

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; Joseilson 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

details of the 2007 Delaware horseshoe crab trawl and spawning surveys.

LITERATURE CITED

- ALBRIEU, C., S. IMBERTI, AND S. FERRARI. 2004. Las aves de la Patagonia Sur, el estuario del Río Gallegos y zonas aledañas. Universidad Nacional de la Patagonia Austral, Río Gallegos, Argentina.
- ALERSTAM, T., G. A. GUDMUNDSSON, AND K. JOHANNESSON. 1992. Resources for long distance migration: intertidal exploitation of *Littorina* and *Mytilus* by Red Knots *Calidris canutus* in Iceland. *Oikos* 65:179-189.
- ALLEN, A. S. 1995. Tidepool value as foraging patches for breeding and migrating birds in tidal salt marshes in the lower Chesapeake Bay. M. A. thesis, College of William and Mary, Williamsburg, VA.
- ANTAS, P. T. Z., AND I. L. S. NASCIMENTO. 1996. Analysis of Red Knot *Calidris canutus rufa* banding data in Brazil. *International Wader Studies* 8:63-70.
- ARAÚJO, F. A. A., M. Y. WADA, E. V. DA SILVA, G. C. CAVALACANTE, V. S. MAGALHAES, G. V. FILHO, S. G. RODRIGUES, L. C. MARTINS, C. E. FEDRIZZI, A. SCHERER, L. V. MORH, M. A. B. DE ALMEIDA, B. S. BUNA, L. R. O. CSOTA, S. B. SCHERER, R. S. VIANNA, AND V. L. GATAS. 2003. Primeiro inquérito sorológico em aves migratórias no Parque Nacional da Lagoa do Peixe para detecção do vírus da febre do Nilo Ocidental. Secretaria de Vigilância em Saúde. Ministério da Saúde. <http://www.ibama.gov.br/cemave/index.php?id_menu=297> (10 January 2008).
- ARAYA, B., AND G. MILLIE. 1996. Guía de campo de las aves de Chile. Séptima edición. Editorial Universitaria, Santiago, Chile.
- ATLANTIC STATES MARINE FISHERIES COMMISSION. 2001. Addendum II to the interstate fishery management plan for horseshoe crab. Atlantic State Marine Fisheries Commission, Washington, DC.
- ATKINSON, P. W., G. F. APPLETON, J. A. CLARK, N. A. CLARK, S. GILLINGS, I. G. HENDERSON, R. A. ROBINSON, AND R. A. STILLMAN. 2003. Red Knots *Calidris canutus* in Delaware Bay 2002. Survival, foraging and marking strategy. British Trust for Ornithology Research Report 308, Thetford, UK.
- ATKINSON, P. W., A. J. BAKER, R. M. BEVAN, N. A. CLARK, K. B. COLE, P. M. GONZÁLEZ, J. NEWTON, L. J. NILES, AND R. A. ROBINSON. 2005. Unravelling the migratory strategies of a long-distance migrant using stable isotopes: Red Knot *Calidris canutus* movements in the Americas. *Ibis* 147:738-749.
- ATKINSON, P. W., A. J. BAKER, K. A. BENNETT, N. A. CLARK, J. A. CLARK, K. B. COLE, A. DEKINGA, A. DEY, S. GILLINGS, P. M. GONZÁLEZ, K. KALASZ, C. D. T. MINTON, L. J. NILES, R. A. ROBINSON, AND H. P. SITTERS. 2007. Rates of mass gain and energy deposition in Red Knot on their final spring staging site is both time- and condition-dependent. *Journal of Applied Ecology* 44:885-895.
- AUBRY, Y., AND R. COTTER. 2001. Using trend information to develop the Quebec Shorebird Conservation Plan. *Bird Trends* 8:21-24.
- AVISE, J. C. 1989. A role for molecular genetics in the recognition and conservation of endangered species. *Trends in Ecology and Evolution* 4:279-281.
- BAKER, A. J., T. PIERSMA, AND A. GREENSLADE. 1999a. Molecular versus phenotypic sexing in Red Knots. *Condor* 101:887-893.
- BAKER, A. J., T. PIERSMA, AND L. ROSENMEIER. 1994. Unraveling the intraspecific phylogeography of Red Knots (*Calidris canutus*)—a progress report on the search for genetic markers. *Journal für Ornithologie* 135:599-608.
- BAKER, A. J., P. M. GONZÁLEZ, L. BENEGAS, S. RICE, V. L. D'AMICO, M. ABRIL, A. FARMER, AND M. PECK. 2005b. Annual international shorebird expeditions to Río Grande in Tierra del Fuego 2000-2004. *Wader Study Group Bulletin* 107:19-23.
- BAKER, A. J., P. M. GONZÁLEZ, I. L. SERRANO, W. R. T. JÚNIOR, M. EFE, S. RICE, V. L. D'AMICO, M. ROCHA, AND M. A. ECHAVE. 2005a. Assessment of the wintering area of Red Knots in Maranhão, northern Brazil, in February 2005. *Wader Study Group Bulletin* 107:10-18.
- BAKER, A. J., P. M. GONZÁLEZ, T. PIERSMA, L. J. NILES, I. L. S. DO NASCIMENTO, P. W. ATKINSON, N. A. CLARK, C. D. T. MINTON, M. K. PECK, AND G. AARTS. 2004. Rapid population decline in Red Knot: fitness consequences of decreased refueling rates and late arrival in Delaware Bay. *Proceedings of the Royal Society B* 25:125-129.
- BAKER, A. J., P. M. GONZÁLEZ, T. PIERSMA, C. D. T. MINTON, J. R. WILSON, H. SITTERS, D. GRAHAM, R. JESSOP, P. COLLINS, P. DE GOEIJ, M. PECK, R. LINI, L. BALA, G. PAGONI, A. VILA, E. BREMER, R. BASTIDA, E. IENO, D. BLANCO, Y DE LIMA S. DO NASCIMENTO, S. S. SCHERER, M. P. SCHNEIDER, A. SILVA, AND A. A. F. RODRIGUES. 1999b. Northbound migration of Red Knots *Calidris canutus rufa* in Argentina and Brazil: report on results obtained by an international expedition in March-April 1997. *Wader Study Group Bulletin* 88:64-75.
- BALA, L. O., V. L. D'AMICO, AND P. STOYANOFF. 2002. Migrating shorebirds at Península