Summary Report- 30 June 2011

Aerial Photographic Survey of Brant Colonies on the Yukon-Kuskokwim Delta, Alaska, 2011

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ABSTRACT I conducted an aerial photographic survey of nesting Pacific black brant (*Branta bernicla nigricans*) at the five primary colonies on the Yukon-Kuskokwim Delta (YKD), Alaska, USA: Kokechik Bay (KB), Tutakoke River (TR), Kigigak Island (KI), Baird Peninsula (BP), and Baird Island (BI), between 3-4 June 2011. Total number of nests for all colonies increased by 26% between 2011 (12,106) and 2010 (9,641), although the 2011 estimate remained 25% lower than the long term average (16,089; 1992-2011). All colonies experienced an increase in brant nests from the previous year (range: 2 to 80%), with the exception of BP (-49%), where substantial flooding occurred during the photographic survey. Overall, the trend in annual YKD estimates of nesting brant among the five primary colonies continues to be negative (currently -3.2%/yr), although site-specific long-term trends (with the exception of BP) all improved slightly in 2011. The long-term trends at TR and KB (including 2011) marked the fourth consecutive year of substantial negative departures from the long-term YKD log-linear trend (e.g., 4-6% annual declines at TR and KB versus 3.2% annual decline for all YKD), indicating that most of the long term decline continues to be attributed to reductions at KB and TR. Based on aerial imagery and ground-truthing, 2011 reflected a better than average nesting year for colonial nesting brant on the YKD relative to the 3-yr running average, with few indications of fox or avian predation. Although substantial wind and tide-induced flooding at BP resulted in reduced brant nests at that location (-49% reduction from 2010), nearby BI increased by 80% (from 2010), providing continued evidence that the two neighboring colonies may functionally behave as one, with alternating nesting conditions influencing annual nesting densities. Human activity (based on numbers of photos with footprints and vehicle tracks) was reduced at all colonies in 2011.

KEY WORDS aerial photographic survey, nesting colonies, Pacific black brant, Yukon-Kuskokim Delta

During the mid-1980's, declining numbers of nesting Pacific black brant (*Branta bernicla nigricans*) on the Yukon-Kuskokwim Delta (YKD), Alaska (Sedinger et al. 1993) generated interest in developing an efficient method to estimate the number of individuals nesting in large colonies. Previously, ground crews surveyed colonies with strip transects or circular plots (Byrd et al. 1982, J. Sedinger unpubl. data). However, due to high nest densities and large areas associated with colonies, labor intensive ground-plots were considered impractical and visual counts from aircraft were considered imprecise for estimating colony size. As an alternative, aerial imagery was tested (Anthony et al. 1995), and beginning in 1992, aerial videographic surveys were conducted annually at 5 major brant nesting colonies on the YKD (Anthony 1992-2003; Fig. 1). In 2004, the survey changed from videography (i.e., using a digital camcorder) to still-frame, digital photography (Anthony 2004-2006). The goal of these surveys is to establish YKD colony indices to help guide population recovery efforts for Pacific black brant, including annual harvest guidelines (Pacific Flyway Council 2002). Additionally, data collected from photographic surveys provides information on human use of colony areas, nest densities of other species (e.g., cackling goose; *Branta hutchinsii minima*), and habitat change. Herein, I report the results of the 2011 survey.

STUDY AREA

I conducted aerial photographic surveys of nesting Pacific black brant at the five primary colonies currently recognized on the YKD, Alaska, USA (Fig. 1): Kokechik Bay (KB; 165°56'59W, 61°38'51N), Tutakoke River (TR; 165°36'59W, 61°14'N), Kigigak Island (KI; 165°00'36W, 60°50'N), Baird Peninsula (BP; 164°41'16W, 60°53'N), and Baird Island (BI; 164°36'18W, 60°50'33N), on 3-4 June 2011.

METHODS

Aerial Survey

Transects were flown at 122 m above ground level and I used a single, vertically-mounted Nikon D700 SLR® digital still camera with an image-stabilizing lens (70-200 mm) to photograph colonies. Transects were flown at speeds ranging from 92-148 km/hr (50-80 knots, 58-92 mph ground-speed) over all colonies. All transects were flown into the wind, with ~10° of flaps deployed. This slowed the aircraft (an amphibious Cessna 206) and maximized the number and quality of photos that could be taken on each transect. KB, TR, KI, BP, and BI required 0:57 (hours:minutes), 1:45, 1:24, 0:49, and 0:48, respectively, from start of first transect to end of last transect. The camera was set to maximum shutter speed with an aperture of f2.8, focal length of 105-mm, and auto-focused at survey altitude (usually near infinity). After the focus was set, I turned off the auto focus function and taped the focal ring in place.

The Nikon D700 camera had a 12.1-megapixel FX-format CMOS 23.9 x 36 mm photo sensor and sampled non-overlapping 0.12-hectare (41.8 x 27.9 m) ground footprints through holes in the floor of a Cessna-206 amphibious aircraft. Sampling protocol was similar to that in previous years, where systematically spaced flight lines (200 m apart) were flown along the long axis of all colonies (Anthony 2003-2006).

The location of transects, lead-in lines to transects, as well as the track of the moving aircraft were displayed on a GPS (Garmin 296®) mounted to the dash of the Cessna-206 and monitored by the pilot during the survey. A separate handheld GPS unit (Garmin 60Cx®) was interfaced with a laptop computer attached to the digital camera. Latitude-longitude, GPS altitude, time-date, and other photographic information were stored internally with each image (Anthony 2004). Additionally, a continuous GPS track-file (in which new coordinates were recorded every 3 sec.) was logged during all survey flights. I used the time-differential between the time stamp on the GPS (track file) and the time stamp on the photos to interpolate image locations using GPS-Photo Link software (GPS-PHOTO LINK 2006).

Ground-truthing, nest detection, and correction factors

An assistant and I ground-truthed a sub-sample of photos at KI, KB, and TR (areas with good access by float plane), to determine the nest detection probability as estimated in digital images. Preparation for ground-truthing involved processing digital photos in GPS-Photo link®, printing 8.5 x 11" copies of photos to be truthed,

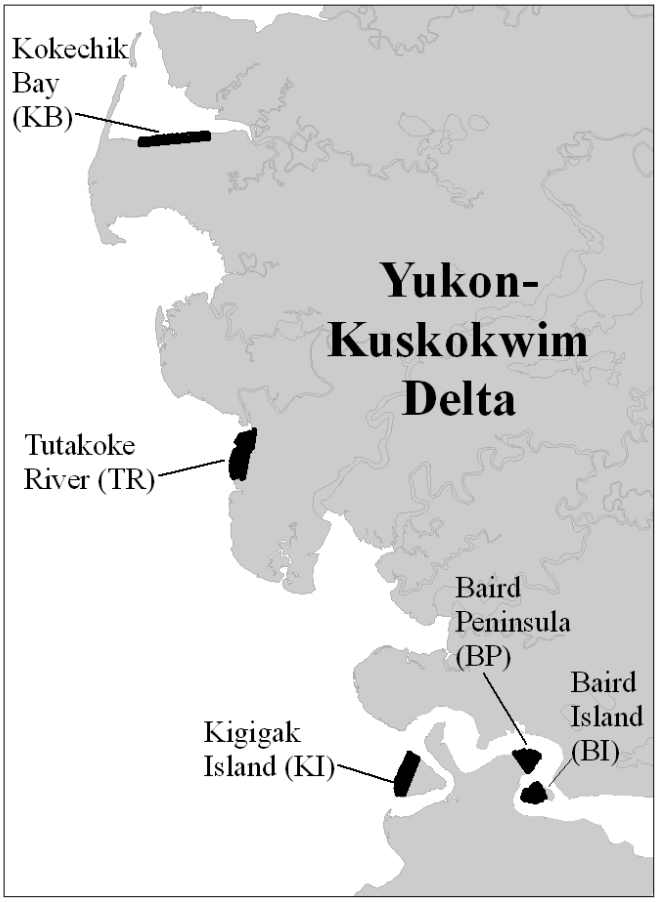

Figure 1. Photographic survey areas of the five primary Pacific black brant nesting colonies on the Yukon-Kuskokwim Delta.

creating ArcMap geographic information system (GIS) shapefiles (.shp) and Google Earth files (.kml) of photo locations, and mapping photo locations on high resolution (1m/pixel) satellite imagery (IKONOS 2008). To aid in navigation during ground-truthing, we created maps of photo locations and downloaded true photo center-point coordinates to hand-held GPSs. We performed the ground-truthing by carefully searching each of the selected photo locations and recording all waterfowl nests observed, identified to

species, and considered active, abandoned, or destroyed, within the boundaries of each printed photo. Because I included both errors of omission (not counting incubating brant) and commission (misidentifying other objects as incubating brant, e.g., standing brant or incubating cackling geese), my detection metric had the potential to be >1, and thus, was better termed an "index ratio" (Bart et al. 1998), than a probability. I calculated this index ratio ($\hat{R}$) as the pooled number of brant nests observed on aerial images (y) to brant nests located on the ground (x) across the three ground-truthed colonies, and used the variance of the index ratio (assuming no covariance between x and y) according to Cochran (1963),

$$Var\,\hat{R} = \frac{\sum\left(y_i - \hat{R}\,x_i\right)^2}{n(n-1)\cdot\left(x_i\right)^2}.$$

I then used the inverse of $\hat{R}$ as a visibility correction factor for all colonies to correct image-based counts (y) for combined errors of commission and omission, according to the formula,

$$\text{Corrected count} = \frac{y}{\hat{R}}.$$

Image processing

I determined total area in each colony with ArcGIS. I used the colony boundaries as re-outlined in 2009 (using IKONOS imagery base maps, 1m/pixel resolution). I computed the area sampled by the photographs based on altitude, lens focal length, and the number of photographs taken per colony within the colony boundaries. Assistants and I viewed image files (.jpg) on computers with a custom program written in MATLAB®). Images of known nests from previous years were displayed as background on the computer monitor and on printed sheets as a reference for image-scale and appearance of different postures and behaviors of birds. As images were reviewed, text data files were created, including image file name, photo sub-area being viewed, and a two-digit observation code characterizing observed behavior (e.g., standing, sitting on nest, flying), and species identification. All photos with observations were reviewed by a second observer, as a means of quality control.

Boot tracks and motorized vehicle tracks were counted at KB, BP, and BI, but no measure of human activity was quantified at KI or TR because of ongoing research activity at those sites.

Species other than brant

In addition to recording observations of brant, assistants and I recorded Pacific (*Gavia pacifica*) and red-throated loons (*G. stellata*), tundra swans (*Cygnus columbianus*),

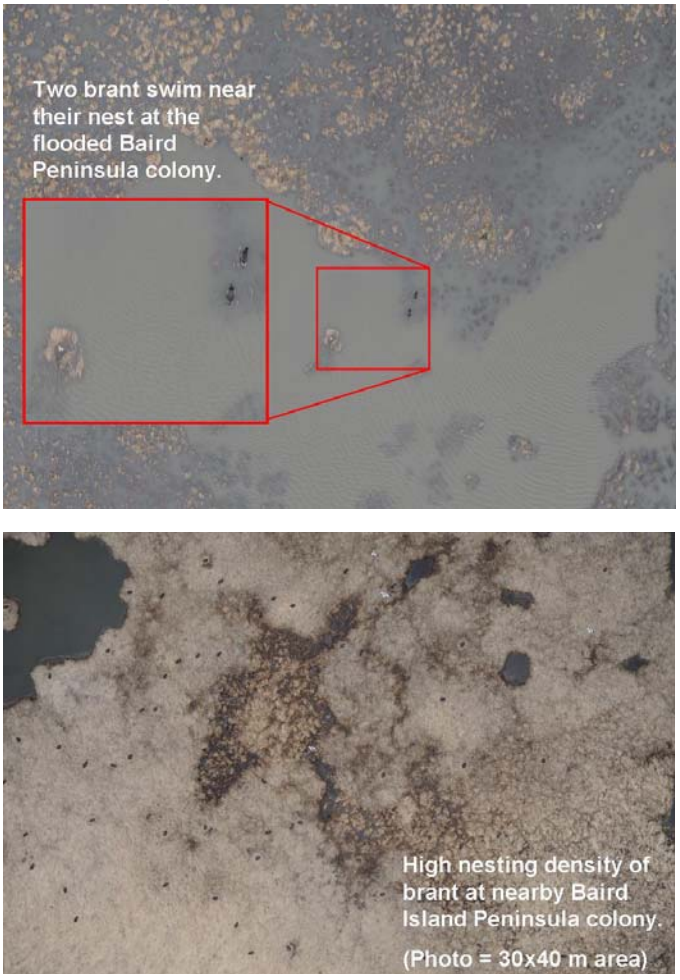

Figure 2. High-resolution digital images (Nikon D700 SLR camera) of 2011 flooded nesting environment at Baird Peninsula (above) versus high density brant nesting at nearby Baird Inlet Island (below: black dots in full scale photo are nesting and standing brant as seen from an altitude of 122 m).

emperor geese (*Chen canagica*), white-fronted geese (*Anser albifrons frontalis*), cackling geese (*Branta hutchinsii*), common and spectacled eiders (*Somateria*

mollissima, S. fischeri), greater scaup (*Aythya marila*), long-tailed ducks (*Clangula hyemalis),* northern shovelers (*Anas clypeata*), and northern pintails (*Anas acuta*). Given the high resolution, large sample size, and improved coverage of images with the Nikon D700 camera, I had sufficient observations to generate nest population estimates for cackling, emperor, and greater white-fronted geese, as well as eiders (common and spectacled combined) within the brant colony study areas. Results for these other species are presented in Appendix 1.

RESULTS

The number of images collected at KB, TR, KI, BP, and BI within colony boundaries was 1070, 1232, 1048, 562, and 486, respectively. Thus, given total colony areas of 1044 (KB), 1468 (TR), 1130 (KI), 666 (BP), and 583 (BI) hectares, the 2011 photos represented a sample of 11.9, 9.8, 10.8, 9.8, and 9.7% of each of the respective colony areas and was equivalent to the coverage achieved in previous years (2009 coverage range: 10.3-12.3%, 2010 coverage range: 8.8-15.7%). Surveys at KB and TR were conducted on 3 June 2011 between 12:14 and 15:15 hrs. Surveys at KI, BP, and BI, and KI were conducted on the following day, 4 June 2011, between 16:16 and 19:50 hrs. Survey weather conditions were ideal on the first day (partly sunny with broken ceilings at ~3000 ft, 15-30 kt winds), producing sharp images with good contrast at KB and TR. However, darker conditions the second day (low overcast and broken clouds at~1800 ft.) reduced available light and increased the variation in quality images. Slow ground-speeds achieved by flying into strong southwesterly winds (25-40 kts) could not compensate for low light conditions in all cases.

Nest detection

I calculated standard errors of estimated nests at each colony using inter-photo variance (photo as the sample unit), rather than inter-transect variance (1992-2008). The index ratio (i.e., brant nest detection probability) based on pooled image:ground counts across all ground-truthed colonies (KB, TR, and KI; n = 246 photos with 185 brant nests) was 1.05 (SE: 0.03). Thus, the correction factor for image-based counts was 0.95. Most detection errors appeared to be misclassification of a standing brant as a nesting brant in high density locations.

All YKD brant colonies combined

Total estimated number of nests for all colonies (12,106) was 26% higher in 2011 than in 2010 (9,641), 25% lower than the long term average (16,089; 1992-2011), and 6.5% higher than the 3-yr running average (11,318, 2009-2011 Table 1). All colonies experienced an increase in active brant nests from the previous year (range: 2 to 79%) with the exception of BP, which decreased by 49% from 2010, likely due to substantial flooding. The trend in annual YKD estimates of nesting brant continues to be negative (-3.2%/yr; Fig. 4), although colony-specific long-term trends, with the exception of BP, improved in 2011 (from -5-6% in previous years to -3-4% or less in 2011). All colonies continue to be in long-term decline.

Kokechik Bay (KB)

The estimated number of nests at KB was 44% higher than in 2010, but 2.8% lower than the long-term average at that site. Further, the within-colony trend at KB remained 1.5 percentage points lower (λlog-linear(KB): 0.95, SE: 0.03) than the overall trend for the YKD. No researchers visited KB in 2011. However fox control occurred at this site in April 2011, during which 12 arctic (*Vulpes lagopus;* targeted) and 6 red fox (*V. vulpes;* incidental) were collected (M. Pratt, APHIS, pers. comm.). Few indications of fox and avian predation were observed in digital photos or during ground-truthing. However, evidence of potential human disturbance (e.g., footprints leading to destroyed nests) was observed in digital photos. In 2011, boot tracks were observed in 62 of 1070 images at KB (5.8%) and motorized vehicle tracks (snowmachine and/or ATV) within 4 images (<1%). Overall, detectable local human disturbance of the area was reduced by nearly half from the previous year (96 of 954 (10%) of photos had boot tracks and 56 (6%) had vehicle tracks in 2010), suggesting human disturbance at KB may be declining.

Tutakoke River (TR)

The estimated number of nests at TR increased by 26% compared to 2010, but was 28% lower than the long-term site-average. Further, the within-colony trend at

TR was 2.4 percentage points lower (λlog-linear(TR): 0.944, SE: 0.02) than the overall trend for the YKD. Overall, the 2010 estimate indicated an average to better than average nesting year at TR relative to the previous three 3-yrs at that site (Table 1). Local researchers reported one fox in the southern colony and modest depredation in that area, but did not report extensive damage or continued fox observations throughout the nesting season. Overall depredation appeared to be minimal at the time of photography and ground-truthing and numbers of active nests appeared to be higher than in the previous 2-3 years. Fox control occurred at TR in April 2010 with ~15 animals taken during the multi-week control period.

Kigigak Island (KI)

The estimated numbers of brant nests within the KI brant colony study area remained relatively stable, increasing only slightly (by 2%) in 2011 relative to the previous year. However, KI continued to decrease (-33%) relative to the long-term average for the site. Further, the long-term, log-linear trend at KI continued to slope downward in 2011 (λlog-linear(KI): 0.992, SE: 0.02). Overall, brant nest success within the KI colony study area appeared moderate to high in 2011 based on imagery data and nest monitoring by local researchers (M. Gabrielson pers comm.), with some indications of nest destruction due to fox and avian (e.g., gull/jaegar) predation - primarily in the southern part of the island. However, ultimate cause of depredation could not be reliably apportioned between foxes and avian predators in any portion of the island. No fox control occurred at KI in 2011.

Baird Inlet Island (BI)

The estimated number of nests at BI increased by 79% in 2011 compared to 2010 and remained 2.6% lower than the long term site-average. Further, the long-term, log-linear trend at BI continued to be slightly decreasing (λlog-linear(BI): 0.981, SE: 0.01). No ground-based research at BI was conducted in 2011, and thus, no ground-based evaluations of factors influencing nest success are available. As in 2007-2010, no motorized vehicle tracks were observed on the island, and boot tracks were only observed in only 2 of 486 photos (<1%) in 2011, representing a substantial reduction from the previous year (2.9%; 23 of 785 photos images (55 subareas) in 2010). However, some observed flooding during the photographic survey may have obscured boot tracks. No fox control occurred at BI in 2011.

Baird Peninsula (BP)

The estimated number of nests at BP decreased by 49% compared to 2010 and this colony remained 6% below its long term site-average. Further, the log-linear trend at BP continued to slope downward in 2011 (λlog-linear (BP): 0.981, SE: 0.04). Evidence of substantial flooding (particularly in the inland portion of the peninsula) could be observed in images taken at this site. Boot tracks were observed in only 7 of 562 (1.2%) images in 2011, similar to 2010 (6 of 523; 1.2%), and less than 2009 (14 of 592; 2.3%), suggesting a sustained decrease in detectable local human disturbance of the area. However, substantial flooding and subsequent obscuration of mud, likely resulted in reduced detection of tracks in 2011. No fox control occurred at BP in 2011, and as in all previous years, no motorized vehicle tracks were observed at this colony.

DISCUSSION

Abundance and trends of Pacific black brant at nesting colonies on the YKD are important management indices used by the Pacific Flyway. Previous Flyway prescriptions for Pacific black brant mandated harvest closure if: a) the 3-yr average of the midwinter survey was <90,000, *and* b) the YKD-wide colony nest population estimate declined by 50% relative to the previous year (Pacific Flyway Council 2002). The 2011 YKD colony nest population estimate (12,106) was substantially increased (+26%) compared to the previous year's estimate and was not in danger of reaching the 50% reduction benchmark outlined by the Flyway. In 2009, the Pacific Flyway discussed adopting a revised brant management strategy which would dictate harvest closure when: a) the 3-yr average of the midwinter survey was <90,000 *and* b) *the 3-yr average* of the YKD-wide colony nest population estimate was <10,000 nests. In 2011, the 3-yr average was 11,318; well above the proposed alternative closure threshold. Overall, 2011 reflected a better than average nesting year for brant at four of the five primary colonies on the YKD based on aerial imagery and ground-truthing and relative to the 3-yr running average. Indications of

fox and avian depredation were light to moderate, with significant flooding and subsequent nest loss only appearing at BP. Fox removal occurred at the TR and KB colonies in April 2011, but was not conducted at any other colony locations. Limited aerial imagery data for other sympatrically nesting species within the brant colonies (e.g., cackling, emperor, and greater white-fronted geese, and eiders; Appendix 1), indicated that 2011 may have also been an average to better than average nesting year for species other than brant within the colony areas. However, this information, when coupled with very different trends for cackling and greater-white fronted geese elsewhere across the YKD (e.g., substantial increases; Fischer et al. 2010, Bollinger and Hodges 2010), would suggest that nesting patterns within the five primary brant colonies are likely to be very different from those outside the colonies.

Human activity (based on numbers of photos with footprints and vehicle tracks) decreased at KB, BP, and BI in 2011, relative to 2010. Review of photos suggested some human egg-predation at KB, but few vehicle tracks. Human presence at BI had not appreciably changed since 2010, and detection of human tracks at BP was likely hampered by local flooding. Overall, human disturbance of these colonies was stable to decreasing in 2011

Finally, although the number of brant nests at all colonies except BP increased from 2010 to 2011, the magnitude of the increase varied substantially among colonies; from a 3% increase at KI to a 79% increase at BI. However, proportional changes in colony size relative to the previous year's estimates are not directly comparable in terms of actual numbers of nesting brant. A better metric may be comparison of the current year's estimate to long-term averages and evaluation of individual long-term trends at each colony. For example, the long-term trends at TR and KB (including 2011) marked the fourth consecutive year of negative departures from the long-term YKD log-linear trend (e.g., 4-5% annual declines at TR and KB vs. 3% annual decline for all YKD), indicating that most of the long term decline in numbers of nesting brant on the YKD continues to be attributed to reductions from historical estimates at KB and TR. Fluctuations in numbers of nesting brant between BI and BP over the past three years continues to suggest that these neighboring colonies may functionally behave as one, with alternating nesting conditions influencing annual nesting densities. The number of active brant nests decreased by 566 at BP in 2011, while correspondingly increasing by 1370 at nearby BI. Substantial reductions in numbers of active nests at BP in 2011 (due to severe flooding), coupled with increases at BI, provided the first real evidence of shifting between sites based on differential local habitat conditions.

ACKNOWLEDGEMENTS

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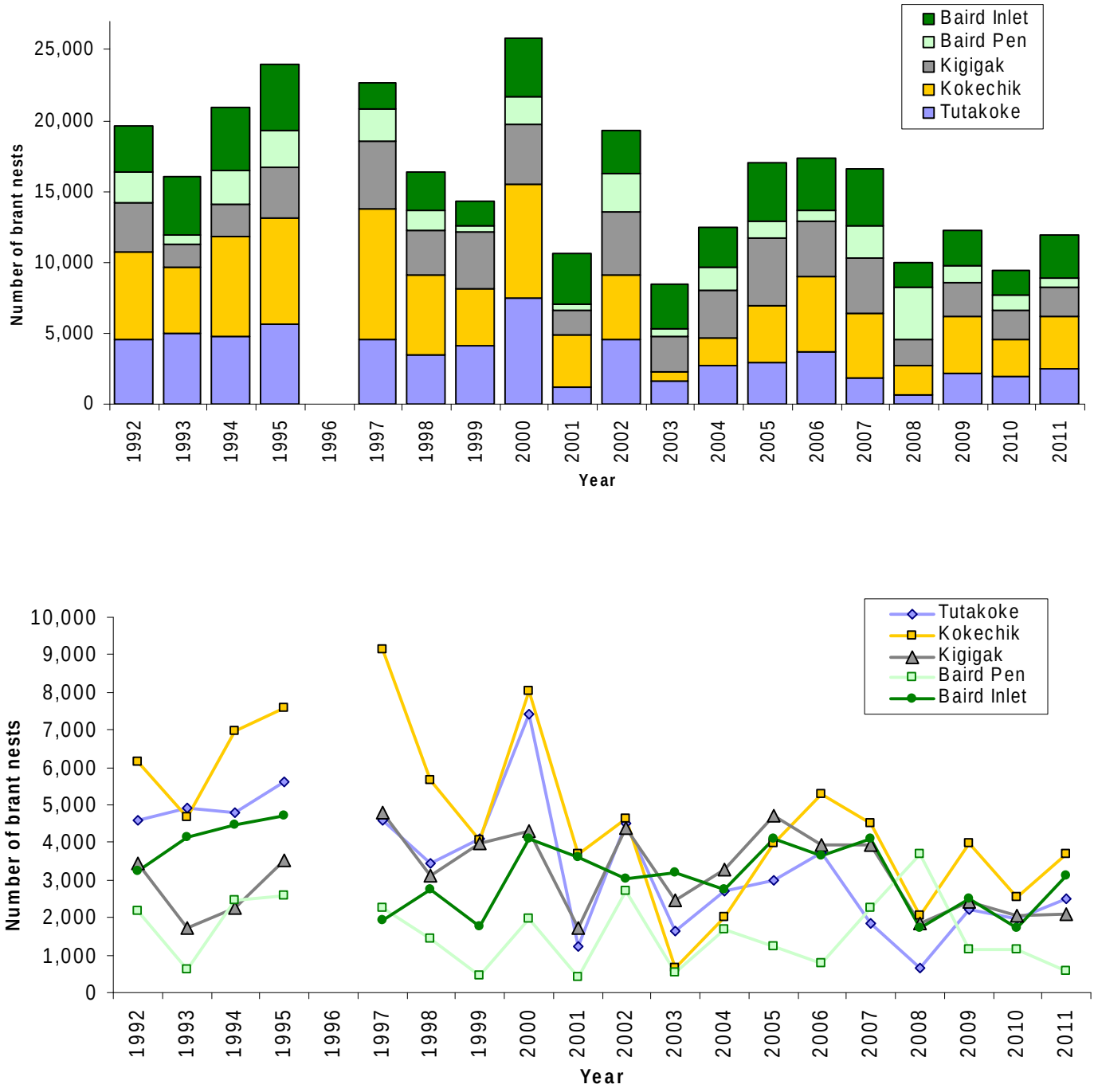
Table 1. Annual estimates and standard errors (± 1 SE, presented in # of nests) from photographic aerial surveys of brant nests at the five primary colonies on the Yukon-Kuskokwim Delta, Alaska (1992-2011); Tutakoke River (TR), Kokechik Bay (KB), Kigigak Island (KI), Baird Inlet Island (BI), and Baird Peninsula (BP).

	Colony Nest Estimates										
Year	**TR**	**(SE)**	**KB**	**(SE)**	**KI**	**(SE)**	**BP**	**(SE)**	**BI**	**(SE)**	**Total**
1992	4,600 [2]	(202)	6,134 [2]	(295)	3,440 [1]	(154)	2,157 [1]	(151)	3,258 [1]	(347)	19,589
1993	4,937 [2]	(190)	4,667 [1]	(577)	1,727 [2]	(90)	614 [1]	(77)	4,156 [1]	(357)	16,101
1994	4,807 [1]	(400)	6,978 [2]	(196)	2,260 [2]	(92)	2,441 [1]	(142)	4,461 [1]	(454)	20,947
1995	5,596 [2]	(297)	7,573 [2]	(351)	---	---	2,591 [1]	(184)	4,720 [1]	(474)	23,998
1997 [2]	4,588	(554)	9,144	(1092)	4,776	(595)	2,259	(282)	1,944	(242)	22,711
1998 [2]	3,448	(292)	5,655	(471)	3,105	(238)	1,431	(169)	2,747	(264)	16,386
1999 [1]	4,100	(96)	4,072	(74)	3,962	(402)	448	(81)	1,777	(80)	14,359
2000	7,437 [2]	(584)	8,021[2]	(866)	4,286 [1]	(647)	1,962 [1]	(142)	4,088	(324)	25,794
2001[2]	1,212	(73)	3,677	(215)	1,721	(107)	421	(36)	3,604	(198)	10,635
2002 [2]	4,524	(314)	4,634	(362)	4,380	(255)	2,708	(147)	3,052	(199)	19,298
2003 [2]	1,622	(79)	655	(52)	2,474	(118)	547	(46)	3,202	(135)	8,500
2004 [2]	2,704	(153)	1,996	(116)	3,284	(208)	1,687	(76)	2,759	(160)	12,430
2005 [2]	2,977	(205)	3,985	(177)	4,728	(213)	---	---	4,093	(256)	17,023 [3]
2006 [2]	3,714 [4]	(286)	5,280	(341)	3,920	(240)	793	(61)	3,628	(262)	17,335
2007 [2]	1,842	(137) [4]	4,521	(304) [4]	3,924	(304) [4]	2,241	(203) [4]	4,106	(264) [4]	16,634
2008 [2]	669	(68) [5]	2,062	(174) [5]	1,856	(158) [5]	3,695	(341) [5]	1,713	(151) [5]	9,995
2009 [2]	2,197	(235) [6]	3958	(344) [6]	2,398	(226) [6]	1,154	(141) [6]	2,499	(239) [6]	12,206
2010 [2]	1,963	(176) [6]	2,560	(208) [6]	2,061	(184) [6]	1,146	(130) [6]	1,739	(142) [6]	9,641
2011 [2]	**2,481**	**(221) [6]**	**3,682**	**(244) [6]**	**2,104**	**(187) [6]**	**580**	**(84) [6]**	**3,109**	**(445) [6]**	**12,106**
3-yr average (2009-2011)	2,214		3,400		2,188		960		2,449		11,318
Long-term average (1992-2011)	3,443		4,698		3,134		1,604		3,192		16,089

[1]Estimates based on Lincoln-Petersen analysis of counts by two observers.
[2]Estimates based on correction factors from ground-truthed transects.
[3]Mean of 1994 and 1997 KI estimates included in 1995 KI total and average, and mean of 2004 and 2006 BP estimates included in 2005 BP total and average.
[4]2006 TR estimate based on 63% of the images analyzed.
[5]Standard errors in 2007-2009 calculated using the variance of the ratio estimate, rather than binomial variance (as in 1992-2006).
[6]Standard errors in 2009-2011 were calculated using inter-photo variance (photos as the sample unit), rather than inter-transect variance (as in 1992-2008).



Figures 3a and 3b. Estimates of number of nests at the five primary brant colonies on the Yukon-Kuskokwim Delta (1992-2011) from photographic surveys; Tutakoke River (TR), Kokechik Bay (KB), Kigigak Island (KI), Baird Peninsula (BP), and Baird Island (BI).

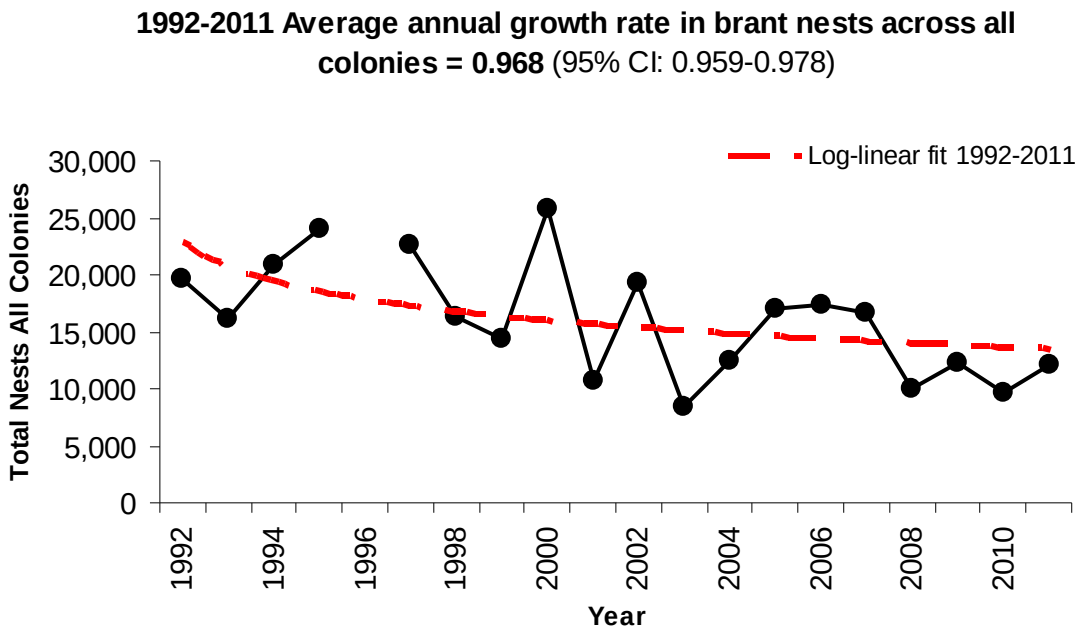


Figure 4. Log-linear trend of annual estimates of brant nests (red dashed line) from photographic surveys across all brant colonies on the Yukon-Kuskokwim Delta (1992-2011). Note: Estimates do not exist for 1996, and in 2005 only four of five colonies were surveyed.

Appendix 1. Estimates and standard errors (± 1 SE, presented in # of nests) of species other than brant from photographic aerial surveys within the five primary brant colonies on the Yukon-Kuskokwim Delta, Alaska; Tutakoke River (TR), Kokechik Bay (KB), Kigigak Island
(KI), Baird Inlet Island (BI), and Baird Peninsula (BP) 2009-2011.

		Estimates of number of nests										
Species		**TR**	(SE)	**KB**	(SE)	**KI** [2]	(SE)	**BP**	(SE)	**BI**	(SE)	**Total** (SE)
Cackling goose [1]	2009	1,615	(248) [6]	1,582	(288)	2,271	(382)	2609	(436)	1,999	(349) [6]	9,898 (1556)
	2010	616	(139)	601	(136)	1,214	(257)	1,264	(274)	808	(172)	4,453 (915)
	2011	**1,783**	(381)	**1,372**	(295)	**1,642**	(350)	**1,527**	(330)	**1,624**	(350)	**7,852** (1606)
Emperor goose	2009	96	(29)	75	(27)	392	(61)	205	(50)	196	(47)	969 (111)
	2010	60	(21)	48	(20)	282	(48)	69	(27)	241	(38)	767 (85)
	2011	**163**	(43)	**59**	(21)	**259**	(52)	**91**	(30)	**298**	(62)	848 (113)
Greater white-fronted goose	2010	109	(30)	57	(22)	34	(16)	35	(19)	13	(9)	244 (46)
	2011	**234**	(57)	**42**	(18)	**28**	(15)	**10**	(10)	**10**	(10)	**315 (63)**
Eider spp. [3]	2009	420	(97)	289	(79)	245	(66)	96	(38)	46	(26)	**1103** (208)
	2010	153	(52)	48	(20)	265	(71)	---	---	---	---	471 (93)
	2011	**265**	(72)	**125**	(39)	**323**	(82)	**–**	---	**–**	---	**724** (126)

[1] Estimates for cackling geese were based on a detection index ratio specific to cackling geese in 2011 (0.95, SE: 0.19), from ground-truthed transects at (KB, TR, and KI in 2011; n = 246 photos). Estimates for emperor geese, greater white fronted geese, and eiders were based on the average detection index ratio between brant and cackling geese in 2011 (1.0, SE: 0.08).
[2]Estimates for the area covered at KI overlap with coverage from the YKD random nest plots survey (Fischer et al. 2010).
[3]"Eider spp." indicates combined observations of spectacled (*Somateria fischeri*) and common eiders (*S. mollissima v. nigra*), as incubating hens without attending males could not consistently be identified to species.