

Vulture movements and activity at Everglades National Park and Key West Naval Air Station  
Final Study Report; December 2017

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North American vulture populations have increased markedly in recent years (Avery 2004, Runge et al. 2010). Coincident with rising populations have been reports of increased property damage, livestock depredations, and aircraft safety issues associated with vultures. Black vultures (*Coragyps atratus*) and turkey vultures (*Cathartes aura*) represent substantial hazards to civil and military aviation (Avery et al. 2011). According to the US Air Force BASH bird strike database, turkey vultures and black vultures are ranked number 2 and number 5, respectively, in terms of total cost of bird strikes to the Air Force ([http://afsafety.af.mil/SEF/Bash/SEFW\\_stats.shtml](http://afsafety.af.mil/SEF/Bash/SEFW_stats.shtml)).

#### Turkey vultures

On Key West, turkey vultures are a major concern for aircraft safety, yet virtually no information exists on their movement patterns or behavior in relation to training activity and maneuvers at the Key West Naval Air Station (KWNAS). Turkey vultures are often the most abundant species recorded on the Christmas Bird Count at Key West, and the apparent increasing trend of the winter turkey vulture population suggests that the risk to aircraft in the vicinity is not likely to diminish. Quantitative information on local vulture activity and movement patterns can help in development of effective management strategies to lessen risks at Key West and nearby military and civil airfields.

Data from the Breeding Bird Survey indicate that the turkey vulture population nationwide has an upward trend of 3.0% annually across the past 10 years (Sauer et al. 2011). In Florida, the trend is more modest, 0.2% annually. However, Florida is the winter home for many thousands of turkey vultures, and the trends from Christmas Bird Count (CBC) data are revealing. Winter vultures (TUVU) recorded at Key West plus 3 other CBC sites (Coot Bay, Long Pine Key, Plantation Key) within 135 km (85 mi) of Key West increased 60%.

Turkey vultures are highly migratory with large numbers of wintering birds swelling the local populations from late fall to early spring. Movement patterns of wintering turkey vultures in south Florida and the Keys have been subject of speculation for many years (Darrow 1983, Moore 2000). While vultures are not the only threat to aviation safety, they are a major one and quantitative information on local vulture activity and movement patterns can help in development of effective management strategies to lessen risks to pilots at KWNAS and at nearby airfields.

#### Black vultures

Everglades National Park (ENP) is approximately 100 km straight-line distance from KWNAS. Recently, nuisance black vulture activity at the park has become a serious problem (Morgan 2010). There is nothing known about the movements and activities of vultures at ENP, so development of management

strategies is hampered. In Florida, black vultures are resident year-round, but the nature of their local non-migratory movements is poorly understood. We are unaware of any investigation in Florida of black vulture movements using marked individuals that predates our initial study (Humphrey et al. 2000).

Information collected on the short- and long-term movements by vultures trapped at ENP will form a scientific basis for management of persistent nuisance damage problems there and also provide ENP personnel with opportunities for public outreach and education focused on vulture management and biology.

## Methods

Capture, tagging, and transmitter attachment followed standard procedures we have used previously. We captured black and turkey vultures using a baited walk-in trap (9.3 m x 3.1 m x 1.8 m; Humphrey et al. 2000). Each bird received a uniquely coded white or pink cattle ear-tag (Allflex, Inc., Dallas, TX) attached to the patagium of the right wing (Wallace et al. 1980, Sweeney et al. 1985). Our contact information was also on the tags to facilitate reporting when tagged birds were resighted. We recorded body mass, wing chord, tarsus length, and length of bill from the nostril (Baldwin et al. 1931). We assigned each vulture to an age class (hatch year HY, second year SY, or after second year ASY) based on the time of year, bill color, and the amount of feathering and wrinkling on the head (Kirk and Mossman 1998, Buckley 1999). To determine gender of vultures we pricked the tarsal vein of the bird with a sterile needle and collected a small drop of blood to transfer to a blood collection (Whatman®) card. We restrained the bird in a large sack with one of its legs exposed. While one investigator controlled the bird, a second person swabbed the area around the tarsal vein with alcohol and then removed the blood sample using a sterile syringe. We applied pressure on the insertion point with a sterile gauze pad until blood from the puncture wound clotted. We labeled each Whatman card with the bird's tag number and sent the cards to the NWRC Wildlife Genetics lab in Fort Collins, CO for processing. We compared mensural data between genders within each age class using t-tests (2-tailed).

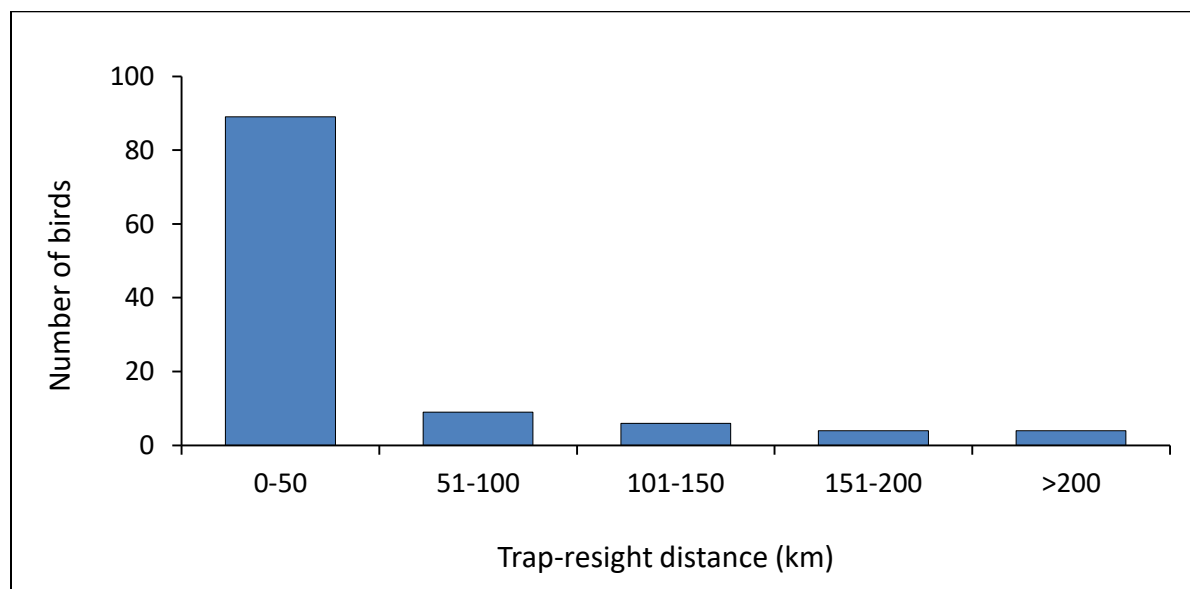
We attached solar-powered GPS/GSM transmitters (Argos GPS Solar PTT-100; GPS Solar/GSM 20-70; Microwave Telemetry, Inc., Columbia, MD) to vultures with a Teflon tape backpack harness (Humphrey et al. 2000, Humphrey and Avery 2014). We released captured birds at the trap site. The transmitters recorded latitude–longitude, altitude above ground level (resolution 22 m), speed, and direction on the hour from dawn to dusk. For turkey vultures, we defined each bird's migratory behavior by recording the onset and duration of consistent, day-to-day, movement in the seasonally appropriate direction. We tabulated resightings of tagged birds as reports came to us directly or through the USGS Bird Banding Lab. Resightings included observations of free-flying birds, reports of dead birds, and photographs from camera traps.

### Everglades National Park (ENP)

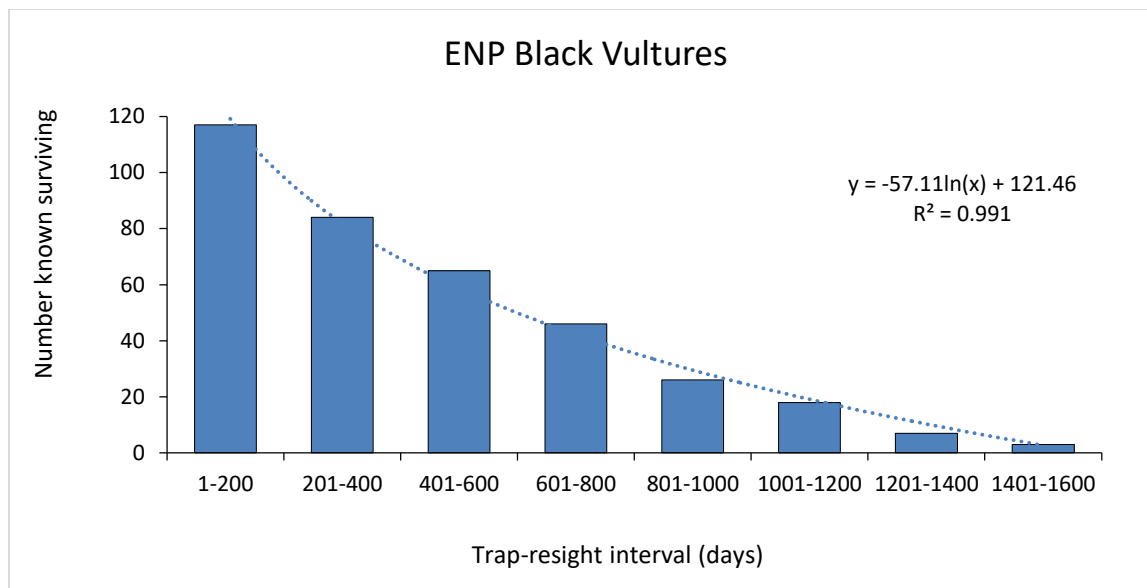
We trapped vultures at ENP on 4 occasions; altogether, we tagged and released 301 black vultures and 17 turkey vultures. We deployed 5 black vultures with satellite GPS transmitters.

Trapping dates	BLVU	TUVU
29 Nov-3 Dec 2012	142	1
15-16 April 2013	52	1
23 Jan 2014	28	5
25-26 Feb 2015	79	10

Among the 301 black vultures tagged and released, 115 individuals were resighted a total of 223 times. Most resightings were very local, reported by Park visitors and staff from parking areas, campgrounds, boat ramps, and trails. Eighty percent (92 birds) of the individuals resighted were within 50 km of their trap site. Outside of the Park, the Miami-Dade County Landfill, 37 km from the trap site, was the location that produced the most resightings (12 individuals). The most distant reports were from Port Richey (382 km away), Kennedy Space Center (359 km), and Disney Animal Kingdom (344 km). In Louisiana, Parmalee and Parmalee (1967) reported that 97% of recoveries of banded black vultures were within 322 km of the banding site. We had a similar result in that the maximum trap-to-resight distance for 97% of the 115 resighted individuals was <322 km.

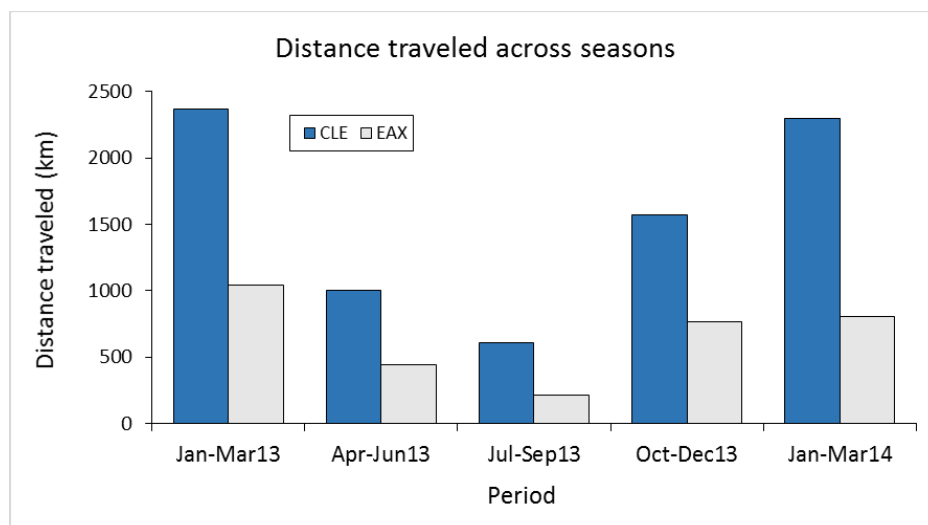


The interval from tagging/release to subsequent resighting of a tagged bird ranged up to 1552 days. A plot of the longest release-resight interval for each of the 115 birds resighted in 200-day increments indicates a logarithmic decline over time. We know of just one confirmed death among the 301 tagged black vultures. This individual died at the Busch Wildlife Sanctuary in Jupiter, FL where it ventured into the river otter (*Lontra canadensis*) exhibit and was attacked and killed by the otters.

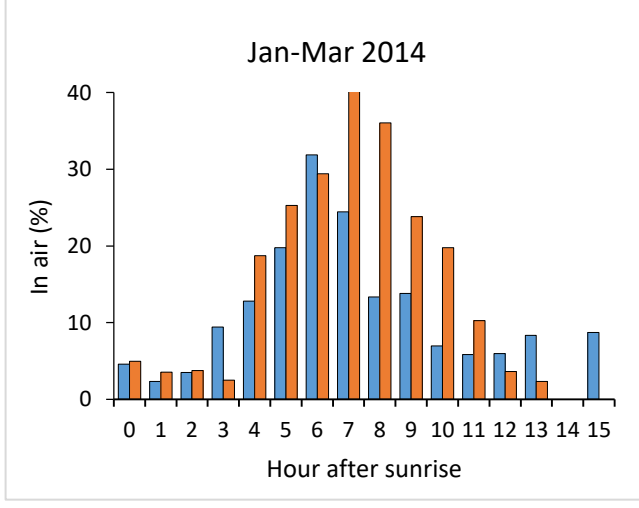
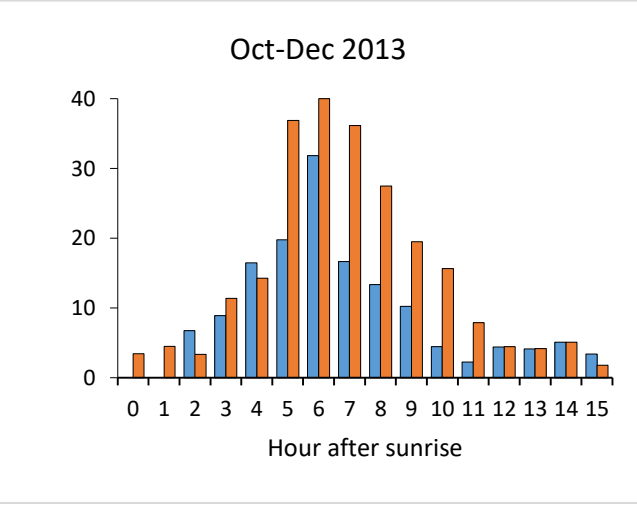
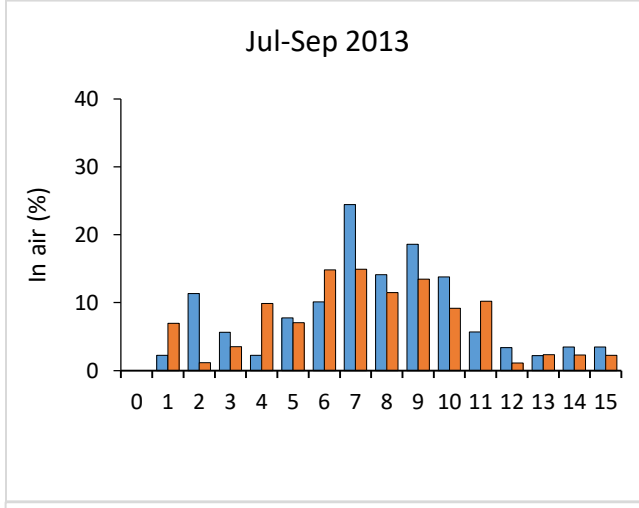
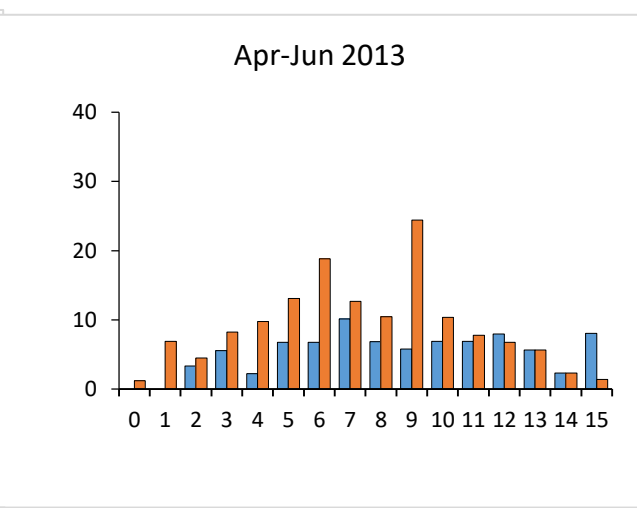
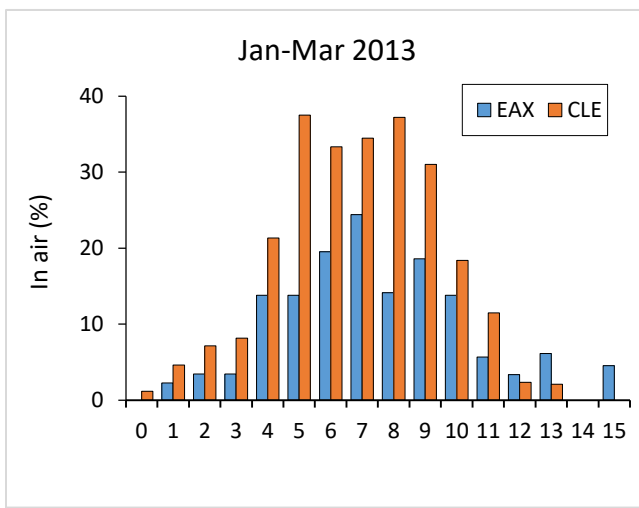


#### Black Vulture Movements

Of the 5 birds outfitted with transmitters, CLE (#121785) and EAX (#121786) each consistently provided movement data for >1 year. CLE traversed much more area than EAX throughout, but the seasonal patterns of activity were similar – winter was the period of greatest activity and summer the least active period. This was the same seasonal pattern we documented among black vultures at Beaufort, SC (Avery et al. 2011).



Each bird showed peaks of daily activity in mid-day, hours 5 through 9 after sunrise, with the disparity in activity between the 2 birds less evident during the Jul-Sep period than in the rest of the year.



### Black Vulture Measurement Data

Numbers of HY and SY birds were inadequate to conduct statistical analyses. Among ASY birds, females tended to be larger in terms of body mass and beak length, but wing chord and tarsus did not differ between genders.

Age	Sex	Body mass (g)				Beak length (mm)				Wing chord (mm)				Tarsus (mm)			
		N	Mean	SD	P	N	Mean	SD	P	N	Mean	SD	P	N	Mean	SD	P
HY	M	2	1975	75	n/a	1	33.5	n/a	n/a	2	435	0	n/a	1	80	n/a	n/a
	F	1	2010	n/a	n/a	0	n/a	n/a	n/a	1	397	n/a	n/a	0	n/a	n/a	n/a
	U	8	1890	180	n/a	0	n/a	n/a	n/a	8	430	10	n/a	0	n/a	n/a	n/a
SY	M	3	2027	39	n/a	3	n/a	n/a	n/a	3	420	5	n/a	3	79	2	n/a
	F	1	2050	n/a	n/a	1	n/a	n/a	n/a	1	414	n/a	n/a	1	78	n/a	n/a
	U	2	2060	n/a	n/a	2	n/a	n/a	n/a	5	430	10	n/a	2	79	n/a	n/a
ASY	M	40	2071	124	0.0005	25	34.5	2.4	0.0078	41	431	14	0.501	27	80	2	0.278
	F	37	2190	167		25	36.2	1.8		37	433	13		28	80	2	
	U	35	2130	140	n/a	2	34.9	n/a	n/a	72	433	11	n/a	2	78	n/a	n/a

These data are consistent with previous reports of black vulture measurements in Florida.

Sex	Body mass (g) <sup>1</sup>			Wing chord (mm) <sup>2</sup>			Tarsus (mm) <sup>2</sup>		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
M	6	1989	79	12	428	8	12	80	4
F	6	2172	118	12	432	19	12	79	3

<sup>1</sup> Hartman 1955; <sup>2</sup> Buckley 1999.

### Turkey vultures at ENP

Of the 17 turkey vultures tagged and released, 3 were resighted a total of 8 times. One of these birds, CAL, was reported from Ontario in April 2015 (2250 km away) and October 2016 (2032 km away). The other two birds were resighted in south Florida only.

## Key West Naval Air Station (KWNAS)

### Birds without transmitters

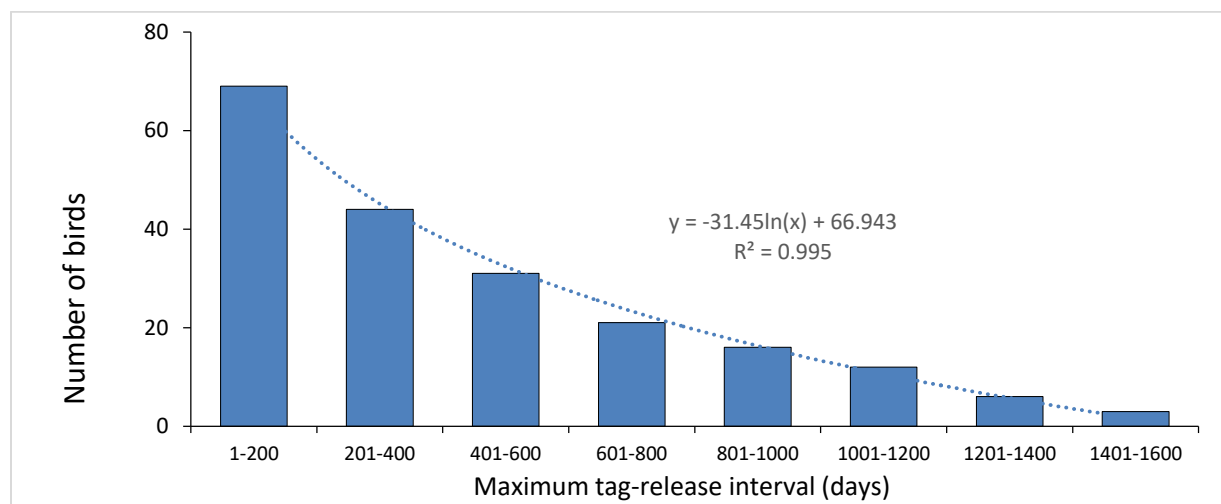
We trapped at KWNAS 3 times; altogether we tagged and released 255 turkey vultures (Table 1). We trapped no black vultures. Gender was determined for 138 of the birds we tagged. The sex ratio (M:F) was 21:23 for HY birds, 18:18 for SY, and 26:30 for ASY.

Trapping dates	Number tagged			Transmitters deployed – tag code and unit
	HY	SY	ASY	
31 Jan-3 Feb 2013	0	96	52	ELV(787), EMH(788), HAL(789)
11-13 Dec 2013	13	0	15	JML(281), JMX(280), JPM(942), JTA(943)
18-20 Nov 2014	61	8	10	LCV(280), LMP(453), LMV(454), LTH(451), LVA(452)
Total	74	104	77	12 units - 8 GPS, 4 GSM; unit 280 was recovered, reused

Of the 243 birds released without transmitters, 70 of them were resighted at least once (total of 121 resightings as of 30 January 2017; Table 2). For birds with multiple resightings, we include just the longest interval for each bird in the discussion and analyses that follow. HY birds were resighted less frequently than birds in other age classes. The greatest tag-resight interval for HY birds was 766 days.

Age class	Number of birds		Resightings/bird		Tag-resight interval (days)	
	Tagged	Resighted	Mean	Max	Range	Mean
HY	74	10 (13.5%)	1.3	4	58 – 766	401
SY	102	39 (38.2%)	1.7	8	5 – 1519	405
ASY	67	21 (31.3%)	2.1	10	19 – 1489	630

A plot of the maximum tag-resight value for each of the 70 birds, grouped by 200-day intervals, suggests a logarithmic decline suggesting roughly constant probability of survival across time. The greatest tag-resight interval to date is 1622 days. This bird tagged in January 2013 and resighted in Ohio in July 2017.



Most (40) birds were resighted in the Florida Keys, and 11 birds were resighted on mainland Florida. The remaining reports came from 8 states and 3 Canadian provinces. Twenty-nine birds were subsequently observed >1000 km from Key West. One bird was seen at separate locations in New Jersey in successive years, while another one was reported from separate cities in New York in successive years. The most distant report was from New Brunswick (2727 km straight line distance from Key West) where the same turkey vulture was observed in 2015, 2016, and 2017. The northernmost resighting was reported from Whitefish Point, MI (latitude 46.77°N), and the most westward resighting occurred in Medaryville, IN (longitude -86.80°W).

### Vultures with Transmitters

We equipped 12 birds with transmitters. Eight of them received satellite GPS units which recorded locations hourly. We reused transmitter 280 after the first bird (JMX) was killed and we were able to recover the unit and have it refurbished by the vendor. LMP and LMV are still active (as of 1 November 2017) and with each making its third annual trip to breeding areas in the Great Lakes region.

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Tag	Unit	Age	Sex	Date tagged	Last contact	Final location
ELV	787	ASY	F	31 Jan 2013	2 May 2013	Dead; downed off Marquesas Keys
EMH	788	ASY	M	31 Jan 2013	4 Nov 2014	Dead in Pennsylvania
HAL	789	SY	F	2 Feb 2013	30 Jun 2014	Dead on Big Pine Key
JML	281	ASY	F	11 Dec 2013	15 Sep 2015	Dead in Georgia
JMX	280	ASY	F	11 Dec 2013	30 Jan 2014	Dead in Key West (traffic)
JPM	942	ASY	F	13 Dec 2013	8 Jan 2017	Dead in Key West
JTA	943	ASY	M	13 Dec 2013	18 Aug 2014	Dead in New York (traffic)
LCV	280	SY	F	18 Nov 2014	April 2015	Dead; downed in water off Key West
LMP	453	ASY	M	19 Nov 2014	Active	
LMV	454	ASY	M	19 Nov 2014	Active	
LTH	451	ASY	F	20 Nov 2014	16 Feb 2015	Last signal from over Boca Grande Key
LVA	452	ASY	F	20 Nov 2014	10 Dec 2014	Last signal from over Key West

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Each of the ASY birds for which we recorded >6 months of data made seasonal trips north, presumably for breeding. EMH and JTA, were killed in Pennsylvania and New York, respectively. JML died in Georgia after making a round trip to the Lake Michigan area. JPM died in Key West after completing its third consecutive round trip to the Windsor, ON area. Signal transmissions from LTH and LVA ceased soon after deployment. There was no evidence of traumatic events, and the reason for the losing contact with these two birds is unknown.



Six telemetered birds left the Keys and migrated north at least one time. Dates of departure by these birds from the Keys varied considerably, from mid-December to early April. Seven of eight crossings to the mainland occurred at Key Largo. The exception (JML) crossed at Lower Matecumbe Key, 48 km SW of Key Largo, where turkey vultures have previously been observed crossing (Darrow 1983). The distance to the mainland is about 35 km at Lower Matecumbe Key, compared to roughly 11.5 km at Key Largo. JML followed a series of small islets almost directly north from Lower Matecumbe Key to the mainland just east of Madeira Hammock. For most of the hour-long trip, JML maintained an altitude of 100-400 m.

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<u>When and where departed Keys</u>					
Tag	Unit #	Date tagged	Date	Crossing location	Destination
EMH	788	31-Jan-13	5-Mar-13	Key Largo	Pennsylvania
JML	281	11-Dec-13	21-Mar-14	Lower Matecumbe Key	Indiana
JPM	942	13-Dec-13	11-Mar-14	Key Largo	Windsor, ON
			18-Mar-15	Key Largo	Windsor, ON
			7-Apr-16	Key Largo	Windsor, ON
JTA	943	13-Dec-13	22-Mar-14	Key Largo	New York
LMP	453	19-Nov-14	14-Dec-14	Key Largo	Michigan
				did not return to Keys in 2015, 2016 or 2017	Michigan
LMV	454	19-Nov-14	11-Dec-14	Key Largo	Ohio, Lake Erie
				did not return to Keys in 2015, 2016 or 2017	Ohio

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On the day that JML crossed over, prevailing winds were from the N-NW throughout the morning, but became calm or southerly in the afternoon (Wunderground 2017).

### **Turkey Vulture Migration**

Six birds provided a total of 13 northward migrations and 11 southward legs.

	Departure		Arrival		Duration (days)		Distance (km)		
	Mean	Range	Mean	Range	Mean	SD	Mean	SD	Daily max
Northward (13)	14-Mar	21 Feb - 4 Apr	3-Apr	16 Mar - 1 May	22	8	2019	324	384
Southward (11)	27-Oct	8 Oct - 29 Nov	20-Nov	3 Nov - 19 Dec	27	11	1947	231	355

Northward migration started in mid-March, continued for an average of 22 days, and covered about 2000 km. The return trip south typically began in late October, with a mean duration of 27 days.

## Turkey Vultures Falling Out into the Gulf

Three transmittered birds and one with only a patagial tag were downed in the Gulf of Mexico.

1. On 30 April 2013 at 1500, ELV (PTT 787) was 710 m above Marquesas Keys, approximately 35 km west of Key West. An hour later, it was in the water, 10.5 km to the southeast drifting near Boca Grande Key. It continued to transmit from the water until 1000 on 2 May.
2. JML (GSM 281) departed the Keys in March 2014 and spent the summer in northern Indiana. It returned to the Key West area in winter 2014/2015. Instead of migrating north in 2015, it remained in the Keys. On 13 July at 1532, it was flying at over 1200 m when it rapidly descended during the next 4 minutes and landed in the water approximately 3 km north of Marathon, FL. The bird drifted southwesterly toward the Seven Mile Bridge for about an hour until it was spotted by a charter boat captain returning to Marathon. The captain dipped JML out of the water, and turned it over to a wildlife rehabilitation center when they returned to the marina. After 2 days in the rehab center, JML was declared healthy and was released. (<http://www.miamiherald.com/news/local/community/florida-keys/article27860335.html>) In the next several days, JML moved up the Keys and onto the mainland. It proceeded up the center of peninsular Florida to southern Georgia. It died on or about 18 August 2015. We recovered the transmitter on 15 September, but the carcass was too deteriorated to determine cause of death.
3. On 11 April 2015, LCV (GSM 280) was island-hopping in Bay Keys, approximately 6 km north of Key West. At 1457 it was at 112 m altitude and flying south-southwest. In the next 2 minutes, over open water, it dropped to 66 m and 37 m, respectively. At 1503, it struck the water. The unit continued to transmit as LCV drifted in and out with the tides for 54.5 hours in a generally westward direction. The last signal (2137 on 13 April) was from about 3 km northwest of Cottrell Key, or 16 km northwest of Key West, and 16 km from where it struck water. The transmitter carried by this bird eventually washed up on the south side of Big Pine Key and was recovered on 18 September 2015 approximately 65 km from the location of the last signal.
4. LEA was rescued out of the water just off of Fort Zachary Taylor rock jetty, in Key West, on 15 January 2015. It had been tagged as an HY bird on 18 November 2014. It appeared unharmed and was released after it had dried off.

Darrow (1983) and Moore (2000) have previously documented that some turkey vultures attempting to cross Florida Bay succeed but others ditch in the water. Furthermore, in November 2010, a fall out occurred in Florida Bay in which 475 turkey vultures were documented to have died. Based on the additional carcasses seen but not recovered, observers stated that the actual number lost could easily have been twice that (Parry and King 2010). On 30 December 2014, a fishing guide reported "thousands" of dead turkey vultures floating 5-8 km west of Sandy Key. Details of this fallout are not available, but it occurred in roughly the same area as the 2010 event and the one reported from January 1990 by Moore (2000).

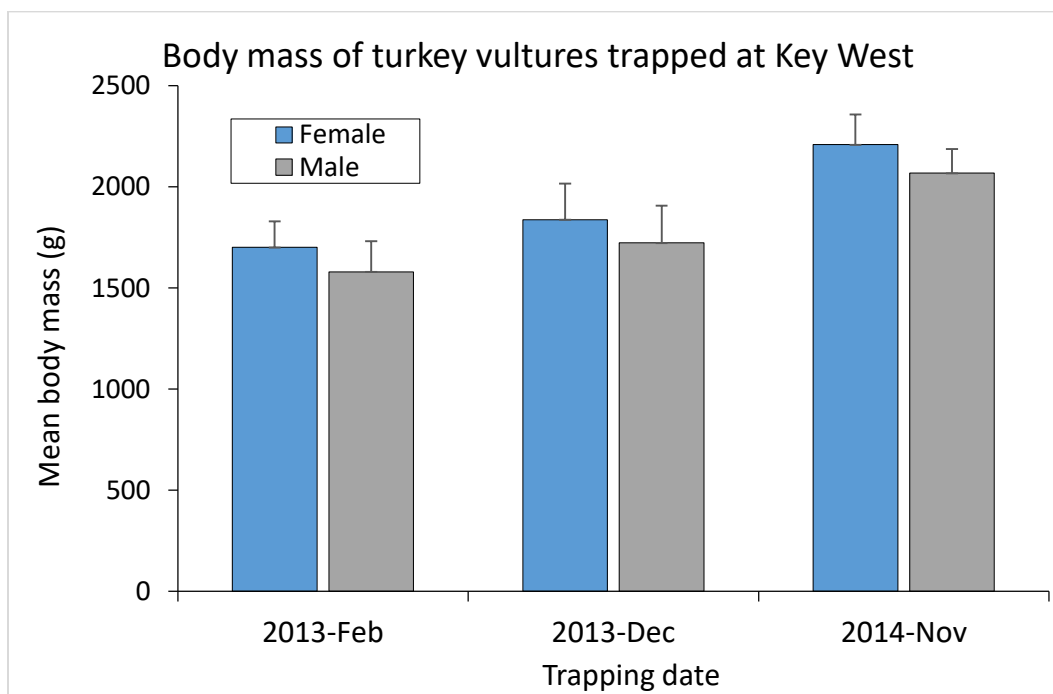
### Measurement Data

We determined gender of 123 birds for which we also recorded mensural data. Generally, females were larger than males, as has been noted by others (Kirk and Mossman 1998). In our sample, the size difference between sexes was particularly evident in body masses of the SY and ASY age classes.

Measurements (mean and standard deviation) from 123 turkey vultures trapped, tagged and released at Key West Naval Air Station. The *P* values are results of 2-tailed t-tests between genders for each measurement within each age class.

Age	Sex	N	Body mass (g)			Beak length (mm)			Wing chord (mm)			Tarsus (mm)		
			Mean	SD	<i>P</i>	Mean	SD	<i>P</i>	Mean	SD	<i>P</i>	Mean	SD	<i>P</i>
HY	M	15	1959	218	0.758	26.6	1.2	0.058	515	17	0.110	61	2	0.442
	F	17	1932	282		27.5	1.3		526	17		62	2	
SY	M	20	1568	198	0.006	27.5	1.0	0.011	531	14	0.453	61	2	0.016
	F	21	1780	253		28.3	0.7		535	18		62	2	
ASY	M	25	1746	224	0.011	27.9	1.3	0.114	529	16	0.456	63	3	0.284
	F	25	1918	237		28.5	1.0		533	19		62	2	

The gender difference in body size was consistent across the 3 trapping sessions we conducted at KWNAS. The reason for the evident trend in larger body mass from February 2013 to November 2014 is not clear.



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