	none (1)	medium (10) 10–100	medium (10) 10–100
Sapelo Island	very high (15) 1,000	medium (10) 10–100	medium (10) 10–100
Wolf Island	very high/critical (20) 1,000–10,000	medium (8) 10–100	high (17) 100–1,000
Little Egg Island Bar	very high/critical (20) 1,000-10,000	medium (8) 10–100	medium (15) 10–100
Little St. Simons Island	very high/critical (20) 1,000–10,000	medium (10) 10–100	high (15) 100
Sea Island	none (1)	medium (10) 10–100	low (5) 10–100
Gould's Inlet, St. Simons Island	none (1)	medium (12) 10–100	medium (10) 10–100
Jekyll Island	none (1)	low (5) 10–100	medium (8) 10–100
Little Cumberland Island	none (1)	low (3) 10	lLow (5) 10
Cumberland Island	none (1)	high (15) 100–1,000	medium (12) 100

ern beaches of Sapelo Island (national estuarine research reserve), Wolf Island and its bar (national wildlife refuge), Little Egg Island Bar (state natural area), and Little St. Simons Island (privately owned, undeveloped) (Appendix 1, map 14).

Temporally, Red Knots begin to arrive in late July and early August, build in number into mid-September, and disperse by mid-October. The length of stay for individual birds is not yet known. Birds banded in Delaware Bay, South Carolina, and Georgia make up nearly 100% of

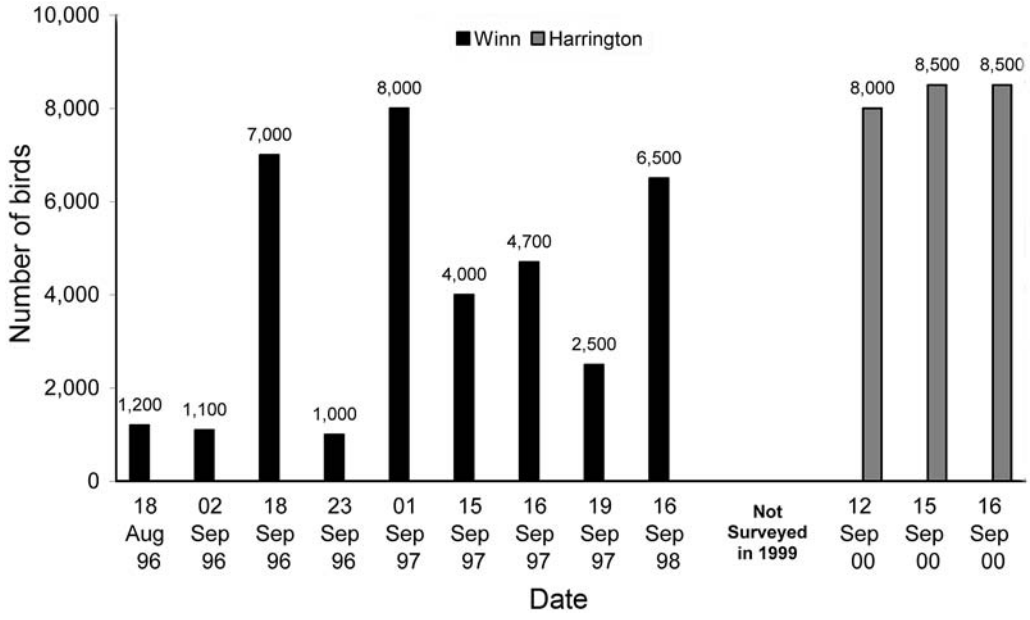

FIGURE 41. Number of Red Knots counted at Altamaha Estuary, Georgia, 1996–1998 (B. Winn, unpubl. data) and 2000 (B. A. Harrington, unpubl. data).

the individually color-marked Red Knots seen in the fall staging event, and throughout the winter in Georgia.

The number of wintering Red Knots in Georgia varies between and within years. Results of an annual winter survey for the entire Georgia coast show the minimum number of Red Knots to be in the hundreds of birds, and the highest to be nearly 5,000. The distribution of wintering Red Knots is generally unpredictable and dispersed over much of the barrier coast. The distribution appears to be linked closely with the abundance and availability of *Mulinia* clams.

Spring migrant use of the Georgia coast has not been studied well. Knots appear to increase in number during late April and May. Knots banded in Georgia and South Carolina can be seen with Red Knots banded in Delaware Bay, Argentina, and Chile. Red Knot use of horseshoe crab eggs appears to increase during the last 2 wk of May in specific locations. By early June, Red Knots have moved out of Georgia

United States Fish and Wildlife Service
Region 4 – South Carolina

Four surveys were conducted in the Cape Romain area and one in St. Helena Sound during the period 2001–2004. The Cape Romain surveys suggest Red Knot numbers peak in April and May during spring passage and then again in late August, September and October during fall passage (Appendix 1, map 15).

The graph of combined Bulls Island and Cape Romain NWR data (Fig. 42) indicate that Red Knot numbers declined between 2001 and 2004. Bulls Island beach surveys suggest a 75% decline in Red Knots moving through in the spring from 2002–2004. The Cape Romain NWR surveys often did not include Bulls Island, which is part of Cape Romain NWR. Therefore, numbers can be added for a more accurate total of Red Knots in the Refuge.

Few surveys have occurred in the area north of Cape Romain to Pawley's Island. Most of this coastline is undeveloped and remote. The habitat appears optimal for Red Knot and they are often observed there. Deveaux Bank and Bird Key, south of Charleston, are South Carolina Department of Natural Resources preserves for seabird nesting. These areas are visited in April to post the nesting area. Flocks of 200–400 Red Knots have been observed on these islands during April although formal surveys have not been conducted. Systematic surveys are required to document abundance, distribution and habitat use by Red Knots in coastal South Carolina. Surveys for shorebirds were conducted between 1997 and 2004 in the Cape Romain region north of Charleston, South Carolina (Fig. 42, Table 24). The amount of coastal habitat surveyed differed between years, so it is difficult to determine trend for

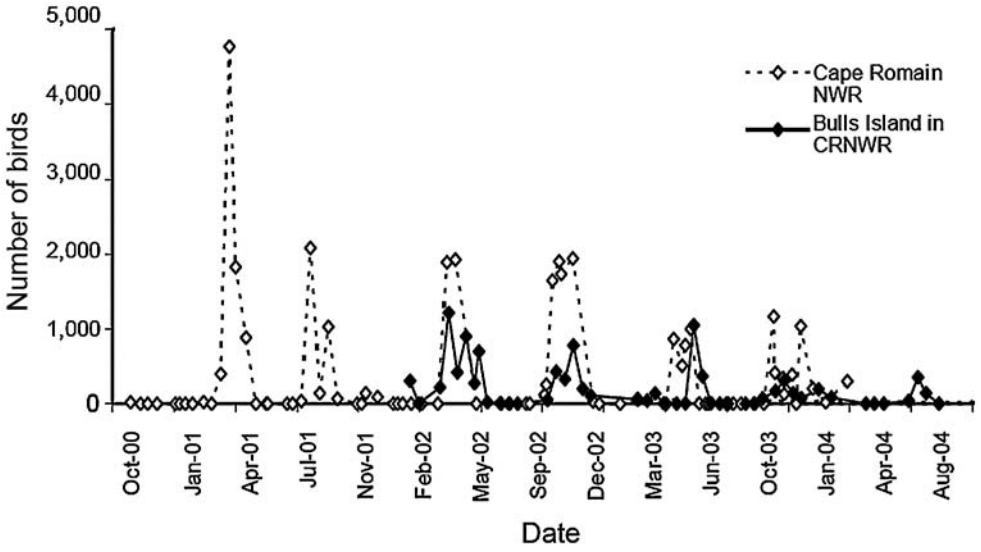

FIGURE 42. Red Knot surveys conducted between 2000 and 2004 in the Cape Romain region of Charleston, South Carolina (sources provided in Table 24).

TABLE 24. RED KNOT SURVEYS CONDUCTED BETWEEN 2000 AND 2004 IN THE CAPE ROMAIN REGION OF CHARLESTON, SOUTH CAROLINA.

Cape Romain NWR (S. Dawsey, pers. comm.)		Bull's Island, Cape Romain National Wildlife Refuge (D. Cubie, pers. comm.; P. Nugent, pers. comm.)	
Date surveyed	N birds	Date surveyed	N birds
30 Oct 2000	18	28 Jan 2002	303
15 Nov 2000	0	11 Feb 2002	5
27 Nov 2000	0	18 Mar 2002	219
12 Dec 2000	0	1 Apr 2002	1,210
11 Jan 2001	0	15 Apr 2002	417
18 Jan 2001	0	29 Apr 2002	900
27 Jan 2001	0	13 May 2002	274
8 Feb 2001	0	20 May 2002	694
26 Feb 2001	25	3 Jun 2002	20
11 Mar 2001	0	24 Jun 2002	9
26 Mar 2001	401	8 Jul 2002	0
9 Apr 2001	4,771	22 Jul 2002	0
19 Apr 2001	1,825	9 Sep 2002	49
6 May 2001	885	23 Sep 2002	426
22 May 2001	0	7 Oct 2002	327
8 Jun 2001	0	21 Oct 2002	778
10 Jun 2001	0	5 Nov 2002	201
12 Jul 2001	0	18 Nov 2002	110
21 Jul 2001	0	3 Feb 2003	58
4 Aug 2001	36	18 Feb 2003	44
19 Aug 2001	2,080	3 Mar 2003	135
3 Sep 2001	140	17 Mar 2003	4
17 Sep 2001	1,030	7 Apr 2003	0
2 Oct 2001	65	21 Apr 2003	4
3 Nov 2001	0	5 May 2003	1,047
10 Nov 2001	0	19 May 2003	368
17 Nov 2001	140	2 Jun 2003	6
6 Dec 2001	91	16 Jun 2003	0
1 Jan 2002	0	30 Jun 2003	0
8 Jan 2002	0	28 Jul 2003	0

TABLE 24. CONTINUED.

Cape Romain NWR (S. Dawsey, pers. comm.)		Bull's Island, Cape Romain National Wildlife Refuge (D. Cubie, pers. comm.; P. Nugent, pers. comm.)	
Date surveyed	N birds	Date surveyed	N birds
16 Jan 2002	0	11 Aug 2003	0
30 Jan 2002	0	25 Aug 2003	72
16 Feb 2002	0	15 Sep 2003	167
14 Mar 2002	0	29 Sep 2003	310
29 Mar 2002	1,887	14 Oct 2003	142
12 Apr 2002	1,923	27 Oct 2003	74
16 May 2002	0	24 Nov 2003	191
25 Jun 2002	0	15 Dec 2003	81
9 Jul 2002	0	9 Feb 2004	0
5 Aug 2002	0	23 Feb 2004	0
11 Aug 2002	0	9 Mar 2004	0
4 Sep 2002	121	19 Apr 2004	41
7 Sep 2002	253	4 May 2004	350
17 Sep 2002	1,646	17 May 2004	140
28 Sep 2002	1,900	7 Jun 2004	0
1 Oct 2002	1,730		
20 Oct 2002	1,940		
22 Nov 2002	30		
2 Dec 2002	0		
5 Jan 2003	0		
2 Feb 2003	60		
3 Mar 05 0			
21 Mar 2003	0		
2 Apr 2003	864		
16 Apr 2003	510		
21 Apr 2003	782		
30 Apr 2003	996		
14 May 2003	5		
24 May 2003	0		
29 May 2003	0		
27 Jun 2003	0		
8 Jul 20030			
21 Jul 2003	0		
12 Aug 2003	0		
27 Aug 2003	0		
12 Sep 2003	1,164		
14 Sep 2003	415		
27 Sep 2003	345		
29 Sep 2003	130		
12 Oct 2003	386		
19 Oct 2003	0		
26 Oct 2003	1,035		
15 Nov 2003	202		
6 Dec 2003	18		
10 Jan 2004	300		

entire period. Surveys of the same area during the period 2001–2004 show a decline in Red Knots peak numbers in April and May and then in late August, September, and October (Figs. 43–45). The Cape Romain region was surveyed in 1988–1989. High counts for surveyed sites were also recorded in May and August through September suggesting these months are peak migration months in South Carolina.

United States Fish and Wildlife Service Region 4 – North Carolina

Based on the limited survey information and anecdotal observations by wildlife professionals and local ornithologists, the following sites, presented from south to north, are believed to be important stopover and wintering areas for Red Knots (Table 25; Appendix 1,

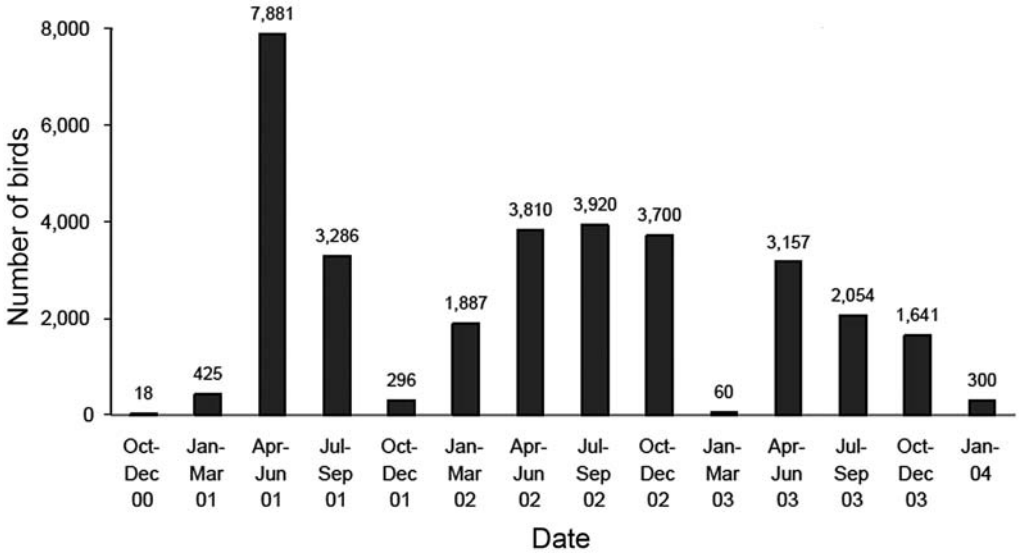

FIGURE 43. Number of Red Knots counted at Cape Romain National Wildlife Refuge, South Carolina, 2000–2004 (S. Dawsey, pers. comm.).

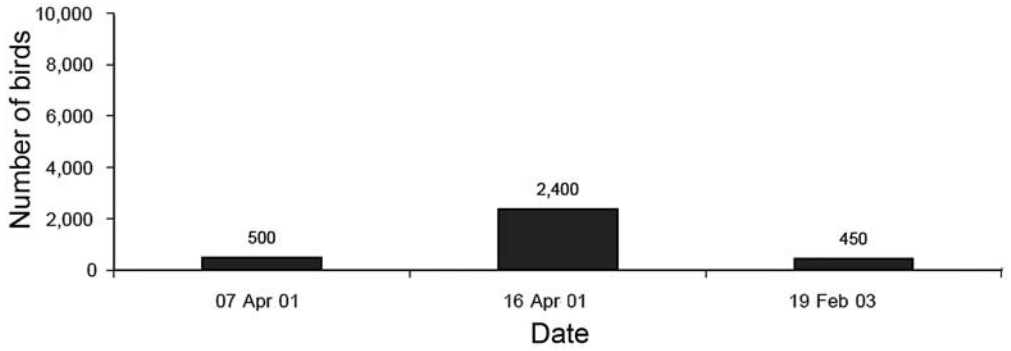

FIGURE 44. Number of Red Knots counted at Harbor Island, South Carolina, 2001–2003 (B. A. Harrington, unpubl. data).

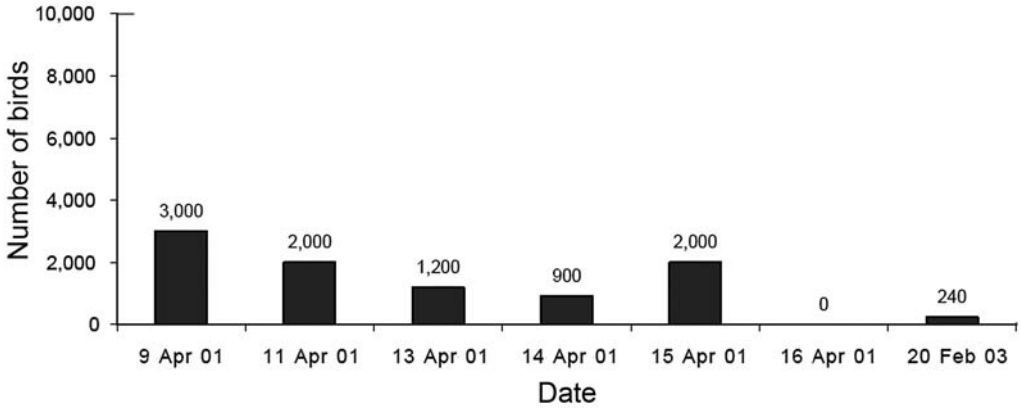

FIGURE 45. Number of Red Knots counted at Hunting Island, South Carolina, 2001–2003 (B. A. Harrington, unpubl. data).

TABLE 25. STOPOVER AND POTENTIAL WINTERING AREAS FOR RED KNOTS IN NORTH CAROLINA.

Location	Spring	N	Fall	N	Winter	N
Tubbs Inlet	28 April 2004	500	–	–	–	–
	5 April 2005	90	–	–	–	–
Ocean Isl. Beach	25 April 1986	200	–	–	–	–
Fort Fisher	–	–	–	–	Consistent winter use; CBC[a] also records Red Knots at this location (J. Fussell pers. comm.)	~30
Bear Is.-	18 May 1985	200	–	–	February (year	2
Bogue Inlet	19 May 1989	1,250	–	–	unknown)	–
	May (late 1990s) (J. Fussell, pers. comm.)	max. 100	–	–	–	–
Bird Shoals	–	–	–	–	Winter (J. Fussell, pers.	Max. 100
	–	–	–	–	comm.)CBC [a]	~4
Cape Lookout Nat. Seashore North Core Banks	Early May, 2005	1,000[b]	–	–	–	–
Cape Hatteras Nat. Seashore Ocracoke	Early May, 2005	1,000[b]	–	–	–	–
Pea Island NWR	–	–	–	–	November (year unknown)	100
Rachel Carson Reserve	–	–	–	–	Winter consistent use (J. Fussell, pers. comm.)	100
Cedar Island NWR	May consistent use (J. Fussell, pers.comm.)	50–200 individuals	–	–	–	–

[a] Christmas Bird Count.
[b] These counts may represent the same birds.

map 16). Available information suggests Red Knots are consistently using coastal areas of North Carolina during spring and fall migration. Knots are wintering in North Carolina in limited numbers. Systematic surveys during migration and wintering seasons are necessary to determine distribution, abundance and habitat use of coastal areas by Red Knots.

On Tubbs Inlet, 90 Red Knots were observed foraging on the ocean side of the island in early April 2005 and 500 Red Knots were observed roosting on the bay side of the island in late April 2004. Little or no information is available concerning use of Red Knots during fall or winter months.

Fort Fisher State Historic Site hosts a natural rock outcrop that appears to be an important feeding area for small numbers of birds each winter and almost certainly in migration. Approximately 30 Red Knots are recorded there each winter by J. Fussell (pers. comm.) and the CBC.

Bear Island and Bogue Inlet regularly host small numbers of Red Knots. The maximum number recorded in spring was 60 individuals and two birds were observed in winter (February). Historically, good numbers of Red Knots occurred at the outer beaches of Bear Island. This area has not been systematically surveyed.

Bird Shoals is potentially an important wintering site for Red Knots. A few Red Knots have been recorded at this site during the CBC in December. J. Fussell (pers. comm.) has documented up to 100 birds here in the winter. No systematic surveys have been conducted during spring or fall migration to determine shorebird abundance.

Surveys conducted in 1992–1993 revealed moderate numbers of Red Knots using the Outer Banks of Cape Lookout National Seashore during migration and in winter (Dinsmore et al. 1998). Most observations during this study were on North Core Banks. Recent observations suggest that South Core Banks and North Core Banks have significant numbers of Red Knots. About 1,000 birds were observed on the north end of North Core Banks in early May, 2005. Good numbers were observed foraging on outer beach of South Core Banks2006. North Carolina Nongame and Endangered Wildlife Program started an ISS survey at New Drum Inlet on the north end of South Core Banks. This survey will continue in the fall. Portions of Cape Lookout are important stopover sites. The east end of Shackleford Banks has extensive intertidal flats

TABLE 26. NUMBER OF RED KNOTS OBSERVED DURING THE 2001–2002 INTERNATIONAL SHOREBIRD SURVEY ON CLAM SHOAL, NORTH CAROLINA.

Date	N
14 February 2001	80
26 July 2001	–
16 August 2001	–
10 October 2001	218
31 October 2001	398
9 January 2002	305
21 February 2002	–
18 April 2002	31
15 May 2002	25

bordering Bardens Inlet and Back Sound and is considered a suitable migratory stopover for Red Knots in spring

Approximately 1,000 Red Knots were observed on south end of Ocracoke on Cape Hatteras National Seashore in early May 2005. These may be the same birds observed on North Core Banks. Red Knots numbering from 10–200 (maximum = 400) are observed on Ocracoke (S. Maddock, pers. comm.)

Results of the ISS on Clam Shoal (Table 26) indicate this site is an important wintering area and is used during spring and fall migration.

Refuge staff at Pea Island NWR conduct shorebird surveys and record small numbers of Red Knots. Staff recorded a peak of 100 birds in November. This site is likely serving as a stopover and wintering location for Red Knots.

A consistent number of about 100 Red Knots are observed in winter at the Rachel Carson Reserve (J. Fussell, pers. comm.).

Small numbers of Red Knots (50–200 individuals) are regularly seen in the spring along a 9.6-km stretch of beach on the Pamlico Sound Shoreline of Cedar Island, part of which is within Cedar Island NWR (the northwest end).

United States Fish and Wildlife Service Region 5 – Virginia

On 23 May 2005 at the request of the NJDFW, Bryan Watts of the Center for Conservation Biology and Barry Truitt of TNC's Virginia Coast Reserve conducted an aerial survey of Virginia barrier islands for Red Knots. The survey resulted in a total estimate of 9,150 Red Knots along the island chain. Significant concentrations were observed on Wreck Island, Paramore Island, Hog Island, and Myrtle Island.

Aerial surveys conducted throughout the springs of 1994—1996 by the same observers and using the same techniques showed that Red Knot migration on the Virginia Barrier Islands peaks during the third weak of May. The peak estimate during these 3 yr was 8,955 birds documented on 21 May 1996. The estimate for 2005 is within 200 individuals of the peak estimate from 10 yr earlier. It should be noted that the Chimney Pole Marsh-Sandy Island complex inside Quinby Inlet was surveyed in 2005 (710 Red Knots detected) but not in the mid-1990s. Although overwhelming evidence shows that the Red Knot population within the Western Hemisphere has experienced dramatic declines, current use of the Virginia Barrier Islands by migrating Red Knots appears to be similar to the mid-1990s (Tables 27–29,

TABLE 27. RESULTS OF AERIAL SURVEYS CONDUCTED AT LOW TIDE FOR RED KNOTS ALONG OUTER BEACH SURF ZONE OF VIRGINIA BARRIER ISLANDS FROM VIRGINIA–MARYLAND BORDER TO MOUTH OF CHESAPEAKE BAY IN 1995[A], 1996[B], AND 2005 (B. WATTS, PERS. COMM.; B. TRUITT, PERS. COMM.).

Site	1995	1996	2005
Assateague Island	57	174	60
Wallops Island	20	395	0
Assawoman Island	500	214	0
Metompkin Island	1,915	1,272	230
Cedar Island	486	1,622	200
Dawson Shoals			
Parramore Island	2,485	1,758	1,040
Chimney Pole Marsh	n/a	n/a	710
Hog Island	1,260	1,243	1,115
Cobb Island	675	1,030	780
Little Cobb Island	0	0	0
Wreck Island	5	31	4,250
Ship Shoal Island	42	150	75
Myrtle Island	90	150	500
Smith Island	423	883	100
Fisherman Island	0	0	90
Total	7,958	8,922	9,150

[a] Results for the 1995 survey represent the high count of five surveys conducted between 25 April and 30 May 1995. See Table 28 for results of all 1995 surveys.
[b] Results for the 1996 survey represent the high count of six surveys conducted between 27 April and 10 June 1996. See Table 29 for results of all 1996 surveys.

TABLE 28. RESULTS OF AERIAL SURVEYS CONDUCTED AT LOW TIDE FOR RED KNOTS ALONG OUTER BEACH SURF ZONE OF VIRGINIA BARRIER ISLANDS FROM VIRGINIA–MARYLAND BORDER TO MOUTH OF CHESAPEAKE BAY IN 1995 (B. WATTS, PERS. COMM.; B. TRUIT, PERS. COMM.).

SITE	25 April 1995	9 May 1995	16 May 1995	24 May 1995	30 May 1995
Assateague Island	0	0	0	57	418
Wallops Island	0	0	190	20	5
Assawoman Island	0	0	0	500	5
Metompkin Island	0	20	1,000	1,915	34
Cedar Island	0	0	10	486	80
Dawson Shoals					
Parramore Island	0	20	505	2,485	1,095
Hog Island	0	0	155	1,260	655
Cobb Island	0	0	940	675	700
Little Cobb Island	0	0	0	0	0
Wreck Island	0	0	0	5	5
Ship Shoal Island	0	0	95	42	30
Myrtle Island	0	0	175	90	120
Smith Island	0	0	305	423	140
Fisherman Island	0	0	0	0	8
Total	0	40	3,375	7,958	3,295

TABLE 29. RESULTS OF AERIAL SURVEYS CONDUCTED AT LOW TIDE FOR RED KNOTS ALONG OUTER BEACH SURF ZONE OF VIRGINIA BARRIER ISLANDS FROM VIRGINIA–MARYLAND BORDER TO MOUTH OF CHESAPEAKE BAY IN 1996 (B. WATTS, PERS. COMM.; B. TRUITT, PERS. COMM.).

SITE	27 April 1996	5 May 1996	13 May 1996	21 May 1996	1 June1996	10 June1996
Assateague Island	0	0	0	235	174	0
Wallops Island	0	0	0	0	395	0
Assawoman Island	0	0	0	0	214	0
Metompkin Island	0	0	0	2,150	1,272	0
Cedar Island	0	0	400	1,940	1,622	0
Parramore Island	0	0	1,035	1,459	1,758	0
Hog Island	0	0	60	947	1,243	200
Cobb Island	0	0	0	30	1,030	0
Little Cobb Island	0	0	0	0	0	0
Wreck Island	0	0	85	25	31	0
Ship Shoal Island	0	0	80	30	150	0
Myrtle Island	0	0	0	55	150	0
Smith Island	0	0	20	1,713	883	0
Fisherman Island	0	0	0	0	0	3
Total	0	0	1,680	8,584	8,922	203

Fig. 46). Volunteers have conducted weekly shorebird surveys along the outer beach surf zone of Chincoteague NWR since 1992 (Table 30). Extensive shorebird surveys conducted by the late Claudia P. Wilds at Chincoteague in the 1970s and 1980s indicated that most of the Red Knots documented in the area were found on Tom's Cove Beach.

Surveys of the outer beach surf zone of Fisherman Island NWR at the southern tip of the Delmarva Peninsula indicate very little use of the island by the Red Knots during spring migration (Tables 27–29). It should be noted that over 200 Red Knots were documented on the island in May of 2005 (P. Denmon, pers. comm.). In 2004, refuge personnel initiated systematic fall shorebird surveys following ISS protocol (Table 31). One year of results indicate very little use of the island by Red Knots between August and October.

Ten years of shorebird survey data along the ocean facing beaches of Back Bay NWR and False Cape State Park suggest that the number of Red Knots using those beaches during spring migration is insignificant relative to the amount of use received by the barrier islands bordering the Delmarva Peninsula (D. Schwab, pers. comm.).

Shorebird surveys conducted during a May 2000 invertebrate study, showed that Red Knot numbers peaked on Metompkin Island on 19 May with approximately 3,000 birds present and on Parramore Island on 21 May with approximately 3,000 present. A total of 68 banded and flagged birds were noted, with 37 from Argentina, 27 from Delaware Bay, and four from Brazil.

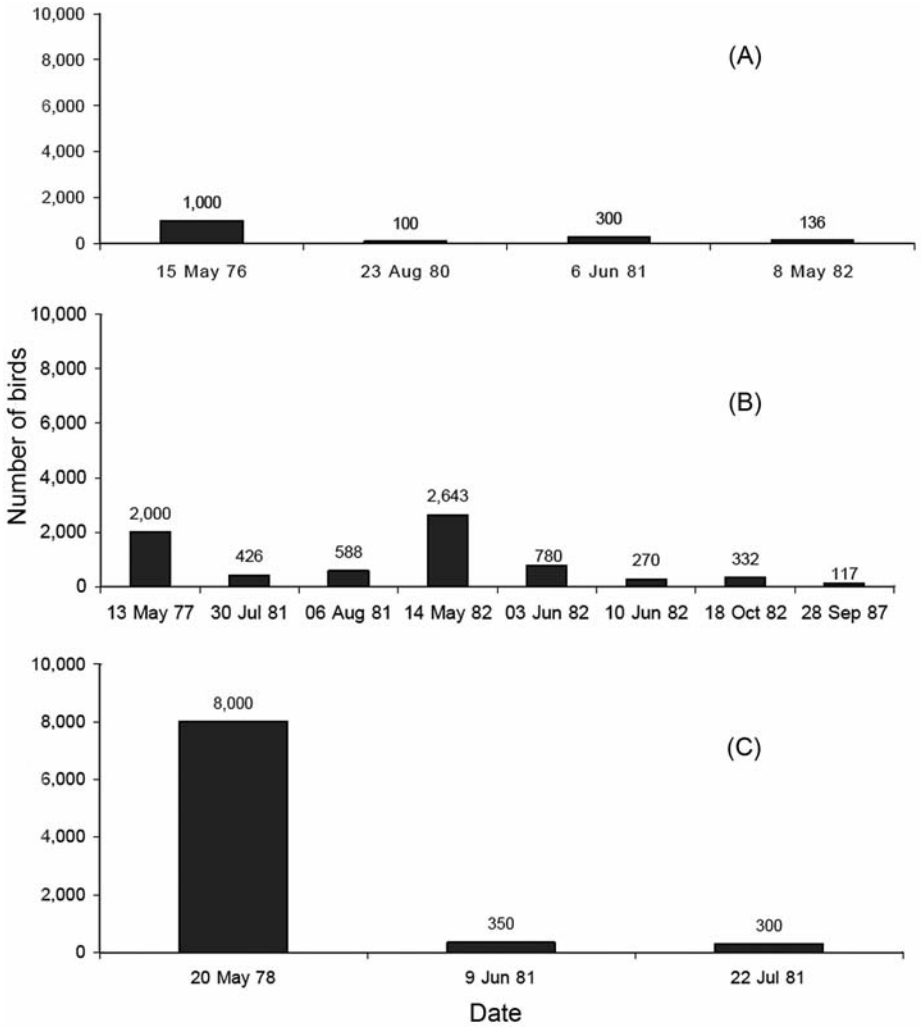

FIGURE 46. Number of Red Knots counted at (A) Wallops Island, (B) Chincoteague, and Metompkin Island, Virginia, 1976–1982 (B. A. Harrington, unpubl. data).

TABLE 30. GROUND SURVEYS FOR RED KNOTS ON CHINCOTEAGUE NATIONAL WILDLIFE REFUGE, 1992–2003. NUMBERS INDICATE PEAK COUNT [a].

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
January	0	0	0	0	0	0	0	0	0	0	6	0
February	0	4	0	0	0	0	0	0	0	0	0	0
March	1	0	0	0	0	0	0	0	0	0	0	0
April	0	0	1	0	0	0	0	0	0	0	7	0
May	15	36	47	144	133	73	54	90	5	0	543	4
June	28	9	124	98	5	11	42	48	13	66	282	0
July	105	27	58	143	3	62	25	1	0	2	8	0
August	209	106	306	20	5	13	0	0	3	4	88	24
September	23	19	65	99	10	5	1	0	0	1	35	0
October	37	0	0	0	8	0	0	0	0	0	1	55
November	26	2	0	12	1	1	4	0	0	0	0	0
December	0	1	11	25	52	8	0	0	0	1	64	0

[a] One to five counts conducted monthly at varying tidal stages.

TABLE 31. RESULTS OF SHOREBIRD SURVEYS CONDUCTED ON FISHERMAN ISLAND NATIONAL WILDLIFE REFUGE, VIRGINIA, FOLLOWING INTERNATIONAL SHOREBIRD SURVEY PROTOCOL IN 2004[a].

Date	N Red Knots
11 August 2004	0
24 August 2004	0
7 September 2004	0
13 September 2004	2
23 September 2004	0
7 October 2004	1
14 October 2004	0

[a] Data collected and provided to Fisherman Island NWR by volunteers.

Various studies and surveys documenting Red Knot use of habitats in Virginia are summarized as follows:

1. Chesapeake Bay, western shore, various years—no systematic survey data exists for the isolated beaches that occur along the western shore of the Chesapeake Bay. These areas are almost certainly used by Red Knots during migration, but in unknown numbers. Over 200 individuals have been observed at Plumtree Island, NWR in mid-May. Fewer numbers have been observed at Goodwin Island. Other areas that may be used by Red Knots include the beaches at Newpoint Comfort, Melford Haven and Grandview Beach (B. Watts, pers. comm.).
2. Chesapeake Bay, western shore (Craney Island), 1975—shorebird surveys conducted on Craney Island 2–3 d/wk from 18 February through 17 July 1975 recorded large numbers of shorebirds of various species but only a single Red Knot near the end of May (Shopland 1975).
3. Lower western shore salt marshes, 1992—surveys conducted for birds using 30 salt marshes along the lower western shore of the Chesapeake Bay between 6 May and 10 July 1992. More than 1,800 shorebirds were recorded including three Red Knots (Watts, 1992).
4. Lower western shore salt marshes, 1993—tidepool surveys within salt marshes of the lower western shore of the Chesapeake Bay were conducted from 25 April through 23 October of 1993. Several hundred shorebirds were recorded using tidepools but no Red Knots were observed (Allen 1995).
5. Chesapeake Bay, Eastern Shore, various years—no systematic survey data exist for the Eastern Shore of the Chesapeake Bay. Flocks of >500 Red Knots have been observed during aerial surveys over Plantation Creek, Northampton County, Virginia (B. Watts, pers. comm.).
6. Lower Delmarva mainland, 1991–1992—shorebird surveys within 400 agricultural fields in Northampton County, Virginia from March 1991 to February 1992 recorded more than 20,000 observations of 21 species. Only one observation of a Red Knot was made during the study. This individual was observed in May (Rottenborn 1992).
7. Beaches of Norfolk and Virginia Beach, 1992—shorebird surveys were conducted along six beach segments within Norfolk and Virginia Beach from 8 February to 11 June, 1992 with >3,000 observations including <50 Red Knots (McLean 1993).

To date, no formal resighting surveys have been conducted in Virginia. In 2005, casual scans of Red Knot flocks on Virginia's barrier islands during spring migration revealed a number of observations of birds that were banded throughout their range (Appendix 1, map 17). This suggests that the development of a formal and systematic spring migration resighting survey effort on the barrier islands would be worthwhile expenditure of time and resources.

United States Fish and Wildlife Service Region 5 – Maryland

The state of Maryland does not conduct or sponsor any organized surveys that include Red Knots, and no research, monitoring or management efforts regarding Red Knots have been done in the state (G. Therres, pers. comm.). Suitable habitats do exist within the state including: Hart Miller Island, Assateague Island, and Poplar Island. Poplar Island is located off the Chesapeake Bay coastline, about 54 km south of Baltimore in Talbot County. At the time of this writing no accessible records of sightings of Red Knots had been made within the state.

United States Fish and Wildlife Service Region 5 – New Jersey and Delaware

The Delaware Bay is a migratory stopover of hemispheric importance for Red Knots and at least five other species of shorebird including Ruddy Turnstone, Sanderling, Dunlin, Short-billed Dowitcher (*Limnodromos griseus*), and Semipalmated Sandpiper. This section presents information specific to New Jersey and Delaware habitats and shorebird populations. Historic and current research has been conducted from the perspective of the Delaware Bay ecosystem because migratory shorebirds use the entire bay to meet their energetic needs.

Delaware Bay, a major estuary of the U.S. middle Atlantic coastal region, is located at the mouth of the Delaware River in the states of Delaware and New Jersey. Delaware Bay serves as critical stopover habitat for migrating shorebirds, especially during the spring migration when it supports some of the highest numbers recorded in the lower 48 states (Clark et al. 1993). Many of these migrants rely heavily on the eggs of horseshoe crabs, which come to spawn in Delaware Bay in high numbers (Castro and Myers 1993, Tsipoura and Burger 1999). Because a significant proportion of the Red Knot population moves through Delaware Bay during the spring migration, this area is of critical concern.

Delaware Bay is fringed by extensive coastal marshes and mudflats typically fronted by a sandy barrier beach. The sandy barrier beaches overlay marsh sediments (generally a fibrous peat formed by the root mat of the marsh plants) and vary in thickness from a thin veneer to about 2-m thick (Phillips 1986a). The back beaches, above normal high tide, form a low dune and are often colonized by common reed (*Phragmites australis*; Phillips 1987). The intertidal portions of these sandy barrier beaches are of special significance as these are the locus of horseshoe crab spawning activity and the Red Knots' foraging activities. At a bay-wide scale, the use of intertidal beaches as horseshoe crab spawning habitat is limited in the north (Sea Breeze in New Jersey and Woodland Beach in Delaware) by low salinity and by ocean-generated energy in the south (North Cape May, New Jersey, and Broadkill, Delaware).

Not surprisingly, migratory shorebird abundance is spatially variable within the Delaware Bay estuary as a consequence of these larger bay-wide patterns of horseshoe crab abundance and spawning activity. In their study of site selection of migratory shorebirds in Delaware Bay, Botton et al. (1994) found that migrant shorebirds, including Red Knots, showed a strong preference for beaches with higher numbers of crab eggs. Shorebirds were recorded to aggregate near shoreline discontinuities, such as salt-marsh-creek deltas and jetties that acted as concentration mechanisms for passively drifting eggs. Foraging and roosting shorebirds also react to human disturbance and are often displaced from prime foraging areas (Burger 1986, Erwin 1996). Thus near-shore development or high human use may lower a beach's value as optimal shorebird foraging habitat. During the spring 2005 migratory period, NJDFW took aggressive measures to limit access of people and pets to key stretches of beach habitat as a means of minimizing disturbance to foraging and resting shorebirds. These various studies suggest that a complex array of factors determines the optimality of particular Delaware Bay beaches as horseshoe crab spawning and shorebird foraging habitat.

Aerial surveys of migrating shorebirds have been conducted along Delaware bayshore since 1982 (Dunne et al. 1982, Kochenberger 1983, Clark et al. 1993). In 1982 and 1983, surveys were done by NJAS up to three times in the stopover period; since 1986 surveys have followed a standardized method (Clark et al. 1993). All bayshore surveys were conducted from Cape May Canal to Cohansey River in New Jersey, and Cape Henlopen to Woodland Beach in Delaware (Appendix 1, maps 19 and 20). Surveys were conducted once per week for the 6-wk period of early May to mid-June each year. Aerial survey data are summarized as a single-day peak count of Red Knots each year (Table 32). These survey data are analyzed in conjunction with other data sources within this document. A simple correlation analysis shows that Red Knot counts have declined by 52%; however, birds' length of stay is a strong influence when calculating the population

TABLE 32. PEAK COUNTS OF RED KNOTS OBSERVED IN AERIAL SURVEYS OF DELAWARE BAY SHORELINE.

Year	N Red Knots
1982[a]	95,530
1983[b]	16,859
1984	No survey
1985	No survey
1986[c]	55,531
1987	38,750
1988	38,190
1989	94,460
1990	45,785
1991	27,280
1992	25,595
1993	44,000
1994	52,055
1995	38,600
1996	19,445
1997	41,855
1998	50,360
1999	49,805
2000	43,145
2001	36,125
2002	31,695
2003	16,255
2004	13,315
2005	15,345
2006	13,445
Geometric mean	34,279
Correlation with year	–0.52 (P = 0.009)

[a] 1982 by Dunne et al. (1982).
[b] 1983 by Kochenberger (1983).
[c] 1986–2005 by Clark et al. (1993).

trend in the bay. As the horseshoe crab egg food source declines, birds must spend more time in the bay, and the likelihood of counting the same birds in multiple weekly surveys increases. Such a scenario would mean the actual decline is >52%.

Aerial survey data were mapped to illustrate the distribution of Red Knots in two time periods: 1986–1990 and 2001–2005 representing pre- and post-horseshoe crab decline, respectively. The survey data were summarized into the 5-yr periods, the total number of Red Knots summed (across the entire study area) and the percentage of the total 5-yr sum calculated for each beach segment. The survey data were analyzed as percentages to examine the spatial distribution of beach use on a relative, rather than an absolute basis.

Comparison of the maps for these two time periods suggests that the spatial distribution of Red Knot use has changed (Fig. 20). During the 1986–1990 time period, the Red Knots were relatively evenly distributed along the New Jersey shoreline from Reeds Beach to Ben Davis Point. However, during the 2001–2005 a greater concentration appeared to be in the Norbury's Landing to Reed's Beach area and the Egg Island Point to Gandy's Beach area. During 1986–1990, Red Knots were relatively evenly distributed along Delaware shoreline from Bowers Beach through Bombay Hook NWR, with a major concentration in the Slaughter Beach-Mispillion Harbor area. During 2001–2005, a much greater concentration occurred in the Slaughter Beach-Mispillion Harbor and Bowers Beach areas. Mispillion Harbor should be noted as the site of incredibly high concentrations consistently containing upward of 15–20% of all the Red Knots recorded on the Bay.

Other areas of the Bayshore were recorded as receiving comparatively minimal use by Red Knots; for example, the Cape May Peninsula south of Norbury's Landing, the central (Big Stone Beach) and eastern most (Prime Hook-Broadkill Beach to Cape Henlopen) sections of the Delaware shoreline. It is interesting to note that these low bird use areas coincide with areas of low horseshoe crab spawning activity as recorded by Smith et al. (2002a).

In addition to the aerial surveys, ground-based surveys have been conducted by NJENSP to identify other high use areas for Red Knots during the spring stopover. In particular, large numbers of Red Knots have been recorded using the Stone Harbor Point area on the Atlantic coast of Cape May County, New Jersey (Sitters et al. 2001, unpubl. data). Stone Harbor Point and adjacent islands contain undeveloped sand beach/bar, mudflat, and salt marsh and serve as both foraging and resting habitat for Red Knots. In 2001, Red Knots were surveyed roosting (Table 33) and feeding (Table 34) in the Stone Harbor Point area, reaching a maximum count of 18,000 on 28 May 2001. In 2005, H. P. Sitters (unpubl. data) recorded both nighttime counts in the area and the presence of telemetered Red Knots (Table 35). These data suggest possibly all Red Knots in Delaware Bay were using the Stone Harbor Point area for nighttime roosting in late May 2005, and underscore the importance of this area for the population.

Thus, while the Delaware Bay intertidal beaches are essential for horseshoe crab spawning and are the egg resource for Red Knots, migrating shorebirds including the Red Knot move actively between Delaware Bay habitats with changes in the tidal cycle (Burger et al. 1997; H. P. Sitters, unpubl. data). Shorebirds use all these habitats for foraging and resting

TABLE 33. NUMBERS OF RED KNOTS ROOSTING AT HIGH WATER BY DAY AND AT DUSK AT STONE HARBOR POINT, NEW JERSEY, DURING MAY 2001 (H. P. SITTERS, UNPUBL. DATA).

Date	Time of high tide	N Red Knots roosting	Day or dusk
9 May	1032 H	152	day
10 May	1120 H	100	day
21 May	2011 H	11,000	dusk
22 May	2050 H	14,000	dusk
23 May	0922 H	700	day
23 May	2130 H	15,000	dusk
24 May	1008 H	1,200	day
27 May	1253 H	12,000	day
28 May	1353 H	18,000	day
29 May	1451 H	15,000	day
30 May	1550 H	3,200	day
1 June	1747 H	3,000	day
2 June	1841 H	1,500	dusk
3 June	1931 H	2,000	dusk

TABLE 34. OBSERVATIONS OF RED KNOTS FEEDING IN THE STONE HARBOR AREA WETLANDS DURING MAY 2001 (H. P. SITTERS, UNPUBL. DATA).

Date in May	Time of low water	N Red Knots in wetlands	Time observed	Knots Location	Total daily counts of Red Knots
4	1258 H	2	1400–1445 H	Grassy Sound	2
5	1346 H	250	1120–1530 H	Great Sound	250
7	1519 H	500	1415–1630 H	Great Sound	500
8	1602 H	700	1420–1740 H	Great Sound	700
9	1644 H	700	1500–1815 H	Great Sound	700
10	1724 H	1,400	1630–1830 H	Great Sound	1,400
17	1100 H	43	0930–1230 H	Great and Jenkins Sound	43
19	1239 H	300	1015–1450 H	Jenkins Sound	300
21	1404 H	700	1445–1500 H	Stone Harbor	700
22	1448 H	800	1440–1510 H	Back-bay Stone Harbor	
		200	1530–1555 H	Grassy Sound	
		3,500	1600–1625 H	Stone Harbor	3,500
23	1533 H	130	1330 H	Stone Harbor	
		156	1340 H	Back-bay Stone Harbor	
		350	1400–1500 H	Back-bay Stone Harbor	
		200	1520–1550 H	Grassy Sound	
		150	1615 and 1637 H	Back-bay Stone Harbor	
		700	1630 H	Stone Harbor	850
24	1618 H	600	1445–1700 H	Back-bay Stone Harbor	
		500	1445–1700 H	Back-bay Stone Harbor	
		37	1740 H	Stone Harbor	1,200
27	0647 H	6,500	0930–1000 H	Stone Harbor	
	1847 H	3,000	1745–1845 H	Stone Harbor	
		5,000	1745–1845 H	Back-bay Stone Harbor	8,000
28	0743 H	250	0800–0900 H	Stone Harbor	
		950	0800–0900 H	Back-bay Stone Harbor	
	1950 H	3,000	1800–1900 H	Stone Harbor	
		2,200	1800–1900 H	Back-bay Stone Harbor	5,500
29	0845 H	3,000	0945 H	Stone Harbor	
		7,000	0955–1040 H	Jenkins Sound	7,000
		5,000	2000–2015 H	Back-bay Stone Harbor	5,000
30	0949 H	400	1100 H	Stone Harbor	
		2,000	1130 H	Jenkins Sound	2,400
31	1048 H	700	1100 H	Stone Harbor	
		1,800	1100 H	Back-bay Stone Harbor	
		3,000	1130 H	Jenkins Sound	5,500

TABLE 35. SUMMARY OF RED KNOT EVENING AND NIGHT COUNTS AND NUMBER OF RADIO-TAGGED RED KNOTS AT HEREFORD INLET, STONE HARBOR, NEW JERSEY, DURING 19–31 MAY 2005 (H. P. SITTERS, UNPUBL. DATA).

Date	Time of high tide	Time of observations	Red Knots counted	Radio-tagged Red Knots recorded
19 May	1735 H	1800–1900 H	3,500	
20 May	1821 H	1800–1900 H	4,500	
21 May	1904 H	1900 H	4,500	
22 May	1946 H	1900–2000 H	13,000	
23 May	2029 H	1900–2000 H	20,000	
24 May	2114 H	1900–2030 H	16,000	
25 May	2204 H	2030 H	14,000	21
		2100 H		28
26 May	2259 H	2030 H	14,000	16
		2315 H		33
27 May	2359 H	2350 H		30
29 May	0059 H	0040 H		26
30 May	0159 H	0215 H		25
31 May	0257 H	0305 H		20

depending on location, seasonal date, time of day, tide, and species. Though the beaches are of critical importance, during high tide they are often too narrow for foraging, and the birds go elsewhere, including nearby salt marshes, tidal mudflats, and creeks. Radio telemetry has documented flights by Red Knots across Delaware Bay from Mispillion Harbor and across Cape May Peninsula to use the sand beach and salt marshes near Stone Harbor Point for foraging, resting, and roosting (H. P. Sitters, unpubl. data). Burger et al. (1997) suggested that in addition to the massive food resource provided by spawning horseshoe crabs, Delaware Bay's complex mosaic of coastal habitat types of mudflats, beaches, tidal creeks, and salt marshes is essential to maintain the large migrant shorebird population. H. P. Sitters (unpubl. data) suggested that Red Knots move to Atlantic coast habitats in the Stone Harbor area when horseshoe crab eggs are limited on the bayshore; they will forage on mussel spat when that is available. In recent years Red Knots made daily flights to roost at Stone Harbor even though they foraged at Mispillion in Delaware and Fortescue in New Jersey (H. P. Sitters, unpubl. data). This suggests that safe, predator-free roost sites are also of critical importance.

United States Fish and Wildlife Service Region 5—New York

The Red Knot does not occur in high numbers in the Jamaica Bay area. The East Pond, an impoundment that is part of the Jamaica Bay Wildlife Refuge, is the most common location where Red Knots occur (Appendix 1, map 21).

Plumb Beach is also a site where Red Knots feed on horseshoe crab eggs. Plumb Beach is the prime location for horseshoe crab spawning in the Jamaica Bay area. Several other secondary sites serve as suitable habitat for Red Knots. Gerritsen Inlet (Saltmarsh Nature Center and city parks) has an extensive shoreline that is used by Red Knots and other shorebirds. Red Knots are also consistently seen in the area of Far Rockaway, Long Beach, and Jones Beach.

Although most of the Long Island shorebird experts queried do not believe these secondary areas host large numbers of Red Knots, these sites are used consistently by small numbers of Red Knots during spring and fall migration and should be considered suitable.

United States Fish and Wildlife Service Region 5—Connecticut

The state of Connecticut does not have habitat deemed critical to Red Knots, though there is some consistent use in the state by a small number of birds (J. Dickson, pers. comm.). Records indicate, however, that Red Knot populations within the state have declined. CBC data from 1972–2001 indicate that the highest numbers of Red Knots in the state occurred in 1986 (20 Red Knots recorded) and in 1992 (27 Red Knots recorded). Based on surveys by the Connecticut Department of Environmental Protection, the maximum number of Red Knots found in the state during migration surveys was 90, during August 1984. The maximum observance rate of Red Knots in surveys was <22%, typically between May and October (Varza 2004).

Important habitats in Connecticut may include the Housantonic River mouth (four Red Knots observed in 2001) which is a key migratory corridor. Specifically, the outer bars—Short Beach on the south side of Milford Point in the Housantonic River mouth—was the site of all the recorded Red Knots activity. Other areas that may be important to Red Knots in Connecticut are Milford Point (Milford), Long Beach (Stratford), and Sandy Point (West Haven) where small numbers of birds (<9 Red Knots recorded in these location in 2001) have been recorded (Appendix 1, map 22; Varza (2004). The sand bars on Cockenoe Island (Westport) are regularly used by three–six Red Knots during spring and fall migration according to data from Connecticut Audubon and the Connecticut Ornithological Association.

United States Fish and Wildlife Service Region 5—Rhode Island

No historic records exist of large numbers of Red Knots using coastal areas of Rhode Island during spring or fall migration. Red Knots occur consistently but intermittently and in low numbers, at three of five important shorebird migratory stop overs in Rhode Island—Napatree Point-Sandy Point Island, Westerly; Ninigret Pond, Charlestown; and Quicksand Pond, Little Compton (Appendix 1, map 22). In an historical compilation of Rhode Island birds, R. L. Ferren (unpubl. data) cites only a single count of >100 birds. Maximum counts on any given site rarely exceed 50 individuals. No stopover sites in Rhode Island are considered to be critical for Red Knots; however, existing stopover sites for Red Knots tend to be areas that host relatively large concentrations of other shorebirds as well.

The movement of Red Knots through Rhode Island on northward migration in spring is decidedly uni-modal, peaking between the third week of May and the first week of June. Conversely, the number of Red Knots on southward migration (July–October) is generally greater than spring

but much more sporadic, with a loose peak around 22 August. The intermittent nature of Red Knot use of Rhode Island stopovers may be related to inclement weather; that is, storms or fog may force coastal or pelagic migrating Red Knots to seek safe roosts or foraging areas along the Rhode Island shoreline. While most shorebird species moving through Rhode Island have regular and predictable migration patterns, the Red Knot stands out as a species with unpredictable migration patterns, particularly on southward migration. At Napatree Point, where shorebird surveys have been conducted regularly (C. Raithel, pers. comm.) since 1980, high (25+ birds) Red Knot counts have been recorded between 1982 and 2004 (Table 36).

It is evident in contrast to R. L. Ferren (unpubl data), that large counts of Red Knots are much more likely to occur in fall (three of the 19 records above were in spring). The sporadic nature of Red Knot migration is evident even in these cursory numbers. High counts (≤100 individuals) occurred in only 10 of 24 yr of this survey. Some years are apparently much better for Red Knots than others in Rhode Island. For example, seven of the 19 high counts occurred in 1989. This phenomenon could simply be due to autocorrelation in the data—when large numbers of Red Knots appear in Rhode Island, they tend to stay for a while and are therefore counted repeatedly. However, the spread of fall dates (between 21 July and 25 September) for high counts is similarly unusual for Rhode Island shorebirds—most species display a very predictable bimodal or uni-modal fall pattern. These numbers suggest that the variance in survey counts for the Red Knot (at least in this area) is higher than that for other shorebirds.

It would be interesting if the sporadic nature of Red Knot migration in Rhode Island (relative to other shorebird species) is related to its demonstrably greater vulnerability, because examples with other species groups where high variation in breeding cycles and/or habitat use seem to be linked to vulnerability at landscape scales. Other researchers have suggested that Red Knots use highly ephemeral resources, such as mussel spat and small surf clams (*Donax variabilis*), and Red Knot distribution from year-to-year likely depends on the abundance of these food resources. It is unknown if this is a factor contributing to Red Knot abundance and distribution on coastal Rhode Island.

However, the sporadic nature of Red Knot use of some coastal areas all along the eastern seaboard suggests Red Knots may have a narrower foraging niche in time and space than other species. As long as a heterogeneous mixture of suitable habitats exists, and prey are available at least in some locations, Red Knots can persist. However, as habitats become lost to disturbance, development, abundant predators, and subject to activities that reduce prey availability (e.g., beach replenishment), foraging, and roosting options for Red Knots become limited. Particularly on northbound migration where time is critical, these factors are likely to negatively impact the population.

United States Fish and Wildlife Service Region 5 – Massachusetts

During southward migration, regions on Cape Cod and Massachusetts Bay are important migration staging sites (Appendix 1, map 23). To identify major stopover locations, we searched

TABLE 36. SUMMARY OF SPRING AND FALL MIGRATION SURVEYS FOR RED KNOTS IN RHODE ISLAND BETWEEN 1982 AND 2004 (C. RAITHEL, PERS. COMM.).

Spring migration			Fall migration		
Year	Day	N Red Knots	Year	Day	N Red Knots
1982	2 Jun	60	1984	11 Aug	43
1983	22 May	26	1989	15 Aug	33
2002	4 Jun	28	1989	22 Aug	67
			1989	5 Sep	36
			1989	11 Sep	32
			1989	21 Sep	65
			1989	22 Sep	72
			1989	25 Sep	25
			1990	9 Aug	32
			1990	13 Aug	51
			1994	22 Aug	51
			1996	21 Jul	55
			2000	21 Aug	33
			2000	5 Sep	31
			2000	6 Sep	47
			2004	22 Aug	50

historical records in publications such as *Records of New England Birds* (1939–1972), volumes in migration seasons of *Audubon Field Notes* (and its successor *American Birds*) (1948–1999), *Bird Observer of Eastern Massachusetts* (1970–2002), and the ISS (1974–2002). In general, these sources (except the ISS, which follows prescribed count routines) record early and late arrival dates, and often, maximum seasonal counts.

Where available, maximum counts during south migration were made during south migration in each of three regions of Massachusetts (the coast North of Boston, Western Cape Cod Bay, and Eastern Cape Cod; B. A. Harrington, unpubl. data; Appendix 1, map 23). Although maximum counts are difficult to statistically assess, a strong correlation ($r^2 = 0.90$, $P < 0.001$) exists between maximum and mean ISS counts of Red Knots during south migration in Massachusetts (B. A. Harrington, unpubl. data), indicating that maximum counts are a reasonable metric for an historic review.

The historic count data summarized in Fig. 47 indicate relatively consistent use of eastern Cape Cod locations by Red Knots during the last 50 yr, as well as less regular periods when high numbers used sites on Western Cape Cod Bay. In contrast, the North Shore of Massachusetts was relatively little used by Red Knots throughout the 50 yr.

It is appropriate to note that Massachusetts is clearly used by southbound Red Knots with South American destinations during July and August. However, it also is clear that numbers of Red Knots using the Massachusetts coast are substantially lower than the numbers that pass through Delaware Bay during the northward migration (Fig. 48; Morrison and Harrington 1992). The banding locations were identified for 327 of the 334 color-banded Red Knots found in Massachusetts during southward migration. Most (75%, N = 245) of the identified birds had been marked on Delaware Bay, 23% (N = 77) had been marked in South America, and only five (2%) had been marked in South Carolina. None from Georgia were found. The frequencies of marked Red Knots from different banding locations were not statistically significantly different from the frequencies found in Delaware Bay ($\chi^2 = 10.54$, df = 5, $P > 0.05$).

United States Fish and Wildlife Service Region 5 – New Hampshire

New Hampshire does not host large numbers of staging Red Knots. At the time of writing, the Nongame Program of the New Hampshire Department of Natural Resources does not conduct any surveys, monitor or have any available data on Red Knots within the state. All records for this state are from bird sightings submitted to New Hampshire Audubon. According to these reports, no more than 50 Red Knots were ever seen at any one place in New Hampshire from 1986–2004. Though not seen in large numbers, intermittent use seems to occur at least three locations—Hampton Harbor, Seabrook Harbor, and White and Seavey islands (Appendix 1, maps 24 and 26; Audubon Society of New Hampshire, unpubl. data).

United States Fish and Wildlife Service Region 5 – Maine

The state of Maine conducts coast-wide counts between July and September of shorebirds to identify shorebird habitats (Table 37; L. Tudor, pers. comm.). Currently, it is not believed that Maine provides Red Knots with critical stopover habitats. Red Knots are usually not seen on northward migration, always on southward migration. Habitats that may possibly be important for Red Knots include Petite Manan Island and Bluff and Stratton islands (Appendix 1, maps 24, 25, and 26). The most productive staging area for shorebirds in Maine is Lubec and Sprague Neck (Appendix 1, maps 24 and 25). In 1979 and 1980, these areas were surveyed intensively, only 11 Red Knots were recorded at Lubec and 64 Red Knots were recorded at Sprague Neck. In 1989, the state of Maine began intensive shorebird surveys to locate and designate critical staging areas. Surveys were concentrated on one section of coastline per year, with surveys completed in 1995. Areas were surveyed every 2 wk at varying tides starting in mid-July through the end of September. Since 1995, the state has monitored key sites in Washington County and has started collecting data for the Program for Regional and International Shorebird Monitoring (PRISM). PRISM is being implemented by the Canada-U.S. Shorebird Monitoring and Assessment Committee formed in 2001 by the Canadian Shorebird Working Group and the U.S. Shorebird Council. PRISM is based on the shorebird conservation plans recently completed in Canada and the U.S. and provides a single blueprint for implementing both of these plans. For more information see http://www.fws.gov/shorebirdplan/USShorebird/downloads/PRISMOverview1_02.doc

These surveys start in mid-July and go through end of September, covering select areas every 2–3 wk. The state also cooperates with non-government organizations working on nesting tern islands which record shorebird numbers, these data are collected from June to end of July with scattered data collected in August.

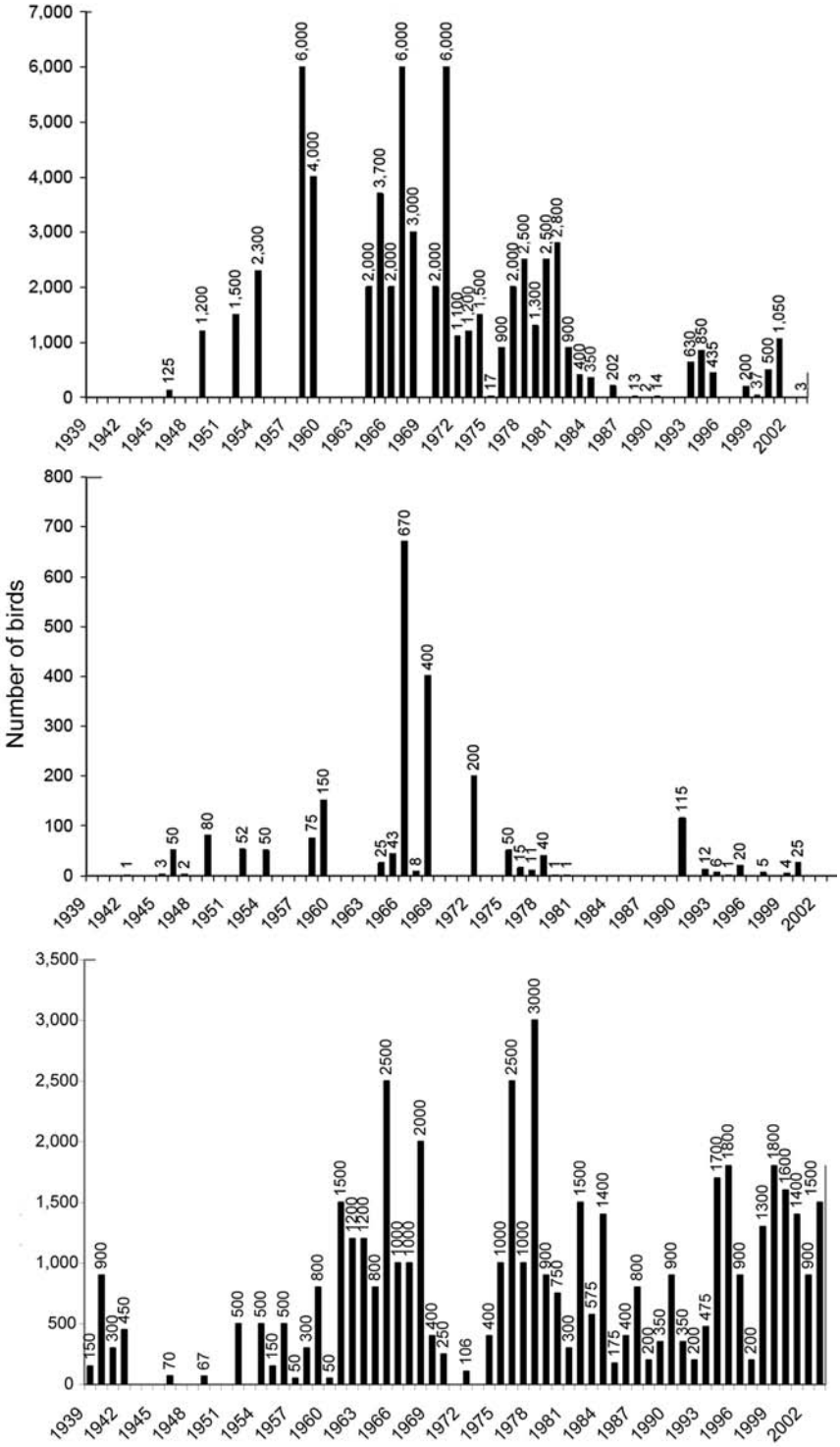

FIGURE 47. Maximum historic Red Knot counts from three regions of Massachusetts: (A) western Cape Cod, (B) North Shore, and (C) eastern Cape Code during southbound migration (B. A. Harrington, unpubl. data).

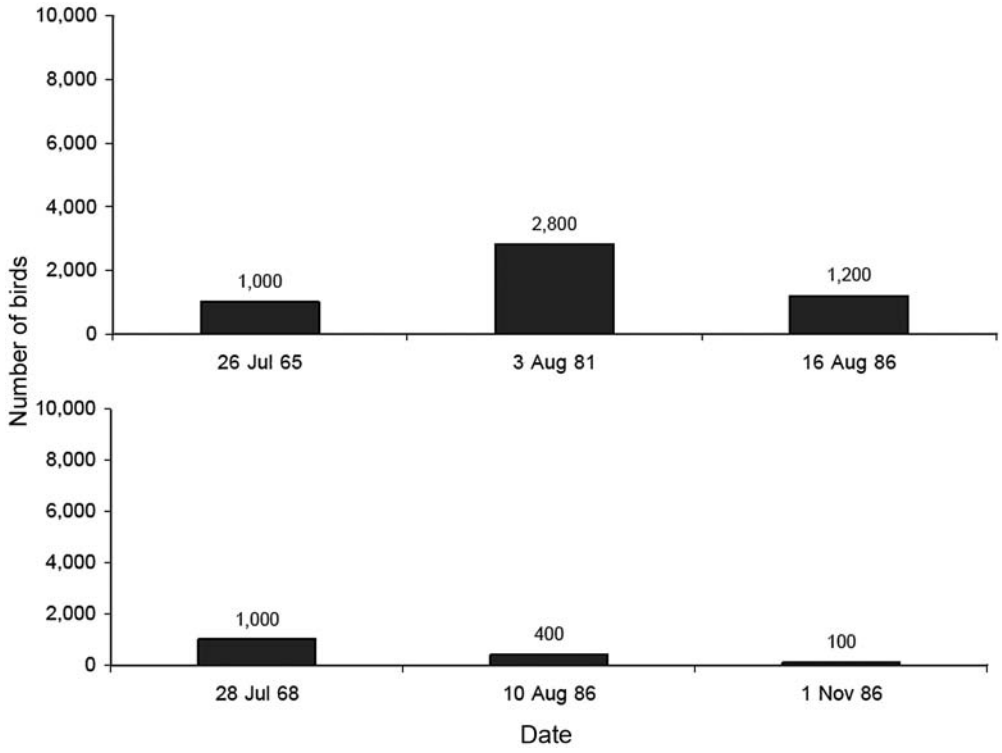

FIGURE 48. Number of Red Knots counted at Scituate (upper) and Monomoy (lower), Massachusetts, 1965–1986 (B. A. Harrington, unpubl. data).

Canada

Although the entire adult population of *C. c. rufa* breeds in Arctic Canada, estimating the population on its arctic breeding grounds is problematical owing to very low breeding densities (e.g., Southampton Island), lack of detailed habitat maps and information, and the need to extrapolate over very large areas. Trends may be derived from counts at migration areas, though in North America such counts may involve mixtures of populations from different wintering areas. For *C. c. rufa* wintering in southern South America, the most authoritative counts are those conducted at the main wintering sites in Tierra del Fuego.

During spring migration in North America, it appears that many *C. c. rufa* may fly directly to the breeding grounds from Delaware Bay. Large flights of Red Knots have been observed passing northward through southern James Bay at the end of May or start of June (R. I. G. Morrison, unpubl. data; M. Peck, unpubl. data), having probably flown directly from Delaware Bay (Morrison and Harrington 1992). Large concentrations are occasionally found around Lake Ontario (e.g., 400 at Presqu'ile Provincial Park on 18 May 1969, 1,500 at Prince Edward Point on 30 May 1979,and 1,000 near Amherstview on 21 May 1985), though these probably represent weather-related dropouts from the main migration (McRae 1982, Weir 1989, Morrison and Harrington 1992). The sighting of a Red Knot that had been color-banded at Lagoa do Peixe in southern Brasil at Presqu'ile Provincial Park indicates that these birds include migrants from the southern *C. c. rufa* population. Knots are rare in spring on the Atlantic coast of Canada, where food resources have not yet recovered from winter ice conditions. Farther west along the route of the interior flyway, occasional observations have been made of Red Knots occurring briefly in atypical habitats during spring migration; these are likely to involve birds wintering in Florida (or Maranhão). For example, 2,500 were seen on a burned over stubble field near Last Mountain Lake, Saskatchewan, on 21 May 1972 (Skagen et al. 1999). Such records probably again relate to migrants bound for the western edge of *C. c. rufa's* breeding range being forced to land during poor weather. We know of no similar records in more recent years.

The number of Red Knots occurring at autumn migration stopover sites in Canada,

TABLE 37. RED KNOT SURVEY DATA FOR MAINE (1980–2004).

Date	N Red Knots	Location
Aug 1989	115	Hog Bay, Franklin, Hancock County
Sep 1989	27	Hog Bay
Aug 1985	10	Spruce Island, Deer Isle, Hancock County
Jun 2004	2	Ship Island, Tremont, Hancock County
May 1988	38	Over Point, Milbridge, Washington County
May 1989	15	Over Point
Oct 1988	12	Over Point
Oct 1989	9	Over Point
Aug 2004	1	Over Point
Aug 1989	14	Petit Manan Island, Milbridge, Washington County
Aug 1999	4	Petit Manan Island
Jul 2004	6	Petit Manan Island
Sep 1989	8	Petit Manan Point, Steuben, Washington County
Sep 1980	80	Holmes Creek, Cutler, Washington County
1980	87	Sprague Neck, Cutler, Washington County
Sep 1994	26	Sprague Neck
Aug 1994	10	Mash harbor, Addison, Washington County
Aug 2004	1	Flat Bay, Addison, Washington County
Sep 1991	10	West River-Indian River, Addison Jonesport, Washington
1980	11	Lubec Flats, Lubec, Washington County
Sep 1980	25	Lubec Flats
Sep 1991	6	Lubec Flats
Aug 1994	25	Lubec Flats
Sep 1996	10	Lubec Flats
Sep 1996	18	Lubec Flats
Sep 2002	13	Lubec Flats
Oct 2002	4	Lubec Flats
Aug 1993	53	Eastern Egg Rock, St George, Knox County
Jul 1993	26	Eastern Egg Rock
Jul 1994	20	Eastern Egg Rock
Aug 1994	7	Eastern Egg Rock
Sep 1993	16	Scarborough Marsh, Scarborough, Cumberland County
May 1985	26	Biddeford Pool, Biddeford, York County
Jul 1993	14	Bluff and Stratton Island, Old Orchard Beach, York County
Jul 1993	6	Bluff and Stratton Island
Aug 2004	5	Bluff and Stratton Island
Aug 2004	3	Bluff and Stratton Island

such as James Bay, the Bay of Fundy, and on the Mingan Islands in the Gulf of St. Lawrence, is greater than in spring (Hicklin 1987; R. I. G. Morrison, unpubl. data; M. Peck, unpubl. data). Large numbers of Red Knots pass southward through the southwestern coast of Hudson Bay (Manitoba and Ontario) and the western and southern coasts of James Bay during July and August (Hope and Shortt 1944, Manning 1952, Ross et al., pers. commun.). Mainland coastal surveys in late July 1990 and early August 1991 resulted in totals of 23,251 and 15,055, respectively (R. I. G. Morrison and R. K. Ross, unpubl. data). The southeast corner of Akimiski Island also appears to be important for Red Knots, with 6,900 being observed on a survey in late August 1995 (R. K. Ross, pers. comm.). Counts of 100–350 Red Knots have been recorded on the south coast of James Bay in Quebec (Aubry and Cotter 2001). Currently, the most important area for Red Knots on migration in eastern Canada is along the north shore of the St. Lawrence River in Quebec and the Mingan archipelago where counts of 1,000 or more have been made in late July or early August in several years (Étude des Populations d'Oiseaux du Québec, unpubl. data; Y. Aubry, pers. comm.; Fig. 49). During July to September 2006, 842 different individually banded Red Knot from elsewhere in the west Atlantic flyway were seen amongst those stopping over on the Mingan Islands. Most (585) had been banded during northward migration in Delaware Bay, but as many as 217 had been banded in Argentina and Chile confirming that the majority belonged to the *C. c. rufa* population that winters in southern South America (Fig. 49; Y. Aubry, pers. comm.). In view of the approximate proportion of banded birds in the *C. c. rufa* population (~10%) and the fact that some are likely to have been missed, it would seem probable that around a half of the flyway population stopped in the Mingan Islands in

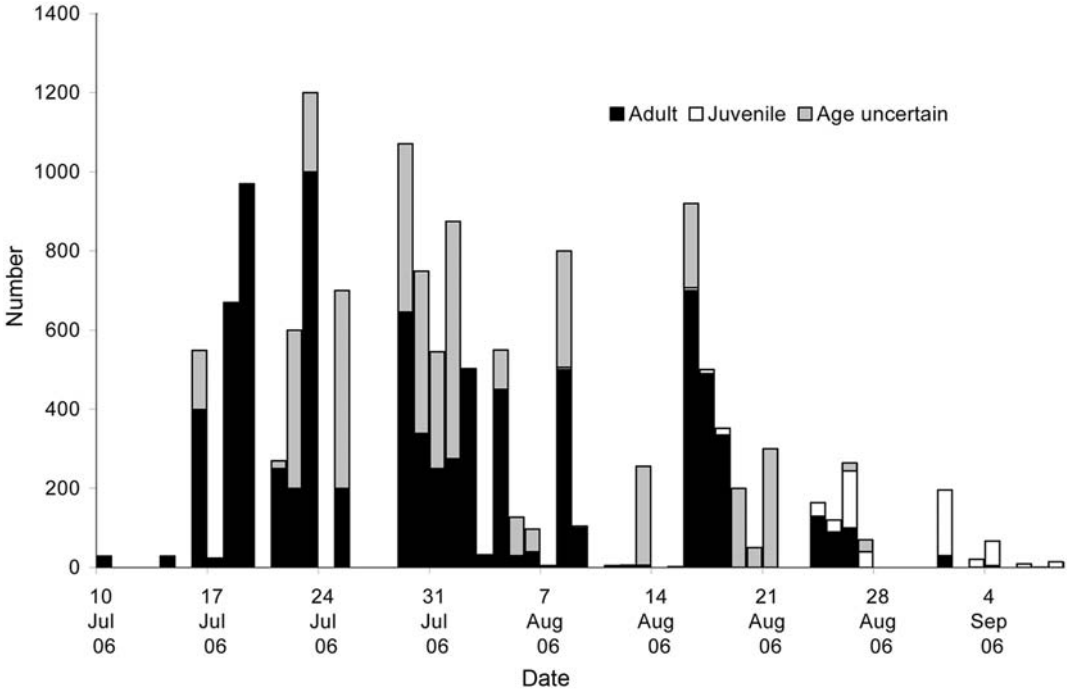

FIGURE 49. Counts of Red Knots on four islands (Nue, Grande, Quarry, and Niapiskau) of the Mingan archipelago in the Gulf of St Lawrence, Quebec, Canada, during July–September 2006 (Y. Aubry, pers. comm.).

2006. The islands are granitic and their shores are mostly rocky. However, on their southern sides there are small intertidal flats of gravel or sand that support an abundance of invertebrates (*Mytilus*, *Littorina*, and *Gamarus* spp.) suitable for foraging Red Knots. These invertebrates are mostly attached to the *Fucus* spp.and the other algae that cover the flats.

Up to the early 1980s, Red Knots were moderately numerous during southward migration in the upper Bay of Fundy, but fell rapidly to low levels in the mid 1980s and have remained at low levels since then. This may represent a withdrawal from relatively peripheral areas as the population started decreasing. Trend analyses of data from both Quebec and the Atlantic provinces of Canada have indicated significant declines (Morrison et al. 2006).

THREATS

Under section 4 of the Endangered Species Act 1973 (ESA), a species that is endangered or threatened may be listed as such if it is endangered or threatened because of: (1) the present or threatened destruction, modification, or curtailment of its habitat or range, and/or (2) overutilization for commercial, recreational, scientific, or educational purposes, and/or (3) disease or predation, and/or (4) the inadequacy of existing regulatory mechanisms or other natural or man-made factors affecting its continued existence.

Threats are therefore listed under these headings. In principle, a threat is only important if it has or may have an adverse impact on an animal's evolutionary fitness—its ability to survive and reproduce. In conservation science, perceived threats are often assumed to have fitness implications, but except where actual mortality occurs this is seldom proved. Therefore, a major focus of *C. c. rufa* studies has been to measure adult survival and attempt to identify those factors that lead to its reduction. This has met with some success, as described below. Nevertheless several threats are identified which in our opinion are likely to have fitness consequences, but we are unable to prove that this is the case.

Threats to Habitats in Delaware Bay During Spring Migration

The principal known threat to a substantial proportion of Red Knots in the Americas is the dwindling supply of their main food resource at their final spring stopover in Delaware Bay, the eggs of the horseshoe crab. As described in the habitats section, this once abundant resource