Population dynamics of Red Knots stopping over in Virginia during spring migration

Center for Conservation Biology
College of William and Mary
& Virginia Commonwealth University

Population dynamics of Red Knots stopping over in Virginia during spring migration.

Adam E. Duerr, PhD
Bryan D. Watts, PhD
Fletcher M. Smith

Center for Conservation Biology
College of William and Mary & Virginia Commonwealth University

Recommended Citation:

Duerr, A.E., B.D. Watts, and F.M. Smith. 2011. Population dynamics of Red Knots stopping over in Virginia during spring Migration. Center for Conservation Biology Technical Report Series, CCBTR-11-04. College of William and Mary & Virginia Commonwealth University, Williamsburg, VA. 48 pp.

Project Partners:
National Fish and Wildlife Foundation
US Fish and Wildlife Service
The Nature Conservancy
Virginia Coastal Zone Management Program

Front Cover: Red Knots on Hog Island, Virginia. Photo by Barry Truitt/TNC.

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.

TABLE OF CONTENTS

BACKGROUND..... 1
Objectives..... 1

METHODS..... 1
Field methods 1
Data verification..... 3
Modeling Methods..... 3
Modeling stopover duration and population of Red Knots in Virginia..... 3
Modeling annual survival and fidelity..... 4

RESULTS..... 5
Duration and numbers of Red Knots stopping over in Virginia 5
Annual survival and fidelity 11

DISCUSSION..... 15

ACKNOWLEDGEMENTS..... 17

LITERATURE CITED..... 18

Appendix 1. The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010..... 20

TABLE OF TABLES..... iv
TABLE OF FIGURES..... iv

TABLE OF TABLES

Table 1. Models compared to estimate arrival (recruitment), departure (apparent survival), and resight probability included variation of apparent survival and recruitment by week. All models included date specific resight probabilities. 3

Table 2. First and last dates that individually-marked Red Knots were observed along the barrier islands of the lower Delmarva Peninsula in Virginia from 2006-2010. 5

Table 3. Results of model selection for 16 models describing patterns of arrival and departure of Red Knots to the lower Delmarva Peninsula during spring migration 2006 – 2010. 6

Table 4. Fidelity, arrival, and resight probabilities (SE) for Red Knot observed in Virginia from 2006-2010, after model averaging. Estimates vary according to 6 unique periods based upon 1, 2, 3, or 6-week (constant) summary periods. 7

Table 5. Aerial counts of Red Knots and estimated total numbers that passed through the lower Delmarva Peninsula, Virginia from 2006 – 2010. 12

Table 6. Alternative models used to estimate survival and annual fidelity of Red Knots to the lower Delmarva Peninsula, Virginia from 2006 – 2010. 13

Table 7. Model averaged estimates of annual and within-year demographic rates for Red Knots that stopover during spring migration in Virginia, 2006 – 2010. 14

Table 8. A deterministic matrix model for Red Knots that move through Virginia during spring migration. The model is based upon demographic estimates from individually marked Red Knots that were observed in Virginia from 2006-2010. 14

TABLE OF FIGURES

Figure 1. Locations of survey transects for individually marked Red Knots in Virginia during 2006-2010. 2

Figure 2. Stopover duration during spring migration (A) includes time since a Red Knot arrived (B) and time until a knot departed (C) the lower Delmarva Peninsula in Virginia from 2006 – 2010. Dashes are 1 SE above and below stopover durations. 10

Figure 3. Number of Red Knots that move through Virginia based upon adjustment of weekly aerial surveys (passage number) and projection of knot population based upon population model including Virginia and an unobserved stopover location outside of Virginia. Projected numbers assumes a stable population, a starting population equal to the number passing through Virginia in 2007, and includes 2 years for the population to stabilize. 15

BACKGROUND

The Western Hemispheric subspecies of the Red Knot (*Calidris canutus rufa*) has declined by 80-90% in North America (Piersma and Davidson 1992, Baker *et al*. 2004). Concern for this species led to an application to the U.S. Fish and Wildlife Service for fast track consideration for federal listing under the Endangered Species Act (ESA) in 2005 and a large-scale investigation of conflicts between migrant shorebirds and the Horseshoe Crab (*Limulus polyphemus*) industry (Baker *et al*. 2004, McGowan et al. 2010). Most of the conservation efforts to date have focused on the Delaware Bay, where the Red Knot is a specialist on eggs of Horseshoe Crabs (Harrington 1996, Karpanty *et al*. 2006). It appears that specialized feeding of Red Knots using Delaware Bay, coupled with lack of adequate Horseshoe Crab eggs, increases their risk of adult mortality, which is the single most important factor influencing persistence of shorebird populations (Davidson and Piersma 1992, Baker and Piersma 2000).

Numbers of Red Knots using the barrier islands along the lower Delmarva Peninsula in Virginia appear to be more stable than in Delaware Bay. During the mid-1990s, 8-10,000 Red Knots were counted during peak migration in the spring (Watts and Truitt 2000). Repeat surveys in 2006-2010 counted 6-8,500 Red Knots (Watts, unpublished data). In 2007, a concurrent count of Red Knots along the entire spring migration route of the Eastern U.S. showed that 37% of the population was located in Virginia, while 46% was in Delaware Bay. These data indicate that the barrier islands of Virginia, where knots stop during spring migration, may play an important role in the long-term persistence of the Red Knot population. However, we do not know critical demographic information on the migratory population of Red Knots in Virginia. Estimates of annual survival rates, stopover duration, and between-year fidelity rates to Virginia are needed to more accurately assess the quality of the Virginia coast as a migration stopover for this species.

Our objectives for this study are to:
1. Determine stopover duration for Red Knots that use Virginia.
2. Estimate annual survival of Red Knots and annual fidelity to Virginia.
3. Use demographic information to develop a population model for Red Knots in Virginia.
4. Determine total population size that passes through Virginia on an annual basis.

METHODS

Field methods

Red Knots move through Virginia during spring migration from late April through mid-June and use barrier islands located along the lower Delmarva Peninsula (Fig. 1). We and cooperators observed Red Knots during spring migration in 2006 – 2010. Knots are easiest to observe when they forage along sand beaches and peat banks that are exposed from mean tide to low tide; therefore, we completed surveys from 1.5 hours before to 1.5 hours after low tide during daylight hours. We surveyed along transects that we could cover within this 3 hour observation period. During each survey, we used high-quality spotting scopes (Leica ™ and Zeiss ™) fitted with 20-

60x zoom eye pieces to read flag codes from individually marked knots and recorded codes following a standard resighting protocol (Kalasz 2006).

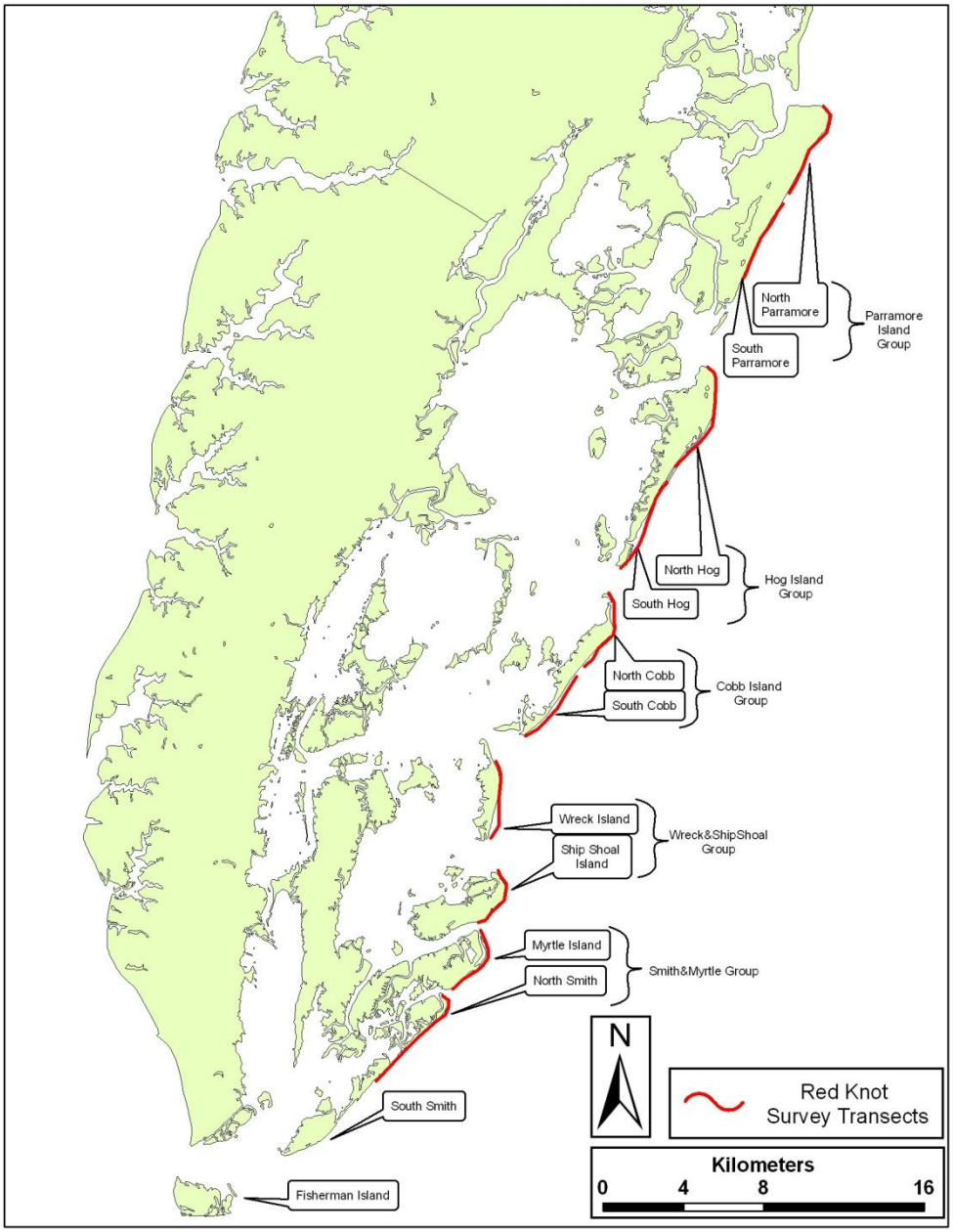

Figure 1. Locations of survey transects for individually marked Red Knots in Virginia during 2006-2010.

We surveyed for Red Knots along each transect once or twice per week. Initially, we completed surveys at locations where Red Knots were most abundant the previous year. Concurrent with this study, shorebirds were counted along the barrier islands from airplane (see Watts and Truitt 2000). We altered the survey schedule for banded knots based upon results of aerial surveys by

excluding transects where knots were absent and increasing surveys on transects where knots were most abundant.

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 (Bandedbirds.org and P. M. Gonzales; personal communications). We excluded observations that did not correspond to their banding data.

Modeling Methods:

Modeling stopover duration and population of Red Knots in Virginia

To determine stopover duration of Red Knots in Virginia, we created capture histories of each individually marked bird. We standardized each year to start at the earliest and end at the latest dates that marked knots were observed from all years, creating capture histories for all years combined into a single composite spring. We did not include time periods between years. Our time interval for analysis was 1 day, therefore our estimates of stopover duration are number of days. We used resight data from each knot from only a single year; either the year that each knot had the greatest number of observations or the first year it was observed.

Table 1. Models compared to estimate arrival (recruitment), departure (apparent survival), and resight probability included variation of apparent survival and recruitment by week. All models included date specific resight probabilities.

Model	Apparent survival	Recruitment rate
1	constant	constant
2	week	constant
3	2 week	constant
4	3 week	constant
5	constant	week
6	week	week
7	2 week	week
8	3 week	week
9	constant	2 week
10	week	2 week
11	2 week	2 week
12	3 week	2 week
13	constant	3 week
14	week	3 week
15	2 week	3 week
16	3 week	3 week

We used a 2-step analysis to estimate stopover duration. The first step included comparing alternative models for stopover dynamics and then estimating stopover duration for these models (Schaub et al. 2001, Choquet and Pradel 2003, Gillings et al. 2009). Parameters that influence stopover duration are rates of daily fidelity and daily recruitment to the stopover site, which are measured as apparent survival and recruitment, respectively. Fidelity is the complement of departure from the site and recruitment is of arrival to the site. These rates must be corrected for resight probability, the probability that an individually marked bird is observed when present at the site. Our first step was estimating apparent survival, recruitment, and resight probability using Pradel models (Pradel 1996) within Program MARK (White and Burnham 1999). We developed a model set that allowed fidelity and recruitment to differ approximately by weekly intervals (Table 1). We divided the number of days in the spring migration into periods of nearly equal numbers of days: 5 periods (7-8 days, ~1 week), 3

periods (12-13 days, ~2 weeks), 2 periods (18-19 days, ~3 weeks), and 1 period (38 days, constant). For all models, we allowed resight probability to vary by date (time). Our model set included 16 models.

We used an information theoretic approach to identify models with support in the data (Burnham and Anderson 2001;2002, Burnham and Anderson 2004). Additionally, we accounted for overdispersion in the data by first estimating median c-hat based upon the corresponding Cormack, Jolly, Seber (CJS) model to our global model (survival varying by week and resight probability varying by time) and applied that estimate of c-hat to our comparison of Pradel models. Thus, we used Quasi-Akaike Information Criterion corrected for small sample size (QAICc) as the basis for our comparisons (Burnham and Anderson 2002).

For the second step of the analysis, we estimated stopover duration using program SODA (stopover duration analysis) (Schaub et al. 2001) for all models in the data set. SODA calculates (1) stopover duration for individuals present at each time step in the analysis, and duration of time present (2) before and (3) after each time step and variance of each measure by bootstrapping data. Once model simulations are completed, one can calculate variation in estimates from simulation output. We ran 100 simulations for each of the 16 models in our model set. We then model averaged estimates and SEs of stopover duration, stopover prior to a given date, and stopover after a given date to determine the best estimates given the data (Buckland et al. 1997, Burnham and Anderson 2002). Error estimates include added variation due to model selection uncertainty.

From counts of Red Knots from 2006 – 2010 and estimates of daily fidelity, we calculated the total number of knots that passed through Virginia each year (Frederiksen et al. 2001). Watts and Truitt completed aerial counts of Red Knots along the lower Delmarva Peninsula (see Watts and Truitt 2000). From daily fidelity, we can estimate the number of knots that remained in Virginia from one count to the next and thus determine the number of new arrivals or uncounted knots in subsequent counts.

Modeling annual survival and fidelity

We estimated annual survival and fidelity to Virginia using an open robust design with multiple strata (Kendall and Bjorkland 2001). The robust design incorporates multiple secondary capture or resight sessions within a primary resight session. Primary sessions are spring migration periods for each year of the study, which provide information on annual survival and annual rates of movement away from Virginia and return to Virginia. The multi-strata design incorporates an unobserved location that Red Knots can move through instead of Virginia during spring migration. Movement from Virginia to the unobserved location (Away) is the complement of annual fidelity. We also estimated rates knots move from the unobserved location (Away) back to Virginia.

Secondary sessions included 5 periods that we used in the stopover duration analysis corresponding to 1 week intervals, as opposed to daily intervals used in the stopover duration analysis. We used 5 secondary periods to maximize the number of secondary sessions, to use a time frame that is easily interpretable (~1 week) and to remain consistent with analysis of

stopover duration. From secondary sessions, we estimated a resight probability for each session, and probabilities that knots will enter Virginia or remain in Virginia between sessions. From these, you can also estimate stopover duration; however, estimates are numbers of weekly intervals instead of number of days.

For this analysis, we developed a set of models to describe survival, movement, resight probability, and entry to and remaining in Virginia. All models included constant annual survival, and constant movement rates to and from Virginia among years. All models also included time specific estimates of resight probabilities among secondary sessions within years, with the same estimates used each year. Alternative models allowed for either constant or time specific estimates of probability of entering Virginia and remaining in Virginia among secondary sessions, with estimates remaining constant among years. Thus, we compared 4 models using an information theoretic approach (Burnham and Anderson 2001;2002, Burnham and Anderson 2004) and model averaged (Buckland et al. 1997) to obtain the most likely estimates from these models.

With estimates of annual survival and fidelity, we constructed a population model for Red Knots that move through Virginia during spring migration. This model provides deterministic projections of population changes given estimates of annual survival, movement away from and return to Virginia from our analyses. Estimates of annual productivity and survival of juvenile Red Knots are not available (Baker et al. 2004); therefore, we estimated a rate that knots are recruited to the breeding population such that numbers of knots from the model approximately match numbers of knots that moved through Virginia from 2006-2010. As is standard when modeling populations, we modeled the number of females that move through and are recruited to Virginia in spring. For the model, we assume that the number of females equals half of the number of knots estimated from aerial surveys, and that males and females move into and out of Virginia at the same rate during spring.

RESULTS

Duration and numbers of Red Knots stopping over in Virginia

Table 2. First and last dates that individually-marked Red Knots were observed along the barrier islands of the lower Delmarva Peninsula in Virginia from 2006-2010.

Year	First	Last	No. of banded birds observed
2006	14 May	24 May	29
2007	5 May	11 June	204
2008	19 May	3 June	53
2009	6 May	9 June	313
2010	13 May	3 June	389
All years	5 May	11 June	882

The duration of time in which we observed individually marked Red Knots varied by year, therefore the earliest and latest observation dates among years defined a 38-day stopover season beginning on 5 May and ending on 11 June (Table 2). In total, we observed 882 individually marked Red Knots from 2006 – 2010, with 192 observed in 2 years and 5 observed in 3 years (Appendix 1). We excluded an additional 59 observations that did not match banding records.

Mark-resight data (CJS) appears to be overdispersed with median c-hat = 1.36. We used this estimate to compare alternative models for arrival (recruitment) and departure (apparent survival) of Red Knots (Table 3). The best model (QAICc weight = 0.38) included constant recruitment (arrival) to Virginia with separate fidelity rates every 2 weeks. The effects of constant arrival and 2-week fidelity had the most support in the data with evidence weights of 0.59 and 0.55, respectively. We also found some support for the next 12 models with QAICc weights of 0.01-0.13 (Table 3).

Table 3. Results of model selection for 16 models describing patterns of arrival and departure of Red Knots to the lower Delmarva Peninsula during spring migration 2006 – 2010.

Departure (apparent survival)				Arrival (recruitment)				QAICc	Delta QAICc	QAICc Weights	QDeviance	Num. Par
constant	1 week	2 week	3 week	constant	1 week	2 week	3 week					
		1		1				5356.51	0.00	0.38	457.06	42
		1					1	5358.66	2.16	0.13	457.05	43
1				1				5359.13	2.62	0.10	463.99	40
1						1		5359.38	2.87	0.09	459.93	42
1							1	5359.91	3.40	0.07	462.62	41
		1				1		5359.92	3.41	0.07	456.15	44
			1	1				5360.54	4.03	0.05	463.25	41
			1			1		5361.54	5.03	0.03	459.93	43
			1				1	5362.01	5.50	0.02	462.56	42
	1			1				5362.80	6.30	0.02	459.03	44
		1			1			5363.25	6.74	0.01	455.14	46
1					1			5363.31	6.81	0.01	459.54	44
	1						1	5364.96	8.46	0.01	459.02	45
			1		1			5365.41	8.91	0.00	459.47	45
	1					1		5366.29	9.78	0.00	458.17	46
	1				1			5369.12	12.61	0.00	456.65	48
0.27	0.03	0.59	0.11	0.55	0.03	0.19	0.23	Relative variable importance[a]				

[a] Effect weights are the sum of QAICc weights for models that include each effect.

After model averaging, fidelity (apparent survival) and arrival (recruitment) rates varied over 6 periods defined by a unique combination of periods from alternative submodels (Table 4). Arrival, interpreted as the proportion of (marked) Red Knots present that will arrive over the next time interval, ranged from 0.76 to 0.79. Arrival was nearly the same within each of five 1-week intervals, supporting the finding that recruitment was constant throughout spring stopover. Fidelity, the proportion of (marked) Red Knots that remained until the next time period, ranged

Table 4. Fidelity, arrival, and resight probabilities (SE) for Red Knot observed in Virginia from 2006-2010, after model averaging. Estimates vary according to 6 unique periods based upon 1, 2, 3, or 6-week (constant) summary periods.

Date (resight probability)	Interval (arrival and departure)	Period numbers: 1 week	2 weeks	3 weeks	constant	Period after model averaging	Fidelity (apparent survival)	Arrival (recruitment)	Resight probability
5-May									0.042 (0.0619)
6-May	5 May to 6 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0.015 (0.0224)
7-May	6 May to 7 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0 (0)
8-May	7 May to 8 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0 (0)
9-May	8 May to 9 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0.015 (0.0162)
10-May	9 May to 10 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0.034 (0.0289)
11-May	10 May to 11 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0.011 (0.0107)
12-May	11 May to 12 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0.003 (0.0044)
13-May	12 May to 13 May	1	1	1	1	1	0.84 (0.0584)	0.757 (0.1162)	0.087 (0.0409)
14-May	13 May to 14 May	2	1	1	1	2	0.836 (0.0541)	0.751 (0.0577)	0.107 (0.0411)
15-May	14 May to 15 May	2	1	1	1	2	0.836 (0.0541)	0.751 (0.0577)	0.052 (0.0192)
16-May	15 May to 16 May	2	1	1	1	2	0.836 (0.0541)	0.751 (0.0577)	0.008 (0.0053)
17-May	16 May	2	1	1	1	2	0.836	0.751	0.019

Date (resight probability)	Interval (arrival and departure)	Period numbers: 1 week	2 weeks	3 weeks	constant	Period after model averaging	Fidelity (apparent survival)	Arrival (recruitment)	Resight probability
	to 17 May						(0.0541)	(0.0577)	(0.0078)
	17 May						0.836	0.751	0.009
18-May	to 18 May	2	1	1	1	2	(0.0541)	(0.0577)	(0.0047)
	18 May						0.769	0.772	0.176
19-May	to 19 May	2	2	1	1	3	(0.0277)	(0.03)	(0.0334)
	19 May						0.769	0.772	0.113
20-May	to 20 May	2	2	1	1	3	(0.0277)	(0.03)	(0.0216)
	20 May						0.768	0.774	0.273
21-May	to 21 May	3	2	1	1	3	(0.0268)	(0.0263)	(0.0384)
	21 May						0.768	0.774	0.125
22-May	to 22 May	3	2	1	1	3	(0.0268)	(0.0263)	(0.021)
	22 May						0.768	0.774	0.04
23-May	to 23 May	3	2	1	1	3	(0.0268)	(0.0263)	(0.0106)
	23 May						0.768	0.774	0.161
24-May	to 24 May	3	2	1	1	3	(0.0268)	(0.0263)	(0.0266)
	24 May						0.766	0.779	0.119
25-May	to 25 May	3	2	2	1	4	(0.0268)	(0.0234)	(0.0216)
	25 May						0.766	0.779	0.077
26-May	to 26 May	3	2	2	1	4	(0.0268)	(0.0234)	(0.0165)
	26 May						0.766	0.779	0.11
27-May	to 27 May	3	2	2	1	4	(0.0268)	(0.0234)	(0.0217)
	27 May						0.765	0.779	0.067
28-May	to 28 May	4	2	2	1	4	(0.0282)	(0.0238)	(0.016)
	28 May						0.765	0.779	0.115
29-May	to 29 May	4	2	2	1	4	(0.0282)	(0.0238)	(0.0247)
	29 May						0.765	0.779	0.211
30-May	to 30 May	4	2	2	1	4	(0.0282)	(0.0238)	(0.0432)

Date (resight probability)	Interval (arrival and departure)	Period numbers					Fidelity (apparent survival)	Arrival (recruitment)	Resight probability
		1 week	2 weeks	3 weeks	constant	Period after model averaging			
31-May	30 May to 31 May	4	3	2	1	5	0.909 (0.1108)	0.785 (0.0379)	0.056 (0.0149)
1-Jun	31 May to 1 Jun	4	3	2	1	5	0.909 (0.1108)	0.785 (0.0379)	0.044 (0.0152)
2-Jun	1 Jun to 2 Jun	4	3	2	1	5	0.909 (0.1108)	0.785 (0.0379)	0.053 (0.024)
3-Jun	2 Jun to 3 Jun	4	3	2	1	5	0.909 (0.1108)	0.785 (0.0379)	0.012 (0.0086)
4-Jun	3 Jun to 4 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0 (0)
5-Jun	4 Jun to 5 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0.007 (0.0066)
6-Jun	5 Jun to 6 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0.002 (0.003)
7-Jun	6 Jun to 7 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0 (0)
8-Jun	7 Jun to 8 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0 (0)
9-Jun	8 Jun to 9 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0.002 (0.004)
10-Jun	9 Jun to 10 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0 (0)
11-Jun	10 Jun to 11 Jun	5	3	2	1	6	0.916 (0.1079)	0.791 (0.0551)	0.002 (0.0054)

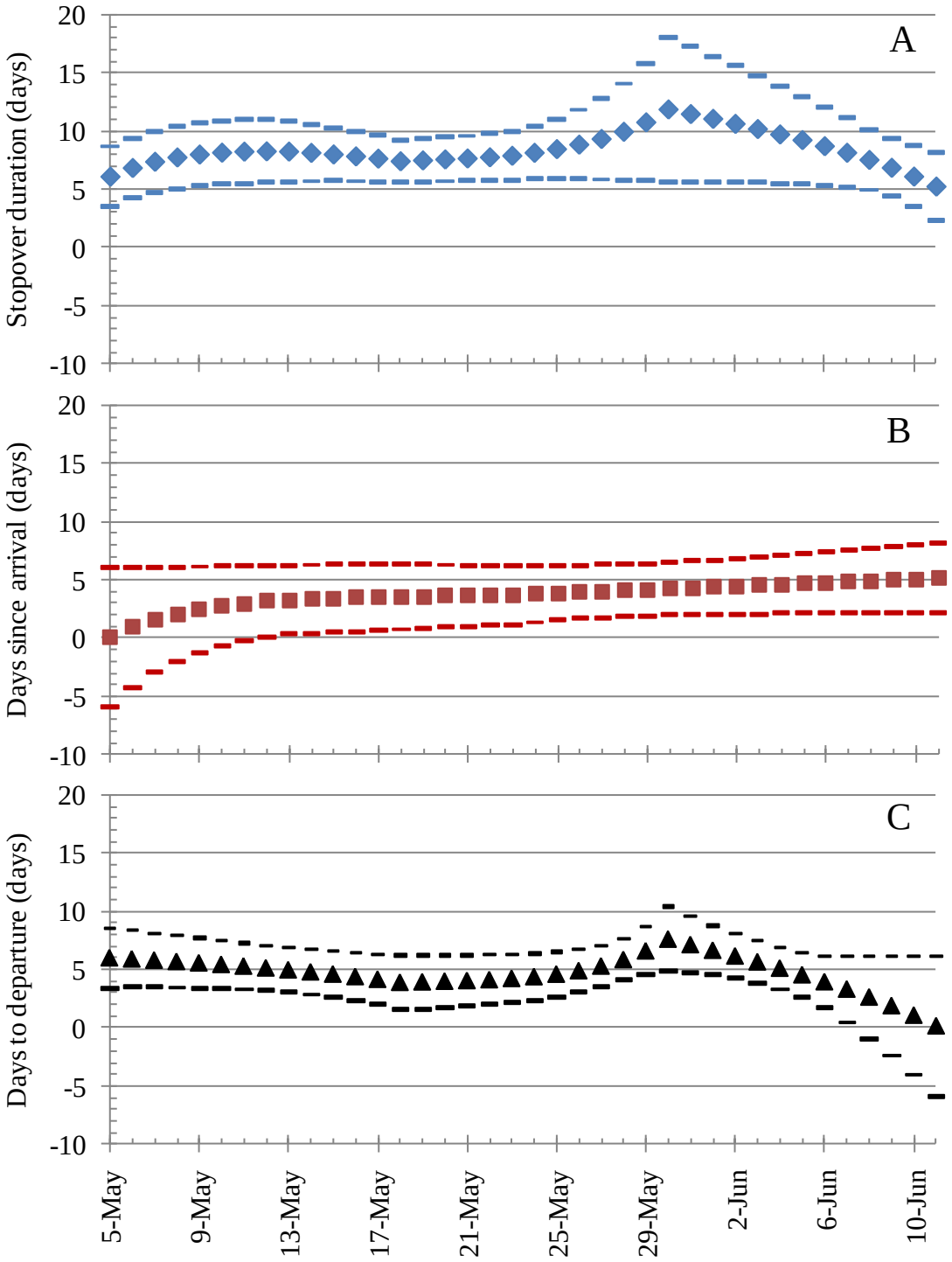

Figure 2. Stopover duration during spring migration (A) includes time since a Red Knot arrived (B) and time until a knot departed (C) the lower Delmarva Peninsula in Virginia from 2006 – 2010. Dashes are 1 SE above and below stopover durations.

from 0.76 to 0.92. The patterns of fidelity and arrival closely follow the QAICc best model, with variation added by other models in the model set.

Model averaged estimates of stopover duration ranged from 5.2 to 11.8 days (Fig. 2 A). The pattern of stopover duration appeared to be bimodal, with a peak of 8.3 days at day 8 and the maximum stopover duration of 11.8 days at day 26. The number of days a knot was present prior to a given date is consistent throughout the stopover season, although SE is greatest at the start of the season (Fig. 2 B). The number of days a knot will remain after a given date varied throughout the season, with the highest SE at the end of the season (Fig. 2 C). Stopover duration ranged from 7.4 to 11.8 days after excluding periods of highest SE (first and last 3 days of stopover season), which are unreliable due to low sample size (Gillings et al. 2009)..

The number of Red Knots that pass through Virginia from 2007 to 2010 ranged from 12,600 to 14,700 (Table 5). The estimate for 2006 was 9,785; however, there was a 3-week gap in counts during this year which biases the number of knots passing through because knots could have arrived and departed without being counted. The majority (83 – 100%) of knots were not present during previous weekly counts, except for the last week. The last count during the first week of June did not record new knots, except in 2006.

Annual survival and fidelity

For models that estimate annual survival and fidelity, we found support in the data for the model that included time varying probability of entry (recruitment) and constant probability of remaining in Virginia (fidelity) during spring stopover (Table 6), which is consistent with stopover duration analysis. The second best model in the model set including time varying probability of remaining in Virginia with all other parameters the same as the best model. Survival was high (0.87) as were movement away (0.60) and return (0.48) to Virginia (Table 7). Weekly resight probabilities during each of 5 weeks varied from 0.02 to 0.62 with the highest in week 3. Stopover duration was constant (1.43 weeks or 10 days) in this analysis.

We based a population model on annual survival and movement rates to Virginia from Away and from Away to Virginia. Red Knots survived (0.87) and either move from Virginia to Away (0.60) or remained in Virginia (0.40). Likewise, those knots that were in the unobserved stopover location survived and either returned to Virginia (0.48) or remain Away (0.52). This produces a 2x2 matrix model (Caswell 2001) that projects the number of females with recruitment of female offspring (Table 8). Total number of Red Knot is then twice the projected numbers, assuming a balanced sex ratio. To achieve a steady population in Virginia, recruitment of female offspring to the breeding population must be 0.13 females per female or 0.26 offspring (males and females) per pair. In this model, recruitment is the product of fecundity (fledging rate) and first year survival. Our population model is based upon numbers of knots counted in 2007, and shows that 44% of knots that use Virginia during spring migration over time are present in Virginia in a given year (Fig. 3). Of knots cycling through Virginia, more are present Away from Virginia than within Virginia each year.

.

Table 5. Aerial counts of Red Knots and estimated total numbers that passed through the lower Delmarva Peninsula, Virginia from 2006 – 2010.

Year	Dates							Peak	Total
2006	25-Apr			16-May	23-May	30-May	7-Jun		
Count	180			2726	5783	2201	823	5783	
New knots	180			2721	5227	1392	264		9785
2007	25-Apr	3-May	11-May	17-May	22-May	30-May	6-Jun		
Aerial count	0	155	1029	3290	5939	4111	602	5939	
No. new knots	0	155	991	2947	5003	3516	0		12611
2008	25-Apr	1-May		16-May	21-May	29-May	5-Jun		
Aerial count	26	135		2,402	8,465	5,418	736	8465	
No. new knots	26	126		2,393	7,637	4,506	0		14688
2009	25-Apr	30-Apr	14-May	21-May	25-May	1-Jun			
Count	280	78	2,175	3,339	6,079	3,961		6079	
New knots	280	0	2,175	2,813	5,099	3,030			13398
2010	27-Apr		7-May	14-May	24-May	2-Jun	11-Jun		
Count	0		78	2,175	8,172	3,805	45	8172	
New knots	0		78	2,152	7,936	2,793	0		12959

Table 6. Alternative models used to estimate survival and annual fidelity of Red Knots to the lower Delmarva Peninsula, Virginia from 2006 – 2010.

			P (entry)		P (remain)		P (resight)					
Survival (constant)	Movement away (constant)	Movement return (constant)	Constant	Time within year	Constant	Time within year	Time within year	AICc	Delta AICc	AICc Weights	Deviance	Num. Par
1	1	1		1	1		1	3795.08	0	0.93	3768.74	13
1	1	1		1		1	1	3800.20	5.12	0.07	3767.69	16
1	1	1	1		1		1	3820.98	25.90	0	3800.78	10
1	1	1	1			1	1	3827.54	32.46	0	3801.20	13
1.00	1.00	1.00	0	1.00	0.93	0.07	1.00			Relative variable importance		

Table 7. Model averaged estimates of annual and within-year demographic rates for Red Knots that stopover during spring migration in Virginia, 2006 – 2010.

Annual rates					
Survival	0.87 (0.182)				
Movement away	0.60 (0.122)		Return from away	0.48 (0.412)	
Within year rates					
Resight sessions	1	2	3	4	5
Resight probability	0.02 (0.008)	0.40 (0.189)	0.62 (0.147)	0.27 (0.086)	0.05 (0.083)
Stopover duration	1.43 (0.891)	1.43 (0.891)	1.43 (0.891)	1.43 (0.891)	1.43 (0.891)
Interval between sessions	1-2	2-3	3-4	4-5	
Probability of entering between sessions	0.001 (0.018)	0.17 (0.062)	0.32 (0.089)	0.04 (0.298)	
Probability of remaining between sessions	0.34 (0.111)	0.33 (0.072)	0.33 (0.088)	0.36 (2.824)	

Table 8. A deterministic matrix model for Red Knots that move through Virginia during spring migration. The model is based upon demographic estimates from individually marked Red Knots that were observed in Virginia from 2006-2010.

	Virginia	Away
Virginia	S * (1-VtoA) + Recruitment	S * AtoV
Away	S * VtoA	S * (1-AtoV) + Recruitment

Parameters required for stable population over time ($\lambda = 1.0$)

	Virginia	Away	Recruitment (females per female)
Virginia	0.478	0.417	
Away	0.521	0.583	0.131

Seeded population 28,404[a]

Year	Females in Virginia	Females away	Total Females	Total Knots in Virginia	λ	% in Virginia
Seeded no. females	14,202	0	14,202	28,404		100.0%
Stabilizing year 1	6,798	7,403	14,202	13,597	1.00	47.9%
Stabilizing year 2	6,338	7,864	14,202	12,676	1.00	44.6%
2007	6,309	7,893	14,202	12,619	1.00	44.4%
2008	6,308	7,894	14,202	12,615	1.00	44.4%
2009	6,307	7,894	14,202	12,615	1.00	44.4%
2010	6,307	7,894	14,202	12,615	1.00	44.4%

[a] Number of knots passing through Virginia in 2007 = 12611 / 44.4% of population in Virginia.

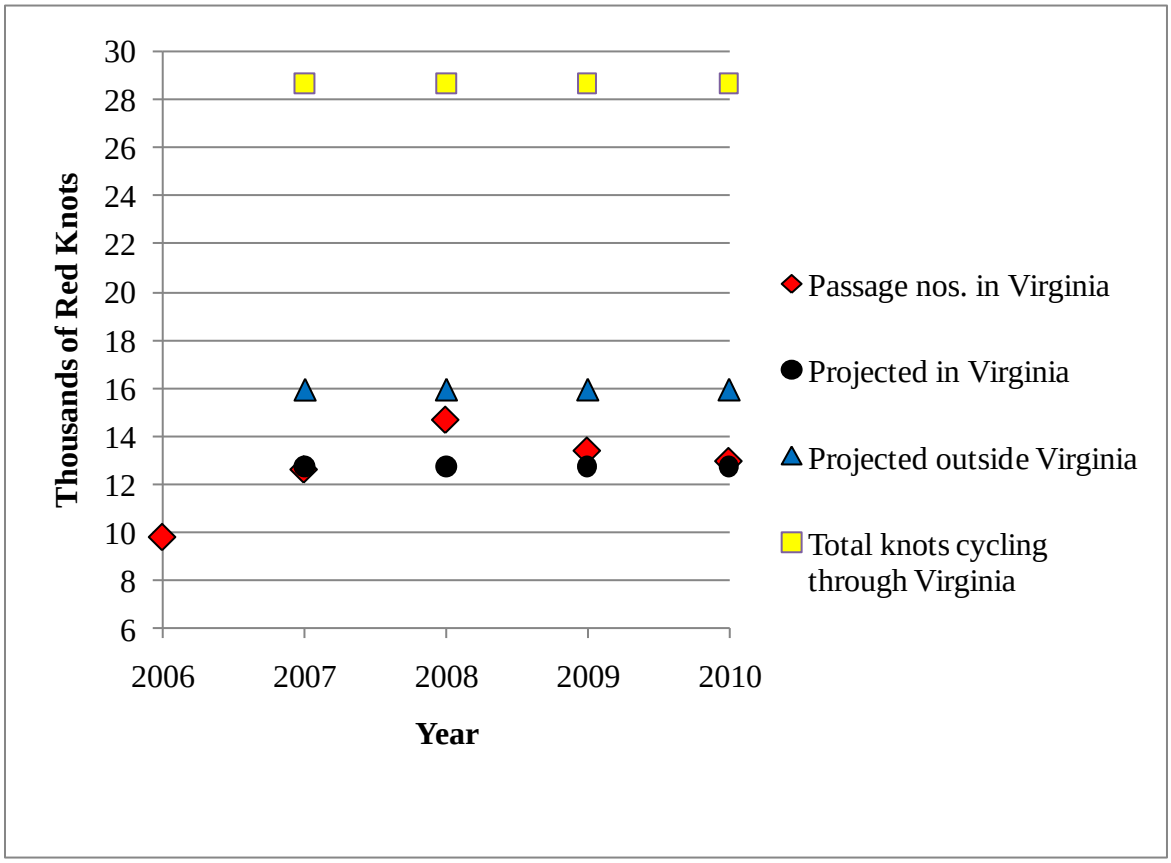

Figure 3. Number of Red Knots that move through Virginia based upon adjustment of weekly aerial surveys (passage number) and projection of knot population based upon population model including Virginia and an unobserved stopover location outside of Virginia. Projected numbers assumes a stable population, a starting population equal to the number passing through Virginia in 2007, and includes 2 years for the population to stabilize.

DISCUSSION

Stopover dynamics of Red Knots in Virginia provides an interesting contrast to dynamics of knots in Delaware Bay, where a majority make their ultimate stopover during spring migration (Niles et al. 2008). Stopover duration for knots in Virginia from 2006-2010 is shorter, on average, than for Delaware Bay. The duration in Virginia was 7-8 days through 25 May, and increased to 9-12 days from 26 May to 6 June. This pattern is opposite of that observed in Delaware Bay in 2004, when stopover in May was 11-12 days and stopover in early June decreased to 8-10 days (Gillings et al. 2009). Like Delaware Bay, knots arrived and departed throughout spring migration. Also like Delaware Bay, we found evidence of a second wave of arrivals at the end of May. In Virginia, Red Knots exhibited 2 peaks in the duration of stopover. The first occurred during the first through third week of May, and the second occurred from the last week in May to the first week in June. The pattern of stopover duration in Virginia may be

driven by abundance of benthic prey. In 2007, prey peaked at the end of May through early June (Cohen et al. 2009a).

Stopover in Virginia is also driven by changes in daily fidelity as opposed to recruitment rates. Arrival to Virginia appears to be constant throughout stopover, while changes in fidelity rates (0.76 – 0.84) mirror peaks in total stopover duration. Cohen et al. (2007) followed knots that were captured and radio-tagged and found that daily fidelity to Virginia was high (0.87 – 0.99) through peak counts of Red Knots in 2006 and 2007 and dropped afterward (0.56) in 2006. The stopover pattern for radio-tagged knots suggested that once knots arrive in Virginia, they remain until late in the migration season (Cohen et al. 2009b). Differences in results could be related to handling effects (Warnock and Bishop 1998), lengthening stopover for knots captured and radio tagged. Our findings indicate the rate that knots leave Virginia is greater and overall stopover duration is shorter than previously thought; therefore, the number of Red Knots using Virginia must also be higher than thought.

By combining estimates of daily fidelity with weekly counts of Red Knots from aerial surveys completed in 2006 - 2010, we estimated the size of the passage population (Frederiksen et al. 2001, Cohen et al. 2009b). The lowest number of knots passing through Virginia was in 2006 (9,785). This estimate is 35% larger than one based on radio-tagged knots (Cohen et al. 2009b), even though there was a 3-week gap in surveys during early migration in which knots arrived and departed without being counted. Our lowest estimate of the passage population, without large gaps between surveys was 12,611 in 2007, which is 51% larger than the estimate based on radio-tagged birds. The overall average from 2007 – 2010 was 13,400 knots passing through Virginia during spring migration.

Understanding the relative number of knots moving through Virginia compared to Delaware Bay becomes difficult when comparing studies. Gillings et al. (2009) used methods very similar to ours and estimated the passage population for Delaware Bay in 2004 at 18,000. Estimates based on radio-tagged knots for 2004 and 2006 were 17,100 and 19,500, respectively (Cohen et al. 2009b). Admittedly, our most reliable estimates are from different years (2007-2010) compared to other studies, but this provides an indication of relative population sizes from these 2 stopover sites. Virginia hosts 74% as many knots as Delaware Bay, when comparing our average for 2007-2010 with the average from studies in Delaware Bay from 2004 and 2006. However, the total number of knots from this comparison sum to 31,567 birds, which is 28% greater than the number in South America during the winter of 2005-06 (17,211) and Florida in 2004-06 (7,500) combined (Niles et al. 2008). This discrepancy suggests either all wintering locations of knots are not known or that knots use multiple stopover locations in the mid-Atlantic region.

Analysis of mark-resight data on an annual basis provides evidence that Red Knots from Virginia move between Virginia and one or more other spring locations. We found movement from Virginia to an unobserved location (60%) was greater than fidelity to Virginia (40%). However, this movement was not permanent, as many (48%) returned in subsequent years. When we combined movement rates and survival estimates from this analysis into a population model, we found that recruitment of young to the breeding population must equal 0.262 young per female to achieve a stable population of knots that stopover in Virginia. We then found that only 44% of Red Knots that use Virginia are present in a given year. Using estimates of passage population from 2007, this means that nearly 16,000 knots that use Virginia at one time are found away from Virginia in a given year.

Virginia supports the second largest number of Red Knots in the eastern US during their final stopover during the northward migration in spring. Numbers of knots in Virginia appear to be stable based upon aerial counts during the peak of migration (Watts and Truitt 2000,Watts, unpublished data). Although numbers of animals that use an area is not an indication of habitat quality (Van Horne 1983), survival of those animals is a valid indicator of quality. Our estimate of annual survival (0.87) is higher than the estimates for knots from Tierra del Fuego and Delaware Bay prior to (0.84) and after (0.54) a population decline in 2000 (Baker et al. 2004). Based upon a more recent analysis, annual survival in Virginia is slightly less than estimates for knots whose mass is less than critical mass of 180g required to fuel migration to breeding areas (0.918) and knots with mass greater than the critical mass (0.918) in Delaware Bay from 1995-2008 (McGowan et al. 2011). Thus, given our estimate of apparent survival, Virginia appears to be a high quality stopover site for knots along with Delaware Bay.

The most likely location of the unobserved location from our population model is Delaware Bay. From 2006 – 2010, 521 of 882 knots that were observed in Virginia were also observed in Delaware Bay (Watts, Duerr, Smith, Niles, Dey, Kalasz; unpublished data). These numbers include 21 knots that were observed in both locations on the same day. Given the magnitude of numbers of Red Knots moving between these sites, we are collaborating with researchers in Delaware Bay to directly estimate movement between these locations. The combined analysis of Virginia and Delaware Bay data should also provide more informed estimates of survival, and the contribution of each location to survival.

The barrier islands along the Delmarva Peninsula in Virginia provide high quality habitat for migrating Red Knots. This area contributes to high survival, and supports tens of thousands of birds. Early preservation of the barrier islands and lagoon systems in Virginia contribute to the long-term survival of the *rufa* subspecies, potentially helping to avert steep short-term declines that were predicted (Baker et al. 2004) for Delaware Bay. We have strong evidence that the knots using Virginia and Delaware Bay constitute a single population that includes Red Knots from throughout their winter range (see Appendix 1).

ACKNOWLEDGMENTS

Funding for this project was provided by National Fish and Wildlife Foundation, The US Fish and Wildlife Service, and Virginia Coastal Zone Management Program. Tom Badger, Leaf Burhans, Tom Goblet, Julie Murphy, Amy Whitear, and Beth Wright assisted in all aspects of field work. Susan Brown, Amanda Daisey, Grant Harter, David Melton, and Sue Rice contributed considerable efforts to resights. Barry Truitt and Alex Wilke provided technical and field support. Amanda Dey, Patricia Gonzales, Kevin Kalasz, Larry Niles and Jeannine Parvin assisted with data verification. Finally, we gratefully acknowledge administrative support from Erica Lawler, Cindy Corbett, and Jane Lopez at the College of William and Mary.

LITERATURE CITED

Baker, A. J., P. M. Gonz lez, T. Piersma, L. J. Niles, I. d. L. S. d. 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 Refuelling Rates and Late Arrival in Delaware Bay. Proceedings of the Royal Society of London: Series B 271:875-882.

Baker, A.J., and T. Piersma. 2000. Life history characteristics and the conservation of migratory shorebirds, p. 105-124. *In* L.M. Gosling and W.J. Sutherland [EDs.]. Behaviour and conservation. Cambridge University Press, Cambridge, UK.

Buckland, S. T., K. P. Burnham, and N. H. Augustin. 1997. Model selection: An integral part of inference. Biometrics 53:603-618.

Burnham, K. P., and D. R. Anderson. 2001. Kullback-Leibler information as a basis for strong inference in ecological studies. Wildlife Research 28:111-119.

_____. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer, New York.

Burnham, K. P., and D. R. Anderson. 2004. Multimodel inference: understanding AIC and BIC in model selection. Sociological Methods and Research 33:261-304.

Caswell, H. 2001. Matrix population models: construction, analysis, and interpretation. Sinauer Associates, Inc., Sunderland, MA.

Choquet, R., and R. Pradel. 2003. User's manual for SODA. *in* Mimeographed document. CEFE/CNRS, Montpellier.

Cohen, J. B., S. M. Karpanty, J. D. Fraser, and B. R. Truitt. 2009a. The effect of benthic prey abundance and size on red knot (Calidris canutus) distribution at an alternative migratory stopover site on the US Atlantic Coast. Journal of Ornithology OnLine First.

Cohen, J. B., S. M. Karpanty, J. D. Fraser, B. D. Watts, and B. R. Truitt. 2009b. Residence probability and population size of red knots during spring stopover in the mid-Atlantic region of the United States. Journal of Wildlife Management 73:939-945.

Frederiksen, M., A. D. Fox, J. Madsen, and K. Colhoun. 2001. Estimating the Total Number of Birds using a Staging Site. Journal of Wildlife Management 65:282-289.

Gillings, S., P. W. Atkinson, A. J. Baker, K. A. Bennett, N. A. Clark, K. B. Cole, P. M. Gonzalez, K. S. Kalasz, C. D. T. Minton, L. J. Niles, R. C. Porter, I. D. Serrano, H. P. Sitters, and J. L. Woods. 2009. Staging Behavior in Red Knot (Calidris Canutus) in Delaware Bay: Implications for Monitoring Mass and Population Size. Auk 126:54-63.

Kalasz, K. S. 2006. Resighting protocol for individually color-marked shorebirds on Delaware Beaches. Natural Heritage and Endangered Species Program, Delaware Division of Fish and Wildlife, DNREC.

Kendall, W. L., and R. Bjorkland. 2001. Using open robust design to estimate temporary emigration from capture-recapture data. Biometrics 57:1113-1122.

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: linkiing red knot survival to horseshoe crab spawning abundance. Ecosphere In Press.

McGowan, C. P., D. R. Smith, J. A. Sweka, J. Martin, J. D. Nichols, R. Wong, J. E. Lyons, L. J. Niles, K. Kalasz, J. Brust, M. Klopfer, and B. Spear. 2010. Multispecies Modeling for Adaptive Management of Horseshoe Crabs and Red Knots in the Delaware Bay. Natural Resource Modeling 24:117-156.

Niles, L., H. Sitters, A. Dey, P. W. Atkinson, A. J. Baker, K. A. Bennett, R. Carmona, K. E. Clark, N. A. Clark, C. Espoz, P. M. Gonz lez, B. A. Harrington, D. E. Hern ndez, 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. z. L. Serrano. 2008. Status of the Red Knot (Calidris canutus rufa) in the Western Hemisphere. Studies in Avian Biology 36:1-185.

Piersma, T., and N.C. Davidson. 1992. The migrations and annual cycles of five subspecies of knots in perspective. Wader Study Group Bull. Suppl. 64:52-63.

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. Biometrics 52:703-709.

Schaub, M., R. Pradel, L. Jenni, and J.-D. Lebreton. 2001. Migrating Birds Stop Over Longer than Usually Thought: An Improved Capture-Recapture Analysis. Ecology 82:852-859.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Warnock, N., and M. A. Bishop. 1998. Spring Stopover Ecology of Migrant Western Sandpipers. Condor 100:456-467.

Watts, B. D., and B. R. Truitt. 2000. Abundance of Shorbirds along the Virginia Barrier Islands during Spring Migration. Raven 71:33-39.

White, G. C., and K. P. Burnham. 1999. Program MARK: Survival estimation from populations of marked animals. Bird Study 46:120-138.

Appendix 1. The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/14/2006	FLJMM	Shipshoal Island	USA
5/14/2006	FLTKM	Shipshoal Island	USA
5/14/2006	FLTLN	Shipshoal Island	USA
5/14/2006	FLUNP	Shipshoal Island	USA
5/14/2006	FLVCP	Shipshoal Island	USA
5/17/2006	FLT6:O	Hog Island	USA
5/17/2006	FOD8	Hog Island	Argentina
5/23/2006	FLCE:G	Hog Island	USA
5/23/2006	FLCVC	Hog Island	USA
5/23/2006	FLVCV	Hog Island	USA
5/23/2006	FLVNY	Hog Island	USA
5/23/2006	FLXUN	Hog Island	USA
5/23/2006	FLXVT	Hog Island	USA
5/23/2006	FLYAH	Hog Island	USA
5/23/2006	FLYAT	Hog Island	USA
5/23/2006	FLYCJ	Hog Island	USA
5/23/2006	FLYCX	Hog Island	USA
5/23/2006	FOAIP	Hog Island	Argentina
5/23/2006	FOAUM	Hog Island	Argentina
5/23/2006	FOK8	Hog Island	Argentina
5/23/2006	FOSY	Hog Island	Argentina
5/24/2006	FLNA:O	Hog Island	USA
5/24/2006	FLXVK	Hog Island	USA
5/24/2006	FLYAA	Hog Island	USA
5/24/2006	FLYAP	Hog Island	USA
5/24/2006	FOCOK	Hog Island	Argentina
5/24/2006	FOU7	Hog Island	Argentina
5/24/2006	FOZ3	Hog Island	Argentina
5/24/2006	FRII	Hog Island	Chile
5/5/2007	FLAA5	Hog Island	USA
5/5/2007	FLHU5	Myrtle Island	USA
5/5/2007	FLUYV	Myrtle Island	USA
5/5/2007	FLXYA	Myrtle Island	USA
5/5/2007	FLYAL	Myrtle Island	USA
5/5/2007	FODT	Hog Island	Argentina
5/5/2007	FOXE	Hog Island	Argentina
5/9/2007	FLTT5	Fisherman Island	USA
5/9/2007	FLVUL	Fisherman Island	USA
5/10/2007	FL7N:O	Hog Island	USA
5/10/2007	FLEHA	Hog Island	USA

5/10/2007	FLJVH	Hog Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/10/2007	FLEHA	Hog Island	USA
5/10/2007	FLJVH	Hog Island	USA
5/10/2007	FLKCK	Fisherman Island	USA
5/10/2007	FLKEJ	Hog Island	USA
5/10/2007	FLKY0	Hog Island	USA
5/10/2007	FLPHH	Hog Island	USA
5/10/2007	FLUVV	Hog Island	USA
5/10/2007	FLVMP	Hog Island	USA
5/10/2007	FLXYH	Hog Island	USA
5/14/2007	FLHTV	Smith Island	USA
5/14/2007	FLLNJ	Myrtle Island	USA
5/14/2007	FLOW:G	Myrtle Island	USA
5/14/2007	FLXTY	Smith Island	USA
5/14/2007	FLXYJ	Myrtle Island	USA
5/15/2007	FLYCE	Parramore Island	USA
5/15/2007	FOCGH	Parramore Island	Argentina
5/15/2007	FOECJ	Parramore Island	Argentina
5/15/2007	FOLCU	Parramore Island	Argentina
5/17/2007	FLAET	Hog Island	USA
5/17/2007	FLJA0	Hog Island	USA
5/17/2007	FLJCU	Hog Island	USA
5/17/2007	FLJVM	Hog Island	USA
5/17/2007	FLLTN	Hog Island	USA
5/17/2007	FLUMK	Hog Island	USA
5/17/2007	FLUNK	Hog Island	USA
5/17/2007	FLYAN	Hog Island	USA
5/17/2007	FLYCV	Hog Island	USA
5/17/2007	FOAON	Hog Island	Argentina
5/17/2007	FOAY	Hog Island	Argentina
5/17/2007	FOB55	Hog Island	Argentina
5/17/2007	FOLMH	Hog Island	Argentina
5/17/2007	FRCP	Hog Island	Chile
5/19/2007	FLKLN	Hog Island	USA
5/19/2007	FLUL4	Hog Island	USA
5/19/2007	FOACN	Hog Island	Argentina
5/20/2007	FLCHL	Hog Island	USA
5/20/2007	FLKEM	Hog Island	USA
5/20/2007	FLKT0	Hog Island	USA
5/20/2007	FLULL	Hog Island	USA
5/20/2007	FLXUM	Hog Island	USA
5/20/2007	FOCCK	Hog Island	Argentina

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/10/2007	FLKCK	Fisherman Island	USA
5/10/2007	FLKEJ	Hog Island	USA
5/10/2007	FLKY0	Hog Island	USA
5/10/2007	FLPHH	Hog Island	USA
5/10/2007	FLUVV	Hog Island	USA
5/10/2007	FLVMP	Hog Island	USA
5/10/2007	FLXYH	Hog Island	USA
5/14/2007	FLHTV	Smith Island	USA
5/14/2007	FLLNJ	Myrtle Island	USA
5/14/2007	FLOW:G	Myrtle Island	USA
5/14/2007	FLXTY	Smith Island	USA
5/14/2007	FLXYJ	Myrtle Island	USA
5/15/2007	FLYCE	Parramore Island	USA
5/15/2007	FOCGH	Parramore Island	Argentina
5/15/2007	FOECJ	Parramore Island	Argentina
5/15/2007	FOLCU	Parramore Island	Argentina
5/17/2007	FLAET	Hog Island	USA
5/17/2007	FLJA0	Hog Island	USA
5/17/2007	FLJCU	Hog Island	USA
5/17/2007	FLJVM	Hog Island	USA
5/17/2007	FLLTN	Hog Island	USA
5/17/2007	FLUMK	Hog Island	USA
5/17/2007	FLUNK	Hog Island	USA
5/17/2007	FLYAN	Hog Island	USA
5/17/2007	FLYCV	Hog Island	USA
5/17/2007	FOAON	Hog Island	Argentina
5/17/2007	FOAY	Hog Island	Argentina
5/17/2007	FOB55	Hog Island	Argentina
5/17/2007	FOLMH	Hog Island	Argentina
5/17/2007	FRCP	Hog Island	Chile
5/19/2007	FLKLN	Hog Island	USA
5/19/2007	FLUL4	Hog Island	USA
5/19/2007	FOACN	Hog Island	Argentina
5/20/2007	FLCHL	Hog Island	USA
5/20/2007	FLKEM	Hog Island	USA
5/20/2007	FLKT0	Hog Island	USA
5/20/2007	FLULL	Hog Island	USA
5/20/2007	FLXUM	Hog Island	USA
5/20/2007	FOCCK	Hog Island	Argentina
5/20/2007	FOCCM	Hog Island	Argentina

5/20/2007	FOLLN	Hog Island	Argentina

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/23/2007	FBBC	Fisherman Island	Brazil
5/23/2007	FLKPH	Shipshoal Island	USA
5/23/2007	FLPKC	Fisherman Island	USA
5/23/2007	FLULN	Shipshoal Island	USA
5/23/2007	FLYM4	Wreck Island	USA
5/23/2007	FOMCJ	Wreck Island	Argentina
5/23/2007	FOXY	Fisherman Island	Argentina
5/23/2007	FRDW	Fisherman Island	Chile
5/23/2007	FRJJ	Wreck Island	Chile
5/24/2007	FLI7:O	Smith Island	USA
5/24/2007	FLKYH	Fisherman Island	USA
5/24/2007	FLKYK	Fisherman Island	USA
5/24/2007	FLNY:G	Fisherman Island	USA
5/24/2007	FLVHN	Myrtle Island	USA
5/24/2007	FLXXX	Smith Island	USA
5/24/2007	FLXYE	Smith Island	USA
5/24/2007	FOCJE	Smith Island	Argentina
5/24/2007	FOCSU	Fisherman Island	Argentina
5/24/2007	FOEAV	Myrtle Island	Argentina
5/24/2007	FOJD	Smith Island	Argentina
5/24/2007	FOT2	Myrtle Island	Argentina
5/25/2007	FOAOK	Parramore Island	Argentina
5/25/2007	FOCKE	Parramore Island	Argentina
5/25/2007	FOLVL	Parramore Island	Argentina
5/26/2007	FLHAT	Hog Island	USA
5/26/2007	FLKLY	Hog Island	USA
5/26/2007	FLLV1	Hog Island	USA
5/26/2007	FLMA5	Hog Island	USA
5/26/2007	FLMTC	Hog Island	USA
5/26/2007	FLOB:G	Hog Island	USA
5/26/2007	FLPCE	Hog Island	USA
5/26/2007	FLTCV	Hog Island	USA
5/26/2007	FLYAV	Hog Island	USA
5/26/2007	FOAPD	Hog Island	Argentina
5/26/2007	FOCJL	Hog Island	Argentina
5/26/2007	FOEEA	Hog Island	Argentina
5/26/2007	FOLHJ	Hog Island	Argentina
5/26/2007	FOLLM	Hog Island	Argentina
5/26/2007	FOTB	Hog Island	Argentina
5/26/2007	FOWY	Hog Island	Argentina
5/26/2007	FRYS	Hog Island	Chile

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/27/2007	FLCJT	Fisherman Island	USA
5/27/2007	FLHMP	Wreck Island	USA
5/27/2007	FLO4:G	Wreck Island	USA
5/27/2007	FLTTL	Wreck Island	USA
5/27/2007	FLVHM	Shipshoal Island	USA
5/27/2007	FLVX4	Wreck Island	USA
5/27/2007	FLYCN	Wreck Island	USA
5/27/2007	FOADJ	Wreck Island	Argentina
5/27/2007	FOHX	Wreck Island	Argentina
5/27/2007	FOPT	Wreck Island	Argentina
5/30/2007	FLAAH	Hog Island	USA
5/30/2007	FLAKM	Hog Island	USA
5/30/2007	FLCEL	Hog Island	USA
5/30/2007	FLEAY	Hog Island	USA
5/30/2007	FLEHP	Hog Island	USA
5/30/2007	FLHT:G	Hog Island	USA
5/30/2007	FLJV1	Hog Island	USA
5/30/2007	FLKHU	Hog Island	USA
5/30/2007	FLKVC	Hog Island	USA
5/30/2007	FLMJP	Hog Island	USA
5/30/2007	FLMML	Hog Island	USA
5/30/2007	FLNCK	Hog Island	USA
5/30/2007	FLNHN	Hog Island	USA
5/30/2007	FLPEC	Hog Island	USA
5/30/2007	FLPTK	Hog Island	USA
5/30/2007	FLTC:O	Hog Island	USA
5/30/2007	FLTTA	Hog Island	USA
5/30/2007	FLTVE	Hog Island	USA
5/30/2007	FLTX:G	Hog Island	USA
5/30/2007	FLTXX	Hog Island	USA
5/30/2007	FLVYC	Hog Island	USA
5/30/2007	FLXXY	Hog Island	USA
5/30/2007	FLYHT	Hog Island	USA
5/30/2007	FLYY0	Hog Island	USA
5/30/2007	FOAB	Hog Island	Argentina
5/30/2007	FOCAH	Hog Island	Argentina
5/30/2007	FOCAJ	Hog Island	Argentina
5/30/2007	FOCLN	Hog Island	Argentina
5/30/2007	FOCLT	Hog Island	Argentina
5/30/2007	FOCSN	Hog Island	Argentina
5/30/2007	FOECL	Hog Island	Argentina

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/30/2007	FOEJN	Hog Island	Argentina
5/30/2007	FOHO	Hog Island	Argentina
5/30/2007	FOLJJ	Hog Island	Argentina
5/30/2007	FOLLC	Hog Island	Argentina
5/30/2007	FOLTC	Hog Island	Argentina
5/30/2007	FOLYP	Hog Island	Argentina
5/30/2007	FOMAY	Hog Island	Argentina
5/30/2007	FOT1	Hog Island	Argentina
5/30/2007	FOWX	Hog Island	Argentina
5/30/2007	FREU	Hog Island	Chile
5/30/2007	FRKI	Hog Island	Chile
5/30/2007	FROA	Hog Island	Chile
5/30/2007	FRWD	Hog Island	Chile
5/31/2007	FLMAY	Smith Island	USA
5/31/2007	FLTEN	Smith Island	USA
5/31/2007	FLXXN	Smith Island	USA
5/31/2007	FOLXA	Smith Island	Argentina
5/31/2007	FOUS	Myrtle Island	Argentina
5/31/2007	FROX	Smith Island	Chile
5/31/2007	FRUY	Smith Island	Chile
6/1/2007	FLCEE	Parramore Island	USA
6/1/2007	FLEA5	Parramore Island	USA
6/1/2007	FLJ9:O	Parramore Island	USA
6/1/2007	FLTPY	Parramore Island	USA
6/1/2007	FLTTE	Parramore Island	USA
6/1/2007	FLTVK	Parramore Island	USA
6/1/2007	FLXXT	Parramore Island	USA
6/1/2007	FOADI	Parramore Island	Argentina
6/1/2007	FOAZN	Parramore Island	Argentina
6/1/2007	FOB13	Parramore Island	Argentina
6/1/2007	FOCAE	Parramore Island	Argentina
6/1/2007	FOCEL	Parramore Island	Argentina
6/1/2007	FOCON	Parramore Island	Argentina
6/1/2007	FOEJP	Parramore Island	Argentina
6/1/2007	FOJJ	Parramore Island	Argentina
6/1/2007	FOLJU	Parramore Island	Argentina
6/1/2007	FOLPA	Parramore Island	Argentina
6/1/2007	FOLXX	Parramore Island	Argentina
6/1/2007	FOP3	Parramore Island	Argentina
6/1/2007	FRLX	Parramore Island	Chile
6/1/2007	FRSM	Parramore Island	Chile

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
6/2/2007	FLBE:G	Hog Island	USA
6/2/2007	FLHUT	Hog Island	USA
6/2/2007	FLLA5	Hog Island	USA
6/2/2007	FLLX0	Hog Island	USA
6/2/2007	FLLY0	Hog Island	USA
6/2/2007	FLMVA	Hog Island	USA
6/2/2007	FLPLL	Hog Island	USA
6/2/2007	FLTA5	Hog Island	USA
6/2/2007	FLTXJ	Hog Island	USA
6/2/2007	FLTXY	Hog Island	USA
6/2/2007	FLUP0	Hog Island	USA
6/2/2007	FLXCA	Hog Island	USA
6/2/2007	FLXY:G	Hog Island	USA
6/2/2007	FLYEL	Hog Island	USA
6/2/2007	FLYPT	Hog Island	USA
6/2/2007	FOA12	Hog Island	Argentina
6/2/2007	FOAJU	Hog Island	Argentina
6/2/2007	FOLC	Hog Island	Argentina
6/2/2007	FOMAN	Hog Island	Argentina
6/2/2007	FRWW	Hog Island	Chile
6/6/2007	FLVV7	Hog Island	USA
6/9/2007	FLTVA	Hog Island	USA
6/11/2007	FLNC5	Hog Island	USA
6/11/2007	FLYC5	Hog Island	USA
5/19/2008	FL0KX	Fisherman Island	USA
5/19/2008	FLLL0	Fisherman Island	USA
5/19/2008	FLLVY	Fisherman Island	USA
5/19/2008	FRAKV	Fisherman Island	Chile
5/21/2008	FOAGK	Fisherman Island	Argentina
5/21/2008	FOAMC	Fisherman Island	Argentina
5/21/2008	FOH9	Fisherman Island	Argentina
5/21/2008	FOKJ	Fisherman Island	Argentina
5/21/2008	FOPU	Fisherman Island	Argentina
5/21/2008	FOTX	Fisherman Island	Argentina
5/21/2008	FOZL	Fisherman Island	Argentina
5/29/2008	FLAM0	Fisherman Island	USA
5/29/2008	FOA6D	Fisherman Island	Argentina
5/29/2008	FOH4A	Fisherman Island	Argentina
5/29/2008	FOKO	Fisherman Island	Argentina
5/29/2008	FOKZ	Fisherman Island	Argentina
5/29/2008	FOLM	Fisherman Island	Argentina

Appendix 1 cont... The date, flag color and alpha-numeric combination, the location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/29/2008	FRAAH	Fisherman Island	Chile
5/29/2008	FRAS	Fisherman Island	Chile
5/29/2008	FROO	Fisherman Island	Chile
5/29/2008	FRSD	Fisherman Island	Chile
5/30/2008	FLMP2	Fisherman Island	USA
5/30/2008	FLTJ0	Fisherman Island	USA
5/30/2008	FLTTX	Fisherman Island	USA
5/30/2008	FLTV5	Fisherman Island	USA
5/30/2008	FOC3C	Fisherman Island	Argentina
5/30/2008	FOC7L	Fisherman Island	Argentina
5/30/2008	FOCHA	Fisherman Island	Argentina
5/30/2008	FOE3S	Fisherman Island	Argentina
5/30/2008	FOP4	Fisherman Island	Argentina
5/30/2008	FRACH	Fisherman Island	Chile
5/30/2008	FRACU	Fisherman Island	Chile
6/2/2008	FLAJ:O	Fisherman Island	USA
6/2/2008	FLJMJ	Fisherman Island	USA
6/2/2008	FLLY5	Fisherman Island	USA
6/2/2008	FLPY5	Fisherman Island	USA
6/2/2008	FLTJJ	Fisherman Island	USA
6/2/2008	FLTUK	Fisherman Island	USA
6/2/2008	FOCL7	Fisherman Island	Argentina
6/2/2008	FOCTN	Fisherman Island	Argentina
6/2/2008	FOE1	Fisherman Island	Argentina
6/2/2008	FOE38	Fisherman Island	Argentina
6/2/2008	FOEAT	Fisherman Island	Argentina
6/2/2008	FRACT	Fisherman Island	Chile
6/3/2008	FL43:O	Fisherman Island	USA
6/3/2008	FLT4J	Fisherman Island	USA
5/5/2009	FOH7T	Hog Island	Argentina
5/6/2009	FLOL:G	Metompkin Island	USA
5/6/2009	FOLAM	Metompkin Island	Argentina
5/9/2009	FOLXE	Metompkin Island	Argentina
5/11/2009	FLUJ1	Metompkin Island	USA
5/11/2009	FOCDM	Metompkin Island	Argentina
5/11/2009	FRHO	Metompkin Island	Chile
5/13/2009	FLHU1	Metompkin Island	USA
5/13/2009	FLHXM	Metompkin Island	USA
5/13/2009	FLKEV	Metompkin Island	USA
5/13/2009	FLKVV	Metompkin Island	USA
5/13/2009	FLLT8	Metompkin Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/13/2009	FLTH9	Metompkin Island	USA
5/13/2009	FOA6K	Metompkin Island	Argentina
5/13/2009	FOAUD	Metompkin Island	Argentina
5/14/2009	FL1KJ	Parramore Island	USA
5/14/2009	FL9I:G	Metompkin Island	USA
5/14/2009	FLC3T	Metompkin Island	USA
5/14/2009	FLJT2	Metompkin Island	USA
5/14/2009	FLKED	Parramore Island	USA
5/14/2009	FLTVT	Metompkin Island	USA
5/14/2009	FLYC2	Parramore Island	USA
5/14/2009	FOETV	Metompkin Island	Argentina
5/14/2009	FOLTT	Metompkin Island	Argentina
5/15/2009	FLC2C	Metompkin Island	USA
5/15/2009	FLJNL	Metompkin Island	USA
5/15/2009	FLL9K	Hog Island	USA
5/15/2009	FLPJJ	Metompkin Island	USA
5/15/2009	FLTXH	Metompkin Island	USA
5/15/2009	FO13	Wallops Island	Argentina
5/15/2009	FOCIK	Metompkin Island	Argentina
5/15/2009	FOE9V	Wallops Island	Argentina
5/15/2009	FOK9A	Wallops Island	Argentina
5/15/2009	FRANX	Wallops Island	Chile
5/15/2009	FRAPJ	Metompkin Island	Chile
5/16/2009	FLHAV	Metompkin Island	USA
5/16/2009	FLU4J	Metompkin Island	USA
5/19/2009	FLCH8	Parramore Island	USA
5/19/2009	FLHHH	Parramore Island	USA
5/19/2009	FLKM8	Parramore Island	USA
5/19/2009	FLL9C	Metompkin Island	USA
5/19/2009	FLLP1	Fisherman Island	USA
5/19/2009	FLNX5	Parramore Island	USA
5/19/2009	FOE7C	Metompkin Island	Argentina
5/19/2009	FOKA	Fisherman Island	Argentina
5/19/2009	FOLUL	Fisherman Island	Argentina
5/19/2009	FRMA	Metompkin Island	Chile
5/20/2009	FL0JV	Hog Island	USA
5/20/2009	FLHYY	Hog Island	USA
5/20/2009	FLJUJ	Metompkin Island	USA
5/20/2009	FLXV5	Hog Island	USA
5/20/2009	FLYAD	Hog Island	USA
5/20/2009	FLYZP	Hog Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/20/2009	FOE4S	Hog Island	Argentina
5/20/2009	FOE70	Hog Island	Argentina
5/20/2009	FOMLE	Hog Island	Argentina
5/20/2009	FRACV	Hog Island	Chile
5/21/2009	FL0KY	Hog Island	USA
5/21/2009	FL0XC	Hog Island	USA
5/21/2009	FL8A:O	Parramore Island	USA
5/21/2009	FLA4A	Hog Island	USA
5/21/2009	FLA4J	Hog Island	USA
5/21/2009	FLAAA	Hog Island	USA
5/21/2009	FLAU5	Hog Island	USA
5/21/2009	FLCCM	Hog Island	USA
5/21/2009	FLCN:O	Hog Island	USA
5/21/2009	FLDE:G	Parramore Island	USA
5/21/2009	FLEVM	Hog Island	USA
5/21/2009	FLEXP	Parramore Island	USA
5/21/2009	FLEY5	Hog Island	USA
5/21/2009	FLH5A	Parramore Island	USA
5/21/2009	FLHE0	Hog Island	USA
5/21/2009	FLHHE	Hog Island	USA
5/21/2009	FLHMT	Parramore Island	USA
5/21/2009	FLJCT	Hog Island	USA
5/21/2009	FLJHK	Metompkin Island	USA
5/21/2009	FLJKJ	Hog Island	USA
5/21/2009	FLJV5	Hog Island	USA
5/21/2009	FLKJ:G	Hog Island	USA
5/21/2009	FLLXP	Hog Island	USA
5/21/2009	FLM2N	Hog Island	USA
5/21/2009	FLN2N	Hog Island	USA
5/21/2009	FLNUU	Hog Island	USA
5/21/2009	FLTC0	Hog Island	USA
5/21/2009	FLTVM	Hog Island	USA
5/21/2009	FLUK5	Hog Island	USA
5/21/2009	FLUKJ	Hog Island	USA
5/21/2009	FLUTH	Parramore Island	USA
5/21/2009	FLUVU	Hog Island	USA
5/21/2009	FLVNT	Parramore Island	USA
5/21/2009	FLVV5	Metompkin Island	USA
5/21/2009	FLXH5	Hog Island	USA
5/21/2009	FLYJ8	Hog Island	USA
5/21/2009	FOAL	Parramore Island	Argentina

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/21/2009	FOANA	Metompkin Island	Argentina
5/21/2009	FOATM	Hog Island	Argentina
5/21/2009	FOB7	Fisherman Island	Argentina
5/21/2009	FOC3X	Hog Island	Argentina
5/21/2009	FOCHD	Parramore Island	Argentina
5/21/2009	FOCSP	Parramore Island	Argentina
5/21/2009	FOE7M	Hog Island	Argentina
5/21/2009	FOEJJ	Hog Island	Argentina
5/21/2009	FOEJY	Hog Island	Argentina
5/21/2009	FOELV	Hog Island	Argentina
5/21/2009	FOHY	Hog Island	Argentina
5/21/2009	FOK47	Hog Island	Argentina
5/21/2009	FRAAC	Fisherman Island	Chile
5/21/2009	FRAHK	Hog Island	Chile
5/21/2009	FRAMX	Hog Island	Chile
5/21/2009	FRCI	Hog Island	Chile
5/21/2009	FRCL	Hog Island	Chile
5/21/2009	FRECK	Hog Island	Chile
5/22/2009	FLAXD	Metompkin Island	USA
5/22/2009	FLKC0	Cedar Island	USA
5/22/2009	FLKLU	Cedar Island	USA
5/22/2009	FLL1M	Metompkin Island	USA
5/22/2009	FLM4H	Metompkin Island	USA
5/22/2009	FLV1H	Metompkin Island	USA
5/22/2009	FLXO:O	Metompkin Island	USA
5/22/2009	FLYCA	Parramore Island	USA
5/22/2009	FOAD	Cedar Island	Argentina
5/22/2009	FOC9J	Parramore Island	Argentina
5/22/2009	FODW	Cedar Island	Argentina
5/22/2009	FOE7O	Metompkin Island	Argentina
5/22/2009	FOT9	Cedar Island	Argentina
5/22/2009	FRECU	Cedar Island	Chile
5/22/2009	FRHNN	Parramore Island	Chile
5/22/2009	FRMZ	Parramore Island	Chile
5/22/2009	FRTL	Cedar Island	Chile
5/22/2009	FWAK	Parramore Island	Canada
5/23/2009	FLKY5	Smith Island	USA
5/23/2009	FLP6:O	Metompkin Island	USA
5/23/2009	FOMCI	Smith Island	Argentina
5/23/2009	FOPH	Metompkin Island	Argentina
5/24/2009	FL0DP	Hog Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/24/2009	FL1EN	Hog Island	USA
5/24/2009	FL1KK	Hog Island	USA
5/24/2009	FLBA:O	Metompkin Island	USA
5/24/2009	FLC5P	Hog Island	USA
5/24/2009	FLPNM	Hog Island	USA
5/24/2009	FLU0K	Hog Island	USA
5/24/2009	FLXD:O	Metompkin Island	USA
5/24/2009	FLY7P	Hog Island	USA
5/24/2009	FOCPD	Hog Island	Argentina
5/24/2009	FOD9	Metompkin Island	Argentina
5/24/2009	FOE7V	Metompkin Island	Argentina
5/24/2009	FOH7E	Metompkin Island	Argentina
5/24/2009	FOK7	Fisherman Island	Argentina
5/24/2009	FOK9E	Metompkin Island	Argentina
5/24/2009	FOML	Hog Island	Argentina
5/24/2009	FRAVA	Metompkin Island	Chile
5/24/2009	FRAXX	Metompkin Island	Chile
5/25/2009	FLC5H	Metompkin Island	USA
5/25/2009	FLC5K	Metompkin Island	USA
5/25/2009	FLL7F	Fisherman Island	USA
5/25/2009	FLPL9	Parramore Island	USA
5/25/2009	FLPU:O	Metompkin Island	USA
5/25/2009	FLYYD	Parramore Island	USA
5/25/2009	FOAS	Parramore Island	Argentina
5/25/2009	FOE3V	Parramore Island	Argentina
5/25/2009	FOEPX	Parramore Island	Argentina
5/25/2009	FOJ4M	Metompkin Island	Argentina
5/25/2009	FOJ7A	Fisherman Island	Argentina
5/25/2009	FOLVH	Parramore Island	Argentina
5/25/2009	FOMET	Wallops Island	Argentina
5/25/2009	FOTZ	Metompkin Island	Argentina
5/25/2009	FRNM	Parramore Island	Chile
5/25/2009	FWPP	Parramore Island	Canada
5/26/2009	FOAHE	Metompkin Island	Argentina
5/26/2009	FOCXU	Metompkin Island	Argentina
5/26/2009	FOCZI	Metompkin Island	Argentina
5/26/2009	FOE3N	Metompkin Island	Argentina
5/26/2009	FOK7E	Metompkin Island	Argentina
5/26/2009	FOK7L	Metompkin Island	Argentina
5/26/2009	FOLKH	Metompkin Island	Argentina
5/27/2009	FL0PY	Metompkin Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/27/2009	FL1HC	Hog Island	USA
5/27/2009	FLA0T	Metompkin Island	USA
5/27/2009	FLCC9	Metompkin Island	USA
5/27/2009	FLCCH	Hog Island	USA
5/27/2009	FLL2M	Hog Island	USA
5/27/2009	FLL9L	Hog Island	USA
5/27/2009	FLMAH	Metompkin Island	USA
5/27/2009	FLTL4	Hog Island	USA
5/27/2009	FLXUP	Hog Island	USA
5/27/2009	FOA6M	Metompkin Island	Argentina
5/27/2009	FRALT	Metompkin Island	Chile
5/27/2009	FRANA	Metompkin Island	Chile
5/27/2009	FRIH	Hog Island	Chile
5/28/2009	FL0YP	Fisherman Island	USA
5/28/2009	FLA7N	Fisherman Island	USA
5/28/2009	FLJVT	Fisherman Island	USA
5/28/2009	FLK8X	Fisherman Island	USA
5/28/2009	FLKXH	Fisherman Island	USA
5/28/2009	FLL7E	Fisherman Island	USA
5/28/2009	FLTXK	Fisherman Island	USA
5/28/2009	FLU0L	Fisherman Island	USA
5/28/2009	FLUT0	Parramore Island	USA
5/28/2009	FLXK0	Fisherman Island	USA
5/28/2009	FOAAJ	Cedar Island	Argentina
5/28/2009	FOATP	Fisherman Island	Argentina
5/28/2009	FOCCE	Fisherman Island	Argentina
5/28/2009	FOCHM	Cedar Island	Argentina
5/28/2009	FOCOM	Fisherman Island	Argentina
5/28/2009	FOCXT	Fisherman Island	Argentina
5/28/2009	FOETD	Cedar Island	Argentina
5/28/2009	FOK7J	Cedar Island	Argentina
5/28/2009	FOK9C	Wallops Island	Argentina
5/28/2009	FOL9	Fisherman Island	Argentina
5/28/2009	FOMJE	Parramore Island	Argentina
5/28/2009	FOMKX	Fisherman Island	Argentina
5/28/2009	FOOX	Fisherman Island	Argentina
5/28/2009	FRAEM	Fisherman Island	Chile
5/28/2009	FRAEW	Fisherman Island	Chile
5/28/2009	FRAXT	Fisherman Island	Chile
5/28/2009	FRIK	Fisherman Island	Chile
5/29/2009	FL0CK	Hog Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/29/2009	FL0MN	Fisherman Island	USA
5/29/2009	FL0PM	Hog Island	USA
5/29/2009	FL0YN	Hog Island	USA
5/29/2009	FL1CT	Hog Island	USA
5/29/2009	FL1HV	Hog Island	USA
5/29/2009	FL1JU	Fisherman Island	USA
5/29/2009	FLEND	Hog Island	USA
5/29/2009	FLHC3	Hog Island	USA
5/29/2009	FLHYN	Hog Island	USA
5/29/2009	FLTLE	Hog Island	USA
5/29/2009	FLTNP	Hog Island	USA
5/29/2009	FLVX5	Hog Island	USA
5/29/2009	FLXPY	Hog Island	USA
5/29/2009	FOAKL	Hog Island	Argentina
5/29/2009	FOCIJ	Hog Island	Argentina
5/29/2009	FOCJJ	Hog Island	Argentina
5/29/2009	FOZ7	Fisherman Island	Argentina
5/29/2009	FRA7I	Hog Island	Chile
5/29/2009	FRATX	Hog Island	Chile
5/29/2009	FRHTC	Fisherman Island	Chile
5/29/2009	FRTE	Fisherman Island	Chile
5/29/2009	FRZH	Hog Island	Chile
5/29/2009	FWVP	Hog Island	Canada
5/30/2009	FLCE9	Fisherman Island	USA
5/30/2009	FRBN	Fisherman Island	Chile
5/31/2009	FL1CM	Hog Island	USA
5/31/2009	FLCH3	Hog Island	USA
5/31/2009	FLCV8	Hog Island	USA
5/31/2009	FLEC5	Hog Island	USA
5/31/2009	FLHUN	Hog Island	USA
5/31/2009	FLK8M	Hog Island	USA
5/31/2009	FLKX0	Hog Island	USA
5/31/2009	FLKXG	Hog Island	USA
5/31/2009	FLKYM	Hog Island	USA
5/31/2009	FLLCM	Hog Island	USA
5/31/2009	FLLEF	Hog Island	USA
5/31/2009	FLUPB	Hog Island	USA
5/31/2009	FLXXJ	Hog Island	USA
5/31/2009	FOCTL	Hog Island	Argentina
5/31/2009	FOEAH	Hog Island	Argentina
5/31/2009	FOJZA	Hog Island	Argentina

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/31/2009	FOK3T	Hog Island	Argentina
5/31/2009	FRLK	Hog Island	Chile
6/1/2009	FL0YH	Parramore Island	USA
6/1/2009	FLAK:G	Parramore Island	USA
6/1/2009	FLJN9	Parramore Island	USA
6/1/2009	FOE3Y	Parramore Island	Argentina
6/1/2009	FOE7	Parramore Island	Argentina
6/1/2009	FOLYH	Parramore Island	Argentina
6/2/2009	FL0UY	Hog Island	USA
6/2/2009	FOAIK	Hog Island	Argentina
6/2/2009	FOCTX	Wallops Island	Argentina
6/2/2009	FOOA	Wallops Island	Argentina
6/5/2009	FLH0E	Hog Island	USA
6/5/2009	FLL9H	Hog Island	USA
6/5/2009	FLTUH	Hog Island	USA
6/5/2009	FOHG	Hog Island	Argentina
6/5/2009	FOKGN	Hog Island	Argentina
6/9/2009	FOATE	Wallops Island	Argentina
6/9/2009	FOE4V	Wallops Island	Argentina
8/22/2009	FLH1C	Assateague Island	USA
5/13/2010	FL1UU	Hog Island	USA
5/13/2010	FL2NX	Hog Island	USA
5/13/2010	FL74	Hog Island	USA
5/13/2010	FL7EE	Hog Island	USA
5/13/2010	FLA1M	Hog Island	USA
5/13/2010	FLKMV	Smith Island	USA
5/13/2010	FLL8M	Hog Island	USA
5/13/2010	FLLKN	Hog Island	USA
5/13/2010	FLMVX	Hog Island	USA
5/13/2010	FLNU1	Hog Island	USA
5/13/2010	FLPK1	Hog Island	USA
5/13/2010	FLT4:G	Hog Island	USA
5/13/2010	FLTHV	Hog Island	USA
5/13/2010	FLU3N	Hog Island	USA
5/13/2010	FLXJT	Hog Island	USA
5/13/2010	FOEAL	Hog Island	Argentina
5/13/2010	FOEPE	Smith Island	Argentina
5/13/2010	FOMCX	Hog Island	Argentina
5/13/2010	FWJU	Hog Island	Canada
5/14/2010	FL0TN	Hog Island	USA
5/14/2010	FL2PA	Hog Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/14/2010	FLEAP	Hog Island	USA
5/14/2010	FLEHT	Hog Island	USA
5/14/2010	FLHAE	Hog Island	USA
5/14/2010	FLHY7	Hog Island	USA
5/14/2010	FLJEE	Hog Island	USA
5/14/2010	FLKLJ	Hog Island	USA
5/14/2010	FLXAK	Hog Island	USA
5/14/2010	FOAX	Hog Island	Argentina
5/14/2010	FOMLN	Hog Island	Argentina
5/14/2010	FRAVJ	Cedar Island	Chile
5/15/2010	FLAJ:G	Parramore Island	USA
5/15/2010	FLNN6	Parramore Island	USA
5/15/2010	FLT4:O	Parramore Island	USA
5/15/2010	FLTCC	Parramore Island	USA
5/18/2010	FLJM9	Myrtle Island	USA
5/18/2010	FLU5E	Cedar Island	USA
5/18/2010	FOEXY	Cedar Island	Argentina
5/18/2010	FOL3S	Cedar Island	Argentina
5/18/2010	FWTC	Cedar Island	Canada
5/19/2010	FL1TM	Hog Island	USA
5/19/2010	FL2JC	Hog Island	USA
5/19/2010	FL3HJ	Hog Island	USA
5/19/2010	FL50E	Hog Island	USA
5/19/2010	FL74E	Hog Island	USA
5/19/2010	FL7JA	Hog Island	USA
5/19/2010	FL95H	Hog Island	USA
5/19/2010	FL9TH	Hog Island	USA
5/19/2010	FLA4H	Hog Island	USA
5/19/2010	FLA4X	Hog Island	USA
5/19/2010	FLA7Y	Hog Island	USA
5/19/2010	FLAM9	Hog Island	USA
5/19/2010	FLEXX	Hog Island	USA
5/19/2010	FLJ3N	Hog Island	USA
5/19/2010	FLJ4E	Hog Island	USA
5/19/2010	FLJ9K	Hog Island	USA
5/19/2010	FLKH5	Hog Island	USA
5/19/2010	FLKL9	Hog Island	USA
5/19/2010	FLL2A	Hog Island	USA
5/19/2010	FLL8V	Hog Island	USA
5/19/2010	FLL9A	Hog Island	USA
5/19/2010	FLL9M	Hog Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/19/2010	FLLBV	Hog Island	USA
5/19/2010	FLLH5	Hog Island	USA
5/19/2010	FLLM9	Hog Island	USA
5/19/2010	FLLYK	Hog Island	USA
5/19/2010	FLML9	Hog Island	USA
5/19/2010	FLMU6	Hog Island	USA
5/19/2010	FLOX:G	Hog Island	USA
5/19/2010	FLP6U	Hog Island	USA
5/19/2010	FLP7X	Hog Island	USA
5/19/2010	FLPAM	Hog Island	USA
5/19/2010	FLT2X	Hog Island	USA
5/19/2010	FLTCM	Hog Island	USA
5/19/2010	FLTHY	Hog Island	USA
5/19/2010	FLTPJ	Hog Island	USA
5/19/2010	FLTTU	Hog Island	USA
5/19/2010	FLTXC	Hog Island	USA
5/19/2010	FLV4V	Hog Island	USA
5/19/2010	FLVC1	Hog Island	USA
5/19/2010	FLXLT	Hog Island	USA
5/19/2010	FLXN:Q	Hog Island	USA
5/19/2010	FLXP1	Hog Island	USA
5/19/2010	FLXPN	Hog Island	USA
5/19/2010	FLY0T	Hog Island	USA
5/19/2010	FLY2U	Hog Island	USA
5/19/2010	FLY6U	Hog Island	USA
5/19/2010	FLYAX	Hog Island	USA
5/19/2010	FLYNX	Hog Island	USA
5/19/2010	FOA9E	Hog Island	Argentina
5/19/2010	FOAZK	Hog Island	Argentina
5/19/2010	FOCJK	Hog Island	Argentina
5/19/2010	FOCPO	Hog Island	Argentina
5/19/2010	FOE7U	Hog Island	Argentina
5/19/2010	FOELY	Hog Island	Argentina
5/19/2010	FOJ9T	Hog Island	Argentina
5/19/2010	FOK4	Hog Island	Argentina
5/19/2010	FOL6U	Hog Island	Argentina
5/19/2010	FOL9A	Hog Island	Argentina
5/19/2010	FOLYT	Hog Island	Argentina
5/19/2010	FOP3T	Hog Island	Argentina
5/19/2010	FRAI	Hog Island	Chile
5/19/2010	FRJUT	Hog Island	Chile

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/19/2010	FRMT	Hog Island	Chile
5/19/2010	FRTM	Hog Island	Chile
5/19/2010	FWEN	Hog Island	Canada
5/19/2010	FWKX	Hog Island	Canada
5/20/2010	FBAT	Hog Island	Brazil
5/20/2010	FL05H	Hog Island	USA
5/20/2010	FL1TH	Hog Island	USA
5/20/2010	FL1TU	Hog Island	USA
5/20/2010	FL2CA	Hog Island	USA
5/20/2010	FL2TT	Hog Island	USA
5/20/2010	FL90E	Hog Island	USA
5/20/2010	FL93H	Hog Island	USA
5/20/2010	FLEUV	Hog Island	USA
5/20/2010	FLJ9P	Hog Island	USA
5/20/2010	FLJPE	Hog Island	USA
5/20/2010	FLKMY	Hog Island	USA
5/20/2010	FLN7K	Hog Island	USA
5/20/2010	FLPJ9	Hog Island	USA
5/20/2010	FLTHC	Hog Island	USA
5/20/2010	FLY3X	Hog Island	USA
5/20/2010	FOA3D	Hog Island	Argentina
5/20/2010	FOA3O	Hog Island	Argentina
5/20/2010	FOAT	Hog Island	Argentina
5/20/2010	FOC7K	Hog Island	Argentina
5/20/2010	FOEKY	Hog Island	Argentina
5/20/2010	FOELC	Hog Island	Argentina
5/20/2010	FOH7M	Hog Island	Argentina
5/20/2010	FOMCC	Hog Island	Argentina
5/20/2010	FOMKM	Hog Island	Argentina
5/20/2010	FOT6	Hog Island	Argentina
5/20/2010	FRPM	Hog Island	Chile
5/20/2010	FWMV	Hog Island	Canada
5/21/2010	FBAU	Hog Island	Brazil
5/21/2010	FL0TM	Hog Island	USA
5/21/2010	FL0VH	Hog Island	USA
5/21/2010	FL0YT	Hog Island	USA
5/21/2010	FL16H	Hog Island	USA
5/21/2010	FL1AX	Hog Island	USA
5/21/2010	FL1EA	Hog Island	USA
5/21/2010	FL1LP	Hog Island	USA
5/21/2010	FL1NE	Hog Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/21/2010	FL1UH	Hog Island	USA
5/21/2010	FL2KT	Hog Island	USA
5/21/2010	FL2LA	Hog Island	USA
5/21/2010	FL2LU	Hog Island	USA
5/21/2010	FL5U:G	Hog Island	USA
5/21/2010	FL61E	Hog Island	USA
5/21/2010	FL91H	Hog Island	USA
5/21/2010	FLA0M	Hog Island	USA
5/21/2010	FLCP0	Hog Island	USA
5/21/2010	FLE6:O	Hog Island	USA
5/21/2010	FLEC:O	Hog Island	USA
5/21/2010	FLIM:G	Hog Island	USA
5/21/2010	FLJAP	Hog Island	USA
5/21/2010	FLJTE	Hog Island	USA
5/21/2010	FLJTT	Hog Island	USA
5/21/2010	FLJV7	Hog Island	USA
5/21/2010	FLM3H	Hog Island	USA
5/21/2010	FLMUA	Hog Island	USA
5/21/2010	FLTTH	Hog Island	USA
5/21/2010	FLUE:O	Hog Island	USA
5/21/2010	FLXH0	Hog Island	USA
5/21/2010	FLXHE	Hog Island	USA
5/21/2010	FLY0J	Hog Island	USA
5/21/2010	FLY2H	Hog Island	USA
5/21/2010	FLYY9	Hog Island	USA
5/21/2010	FOA6L	Hog Island	Argentina
5/21/2010	FOA6U	Hog Island	Argentina
5/21/2010	FOA8U	Hog Island	Argentina
5/21/2010	FOC9K	Hog Island	Argentina
5/21/2010	FOJP	Hog Island	Argentina
5/21/2010	FOK6H	Hog Island	Argentina
5/21/2010	FOMCK	Hog Island	Argentina
5/21/2010	FOMKN	Hog Island	Argentina
5/21/2010	FOP3P	Hog Island	Argentina
5/21/2010	FOPCP	Hog Island	Argentina
5/21/2010	FOPO	Hog Island	Argentina
5/21/2010	FREAX	Hog Island	Chile
5/21/2010	FRYE	Hog Island	Chile
5/21/2010	FRYN	Hog Island	Chile
5/21/2010	FWKH	Hog Island	Canada
5/21/2010	FWPJ	Hog Island	Canada

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/22/2010	FL00H	Wreck Island	USA
5/22/2010	FL06H	Wreck Island	USA
5/22/2010	FL0EP	Wreck Island	USA
5/22/2010	FL0HK	Wreck Island	USA
5/22/2010	FL0PK	Wreck Island	USA
5/22/2010	FL0XA	Wreck Island	USA
5/22/2010	FL12H	Wreck Island	USA
5/22/2010	FL13H	Wreck Island	USA
5/22/2010	FL17	Wreck Island	USA
5/22/2010	FL2MC	Wreck Island	USA
5/22/2010	FL3NY	Wreck Island	USA
5/22/2010	FLAH1	Wreck Island	USA
5/22/2010	FLAY5	Wreck Island	USA
5/22/2010	FLC5X	Wreck Island	USA
5/22/2010	FLKU7	Wreck Island	USA
5/22/2010	FLM0A	Wreck Island	USA
5/22/2010	FLM1L	Wreck Island	USA
5/22/2010	FLTYK	Wreck Island	USA
5/22/2010	FLVP3	Wreck Island	USA
5/22/2010	FLXPU	Wreck Island	USA
5/22/2010	FLXVE	Wreck Island	USA
5/22/2010	FLY6A	Wreck Island	USA
5/22/2010	FLY6P	Wreck Island	USA
5/22/2010	FOH7P	Wreck Island	Argentina
5/22/2010	FOL3E	Wreck Island	Argentina
5/22/2010	FON6Y	Wreck Island	Argentina
5/22/2010	FON9P	Wreck Island	Argentina
5/22/2010	FONP5	Wreck Island	Argentina
5/22/2010	FONPL	Wreck Island	Argentina
5/22/2010	FOP1	Wreck Island	Argentina
5/22/2010	FRAT	Wreck Island	Chile
5/22/2010	FRAVU	Wreck Island	Chile
5/23/2010	FO98	Cedar Island	Argentina
5/23/2010	FOAOH	Cedar Island	Argentina
5/23/2010	FOF4O	Cedar Island	Argentina
5/24/2010	FL0JK	Wreck Island	USA
5/24/2010	FL0XL	Wreck Island	USA
5/24/2010	FL0YV	Wreck Island	USA
5/24/2010	FL1LE	Wreck Island	USA
5/24/2010	FL2NY	Wreck Island	USA
5/24/2010	FLJHX	Fisherman Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/24/2010	FLKPA	Fisherman Island	USA
5/24/2010	FLL3H	Wreck Island	USA
5/24/2010	FLP8A	Wreck Island	USA
5/24/2010	FLTYH	Wreck Island	USA
5/24/2010	FLYEM	Wreck Island	USA
5/24/2010	FOH3L	Wreck Island	Argentina
5/24/2010	FOK9M	Wreck Island	Argentina
5/24/2010	FOL3J	Wreck Island	Argentina
5/24/2010	FOL4S	Wreck Island	Argentina
5/24/2010	FOL7E	Wreck Island	Argentina
5/24/2010	FON7L	Fisherman Island	Argentina
5/24/2010	FOP4K	Fisherman Island	Argentina
5/24/2010	FOS3J	Wreck Island	Argentina
5/24/2010	FOS4V	Wreck Island	Argentina
5/24/2010	FOS6Y	Wreck Island	Argentina
5/24/2010	FOXP1	Wreck Island	Argentina
5/24/2010	FRXT	Wreck Island	Chile
5/25/2010	FL03H	Hog Island	USA
5/25/2010	FL4J:O	Hog Island	USA
5/25/2010	FLA3M	Hog Island	USA
5/25/2010	FLAXL	Hog Island	USA
5/25/2010	FLC6E	Hog Island	USA
5/25/2010	FLKCC	Hog Island	USA
5/25/2010	FLKLL	Hog Island	USA
5/25/2010	FLMLV	Fisherman Island	USA
5/25/2010	FLTCP	Hog Island	USA
5/25/2010	FLU2V	Fisherman Island	USA
5/25/2010	FOCJC	Hog Island	Argentina
5/25/2010	FOJ3	Hog Island	Argentina
5/25/2010	FOMOM	Fisherman Island	Argentina
5/25/2010	FOMPN	Fisherman Island	Argentina
5/25/2010	FWAH	Hog Island	Canada
5/25/2010	FWHM	Hog Island	Canada
5/25/2010	FWTA	Hog Island	Canada
5/25/2010	FWYL	Hog Island	Canada
5/26/2010	FL1JC	Parramore Island	USA
5/26/2010	FLJ4Y	Parramore Island	USA
5/26/2010	FLML5	Metompkin Island	USA
5/26/2010	FOE9M	Metompkin Island	Argentina
5/27/2010	FB1B7	Smith Island	Brazil
5/27/2010	FL14H	Smith Island	USA

Date	Flag Color and Alpha-numeric Combo	Location of Resight	Band Origin
5/27/2010	FL1LH	Smith Island	USA
5/27/2010	FLHM6	Smith Island	USA
5/27/2010	FLM8N	Smith Island	USA
5/27/2010	FLTL3	Smith Island	USA
5/27/2010	FLU2X	Smith Island	USA
5/27/2010	FLV3K	Smith Island	USA
5/27/2010	FLVJ9	Smith Island	USA
5/27/2010	FLXPA	Smith Island	USA
5/27/2010	FLYCU	Smith Island	USA
5/27/2010	FLYGU	Smith Island	USA
5/27/2010	FLYNC	Smith Island	USA
5/27/2010	FOA3S	Smith Island	Argentina
5/27/2010	FOAOM	Smith Island	Argentina
5/27/2010	FOATA	Smith Island	Argentina
5/27/2010	FOCTC	Smith Island	Argentina
5/27/2010	FOECT	Smith Island	Argentina
5/27/2010	FOETC	Smith Island	Argentina
5/27/2010	FOH7L	Smith Island	Argentina
5/27/2010	FOP4P	Smith Island	Argentina
5/27/2010	FOP6T	Smith Island	Argentina
5/27/2010	FOPAP	Smith Island	Argentina
5/27/2010	FOS3T	Smith Island	Argentina
5/27/2010	FRPZ	Smith Island	Chile
5/29/2010	FLA3:G	Hog Island	USA
5/29/2010	FOAPN	Hog Island	Argentina
5/29/2010	FOASJ	Hog Island	Argentina
5/29/2010	FOC3Y	Hog Island	Argentina
5/29/2010	FOE69	Hog Island	Argentina
5/29/2010	FOJ3J	Hog Island	Argentina
5/29/2010	FOJ4K	Hog Island	Argentina
5/29/2010	FOK3A	Wreck Island	Argentina
5/29/2010	FONAH	Hog Island	Argentina
5/29/2010	FRHEE	Hog Island	Chile
5/30/2010	FL2LP	Cedar Island	USA
5/30/2010	FL2ML	Cedar Island	USA
5/30/2010	FL2XT	Cedar Island	USA
5/30/2010	FL89H	Cedar Island	USA
5/30/2010	FLJ5K	Cedar Island	USA
5/30/2010	FLJ6J	Cedar Island	USA

5/30/2010	FLK0X	Cedar Island	USA
5/30/2010	FLKUX	Cedar Island	USA

Appendix 1 cont... The date, flag color and alpha-numeric combination, location of resight, and country of band origin for all individually tagged Red Knots resighted in Virginia between 2006-2010.