MONITORING THE EMPEROR GOOSE POPULATION BY AERIAL COUNTS AND FALL AGE RATIO – FALL 2006.

By

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Abstract

Flocks of emperor geese (*Chen canagica)* staging during fall migration in estuaries along the north side of the Alaska Peninsula were photographed for the 22nd consecutive year to obtain an estimate of the proportion of juveniles in the fall population. From 28-29 September and 2-3 October, 2006, 469 digital photographs were taken of emperor goose flocks. Based on the gray head and neck plumage still evident on juvenile geese, we determined ages of 9,773 emperor geese comprised of 6,212 adults and 3,561 juveniles which comprised a self-weighted proportion of 0.364 The estimated ratio was 0.352 juveniles using a stratified sampling design with stratum weights based on the proportion of the total emperor population counted in each estuary during an independent aerial survey (i.e. count-weighted). The proportion of juveniles observed in 2006 was the highest recorded since the photographic monitoring began in 1985. Data from 1985-2006 indicate an overall average of 0.191 juveniles in the fall emperor goose population with a range from 0.092-0.352. A tabulation of consecutive years of population count data partitioned by young and adult birds estimated the average combined-age annual survival rate as 0.83.

Objectives

The primary objective of this monitoring study is to provide an annual estimate of the proportion of juvenile (hatching-year) emperor geese in the fall staging population. These data help fulfill the requirement for productivity data stipulated in the Pacific Flyway Management Plan (section B.3, Pacific Flyway Council 2006). In combination with a similarly timed, independent aerial population survey, these data also address secondary objectives including estimation of population trend, productivity, and average annual survival rate. Data on geographic distribution of emperor geese and associated bird species are especially valuable for addressing possible impacts from various types of development activities affecting waterbird habitats within Bristol Bay.

Methods

Butler et al. (1995) described in detail the methods used for both data acquisition and analysis with regard to both the fall population and productivity surveys. We followed the same survey protocols except that in 2006, digital photography replaced conventional color slides. We used a Canon 20D digital camera with a 135mm lens. The focal length was set at infinity and speed at 1:500 second. The LCD display allowed for rapid assessment of image quality. Downloaded images were viewed on a laptop computer and each bird was classified by age. Gray head and neck plumage retained by young of the year into early October contrasts with the white head plumage of adult geese. The estimated mean proportion of juveniles in each survey region (adjacent barrier island, beach, mudflat, and lagoon estuarine system) was calculated as a ratio estimate with each photo as an independent sample unit. In each region, the mean proportion was weighted by the proportion of the total fall population in that region based on a similarly timed independent aerial survey count (Mallek and Dau 2005, report in prep.). In addition to this count-weighted stratified estimate, the self-weighted proportion of juveniles is also reported. Self-weighted estimates are appropriate when the sampling intensity (i.e. the number of birds in photographs) is proportional to the population size within each region (i.e. more birds photographed where more birds are present). The age ratio calculated by either weighting method did not differ appreciably. The largest difference between methods was 0.018. The self-weighted method estimated slightly more juveniles in 13 of 22 years, and the average difference was -0.002 (SD = 0.0099) including all years of data. We preferred the count-weighted method because it used more information and, assuming population survey counts are timely and accurate, gave a defensible design-based estimate not reliant on an untested assumption of strictly proportionate sampling.

Annual data on population size and age composition allowed estimation of both production and mean survival rate (Lynch and Singleton 1964, Ogilvie 1978, Owen 1980, Kirby et al. 1986). Annual mortality was calculated by subtracting the estimated adult population of the current year from the total population count of the previous year (i.e. the birds missing from last October's population). Mortality rate was the mortality number divided by the total population count of the earlier year. Survival rate was 1- mortality rate. Although the population count each year may be imprecise due to sampling error or other influences, the errors compensate when the population table is analyzed over consecutive years. A deviation resulting in a relatively high population count, thus a low number missing and high survival rate from the previous year, will most often be followed by a high number missing and low survival rate when calculated from that same high count now compared to the population count of the next year. Deviations in population count or conditions tend to return towards a typical or central value resulting in alternating high and low survival estimates. Any error in population count amplified the variability among estimates of annual survival; however, the mean of consecutive survival estimates became less variable due to the compensating effect of alternating errors. We calculated annual survival estimates, and the average consecutive survival estimates for 2 years (prior and current year) and 6 years (3 years prior, current year, and 2 years post).

Results and Discussion

Karen Bollinger piloted the photographic flights in Cessna 206 amphib N234JB on 29 September and 2-3 October. Edward Mallek piloted DH-2T N754 for the population count from 26-28 September and a preliminary photographic flight on 28 September. Christian Dau was the photographer and observer throughout. The fall population count was 81,078 emperor geese (Mallek and Dau 2006, report in prep.). The photographic sample in 2006 included 469 digital images with an average of 20.8 birds per image. The 1985-2005 data averaged 398 images with 28.5 birds per image. We sampled 9,773 birds identifying 6,212 as adults and 3,561 as juveniles for a self-weighted estimate of 0.364 young. The stratified count-weighted proportion of juveniles was 0.352 with a standard error (SE) of 0.0230 (Fig. 1, Table 1). Proportional distribution has varied somewhat throughout the duration of the study (Table 2). The count-weighted proportion of juveniles ranged from 0.092 in 2003 to 0.352 in 2006. The estimated precision of the mean proportion, the SE, was 0.0230 in 2006 and comparable to the average SE of 0.0226 from all survey years. The range of SE among years was 0.0142-0.0461. The two least precise estimates had a sample size of less than 200 photos. Plotting SE in all years against sample sizes indicated that a minimum of about 330 photographs with 7000 birds provided consistently precise estimates.

We used the photographic estimate of the proportion of juveniles to determine the composition of the total population (Fig. 2, Table 3). The total fall count of the previous year minus adult-plumaged birds from the current year yields the number of birds that were lost (mortality number) during the year since the previous fall count (Table 3). The average from 1986-2006 (n=21) October-to-October mortality number is 14,045 birds. The negative mortality estimates in 1990, 2002, and 2004 reflected counting errors (Table 3). Averaging the annual survival rate across consecutive years incorporated the compensating effect of error in counts and provided an increasingly reliable depiction of trend in average survival rate (Fig. 3). The overall annual October to October survival rate from 1986-2006 for all ages of emperor geese was 0.83 (Table 3). Annual estimates of survival rate have been relatively high (>0.86) for 5 of the last 7 years (Fig. 3). The 7-year average annual survival rate of 0.880 for 2000-2006 exceeded the average survival rate of 0.806 in the previous 14 years from 1986-1999.

The average annual production of 14,170 young birds in October (1985-2005, n=21) exceeded the average mortality number of 14,045 (1986-2006, n=21) by only 125 birds per year (Table 3). The long-term near balance of production and mortality in this population emphasizes the importance of reduction of manageable mortality factors, primarily illegal harvest and predation. Increased adult survival and increased production and survival of young are essential for recovery of the population.

The strong cohort of young produced in 2006 is a remarkable change from a pattern of low and declining age ratios recorded since 1985 (Fig. 1). Historic data (Pacific Flyway Council 2006) collected by ground observers at Izembek Lagoon included age ratios above 30% juveniles in 7 of 18 years between 1966 and 1984, before the current Alaska Peninsula photographic sampling began. Only 3 years, 1975 (35%), 1977 (41%), and 1969 (42%), had equal or higher age ratios than 2006. Since 1985, in only one of 22 years has the age ratio estimate been above 30% juveniles (1987, 33.8%).

Aerial transect surveys and nest plot sampling on the Yukon-Kuskokwim Delta during early June 2006 indicated no unusual change in population indices for emperor geese. Estimated numbers of breeding pairs and nests have slowly increased during the last 10 years. The number of nests and production of eggs in 2006 were slightly less than in 2005.

Reasons for the high proportion of juvenile emperor geese in fall 2006 are unknown. We believe post-breeding storm surges, which have inundated emperor goose habitats during recent years on the Yukon-Kuskokwim Delta, may be important contributing factors. These storm surges essentially eliminated microtine rodents from a large proportion of emperor goose breeding habitats and removed a primary food source for Arctic foxes (*Alopex lagopus*), a primary nest predator. As a result, indications are that fox population size and productivity have both declined (P. Flint, USGS-ASC, pers comm.). Decreased fox numbers may have increased survival of eggs and goslings and may partially explain the high productivity we observed.

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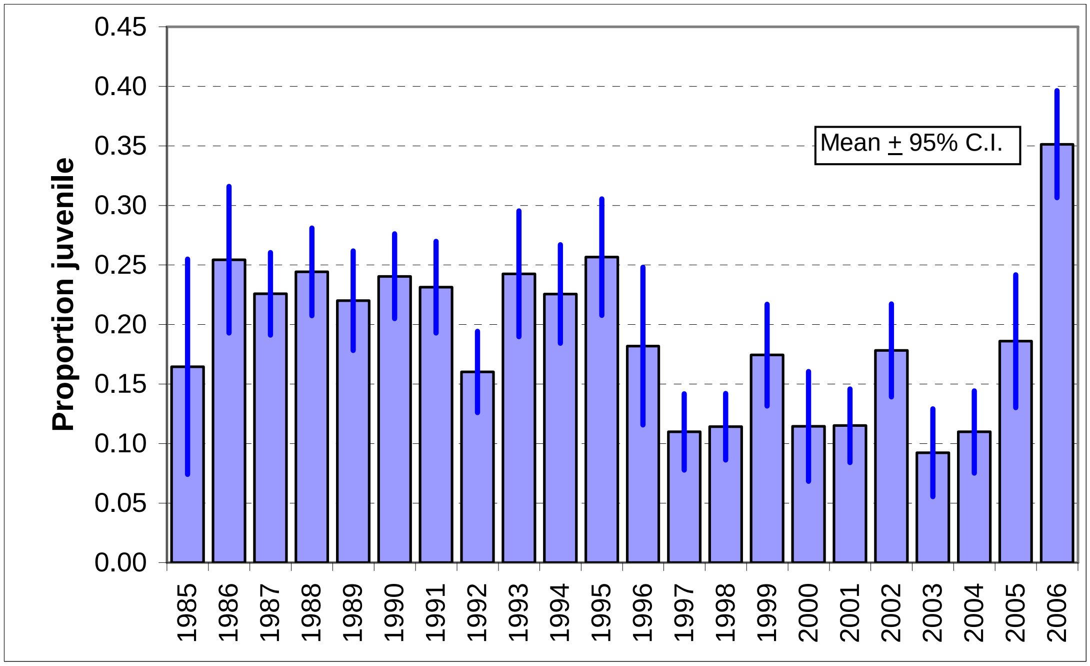

Figure 1. Observed proportion of juvenile emperor geese in the fall population on the Alaska Peninsula, 1985-2006.

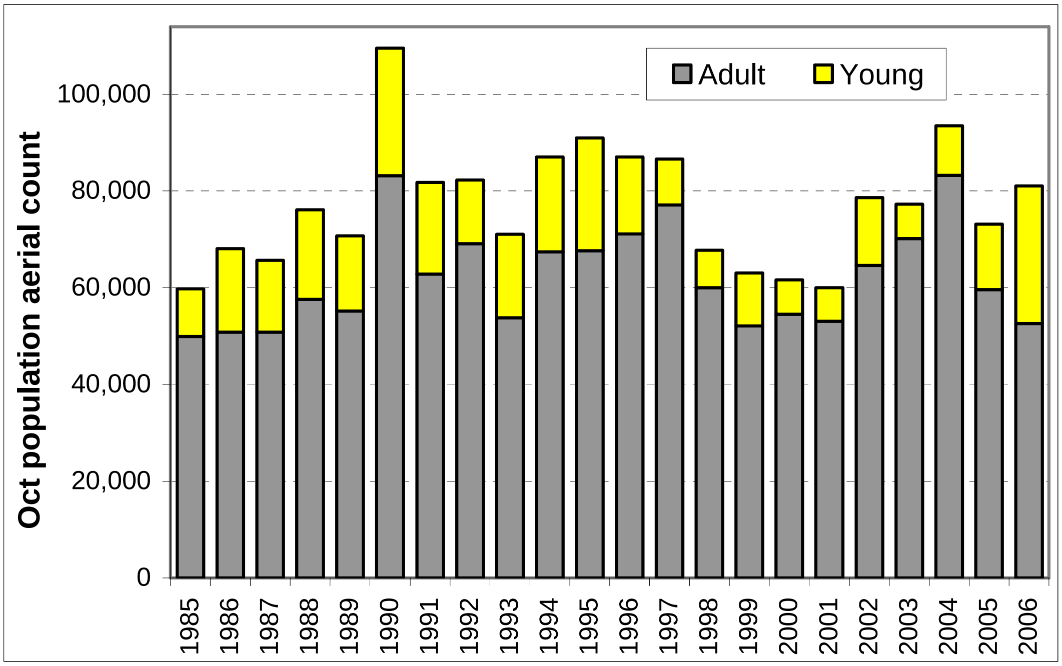

Figure 2. Demography of the fall emperor goose population along the north side of the Alaska Peninsula.

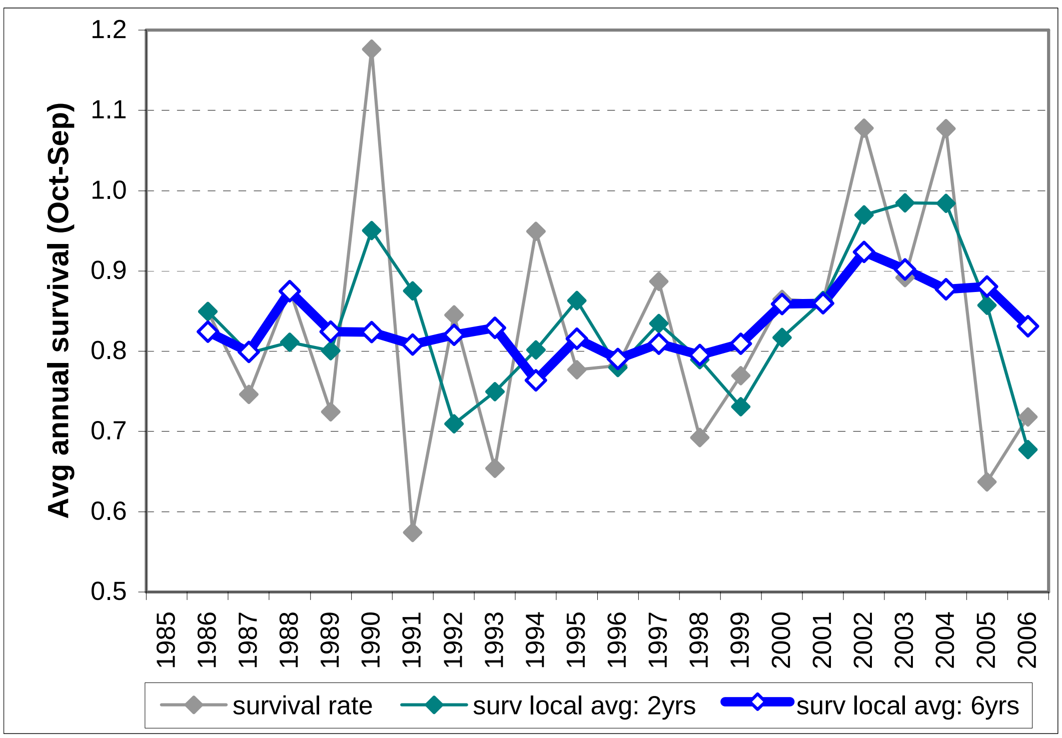

Figure 3. Annual, 2-year average, and 6-year average survival rates for emperor geese calculated from a population table including annual fall population counts and age ratios.

Table 1. Survey timing, sample size, and overall proportion of juvenile emperor geese in aerial photographic samples of flocks on the Alaska Peninsula, 1985-2006.

Year	Dates	Number of photos	Birds per photo	Total birds	Juveniles	Count-weighted Mean	Count-weighted SE	Self-weighted Mean	Self-weighted SE
1985	24 Sept., 2,3,6,10 Oct.	155	20.6	3193	536	0.1646	0.0461	0.1679	0.0322
1986	30 Sept., 1,2,4,5,11,13,15 Oct.	311	20.5	6380	1659	0.2543	0.0314	0.2600	0.0266
1987	16, 24, 26 Sept., 6, 7, 8, 10 Oct.	703	14.5	10177	2417	0.2259	0.0177	0.2375	0.0166
1988	7,21,25,26,27,30 Sept., 3 Oct.	483	23.1	11180	2747	0.2442	0.0188	0.2457	0.0192
1989	23, 25, 28 Sept., 3 Oct.	390	32.6	12718	2684	0.2201	0.0213	0.2110	0.0204
1990	28, 29, 30 Sept., 2, 4 Oct.	474	28.6	13541	3418	0.2405	0.0181	0.2524	0.0184
1991	28,29 Sept., 1, 3, 4 Oct.	412	35.4	14569	3433	0.2312	0.0196	0.2356	0.0194
1992	26, 27, 30 Sept., 3, 4 Oct.	403	36.8	14832	2154	0.1602	0.0174	0.1452	0.0158
1993	1, 2, 3 Oct.	255	22.5	5735	1372	0.2426	0.0269	0.2392	0.0266
1994	26 Sept.	535	31.6	16881	3974	0.2256	0.0211	0.2354	0.0184
1995	26-29 Sept.	382	30.5	11664	2947	0.2566	0.0249	0.2527	0.0258
1996	23, 25, 26 Sept.	182	59.3	10793	1847	0.1818	0.0338	0.1711	0.0167
1997	30 Sept.,1 Oct.	205	54.3	11138	1183	0.1098	0.0164	0.1062	0.0148
1998	29 Sept.,1 Oct.	337	49.1	16544	2185	0.1142	0.0142	0.1321	0.0117
1999	28 Sept.,1 Oct.	457	29.5	13489	2155	0.1743	0.0218	0.1598	0.0200
2000	25, 28, 29 Sept.	340	22.8	7748	1016	0.1144	0.0235	0.1311	0.0362
2001	26 Sept., 1 Oct.	382	29.3	11186	1410	0.1150	0.0157	0.1261	0.0195
2002	1, 2, 4 Oct.	432	14.9	6458	1174	0.1784	0.0199	0.1818	0.0197
2003	24-25, 27 Sept.	489	17.8	8686	760	0.0923	0.0187	0.0875	0.0167
2004	4, 6 Oct.	464	13.4	6237	642	0.1099	0.0176	0.1029	0.0171
2005	2, 3, 6 Oct.	576	11.4	6563	1274	0.1859	0.0284	0.1941	0.0335
2006	28, 29 Sept., 2, 3 Oct.	469	20.8	9773	3561	0.3515	0.0230	0.3644	0.0199

Table 2. Proportion of juvenile emperor geese in estuaries along the Alaska Peninsula, 1985-2006.

Year	Egegik Bay	Ugashik Bay	Cinder River	Port Heiden	Seal Islands	Nelson Lagoon	Izembek & Cold Bay
1985			0.0868	0.2179	0.2354	0.1528	0.1747
1986	0.1740	0.2684	0.2772	0.1563	0.1642	0.3371	0.3175
1987		0.0459	0.2506	0.1952	0.2204	0.2607	0.2303
1988	0.2530	0.1667	0.2734	0.2387	0.1982	0.2538	0.2319
1989	0.2424	0.0925	0.1959	0.1909	0.1295	0.2822	0.2215
1990	0.1556	0.1708	0.3393	0.2237	0.2322	0.2468	0.1659
1991	0.1988	0.1056	0.3018	0.2373	0.2070	0.2246	0.2135
1992	0.0761	0.0885	0.1805	0.1222	0.0686	0.1765	0.2331
1993	0.0940	0.2109	0.2306	0.1709	0.1481	0.2958	0.2977
1994	0.2364	0.1923	0.2351	0.2480	0.2614	0.2195	0.1661
1995	0.2556	0.1278	0.2895	0.2348	0.2165	0.2562	0.2592
1996	0.2695	0.0000	0.1497	0.1649	0.1774	0.2255	0.1557
1997	0.1479	0.0368	0.1034	0.1422	0.1021	0.0915	0.0826
1998	0.1918		0.1411	0.1138	0.1505	0.0665	0.1030
1999	0.5544		0.0705	0.1574	0.0931	0.2015	0.1704
2000	0.0945	0.0551	0.1893	0.1125	0.0873	0.0614	0.2542
2001	0.1787	0.1443	0.1493	0.0375	0.1128	0.1043	0.1429
2002	0.1889	0.2708	0.1761	0.1785	0.1917	0.1704	0.1722
2003	0.0667	0.0512	0.1205	0.0484	0.1359	0.0691	0.0507
2004	0.1250	0.1157	0.1017	0.0623	0.1481	0.1168	0.0814
2005	0.0909	0.1687	0.1201	0.1383	0.2336	0.1983	0.3784
2006	0.2595	0.4308	0.3702	0.2973	0.3000	0.3917	0.3767

Table 3. Fall population count, composition and estimate of annual survival, Alaska Peninsula, 1985-2006.

Year	Population Count	Age-ratio[1]	Adults	Juveniles	Mortality Number[2]	Survival Rate[3]
1985	59790	0.1646	49947	9843		
1986	68051	0.2543	50282	17151	9508	0.841
1987	65663	0.2259	50829	14834	16604	0.754
1988	76165	0.2442	57564	18601	8099	0.877
1989	70729	0.2201	55162	15567	21003	0.724
1990	109531	0.2405	83189	26342	-12460	1.176
1991	75295	0.2312	57885	17409	51646	0.528
1992	82295	0.1602	69110	13185	6184	0.918
1993	71051	0.2426	53817	17234	28478	0.654
1994	87086	0.2256	67438	19648	3613	0.949
1995	91009	0.2566	67653	23356	19433	0.777
1996	87018	0.1818	71201	15817	19808	0.782
1997	86669	0.1098	77152	9517	9866	0.887
1998	67744	0.1142	60007	7737	26662	0.692
1999	60226	0.1743	49727	10499	18017	0.734
2000	61626	0.1144	54574	7052	5652	0.906
2001	59987	0.1150	53087	6900	8539	0.861
2002	78692	0.1784	64657	14035	-4670	1.078
2003	77290	0.0923	70154	7136	8538	0.891
2004	93544	0.1099	83265	10279	-5975	1.077
2005	73212	0.1859	59603	13609	33941	0.637
2006	81078	0.3515	52579	28499	20633	0.718

[1] Count-weighted.
[2] Population count minus adult plumaged birds the following year.
[3] Adults divided by population count from the previous year.