



2008 Aerial Dall's Sheep Survey in the Itkillik Preserve, Gates of the Arctic National Park and Preserve, Alaska

Natural Resource Technical Report NPS/ARCN/NRTR—2010/409



ON THE COVER

A group of Dall's sheep in the Itkilik Preserve, Gates of the Arctic National Park and Preserve,
Alaska, July 2008

Photograph by: Inga Conti-Jerpe, NPS-Arctic Network

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Abstract

This report summarizes methods and results for an aerial Dall's sheep (*Ovis dalli dalli*) survey conducted in 2008 by the National Park Service Arctic Network Inventory and Monitoring Program, with support from the Alaska Department of Fish and Game, in the northeastern portion of Gates of the Arctic National Park and Preserve, Alaska. This area includes the Itkillik Preserve, where the highest densities of Dall's sheep in the Park and Preserve have been found, and both subsistence and sport hunting are allowed. Approximately 1905 km² of delineated habitat were surveyed via small, fixed-wing aircraft from 9-14 July. Sheep groups were counted and classified as lambs, ewe-like sheep (ewes, yearlings and rams with less than ½ curl horns), sub-curl rams ($\geq \frac{1}{2}$ curl and $<$ full-curl) and \geq full curl rams. We observed 315 groups of Dall's sheep, totaling 1239 individuals (961 adults, 276 lambs, and two sheep that could not be classified). There were 40 lambs per 100 ewe-like sheep, 41 rams per 100 ewe-like sheep, and 19% of the rams were full-curl. Overall density of observed sheep was 0.65 sheep/km². These are unadjusted count and composition data collected for the Arctic Network's monitoring program with the objective of detecting trends in the abundance and distribution of Dall's sheep in the central and western Brooks Range. The 2008 data, as well as data from a more extensive survey conducted in 2005, indicate a healthy and productive sheep population that has likely increased since a regional decline observed in the early 1990s, albeit not to the numbers counted in the same area in the early 1980s. Recommendations for future survey work are discussed.

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Introduction

Dall's sheep (*Ovis dalli dalli*) populations in the Brooks Range of Alaska are at the northernmost limit of their range. Population declines were observed across the region in the late 1980s and early 1990s following a few winters with icing events and higher than average snowfall that may have reduced foraging opportunities and increased vulnerability to predation (Ayres 1996, Whitten 1997, Brubaker and Whitten 1998). Although recent surveys indicate an increase in the population in the western Baird Mountains (Shults 2004, National Park Service unpublished 2009 survey data) and stabilization of the population surrounding Anaktuvuk Pass (Lawler 2004), Dall's sheep numbers remain lower in the central and western Brooks Range than were observed in the early 1980s (Singer et al. 1983, Singer 1984, Rattenbury and Lawler 2010).

The central and western Brooks Range encompasses more than 41,000 km² of potential Dall's sheep habitat, most of which is in Gates of the Arctic National Park and Preserve (Gates of the Arctic), Noatak National Preserve (Noatak) and northern Kobuk Valley National Park (Kobuk Valley). The National Park Service (NPS) is mandated by the Alaska National Interest Lands Conservation Act (ANILCA) to protect and conserve 'natural and healthy populations' of Dall's sheep and to provide for continued subsistence opportunities within these ANILCA-established parklands (ANILCA 1980). Due to the sensitivity of Dall's sheep to local environmental conditions (Murphy 1974, Hoefs and Cowan 1979, Burles and Hoefs 1984), monitoring trends in abundance, distribution, and sex and age ratios is critical to this mandate. The NPS Arctic Network Inventory and Monitoring Program (Arctic Network) is developing a long-term monitoring plan for Dall's sheep based on aerial observation at two scales: 1) region-wide sampling to generate abundance estimates in Gates of the Arctic, Noatak and northern Kobuk Valley; and 2) count and composition (classification of sex and age) surveys in two reference areas of high priority for harvest management: the Preserve and adjacent Park in the northeastern corner of Gates of the Arctic (Itkillik study area) and the western Baird Mountains of southwestern Noatak (Lawler et al. 2009).

The Itkillik Preserve contains the highest densities of Dall's sheep recorded in Gates of the Arctic (Singer 1984, Brubaker and Whitten 1998). The preserve is open to subsistence hunting, and sport hunting is accessible via the Dalton Highway. Count and composition data for the area are available from 1983 (Singer 1984), 1996 (Whitten 1997, Brubaker and Whitten 1998) and 2005 (Rattenbury and Lawler, in review), however these studies varied in scope, technique and success (Table 1). An objective of the Arctic Network monitoring plan is to establish regular surveys to detect trends in abundance and sex and age ratios of Dall's sheep in the Itkillik study area. The Arctic Network conducted an aerial, minimum count survey from 6-14 July, 2008 as a pilot study for this portion of the monitoring plan.

Study Area

The Itkillik study area covers the preserve and adjacent parkland south to the upper reaches of the Anaktuvuk River, Ernie Creek and North Fork of the Koyukuk River (Figure 1). There are 2470 km² (954 mi²) of delineated Dall's sheep habitat, divided into 38 survey units by Brubaker and Whitten (1998). Collectively these units make up two of the larger survey units (units 17 and 18) delineated by Singer (1984). Some units lie outside of the park and preserve on Native corporation and Bureau of Land Management land where contiguous habitat is present. The area is also within multiple game management units (GMU) of the Alaska Department of Fish and Game (ADF&G): 24A, 24B, 26A and 26B. Anaktuvuk Pass is west of the study area and the Atigun River and Dalton Highway form a portion of the eastern border.

The study area is mostly north of the Continental Divide, from 67° 55' to 68° 30' north and 149° 20' to 151° 35' west. The minimum elevation is 670 m ASL in the lowest river valleys rising to a maximum of 2320 m ASL at Cockedhat Mountain. The climate for the central Brooks Range north of the Continental Divide is characterized by long, cold winters, and short summers influenced by the Arctic Ocean. Results from climate mapping with the Parameter Regression on Independent Slopes Model (PRISM) show mean annual precipitation ranging spatially from 300 mm in the river valleys to 800 mm in the highest peaks on the eastern border of Gates of the Arctic for the study area (Davey et al. 2007). PRISM maps also show mean annual temperatures below -14°C in the highest areas of northeastern Gates of the Arctic, with mean minimum January temperatures ranging spatially from -33 to -29°C across the study area and mean maximum July temperatures ranging spatially from 10 to 18°C across the study area (Davey et al. 2007).

The landscape is characterized by steep, rugged mountains and glacier-sculpted valleys draining the headwaters of the Itkillik, North Fork of the Koyukuk, Anaktuvuk and Atigun Rivers. Small, permanent snow fields persist at the highest elevations, although the ridgelines are dominated by sparsely-vegetated rocky outcrops, which provide cave-like escape terrain for Dall's sheep. The predominant vegetation communities below the rock-rubble fields are *Dryas*-sedge-lichen tundra and *Dryas*-mixed herb-lichen tundra while the river valleys are primarily moist to wet tussock tundra with *Eriophorum vaginatum* the most common tussock species.

Methods

The survey was conducted from 9-14 July, 2008. Three fixed-wing Piper PA-18 Super Cub aircraft were based at the Galbraith Lake airstrip. One plane moved to Anaktuvuk Pass midway through the project to survey the western units. Pilots with extensive experience surveying Dall's sheep in this area were selected for the project. Observers had prior experience with aerial surveys or were trained in data collection methods before the survey. Survey unit boundaries delineated by Brubaker and Whitten (1998) were used with the numbering system developed for park-wide surveys conducted from 2005-2007 (Figure 1; Rattenbury and Lawler 2010). The 38 survey units have an average area of 65 km² (range 16-95 km²).

For navigation, all pilots and observers were given paper maps of the survey units, and survey unit boundaries were uploaded onto a Global Positioning System (GPS) in each aircraft. Combinations of adjacent survey units were assigned each morning based on observed and forecasted weather conditions. Survey flights typically occurred between 0500 and 1200, or later if wind and cloud ceiling conditions were not favorable in the early morning but improved later in the day. Aircraft were flown at low altitude (below 150 m), following contours with the goal of observing all sheep in a unit. Search effort was increased in units with more rugged terrain where detectability of Dall's sheep was expected to be lower.

When a group of Dall's sheep was spotted, the location was marked with the aircraft GPS, and the group was circled as necessary to make an accurate assessment of group size and composition. Group composition was based on the following classification: lambs, ewe-like sheep (including ewes, yearlings and rams with less than ½ curl horns), sub-curl rams (\geq ½ curl and $<$ full-curl horns), full-curl rams (\geq full-curl horns), unclassified rams (horn size \geq ½ curl but not distinguishable as $<$ or \geq full-curl) and unclassified sheep. The observer recorded all data on a paper datasheet including survey time per unit, weather conditions, and group location, size and composition (Appendix 1). Digital photographs were taken to check and, if necessary, correct count and composition for large groups. Corrections were verified by two observers having multiple years of survey experience with Dall's sheep, and increases in group size were only made when the count in the photograph was higher than the recorded data with consideration for adjacent groups that may have become commingled. Because it was often difficult to photograph large and/or scattered groups of sheep, we did not adjust counts if fewer sheep were found in the photographs compared with the observer-recorded data.

While the use of digital photography is a new addition to NPS aerial surveys of Dall's sheep, the format of using fixed-wing aircraft for minimum count and composition surveys is similar to surveys conducted elsewhere in the region (e.g., Lawler 2004, Shults 2004, Caikoski 2008). Previous Dall's sheep surveys in the Itkillik study area have included minimum count by helicopter (Singer 1984), double sampling using helicopter and fixed-wing aircraft (Whitten 1997, Brubaker and Whitten 1998), and stratified random sampling using fixed-wing aircraft (Rattenbury and Lawler, in review), although all of these studies involved a larger survey area than the Itkillik (Table 1).

Results

Poor visibility, low cloud ceilings, strong winds and rain prevented flying on some survey days, but 1905 km², or 77% of the study area, was surveyed (Figure 1). Total survey time (not including ferry time or unfinished units) was 48.55 hours, with 83% of the survey occurring on July 10 and 12 when the weather was clearest. Twenty-nine of 38 units were surveyed. Units 4B, 4C, 4E, 4H, 4I, 4M, 4R, 4T and 4W were not completed, although 4R, 4T and 4W were attempted. Overall search intensity including classification time was 1.53 min/km², with an average of 1.57 min/km² and a range of 0.78-2.69 min/km² among units.

Observer-pilot teams located 315 groups of Dall's sheep totaling 1239 individuals (961 adults, 276 lambs, and 2 unclassified sheep) in the completed survey units (Table 1, Appendix 2). All units contained at least one group of sheep. Group size ranged from one to 29 sheep ($\bar{X} = 3.9$, median = 2). Most groups were on ridges at high elevation. For those units surveyed completely, the overall density was 0.65 sheep/km². There were 40 lambs per 100 ewe-like sheep, 41 rams per 100 ewe-like sheep, and 19% of the rams (not including unclassified rams) were full-curl. Another 20 groups totaling 67 individuals (55 adults and 12 lambs) were located in units that were not completely surveyed due to deteriorating weather conditions.

The digital photograph check resulted in composition changes to 22 of the 315 sheep groups observed (7%). Typically these corrections involved changes between ram classes or separating lambs from yearlings (yearlings being moved to the ewe-like group). Photograph verification also resulted in an increase in the total sheep count for four groups, totaling nine additional ewe-like sheep. We also removed a double-count of one group that was seen in two adjacent units on different days based on group composition and photographs that indicated the observations were of the same group. The use of digital photography to verify group count and composition have not previously been used for NPS surveys of Dall's sheep in the Arctic Network. The ability to take photographs of sufficient quality to verify count and composition takes practice; and light conditions also affect photograph quality. We were able to take photographs of sufficient quality for 84% of the large groups (groups with five or more sheep) and 85% of groups with rams. However, data recorded for most of those large or ram groups without photographs (71% of the large groups without photographs and 87% of the ram groups without photographs) were collected by one pilot-observer team having multiple years of experience conducting aerial surveys for count and composition of Dall's sheep.

Discussion

Numbers of sheep observed in the 2008 aerial survey of Dall's sheep in the Itkillik study area are minimum counts for the units that were completely surveyed and represent an unknown proportion of the actual population. Comparison between these results and previous studies in the same area must be done with caution because of differences in survey aircraft, sampling design and methods, search intensity and survey unit coverage (Table 1). The entire study area was surveyed in 1983 and 2005, and all but units 4AA and 4Z were surveyed in 1996 (4AA and 4Z contained <1% of the total sheep observed in 1983 and 2005, and 2% of the total sheep observed in 2008). The total number of sheep counted in the Itkillik study area during the 1983, 1996 and 2005 surveys was 1965, 1365 and 1638 sheep, respectively. The decline in Dall's sheep abundance between the 1983 and 1996 surveys was observed in other areas of the Brooks Range, and is not explained by differences in search intensity (Brubaker and Whitten 1998). The 2005 count indicates some recovery of Dall's sheep numbers in the study area.

Dall's sheep annual distribution and movement patterns within the study area are not known, making it inadvisable to extrapolate data from previous surveys for those units not surveyed in 2008. Where the same area was surveyed in all three years, the number of sheep counted in 2008 (1213) was higher than in 1996 (879) and 2005 (1009), but search intensity was also highest in 2008 (Table 2). Sheep abundance likely did not change markedly between 2005 and 2008. However, it does appear that there were more sheep in the Itkillik study area in 2005 and 2008 than in 1996, but less than in 1983, when we compare the observed density data for the entire study area among the 1983, 1996, 2005 and 2008 surveys (Table 1). The 2005 and 2008 data indicate healthy proportions of lambs per 100 ewe-like sheep and rams per 100 ewe-like sheep in the study area (Table 1). Recruitment is difficult to assess because yearlings were not classified separately from ewes, and rams less than full-curl were not categorized by size. Full-curl rams made up 4% of the total sheep counted in each of the 1983, 2005 and 2008 surveys (Table 1).

The 2005 and 2008 survey data follow general trends seen in other areas of the central and western Brooks Range. Aerial surveys for minimum count and composition of Dall's sheep have been conducted most years from 1986-2009 in the western Baird Mountains in an 1828 km² study area. Dall's sheep abundance in the western Baird Mountains decreased markedly in the early 1990s, but there has been a recovery in numbers since then (Shults 2004, National Park Service unpublished 2009 survey data). Aerial surveys conducted to the west and south of Anaktuvuk Pass from 1998-2002 showed healthy proportions of lambs and rams; however survey coverage varied among years and no increasing or decreasing trend in total or adult numbers was detected during the survey period (Lawler 2004). On the other hand, Lawler (2004) stated that the 1998-2002 counts suggested a lower population of sheep than were observed in the same area in the early 1980s (Singer 1984). Cohorts of rams that would have been born during the late 1980s and early 1990s were low in number based on horn size classes observed through 2004 in the western Baird Mountains (Shults 2004) and the central Brooks Range (Lenart 2005). At the time of the 2005 and 2008 surveys in the Itkillik Preserve, the youngest of these cohorts would now be over 10 years old. The apparent stabilization and slight increase in Dall's sheep populations in some areas in the central and western Brooks Range indicate that the effects of the severe winters of 1988-1993 may be waning, but a return to the higher numbers seen in the early 1980s is not evident.

Although minimum count and composition methods have been a standard for measuring Dall's sheep populations across the state of Alaska, some limitations to these methods should be noted. Differences in counts between survey years may be an effect of annual differences in productivity and survival; changes in movement and distribution; and/or variation in sightability, search effort, observer experience and the number and combination of units flown. While efforts can be made to reduce the variability associated with search effort, observer experience, survey area and to a certain extent survey conditions (e.g., standardize search effort, train and test observers, reduce survey area, fly only during specific weather and survey conditions), these efforts may not meet management objectives and may exceed funding and logistical capacity. More significantly, despite such efforts, minimum count and composition methods do not incorporate a means to measure variability related to survey conditions, sheep distribution and sightability.

Patterns of sheep movement within and into/out of the Itkillik study area are not well known. A study of radio-collared Dall's sheep conducted to the west and south of Anaktuvuk Pass showed minimum convex polygons with a mean area of 72.4 km² (SE=5.04, range 47.5-128.1 km²) and 95% utilization distribution kernels with a mean area of 69.7 km² (SE=7.25, range 13.8-140.2 km², Lawler 2004). If Dall's sheep maintain a similar home range size within the boundaries of the Itkillik study area, then the study area may serve as reasonable bounds for population studies. However, there may also be significant seasonal movement to the east and south of the study area where there is contiguous habitat and few physical barriers.

Visibility bias (sightability) also influences abundance estimates from aerial surveys of wildlife (Caughley 1974, Pollock and Kendall 1987). Because Dall's sheep are white, which contrasts with the sparsely-vegetated, rocky environment of their summer habitat, and because they are often found in groups, it is assumed that detection is higher than for many other species. However, multiple factors may influence the ability to detect sheep including terrain, group size and composition, activity, topographic position and position in relationship to the survey aircraft, type of aircraft, experience of the pilot and observer, search intensity, light level, ground cover and weather conditions (McDonald et al. 1990, Strickland et al. 1992).

Several studies have been conducted to assess the sightability of Dall's sheep including double-sampling methods (McDonald et al. 1990, Whitten 1997), sight-resight methods (McDonald et al. 1990, Strickland et al. 1992, Strickland et al. 1994), and logistic regression models based on mark-resight of collared sheep (Udevitz et al. 2006). A double-sampling study was conducted in 1996 in northeastern Gates of the Arctic including the study area, but weather prevented the helicopter from flying at the optimal search intensity in the double-sampled units, resulting in an overestimated detection rate of 91% (Whitten 1997). Udevitz et al. (2006) re-analyzed the data from these earlier surveys (excluding the Gates of the Arctic results) and estimated detection rates for Dall's sheep ranging from 58% to 76%, while the average detection rate from their mark-resight surveys was 88% in the western Baird Mountains. This suggests that between 12% and 42% of the actual population may not have been detected in the 2008 Itkillik survey. Udevitz et al. (2006) developed a sightability model based on mark-resight of collared Dall's sheep in the western Baird Mountains and found that sightability increases with group size. The model could be applied to the Itkillik study area, but group size was smaller in the 2008 Itkillik survey compared with the western Baird Mountains study. Additionally, terrain complexity may play a larger role in sightability in the Itkillik Preserve than in the western Baird Mountains. An

investigation of the factors affecting sightability should be specific to the survey conditions in the study area.

Management and Monitoring Recommendations

- Count and composition data from the 2008 survey in the Itkillik study area indicate that the Dall's sheep population may have increased since the large-scale decline of the late 1980s and early 1990s, though not to the levels seen in the early 1980s. These data do not include estimates of precision, accuracy or sightability. These factors need to be addressed in a long-term monitoring program that seeks to detect changes in the abundance and sex and age ratios of Dall's sheep in this area.
- Comparisons should be made of aerial census methods versus sampling methods which could produce statistically rigorous estimates of Dall's sheep abundance. The Arctic Network is testing distance sampling methods in 2009 and 2010 across Gates of the Arctic and will assess the viability of applying these methods to a smaller area such as the Itkillik Preserve. These methods may also be useful for estimating the abundance of different sex and age classes over time.
- Digital photography as a means to verify count and composition is a valuable tool for aerial Dall's sheep surveys, particularly for large groups of sheep and where classification of ram curl-size is important for management. Additionally, photographs can improve data quality for large scale surveys involving multiple observers, given that observers are trained and experienced with taking decent quality photographs of wildlife from aircraft. Photograph verification will continue to be a part of the Arctic Network's aerial surveys of Dall's sheep.
- Estimates of sightability and the variance associated with sightability would improve our ability to compare count data between years. Various methods to assess sightability have been developed for Dall's sheep surveys most of which can significantly increase survey cost and complexity (e.g., mark-resight of collared sheep, double sampling). Mark-resight data can be used to develop sightability models for estimating detection rates and variance in later surveys conducted in the same area so long as the variables affecting sightability do not change drastically over time, at which point a new collaring project and model are needed (Udevitz et al. 2006). On the other hand, distance sampling methods incorporate an estimate of detection within the abundance estimate, and produce measures of uncertainty that allow for statistically valid comparisons between different survey years.
- Movement of sheep within and across the study area boundary may influence inter-annual variation in abundance. A multi-year collaring study could be designed to assess productivity, survival, movement and sightability. Such a study would require the input of local residents who are concerned about the effects of collaring on sheep (Lawler 2004), as well as the involvement of neighboring agencies and organizations.
- Although hunting harvest is apparently low and so is likely not impacting Dall's sheep abundance or full-curl ram counts in the study area, periodic harvest reporting should be a component of monitoring the status of Dall's sheep in the Itkillik Preserve. Harvest reported in the Itkillik study area (ADF&G uniform coding units 24Z-K00-1413, 26A-V00-0703, 26A-V00-0704, 26A-V00-0102, 26B-V00-0103) ranged from 6-18 sheep

(\bar{X} =10) annually from 1994-2003, down from 13-39 sheep (\bar{X} =24) annually from 1984-1993. These numbers do not include sheep that may have been harvested in the study area but were reported for a broader region, or estimates for any unreported harvest. Sheep harvested by sport hunters are limited to one full-curl ram, eight-year-old or older ram, or a ram with horns broomed on both sides. Reports for the game management units that span the Itkillik study area (26A, 26B, 24A, 24B, Figure 1) show consistently low sport harvest from 1996-2007 (Hollis 2008, Caikoski 2008), although hunter numbers have increased in 26B (Caikoski 2008). Current subsistence harvest levels are not known for the study area, but are expected to be low. Anaktuvuk Pass has a community harvest quota of 60 sheep per year, of which 10 may be ewes. Residents reported harvesting 5-17 sheep annually from 1997-2002 (\bar{X} =12, Lawler 2004), but most of these sheep were harvested to the west and south of the community in more traditional hunting areas that are outside of the Itkillik Preserve (Brubaker and Whitten 1998).

- The Itkillik Preserve study area is an important area to monitor because of the high densities of Dall's sheep, its popularity to hunters, and the accessibility of the area for repeated surveys (proximity to Galbraith Lake airstrip and facilities). Given a robust population monitoring program, it could also serve as an important reference area for monitoring factors of Dall's sheep ecology which affect abundance, such as forage quantity and quality (already a planned component of the monitoring plan), the effects of weather and snow, predation, harvest levels and health and body condition.

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Table 1. Comparison of methods and results from aerial Dall's sheep surveys conducted in 1983, 1996, 2005 and 2008 in the Itkillik Preserve study area, Gates of the Arctic National Park and Preserve, Alaska.

Methods and Results	1983 ^a	1996 ^{b,c}	2005 ^d	2008
Survey method	Minimum count / composition	Double sampling	Stratified random sampling	Minimum count / composition
Scope of study	Gates-wide ^e	Northeastern Gates ^e	Gates-wide ^e	Itkillik study area
(Total area surveyed)	(13,178 km ²)	(5800 km ²)	(9170 km ²)	(1905 km ²)
Aircraft	Bell 206 helicopter	Super Cub, R-22 helicopter	Super Cub, Husky, Scout	Super Cub
Itkillik study area				
Coverage (%) ^f	2470 km ² (100%)	2346 km ² (95%) ^g	2470 km ² (100%)	1905 km ² (77%) ^h
Survey dates	17-21 Jul 1983	7-17 Jul 1996	20-26 Jun 2005	9-14 Jul 2008
Overall search intensity, min/km ² (range among units)	0.47 ^b	0.89 (0.57-1.70) ⁱ	1.16 (0.46-3.04)	1.53 (0.78-2.69)
Sheep counted in the Itkillik				
Ewe-like ^j (%) ^k	1167 (59.4%)	not available ⁱ	926 (56.5%)	683 (55.1%)
Lambs (%) ^k	341 (17.4%)	268 (19.6%) ⁱ	371 (22.6%)	276 (22.3%)
Rams: ½ ≥ curl < full (%) ^k	351 (17.9%)	not available ⁱ	241 (14.7%)	224 (18.1%)
Rams: ≥ full-curl (%) ^k	80 (4.1%)	not available ⁱ	70 (4.3%)	53 (4.3%)
Unclassified rams (%) ^k	26 (1.3%)	not available ⁱ	0 (0.0%)	1 (0.1%)
Unclassified sheep (%) ^k	0 (0.0%)	0 (0.0%)	30 (1.8%)	2 (0.2%)
Adults (%) ^k	1624 (82.6%)	1097 (80.4%) ⁱ	1237 (75.5%)	961 (77.6%)
Total sheep	1965	1365	1638	1239
Lambs:100 ewe-like ^j	29	not available ⁱ	40	40
Rams:100 ewe-like ^j	39	not available ⁱ	34	41
% full-curl/all classified rams	19	not available ⁱ	23	19
Overall density (sheep/km ²)	0.80	0.58 ⁱ	0.66	0.65

^aData from the 1983 survey were re-analyzed for this table due to miscalculated data in the original report, Singer (1984).

^bWhitten 1997.

^cBrubaker and Whitten 1998.

^dRattenbury and Lawler, in review.

^eGates = Gates of the Arctic National Park and Preserve; Noatak = Noatak National Preserve.

^fPortion of Itkillik study area surveyed that year (total area = 2470 km²).

^gUnits 4AA and 4Z were not surveyed in 1996.

^hUnits 4B, 4C, 4E, 4H, 4I, 4M, 4R, 4T and 4W were not surveyed in 2008.

ⁱData from fixed wing coverage (33 units) except 4F, 4O, and 4V which were only surveyed by helicopter. Data for ewe-like and ram classes were only available for the units surveyed by helicopter (13 of 36 units) and are not reported here.

^jEwe-like sheep include ewes, yearlings and all rams < ½ curl.

^kPercent of total count, including unclassified rams and unclassified sheep. 'Adults' includes all classes except lambs and unclassified sheep.

Table 2. Classification of Dall's sheep observed in 26 survey units completed in 1996, 2005 and 2008 in the Itkillik Preserve study area, Gates of the Arctic National Park and Preserve, Alaska.

Classification of observed sheep	1996^a	2005^b	2008
Ewe-like ^c	not available	542	668
Lambs	177	228	268
Rams: ½ ≥ curl < full	not available	172	221
Rams ≥ full-curl	not available	59	53
Unclassified rams	not available	0	1
Unclassified sheep	0	8	2
Adults ^d	702	773	943
Total sheep	879	1009	1213
Lambs:100 ewe-like ^c	not available	42	40
Rams: 100 ewe-like ^c	not available	43	41
% full-curl/all classified rams	not available	26	19
Overall density for 26 units (sheep/km ²)	0.50	0.57	0.69
Overall search intensity for 26 units, min/km ² (range among units)	0.89 (0.57-1.70)	1.17 (0.63-3.04)	1.50 (0.78-2.69)

Twenty-six units were surveyed in all three years including 1A-1K, 4A, 4D, 4F, 4J, 4K, 4L, 4N, 4O, 4P, 4Q, 4S, 4U, 4V, 4X, 4Y. Total area is 1766 km². Data from the 1983 survey (Singer 1984) were not included because unit locations were not available for all observed groups of sheep.

^aBrubaker and Whitten 1998. Count and composition are from fixed wing coverage, except for units 4F, 4O, and 4V which were only surveyed by helicopter. Data for ewe-like and ram classes were only available for the units surveyed by helicopter (11 of 26 units) and are not reported here.

^bRattenbury and Lawler, in review.

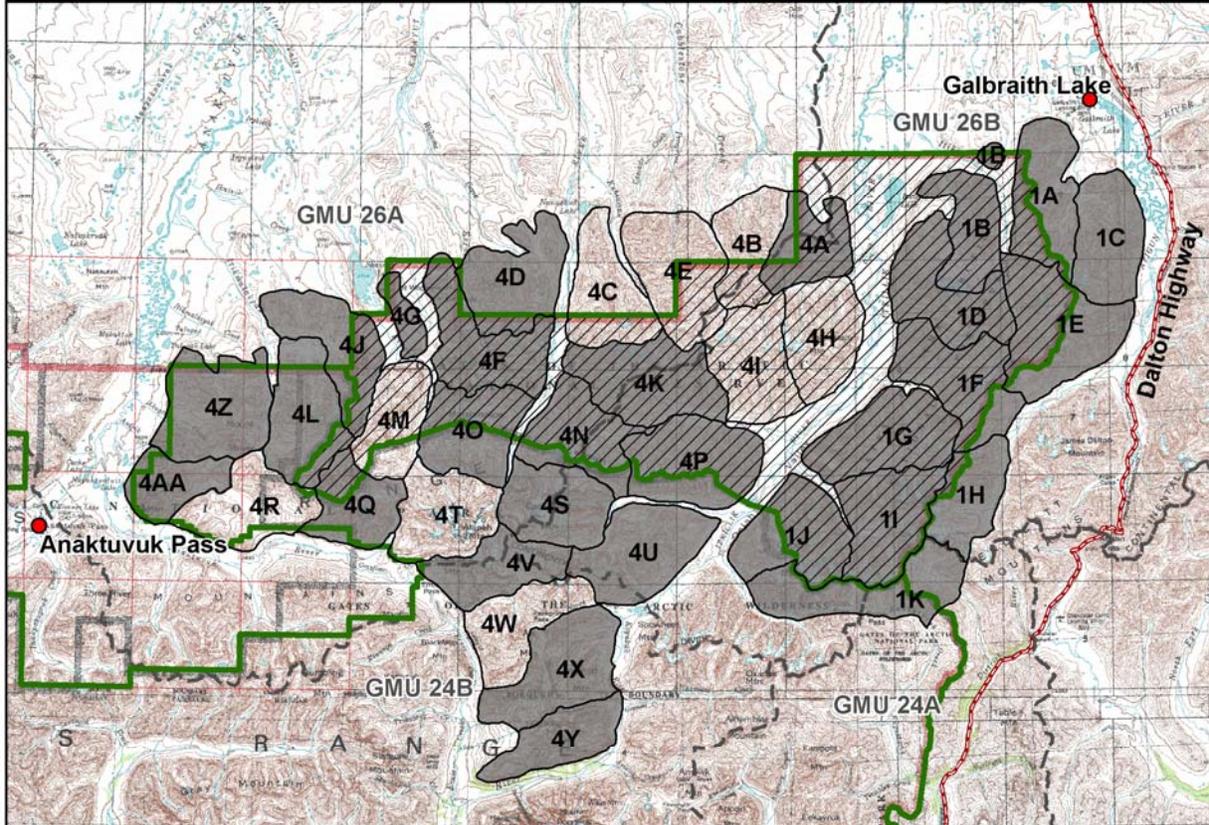
^cEwe-like sheep include ewes, yearlings and all rams < ½ curl.

^dThe category 'adults' includes all classes except lambs and unclassified sheep.

Arctic Network Dall's Sheep Survey

July 2008
Gates of the Arctic National Park and Preserve

National Park Service
U.S. Department of the Interior



<p>Itkillik Survey Area</p> <ul style="list-style-type: none"> Surveyed in 2008 Not surveyed in 2008 <p>Gates of the Arctic National Park and Preserve</p> <ul style="list-style-type: none"> Park/Wilderness lands Preserve lands (Itkillik Preserve) ADF&G Game Management Units 	<p>Map Location</p>	<p>Arctic Network Inventory and Monitoring Program</p>
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Figure 1. Dall's sheep survey units and survey coverage, July 2008, in the Itkillik Preserve study area, Gates of the Arctic National Park and Preserve, Alaska.

Appendix A. Data sheet for fixed-wing Dall's sheep surveys.

Fixed-wing surveys

National Park Service Alaska Region
Dall's Sheep Survey – Data Sheet

Entry/Edit Date	Initials

Survey Unit _____ Park (or general survey area) _____ Page ____ of ____

Date (e.g., 8 Jul 2008) _____

Pilot _____

Observer _____

Aircraft type/N# _____

Weather/Search conditions:

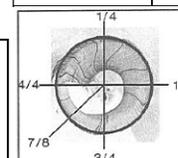
Cloud cover: Clear . . . <1/2 . . . ≥1/2 . . . Overcast

Precipitation: None . . . Rain . . . Snow

Turbulence: None . . . Light . . . Moderate

Light Intensity: High . . . Medium . . . Low

Survey time: Start _____	Stop _____	Total _____
Start _____	Stop _____	Total _____
Start _____	Stop _____	Total _____
Total Elapsed Time (min) _____		



Comments / other conditions that might affect data quality:

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Group #	Ewe-like	Lambs	Sub Rams < 4/4 curl	Full Rams ≥ 4/4 curl	Unclass. Rams	Unclass. Sheep	Total	Data Q*	Waypoints	Comments
Total this page										
Total in unit										

*Data quality: 1)Excellent visual/count; 2)Good visual/count; 3)Poor visual/count

Appendix B. Survey statistics and Dall's sheep classification by unit, July 2008, Itkillik Preserve study area, Gates of the Arctic National Park and Preserve.

17

Unit	Survey Day	Search Time (min)	Area (km ²)	Search Effort (min/km ²)	Ewe-like ^a	Lambs	< Full-curl rams	≥ Full-curl Rams	Unclassified Rams	Unclassified Sheep	Total
1A	10-Jul-08	60	68.40	0.88	16	5	0	0	0	0	21
1B	12-Jul-08	79	54.47	1.45	18	5	0	0	0	0	23
1C	12-Jul-08	60	63.70	0.94	14	7	5	0	0	0	26
1D	12-Jul-08	75	71.66	1.05	32	19	0	1	0	0	52
1E	12-Jul-08	105	94.55	1.11	49	20	7	5	0	0	81
1F	12-Jul-08	110	75.76	1.45	31	9	9	8	0	0	57
1G	11-Jul-08	85	76.07	1.12	37	17	14	5	0	0	73
1H	9-Jul-08	58	49.28	1.18	25	11	3	0	0	0	39
1I	12-Jul-08	95	71.64	1.33	39	12	7	1	0	0	59
1J	10-Jul-08	190	70.51	2.69	12	6	17	2	1	0	38
1K	9-Jul-08	59	75.24	0.78	16	8	2	1	0	0	27
4A	9-Jul-08	100	48.23	2.07	1	0	2	0	0	0	3
4B	Not surveyed	--	--	--	--	--	--	--	--	--	--
4C	Not surveyed	--	--	--	--	--	--	--	--	--	--
4D	9-Jul-08	174	71.11	2.45	21	8	6	2	0	2	39
4E	Not surveyed	--	--	--	--	--	--	--	--	--	--
4F	12-Jul-08	109	72.75	1.50	37	16	8	4	0	0	65
4G	9-Jul-08	38	15.78	2.41	1	0	0	0	0	0	1
4H	Not surveyed	--	--	--	--	--	--	--	--	--	--
4I	Not surveyed	--	--	--	--	--	--	--	--	--	--
4J	9-Jul-08	162	66.09	2.45	15	6	2	0	0	0	23
4K	10-Jul-08	183	82.92	2.21	70	28	56	8	0	0	162
4L	12-Jul-08	93	71.48	1.30	1	0	9	2	0	0	12
4M	Not surveyed	--	--	--	--	--	--	--	--	--	--
4N	12-Jul-08	103	63.35	1.63	30	10	8	1	0	0	49
4O	12-Jul-08	118	65.78	1.79	44	17	18	1	0	0	80
4P	10-Jul-08	111	81.14	1.37	28	15	21	0	0	0	64

Appendix B. Survey statistics and Dall's sheep classification by unit, July 2008, Itkillik Preserve study area, Gates of the Arctic National Park and Preserve (continued).

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Unit	Survey Day	Search Time (min)	Area (km ²)	Search Effort (min/km ²)	Ewe-like ^a	Lambs	< Full-curl rams	≥ Full-curl Rams	Unclassified Rams	Unclassified Sheep	Total
4Q	12-Jul-08	85	50.53	1.68	6	3	2	0	0	0	11
4R	Not surveyed	--	--	--	--	--	--	--	--	--	--
4S	10-Jul-08	53	62.23	0.85	15	5	2	1	0	0	23
4T	Not surveyed	--	--	--	--	--	--	--	--	--	--
4U	10-Jul-08	90	76.44	1.18	27	9	7	4	0	0	47
4V	10-Jul-08	60	54.21	1.11	18	8	5	2	0	0	33
4W	Not surveyed	--	--	--	--	--	--	--	--	--	--
4X	10-Jul-08	162	79.06	2.05	33	16	6	4	0	0	59
4Y	11-Jul-08	75	49.38	1.52	33	8	5	1	0	0	47
4Z	12-Jul-08	122	83.85	1.45	1	1	0	0	0	0	2
4AA	11-Jul-08	99	39.78	2.49	13	7	3	0	0	0	23
TOTAL		2913	1905	1.53	683	276	224	53	1	2	1239

^aEwe-like sheep include ewes, yearlings and all rams < ½ curl.

Appendix C. Survey costs.

Item Description	Cost
Survey plane and pilot (Shadow Aviation)	7090.52
Survey plane and pilot (Arctic Air Alaska)	7036.49
Survey plane and pilot (Tundra Ltd.)	5833.00
Fuel – Av-gas and delivery to Galbraith Lake	2995.00
Fuel – 4 barrels Av-gas for Anaktuvuk Pass	1344.28
Fuel – delivery of barrels to Anaktuvuk	3538.12
Meals, Incidentals & Expenses–6 people, 7 days; 3 people, 3 days	1200.22
TOTAL	29135.58

Costs do not include observer salaries, transportation of observers to Galbraith Lake via NPS and ADF&G vehicles, or satellite phone charges for flight following.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 185/106227, December 2010

National Park Service
U.S. Department of the Interior



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