Emperor Goose (*Chen canagica*) Photographic Age-Ratio Survey, 2015

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ABSTRACT: We used aerial photography to estimate the annual proportion of hatching-year (HY) emperor geese (*Chen canagica*) in the fall staging population along the shorelines of seven lagoons on the north side of the Alaska Peninsula. Geese were photographed between 01 and 06 October 2015. We classified HY vs. adult geese based on the gray/black head and neck plumage evident on HY birds. In 2015, we classified 30,391 geese from 484 photographs. We counted 4,388 HY birds resulting in a self-weighted ratio estimate of 0.144 (SE = 0.006) and a count-weighted estimate of 0.142 (SE = 0.008).

KEY WORDS: aerial survey, Alaska, emperor goose, *Chen canagica*, age-ratio, photography, Alaska Peninsula

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INTRODUCTION

From mid-September through October, most of the emperor goose (*Chen canagica*) population congregates in 7 lagoons on the north side of the Alaska Peninsula (Petersen and Gill 1982; Fig. 1). Staging geese provide an opportunity to sample the population to determine an index of annual productivity because hatching year (HY) emperor geese retain gray/black plumage on their head and neck that contrasts with the complete white head plumage of adult geese (Fig. 2)(Pyle 2008, Baldassare 2014). This plumage difference is used to age classify geese (i.e. HY vs. adult) in aerial photographs.

The objective of this study was to calculate an annual estimate of the proportion of HY emperor geese in the fall staging population. This estimate provides an index to annual production that is defined as the number of hatched young that survive until October and is expressed as a proportion of the total birds classified. In combination with a fall population abundance survey to weight the lagoon-specific age-ratio estimates, these data are necessary to monitor annual productivity. The annual age ratio of emperor geese has been monitored with this survey since 1985.

METHODS

We conducted the photographic age-ratio survey in seven primary sites along the north side of the Alaska Peninsula including Egegik Bay, Ugashik Bay, Cinder River, Port Heiden, Seal Islands, Nelson Lagoon, and Izembek Lagoon (Fig. 1). We attempted to fly the aerial photographic survey when HY geese were approximately 100 days of age to ensure that we could differentiate between the age classes before the juveniles acquired their adult, head plumage. In 2015, the survey was flown in an amphibious-equipped Cessna 206 (N77554). The aircraft was flown at approximately 500-1000 feet above the ground to locate geese. After spotting groups of emperor geese on beaches or flying, the pilot positioned the aircraft to arc around the flock while attempting to provide the best possible distance, angle, and light for the photographer who was located directly behind the pilot. Aircraft maneuvering decisions were made when a flock was first spotted and verbally coordinated with the photographer to maximize photographic opportunities. Once found, we typically descended to 300-400 feet above the ground to photograph flocks. The photographer captured digital images of geese through the aircraft's window port with a hand-held digital SLR camera. Taking photographs from the left rear-seat improved communication between the pilot (i.e., seated in the left front seat) and photographer making it easier to appropriately position the aircraft relative to the flock.

Camera Setting– We used a Canon© EOS 5DS-R camera with a Canon© image-stabilized 70-200 mm,

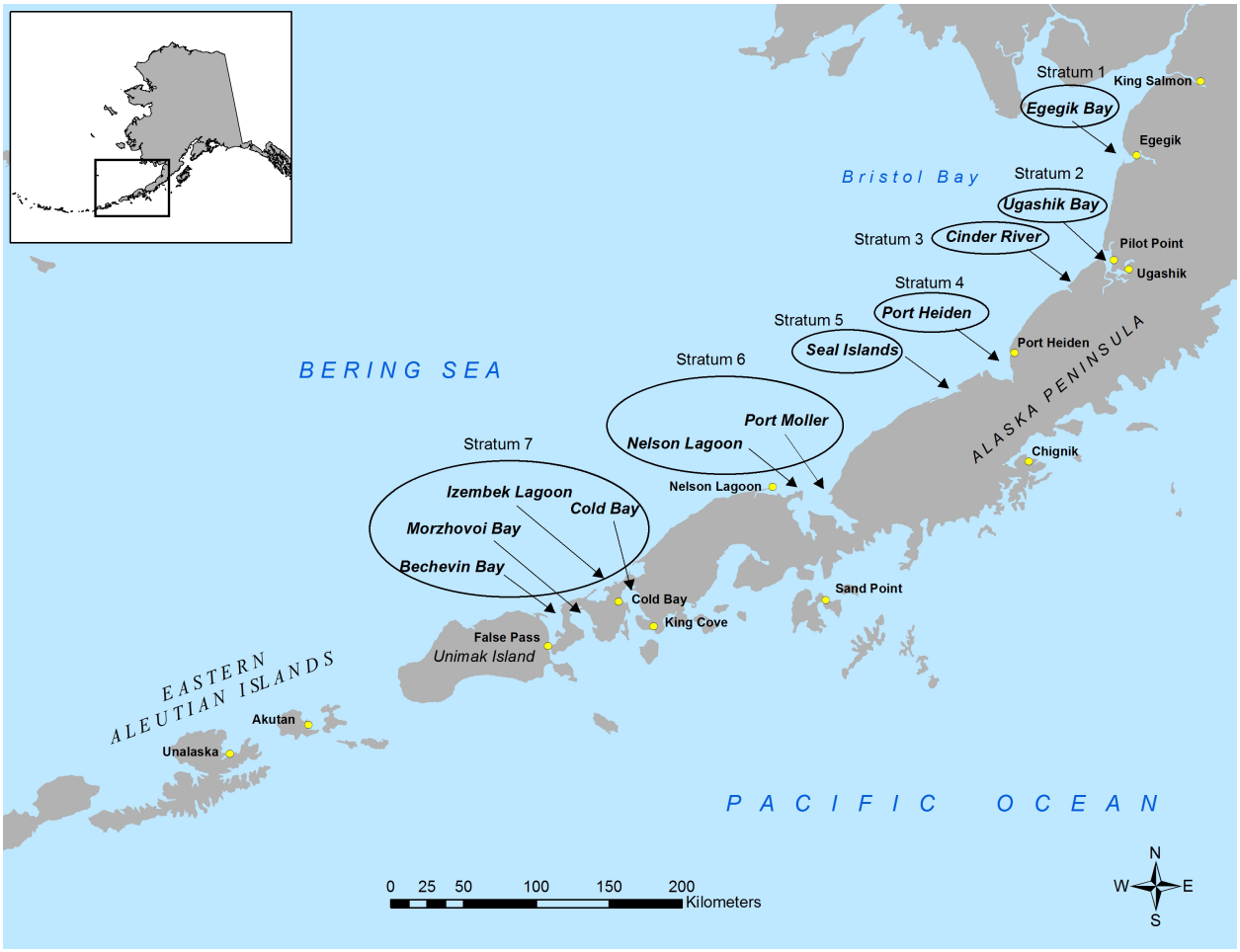

Figure 1: Seven primary fall staging areas for emperor geese along the north side of the Alaska Peninsula where photographs were taken.

f4.0 lens. The LCD display allowed for a rapid assessment of image quality. Image size was 5616 x 3744 pixels, and file size ranged from 5-12 megabytes. The photographer recorded the: Date, Time, Start Photograph #, End Photograph # , and Location (e.g., 9/27/11, 16:25 4927-4970, Egegik Bay). Camera settings for the Canon 5D were:

1. Camera set to take the highest quality JPG image.
2. AF mode set to A1 Servo.
3. Mode set to shutter priority (TV) and shutter speed set to 1250.
4. Metering mode set to Evaluative Metering.
5. ISO set at 800.

Photo Analysis– We viewed digital images in Adobe Photoshop© on a computer with dual 19-inch LCD monitors set at 1280 x 1024 resolution. We used a grid overlay for each photograph and magnified the image as needed to adequately distinguish the age class of each goose. We used the *Count Tool* feature in Photoshop© to mark each goose as adult, juvenile, or unknown (Fig. 3). We did not classify geese on any photographs where the majority of bird images were too small or excessively blurred to reliably determine age class.

Figure 2: Example survey photograph used to distinguish hatching-year and adult emperor geese based on head plumage characteristics.

Statistical Analysis– Stehn and Wilson (2014) describe 2 different estimators to determine the age-ratio for emperor geese (i.e., self-weighted and count-weighted). The count-weighted estimate relies on an annual, fall population count of emperor geese in the 7 sampling areas along the Alaska Peninsula.

Self-Weighted Estimate The self-weighted estimate is simply the ratio of total HY to total geese counted across all photographs:

$$R = \frac{\sum_{ij} J_{ij}}{\sum_{ij} N_{ij}}.$$

Where J is the number of juveniles counted, N is the total number of emperor geese counted (i.e., adult + juvenile), i is the index for strata ($i = \{1, ..., 7\}$), and j is the index for photograph ($j = \{1, ..., P_i\}$ where P_i is the number of photographs per stratum. The standard error (SE) of this ratio estimate was calculated as in Cochran (1963; p. 65, eq. 3.26):

$$SE(R) = \sqrt{(\frac{1-f}{P\hat{N}^2}) \frac{\sum_{ij} J_{ij}^2 - 2R\sum_{ij} J_{ij}N_{ij} + R^2 \sum_{ij} N_{ij}^2}{(P-1)}}.$$

where $P = \sum_i P_i$, $\hat{N} = \sum_i N_i/P$, and the sampling fraction, f, was assumed to be near zero (i.e., $f = 0$ for

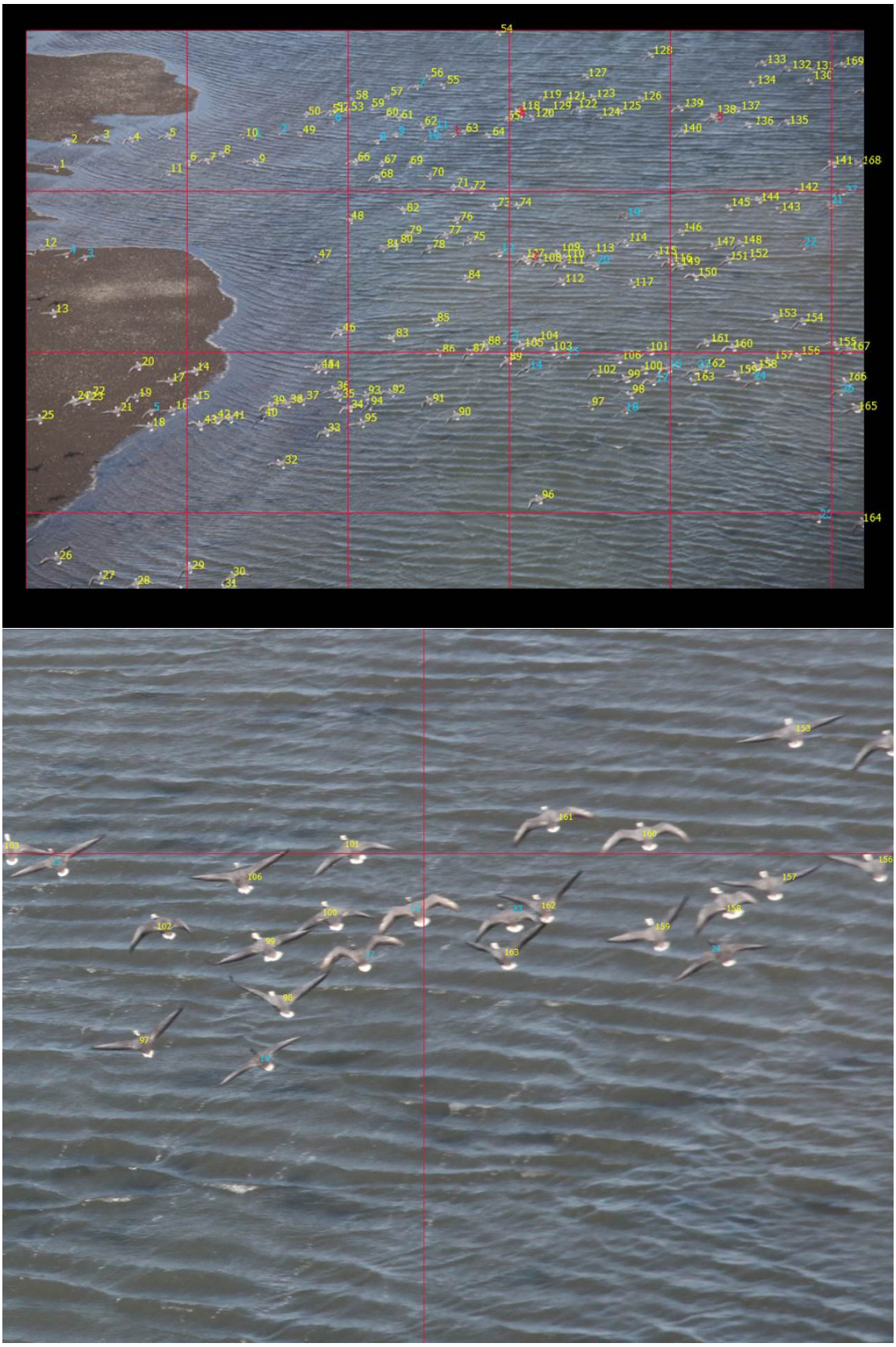

Figure 3: Typical photograph with grid overlay (top) and count tool labels (bottom).

the sample population vs. $f = 1$ when the population is censused and variance = 0).

The self-weighted estimate is appropriate when the sampling intensity or total birds counted in photographs within each stratum is proportional to the population size estimated within each stratum from the independent, fall aerial population survey. In short, the number of photographs taken in each stratum should be proportional to the number of geese in each stratum.

Count-Weighted Estimate The mean ratio of juveniles to total geese was calculated, as above, for each of the seven strata, R_i. The resulting seven strata ratios were then weighted by the proportion of the total fall population observed in each stratum from the similarly timed, independent aerial survey count (Wilson 2017). The resulting weighted stratum estimates were then summed to yield the count-weighted estimate:

$$R' = \sum_i \frac{c_i R_i}{C},$$

where the population total C is calculated as $C = \sum_i c_i$ and c_i is the population count in each stratum. The standard error (SE) of R' was calculated as:

$$SE(R') = \sqrt{\sum_i \left(\frac{c_i}{C}\right)^2 Var(R_i)}.$$

RESULTS

Flights were conducted between 01 and 06 October 2015 with pilot B. Shults and photographer D. Marks (Table 1). Survey timing was approximately 111 days after the average hatch date for emperor geese on the Yukon-Kuskokwim delta (Fischer et al. 2016). Total flight time to complete the survey between King Salmon and Cold Bay was approximately 10 hrs.

We classified 30,391 geese ($\bar{x}$=12,223, 1985-2015) on 484 photographs ($\bar{x}$=403, 1985-2015) (Table 2). We counted an average of 62.8 birds/photograph ($\bar{x}$=30.3, 1985-2015). We identified 4,388 juvenile geese resulting in a self-weighted juvenile : total geese ratio of 0.144 (Fig. 4), and a count-weighted juvenile : total geese ratio of 0.142 (Fig. 5). For comparison, the long-term (i.e., 1985-2014) self-weighted and count-weighted estimates have averaged 0.192 and 0.189, respectively. For lagoons where geese were observed, ratio estimates varied between 0.102 and 0.239 (Table 3). Total number of geese counted at each lagoon (1985-2015) are summarized in Table 4.

DISCUSSION

The 2015 self-weighted estimate (i.e., 0.144) was 23% below the long-term (1985-2014) mean of 0.192 (Fig. 4) and was not notably different than the 2015 count-weighted estimate (i.e., 0.142). The mean calendar day of the 2015 survey period was 5 days (i.e., Day 278) later than the mean calendar day of previous surveys (i.e., Day 273). The mean age of juveniles during the survey period was 111 days based on hatching date estimated by Fischer et al. (2016) and was 11 days older than the estimated mean age of juveniles for all surveys (i.e., 100 days; 1985-2014). Corresponding data collected on the Yukon-Kuskokwim delta by Fischer et al. (2016) showed poor nest success (active nests/total nests) and very low clutch sizes (active eggs/active nest) in 2015 relative to long-term averages. In addition, because juveniles were nearly 2 weeks older, juvenile head plumage was difficult to identify in the photographs. The resulting ratios could be biased low because some juvenile geese may have been classified as adults if their head plumage had nearly completed the molt to white feathers. We recommend that the timing of the age-ratio survey be adjusted annually to coincide with a juvenile mean age estimate of 100 days determined by the current year mean hatching date estimate obtained from the Yukon-Kuskokwim delta nest plot survey.

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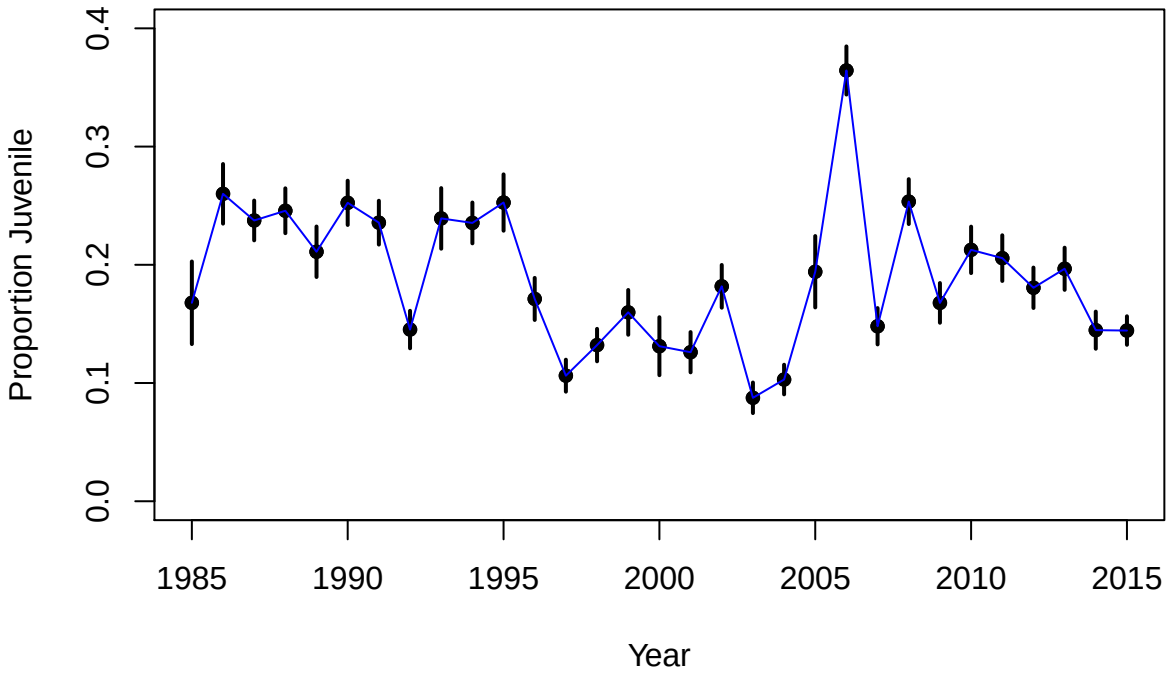

Figure 4: Self-weighted estimates and standard errors of the proportion of juveniles, 1985-2015.

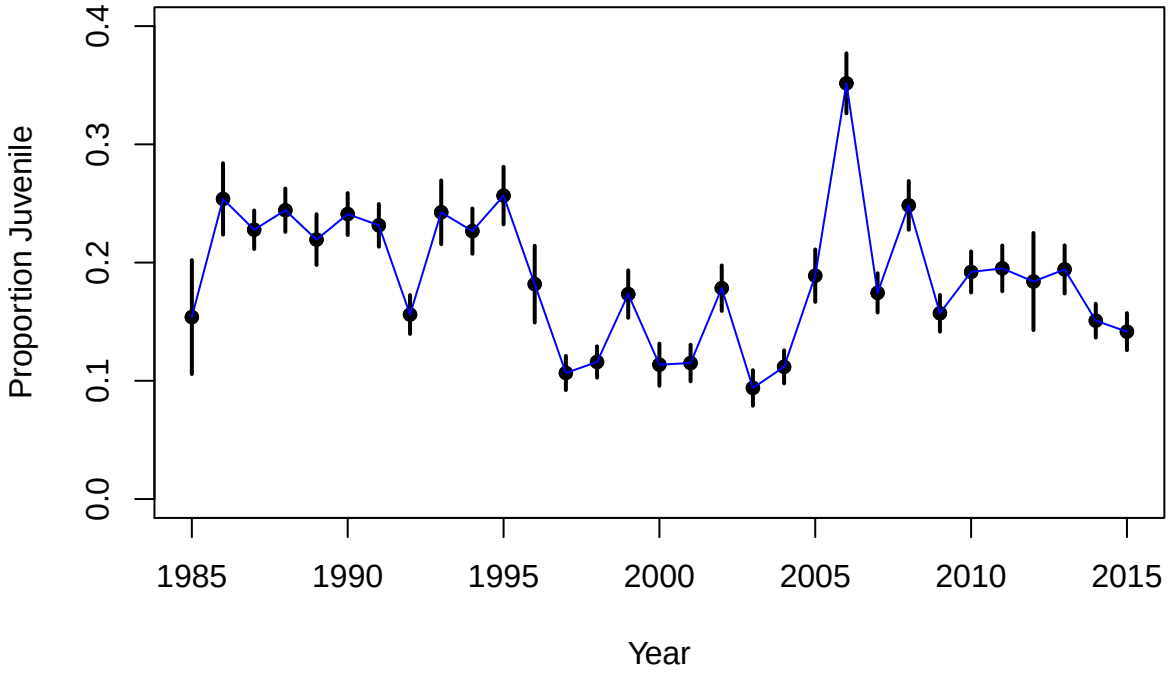

Figure 5: Count-weighted estimates and standard errors of the proportion of juveniles, 1985-2015.

Table 1: Annual Survey Crew and Timing, 1985-2015.

Year	Photograph Dates	Pilot	Photographer
1985	24 Sep; 02,03, 06, 10 Oct	W.I. Butler Jr.	M.R. Petersen
1986	30 Sep; 01,02, 04, 05, 11, 13, 15 Oct	W.I. Butler Jr.	M.R. Petersen
1987	16,24, 26 Sep; 06,07, 08, 10 Oct	W.I. Butler Jr.	M.R. Petersen
1988	07,21, 25, 26, 27, 30 Sep; 03 Oct	W.I. Butler Jr.	M.R. Petersen
1989	23,25, 28 Sep; 03 Oct	W.I. Butler Jr.	M.R. Petersen
1990	28,29, 30 Sep; 02 Oct	W.I. Butler Jr.	M.R. Petersen
1991	28,29 Sep; 01,03, 04 Oct	W.I. Butler Jr.	M.R. Petersen
1992	26,27, 30 Sep; 03,04 Oct	W.I. Butler Jr.	M.R. Petersen
1993	01,02, 03 Oct	W.I. Butler Jr.	G.R. Balogh
1994	26,27, 28, 29 Sep	W.W. Larned	G.R. Balogh
1995	26 Sep	W.W. Larned	G.R. Balogh
1996	23,25, 26 Sep	W.W. Larned	T.J. Tiplady
1997	30 Sep; 01 Oct	W.W. Larned	T.J. Tiplady
1998	29 Sep; 01 Oct	W.W. Larned	T.J. Tiplady
1999	28 Sep; 01 Oct	W.W. Larned	T.J. Tiplady
2000	25,28, 29 Sep	W.W. Larned	P.A. Anderson
2001	26 Sep; 01 Oct	W.W. Larned	P.A. Anderson
2002	01,02, 04 Oct	W.W. Larned	P.A. Anderson
2003	24,25, 27 Sep	W.W. Larned	P.A. Anderson
2004	04,06 Oct	W.W. Larned	P.A. Anderson
2005	02,03, 06 Oct	W.W. Larned	P.A. Anderson
2006	28,29 Sep; 02,03 Oct	K.S. Bollinger	C.P. Dau
2007	27,29 Sep; 02,03 Oct	W.W. Larned	P.A. Anderson
2008	26,27, 28 Sep	W.W. Larned	P.A. Anderson
2009	30 Sep; 02,03, 04, 06, 08 Oct	W.W. Larned	H.M. Wilson
2010	25,26 Sep	W.W. Larned	H.M. Wilson
2011	27,28, 29 Sep	W.W. Larned	H.M. Wilson
2012	28,29 Sep	W.W. Larned	H.M. Wilson
2013	20 Oct	H.M. Wilson	C.P. Dau
2014	26,27, 28 Sep; 04 Oct	B.S. Shults	W.W. Larned
2015	01,04, 06 Oct	B.S. Shults	D. Marks

Table 2: Sample size, survey timing, and proportion of juvenile emperor geese based on self-weighted and count-weighted estimates , Alaska Peninsula, 1985-2015.

Year	Number of Photos	Mean DOY Photo	Mean DOY Hatch[1]	Mean Age of young (days)	Total Juveniles	Total Geese	Self-weighted Estimate	SE	Count-weighted Estimate[2]	SE
1985	155	277	182	95	536	3,193	0.168	0.017	0.154	0.024
1986	311	278	178	100	1,659	6,380	0.260	0.013	0.254	0.015
1987	703	274	178	96	2,417	10,177	0.237	0.008	0.228	0.008
1988	483	269	174	95	2,747	11,180	0.246	0.009	0.244	0.009
1989	390	269	181	88	2,684	12,718	0.211	0.011	0.219	0.011
1990	474	273	172	101	3,418	13,541	0.252	0.009	0.241	0.009
1991	412	273	171	102	3,433	14,569	0.236	0.009	0.231	0.009
1992	403	274	182	92	2,154	14,832	0.145	0.008	0.156	0.008
1993	255	275	172	103	1,372	5,735	0.239	0.013	0.243	0.013
1994	479	270	170	100	3,974	16,881	0.235	0.009	0.227	0.010
1995	361	269	169	100	2,947	11,664	0.253	0.012	0.257	0.012
1996	182	268	169	99	1,847	10,793	0.171	0.009	0.182	0.016
1997	205	273	166	107	1,183	11,138	0.106	0.007	0.107	0.007
1998	336	272	175	97	2,185	16,544	0.132	0.007	0.116	0.007
1999	392	272	178	94	2,155	13,489	0.160	0.009	0.173	0.010
2000	263	272	176	96	1,016	7,748	0.131	0.012	0.114	0.009
2001	365	271	178	93	1,410	11,186	0.126	0.009	0.115	0.008
2002	402	275	169	106	1,174	6,458	0.182	0.009	0.178	0.010
2003	421	268	166	102	760	8,686	0.087	0.006	0.094	0.008
2004	370	278	165	113	642	6,237	0.103	0.006	0.112	0.007
2005	500	276	168	108	1,274	6,563	0.194	0.015	0.189	0.011
2006	469	272	175	97	3,561	9,773	0.364	0.010	0.352	0.013
2007	398	273	170	103	1,796	12,134	0.148	0.008	0.174	0.008
2008	625	270	174	96	2,587	10,207	0.253	0.009	0.248	0.010
2009	607	276	175	101	2,081	12,404	0.168	0.008	0.157	0.008
2010	436	269	171	98	4,439	20,876	0.213	0.010	0.192	0.009
2011	441	271	183	88	3,996	19,432	0.206	0.010	0.195	0.010
2012	378	272	164	108	2,367	13,109	0.181	0.009	0.184	0.021
2013	224	293	181	112	2,216	11,269	0.197	0.009	0.194	0.010
2014	570	271	166	105	2,839	19,619	0.145	0.008	0.151	0.007
2015	484	278	167	111	4,388	30,391	0.144	0.006	0.142	0.008

[1] From Fischer et al. 2016.
[2] Based on Wilson 2017.

Table 3: Estimates of the proportion of juveniles at each staging area along the Alaska Peninsula, 1985-2015.

Year	Egegik	Ugashik	Cinder River	Port Heiden	Seal Islands	Nelson Lagoon	Izembek
1985	0	0	0.087	0.218	0.235	0.153	0.175
1986	0.174	0.268	0.277	0.156	0.164	0.337	0.317
1987	0	0.046	0.251	0.195	0.220	0.261	0.230
1988	0.253	0.167	0.273	0.239	0.198	0.254	0.232
1989	0.242	0.092	0.196	0.191	0.130	0.282	0.221
1990	0.156	0.171	0.339	0.224	0.232	0.247	0.166
1991	0.199	0.106	0.302	0.237	0.207	0.225	0.213
1992	0.076	0.089	0.181	0.122	0.069	0.176	0.233
1993	0.094	0.211	0.231	0.171	0.148	0.296	0.298
1994	0.236	0.192	0.235	0.248	0.261	0.219	0.166
1995	0.256	0.128	0.289	0.235	0.216	0.256	0.259
1996	0.269	0	0.150	0.165	0.177	0.225	0.156
1997	0.148	0.037	0.103	0.142	0.102	0.092	0.083
1998	0.192	0	0.141	0.114	0.150	0.067	0.103
1999	0.554	0	0.070	0.157	0.093	0.202	0.170
2000	0.095	0.055	0.189	0.113	0.087	0.061	0.254
2001	0.179	0.144	0.149	0.038	0.113	0.104	0.143
2002	0.189	0.271	0.176	0.178	0.192	0.170	0.172
2003	0.067	0.051	0.120	0.048	0.136	0.069	0.051
2004	0.125	0.116	0.102	0.062	0.148	0.117	0.081
2005	0.091	0.169	0.120	0.138	0.234	0.198	0.378
2006	0.259	0.431	0.370	0.297	0.300	0.392	0.377
2007	0.217	0.096	0.164	0.084	0.250	0.157	0.243
2008	0.254	0.224	0.316	0.303	0.207	0.244	0.267
2009	0.297	0.074	0.238	0.137	0.134	0.127	0.172
2010	0.297	0.061	0.251	0.200	0.139	0.207	0.163
2011	0.26	0.169	0.229	0.191	0.184	0.192	0.121
2012	0.185	0.237	0.135	0.231	0.180	0.190	0.183
2013	0	0.023	0.100	0.215	0.186	0.254	0.094
2014	0.159	0.059	0.177	0.076	0.169	0.141	0.171
2015	0.163	0.239	0.152	0.143	0.102	0.156	0.130

Table 4: Total emperor geese photographed and classified at each staging area along the Alaska Peninsula, 1985-2015.

Year	Egegik	Ugashik	Cinder River	Port Heiden	Seal Islands	Nelson Lagoon	Izembek
1985	NA	NA	334	156	412	1,106	1,185
1986	362	272	2,038	512	1,060	1,317	819
1987	28	109	2,845	1,721	912	3,659	903
1988	166	354	3,014	2,229	1,342	3,605	470
1989	33	573	3,763	1,210	1,822	3,976	1,341
1990	180	685	3,351	1,842	2,364	4,028	1,091
1991	322	142	3,045	2,170	3,589	4,069	1,232
1992	381	418	3,296	2,430	2,888	4,681	738
1993	117	128	1,327	632	851	2,025	655
1994	440	208	6,058	2,077	4,112	2,884	1,102
1995	313	313	2,636	2,074	1,201	3,989	1,138
1996	668	46	3,740	2,887	930	1,051	1,471
1997	480	543	3,811	2,356	1,156	1,617	1,175
1998	558	NA	8,557	2,092	3,004	1,624	709
1999	395	NA	1,986	3,615	2,289	4,089	1,115
2000	529	236	2,345	1,013	916	1,938	771
2001	610	582	4,219	960	2,031	1,965	819
2002	90	96	1,868	650	2,133	1,203	418
2003	600	215	2,299	1,364	1,251	2,503	454
2004	200	242	1,602	706	736	1,387	1,364
2005	374	326	1,365	1,634	852	918	1,094
2006	158	130	2,534	1,083	830	3,801	1,237
2007	568	272	2,712	4,272	1,322	2,494	494
2008	731	675	1,442	955	2,363	2,736	1,305
2009	626	257	2,653	1,524	2,382	2,988	1,974
2010	2,109	279	6,927	1,588	4,122	4,932	919
2011	1,299	727	6,697	2,359	2,077	5,735	538
2012	671	645	3,383	2,176	4,385	327	1,522
2013	NA	43	502	2,140	5,424	2,477	683
2014	793	409	3,081	3,099	3,649	5,908	2,680
2015	2,229	419	11,443	4,420	4,053	4,929	2,898