

**Investigating Population Dynamics of Red Knot Migration
along the Georgia Coast through Mark/Recapture Analysis of
Resights: 2015 Spring Season**



**A Cooperative Project by: US Fish and Wildlife Service, US Geological Survey,
Georgia Department of Natural Resources Non-game Program, and the Center
for Conservation Biology at the College of William & Mary and Virginia
Commonwealth University.**

Investigating Population Dynamics of Red Knot Migration along the Georgia Coast through Mark/Recapture Analysis of Resights: 2015 Spring Season

Fletcher M. Smith¹
Bryan D. Watts, PhD¹
Jim Lyons, PhD²
Tim Keyes³

¹Center for Conservation Biology at the College of William & Mary and Virginia Commonwealth University, Williamsburg, Virginia 23187. ²USGS Patuxent Wildlife Research Center, Laurel, MD. ³Georgia Department of Natural Resources, Wildlife Resources Division, Non-game Program Brunswick, Georgia 31520

Project Partners:
US Fish and Wildlife Service
US Geological Survey
Georgia Department of Natural Resources Non-game Program
The Center for Conservation Biology

Recommended Citation:

F.M. Smith, B.D. Watts, J. E. Lyons, and T. S. Keyes. 2016. Investigating Population Dynamics of Red Knot Migration along the Georgia Coast through Mark/Recapture Analysis of Resights: Spring 2015 Season. Center for Conservation Biology Technical Report Series, CCBTR-16-05. College of William and Mary/Virginia Commonwealth University, Williamsburg, VA. 13 pp.



The Center for Conservation Biology is an organization dedicated to discovering innovative solutions to environmental problems that are both scientifically sound and practical within today's social context. Our philosophy has been to use a general systems approach to locate critical information needs and to plot a deliberate course of action to reach what we believe are essential information endpoints.

Contents

BACKGROUND and CONTEXT.....	01
OBJECTIVES.....	02
METHODS.....	03
Field Methods.....	03
Data Verification.....	03
Study Area.....	03
Training Session.....	03
Data Storage.....	03
RESULTS.....	07
Resighting.....	07
DISCUSSION.....	07
Acknowledgements.....	09
Literature Cited.....	09

BACKGROUND and CONTEXT

The *rufa* subspecies of the Red Knot (*Calidris canutus*) has declined precipitously over the past two decades leading to the proposed status listing under the Endangered Species Act in the United States (US Fish and Wildlife Service 2013). The Red Knot is a federally listed species in Canada (COSEWIC 2008). Evidence for the decline is seen in long-term surveys of a major spring staging site (Dunne et al. 1982, Clark et al. 1993, Niles et al. 2008) and the largest known over-wintering site (Morrison et al. 2004). In only 30 years, the estimated population has declined from 100,000-150,000 to possibly below 30,000 (Niles et al. 2007) leading some researchers to suggest the population is highly vulnerable to extinction (Baker et al. 2004).

Most research exploring the population decline has focused on studying the foraging conditions within the Delaware Bay (Atkinson et al. 2003, Baker et al. 2004, Haramis et al. 2007). The Delaware Bay is a terminal spring-staging site on the mid-Atlantic seacoast where birds refuel before moving to their breeding grounds in the high arctic (Harrington and Flowers 1996, Harrington 2001). Birds staging within this site feed nearly exclusively on the eggs of the horseshoe crab (*Limulus polyphemus*) (Tsipoura and Burger 1999) and egg densities have been related to foraging rates (Atkinson et al. 2003, Gillings et al. 2007), rates of mass gain (Robinson et al. 2003, Atkinson et al. 2007) and the associated ability of birds to reach threshold leaving weights (Baker et al. 2001, Niles et al. 2008). Leaving weights have been suggested to influence adult survivorship, providing evidence of a link between conditions within the Delaware Bay and recent population declines (Baker et al. 2004). Horseshoe crabs have been harvested commercially in the Delaware Bay for decades, and the rapid emergence of the conch industry has dramatically increased harvest pressures in recent years (Walls et al. 2002). Claims that harvest rates are impacting the strength of spawning events, resulting in egg densities well below those required by staging Red Knots, have led to conflicts between the fishing industry and conservation groups (Odell et al. 2005).

A systematic band resight program was initiated along the Georgia coastal barrier islands during the fall of 2011. The patterns observed suggest that Red Knots are using the Georgia coast in fall in large numbers when forage is abundant (B. Winn and T. Keyes pers. comm.). The fall stopover event in Georgia is used primarily by Red Knots wintering in southeastern states, throughout the Caribbean, and most recently discovered, the coast of Texas. Although movement and settlement “decisions” are likely influenced by foraging conditions throughout the network, investigations into the factors driving movement during migration is necessary to better understand Red Knot migration ecology. This is critical in developing appropriate stopover models and adaptive management tools for land managers. This will require systematic resight efforts over long time scales and large geographic areas.

The Center for Conservation Biology, the US Fish and Wildlife Service, and the Georgia Department of Natural Resources Non-game Section initiated a Red Knot resight program along the Atlantic Coast of Georgia during the spring of 2013. Prior to 2013, there was no systematic resight study of Red Knots in spring migration. Previous population counts along the South

Atlantic Coast focused on aerial or ground counts. These methods are useful for counting peak numbers but are less than ideal for estimating accumulated numbers of knots using a stopover site. The Red Knot Adaptive Modelling Group (McGowan et al. 2011) strongly recommended moving away from these types of counts to methods that use mark recapture and allow for estimation of variance from the data. Estimates of spring migration survival rates, stopover duration, and between-year fidelity rates to Georgia are needed to more accurately assess the quality of the Georgia coast as a spring migration stopover for this species.

OBJECTIVES

Expanding the Red Knot resight program to include other important staging areas along the Atlantic Coast is a stated priority of the USFWS Red Knot Spotlight Species Action Plan (2010) and the Red Knot Conservation Plan (2010). Our objectives in expanding the program into the Georgia Coast during spring migration are to:

- 1) estimate the population of Red Knots using the Georgia Coast as a spring stopover,
- 2) estimate spring stopover duration along the Georgia Coast,
- 3) determine the primary stopover locations and provide this information to local land managers,
- 4) contribute to the range-wide demographic studies and studies in migratory connectivity of the Red Knot in the Western Hemisphere, and
- 5) contribute data to the current listing process initiated by the US Fish and Wildlife Service.

Regional population estimates and identification of major stopover sites are considered to be the highest priority for the Georgia Department of Natural Resources State Wildlife Action Plan, the Atlantic Flyway Shorebird Initiative (Winn et al. 2013), the US Shorebird Plan (Brown et al. 2001), the USFWS Red Knot Action Plan (2010) and the Western Hemisphere Shorebird Reserve Network Red Knot Conservation Plan for the Western Hemisphere (Niles et al. 2010a). Providing a population estimate for various staging areas is a stated goal of the WHSRN Red Knot Conservation Plan for the Western Hemisphere (Niles et al. 2010a), the Atlantic Flyway Shorebird Strategy, and the US FWS Red Knot Action Plan (2010). The Georgia Department of Natural Resources State Wildlife Action Plan ranks the Red Knot as a high priority species (with state status of “Rare”) and ranks research of the Red Knot as one primary conservation actions needed within the state.

METHODS

Field methods

The peak of Red Knot spring migration in Georgia is from early to mid-April through late-May to early-June and Knots use barrier islands located along the entire coastline. Knots are easiest to observe in Georgia when they concentrate at foraging and roost sites; therefore, we focused resight efforts from 2.5 hours before high tide (mid-rising tide) to 2.5 hours after high tide (mid-falling tide) during daylight hours. We surveyed along transects that we could cover within this 5-6 hour observation period. During each survey, we used high-quality spotting scopes fitted with 20-60x zoom eye pieces to read flag codes from individually marked Red Knots and recorded codes following a standard resighting protocol (Kalasz 2006, Smith 2013).

Data verification

Prior to analysis of mark-resight data, we reported each individually-marked Red Knot to other researchers to confirm the existence of each band combination and flag code (J. Parvin / Bandedbirds.org and P. M. Gonzales, pers. comm.). We excluded observations that did not correspond to the banding database.

Study Area:

Study sites were determined based on Red Knot concentrations in prior years (especially based on the 2013 spring field season). The primary study sites in the spring of 2015 were Pelican Spit/Rainbow Beach/Gould's Inlet (and subsequently Little Egg Island and Little Egg Island Bar), Cabretta/S. Blackbeard, Ogeechee Bar and Ossabaw Island, and Tybee Bar/Beach Hammock.

Training:

Volunteers were trained to use standardized protocols (Kalasz 2006, Smith 2013) during the spring 2015 field season.

Data Storage:

Data is stored on Bandedbirds.org servers, under the Georgia Shorebird Resighting Project portal. This data is accessible to the larger demographic studies being conducted for this species. Copies of the database are also backed up on the Center for Conservation Biology's server.

RESULTS

Resighting:

A total of 14 barrier islands were surveyed for Red Knots during the 2015 migration season: Pelican Spit, Gould's Inlet, Little St. Simons Island, Wolf Island, Little Egg Island, Little Egg Island Bar, Cabretta Island and South Blackbeard, St. Catherines Island, Ossabaw Island, Ogeechee Bar, Tybee Island, Tybee Bar, and Little Tybee/Williamson/Beach Hammock. Four locations were intensively surveyed: Pelican Spit/Gould's Inlet, Cabretta and S. Blackbeard Islands, Ossabaw Island and Ogeechee Bar, and Tybee Bar/Beach Hammock. CCB staff surveyed a total of 45 out of 61 potential days during the spring migration window. Project partners were able to cover additional days of surveys of islands outside of the main study areas. Transects were initially set up on the highest Red Knot use islands from the 2013 season, but were repositioned to cover the areas with high Red Knot use in spring 2015. During the 2013 season, Wolf Island, Little Egg Island, and Little Egg Island Bar were dropped as primary survey/resight locations by CCB staff due to low Red Knot use. These sites were used heavily during the latter part of the migration window in spring of 2015. CCB staff surveyed Ossabaw Island, Ogeechee Bar, Pelican Spit/Rainbow Beach/Gould's Inlet, and S.Blackbeard/Cabretta Island intensively.

A total of 45,660 Red Knots were detected on daily resight surveys, of which 1,196 individually banded Red Knots were resighted. A total of 92 marked to unmarked ratios were recorded during the field season, with an average of 4-6% of Red Knots banded (See Figures 1-3 for population estimate, percent marked, and stopover duration).

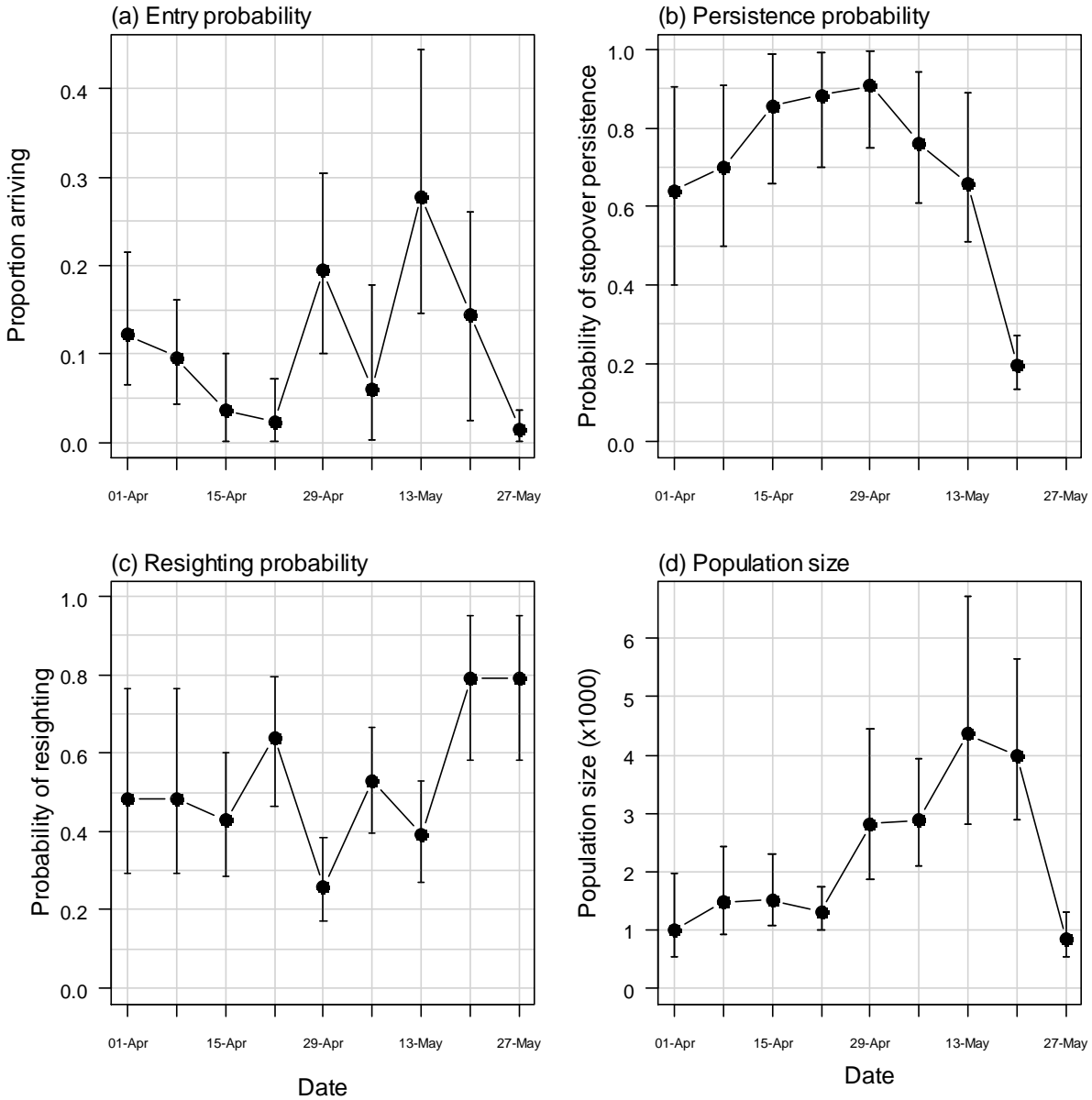


Figure 1. Stopover population dynamics and population size estimates of Red Knots on the Georgia coast during April – May 2015. Parameter estimates are from a fully time-dependent Jolly-Seber model ($b[t]\phi[t]p[t]$). Mark-resight data were aggregated into weekly sampling occasions; x-axis label is the mid-point of each week. Filled circles and error bars show estimated parameters and 95% credible intervals. Estimated superpopulation size is 8,001 birds (95% credible interval: 6,699 – 9,830).

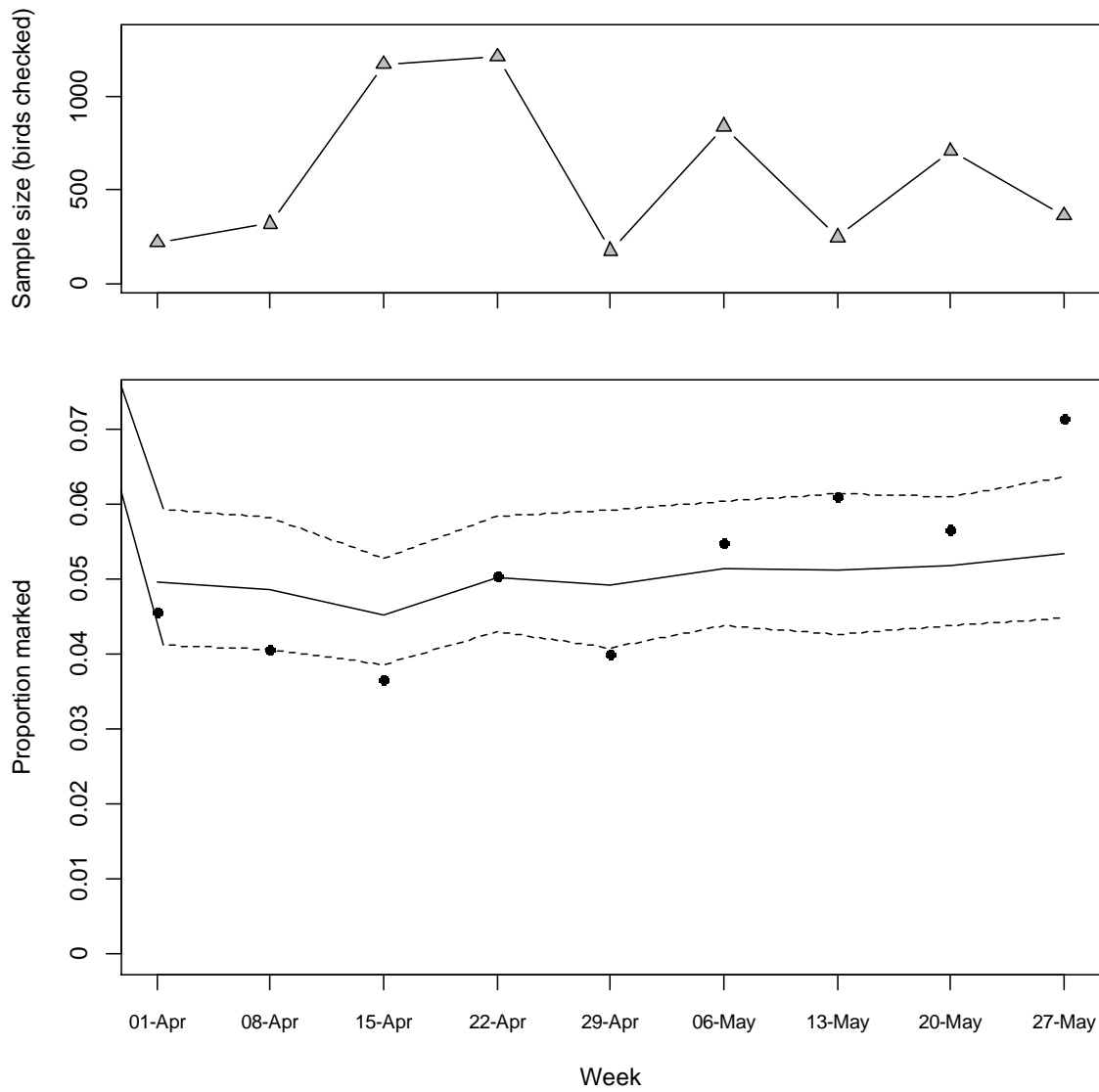


Fig 2. Fraction of the population with marks over time during April – May 2015 at the Georgia coast. Fitted values (solid line) and 95% credible interval (dashed line) are from a generalized linear mixed model (GLMM) with a random effect for each week of the study. Filled circles are the fitted values from a GLM, i.e., the MLEs (#marked/#checked).

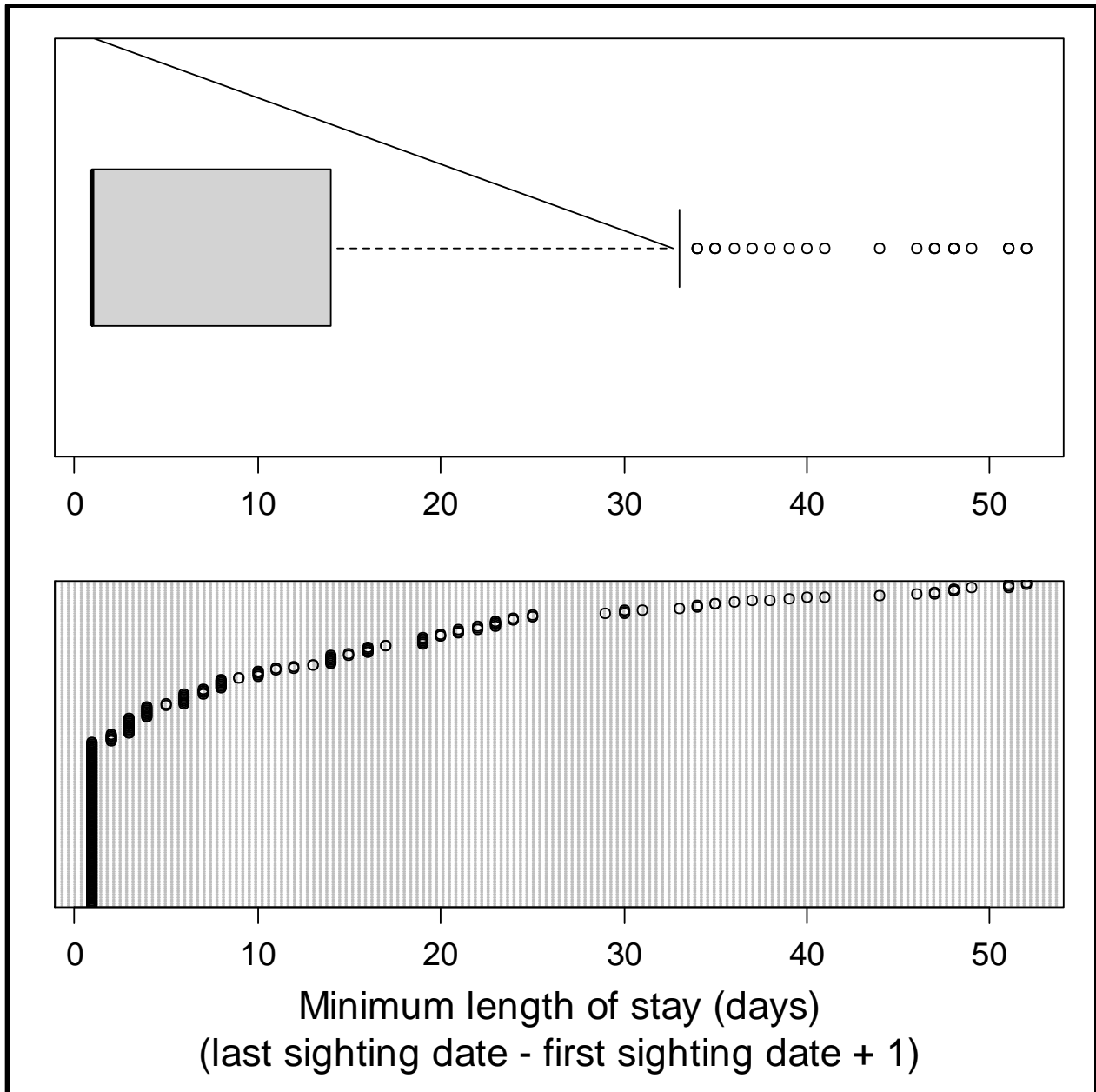


Figure 3. Minimum-length-of-stay of Red Knots on the Georgia coast during April – May 2015. Minimum-length-of-stay is the interval between first and last sighting of an individual marked bird. Does not account for time before first, or after last, sighting.

DISCUSSION

The numbers of Red Knots that utilize the barrier islands along the Georgia Coast varies year to year based on changes in abundance and distribution of the bivalves *Mulinia lateralis* and *Donax variabilis*. This behavior is similar to other stopover sites across the hemispheres (Alerstam et al. 1992, Truitt et al. 2001). Red Knots also opportunistically forage on horseshoe

crab eggs during peak crab spawning years. During periods when the bivalve prey base cycles upwards, many thousands of Red Knots will use Georgia for migration stopover and in certain years for wintering (Niles et al. 2010b). These fall stopover and wintering sites likely play an important role in the long-term persistence of the declining Red Knot population. While studies have been initiated to look at critical demographic parameters of the fall Red Knot population in Georgia, very little work has been conducted in spring migration. Estimates of spring migration survival rates, stopover duration, and between-year fidelity rates to Georgia are needed to more accurately assess the quality of the Georgia coast as a spring migration stopover for this species. Analysis of the data collected during spring 2013 and 2015 will elucidate some of these questions.

The horseshoe crab spawning event of spring 2015 was longer and more substantial than the 2013 event. Many HSCs were observed spawning at Pelican Spit, Ogeechee Bar, Beach Hammock, Tybee Bar, and later at Little Egg Island and Little Egg Bar. The large HSC spawning event at Cabretta Island and S. Blackbeard detected in 2013 was not repeated in 2015. High counts of Red Knots were observed at all of the major HSC spawning sites in 2015. The importance of crab eggs to the survival of Red Knots in Delaware Bay is well documented, and further studies should be undertaken to monitor the cycles of horseshoe crab abundance and spawning along the Georgia Coast. It is unknown whether Red Knots sampled other stopover locations before descending on Georgia en mass, and that question could be answered through a larger resight analysis.

The numbers of Red Knots utilizing the Georgia Coast in spring migration are split between two populations. The “Southeastern” population winters along the South Atlantic Coast into the Caribbean and Texas Coast, and the long distance migrants winter from Brazil to southern South America. The strategies that these two populations use to survive are quite different, though there appears to be much habitat use overlap between the two in Georgia. We documented 49 long distance migrants (Flag Orange or Flag Red) during the 2015 spring season. Georgia is well documented as an important as a stopover and wintering location for the “southeastern” population (Harrington et al. 2007), and is likely more important for the long distance migrants than previously thought. Further analysis looking at the connectivity of the knots migrating through Georgia can shed light on this subject. The increase in the use of geolocators on the species has already shown the importance of stopover sites in the South Atlantic and has shown that the “Southeastern” wintering Red Knots are of the subspecies *rufa*, not *roselaari* as was previously thought (Niles et al. 2012, Newstead et al. 2013).

One of the most important conservation issues on the Georgia Coast is the human disturbance issue (see Figure 13). The focus of regulatory agencies has typically been on resident nesting birds (the Georgia Shorebird Alliance (comprised of federal, state, and private biologists and land managers with the goal of protecting breeding waterbird habitat), Georgia Department of Natural Resources State Wildlife Action Plan). Migratory shorebirds utilize many of the same habitat types as the resident breeding birds and also need disturbance free stretches of beach to replenish fat stores before migrating thousands of miles from the Georgia Coast to arctic habitats. Towards the end of the migration window (middle of May to the first week of June)

human disturbance increased on Ogeechee Bar and Tybee Island, two of the most critical feeding areas for Red Knots and numerous other migratory shorebirds. The monitoring of this issue moving forward should be a focus of biologists and land managers protecting these resources.

Acknowledgements:

Funding and/or logistical support for this project was provided by the US Fish and Wildlife Service, the US Geological Survey, the Georgia Department of Natural Resources Non-game Program, the Nature Conservancy, and the Center for Conservation Biology at The College of William & Mary and Virginia Commonwealth University. Amy Whitear, Pat and Doris Leary, Perri Rothemich, and Chris Depkin assisted in all aspects of field work. Chuck Hayes, Kimberly Hayes, Abby Powell, and Lauren Gingerella contributed considerable efforts to resights and/or Red Knot surveys. The Georgia DNR provided technical and field support. Jeannine Parvin/bandedbirds.org and Patricia Gonzales assisted with data verification. Finally, we gratefully acknowledge administrative support from Erica Lawler at the College of William and Mary.

Literature Cited:

- Alerstam, T., G.A. Gudmundsson, and K. Johannesson. 1992. Resources for long distance migration-intertidal exploitation of *Littorina* and *Mytilus* by knots *Calidris canutus* in Iceland. *Oikos* 65:179-189.
- 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, K. A. Bennett, N. A. Clark, J. A. Clark, K. B. Cole, A. Dekinga, A. Dey, S. Gillings, P. M. Gonzalez, and others. 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.
- Baker, A. J., P. M. González, T. Piersma, L. J. Niles, I. de 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 Knots: Fitness consequences of decreased refueling rates and late arrival in Delaware Bay. *Proceedings of the Royal Society of London, Series B* 271:875-882.
- Baker, A. J., P. M. Gonzalez, C. D. T. Minton, D. B. Carter, L. J. Niles, I. do Nascimento, and T. Piersma. 2001. Hemispheric problems in the conservation of red knots (*Calidris canutus*

- rufa*). In Proceedings of the VI Neotropical Ornithological Congress, International Shorebird Symposium, Monterey, Mexico. Manomet, MA.
- Brown, S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. The U.S. Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, MA.
- Clark, K., L. Niles, and J. Burger. 1993. Abundance and distribution of shorebirds migrating on Delaware Bay, 1986-1992. *Condor* 95:694-705.
- COSEWIC. 2008. Canadian Wildlife Species at Risk. Committee on the Status of Endangered Wildlife in Canada. http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_e.cfm
- Dunne, P., D. Sibley, C. Sutton, and W. Wander. 1982. 1982 aerial shorebird survey of Delaware Bay. *Records of New Jersey Birds* 8:68-75.
- Gillings, S., P. W. Atkinson, S. L. Bardsley, N. A. Clark, S. E. Love, R. A. Robinson, R. A. Stilman, and R. G. Weber. 2007. Shorebird predation of horseshoe crab eggs in Delaware Bay: species contrasts and availability constraints. *Journal of Animal Ecology* 76:503-514.
- Haramis, G. M., W. A. Link, P. S. Osenton, D. B. Carter, R. G. Weber, N. A. Clark, M. A. Teece, and D.S. Mizrahi. 2007. Stable isotope and pen feeding trial studies confirm the value of horseshoe crab *Limulus polyphemus* eggs to spring migrant shorebirds in Delaware Bay. *Journal of Avian Biology* 38:367-376.
- Harrington, B.A., B. Winn, and S.C. Brown. 2007. Molt and Body Mass of Red Knots in the Eastern United States. *Wilson Journal of Orn.* 119(2):35-42.
- Harrington, B. A. 2001. Red knot (*Calidris canutus*). In *The Birds of North America*, No. 563 (ed. A. Poole and F. Gill), pp. 1-32. Philadelphia, PA: The Birds of North America.
- Harrington, B. and C. Flowers. 1996. *The Flight of the Red Knot*. W. W. Norton and Company, New York, NY.
- Kalasz, K., 2006. Resighting Individually Marked Red Knots of Delaware Beaches. Protocol from the Delaware Fish and Wildlife Shorebird Project.
- McGowan, C.P., J.E. Hines, J.D. Nichols, J.E. Lyons, D.R. Smith, K. S. Kalasz, L.J. Niles, A.D. Dey, N.A. Clark, P.W. Atkinson, C.D.T. Minton, and W. Kendall. 2011. Demographic consequences of migratory stopover: linking red knot survival to horseshoe crab spawning abundance. *Ecosphere* 2: article 69.
- Morrison, R. I. G., R. K. Ross, and L. J. Niles. 2004. Declines in wintering populations of red knots in southern South America. *Condor* 106:60–70.

- Newstead, D.J., Niles, L.J., Porter, R.R., Dey, A.D., Burger, J. & Fitzsimmons, O.N. 2013. Geolocation reveals mid-continent migratory routes and Texas wintering areas of Red Knots *Calidris canutus rufa*. Wader Study Group Bull. 120(1): 53–59.
- Niles, L.J., J. Burger, R.R. Porter, A.D. Dey, S. Koch, B.A. Harrington, K. Iaquinto, and M. Boaman. 2012. Migration pathways, migration speeds, and nonbreeding areas used by northern hemisphere wintering Red Knots (*Calidris canutus*) of the subspecies *rufa*. Wader Study Group Bull. 119(2).
- Niles, L., H. Sitters, A. Dey, and Red Knot Status Assessment Group. 2010a. Red Knot Conservation Plan for the Western Hemisphere (*Calidris canutus*), Version 1.1. Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.
- Niles, L.J., H.P. Sitters, A.D. Dey, N. Arce, P.W. Atkinson, V. Ayala-Perez, A.J. Baker, J.B. Buchanon, R. Carmona, N.A. Clark, C. Espoz, J.D. Fraser, P.M. Gonzalez, B.A. Harrington, D.E. Hernandez, K.S. Kalasz, R. Matus, B.J. McCaffery, C.D.T. Minton, R.I.G. Morrison, M.K. Peck, W. Pitts, I.L. Serrano & B.D. Watts. 2010b. Update to the Status of the Red Knot *Calidris canutus* in the Western Hemisphere, April 2010b.
- Niles, L. J., H. P. Sitters, A. D. Dey, P. W. Atkinson, A. J. Baker, K. A. Bennett, R. Carmona, K. E. Clark, N. A. Clark, C. Espoz, P. M. Gonzalez, B. A. Harrington, D. E. Hernandez, K. S. Kalasz, R. G. Lathrop, R. N. Matus, C. D. T. Minton, R. I. G. Morrison, M. K. Peck, W. Pitts, R. A. Robinson, and I. L. Serrano. 2008. Status of the red knot (*Calidris canutus rufa*) in the western hemisphere. *Studies in Avian Biology* 36:1–185.
- Niles L.J., Sitters H.P., Dey A.D., Atkinson P.W., Bennett K.A., Clark K.E., Clark N.A., Espoz C., González P.M., Harrington B.A., Hernandez D.E., Kalasz K.S., Matus R., Minton C.D.T., Morrison R.I.G., Peck M.K. & Serrano I.L. 2007. Status of the Red Knot, *Calidris canutus rufa*, in the Western Hemisphere. US Fish and Wildlife Service, Ecological Services, Region 5, Pleasantville, New Jersey.
- Odell, J., M. E. Mather, and R. M. Muth. 2005. A biosocial approach for analyzing environmental conflicts: A case study of horseshoe crab allocation. *BioScience* 55:735-748.
- Robinson, R. A., P. W. Atkinson, and N. A. Clark. 2003. Arrival and weight gain of Red Knot *Calidris canutus*, Ruddy Turnstone *Arenaria interpres* and Sanderling *Calidris alba* staging in Delaware Bay in spring. British Trust for Ornithology Research Report 307, Thetford, UK.

- Smith, F.M. 2013. Resighting Protocol for Individually Color-marked Red Knots in South Atlantic Coast and Virginia, Version 2.1. 9pp.
- Truitt, B. R., B. D. Watts, B. L. Brown, and W. Dustan. 2001. Red Knot densities and invertebrate prey availability on the Virginia barrier islands. Wader Study Group Bulletin 95:12.
- Tsipoura, N. and J. Burger. 1999. Shorebird diet during spring migration stopover on Delaware Bay. Condor 101:635-644.
- US Fish and Wildlife Service. 2013. Endangered and Threatened Wildlife and Plants; Proposed Threatened Status for the Rufa Red Knot (*Calidris canutus rufa*). Federal Register Vol. 78 No. 189.
- US Fish and Wildlife Service. 2010. Red Knot (*Calidris canutus rufa*) Spotlight Species Action Plan. Lead Field Office: New Jersey Field Office.
- Walls, E. A., J. Berkson, and S. A. Smith. 2002. The horseshoe crab, *Limulus polyphemus*: 200 million years of existence, 100 years of study. Review of Fisheries Science 10:39-73.
- Winn, B., S. Brown, C. Spiegel, D. Reynolds, S. Johnston and the Atlantic Flyway Shorebird Initiative Group. 2012. Atlantic Flyway Shorebird Business Strategy. Available online at: http://manometcenter.pairserver.com/sites/default/files/publications_and_tools/AtlanticFlywayShorebirdBusinessStrategy.pdf

