

# Wildlife Research Annual Progress Report

## Mountain Goat Assessment and Monitoring along the Juneau Access Road Corridor and near the Kensington Mine, Southeast Alaska



Kevin S. White and Neil L. Barten

Alaska Department of Fish and Game  
Division of Wildlife Conservation

October 2010

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Cover photo: Photo of LG-105, an adult female mountain goat on an alpine ridge east of Berners Bay, August 2008.

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## INTRODUCTION

This annual progress report was prepared to meet the reporting requirements for State of Alaska Department of Transportation and Public Facilities and Coeur Alaska. Funding for this project was made available in September 2005 and this report summarizes activities completed by September 30, 2010.

### Background

Coeur Alaska has recently re-initiated development activities at the Kensington mine site, located a short distance northwest of Berners Bay. In addition, the Department of Transportation and Public Facilities has proposed to construct an all-season highway between Echo Cove and the Katzehin River. Among the wildlife species potentially affected by mine development and road construction activities are mountain goats (*Oreamnos americanus*). A small-scale study of mountain goats conducted in the vicinity of the Kensington mine by Robus and Carney (1995) showed that goats moved seasonally from high alpine elevations in the summer and fall to low, timbered elevations during winter months. One of the main objectives of the Robus and Carney (1995) study was to assess the impacts of the mine development activities on habitat use, movement patterns and, ultimately, productivity of mountain goats. However, the mine never became operational, thus these objectives could not be achieved, and by 1995 goat monitoring in the area wound down and eventually ended. Currently, the mine development activities have been re initiated and the Alaska Department of Fish and Game maintains that many of the same concerns that prompted the Robus and Carney (1995) study are still valid and need to be addressed. In addition, large-scale plans for development of the Juneau Access road raise new, potentially more substantial, concerns regarding not only the enlarged “footprint” of industrial development activities in eastern Lynn Canal, but also the cumulative impacts of both development projects on wildlife resources.

The potential effects of mining and road development activities on local mountain goat populations in the vicinity of the Kensington mine and eastern Lynn Canal have potentially important ramifications for management and conservation of the species in this area. Studies conducted elsewhere indicate that mountain goats can be negatively impacted by industrial development activities. Such effects include temporary range abandonment, alteration of foraging behavior and population decline (Chadwick 1973, Foster and Rahe 1983, Joslin 1986, Cote and Festa-Bianchet 2003). Consequently, information about the distribution of mountain goats proximate to the mine and road development corridor is needed to determine the extent to which populations may be affected by associated industrial activities. Information collected by Robus and Carney (1995),

in the vicinity of Kensington mine, as well as Schoen and Kirchoff (1982), near Echo Cove, and more recent work in the project area (White et al. 2006, White et al. 2007, White et al. 2008, White and Barten 2009) suggest that spatial overlap between mountain goats and the proposed industrial activity will be most pronounced when goats are over-wintering in low-elevation habitats.

In response to the above concerns, the Alaska Department of Fish and Game, with funding provided by the Department of Transportation and Public Facilities and Coeur Alaska, initiated monitoring and assessment activities to determine possible impacts of road construction and mine development on mountain goats and identify potential mitigation measures, to the extent needed. Assessment and monitoring work includes collection of vital rate, habitat use and movement data from a sample of radio-marked mountain goats in addition to conducting annual aerial population abundance and productivity surveys. These efforts are aimed at providing the Alaska Department of Fish and Game with information necessary to appropriately manage mountain goats in the proposed areas of development.

Implementation of field objectives were initiated in 2005 and consisted of a 5-year monitoring program (2005-2011) jointly funded by Alaska Department of Transportation and Public Facilities, Coeur Alaska and the Alaska Department of Fish and Game. Beginning in 2007, the Alaska Department of Fish and Game committed additional annual funding for a complementary aerial survey technique development project within and adjacent to the project area. In 2009, the United States Forest Service also began contributing funding to further support aerial survey technique development data collection efforts. And, in 2010, Coeur Alaska reaffirmed their commitment to mountain goat monitoring near the Kensington Mine and adjacent areas and extended project funding for an additional 5 years (until FY2016). Consequently, project activities summarized in this report encompass a compilation of field data collection efforts achieved via financial support of multiple state, federal and private entities.

## STUDY OBJECTIVES

This research is designed to investigate the spatial relationships, vital rates and abundance of mountain goats in the Berners Bay and upper Lynn Canal area. The specific objectives are as follows:

- 1) Determine seasonal movement patterns of mountain goats in areas near the Kensington mine and Juneau Access road corridor;
- 2) Characterize mountain goat habitat selection patterns

and the extent of spatial overlap with areas impacted by Kensington mine and Juneau Access road corridor development activities;

3) Estimate reproductive success and survival of mountain goats in areas near the Kensington mine and Juneau Access road corridor; and

4) Estimate mountain goat population abundance and composition in areas near the Kensington mine and Juneau Access road corridor.

## STUDY AREA

Mountain goats were studied in a ca. 600 km<sup>2</sup> area located in a mainland coastal mountain range east of Lynn Canal, a post-glacial fiord located near Haines in southeastern Alaska (Figure 1). The study area is oriented along a north-south axis and bordered in the south by Berners Bay (58.76N, 135.00W) and by Dayebas Creek (59.29N, 135.35W) in the north. Within this area, three separate study sites were delineated based on the actual or expected extent of industrial activity occurring in or near each locality.

An additional study area located east of Berners Bay was established in spring 2006. This area was not originally included in the study design however recent information about road construction time lines resulted in a re-evaluation of the efficacy of conducting research activities in this area. Research efforts in this area will be limited in scope and low intensity sampling in this area is intended to provide managers with baseline information needed to assist future management efforts in light of the road construction, gravel crushing and/or stock-piling that is likely to occur in this area. Additional ADFG funding was allocated to partially offset costs associated with research activities in this area.

Elevation within the study areas range from sea-level to 6300 feet. This area is an active glacial terrain underlain by late cretaceous-paleocene granodiorite and tonalite geologic formations (Gehrels 2000). Specifically, it is a geologically young, dynamic and unstable landscape that harbors a matrix of perennial snowfields and small glaciers at high elevations (i.e. above 4000 feet) and rugged, broken terrain that descends to a rocky, tidewater coastline. The northern part of the area is bisected by the Katzeihin river, a moderate volume (ca. 1500 cfs; USGS, unpublished data) glacial river system that is fed by a tributary of the Juneau Icefield.

The maritime climate in this area is characterized by cool, wet summers and relatively warm snowy winters. Annual precipitation at sea-level averages 55 inches and winter temperatures are rarely less than 5° F and average 30°

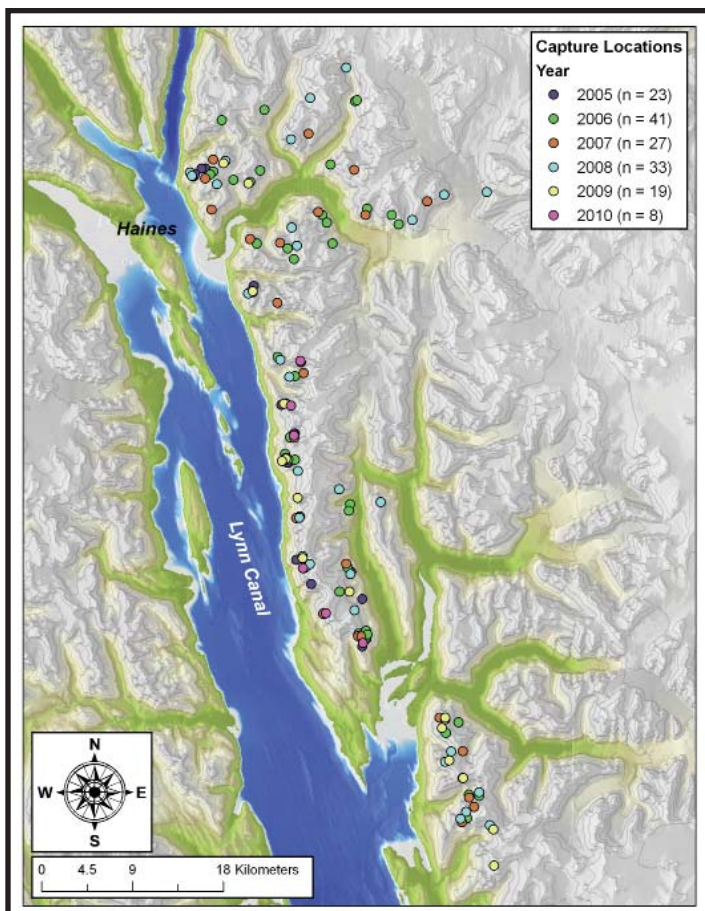


Figure 1: Locations of mountain goats captured and subsequently monitored in the Lynn Canal study area, 2005-2010.

F (Haines, AK; National Weather Service, Juneau, AK, unpublished data). Elevations at 2600' typically receive ca. 250 inches of snowfall, annually (Eaglecrest Ski Area, Juneau, AK, unpublished data). Predominant vegetative communities occurring at low-moderate elevations (<1500') include Sitka spruce (*Picea sitchensis*)-western hemlock (*Tsuga heterophylla*) coniferous forest, mixed-conifer muskeg and deciduous riparian forests. Mountain hemlock (*Tsuga mertensiana*) dominated 'krummholtz' forest comprises a subalpine, timberline band occupying elevations between 1500-2500 feet. Alpine plant communities are composed of a mosaic of relatively dry ericaceous heathlands, moist meadows dominated by grasses and forbs and wet fens. Avalanche chutes are common in the study area, bisect all plant community types and often terminate at sea-level.

## METHODS

### Mountain Goat Capture

Mountain goats were captured using standard helicopter darting techniques and immobilized by injecting 3.0 - 2.55mg of carfentanil citrate, depending on sex and time of year (Taylor 2000), via projectile syringe fired from a Palmer dart gun (Cap-Chur, Douglasville, GA). During handling, all animals were carefully examined and moni-

tored following standard veterinary procedures (Taylor 2000) and routine biological samples and morphological data collected. Following handling procedures, the effects of the immobilizing agent was reversed with 100mg of naltrexone hydrochloride per 1mg of carfentanil citrate (Taylor 2000; Figure 2). All capture procedures were approved by the State of Alaska Animal Care and Use Committee.

### GPS Location Data

Telonics TGW-3590 GPS radio-collars (Telonics, Inc., Mesa, AZ) were deployed on most animals captured (Figure 1). Telonics MOD-500 VHF radio-collars have been deployed on a subset ( $n = 20$ ) of animals to enable longer-term monitoring opportunities. GPS radio-collars were programmed to collect location data at 6-hour intervals (collar lifetime: 2-3 years). During each location attempt, ancillary data about collar activity (i.e. percent of 1-second switch transitions calculated over a 15 minute period following each GPS fix attempt) and temperature (degrees C) were simultaneously collected. Complete data-sets for each individual were remotely downloaded (via fixed-wing aircraft) at 8-week intervals. Location data were post-processed and filtered for “impossible” points and 2D locations with PDOP (i.e. position dilution of precision) values greater than 10, following D’Eon et al. (2002) and D’Eon and Delparte (2005).

### Diet Composition

Fresh fecal pellets were collected from live-captured animals during the summer-fall period (late-July to mid-October). Samples were frozen and archived at ADFG facilities in Douglas, AK. Microhistological techniques (Wildlife Habitat Analysis Lab, Pullman, WA) are used to determine diet composition.

### Habitat Selection and Movement Patterns

*Altitudinal Distribution.*—Comprehensive analyses of mountain goat habitat use and movement patterns will not be conducted until all GPS location information is collected (i.e. 2011). Nevertheless, preliminary analyses focused on describing sex specific variation in terrain use, and movement patterns were conducted using a subset of the data (White 2006). Additional topics related to altitudinal and spatial distribution have been addressed in White et al. (2006, 2007). Descriptive analyses of elevational distribution and movement patterns of mountain goats in the east Berners mountains (near Cascade Point) were conducted in response to a special request from the Alaska Department of Transportation and Public Facilities (R. Yost, pers. comm.) and summarized in White (2010).

### Winter Severity and Snow Modeling Data Collection

Winter distribution of mountain goats is strongly influ-

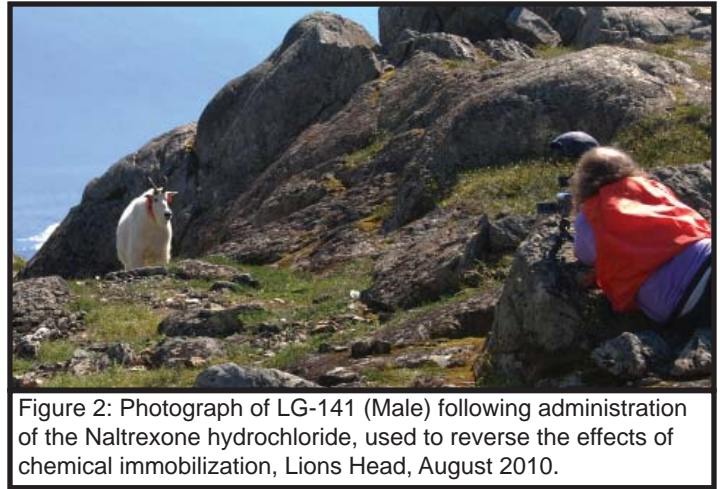


Figure 2: Photograph of LG-141 (Male) following administration of the Naltrexone hydrochloride, used to reverse the effects of chemical immobilization, Lions Head, August 2010.

enced by snow depth and distribution. Since patterns of snow accumulation vary at both small and large spatial scales it is often necessary to collect site-specific field data in order to accurately characterize these relationships within focal areas. Unfortunately, standardized snow depth monitoring information is extremely limited within the study area and additional information is needed in order to properly characterize spatial patterns of snow accumulation and, ultimately, mountain goat winter distribution. Consequently, in 2006 we initiated field efforts designed to create a snow depth database in order to generate spatially explicit snow depth models within the study area. However, during the winter of 2008/2009 field surveys were not conducted as planned in the Echo Cove area because of access limitations; field survey activities were re-initiated in 2009/2010. Daily climate information for reference weather stations was acquired from the National Weather Service (Haines Weather Station) and used to characterize regional patterns of winter severity.

### Reproduction and Survival

Kidding rates and subsequent survival were estimated by monitoring individual study animals during monthly surveys using fixed-wing aircraft (Piper PA-18 Super Cub) equipped for radio-telemetry tracking. During surveys, radio-collared adult female mountain goats were monitored to determine whether they gave birth to kids and, if so, how long they survived. Monitoring kid production and survival was only possible during the non-winter months when animals could be reliably observed in open habitats. We assumed that kids did not survive winter if they were not seen with their mothers the following spring. Cases in which kid status assessments were equivocal were filtered from the data set and not used for subsequent estimates of kid survival.

Mortality of individual radio-collared mountain goats was determined by detecting radio-frequency pulse rate changes during monthly monitoring surveys. In cases where mortality pulse rates were detected, efforts were

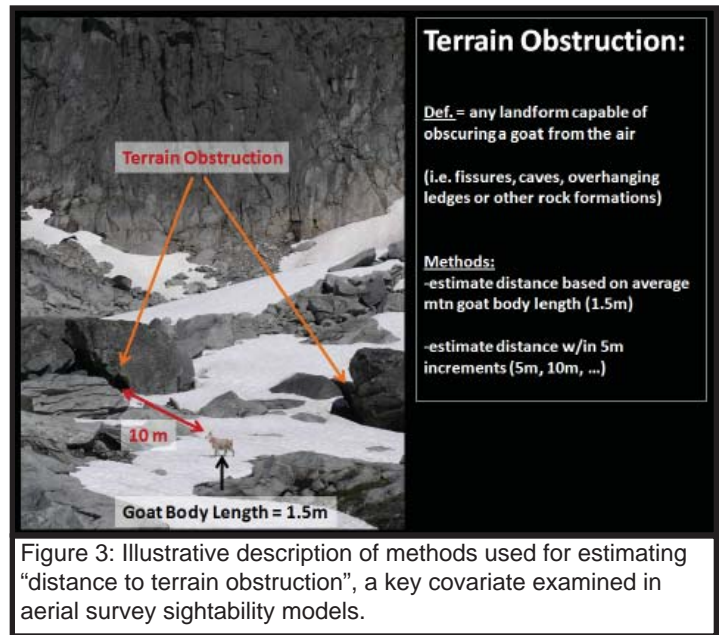
made to investigate sites as soon as possible via helicopter or boat. To the extent possible, all mortalities were thoroughly investigated to ascertain the cause of death and relevant biological samples collected. We determined date of mortalities via examination of activity sensor data logged on GPS radio-collars. Annual survival of radio-collared animals was estimated using the Kaplan-Meier procedure (Pollock et al. 1989). This procedure allows for staggered entry and exit of newly captured or deceased animals, respectively.

## Population Abundance and Composition Estimation

*Aerial Surveys.*—Population abundance and composition surveys were conducted using fixed-wing aircraft (Helio-courier and PA-18 “Super Cub”) and helicopter (Hughes 500) during August-September 2007. Original project planning required flying 3 replicate surveys in the Lions Head, Sinclair and Villard study areas. Additional funding provided by the Alaska Department of Fish and Game and the United States Forest Service provided the opportunity to fly surveys in the East Berners area and additional replicate surveys in the three focal study areas.

Aerial surveys were typically conducted when conditions met the following requirements: 1) flight ceiling above 5000 feet ASL, 2) wind speed less than 20 knots, 3) sea-level temperature less than 65 degrees F. Surveys were typically flown along established flight paths between 2500-3500 feet ASL and followed geographic contours. Flight speeds varied between 60-70 knots. During surveys, the pilot and experienced observers enumerated and classified all mountain goats seen as either adults (includes adults and sub-adults) or kids. In addition, each mountain group observed was checked (via 14X image stabilizing binoculars) to determine whether GPS-collared animals were present. Flight conditions, terrain complexity and animal behavior often complicated efforts to determine whether observed mountain goats were collared. As a result, the number of adults for which collar presence could be ascertained with a high degree of confidence was also recorded for each group observed. Further, for each collared animal seen or not seen during surveys data were collected to characterize behavioral and habitat conditions expected a priori to influence sighting probabilities (Figure 3).

Estimating the probability of observing mountain goats on a given survey (i.e. sightability) is critical for deriving population size estimates for focal areas. This is typically achieved by comparing the number of marked animals in an area to the number of marked animals actually seen (or re-sighted) during a survey. This fairly simple procedure can be complicated when its not always possible to as-



sess whether observed animals are marked. This situation occurs on mountain goat surveys and requires additional refinement of standard mark-resight population estimators. New analytical methods appropriate for estimating mountain goat population size in this study are currently being developed (G. Pendleton, ADFG, unpublished). As a result, mountain goat survey data were summarized in this report to include estimates of population composition and the minimum number of mountain goats seen on surveys (i.e. the number observed) but not the estimated actual number of mountain goats in focal areas.

*Ground Surveys.*—Evaluation of ground-based techniques for estimating mountain goat population size and composition were conducted in a small portion of the Lions Head study area in June 2006, the Mt. Villard area during June 2007, the Mt Villard and Mt Selby areas during June-July 2008, and the East Berners Mountains in July 2009. Previous research has concluded that aerial surveys are often inadequate for providing accurate estimates of the proportion of adult males and females, as well as sub-adults during aerial surveys (Cote and Festa-Bianchet 2003); only the proportion of adults and kids in a population can be reliably estimated. As a result, ground-based survey techniques were tested to evaluate whether this method might serve as a reliable tool for classifying individuals of separate sex and age classes during survey efforts.

Additional field efforts involved collection of GPS-collar activity sensor validation data. In these cases, individual study animals were observed during pre-programmed activity sensor evaluation periods (i.e. 15 minute intervals following fix initiation events). During observation periods, detailed behavioral data were collected using focal animal sampling procedures (Altman 1974).



## RESULTS AND DISCUSSION

### Mountain Goat Capture and Handling

*Capture Activities.*—Mountain goats were captured during one day in mid-August 2010. Overall, 8 animals (5 females and 3 males) were captured using standard helicopter darting methods. Each animal was deployed with a Telonics TGW-3590 GPS radio-collars and a lightweight Telonics MOD-400 VHF radio-collar (370g). Double-collaring animals was conducted to extend to period of time individual animals could be monitored (lifespan, GPS: 3 years, VHF: 6 years), thereby increasing the long-term opportunity to gather mountain goat survival and reproduction data and reducing the frequency in which mountain goats must be captured. Overall, the combined weight of radio-collars attached to animals comprises 1.2% of average male body weight and 2.0% of average female body weight and is well within the ethical standards for instrument deployment on free-ranging wildlife.

Helicopter captures were attempted during periods when mountain goats were distributed at high elevations and weather conditions were favorable (i.e. high flight ceiling and moderate wind speed). Additionally, captures were scheduled to avoid periods within 8 weeks of parturition in order to avoid unnecessary disturbance of adult females and associated neonates. Captures were attempted in areas where mountain goat access to dangerously steep terrain was limited. As a result of these constraints, opportunities to capture mountain goats were fairly limited. Nevertheless, given the fairly large area of study and decent summer weather conditions, it was typically possible to capture approximately six mountain goats per day of effort.

*Biological Sample Collection.*—During handling procedures, standard biological specimens were collected and morphological measures recorded. Specific biological samples collected from study animals included: whole blood (4 mL), blood serum (8 mL), red blood cells (8mL), ear tissue, hair and fecal pellets. Whole blood, serum, red blood cells and fecal pellet sub-samples were either sent to Dr. Kimberlee Beckmen (ADFG, Fairbanks, AK) for disease screening or archived at ADFG facilities in Douglas, AK.

In 2010, a subset of captured animals (n = 5) were tested for prevalence of respiratory bacteria associated with incidence of pneumonia (specifically *Pasteurella trehalosi* and *Mycoplasma ovipneumonia*). It is important to note that even if such bacteria are found in the upper respiratory tracts of animals sampled it does not necessarily mean that a given animal has pneumonia, only that the potential exists. In fact, it is not unusual for reasonably high proportions of animals in a population to have pneumonia associated bacteria and never show adverse effects, par-

Table 1: Incidence of respiratory bacteria documented in mountain goats in the Lynn Canal study area (n = 5), 2010. Results are also provided for three other populations in southeast Alaska in 2010, for comparison.

Area	Lynn Canal	Klukwan	Baranof	Cleveland	All Areas
<i>Pasteurella trehalosi</i>	0	2	5	2	9
<i>Pasteurella</i> sp.	0	1	0	0	1
<i>Pasteurella</i> sp.*	0	0	0	2	2
<b>Total <i>Pasteurella</i></b>	<b>0</b>	<b>3</b>	<b>5</b>	<b>3</b>	<b>11</b>
<i>Arcanobacterium pyogenes</i>	1	1	0	1	2
<i>Mannheimia haemolytica</i>	1	0	0	0	0
<i>Moraxella</i> sp.	1	1	0	0	1
<i>Staphylococcus aureus</i>	0	0	1	1	2
<i>Mycoplasma</i> (culture)	0	0	0	--	0
<i>Mycoplasma ovipneumonia</i> (PCR)	0	0	0	0	0
n (tested)	5	5	5	5	15

**Notes:**  
*Pasteurella* sp. = not identifiable to species  
*Pasteurella* sp.\* = organism most like *P. trehalosi* but looks different than other *P. trehalosi* (grows on MacConkey agar)  
 Total *Pasteurella* = # of animals with some form of *Pasteurella* (CG012 had 2 forms)

ticularly if animals are subject to minimal stress (ie. nutritional limitation, severe winters, etc.). Overall, none of the animals sampled in Lynn Canal tested positive for *Pasteurella trehalosi* or *Mycoplasma ovipneumonia*, though other species of respiratory bacteria were found. While sampling was limited, these results differ from those acquired for samples collected in 2010 from three other populations in southeast Alaska (Table 1). Until additional samples are collected, the overall findings must be considered preliminary.

Tissue samples from all mountain goats captured since the inception of the study were sent Aaron Shafer (University of Alberta) for inclusion in a broad-scale mountain goat population genetics analysis. Results from this study (Shafer et al. 2010) indicate that substantial genetic structuring exists among mountain goats in southeast Alaska. Further, more detailed recent analyses indicate that three genetically distinct mountain goat populations occur in our study area [east Berners mountains, Kakuhan range (Lions Head and Sinclair Mountain), and Mt. Villard] and generally coincide with our specific study area boundaries (A. Shafer, pers. comm.). Overall, these findings indicate that limited movement (ie. gene flow) occurs between these areas. In addition, a collaborative project has been initiated to assess how gene flow is enhanced or impeded by landscape features (ie. terrain complexity, river valleys, glaciers, marine waterways, etc.). This project involves an integration of mountain goat genetic data, GPS-collar location data and remote sensing data layers (A. Shafer, in prep.).

### GPS Location Data

*Collar Retrieval.*—Of the 8 animals that died during

2009/2010, all collars were retrieved from the field and GPS data were downloaded from each collar. An additional six GPS collars released from animals in May/June 2010, and five of these collars were retrieved from the field; one collar released in an inaccessible location and will probably not be retrieved in the future.

*GPS Database Management.*—Over the course of the study GPS data has been compiled from 111 individual animals constituting over 200,000 GPS locations. During this reporting period, a custom GPS database management program was developed to enable efficient access of these data and ensure secure storage on an ADFG network server (B. Lieb, ADFG, pers. comm.). These efforts will facilitate future spatial analyses of this data set.

### Winter Severity and Snow Modeling

*Climate Data.*—Daily climate data were archived from the National Weather Service database to characterize broader scale climate patterns. Mean daily snow depth and snowfall data were summarized from data collected at the National Weather Service station in Haines, AK (Appendix 1). Mean snowfall in Haines during 2009/2010 was 126% of normal (i.e. 10-yr average). While still above average, snow conditions were notably less than the historical record winter of 2006/2007 (Appendix 1). The previous four winters should be considered severe relative to the

historical record for Haines. Nonetheless, the winter of 2009/2010 was similar to the previous winter in terms of patterns of snow accumulation and notably less severe than the previous two winters. Still, the first winter of the study (2005/2006) stands as the only winter thus far that had lower than average snow conditions, and each winter since should be considered severe or very severe in terms of relative effects on mountain goats.

### Survival and Reproduction

*Survival.*—Mountain goats were monitored monthly during fixed-wing aerial telemetry flights and/or via GPS-telemetry. Of the 54 animals monitored during 2009/2010 (i.e. 6/1/2009– 5/30/2010), 8 animals died of various causes. Overall, preliminary survival estimates were 16% higher in 2009/2010 than in 2008/2009 (Table 2). In general, most mortality occurred during late winter (February-May), however, substantially mortality also occurred during October-November, a period coinciding with the onset of winter conditions and the rut (Figure 4). Overall, survival in our study population is correlated with winter snowfall (Figure 5), a finding that is consistent with a recently completed state-wide analysis (White et al, in review). In general, the occurrence of relatively severe winter conditions over the last four years of study has resulted in lower than average survival rates, relative to other populations (Smith 1986, Festa-Bianchet and Cote

Table 2: Estimates of mountain goat survival for different sex classes during 2005-2010, Lynn Canal, AK. Mean winter snow depth and total snowfall recorded in Haines and Eaglecrest, AK is provided to index relative winter severity between years.

Year	Males				Females				Total				Haines		Eaglecrest	
	At Risk	Died	$\hat{S}$	SE	At Risk	Died	$\hat{S}$	SE	At Risk	Died	$\hat{S}$	SE	Snow Depth	Snowfall	Snow Depth	Snowfall
													Mean (in)	Total (in)	Mean (in)	Total (in)
2005/2006	9.6	2	0.79	0.13	10.0	1	0.90	0.09	19.6	3	0.85	0.08	6	114	15	122
2006/2007	25.4	11	0.57	0.10	22.1	4	0.82	0.08	47.5	15	0.68	0.07	46	309	60	381
2007/2008	26.5	6	0.79	0.07	20.8	3	0.88	0.07	47.3	9	0.83	0.05	24	208	45	285
2008/2009	24.2	10	0.66	0.09	21.4	6	0.73	0.09	45.6	16	0.69	0.06	18	240	44	235
2009/2010	25.1	4	0.86	0.07	22.3	4	0.85	0.07	47.4	8	0.85	0.05	18	202	28	166
<b>All years</b>	<b>109.0</b>	<b>34</b>	<b>0.73</b>	<b>0.04</b>	<b>94.7</b>	<b>19</b>	<b>0.82</b>	<b>0.04</b>	<b>204</b>	<b>53</b>	<b>0.77</b>	<b>0.03</b>	<b>22</b>	<b>214</b>	<b>38</b>	<b>238</b>

At Risk = average number of animals monitored per month (per time period)

Snow Depth, Mean = calculated as daily mean between Nov 1-April 30

Eaglecrest, Elevation = 1200 ft.

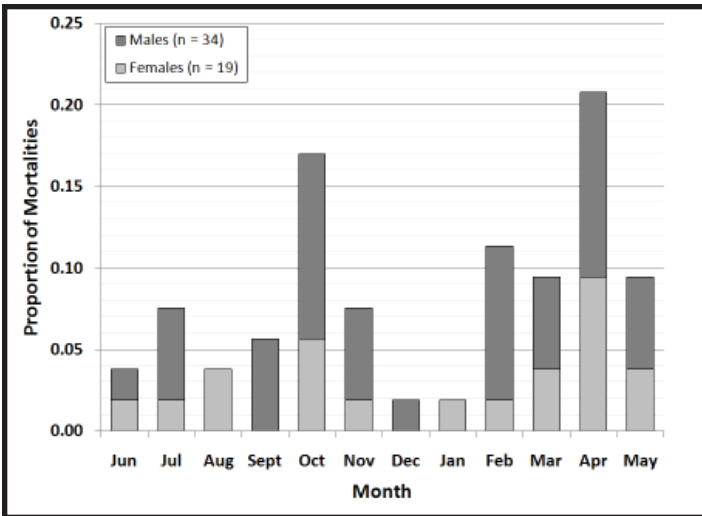


Figure 4: Seasonal frequency of radio-marked mountain goat mortalities in the Lynn Canal study area, 2005-2010.

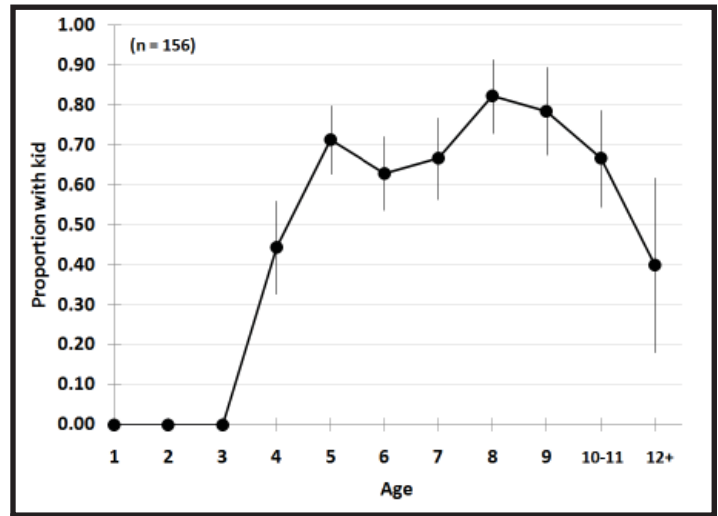


Figure 6: Age-specific estimates of kid production for female mountain goats in different age classes during 2005-2010, Lynn Canal, AK.

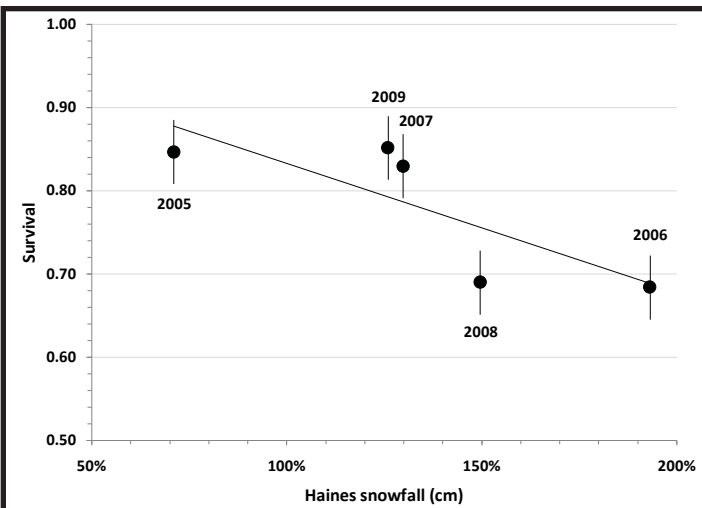


Figure 5: Relationship between mountain goat survival (males and females combined) in Lynn Canal and snowfall in Haines, AK, 2005-2010.

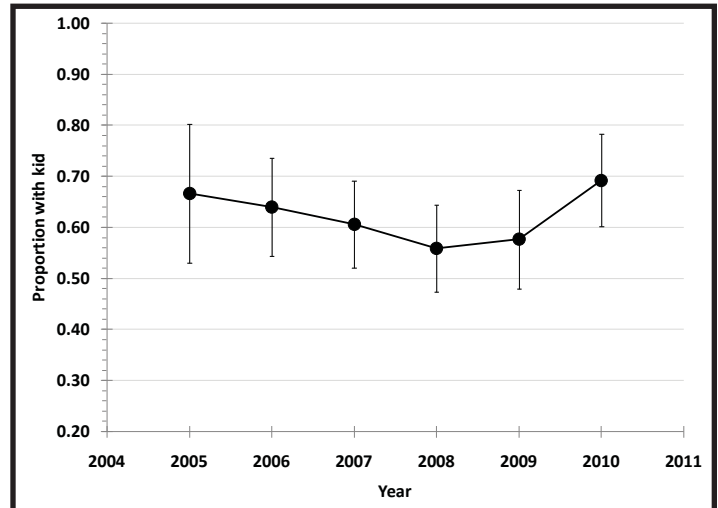


Figure 7: Annual estimates of the proportion of radio-marked adult females with kids at heel during summer 2005-2010, Lynn Canal, AK.

2007). The observed rates of survival have likely precipitated an overall decline in mountain goat populations in the study area, and elsewhere in the region; future analyses will examine this in more detail

**Kid Recruitment.**—Kid recruitment of radio-marked female mountain goats was estimated by determining the percentage of radio-marked females seen with kids during May-June aerial telemetry surveys (n = 3). Since each radio-marked female was not observed daily during the kidding period, it was not possible to determine if kids were born and subsequently died prior to, or between, surveys. As such, estimates of kid production reported here are presumably lower than the actual percentage of females that gave birth. Nevertheless, our estimates of kid production were similar to estimates of kidding rates reported elsewhere (Festa-Bianchet and Cote 2007).

Past studies have documented late age at first reproduction

for mountain goats, as compared to other ungulates (Festa-Bianchet and Cote 2007, Galliard et al. 2000). Consistent with these findings, we did not document any cases where females less than four years of age had kids at heel in summer. Overall, kid production estimates varied with female age (range = 40-82%) such that younger and older females were generally less likely to have a kid at heel than prime-aged females (i.e. 7-9 years old; Figure 6). Annual estimates of kid production ranged from 56-69% between 2005-2010 (Figure 7), however variability in estimates precluded detection of differences between years.

### Population Abundance and Composition

**Aerial Surveys.**—Overall, 3 aerial surveys were conducted in September-October 2009 (Lions Head, n = 1, Sinclair Mountain, n = 0, Mount Villard, n = 1, East Berners, n = 1; Appendix 2). The number of surveys flown was substantially less than planned due to limited air charter operator

availability. However, in 2010 we were able to conduct 7 aerial surveys, as planned (Lions Head, n = 2, Sinclair Mountain, n = 2, Mount Villard, n = 2, East Berners, n = 2; Appendix 2).

Overall, we were able to successfully gather habitat and behavioral covariate data for nearly all marked mountain goats during each survey. The ability to accomplish this was largely related to the use of 14X Fujinon image-stabilizing binoculars and improved coordination between observers and pilots. Overall, data has been collected on 213 "sightability trials" involving marked mountain goats have been conducted between 2007-2010. In addition, prototypical analytic models have been developed using a Bayesian framework in order to derive actual population estimates for each survey (G. Pendleton, ADFG, pers. comm.). Ultimately, such models will be employed to characterize trends in mountain goat population size over time while accounting for variation in survey sighting probabilities (due to weather, habitat use, and other factors).

## FUTURE WORK

Study animals will continue to be monitored monthly to assess reproductive status and survival. Additionally, at 8-week intervals GPS data will be downloaded from each animal during aerial surveys. These data will be post-processed and integrated with the existing GPS location database. Three replicate aerial surveys will be conducted in early-fall 2011, weather permitting, in order to estimate mountain goat sightability, population abundance and composition. Results of these efforts will be summarized and submitted in the final DOT/PF project report on December 31, 2011.

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K.S. White, G. Pendleton, D. Crowley, H. Griese, K. Hundertmark, T. McDonough, L. Nichols, B. Porter, M. Robus, C. Smith and J. Schoen. 2008. Survival of mountain goats in coastal Alaska: synthesis and applications. 16th Biennial Symposium of the Northern Wild Sheep and Goat Council, Midway, UT. (Abstract).

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K.S. White, G. Pendleton, D. Crowley, H. Griese, K. Hundertmark, T. McDonough, L. Nichols, B. Porter, M. Robus, C. Smith and J. Schoen. 2009. Life history and climate effects on mountain goat survival in coastal Alaska. American Society of Mammalogists Meeting, Fairbanks, AK. (Abstract).

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K.S. White, G. Pendleton, D. Crowley, H. Griese, K. Hundertmark, T. McDonough, L. Nichols, B. Porter, M. Robus, C. Smith and J. Schoen. (In Review). Life history and climate effects on mountain goat survival in coastal Alaska. *Journal of Wildlife Management*.

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Appendix 1: Daily snowfall (in.) and snow depth records collected at the NWS weather station in Haines, AK between 2005-2010. Snowfall data depict distinct “peaks” associated with snowfall events. Snow depth data describe the seasonal snow profile and integrate temperature such that distinct “dips” in the snow depth profile depict warm, melting phases.

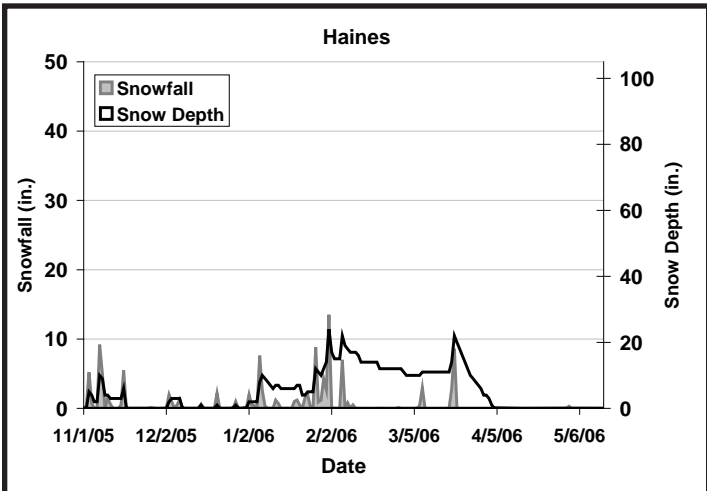


Figure 1: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2005-2006.

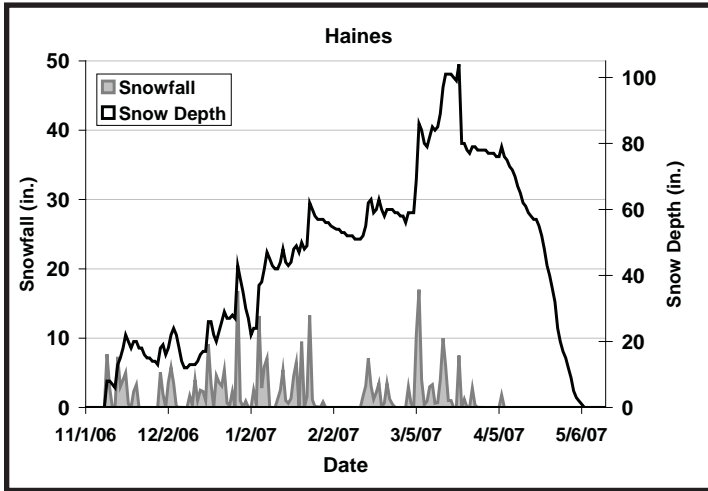


Figure 2: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2006-2007.

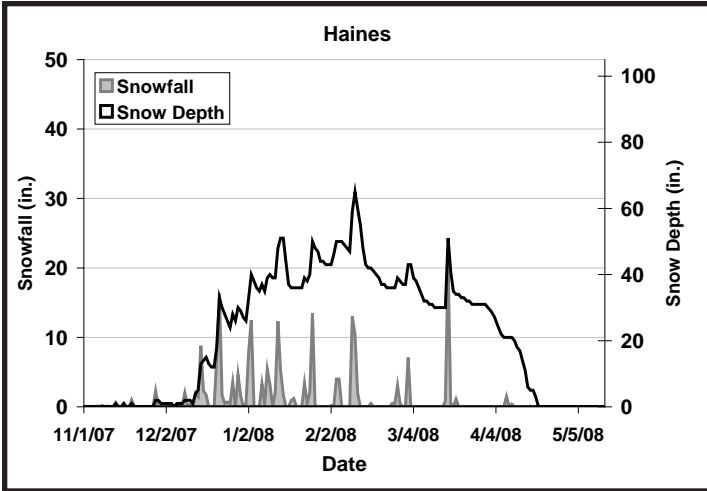


Figure 3: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2007-2008.

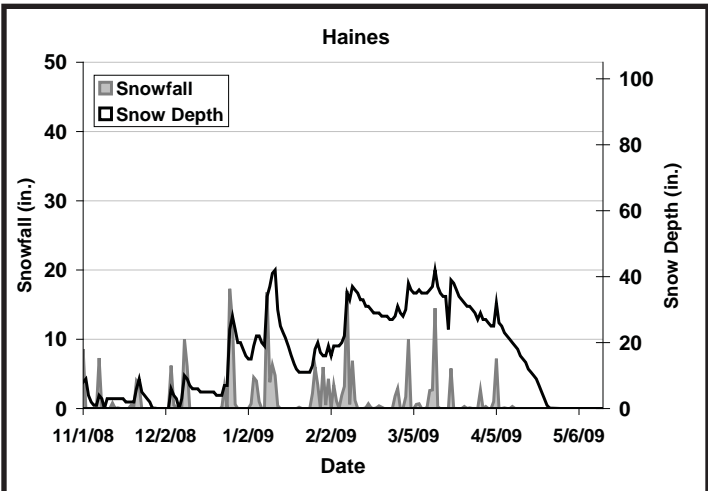


Figure 4: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2008-2009.

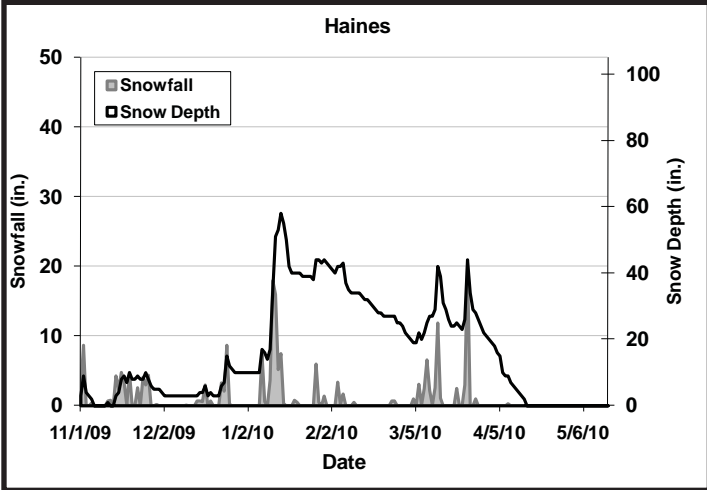
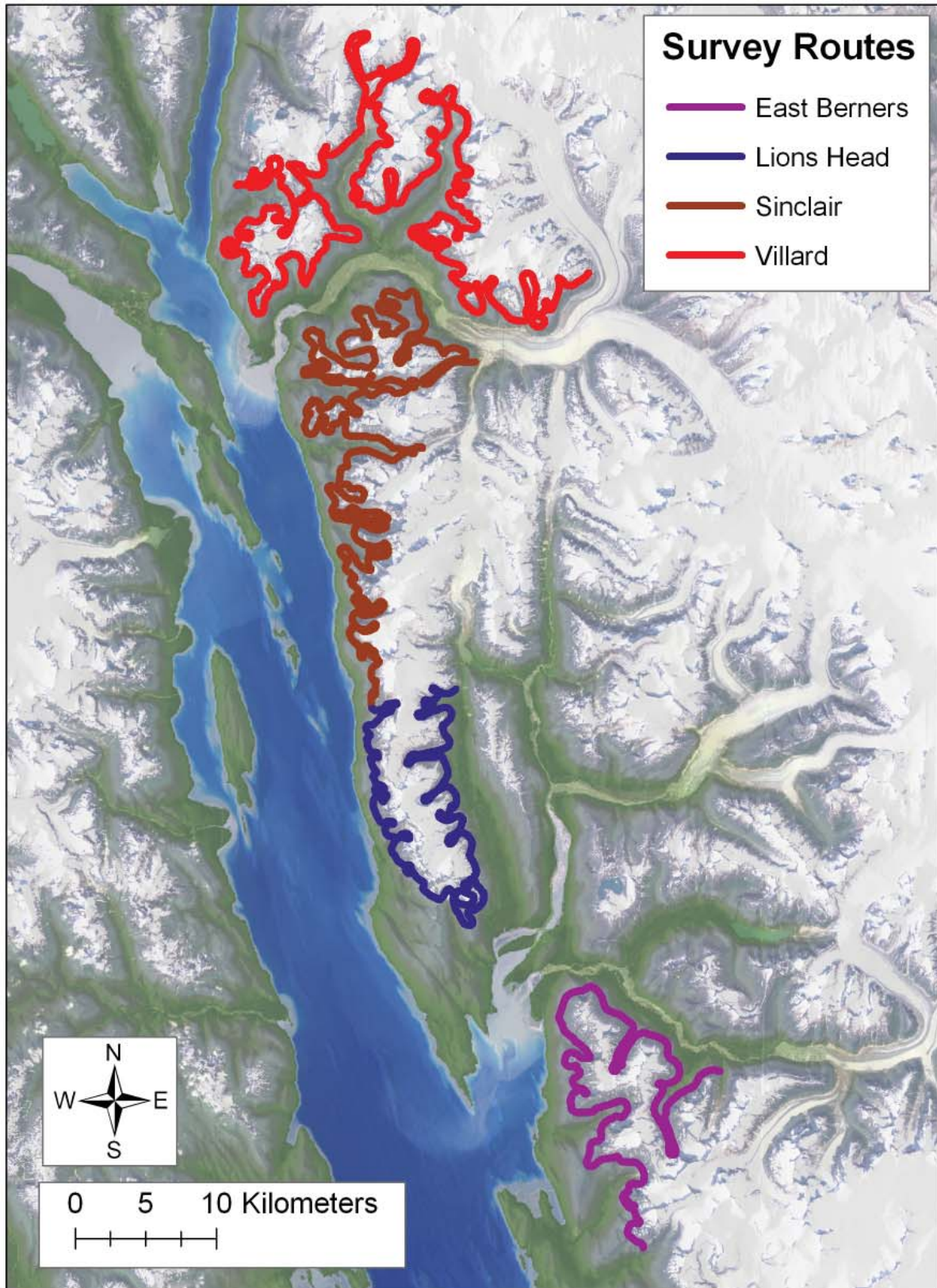


Figure 3: Daily measures of snowfall and snow depth recorded at the NWS station in Haines, AK during the winter of 2009-2010.

Appendix 2: Mountain goat aerial survey routes in the Lynn Canal study area. Each area is normally surveyed by fixed- and/or rotor-wing aircraft in August-October each year.





Appendix 2a: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the East Berners Mountains survey route, 2006-2010. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study Area	Year	Date	Adults	Kids	Total	% Kids	Temp (F)	Weather	Wind	Aircraft
East Berners <sup>b1</sup>	2006	8/28/2006	86	42	128	32.8	40-50	Mostly Clear	0-10	Heliocourier
East Berners	2006	9/3/2006	83	21	104	20.2	51	Partly Cloudy	0-10	Heliocourier
East Berners	2006	10/3/2006	70	22	92	23.9	35-40	High Overcast	5-15	Heliocourier
East Berners	2007	9/2/2007	105	28	133	21.1	44	Clear	0-5	Heliocourier
East Berners	2007	9/22/2007	97	28	125	22.4	35-40	High Overcast	0-10	Cub
East Berners	2008	9/25/2008	125	38	163	23.3	40	Mostly Clear	0-10N	Hughes 500
East Berners	2009	10/2-3/2009	74	26	100	26.0	37-42	High Overcast	0-15S	Cub
East Berners	2010	9/11/2010	72	14	86	16.3	51	Clear	0	Cub
East Berners	2010	9/22/2010	67	15	82	18.3	42	Mostly Clear	0-10N	Cub

<sup>b1</sup> not complete survey: Davies Ck.-Antler Lk. only

Appendix 2b: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the Lions Head survey route, 2006-2010. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study Area	Year	Date	Adults	Kids	Total	% Kids	Temp (F)	Weather	Wind	Aircraft
Lions Head	2005	8/11/2005	35	5	40	12.5	70	Clear	0-10	Cub
Lions Head	2005	10/3/2005	55	8	65	12.3	45	Clear	0-10	Heliocouirer
Lions Head	2006	8/28/2006	49	9	58	15.5	40-50	Mostly Clear	0-10	Heliocourier
Lions Head	2006	9/3/2006	54	11	65	16.9	51	Partly Cloudy	0-10	Heliocourier
Lions Head	2006	10/2/2006	92	13	105	12.4	26-31	Mostly Cloudy	5-15	Heliocourier
Lions Head	2006	10/16/2006	91	23	114	20.2	35-42	Mostly Clear	10-25	Hughes 500
Lions Head	2007	8/10/2007	18	2	20	10.0	51-57	Clear	2-7	Heliocourier
Lions Head	2007	8/27/2007	43	3	46	6.5	44-50	High Overcast	0-5	Heliocourier
Lions Head	2007	9/13/2007	46	5	51	9.8	~45-55	High Overcast/ Low Fog	0-5	Cub
Lions Head	2007	9/28/2007	78	15	93	16.1	35-40	Mostly Clear	0-10	Hughes 500
Lions Head	2008	9/25/2008	62	18	80	22.5	40	Mostly Clear	0-10N	Hughes 500
Lions Head	2008	10/7/2008	63	13	76	17.1	31	Clear/High Overcast	0-15S	Cub
Lions Head	2009	10/3/2009	51	16	67	23.9	40	High Overcast	0-25S	Cub
Lions Head	2010	9/6/2010	49	14	63	22.2	44-48	Mostly Clear	15N	Cub
Lions Head	2010	9/21/2010	58	23	81	28.4	36-42	Clear	0-5S	Cub

Appendix 2c: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the Mt. Sinclair survey route, 2006-2010. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study Area	Year	Date	Adults	Kids	Total	% Kids	Temp (F)	Weather	Wind	Aircraft
Sinclair Mtn.	2005	8/11/2005	77	17	94	18.1	70	Clear	0-10	Cub
Sinclair Mtn.	2005	10/3/2005	159	30	189	15.9	45	Clear	0-10	Heliocourier
Sinclair Mtn. <sup>b2</sup>	2006	8/28/2006	86	21	107	19.6	40-50	Mostly Clear	0-10	Heliocourier
Sinclair Mtn.	2006	9/2/2006	128	31	159	19.5	50-56	High Overcast	0-10	Heliocourier
Sinclair Mtn.	2006	9/23/2006	153	22	182	12.1	40-42	High Overcast	0-10	Heliocourier
Sinclair Mtn.	2006	10/16/2006	227	41	268	15.3	35-42	Mostly Clear	10-25	Hughes 500
Sinclair Mtn.	2007	8/27/2007	57	4	61	6.6	44-50	High Overcast	0-5	Heliocourier
Sinclair Mtn.	2007	9/13/2007	75	13	88	14.8	~45-55	High Overcast/ Low Fog	0-5	Cub
Sinclair Mtn.	2007	9/28/2007	173	38	211	18.0	35-40	High Overcast	0-10	Hughes 500
Sinclair Mtn.	2008	9/25/2008	127	27	154	17.5	40	Mostly Clear	0-10N	Hughes 500
Sinclair Mtn.	2008	10/7/2008	123	26	149	17.4	31	Clear/High Overcast	0-15S	Cub
Sinclair Mtn.	2010	9/6/2010	62	18	80	22.5	44-48	Mostly Clear	15N	Cub
Sinclair Mtn.	2010	9/21/2010	59	19	78	24.4	36-42	Clear	0-5S	Cub

<sup>b2</sup> not complete survey: to Katz lk. only

Appendix 2d: Summary of mountain goat population composition and minimum abundance data collected during aerial surveys on the Mt. Villard survey route, 2006-2009. These data do not account for differences in mountain goat sighting probabilities that occur between surveys. As a result, the number of mountain goats recorded represent the minimum number of animals on the survey route during a given survey.

Study Area	Year	Date	Adults	Kids	Total	% Kids	Temp (F)	Weather	Wind	Aircraft
Mt. Villard	2005	8/12/2005	23	4	27	14.8	68	Clear	0-10	Cub
Mt. Villard	2006	9/2/2006	102	23	125	18.4	50-56	High Overcast	0-10	Heliocourier
Mt. Villard <sup>b3</sup>	2006	9/23/2006	90	12	102	11.8	40-42	High Overcast	0-10	Heliocourier
Mt. Villard <sup>b4</sup>	2006	10/1/2006	41	12	53	22.6	31	Mostly Cloudy	5-15	Heliocourier
Mt. Villard	2006	10/2/2006	165	28	193	14.5	26-31	Mostly Cloudy	5-15	Heliocourier
Mt. Villard <sup>b5</sup>	2006	10/17/2006	145	29	174	16.7	35-31	High Overcast	0-10	Hughes 500
Mt. Villard	2007	9/3/2007	88	23	111	20.7	47-54	Clear	0-10	Heliocourier
Mt. Villard <sup>1</sup>	2007	9/14/2007	74	23	97	23.7	44	Overcast/Fog	0-27	Heliocourier
Mt. Villard	2007	9/22/2007	132	22	154	14.3	35-40	Overcast/Lt Snow/Fog	0-15	Cub
Mt. Villard*	2008	9/6/2008	52	10	62	16.1	45-55	Partly Cloudy/High Overcast	0-10S	Cub
Mt. Villard	2008	9/25/2008	164	30	194	15.5	40	Mostly Clear	0-10 N	Hughes 500
Mt. Villard	2009	10/3/2009	56	16	72	22.2	32	High Overcast	0-30S	Cub

<sup>1</sup> surveyed to Paradise Ridge only

<sup>b3</sup> not complete survey: Meade Gl.-Katz Flats only

<sup>b4</sup> not complete survey: Dayebas Ck. only

<sup>b5</sup> not complete survey: N Meade Gl to NW fork Katzehin