The Uncertain Future of Shorebirds on the Delaware Bay

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This presentation will cover the results of four investigations authored by prominent shorebird scientists from around the world

Trends in Mass Gain and Numbers of Red Knots *Calidris canutus rufa*, Ruddy Turnstones *Arenaria Interpresand* Sanderlings *Calidris Alba* in Delaware Bay

Lawrence J Niles[1], Katheleen Clark[1], Humphrey Sitters[2] Clive Minton[3], Allan Baker[4] Amanda Dey[1] Dick Vetch[6] Joanna Burger[7]

Rapid population decline in red knots *Calidris canutus rufa* since 2000: fitness consequences of late arrival and decreased refueling rates in Delaware Bay

Allan J. Baker [1,2] , Patricia M. González [3] , Lawrence J. Niles [4] , Theunis Piersma [5,6] , Inês de Lima Serrano do Nascimento [7] , Phil W. Atkinson [8] , Nigel A. Clark [8] , Clive D.T. Minton [9] , Mark Peck

Declines in wintering populations of Red Knots *Calidris canutus rufa*
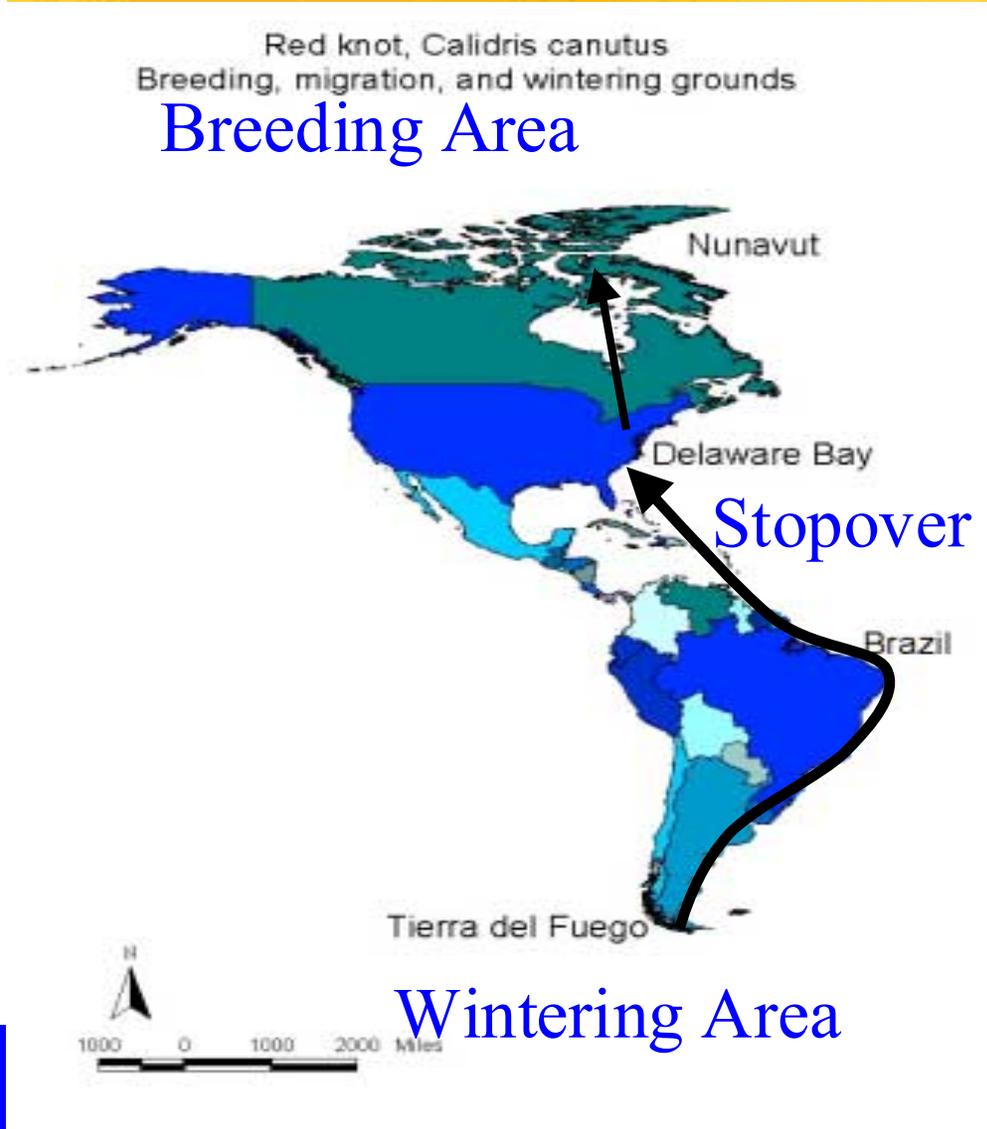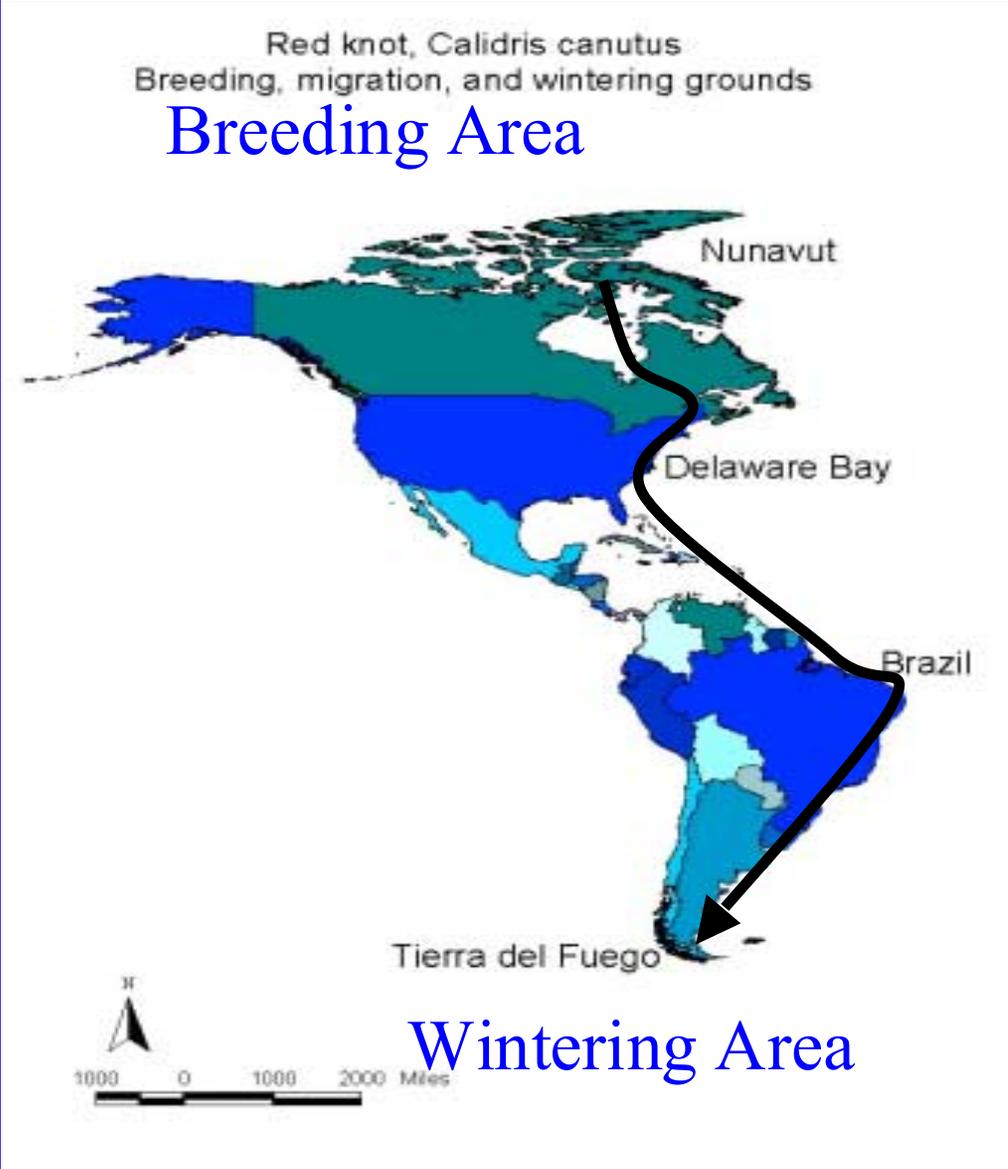
R.I.G. Morrison[1], R.K. Ross[2] and L.J. Niles[3]

Mass Gain and Residence Time in Sandpipers During Spring Migration Stopovers on the Delaware Bay, NJ

David S. Mizrahi

These studies cover 5 different species that migrate from Arctic breeding areas to South American wintering areas. On their northbound return the birds stopover on the Delaware Bay.

Red knot, Calidris canutus
Breeding, migration, and wintering grounds

Breeding Area

Nunavut

Delaware Bay

Brazil

Tierra del Fuego

Wintering Area

1000   0   1000   2000 Miles

South Bound Flight

Northbound Flight

Red knot, Calidris canutus
Breeding, migration, and wintering grounds

Breeding Area

Nunavut

Delaware Bay

Stopover

Brazil

Tierra del Fuego

Wintering Area

1000   0   1000   2000 Miles

This presentation will concentrate on the red knot, as it is the most dependent on the Delaware Bay

The Red Knot comes to the Delaware Bay each spring to doubles it body weight to enable a final flight to Arctic breeding grounds

Arrival

Departure

Shorebirds come to the Delaware Bay to feed on the eggs of the horseshoe crab

the horseshoe crab eggs on the shores of the Delaware Bay several teams of scientist began one of the most comprehensive studies of shorebirds in the World.

- 17 years of baywide counts

- 30,000 captures of six species to measure mass (weight), body condition and color band

- independent studies of food intake, metabolism, competition, baywide movement

- Hemisphere-wide focus

This presentation will use results of the four studies to show the following changes in the red knot population

- Significant decline in the ability of shorebirds to gain weight
- Decline in survival rates
- Drastic decline in wintering population

The first study was based on two baywide field projects

Cannon netting during the same period 1997-2002

Aerial survey done for six weeks starting in first week of May 1986 to 2002

# Red Knots arrive on the Delaware Bay in poorer condition than on any other stopover in the World......

	arrival weights of red knot	ruddy turnstone	sanderling
Delaware Bay	114 g	96.6 g	54 g
Iceland	165 g	120 g	62 g

Because they make a direct flight from northern South America to the Delaware Bay

Nonstop
4500 mi.

In 1997 Red Knots gained 8 grams/day, enough to double their body weight in 12 days. By 2002 they gained only 2 grams/day not enough to make the weight they need to fly on to the Arctic
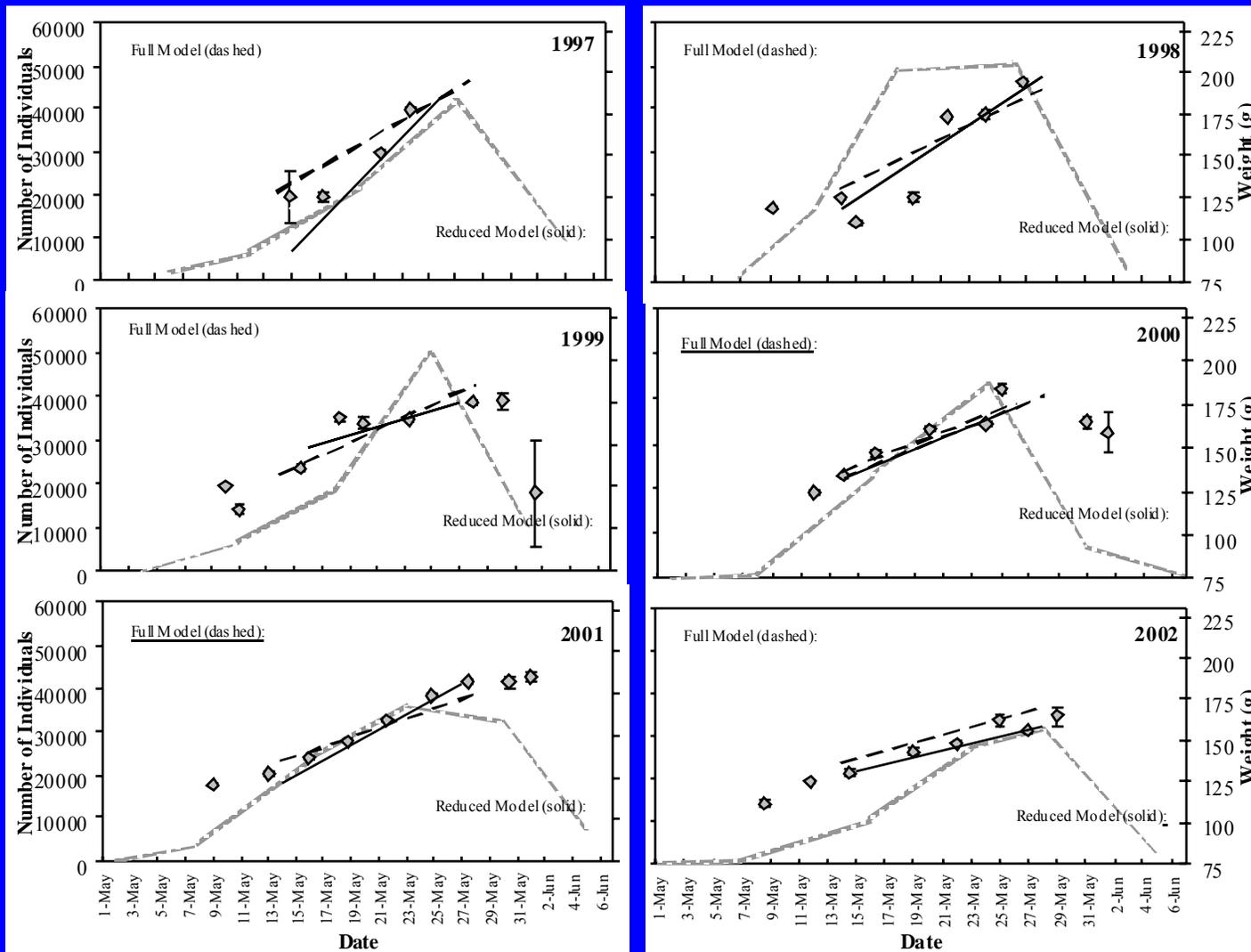
Each year the projected rate of gain has declined leaving many birds without the weight to fly the 2000 miles to their Arctic breeding ground.

Red Knot Rate of Gain
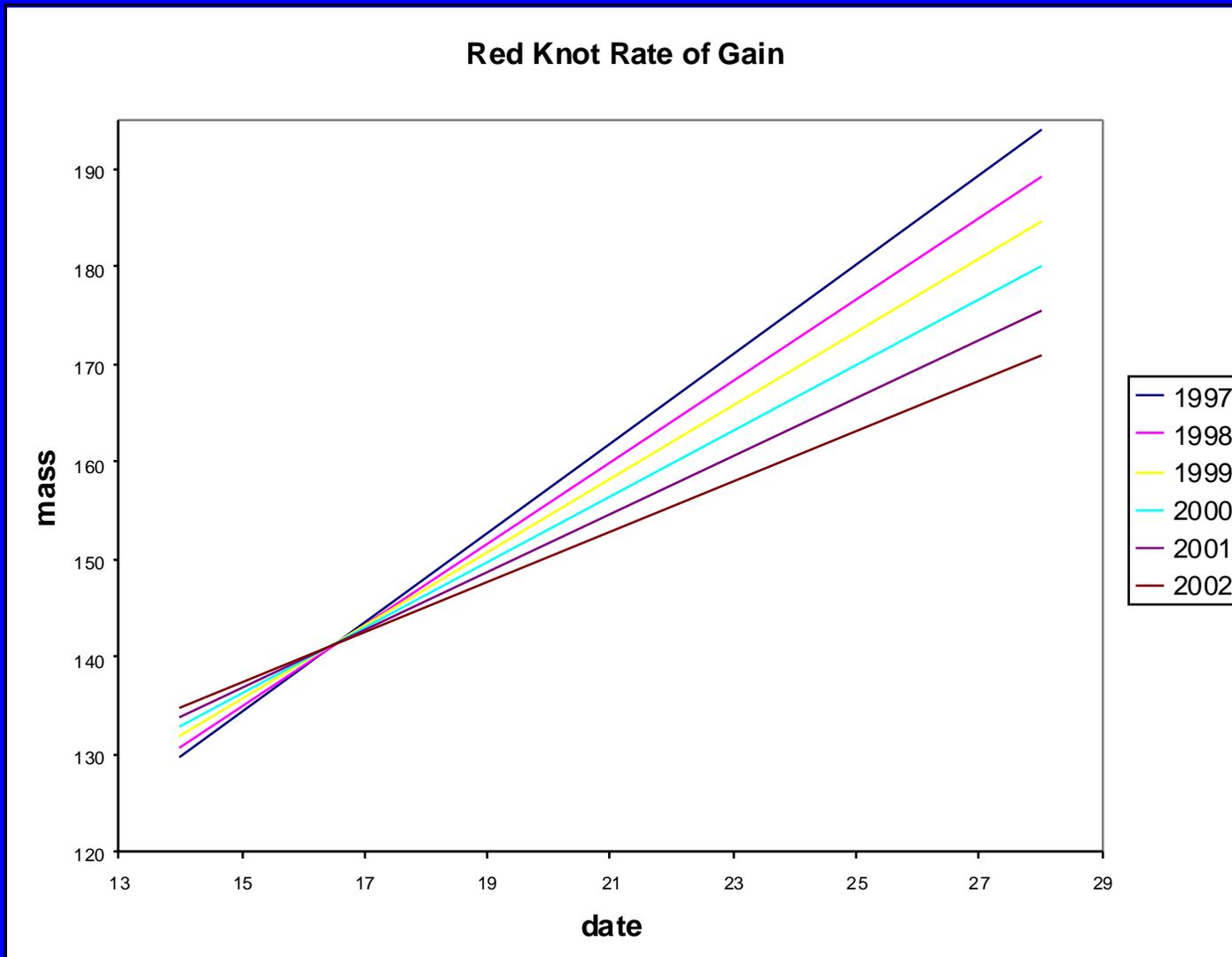
The same decline in weight gain has happened to semi-palmated sandpipers, the most numerous shorebird on the Delaware Bay.
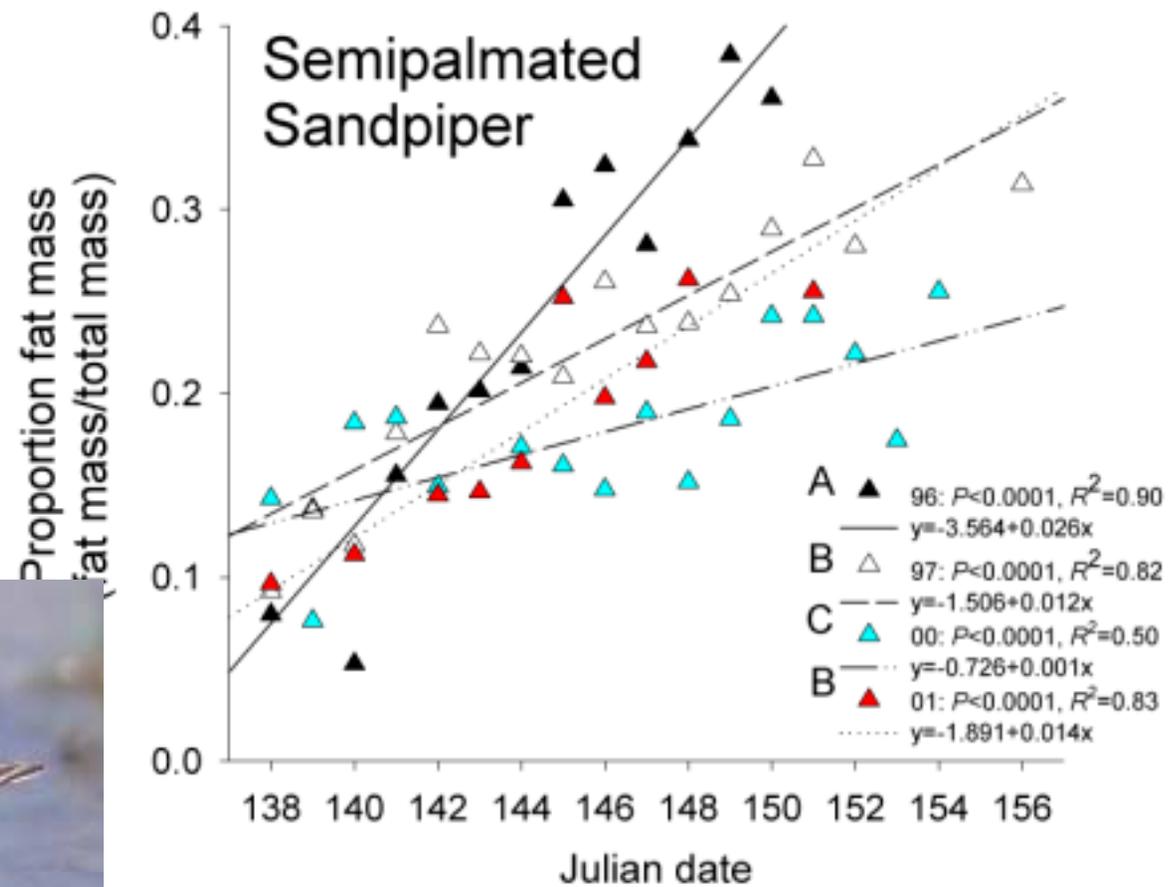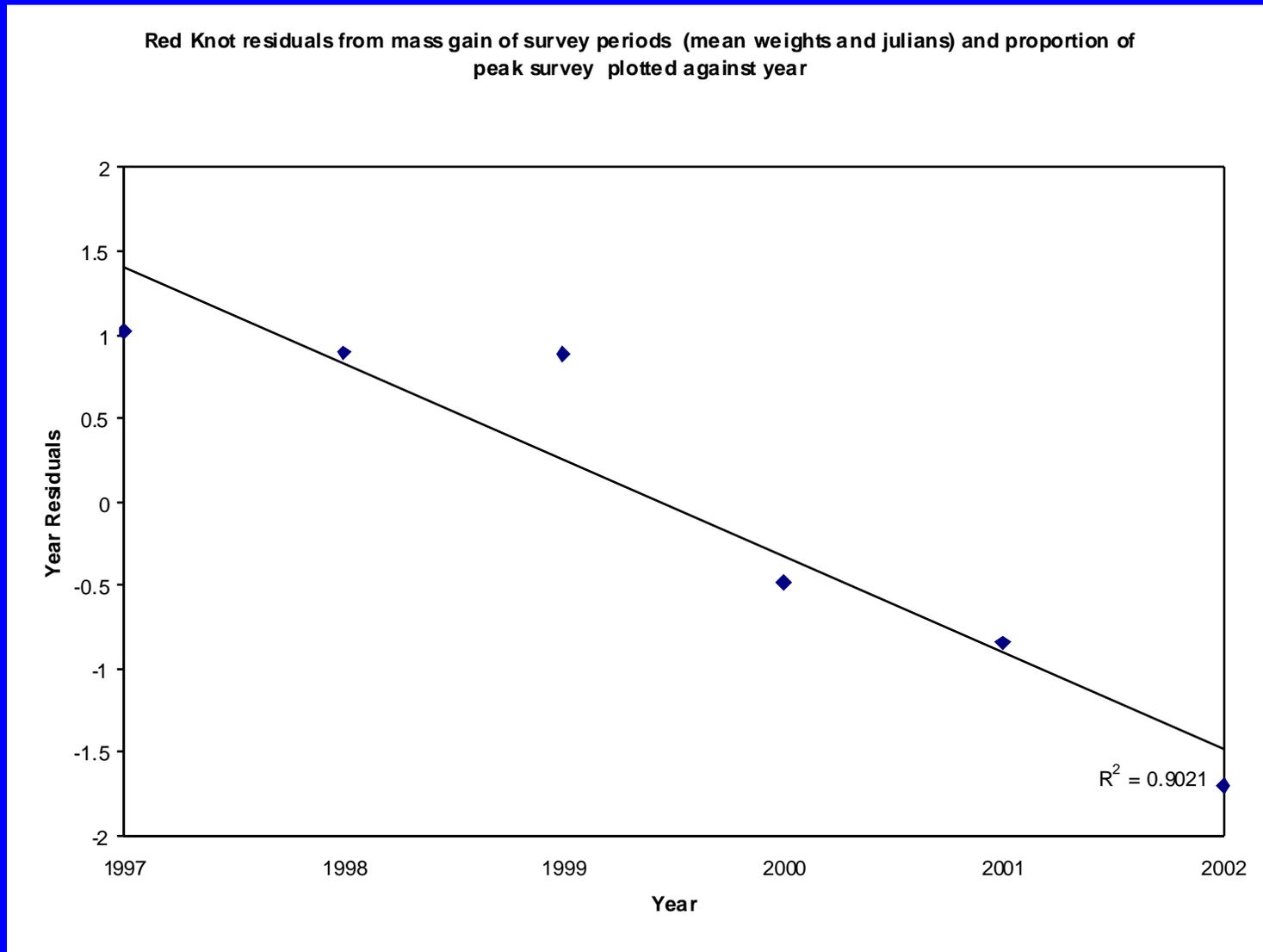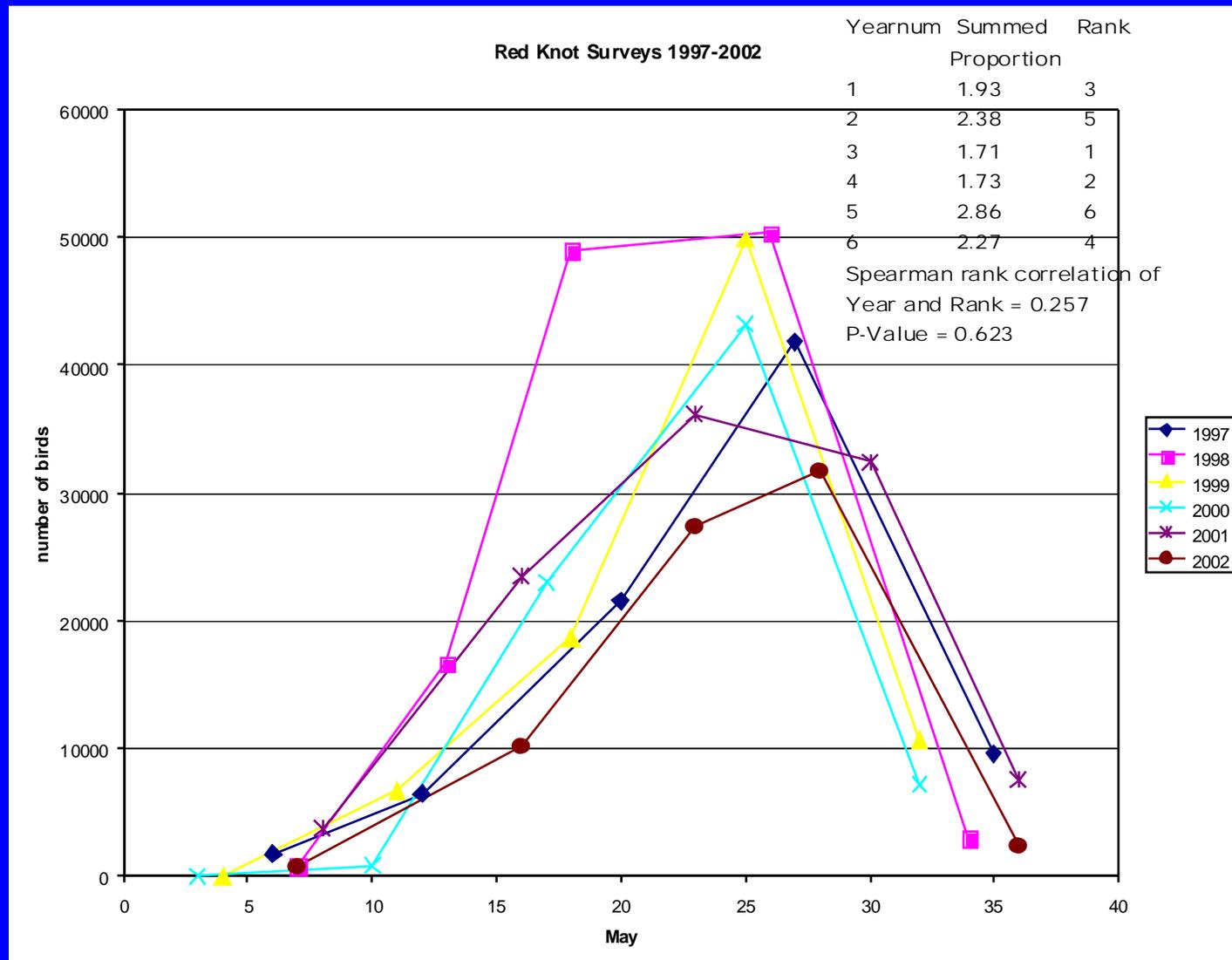
Why the Decline in the Rate of Mass Gain?

Hypotheses:

- 1. Birds are arriving later in recent years artificially depressing rate of mass gain.

- 2. The number of horseshoe crab eggs have declined making it harder for birds to gain weight

We tested the influence of newly arriving red knots by using weekly baywide surveys. Two tests were made. The first integrated the survey data into an analysis of rate of gain. The result was a more precipitous drop in the rate of mass gain.

Red Knot residuals from mass gain of survey periods (mean weights and julians) and proportion of peak survey plotted against year

$R^2 = 0.9021$

The second test was a direct comparison of the weekly survey of knot data for all six years. The chronology of red knot arrival has remained unchanged.

Red Knot Surveys 1997-2002

Yearnum	Summed Proportion	Rank
1	1.93	3
2	2.38	5
3	1.71	1
4	1.73	2
5	2.86	6
6	2.27	4

Spearman rank correlation of Year and Rank = 0.257
P-Value = 0.623

The 2nd hypothesis was that the decline in rate of weight gain in red knots was mainly a consequence of declines in horseshoe crab numbers and eggs. Support comes from two sources. The first is the decline in horseshoe crabs surveyed by trawl in the Delaware Bay.

**DE DFW 30-foot Trawl Survey Horseshoe Crab Index**
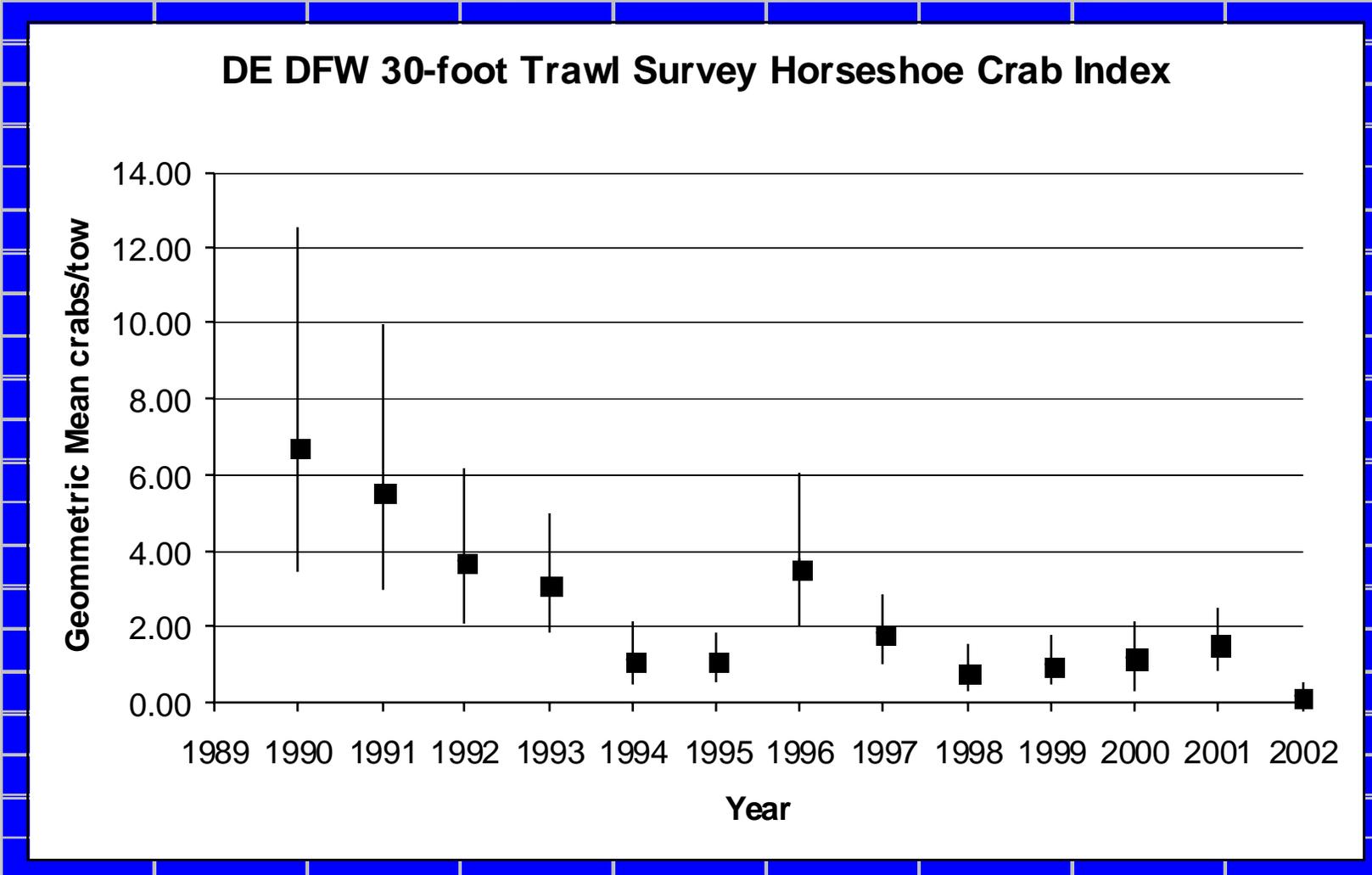
Source: S. Michels, Delaware Fish and Wildlife

The second test comes from a study of egg density on NJ beaches. Eggs abundance fell significantly during the same period as the decline in the ability of knots to gain weight
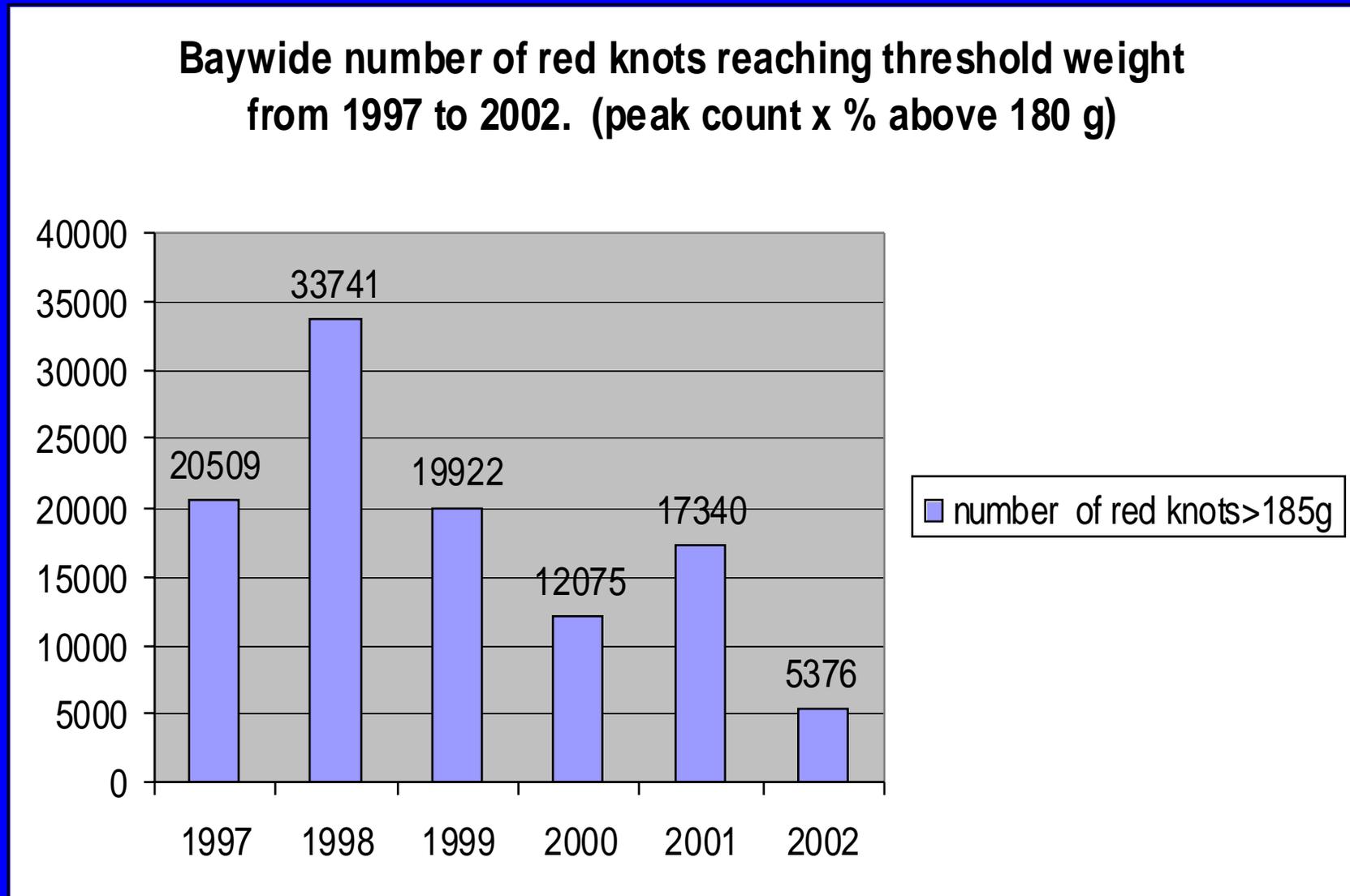
Table . Density of Horseshoe crab eggs at 0-5 cm depth on 6 beaches on the NJ side of the Delaware Bay 2000-2002. (Kruskal Wallis $X^2 = 39.8004$ df=2 P<.0001)

Year	N samples	Eggs/m^2	SE
2000	376	4186.2	580.05
2001	472	3373.8	418.83
2002	465	2629.7	306.03
total	1310	3342.9	249.40

The data also revealed that the decline in egg densities occurred mostly during the period between the full and new moons, when spawning is most intense. This may explain why the beach counts of horseshoe crabs during the full and new moon didn't show a decline in crab density.

Average density of Horseshoe Crab Eggs by sample week, 2000-2002
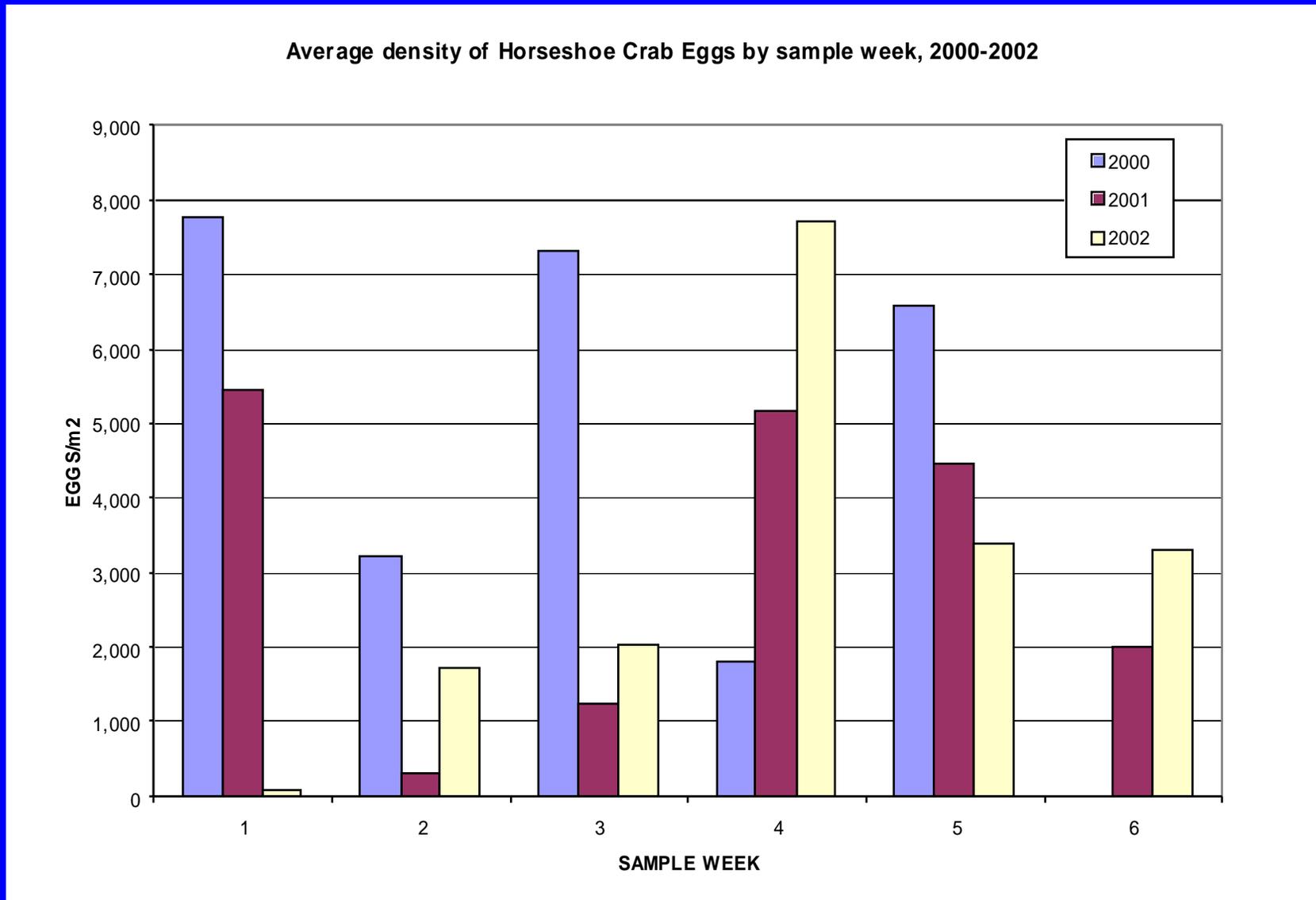
The conclusion is the decline in the ability of red knots to gain weight is a direct result of declining horseshoe crab egg densities. Consequently we have seen a drastic decline in the number of birds reaching sufficient weight to fly to the Arctic.

Baywide number of red knots reaching threshold weight from 1997 to 2002. (peak count x % above 180 g)

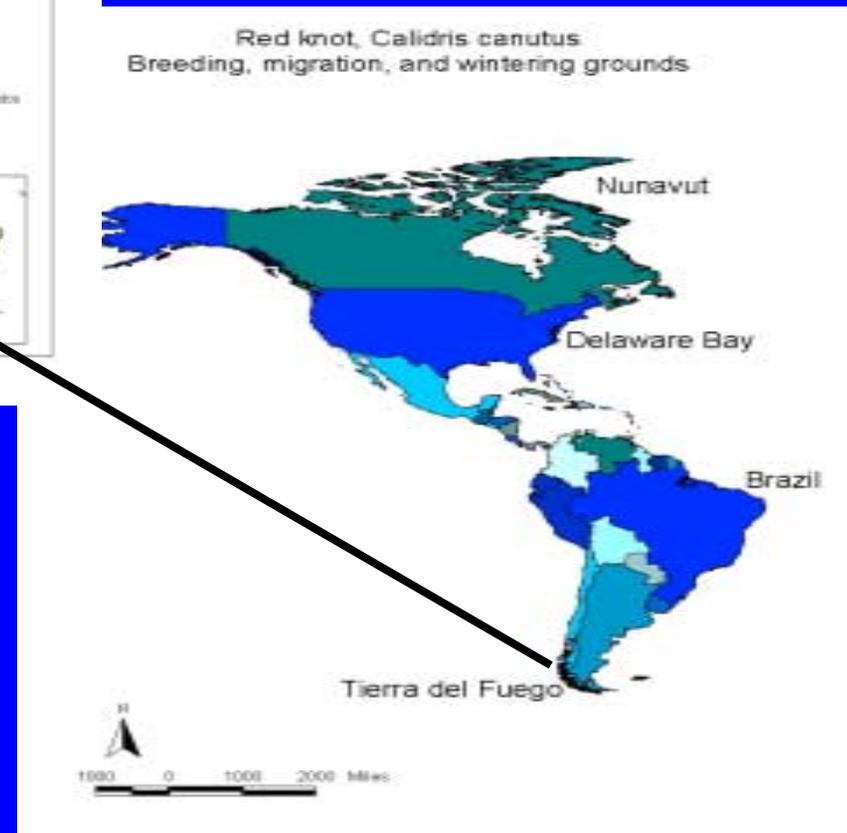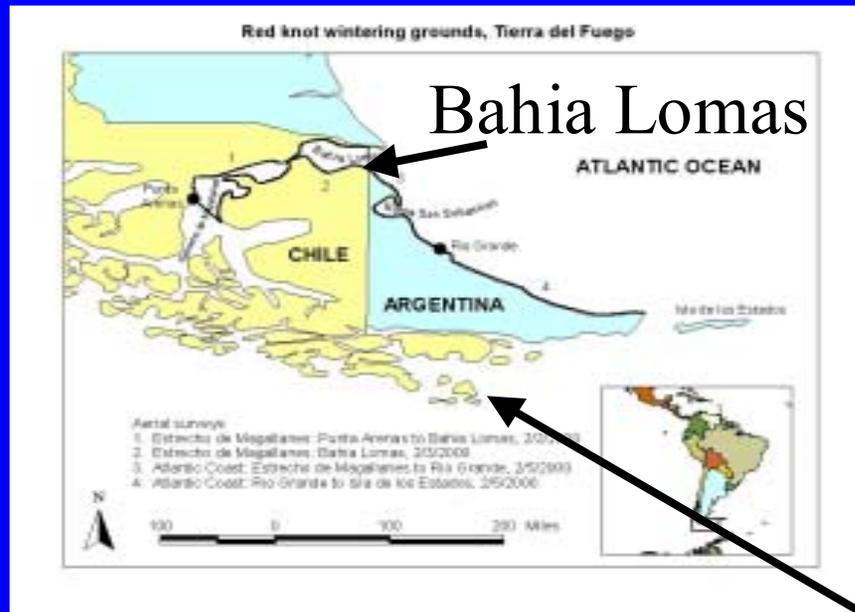| Year	number of red knots>185g
1997	20509
1998	33741
1999	19922
2000	12075
2001	17340
2002	5376

It has been suggested that rising gull populations are the cause of declining horseshoe crab egg densities. But a comparison of gull numbers on NJ beaches shows a drastic decline in gull numbers using the bayshore.

New Jersey Delaware Bay Beaches Gull Counts 1990-2002

Date:	5/31/90	5/29/91	5/19/92	5/26/02
Laughing Gull	6,640	23,150	29,780	10,125
Herring & Black Backed	11,209	14,279	11,412	2,579
Gull sp.	-	-	2,452	-
Total Gulls	17,849	37,429	43,644	12,704

After leaving the Delaware Bay inadequately prepared red knots are either dying en-route or failing to breed. This should result in a decline in the population. To test this we organized four expeditions to the primary wintering area of the Red knot in Tierra Del Fuego, South America.

Red knot wintering grounds, Tierra del Fuego

Bahia Lomas

ATLANTIC OCEAN

CHILE

ARGENTINA

Red knot, Calidris canutus
Breeding, migration, and wintering grounds

Nunavut

Delaware Bay

Brazil

Tierra del Fuego

Duplicating a 1986 survey, we conducted a aerial survey of nearly all known red knot wintering areas and found a decline in red knots of more than 55%

Aerial Survey Eco-units in South America with Total Red Knot Counts

5,023

Rio Colorado

Chile

Argentina
8,691

America.shp
Chile survey areas.shp
Latlong.shp

Peninsula Valdes
650

550

1986 Atlas outside circle

San Jorge
679

2002 inside circle

Rio Gallegos
700

10,470

Tierra del Fuego (Chile)
22172

Tierra del Fuego (Argentina)
5070

42762

N

1986 survey = 67496
2002 survey = 29271

Both surveys 75% of the red knot wintering population occurred in just one place, Bahia Lomas in Southern Chile

LANDSAT 7 ETM+ SATELLITE IMAGE OF TIERRA DEL FUEGO REGION
February 18, 2000

Red knot wintering grounds, Tierra del Fuego

Bahia Lomas

ATLANTIC OCEAN

CHILE

ARGENTINA

LANDSAT 7 ETM+ SATELLITE IMAGE OF BAHIA LOMAS, CHILE
February 18, 2000
True Color Image Display (TM bands 3,2,1)

10   0   10 Kilometers

5   0   5   10 Miles

Image Source: U.S. Geological Survey EROS Data Center
Map produced by CRSSA, Rutgers University, for the NJDEP Endangered Species Program, January 2001

A major portion of the hemisphere's population of Hudsonian godwits also occur on Bahia Lomas. Godwits make the same journey to the Arctic, but don't fly through the Delaware Bay
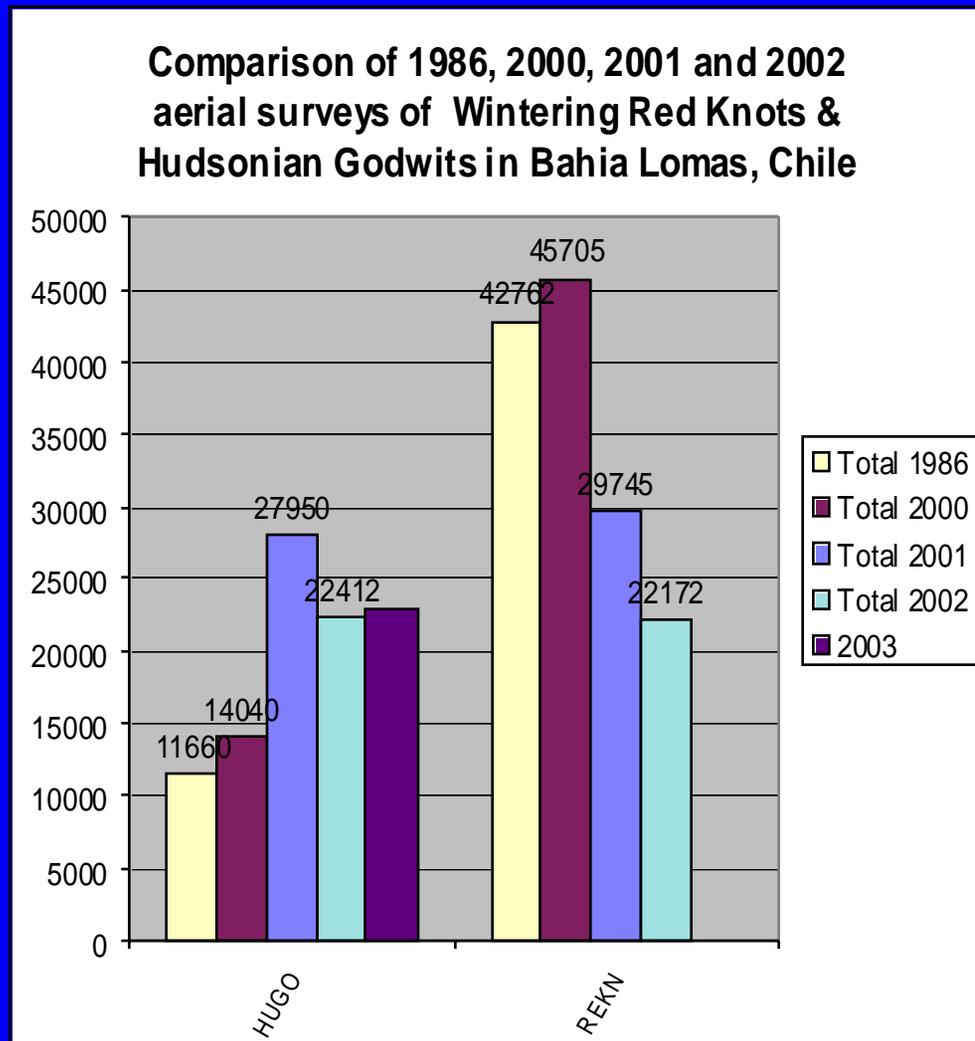

red knot

hudsonian godwit

The red knots on Bahia Lomas fell by over half in 2000 to 2002, while the hudosonian godwit remained stable. The cause of the red knot decline was not in South America.

Comparison of 1986, 2000, 2001 and 2002 aerial surveys of Wintering Red Knots & Hudsonian Godwits in Bahia Lomas, Chile

In Bahia Lomas
2000 - 45705 red knots
2002 - 22171 red knots
2003 - 20000 red knots

We also found that the % of young birds in the red knot population of Bahia Lomas was only 5% compared to the 36% of the godwit population pointing to a decline in red knot productivity in the Arctic.

Percent Immature Birds in Bahia Lomas

Age	Hudsonian Godwit 2002	Red Knot 2002	Red Knot 2003
Immature	41	14	10
Adult	74	217	190
Total captured	115	231	200
Percent Immature birds in wintering population	36%	6%	5%

The last study estimated the survival of red knots using birds color banded primarily on the Delaware Bay. Using sophisticated statistical techniques this study demonstrated a significant decline in the the survival of red knots adults.
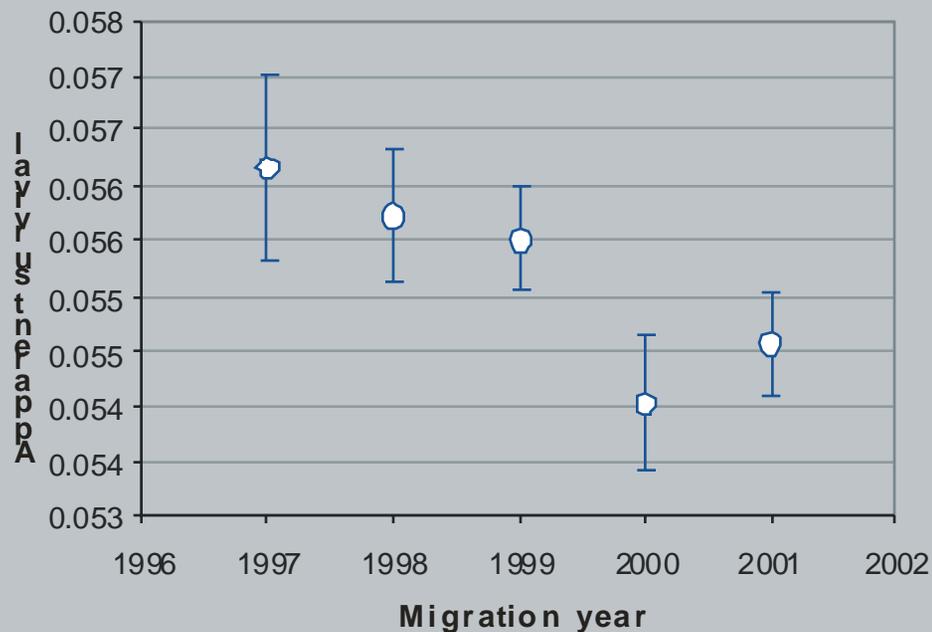

Apparent survival in different years

Table 1. Model selection and parameter estimates for annual survival (φ) of adult red knots in the flyway before July 2000 versus afterwards, and annual recapture rates (p). Model selection, standard errors and confidence intervals calculated with c = 1.728. Annual survival for the period before July 2000 is given by $\varphi1$ and for July 2000-June 2001 by $\varphi2$.

Model	QAICc	Delta QAICc	QAICc Weight	Model Likelihood	#Parameters	QDeviance
{φ(t1,t2)p(t)}	3419.518	0.00	0.71699	1.0000	10.000	62.016
{φ(.) p(t)}	3421.378	1.86	0.28289	0.3945	9.000	65.878
{φ(t) p(t)}	3438.409	18.89	0.00006	0.0001	12.000	76.898
{φ(t) p(.)}	3438.454	18.94	0.00006	0.0001	6.000	88.964
{φ(.) p(.)}	3462.873	43.36	0.00000	0.0000	2.000	121.388

			95% Confidence Interval	
Parameter	Estimate	Standard Error	Lower	Upper
1:$\varphi1$	0.7846	0.0406	0.6944	0.8537
2:$\varphi2$	0.5246	0.0932	0.3464	0.6967
3:p1	0.0127	0.0118	0.0020	0.0751
4:p2	0.0019	0.0025	0.0001	0.0251
5:p3	0.0302	0.0110	0.0147	0.0611
6:p4	0.0268	0.0060	0.0172	0.0414
7:p5	0.0296	0.0048	0.0215	0.0405
8:p6	0.0149	0.0028	0.0103	0.0215
9:p7	0.0559	0.0106	0.0384	0.0808
10:p8	0.0751	0.0203	0.0437	0.1260

The consequence of this decline in survival rate is projected decreases in the population of red knots toward extinction within this decade
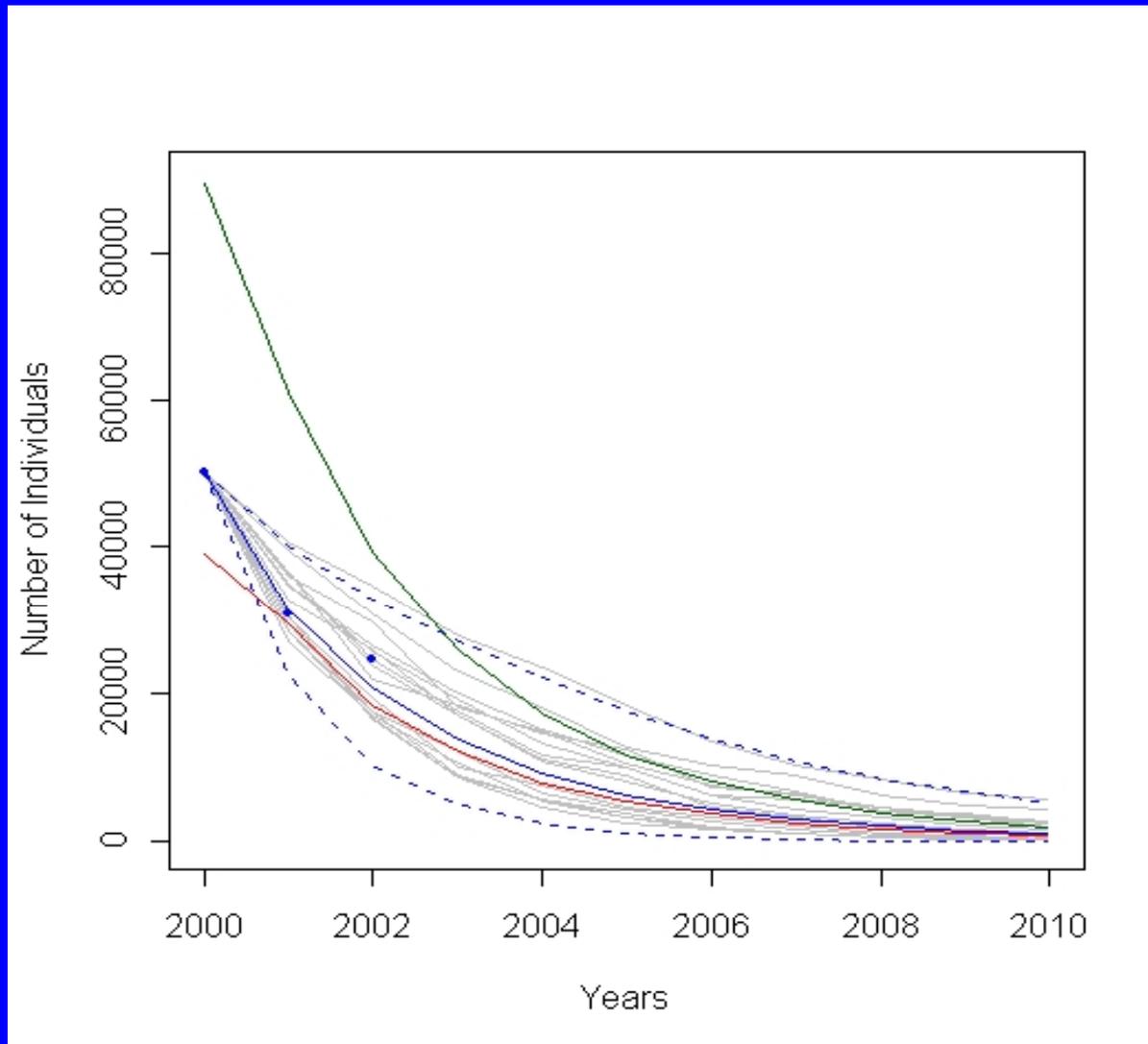
Conclusions of our studies

- On average Red knots can arrive on the Delaware Bay as much as 20% below lean body mass, far lower than any other stopover.
- To reach departure weights knots must gain over 6.5 grams/day.
- The rate of mass gain has declined in the last six years from 8.5 grams/day to 2.2 grams/day
- The proportion of birds reaching sufficient weight to reach the Arctic has fallen from 33,741 to 5,376
- The wintering population has fallen from 67,496 in 1986 to 29,271 in 2002. In Tierra del Fuego where 79% of all red knots winter, counts fell by 42% in the last 3 years.
- The annual survival rate has dropped from 78.5% in the period 1997-99 to 52.5% in 2000-02
- The population of red knot on the Delaware Bay is heading towards extinction

The End