travel money to participate in Red Knot working groups.

Massachusetts:

1. Conduct research and monitoring of human disturbance in shorebird habitats, particularly those disturbances associated with commercial and recreational fishing and public access to beaches.
2. Monitor recruitment through observations of juveniles during fall migration.

Management Needs

The management needs presented in this section are preliminary and largely based on work described in more detail in previous sections. As nearly all management work focused on Red Knot occurs in the area of the Delaware Bay, management needs in other locations will only be determined after preliminary survey and research is complete. However, the experiences of conserving the Delaware Bay stopover, as well as work in Patagonian wintering areas, provide general management needs:

1. On the Delaware Bay, recover and maintain horseshoe crab egg densities at levels sufficient to maintain a stopover population of Red Knots of >100,000 birds.
2. Control impacts of disturbance at all stopovers and wintering areas where appropriate. This is especially important at key stopovers like Delaware Bay, but applies to the many Atlantic coast stopovers that occur in both spring and fall. This would include use restrictions and outreach programs.
3. Create an oil-spill response plan for key stopovers and wintering areas.
4. Maintain precise GIS maps of important use areas in each stopover and on wintering areas.
5. Ensure that all major stopover and wintering areas are recognized in protection initiatives such as WHSRN, International Association of Fish and Wildlife Agency's expanded flyway system, and Ramsar.
6. Avoid impacts of beach replenishment through timing restrictions, and specifications on beach fill to ensure quick recovery of beach invertebrates and horseshoe crab spawning in the Delaware Bay.
7. Clean up and restore all beaches on the Delaware Bay that include any structures impeding crab spawning such as bulkheads, homes, or rip rap. Avoid the placement of any new structures. The cross-bay commuting of Red Knots from feeding sites in Delaware to roosting sites on the Atlantic coast of New Jersey for the whole 14-d stopover is equivalent in distance to almost half the flight to the arctic breeding grounds. In energetic terms, the daily flight involves expenditure of about 83 kJ, which would require the ingestion of about 6,000 horseshoe crab eggs (H. P. Sitters, unpubl. data). Conservation management prescriptions should therefore include ensuring the existence of suitable roosting sites for Red Knots at various locations throughout the bay, especially in Delaware where steps should be taken to conserve the known inland roosting site near Mispillion Harbor. Coastal impoundments should be managed to maximize their potential use as Red Knot roosting sites, or sites created by building isolated sandbars or islands along the shore (such as beside the jetty protecting Mispillion Harbor where suitable high water roosting islands once existed but have since eroded away).

UPDATE TO THE STATUS OF THE RED KNOT (*CALIDRIS CANUTUS*) IN THE WESTERN HEMISPHERE, FEBRUARY 2008

Previous sections of this volume (referred to below as the original review) were based on data available as of June 2006. Since then important new information has become available and is presented in this section based on data and analyses available in February 2008.

Recent information suggests that the population of *Calidris canutus roselaari*, which breeds in Alaska and on Wrangel Island and migrates along the American Pacific coast, may be even more threatened than *C. c. rufa*. Therefore, in this update we give equal emphasis to both subspecies.

Taxonomic Status

According to the original review, Red Knots wintering in Tierra del Fuego are *C. c. rufa*, but the subspecific status of those wintering in Florida and in Maranhão (Brazil) is uncertain and either or both could be partly or wholly *C. c. rufa* or *C. c. roselaari*.

The original review includes the following statement which has been misinterpreted as meaning that the wintering populations of Florida and Tierra del Fuego are genetically distinct: "Despite the lack of fixed genetic differences among subspecies, the population divergence time of the Red Knots that winter in the southeast of the U.S. (presumed to be *C. c. roselaari*) and those that winter in Tierra del Fuego (*C. c. rufa*) is estimated to be about 1,200 yr

ago (Buehler and Baker 2005). Therefore, these populations have not been exchanging a significant number of individuals per generation for a long time, and clearly are independent units for conservation." That statement was made on the assumption that the Red Knots that winter in the southeastern U.S. are *C. c. roselaari*. Therefore, the genetic distinction refers to that between known *C. c. roselaari* from Alaska and known *C. c. rufa* from Tierra del Fuego. To date, no evidence exists of any genetic distinction between Red Knots from the wintering populations of the southeastern U.S., Maranhão, and Tierra del Fuego. Considerable evidence does show little or no interchange between these populations, that they have distinct migrations and ecological scheduling, and they behave as distinct biogeographic populations.

In October 2007, a Red Knot was seen at Guerrero Negro, Baja California, Mexico that had been marked as a breeding adult on Wrangel Island, Russia, during the summer of 2007 (P. S. Tomkovich et al., pers. comm.) and two Red Knots were seen at Guerrero Negro that had been marked on migration through the Yukon-Kuskokwim Delta, Alaska, in May 2006 (P. S. Tomkovich et al., pers. comm.) These observations confirm that Red Knots found on the Pacific coast of North America are of the *C. c. roselaari* subspecies which breeds in Alaska and on Wrangel Island (Tomkovich 1992).

In October 2006, 162 Red Knots were caught and measured at Guerrero Negro (R. Carmona, unpubl. data). These birds, which have not yet been sexed, had longer bill-lengths ($\bar{x}$ = 37.07 mm, 95% CI = 0.27) than males from the winter populations of Maranhão, Florida, and Tierra del Fuego, and also longer than Tierra del Fuego females (Fig. 4). So, unless most or all of the Mexican birds were females (which would seem unlikely), it would appear that *C. c. roselaari* are larger than the Red Knots wintering in Florida, Maranhão, and Tierra del Fuego and therefore larger than *C. c. rufa*.

Current scientific opinion, as expressed in a paper submitted to *Bioscience* on 23 December 2007 by L. J. Niles et al. (including most of the authors of this volume) is that the Florida and Maranhão populations are believed to be *C. c. rufa* (as well as the population of Tierra del Fuego). However, the three wintering populations do show morphological, particularly size, differences, with Tierra del Fuego birds being significantly smaller than those from Maranhão or Florida (Fig. 4). This may suggest that they have discrete breeding areas. However, as yet no proof of this exists (despite unsuccessful efforts to determine the status of Red Knots that breed on Victoria Island during summer 2007). While breeding areas may not currently be clearly delineated, it is important to recognize that the three populations are biogeographically distinct.

Population Status of *Calidris canutus roselaari*

According to Brown et al. (2001), the *C. c. roselaari* population was about 150,000 in 2001. This estimate, however, was based on information for 1975–1980 and was, therefore, out of date when the conservation plan was written. Moreover all attempts to assess the size of the *C. c. roselaari* population have been bedeviled by uncertainty as to which passage or wintering population belongs to which subspecies.

C. c. roselaari breeds in west Alaska and on Wrangel Island (Tomkovich 1992) and several population estimates are based on numbers counted in May on Alaskan estuaries, just before the birds disperse to the breeding grounds. These include 110,000 on the Yukon-Kuskokwim Delta (on the west coast of Alaska) in May 1980 and 40,000 on the Copper River Delta (on the south coast) in May 1975 where up to 100,000 have been thought to occur (Morrison et al. 2006). No records of such large numbers are available before 1975–1980 or since or of similar numbers in the passage-winter sites of *C. c. roselaari* further south along the Pacific coast. Morrison et al. (2006) therefore suggest that at least some of the large numbers seen in Alaska are likely to have been *C. c. rogersi* which breeds in east Siberia (more or less due south of Wrangel Island) and winters in east Australia and New Zealand and whose population has been estimated recently at about 90,000 (C. D. T. Minton, unpubl. data). Precisely why *C. c. rogersi* would migrate from Australasia to Siberia via Alaska in 1975–1980 and why they do not appear to do so now (or do so less) is not clear but the possibility cannot be rejected.

The only recent evidence that moderately large numbers may still pass through Alaska is an unpublished report by Pavel Tomkovich and Maksim Dementyev on observations they made in May 2006 on the Tutakoke River in the Yukon-Kuskokwim Delta (Tomkovich and Dementyev 2006). Most of the Red Knots they saw arrived daily from the south and departed northward. The sum of their counts—5,780—was therefore considered to give a reasonably accurate measure of numbers passing through the area. Since they were unable to cover the entire estuary, they were quite sure that not less than 10,000 Red Knots come through the lower Tutakoke River area. Bearing in mind that the Tutakoke River is only one site among several on the Yukon-Kuskokwim Delta, the

total passage population could still be quite large.

Evidence of numbers farther south along the American Pacific coast is fragmentary and difficult to interpret but suggests that the population that has never exceeded about 10,000. Page et al. (1999) present summed maximum counts for all sites on the U.S. Pacific coast (except Alaska) for 1988–1995 (fall 7,981; winter 4,813; spring 9,035). However, as these are summed peak counts without reference to date, it is highly likely that many individual birds were counted several times over.

In Washington, passage numbers have declined from a few thousand in the 1980s to peaks of 248 in spring 2006 and 446 in spring 2007 (Buchanan 2006, 2007).

In Baja California, 1,053 were counted at Guerrero Negro in January 1994 (Page et al. 1997), but it was not until recently that relatively larger numbers were recorded there. Carmona et al. (2006) working in the Guerrero Negro area counted 2,907 Red Knots in the saltworks alone in October 2005. Subsequently, 6,458 were counted in the saltworks and the adjoining Guerrero Negro and Ojo de Liebre lagoons in September 2006, 4,595 in December 2006 and 4,647 in April 2007 (R. Carmona, unpubl. data). Whether the recent observations represent a real increase in the population is not clear. It is a remote area and this population could have been overlooked in the past.

Summary

1. *C. c. roselaari* might have declined from 100,000+ to <10,000 if the large numbers reported in Alaska in 1975–1980 were *C. c. roselaari* and did not include substantial numbers of *C. c. rogersi*.
2. Alternatively, *C. c. roselaari* has always had a small population, probably <10,000, and has shown no clear long-term trend. Nevertheless, as a small population (probably less than half that of *C. c. rufa*), it is vulnerable and deserves protection.

POPULATION STATUS OF *CALIDRIS CANUTUS RUFA*

All three of the main wintering populations of *C. c. rufa* have shown substantial declines compared with the numbers reported in the original review (Table 39). From 2004–2005 to 2007–2008, counts were conducted each winter in Tierra del Fuego, Maranhão, and on the west coast of Florida, apart from 2005–2006 and 2007–2008 in Maranhão and 2004–2005 in Florida. If the previous years' counts are used for the missing counts in Maranhão and the succeeding year's count is used for the missing count in Florida (which is the most conservative approach in terms of estimating the scale of the decline), the total wintering population declined from 27,728 to 18,350 (33% or 11% per annum) over the four winters. However, since these wintering groups behave as separate populations, it would be more appropriate from the conservation point of view to consider their status individually.

Tierra del Fuego population

In April 2007, approximately 1,300 dead Red Knots were found on the coast of Uruguay, as described in the following report posted on BirdLife International's website (http://www.birdlife.org/).

Recent unexplained Red Knot die-offs have highlighted further the need for research into the variety of threats afflicting the already declining *C. c. rufa* population. In April 2007, 312 dead *C. c. rufa* were discovered at Playa La Coronilla in southeastern Uruguay and the same day over 1,000 birds were found dead at a second site nearby. Joaquín Aldabe (pers. comm.) suggested a possible connection between harmful algal blooms and the deaths, although additional studies are required in order to fully understand this unexpected event. Aves Uruguay, in connection with other national and international organizations, is already working in the area to establish the possible causes of the casualties and the role

TABLE 39. COUNTS OF RED KNOTS DURING THE NORTHERN WINTERS OF 2004–2005 TO 2007–2008 IN TIERRA DEL FUEGO (ARGENTINA AND CHILE), MARANHÃO (BRAZIL), AND ON THE WEST COAST OF FLORIDA (NC = NO COUNT). WHERE NO COUNT OCCURRED, THE TOTALS ROW USES THE PREVIOUS YEARS' COUNT FOR MARANHÃO AND THE SUCCEEDING YEAR'S COUNT FOR FLORIDA (SEE TEXT).

	2004–2005	2005–2006	2006–2007	2007–2008	Observers
Tierra del Fuego	17,653[a]	17,211[a]	17,316	14,800	R. I. G. Morrison and R. K. Ross
Maranhão	7,575[a]	NC	3,000	NC	I. Serrano
Florida west coast	NC	2,500[a]	1,200	550	L. Niles, A. D. Dey, and R. I. G. Morrison
Total	27,728	26,286	21,516	18,350	

[a] Numbers reported in the original review.

of Uruguay as stopover for the species. The death of more than 1,300 Red Knots in Uruguay is of particular concern because this number represents >6% of the *C. c. rufa* population, all of which winter in southern South America (R. Clay, pers. commun.). The discovery underlines the need to better understand factors which may be affecting the species during migration and on its wintering grounds.

Subsequently, PMG and AB interviewed the people who had found the dead knots and it was established that the count of 312 was accurate but the statement that over 1,000 were found dead at a second site was only a very rough estimate. Therefore, there is some doubt as to the total number of birds affected. However, whatever the number seen, it is likely that more died and were lost (e.g., in the sea or to scavengers).

This appears to have been a one-off event but has similarities to a smaller one mentioned in the Status Review that occurred at Lagoa do Peixe in southern Brazil in 1997.

The January 2008 Tierra del Fuego count of 14,800 was 2,516 or 15% lower than the previous year.

Maranhão population

Baker et al. (2005) counted 7,575 Red Knots from the air along 150 km of the shore of Maranhão, Brazil, in February 2005. A repeat count in December 2006 could only find 3,000 (I. Serrano, unpubl. data).

Florida population

The original review made a very tentative estimate of the size of the Florida population as 7,500 and found no clear evidence of a trend. Counts in the winter of 2005–2006 showed a minimum population of about 4,000 plus another 1,500 scattered along the coasts of Georgia, North and South Carolina, and Virginia (Niles et al. 2006). Of the 4,000 in Florida, 2,500 were found along 300 km of the west coast between Anclote Key and Cape Romano where an estimated 10,000 occurred in the 1980s (Morrison and Harrington 1992) indicating a substantial decline in what used to be the main Florida stronghold. Further counts along this coast show that the numbers wintering in this area declined to 1,200 in 2006–2007 and only 550 in 2007–2008.

Are the counts accurate?

The aerial counting of shorebirds requires skill and rapid assessment. Those involved in the counts reported here are all highly qualified counters, particularly R. I. G. Morrison and R. K. Ross who are probably the most experienced aerial counters of shorebirds in the world. Morrison and Ross have conducted all of the Tierra del Fuego counts, so the data have all been collected in a consistent manner by the same observers, and Morrison took part in the last Florida count. The remaining counts were conducted by people who have very considerable experience of counting shorebirds on the ground as well as some experience of counting from the air.

In Tierra del Fuego, all potential Red Knot habitat consists of simple linear shorelines leaving little likelihood that any birds will have been overlooked. In comparison, the shores of west Florida and Maranhão are complex and highly fragmented making accurate counting more difficult. To allow for this, aerial coverage in both areas was more extensive and included not only the ocean shore but also a great variety of back bays and channels where Red Knots might possibly occur.

In all three areas when fewer birds were found than in earlier years, searching was intensified. In some cases, repeat flights were made in case birds had been missed; in others the search was extended to marginal habitats to ensure that all locations where knots might possibly be found were covered. Intensified coverage revealed virtually no additional knots.

It is concluded that all of the counts were of sufficient accuracy giving confidence that the trends shown are true and the scale of the declines is correct.

Could the birds have moved elsewhere?

Generally, arctic-breeding shorebirds, including Red Knots, have been found to be highly site-faithful to their wintering grounds. However, changes in wintering site have not infrequently been recorded and have variously been attributed to changes in the availability of food, changes in the risk of predation, loss of habitat, and improved conditions closer to breeding grounds arising from climate change.

We are not aware of any changes to the habitats used by Red Knots in Maranhão or Tierra del Fuego that could have led the birds to winter elsewhere. In Florida, recreational use of the beaches has increased in recent years to such an extent that it could be a factor that has led birds to change site. However, the main sites occupied in 2005–2006 are well within or towards the middle of the 300 km of coast surveyed each year. Therefore if the birds have moved elsewhere, they must have moved a considerable distance. It should be noted that the population

of the remainder of the south coast of the U.S. has not been surveyed since 2005 so its recent trend is unknown.

In Tierra del Fuego, all coastlines that have supported Red Knots in the past, and especially the core sites supporting the bulk of the population (Bahia Lomas, Bahia San Sebastian, and Rio Grande) have been surveyed from the air in January in the years 2000–2008. Previously occupied areas on the coast of Patagonia were also surveyed in three separate years, but were found to support few Red Knots (2% of the wintering count) compared to the 1980s (14%), indicating the population is now found almost entirely in the core sites, with few in the more peripheral areas, and with no evidence for any redistribution outside the core region. Moreover, we are in regular contact with shorebird observers in Patagonia and there have been no reports of significant numbers of Red Knots wintering north of Tierra del Fuego in Argentina in 2007–2008, again indicating that no significant redistribution has occurred. With consistent declines observed at all migration areas as well, it is considered extremely unlikely that redistribution could account for the declines observed since 2000.

Mass Gain in Delaware Bay

At the time the original review was written, it was well understood that the decrease in the food supply of Red Knots in Delaware Bay—horseshoe crab eggs—was strongly implicated in the decline of the *C. c. rufa* population. Baker et al. (2004) showed that Red Knots unable to gain adequate weight in Delaware Bay for onward migration to the arctic breeding grounds had significantly lower survival. Morrison et al. (2007) also showed that body stores were important indicators of survival in *C. c. islandica* populations of Red Knots breeding in the high Arctic. However, the precise impact of reduced numbers of eggs was not clear. In a study of birds trapped twice during a single spring stopover, Atkinson et al. (2006) showed that the earliest arrivals accumulate mass at a relatively low rate (~4 g/day) but later arrivals can catch up lost time and achieve a much higher rate of mass gain (up to 10–15 g/day). New analyses led by Robert A. Robinson (British Trust for Ornithology, presented to a joint meeting of the Horseshoe Crab and Shorebird Technical Committees of the Atlantic States Marine Fisheries Commission in October 2007) have shown that the earliest arrivals have not suffered reduced rates of mass gain. However, the later arrivals that try to catch up lost time, comprising approximately three quarters of the entire stopover population, have shown a significant year-on-year decline in the rate of mass gain they have achieved over 1998 to 2007. Because lower weight birds have lower survival (Baker et al. 2004), it can be concluded that the reduced availability of crab eggs in Delaware Bay has been a critical factor in the decline of *C. c. rufa* .

As reported in the original review, there has been a tendency for northward passage of knots to be about a week later at three sites in South America. To date no clear evidence has been found (e.g., from the aerial counts) that this has led to later arrival in Delaware Bay. However, if this does occur it will merely exacerbate an already bad situation (more birds will be arriving late and trying to gain mass rapidly on inadequate food supplies).

Horseshoe Crabs and Their Eggs in Delaware Bay

Current evidence suggests that the horseshoe crab population of Delaware Bay has stabilized following the major decline documented in the original review. From the birds' perspective, the key factor in being able to acquire adequate body reserves for onward migration is the density of available eggs. This has shown no significant change over 2000–2007 (though over 2005–2007 it declined; Table 40). Similarly, the number of spawning female crabs has shown no significant trend over 1999–2007; however, the number of breeding males has increased (Table 2). The increase in males might be an indication that the population is on the brink of recovery; however, it is females that lay eggs, so an increase in male crabs is largely irrelevant to the birds. More encouraging however, is a sharp 7–10-fold increase in 2006 and 2007 in the number of crabs recorded by the Delaware Division of Fish and Wildlife's trawl survey (Table 40; Michels et al. 2008). Presumably the increase relates largely to males and/or immature individuals because the number of spawning females has not yet increased. Nevertheless, this might be a welcome indication that the population is starting to recover. However, this evidence should be treated with great caution because the sharp increase recorded by the Delaware trawl in 2006 was not corroborated by the offshore trawl survey conducted by the Horseshoe Crab Research Center (D. Hata, unpubl. data) which recorded a much lower and non-significant increase (2.5–3.0; Table 40).

In summary, recovery in the horseshoe crab population might possibly be starting in response to harvest restrictions, but the evidence is far from clear and, even if it is starting

TABLE 40. POPULATION PARAMETERS OF HORSESHOE CRABS IN DELAWARE BAY FOR 2004–2007.

	2004	2005	2006	2007	Trend	Source
Spawning female (index)	0.77	0.82	0.99	0.89	None[c]	S. Michels et al. (unpubl. data).
Spawning males (index)	2.93	3.23	3.99	4.22	Increase[c]	Michels et al. (unpubl data).
Egg density New Jersey (index)[a]	61	100	49	29	None[d]	NJDFW (unpubl. data.)
Egg density Delaware (index)[a]	No survey	100	73	76	None	DDFW (unpubl. data).
Delaware Trawl Survey (geometric mean)[b]	0.059	0.203	1.372	1.617[e]	Increase	S.F. Michels (pers. comm.).
Offshore trawl core area multiparous females (stratified mean catch/tow)	8.2	10.7	24.6	29.1	Increase	D. Hata (unpubl. data).
Offshore trawl peripheral area multiparous females (stratified mean catch/tow)	3.2	2.8	5.5	2.8	None	D. Hata (unpubl. data)

[a] In top 5 cm of sand, 2005 = 100 .
[b] Data relate to trawls during April–July.
[c] Trend relates to 1999–2007.
[d] Trend relates to 2000–2007; over 2005–2007, the trend is a decline.
[e] The Delaware trawl figure for 2007 is provisional.

it has not yet led to an increase in the number of spawning female crabs or eggs for the birds.

We emphasize that the scale of recovery of the horseshoe crab population needed to sustain the Delaware Bay shorebird stopover is an order of magnitude increase to the levels of the early 1990s, not just an improvement in current numbers.

In the course of preparing this update we realized that from 2005 to 2007, surveys of horseshoe crab eggs have shown much higher densities in Delaware than in New Jersey, though percentage change from year to year is not dissimilar (Table 41; compare with index in Table 40). This is thought to be a sampling problem which does not reflect a systematic difference in egg densities between the two states.

All egg surveys have shown considerable heterogeneity with especially high densities in protected bays and creek mouths. One New Jersey data set avoids samples from known hot-spots (Table 41), another includes such sites, but both show much lower densities than the main Delaware data set. The Delaware data include a known hot-spot, Mispillion Harbor, but even if that site is excluded the difference in mean density between New Jersey and Delaware is still very large.

In principle, there is no reason why egg densities in New Jersey and Delaware should be very different because the density of spawning females in the same years has been quite similar with even higher numbers in New Jersey than in Delaware in 2005 and 2006 (Table 41; Michels et al. 2008). We therefore assumed a systematic difference in habitat quality for spawning crabs occurred between the sites sampled in each state. Discussion is currently under way between the New Jersey and Delaware Divisions of Fish and Wildlife with a view to designing a new survey protocol that will facilitate a better comparison of egg densities across Delaware Bay.

RECOMMENDATIONS

1. In 2006, the USFWS decided that listing *C. c. rufa* as threatened or endangered under the Endangered Species Act was justified but was precluded by species with higher conservation priority. That decision was made on the basis of the information contained in the original review. Since then all three of the main wintering populations have shown significant further decline. Therefore, the

TABLE 41. DENSITY OF HORSESHOE CRAB EGGS IN THE TOP 5 CM OF SAND IN THE BEACHES OF DELAWARE BAY DURING MAY AND JUNE 2004–2007 IN NEW JERSEY AND DELAWARE (SURVEYS CONDUCTED RESPECTIVELY BY THE NEW JERSEY AND DELAWARE DIVISIONS OF FISH AND WILDLIFE).

Mean egg density[a] (eggs /m^2, top 5 cm sand)	2004	2005	2006	2007
New Jersey (no hot-spots)	3,175	5,237	2,551	1,502
New Jersey (with hot-spots)	No survey	7,469	3,772	2,006
Delaware (all sites)	No survey	49,933	36,687	38,131
Delaware (all except Mispillion Harbor)	No survey	33,534	16,357	20,664
New Jersey index of female crab spawning	0.78	0.99	1.17	0.82
Delaware index of female crab spawning	0.76	0.65	0.81	0.96

[a] Data from Michels et al. (unpubl. data); the index is the mean number of female crabs per square meter per night.

priority for listing *C. c. rufa* has increased. Accordingly we recommend that the USFWS reconsider listing *C. c. rufa*. It may be noted that the *C. c. rufa* population has been designated as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2007).

2. Although the status of *C. c. roselaari* may be uncertain because of the lack of comprehensive surveys, it is probable that its population is <10,000, which is considerably less than current estimates for *C. c. rufa*. As a small population, it is particularly vulnerable to stochastic events, harmful genetic mutation, and habitat loss. Therefore we recommend that the USFWS consider listing *C. c. roselaari* as well as *C. c. rufa*.
3. The original review showed that the Delaware Bay population of horseshoe crabs declined by around 90% between 1990 and 2006 as a result of excessive harvest. This has been shown to be strongly implicated in the decline of *C. c. rufa*, a finding now further reinforced by the demonstration that the majority of knots stopping over in Delaware Bay have suffered reduced rates of mass gain over 1998–2007. The suggestion that the crab population might have started to recover in 2006 as a result of harvest management is therefore welcome. However, the recovery needs to be toward the levels of the early 1990s—an order of magnitude increase—before it can be expected to have a beneficial effect on the survival of the Red Knot population. Therefore, we recommend that the Atlantic States Marine Fisheries Commission and the individual states involved further restricts the harvest of adult crabs until such time as there is unequivocal evidence of a strong recovery in the number of spawning crabs and the density of their eggs towards the levels of the early 1990s.

ACKNOWLEDGMENTS

We wish to acknowledge and thank the New Jersey Natural Lands Trust for 20 years of support for shorebird protection and research on the Delaware Bay, including the Arctic and Chile. This assessment, which embodies our cumulative understanding of Red Knot ecology and the factors affecting population decline, would not have been possible without the trust's commitment to protection and long-term support. We also wish to thank the Wildlife Conservation Society for supporting the first five years of research in the Canadian Arctic and Chile. We wish to thank all of the authors who contributed to this document—Olivia Blank, Ruth Boettcher, Susan Cameron, Sharon DeFalco, Pamela Denmon, Jenny Dickson, Nancy Douglass, William Haglan, Michael Haramis, Stephanie Koch, Scott Melvin, David Mizrahi, Nellie Nunez, Tom Penn, Christopher Raithel, Susan Rice, Felicia Sanders, Becky Suomala, Glen Therres, Kim Tripp, Barry Truitt, Lindsay Tudor, Dennis Varza, Julia Victoria, Bryan Watts, Alexandra Wilkie, and Brad Winn. This was a monumental task that could not have been completed without each of them. We also wish to thank Joe Jehl and thirteen anonymous reviewers for commenting on an earlier draft of this review. Additionally, we thank the NJENSP technical staff: Sharon DeFalco, Kim Korth, Pete Winkler, Gretchen Fowles, Patrick Woerner, Mike Davenport and Brian Henderson. We especially express our gratitude to Annette Scherer of the USFWS New Jersey Field Office (NJFO). Not only did she give generously of her time and advice throughout the preparation and revision of this document, but she also commented in detail on each of its various drafts and organized a thorough peer review. The final product owes much to her care, expertise and effort. We wish to thank the following people for their expertise, assistance and/or use of data for preparing this assessment: David Allen, North Carolina Wildlife Resources Commission, Nongame and Endangered Wildlife Program; Joseílson de Assis Costa, CEMAVE, Brazil; John Arvin, Gulf Coast Bird Observatory, Lake Jackson, TX; Luis Bala, CenPat, Argentina; Daniel Blanco, Wetlands International; Milan Bull, Connecticut Audubon Society and Connecticut Ornithological Society; Winnie Burkett, Houston Audubon Society; CEMAVE-IBAMA; Luis A. Espinosa G., Censo de Aves Acuticas Chile, UNORCH; Silvia Ferrari, University Patagonia Austral, John Fussell, North Carolina; Bob Gill, U.S. Geological Survey, Alaska Science Center, Anchorage, AK; William Howe, USFWS, TX; Sid Maddock, Audubon North Carolina; Brian McCaffery, USFWS, Yukon Delta NWR, Bethel, AK; Katy McWilliams, TNC, Charleston, VA; Brent Ortego, Texas Parks and Wildlife Department; Sergio Luis Pereira, Brazil; Don Reipe, American Littoral Society, NY; Wallace Rodrigues Telino-Júnior, Brazil; Ken Ross, Canadian Wildlife Service, National Wildlife Research Center, Ottawa, Canada; and Craig Watson, USFWS, South Carolina. We are grateful to Pavel Tomkovich for providing a copy of the unpublished report on the studies he and Maxim Dementyev carried out in Alaska in May 2006. We also thank S.F. Michels for providing