Summary Report- 18 December 2009

Aerial Photographic Surveys of Brant Colonies on the Yukon-Kuskokwim Delta, Alaska, 2009

HEATHER M. WILSON, U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, 1011 East Tudor Road, Anchorage, AK 99503, USA. August 2007

ABSTRACT I conducted an aerial photographic survey of nesting Pacific black brant (*Branta bernicla nigricans*) at the five primary colonies currently recognized on the Yukon-Kuskokwim Delta, Alaska, USA: Kokechik Bay (KB), Tutakoke River (TR), Kigigak Island (KI), Baird Peninsula (BP), and Baird Island (BI), between 7-8 June 2009. Total number of nests for all colonies increased by 22% between 2009 (12,206) and 2008 (9,995), but the 2009 estimate was still ~39% lower than the long term average (16,853; 1992-2008). All colonies, except BP (which decreased by 69% compared to 2008), experienced a substantial increase in active brant nests from the previous year (range: 25-228%, 542-1896 additional nests). The trend in annual YKD estimates of nesting brant continues to be negative (-2.9%/yr), with most of the long term decline being attributed to reductions at KB (-5%/yr) and TR (-6%/yr). Overall, 2009 reflected an average nesting year for brant on the YKD based on our aerial imagery, with some indications of flooding, but no observations of significant fox predation. Human activity (based on counts of footprints and vehicle tracks) was the highest at KB since 2005, but still lower than estimates from 2001-2004. At BI, counts of footprints were the second highest on record (relative to historical footprint data: 2001-2005) and footprints were observed for the first time at BP in 2009.

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

During the mid-1980's, declining numbers of nesting 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 (J. Sedinger & USFWS unpubl. data). However, due to high nest densities and large areas associated with colonies, ground-plots and ocular surveys from aircraft were impractical and/or inefficient 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 2009 survey.

STUDY AREA

I conducted an aerial photographic survey 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 7-8 June 2009.

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 120-145 km/hr (75-90 mph) over all colonies. All transects were flown into the wind where practicable (i.e., where a head-wind was present), with ~10° of flaps deployed. This slowed the aircraft and maximized the

number and quality of photos that could be taken on each transect. KB, TR, KI, BP, and BI required 0:50 (hours:minutes), 1:07, 0:44, 0:53, and 1:03, 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 taped the focal ring in place and set the focus to 'manual'. This configuration produced images ~41.8 x 27.87 m. 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 footprints (versus 0.05-hectare footprints in 2008 with a Nikon D200 camera) through holes in the floor of a Cessna-206 amphibious aircraft. Sampling protocol was similar to that in previous years; systematically spaced flight lines (~200 m apart) were flown along the long axis of all colonies (Anthony 2003-2006).

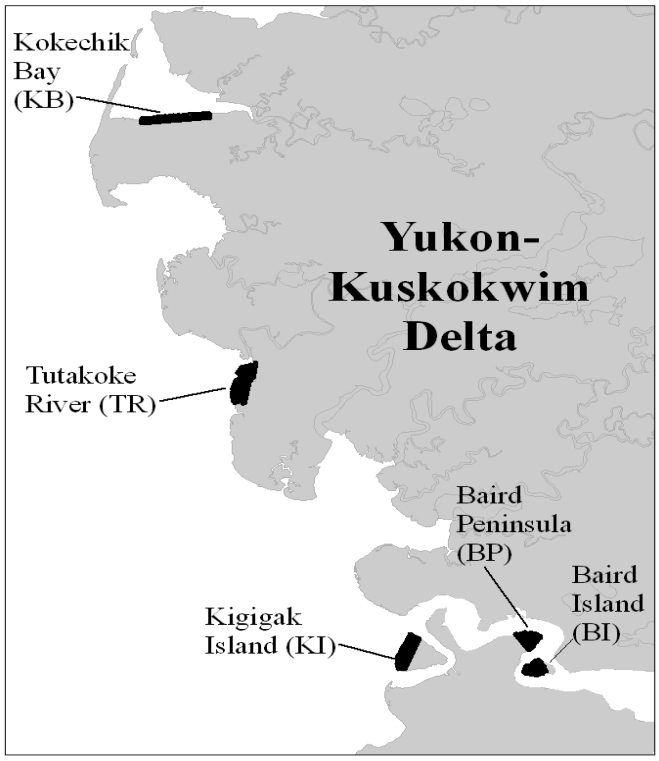


Figure 1. Photographic survey areas of the five primary Pacific black brant nesting colonies on the Yukon-Kuskokwim Delta.

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 GPS (track file) and the camera's internal clock 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 active-nest detection probability as estimated in digital images. Preparation for ground-truthing involved processing digital photos in GPS-Photo link®, printing watermarked 8.5 x 11" copies of photos to be truthed, creating ArcMap geographic information system (GIS) shapefiles (.shp) and Google Earth files (.kml) of photo locations, and mapping photo locations on high resolution IKONOS (IKONOS 2008) satellite imagery. To aid in navigation during ground-truthing, I created maps of photo locations and downloaded true photo center-point coordinates into hand-held GPSs. An assistant and I performed the ground-truthing by walking to each of the selected photo locations and recording all nests observed (identified to species) within the boundaries of each 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),

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

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,

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

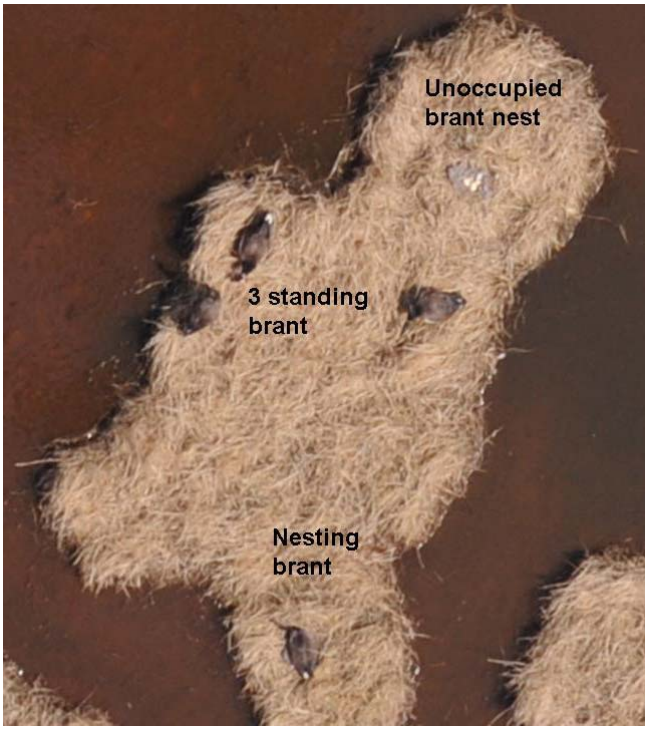


Figure 2. Observations of nesting and standing brant, as well as an unoccupied nest from a high-resolution digital image (using a Nikon D700 SLR camera) recorded during the aerial survey of the Baird Island colony, 2009.

Image processing

I determined total area in each colony with ArcGIS. In 2009, I re-outlined colony boundaries against new IKONOS imagery base maps (1m/pixel resolution), to fine-tune colony boundaries. 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 a computer with a MATLAB image-processing program (Image processing toolbox - 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, which included 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, due to the presence of biological field crews at those sites in 2009.

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*), 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*), northern pintails (*Anas acuta*). Black turnstones (*Arenaria melanocephala*), glaucous gulls (*Larus hyperboreus*), Sabine's gulls (*Xema sabini*), and arctic terns (*Sterna paradisaea*). Given the high resolution, greater number, and improved coverage of images with the Nikon D700 camera used in 2009, I had sufficient observations (>50 across all colonies) to generate population estimates for cackling and emperor geese, and eiders (common and spectacled combined). Results for other species are presented in Appendix 1.

RESULTS

The number of images collected at KB, TR, KI, BP, and BI within colony boundaries was 931, 1467, 1188, 592, and 515, respectively. Thus, given total colony areas of 1044 (KB), 1468 (TR), 1130 (KI), 666 (BP), and 583 (BI) hectares, the 2009 photos represented a sample of 10.4, 11.6, 12.3, 10.4, and 10.3% of each of the respective colony areas; indicating an average improvement of 4 times the coverage achieved in the previous year. Surveys at TR, KI, BP, and BI were conducted in a single day (14:33-20:33 hrs), under sunny conditions (scattered clouds at 1000 ft., broken at 12,000 ft.) and moderate easterly winds (5-10 kts). The prevailing weather resulted in bright sunlight conditions, allowing use of faster shutter speeds, and producing images with stronger shadows and greater clarity relative to historical photos taken in overcast/low-light conditions. Photos at KB were taken the following day (10:24-11:04 hrs.), when similar weather, but even brighter lighting conditions, prevailed.

In 2009, I calculated standard errors of estimated nests at each colony using inter-photo variance (photo as the sample unit), rather than inter-transect variance (as done previously: 1992-2008). The index ratio (i.e., detection probability) based on pooled image:ground counts across all ground-truthed colonies (KB, TR, and KI; n = 198 photos) was 0.90 (SE: 0.05, range: 0.71-1.12). Thus, the correction factor for image-based counts was 1.11. Total estimated number of nests for all colonies (12,206) was 22% higher in 2009 than in 2008 (9,995), but still 39% lower than the long term average (1992-2008) and 6% lower than the 3-year running average (Table 1). All colonies except BP (which decreased by 69% compared to 2008), experienced a substantial increase in active brant nests from the previous year (range: 25-228%; 542-1896 additional nests; Table 1). The trend in the annual sum of estimates across colonies (λlog-linear(All colonies): 0.97, SE: 0.01) continues to be negative (-3%/yr; Fig. 4), with most of the long term decline being attributed to reductions at KB (-5%/yr) and TR (-6%/yr).

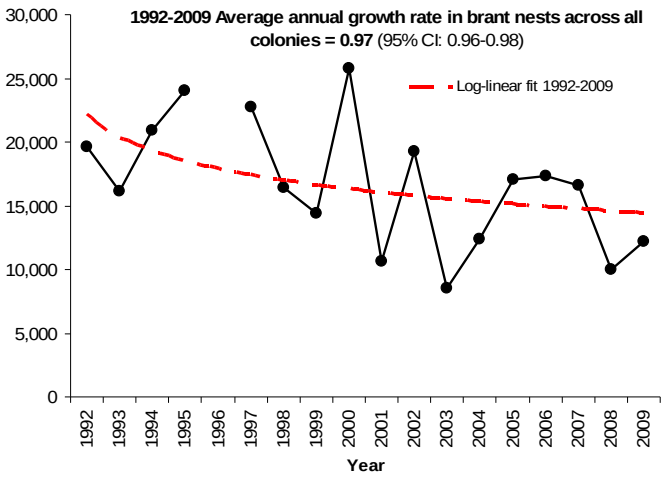


Figure 4. Logistic trend of annual estimates of brant nests (red dashed line) from photographic surveys across all brant colonies on the Yukon-Kuskokwim Delta (1992-2009). Note: Estimates do not exist for 1996 and in 2005 only four of five colonies were surveyed.

Kokechik Bay (KB)

The estimated number of nests at KB was 92% higher than in 2008, and the within-colony trend at KB was 2 percentage points lower (λlog-linear(KB): 0.95, SE: 0.03) than the overall trend for the YKD. There were few signs of nest failure at KB in the areas ground-truthed, but several indications of human nest predation (egging) observed in digital photos (e.g., footprints leading to destroyed nests). In 2009, boot tracks were observed in 62 image-subareas within the 931 (6.7%) images at KB and motorized vehicle tracks (snowmachine and/or ATV) in 28 (3.3%) subareas within images. Overall, human activity at KB in 2009 was within the range of historical counts (2001-2005 range: 30-166 image-subareas/year with boot tracks), but had increased from more recent counts (2006-2008 range; 0-15 image-subareas/year with boot tracks, 1-5 image-subareas/year with vehicle tracks).

Tutakoke River (TR)

The estimated number of nests at TR increased by 228% compared to 2008 and the within-colony trend at TR was 3 percentage points lower (λlog-linear(TR): 0.94, SE: 0.03) than the overall trend for the YKD. The 2009 estimate at TR indicated an average nesting year relative to recent counts (average 2001-2008 = 2,408 nests), but approximately half that of historical estimates (average 1992-2000 = 4,939 nests). Some evidence of nest destruction due to flooding was observed during ground-truthing in the northwestern corner of the colony. Further, local researchers reported flooding was responsible for more extensive damage throughout the colony (J. Sedinger, pers. comm.). Little evidence of fox predation was observed in 2009.

Kigigak Island (KI)

The estimated numbers of nests at KI increased by 29% in 2009 relative to the previous year, and by 28% relative to the long-term average at that site. The long-term, log-linear trend at KI was stable (λlog-linear(KI): 1.00, SE: 0.02). General nest success at KI appeared average to slightly above average, with no indications of substantial nest destruction due to predation or catastrophic environmental events.

Baird Inlet Island (BI)

The estimated number of nests at BI increased by 46% compared to 2009, but was 25% lower than the long term average. The long-term, log-linear trend at BI was slightly decreasing (λlog-linear(BI): 0.98, SE: 0.01), but was still 1 percentage point higher than the overall trend for the YKD. No ground-based research at BI was conducted in 2009, and thus, no estimates of nest success are available (M. Wege, pers. comm.). As in 2007 and 2008, no motorized vehicle tracks were observed on the island, but boot tracks were observed in 158 subareas of 515 photos. One photograph

also revealed a small boat with one occupant along BI's northern slough system.

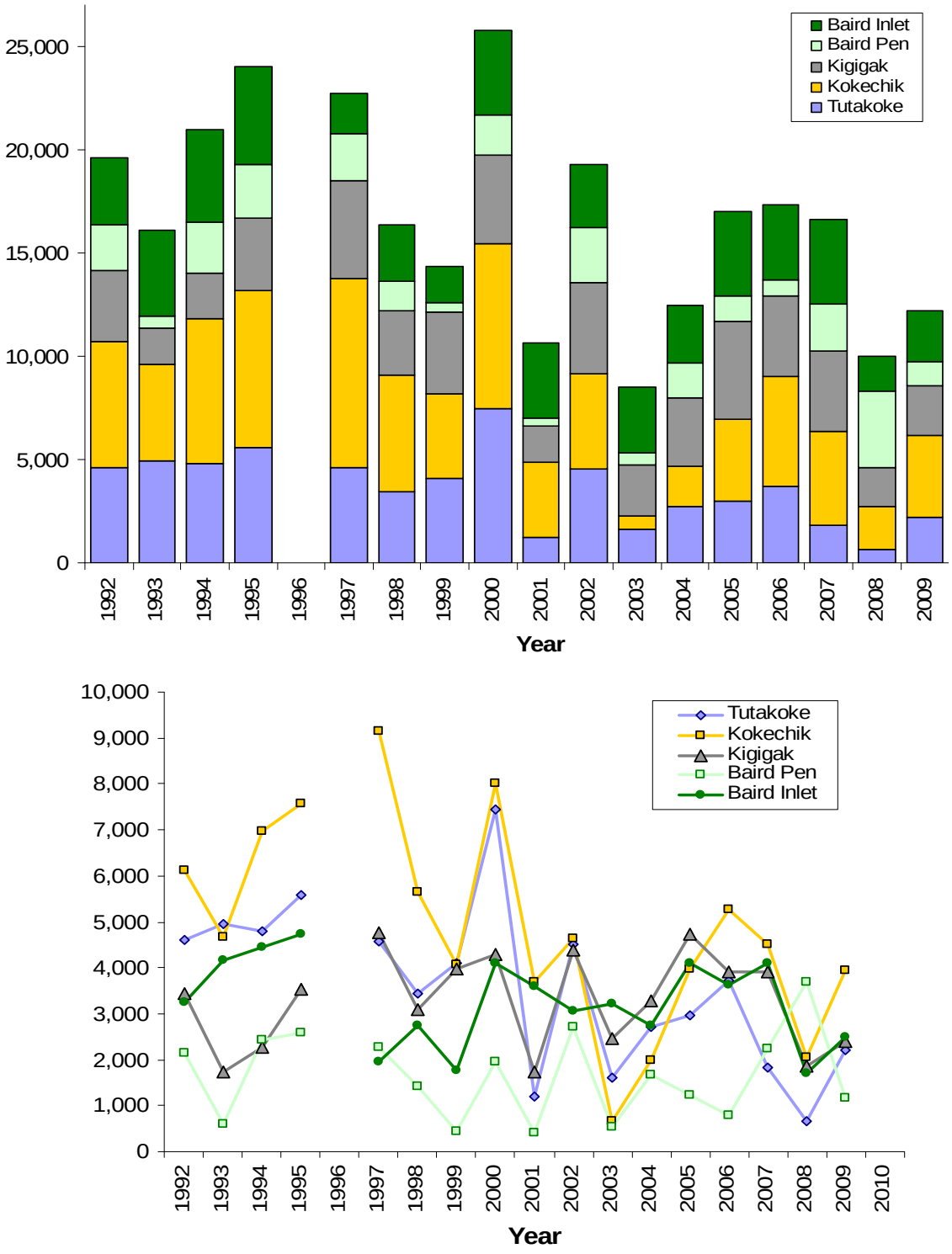
Baird Peninsula (BP)

Unlike any of the other colonies in 2009, the estimated number of nests at BP decreased by 69% compared to 2008, and was 33% lower than the long term average at this location. The log-linear trend at BP continues to be stable (λlog-linear(BP): 1.00, SE: 0.03). No ground-based research was conducted at BP in 2009. However, boot tracks were observed in 14 of 592 (2.3%) images at BP in 2009, versus 1.1% of images in 2008, and 2.4% of images in 2007, indicating a slight increase in local human disturbance of the area (note: no biologists accessed BP in 2007 or 2008). As in all previous years, no motorized vehicle tracks were observed at BP.

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 (1992-2009); 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**
3-yr average (2007-2009)	1,569		3,514		2,726 [3]		2,363 [3]		2,773		12,945
Long-term average (1992-2008)	3,674		4,941		3,335 [3]		1,702 [3]		3,332		16,983 [3]

[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 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 five brant colonies on the Yukon-Kuskokwim Delta (1992-2009) from photographic surveys; Tutakoke River (TR), Kokechik Bay (KB), Kigigak Island (KI), Baird Peninsula (BP), and Baird Island (BI).

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 the 50% relative to the previous year (Pacific Flyway Council 2002). The 2009 YKD colony nest population estimate (12,206) was substantially increased (+22%) compared to the previous years' estimate, and thus, was not in danger of reaching the 50% reduction benchmark outlined by the Flyway. In 2009, the Pacific Flyway adopted a revised brant management strategy which mandates harvest closure when a) 3-yr average of the midwinter survey is <90,000 and b) the 3-yr average of the YKD-wide colony nest population estimate is <10,000 nests.

Overall, 2009 reflected an average nesting year for brant on the YKD based on aerial imagery, with some indications of flooding (northern TR colony only), but no observations of significant fox predation. Predicted hatch dates for brant appeared early-normal in 2009 (Fischer et al. 2009, a pattern typically associated with good nesting conditions. Human activity (based on counts of footprints and vehicle tracks) was the highest at KB since 2005, but still lower than historical estimates (2001-2004). Counts of footprints were the second highest on record for BI (historical footprint data: 2001-2005) and footprints were observed for the first time at BP in 2009

The increase in brant nests on the YKD in 2009 was relatively consistent across all colonies, with the exception of BP. Including 2009 estimates, the long-term trends at TR and KB marked the second consecutive year of substantial negative departures from the long-term YKD log-linear trend (e.g., 5-6% annual declines at TR and KB vs. ~3% annual decline for all YKD). For KB, TR, KI, and BI increases between 2008 and 2009 ranged from 25-221%, while the estimate of brant nests at BP decreased by 69% during the same period. However, these proportional changes in colony size are relative to the 2008 colony size estimates and hence are not directly comparable in terms of actual numbers of nesting brant. Accordingly, most of the long term decline in numbers of nesting brant on the YKD can still be attributed to reductions at KB and TR.

Fluctuations in numbers of nesting brant between BI and BP over the past two years suggest that the two nearby colonies may functionally behave as one, with alternating nesting conditions influencing annual nesting densities. Changes at BI and BP could also represent recruitment, perhaps mediated by dispersal of new breeders from other locations and/or local recruitment. Although dispersal of young birds is a plausible hypothesis, Lindberg et al. (1998) found that dispersal of established breeders was extremely rare (estimated breeding philopatry for brant on the YKD to be 0.91-1.00). Thus, I contend that intra-YKD dispersal of established breeders is not likely the primary source of interannual fluctuations in colony estimates. Further, such annual dispersal of local breeders would tend to create negative correlations among colonies in annual counts, and I found no evidence of such correlations in previous analyses ($p > 0.76$). However, preliminary brant resighting efforts at BI in 2008 (C.Nicolai, pers. comm), did support the hypothesis that young breeders from other locations may be prospecting, and even recruiting to the BI/BP area. As suggested in 2008, increased effort to gather brant recruitment and habitat data at BI and BP and other breeding locations, would aid in understanding the role of dispersal and habitat change on brant population dynamics on the YKD.

ACKNOWLEDGEMENTS

Funding for this survey was provided by the NAWMP Arctic Goose Joint Venture and the U.S. Fish and Wildlife Service (USFWS). Paul Anderson (USFWS, Migratory Bird Management) piloted the survey aircraft, Mike Anthony (USGS, Alaska Science Center, Retired) assisted with ground-truthing, Trisha Wilson assisted with ground-truth mapping in Bethel, Lyndi Denlinger, Jennifer Wiley, and Tim Bowman (USFWS, Migratory Bird Management) assisted with image-processing, and Bob Stehn provided assistance with upgrading data organization and analyses. The Yukon Delta National Wildlife Refuge-USFWS allowed an assistant and I to use their Aviat A1-B Husky aircraft (N724) for accessing field sites for ground-truthing. The Sea Lion Corporation provided access to their lands at Kokechik Bay for ground-truthing.

LITERATURE CITED

Anthony, R. M., W. H. Anderson, J. S. Sedinger, and L. L. McDonald. 1995. Estimating populations of nesting brant using aerial videography. Wildlife Society Bulletin 23:80-87.

Anthony, R. M. 1992-2006. Aerial surveys of brant colonies on the Yukon Delta NWR. U.S. Geological Survey,

Alaska Science Center, Anchorage, Alaska, USA. Unpubl. Reports (1992-2006).
Bart, J., M. A. Fligner, and W. I. Notz. 1998. Sampling and statistical methods for behavioral ecologists. Cambridge University Press, Cambridge, United Kingdom.
Cochran, W. G. 1963. Sampling Techniques. John Wiley & Sons, Inc. New York, New York, USA.
Fischer, J. B., R. A. Stehn, and G. W. Walters. 2009. Nest population size and potential production of geese and spectacled eiders on the Yukon-Kuskokwim Delta, Alaska, 2009. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, Alaska, USA. Unpubl. Report.
IKONOS. 2008. Geoeye, Dulles, Virginia, USA.
GPS Photo-link. 2006. Version 4.0. GeoSpatial Experts, Ft. Collins, Colorado, USA.
Lindberg, M. S., J. S. Sedinger, D. V. Derksen, and R. F. Rockwell. 1998. Natal and breeding philopatry in a black brant, *Branta bernicla nigricans*, metapopulation. Ecology 79:1893-1904.
MATLAB. 2001. Version 6.1, release 12. MathWorks, Natic, Massachusetts, USA.
Pacific Flyway Council. 2002. Pacific Flyway management plan for Pacific brant. Pacific Flyway Study Committee, U.S. Fish and Wildlife Service, Portland, Oregon, USA. Unpubl. Report, 40 pp.
Sedinger, J. S., C. J. Lensink, D. H. Ward, R. M. Anthony, M. L. Wege, and G. V. Byrd. 1993. Current status and recent dynamics of the black brant *Branta bernicla* breeding population. Wildfowl 44:49-59.

Appendix 1. Estimates and standard errors (± 1 SE, presented in # of nests) of species other than brant (for which there were ≥50 total observations) from photographic aerial surveys at 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) in 2009.

	Estimates of number of nests (2009)										
Species	**TR**	**(SE)**	**KB**	**(SE)**	**KI** [2]	**(SE)**	**BP**	**(SE)**	**BI**	**(SE)**	**Total (SE)**
Cackling goose [1]	1,615	(248)	1,582	(288)	2,271	(382)	2609	(436)	1,999	(349)	**9,898** (1556)
Emperor goose	96	(29)	75	(27)	392	(61)	205	(50)	196	(47)	**969** (111)
Eider spp. [3]	420	(97)	289	(79)	245	(66)	96	(38)	46	(26)	**1103** (208)

[1] Estimates for cackling geese were based on a correction factor specific to cackling geese (0.63, SE: 0.10), from ground-truthed transects at (KB, TR, and KI in 2009; n = 198 photos). Estimates for emperor geese and eiders were based on the 2009 correction factor for brant (0.90, SE: 0.05).
[2]Estimates for the area covered at KI overlap with coverage from the YKD random nest plots survey (Fischer et al. 2009).
[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.