*Summary Report*

# Aerial Photographic Surveys of Brant Colonies on the Yukon-Kuskokwim Delta, Alaska, 2007

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**ABSTRACT** We conducted aerial photographic surveys 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 5-6 June 2007. Total number of nests for all colonies (16,634) was 4% lower in 2007 than in 2006 (17,335), and ~7% lower than the long term mean (1992-2006). KI, BP, and BI had more nests than in 2006, but total number of nests for all colonies (combined) was less than 2005 and 2006 due to decreases at KB and TR. Human activity was reduced at KB compared to historical counts of foot prints and vehicle tracks, but new activity was detected at BP. The trend in annual YKD-wide estimates continues to be negative (approximately -2.44%/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 2007 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 5-6 June 2007.

## METHODS

### Aerial Survey

A pilot, assistant, and I flew transects at 122 m above ground level and used two, vertically-mounted Kodak SLR® digital still cameras with image-stabilizing lenses to photograph colonies. The cameras were set to maximum shutter speed with an aperture of f2.8, focal length of 105-mm, and focused to infinity, producing images of ~42 x 28 m (12 mm/pixel resolution). The cameras had a photo sensor equivalent to the area of 35 mm film and sampled non-overlapping 0.12-hectare quadrats (vs. 0.19-hectare in 2005) 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). An external Global Positioning System (GPS) receiver was interfaced with a laptop computer and the location of transects, as well as the track of the moving aircraft was displayed on the computer monitor during survey flights. Each of the two cameras was connected to a separate GPS receiver and laptop computer. Latitude-longitude, GPS altitude, time-date, and other photographic information was stored internally with each image (Anthony 2004).

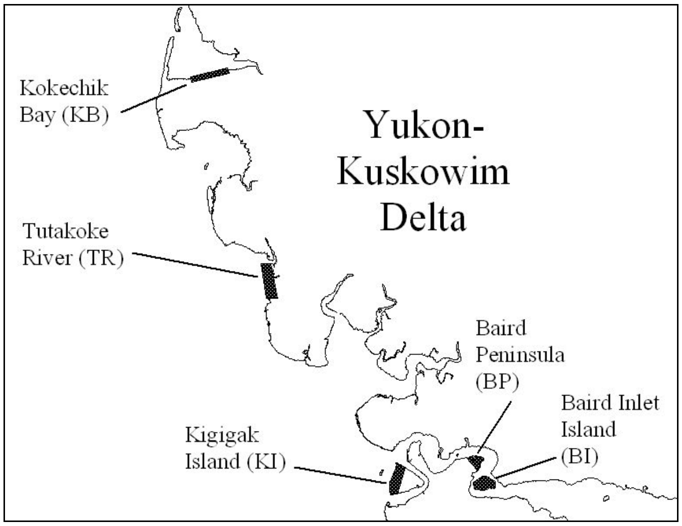


**Figure 1.** Photographic survey areas of Pacific black brant colonies on the Yukon-Kuskokwim Delta.

## 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), in order to determine the nest detection probability in digital images. Ground-truthing involved: 1) mapping photo-quadrats on high resolution georeferenced aerial photos (GPS Photo-link 2006), 2) printing 8.5x11" copies of all photo-quadrats to be ground truthed, 3) walking to each of the selected image-quadrats 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 the variance of the index ratio (assuming no covariance between *x* and *y*) according to Cochran (1963),

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

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

GPS locations stored within images created by the camera in exchangeable image file (Exif) format, were plotted on digitized topographic maps with ArcMap geographical information system (GIS). 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. Image files were first converted from Kodak's proprietary format (.dcr) to a compressed format (.jpg), then 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 video images. Because the images recorded with the digital still camera (4500 x 3000 pixels) covered about 44 times the area of historical video images (640 x 480 pixels; Anthony 2004), the images were viewed in 20 sub-areas that were each equivalent to ~2.2 times that of a video image (Anthony 2006). This additional viewing area provided better images for interpreting content and had the added advantage of reducing processing time. Image file name, sub-area being viewed, and observation codes were recorded automatically to file whenever an observer manually entered a two-digit observation code. In addition to recording observations of brant, cackling geese, emperor geese (*Chen canagica*), white-fronted geese (*Anser albifrons frontalis*), northern pintails (*Anas acuta*), and common and spectacled eiders (*Somateria mollissima, S. fischeri)* were also recorded. Boot tracks and motorized vehicle tracks were counted at BP and KB (see example Fig. 2), but no measure of human activity was attempted at TR, KI, or BI due to the presence of biological field crews at those sites.

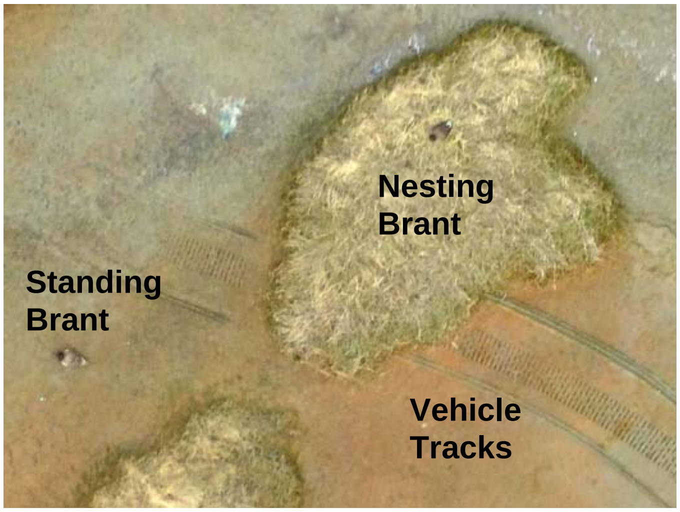


**Figure 2.** Observations of nesting and standing brant, as well as motorized vehicle tracks from a digital image recorded during the aerial survey of the Kokechik Bay colony, 2007.

## RESULTS

We flew transects at flight speeds ranging from 137-162 km/hr over all colonies (head or tail-wind dependent). KB, TR, KI, BP, and BI required 0:26 (hours:minutes), 1:0, 2:28, 0:26, and 2:23, respectively, from start of first transect to end of last transect. Additional time was required at KI and BI due to technical problems. The number of images collected at KB, TR, KI, BP, and BI was 238, 591, 418, 204, and 314, respectively. Thus, given total colony areas of 1111.5 (KB), 1275 (TR), 982.4 (KI), 879.7 (BP), and 667.85 (BI) hectares, the 2007 photos represented a sample of 5.4, 2.8, 4.4, 2.7, and 5.5% of each of the respective colony areas. Surveys at BP and BI were conducted under high overcast, which provided mostly favorable lighting conditions, but poorer/more variable lighting conditions and higher wind speeds resulted in variable image quality at KB, TR, and KI. The index ratio based on pooled image:ground counts across all ground-truthed colonies (KB, TR, KI) was 0.92 (SE: 0.05) and the correction factor for image-based counts was 1.09 (i.e., 1/0.92).

Total number of nests for all colonies (16,634) was 4% lower in 2007 than in 2006 (17,335), and ~7% lower than the long term mean (1992-2006). KI, BI, and BP had more nests than in 2006, but total number of nests for all colonies (combined) was less than 2005 and 2006 due to decreases at KB and TR (Table 1). Further, the trend in the annual sum of estimates across colonies ($\lambda_{log\text{-}linear}$: 0.976, SE: 0.016) continues to be negative (-2.44%/yr; Fig. 4).

### Kokechik Bay (KB)

The estimated number of nests at KB was 14% lower than in 2006, and 13% lower than the long-term average (1992-2006). Human activity was reduced at KB compared to historical counts (i.e., prior to 2006), but increased slightly from 2006 counts. Before 2007, boot tracks were observed in 30 images in 2001, and 34, 160, 166, and 120 in 2002-2005, respectively. In 2006, no boot tracks were counted at KB, but motorized vehicle tracks were seen in 5 images. In 2007, boot tracks were observed in 3 of the 238 images at KB, motorized vehicle tracks in 3 images (see example Fig. 2), and both boot and vehicle tracks in 1 image. There were no signs of nest predation or flooding at KB in the area searched for ground-truthing photographs.

### Tutakoke River (TR)

The estimated number of nests at TR decreased by 50% compared to 2006 and by 54% relative to the long-term average. Although two depredated nests were found during ground-truthing, no evidence of catastrophic fox predation or flooding was observed. However, resident biologists at the TR study site reported large numbers of birds staging away from the primary nesting area and speculated that ≥ 50% of the colony did not attempt to nest in 2007 (J. Sedinger, pers. comm.).

### Kigigak Island (KI) and Baird Inlet Island (BI)

The estimated numbers of nests at KI and BI increased in 2007 compared to 2006 (<1 and 13%, respectively) and compared to the long-term mean (14 and 21%, respectively). Boot and vehicle tracks were not counted at KI or BI due to the presence of resident biologists. No foxes were trapped at KI in 2007, although 40 traps were deployed (Mar.-May; Lake 2007). No evidence of fox depredation was observed during ground-truthing at KI and observations by resident biologists suggested that

**Table 1.** Annual estimates and standard errors (± 1 SE) from photographic aerial surveys of brant nests at five colonies on the Yukon-Kuskokwim Delta, Alaska (1992-2007); 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 |
| **Average** | 3,873 | | 5,132 | | 3,427 | | 1,592 | | 3,439 | | 17,449 [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 mean of 2004 and 2006 BP estimates included in 2005 BP total.
[4] 2006 TR estimate based on 63% of the images analyzed.
[5] Standard errors in 2007 calculated using the variance of the ratio estimate, rather than binomial variance (as in 1992-2006).

overall nest survival was relatively high in 2007 (B. Lake, pers. comm., Lake 2007).

### Baird Peninsula (BP)

The estimated number of nests at BP increased by 183% compared to 2006, and was 48% higher than the long term average. Boot tracks were observed in 5 of the 204 images at BP, indicating some local human disturbance of the area, but no motorized vehicle tracks were observed.

## 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, and b) the YKD-wide colony index declines by >50% relative to the previous years estimate (Pacific Flyway Council 2002). The 2007 YKD colony estimate (16,634) was reduced by only 4% compared to 2006, indicating a stable to slightly decreasing YKD colony nesting population relative to the previous year. However, variation in interannual change across colonies (2006 to 2007) was substantial. For example, the estimate of brant nests at BP increased by 183% from 2006 to 2007, while the estimate at TR decreased by 50%. Although these changes could have been attributed to aberrations in the sampling procedure (i.e., chance sampling of higher or lower density areas within colonies), they may also be indicative of site-specific variation in factors influencing nesting across colonies on theYKD. If this is the case, separating local effects at individual colonies from broader effects (e.g., wintering climate; Sedinger et al. 2006), may be an important area of future investigation.

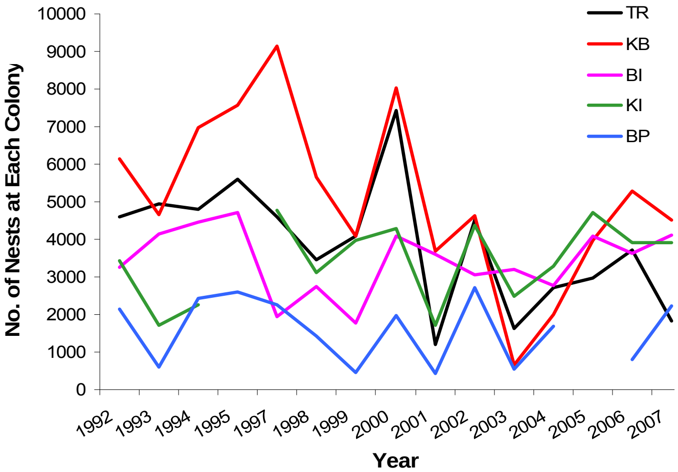


**Figure 3.** Estimates of nests from photographic surveys at five brant colonies on the Yukon-Kuskokwim Delta (1992-2007); Tutakoke River (TR), Kokechik Bay (KB), Kigigak Island (KI), Baird Peninsula (BP), and Baird Inlet Island (BI).

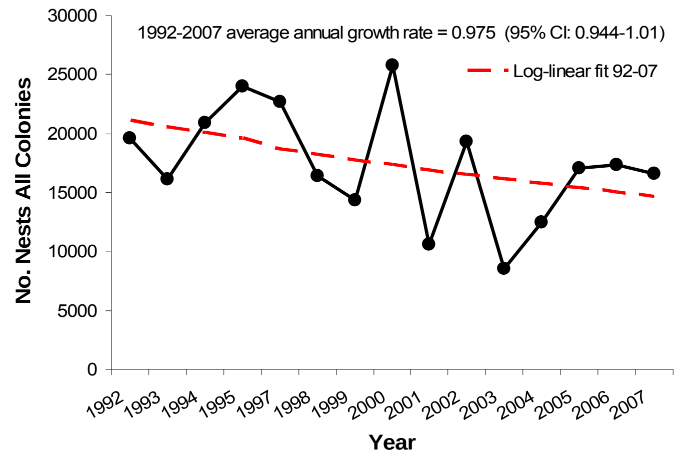


**Figure 4.** Log-linear trend of annual sums (red dashed line) of estimates of brant nests from photographic surveys across all brant colonies on the Yukon-Kuskokwim Delta (1992-2007). Note that annual sums for 1995 and 2005 include site-specific averages (from previous and subsequent years) for 2 unsampled colony-years (Kigigak Island: 1995, Baird Peninsula: 2005).

Further, negative correlations among colony estimates (i.e., increases at one colony coupled with decreases at another) could imply dispersal. However, Lindberg et al. (1998) noted that dispersal of breeding brant among YKD colonies was rare (estimated breeding philopatry was 0.91-1.00), suggesting that dispersal is an unlikely source of correlated interannual fluctuations in colony estimates. Overall, 2007 reflected a more 'normal' nesting season for brant on the YKD, with no indication of flooding, high fox predation, or late break-up among any of the colonies. In addition, predicted hatch dates for brant appeared normal to slightly early, compared to previous years (Fischer et al. 2007); a pattern generally associated with good nesting conditions. However, winter 2006-07 was considered an El Niño according to the Oceanic Niño Index (NOAA 2007), with above average sea surface temperatures for >3 mo., and El Niño conditions have been negatively associated with brant reproduction (Sedinger et al. 2006); at least at one location. However, reproduction was not consistently low across YKD colonies in 2007, as would be expected under the El Niño hypothesis, suggesting local effects may have played a larger role than over-winter disturbances. For example, decreases in nesting brant at some colonies may have been related to over-winter changes to individual nesting areas (e.g., erosion due to storm surges), but further data is needed to explore this hypothesis. Human disturbance appeared to be continuing at selected colonies (e.g., KB, and new activity at BP), but at much lower levels than indicated in historical surveys. No estimate of human activity was quantified at BI in 2007, but in conjunction with the presence of biological crews in the area, the estimate of nesting brant at BI (4,106) was the highest since 1995 (4,720). Thus, anecdotally, the presence of observers/biologists did not appear to have a negative impact on nesting.

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