Summary Report

Aerial Photographic Survey of Brant Colonies on the Yukon-Kuskokwim Delta, Alaska, 2008

HEATHER M. WILSON, U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, 1011 East Tudor Road, Anchorage, AK 99503, USA. July 2008

ABSTRACT We conducted an aerial photographic survey of nesting Pacific black brant (*Branta bernicla nigricans*) at five colonies on the Yukon-Kuskokwim Delta, Alaska, USA: Kokechik Bay (KB), Tutakoke River (TR), Kigigak Island (KI), Baird Peninsula (BP), and Baird Inlet Island (BI) between 7-8 June 2008. Total number of nests for all colonies (9,995) was 40% lower in 2008 than in 2007 (16,634), and the 2008 estimate was ~43% lower than the long term average (1992-2007). All colonies, except BP (which increased by 83% compared to 2007), experienced a substantial decline in active brant nests from the previous year, likely due to increased fox depredation in 2008. Most of the long term decline in numbers of nesting brant on the YKD was attributed to reductions at KB and TR, with the 2008 estimate at TR being the lowest since the survey began. Human activity was increased at KB compared to the previous year, but was still lower than historical estimates (2001-2005) based on counts of foot prints and vehicle tracks. The trend in annual YKD estimates of nesting brant continues to be negative (approximately -3.07%/yr).

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 (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 was to establish YKD colony indices to help guide population recovery efforts for Pacific black brant, particularly 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 2008 survey.

STUDY AREA

I conducted aerial photographic surveys of nesting Pacific black brant at five colonies on the YKD, Alaska, USA (Fig. 1): Kokechik Bay (KB), Tutakoke River (TR), Kigigak Island (KI), Baird Peninsula (BP), and Baird Inlet Island (BI), on 7-8 June 2008.

METHODS

Aerial Survey

Transects were flown at 122 m above ground level and I used a single, vertically-mounted Nikon D200 SLR® digital still camera with an image-stabilizing lens 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 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 0:32 (hours:minutes), 1:50, 1:11, 0:33, and 1:05, 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). This configuration produced images of ~27.4 x 18.3 m (7.08 mm/pixel resolution).

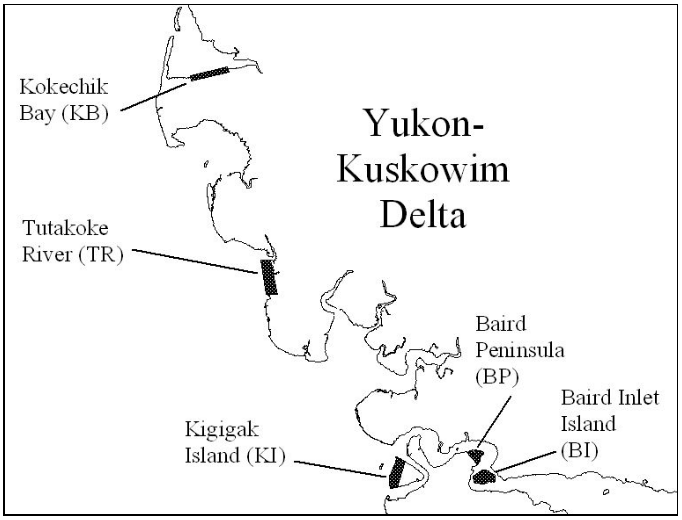

Figure 1. Photographic survey areas of Pacific black brant colonies on the Yukon-Kuskokwim Delta.

The Nikon camera had a 23.6 x 15.8 mm photo sensor (DX format) and sampled non-overlapping 0.05-hectare footprints (versus 0.12-hectare footprints in 2006-2007 with a 35mm-format Kodak camera) through holes in the floor of a Cessna-206 aircraft. Sampling protocol was similar to that in previous years; systematically spaced flight lines were established 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 survey flights. A separate handheld GPS (Garmin 60®) 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 to interpolate image locations using GPS-Photo Link software (GPS-PHOTO LINK 2006).

Ground-truthing, nest detection, and correction factors

I ground-truthed a sub-sample of photos at KI, KB, and TR (areas with good access by float plane), in order to determine the nest detection probability in digital images. Preparation for ground-truthing involved: 1) watermarking and printing 8.5 x 11" copies of photos to be truthed, 2) creating ArcMap geographic information system (GIS) shapefiles and Google Earth files (.kml) of photo locations using GPS-Photo Link 3) mapping photo locations on high resolution IKONOS® satellite images (IKONOS 2007) and georeferenced aerial photos, and 4) printing maps of photo locations and downloading true location waypoints into hand-held GPSs. The ground-truthing was performed by walking to each of the selected photo locations and recording all nests observed within the boundaries of the 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),

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

I then used the inverse of $\hat{R}$ as a visibility correction factor for all colonies in order 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

Total area in each colony was determined with the GIS planimeter function used to outline the boundaries of the colony area. Area sampled by the photographs was computed based on altitude and the focal length of the lens used and the number of photographs per colony within the colony boundaries. Image files (.jpg) were viewed on a computer with a MATLAB image-processing program (MATLAB 2001). Digitized images of known nests from previous years were displayed as background on the computer monitor as a reference to image scale and appearance of different postures of birds in the images.

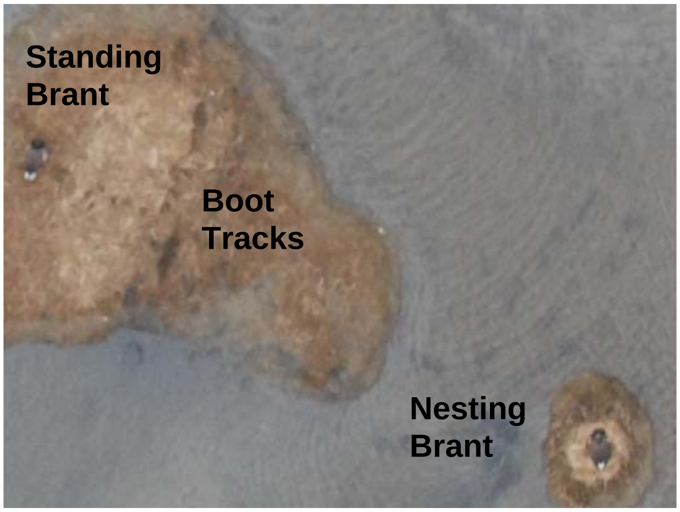

Figure 2. Observations of nesting and standing brant, as well as boot tracks from a digital image recorded during the aerial survey of the Tutakoke River colony, 2008.

We created text data files while viewing images which included image file name, sub-area being viewed, and a two-digit observation code characterizing observed behavior (e.g., standing, sitting on nest, flying), and species identification. In addition to recording observations of brant, I recorded Pacific loons (*Gavia pacifica*), tundra swans (*Cygnus columbianus*), emperor geese (*Chen canagica*), white-fronted geese (*Anser albifrons frontalis*), cackling geese, 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*). Flying black turnstones (*Arenaria melanocephala*), glaucous gulls (*Larus hyperboreus*), Sabine's gulls (*Xema sabini*), and arctic terns (*Sterna paradisaea*), were also clearly identifiable in photos, but were not recorded in the text data. All photos with observations were revued by a second observer, as a means of quality control. Boot tracks and motorized vehicle tracks were counted at KB at BP, but no measure of human activity was quantified at the other colonies due to the presence of biological field crews at those sites.

RESULTS

The number of images collected at KB, TR, KI, BP, and BI within colony boundaries was 661, 1324, 487, 284, and 517, respectively. Thus, given total colony areas of 1020.5 (KB), 1658 (TR), 1157.5 (KI), 663.3 (BP), and 756.2 (BI) hectares, the 2008 photos represented a sample of 3.2, 4.0, 2.1, 2.2, and 3.4% of each of the respective colony areas. Surveys at KB, TR, KI, and BP were conducted in a single day, under low overcast (ceilings ~152 m), resulting in relatively low-light conditions with reduced shadows and glare, but increased grain in the photos. Photos at BI were taken the following day when more variable lighting conditions, with intermittent sunlight and high clouds prevailed.

Total number of nests for all colonies (9,995) was 40% lower in 2008 than in 2007 (16,634), and ~43% lower than the long term average (1992-2007). All colonies except BP experienced a substantial decline in active brant nests from the previous year (Table 1). The index ratio (i.e., detection probability) based on pooled image:ground counts across all ground-truthed colonies (KB, TR, and KI; n = 171 photos) was 0.97 (SE: 0.08) and the correction factor for image-based counts was 1.03. The trend in the annual sum of estimates across colonies ($\lambda_{\text{log-linear}}$: 0.970, SE: 0.015) continues to be negative (-3.07%/yr; Fig. 4).

Kokechik Bay (KB)

The estimated number of nests at KB was 54% lower than in 2007 and the within-colony trend at KB was 3 percentage points lower ($\lambda_{\text{log-linear(KB)}}$: 0.94, SE: 0.03) than the overall trend for the YKD. In 2008, boot tracks were observed in 15 of the 661 images at KB and motorized vehicle tracks (snowmachine) in 1 image. There were many signs of nest failure (primarily due to predation) at KB in the areas ground-truthed. There were also several indications of human nest predation (egging) observed in digital photos (e.g., footprints leading to destroyed nests). Overall, human activity at KB in 2008 was reduced compared to historical counts (2001-2005 range: 30-166 images/year with boot tracks), but increased from more recent counts (2006-2007 range; 0-3 images/year with boot tracks, 3-5 images/year with vehicle tracks).

Tutakoke River (TR)

The estimated number of nests at TR decreased by 64%

compared to 2007 and the within-colony trend at TR was 4 percentage points lower ($\lambda_{log\text{-}linear(TR)}$: 0.93, SE: 0.03) than the overall trend for the YKD. The 2008 estimate at TR was the lowest since this survey began. Evidence of substantial fox predation was observed in all but a few locations within the colony and foxes (and their sign) were frequently observed throughout the breeding area by local researchers. Estimated hatching success for TR in 2008 was ~30% according to ground-based studies (J. Sedinger, pers. comm.).

Kigigak Island (KI)

The estimated numbers of nests at KI decreased by 53% in 2008 and by 50% relative to the long-term average at that site. The long-term, log-linear trend at KI was stable ($\lambda_{log\text{-}linear(KI)}$: 1.00, SE: 0.02). Although 7 foxes were trapped at KI in 2008 (B. Lake, pers. comm), several foxes remained on the island into the nesting season (as observed by resident biologists; B. Lake, pers. comm.). Substantial nest failure, likely due to foxes, was observed during ground-truthing in the northwestern section of KI.

Baird Inlet Island (BI)

The estimated number of nests at BI decreased by 58% compared to 2007, and was 50% lower than the long term average. The long-term, log-linear trend at BI was stable to slightly decreasing ($\lambda_{log\text{-}linear(BI)}$: 0.99, SE: 0.01). Estimated hatching success for BI in 2008 was ~75% according to ground-based studies (M. Wege, pers. comm.). As in 2007, no motorized vehicle tracks were observed on the island. However, evidence of egging and recent hunting activity (e.g., empty shell boxes and shell casings) was increased relative to the previous year (M. Wege, pers. comm). Also, in 2008, no visitors were observed on the island after researchers arrived (M. Wege, pers. comm). Approximately 80 brant originally banded at other YKD colony locations (e.g., KB, TR, KI, BI, Hock Slough, Aknerkokechik River, Big Slough, and Naskonat Peninsula), as well as several locations beyond the YKD (e.g., Prudhoe Bay and Teshekpuk Lake, Alaska, and Wrangel Island and other locations in Canada) were resighted in 2008 by local researchers at BI (C. Nicolai, pers. comm.).

Baird Peninsula (BP)

Unlike any of the other colonies in 2008, the estimated number of nests at BP increased by 83% compared to 2007, and was 35% higher than the long term average at this location. The log-linear trend at BP continues to be stable ($\lambda_{log\text{-}linear(BP)}$: 1.00, SE: 0.03). Boot tracks were observed in 3 of the 284 images at BP in 2008, versus 5 of the 204 images in 2007, indicating a slight decrease in local human disturbance of the area (note: no biologists accessed BP in 2007 or 2008). As in 2007, no motorized vehicle tracks were observed at BP.

DISCUSSION

Abundance and trends of Pacific black brant at nesting colonies on the YKD are important management indices used by the Pacific Flyway. Current Flyway prescriptions for Pacific black brant mandate harvest closure if: a) the 3-yr average of the midwinter survey is <90,000, <u>and</u> b) the YKD-wide colony index declines by the 50% relative to the previous years estimate (Pacific Flyway Council 2002). The 2008 YKD colony nest population estimate (9,995) was substantially reduced (40% lower) compared to the previous years estimate, but did not reach the 50% reduction benchmark outlined by the Flyway. Further, the 3-yr average (2006-2008) of the midwinter brant surveys was 138,387 birds; well above the benchmark prescribed for harvest closure (USFWS unpub. data). The reduction in brant nests on the YKD in 2008 was relatively consistent across all colony locations, with the exception of BP. Including 2008 estimates, the long-term trends at TR and KB marked substantial departures from the long-term YKD log-linear trend (e.g., 6-7% annual declines at TR and KB vs. ~3% annual decline for all YKD). For KB, TR, KI, and BI decreases between 2007 and 2008 ranged from 53-64%, while the estimate of brant nests at BP increased by 83% during the same period and BP experienced a similar increase in the previous year (i.e., between 2006 and 2007). However, these proportional changes in colony size are relative to the 2007 colony size estimates and hence are not directly comparable in terms of actual numbers of nesting brant. Thus, the large proportional increase at BP does not equal the smaller proportional decrease at KB in terms of total numbers of nests, as KB was substantially larger in 2007. Accordingly, most of the long term decline in numbers of nesting brant on the YKD can be attributed to reductions at KB and TR.

The increases at BP over the past two years suggest this site may be experiencing high levels of recruitment, perhaps mediated by dispersal of new breeders from other locations and/or local recruitment. Although increases at one colony could imply local dispersal of established breeders, Lindberg et al. (1998) found that this type of movement to be extremely rare (estimated breeding philopatry on the YKD was 0.91-1.00). Further, such annual dispersal of local breeders would tend to create negative correlations among colonies in annual counts. We found no evidence of such negative correlations among annual estimates of colony size (n = 15, all r values > -0.09, p > 0.76). These results suggest that intra-YKD dispersal of established breeders is not a likely source of correlated interannual fluctuations in colony estimates. However, preliminary brant resighting efforts at BI in 2008, suggest that young breeders from other locations are at least prospecting, and perhaps recruiting to the BI area. Increased effort to gather brant recruitment data at nearby BP and other breeding locations would aid in understanding the role of dispersal in brant nest population dynamics on the YKD.

Overall, 2008 reflected a poor nesting year for brant on the YKD based on our aerial imagery, with indications of significant fox predation on all colonies where local observations could be made. Although predicted hatch dates for brant appeared normal to slightly early in 2008, (a pattern which is typically associated with good nesting conditions), coastal species such as brant, cackling geese, and eiders, all demonstrated reduced numbers of active nests relative to inland species (e.g., emperor and white-fronted geese, and swans) in 2008 (Fischer et al. 2008). This phenomenon could have been caused by higher localized predation in the coastal zone, further corroborating high local predation rates observed at most coastal colonies.

Finally, human disturbance (unrelated to research) appeared to have increased slightly at KB, although still remained much lower at this location than in historical surveys.

Technical note: Comparison of cameras and image coverage in 2008

Overall, the digital still images from the Nikon D200 and Kodak SLR cameras, respectively covered 33 and 44 times the area of historical video images (640 x 480 pixels; Anthony 2004). Although photos from the Nikon D200 captured a 57% smaller footprint on the landscape, the Nikon camera was superior to the Kodak in terms of photo capture and download rates, ease of use, and quality of images. Futher, the smaller footprint could be ameliorated by flying at higher altitudes in future years. Using the intervalometer functions with both cameras, photos could be taken at a rate of 1 every 2 sec. with the Nikon (set to recording .jpgs only), versus 1 every 7 sec. with the Kodak (limited to recording much larger .RAW files only). The Nikon camera provided better images for interpreting content (i.e., greater magnification and clarity). Further, only one camera was necessary to adequately cover each of the study areas in 2008, due to the higher photo-capture rate of the Nikon. In contrast, two Kodak cameras, offset by 3 sec. were required for adequate coverage in previous years; greatly increasing the potential for in-flight problems and post-flight organization and processing.

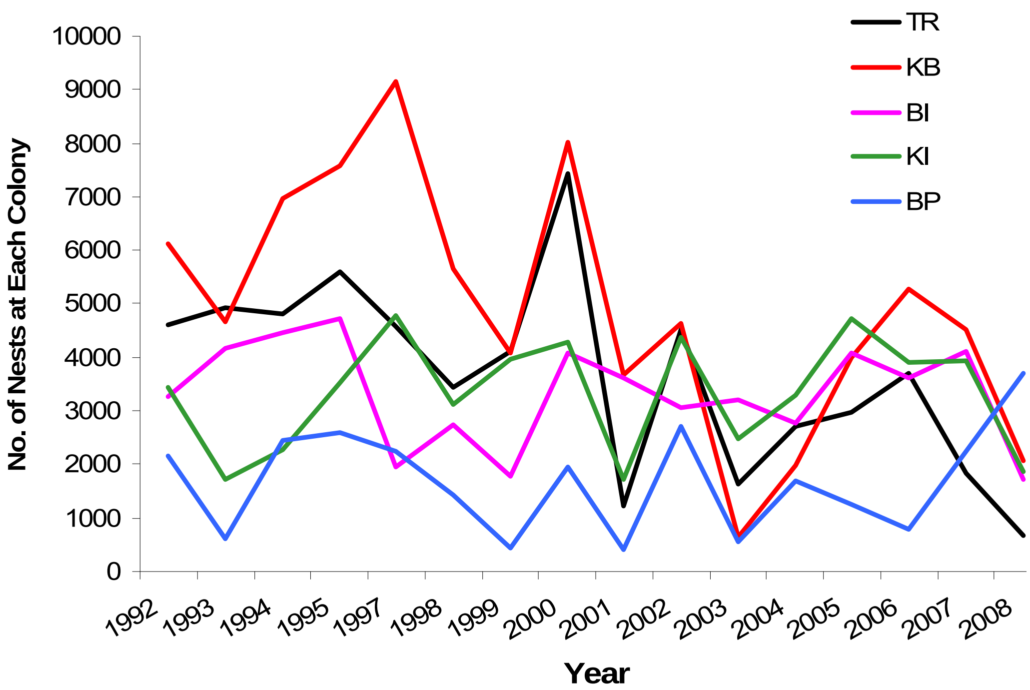

Figure 3. Estimates of nests from photographic surveys at five brant colonies on the Yukon-Kuskokwim Delta (1992-2008); Tutakoke River (TR), Kokechik Bay (KB), Kigigak Island (KI), Baird Peninsula (BP), and Baird Inlet Island (BI).

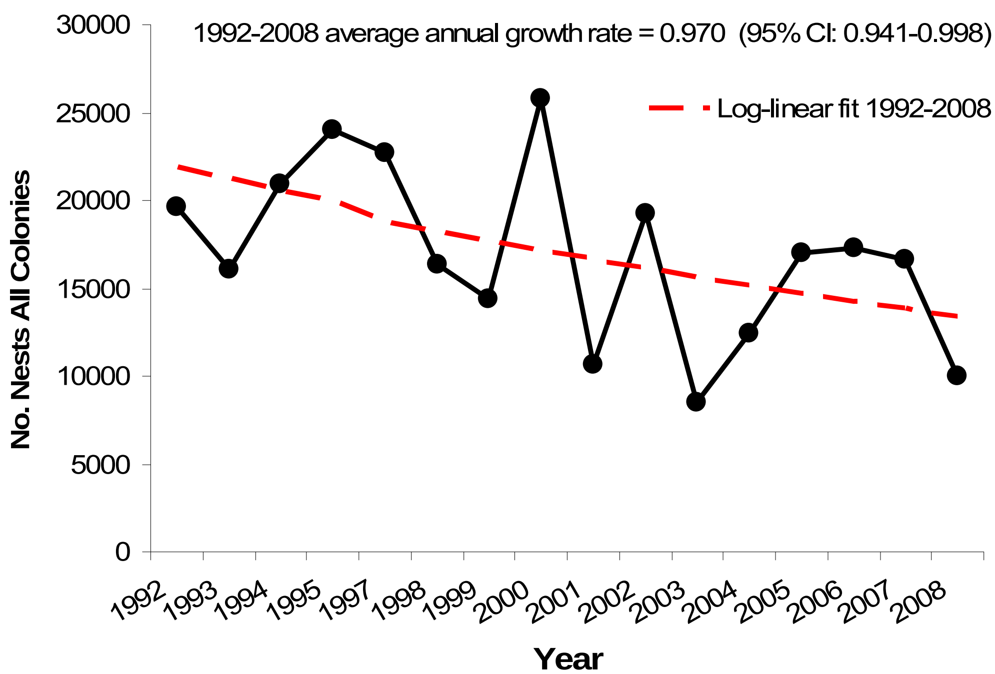

Figure 4. Log-linear trend of annual sums (red dashed line) of estimates of brant nests from photographic surveys across all brant colonies on the Yukon-Kuskokwim Delta (1992-2008). Annual sums for 1995 and 2005 include site-specific averages (from previous and subsequent years) for 2 unsampled colony-years (Kigigak Island: 1995, Baird Peninsula: 2005).

Table 1. Annual estimates and standard errors (± 1 SE, presented in # of nests) from photographic aerial surveys of brant nests at five colonies on the Yukon-Kuskokwim Delta, Alaska (1992-2008); 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)	27,516[3]
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)	18,263 [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) [5]	4,521	(304) [5]	3,924	(304) [5]	2,241	(203) [5]	4,106	(264) [5]	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**
Average	3,673		4,940		3,335 [3]		1,702 [3]		3,331		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, 2008 calculated using the variance of the ratio estimate, rather than binomial variance (as in 1992-2006).

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) skillfully piloted the aircraft, Paul Flint (USGS, Alaska Science Center) assisted with ground-truthing, and Lyndi Denlinger (USFWS, Migratory Bird Management) assisted with ground-truth mapping and image processing. The Yukon Delta National Wildlife Refuge-USFWS provided logistic support, aircraft transport to field sites, a new Nikon D200 camera (on loan), and office/computer space in Bethel during the ground-truthing preparation phase of the survey. The Sea Lion Corporation provided access to their lands at Kokechik Bay for ground-truthing. Mike Wege, Mike Anthony, Julian Fischer, and Paul Flint all gave helpful project advice and reviews of the annual report.

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. 2008. Nest population size and potential production of geese and spectacled

eiders on the Yukon-Kuskokwim Delta, Alaska, 2008. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, Alaska, USA. Unpubl. Report.
IKONOS. 2007. 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. Wildlfowl 44:49-59.