Wildlife Research Annual Progress Report

Mountain goat population monitoring and movement patterns near the Kensington Mine, Alaska

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Alaska Department of Fish and Game Division of Wildlife Conservation

Cover Photo: An adult female mountain goat (LG-151) near Katzehin Lake, September 2011

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INTRODUCTION

This report was prepared to meet the annual reporting requirements for Coeur Alaska, Inc.. Funding for this project was made available in September 2005 and this report summarizes activities completed by December 30, 2017.

Background

In 2005, Coeur Alaska, Inc. re-initiated development activities at the Kensington mine site, located a short distance northwest of Berners Bay. In addition, the Alaska Department of Transportation and Public Facilities (ADOT/PF) proposed construction an all-season highway between Echo Cove and the Katzehin River. In the context of these proposed industrial development activities, mountain goats were identified as an important wildlife species likely to be affected by mine development and road construction activities.

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. In 2005, when the mine development activities were re-initiated, the Alaska Department of Fish and Game (ADFG) maintained that many of the same concerns that prompted the Robus and Carney (1995) study were still valid and needed to be addressed. In addition, large-scale plans for development of the Juneau Access road raised new and 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 the area. Studies 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 Rahs 1983, Joslin 1986, Cote and Festa-Bianchet 2003, Cote et al. 2013, White and Gregovich 2017). Consequently, information about the distribution of mountain goats proximate to the mine and road development corridor is critical for determining the extent to which populations may be affected by associated industrial activities. Information collected by Robus and Carney (1995), White et al. (2012) and White and Gregovich (2017), in the vicinity of Kensington mine, as well as Schoen and Kirchhoff (1982) near Echo Cove, suggest that spatial overlap between mountain goats and industrial activity are most pronounced when goats are over-wintering in low-elevation habitats.

In response to the above concerns, ADFG, with operational funding provided by ADOT/PF, Federal Highway Administration (FHWA) and Coeur Alaska, Inc., 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 has included 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 ADFG with information necessary to appropriately manage mountain goats in the areas of development and provide guidance relative to mitigation measures, to the extent possible.

Implementation of field objectives were initiated in 2005 and consisted of a 5-year monitoring program (2005-2011) jointly funded by ADOT/PF, FHWA, Coeur Alaska, Inc. and ADFG. Beginning in 2007, the ADFG committed additional annual funding for a complementary aerial survey technique development project within and adjacent to the project area. In 2009, the USDA-Forest Service (Tongass National Forest) also began contributing funding to further support aerial survey technique development data collection efforts. And, in 2010, Coeur Alaska, Inc. resumed funding of mountain goat monitoring near the Kensington Mine and adjacent areas (as per the Kensington Plan of Operations, USFS 2005). In 2012, the project components funded by ADOT/PF and associated with the Juneau Access project were completed (see White et al. 2012). Currently, mountain goat monitoring activities are focused on the area surrounding the Kensington mine and north to the Katzehin river, an area considerably smaller than the original Juneau Access/Kensington joint study area.

STUDY OBJECTIVES

Research efforts were designed to investigate the spatial relationships, vital rates, and abundance of mountain goats near the Kensington Mine and upper Lynn Canal. The research objectives were to:

1) determine seasonal movement patterns of mountain goats;

2) characterize mountain goat habitat selection patterns;

3) estimate reproductive success and survival of mountain goats; and

4) estimate mountain goat population abundance and composition.

STUDY AREA

Mountain goats were studied in a ca. 491 km^2 area located in a mainland coastal mountain range east of Lynn Canal, a marine fjord located between Juneau and Haines in southeastern Alaska (Figure 1 and 2). The study area was located in the Kakuhan Range and oriented along a north-south axis and bordered in the south by Berners Bay (58.76N, 135.00W) and the Katzehin River (59.27N, 135.14W) in the north. The Kensington Mine, a hard rock gold mine, is located at the southern end of the study area, immediately south of Lions Head mountain in the Johnson, Slate and Sherman creek watersheds. A majority of above ground mining activity occurs in four principal locations situated between 200–300 meters in elevation. The overall mine "footprint" comprises 56.6 km^2 of patented claims; a significant amount of activity is at low elevation (<300 m) and underground. This study has occurred during both construction and production phases of the mine and possible sources of disturbance to mountain goats in the vicinity included blasting, heavy equipment operation, helicopter operation, and vehicle traffic.

Elevation within the study area ranges from sea level to 2070 m. This area is an active glacial terrain underlain by late cretaceous-paleocene granodiorite and tonalite geologic formations (Stowell 2006). 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. >1200 m) and rugged, broken terrain that descends to a rocky, tidewater coastline. The northern boundary of the area is defined by the Katzehin River, a moderate volume (ca. 1500 cfs; USGS, unpublished data) glacial river system (and putative barrier to mountain goat movement) that is fed by the Meade Glacier, a branch 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 1.4 m and winter temperatures are rarely less than -15° C and average -1° C (Haines, AK; National Weather Service, Juneau, AK, unpublished data). Elevations at 790 m typically receive ca. 6.3 m of snowfall, annually (Eaglecrest Ski Area, Juneau, AK, unpublished data). Predominant vegetative communities occurring at low-moderate elevations (<460 m) include Sitka spruce (Picea sitchensis)-western hemlock (Tsuga heterophylla) coniferous forest, mixed-conifer

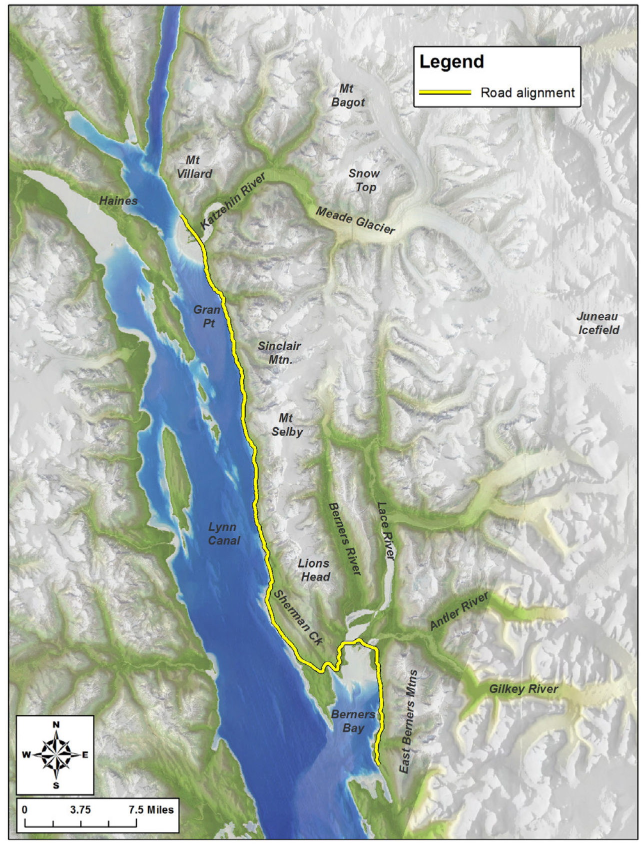

Figure 1: Map of the Lynn Canal and Berners Bay area. Local place names referenced in this report are identified. Mountain goats were studied in this area during 2005-2018.

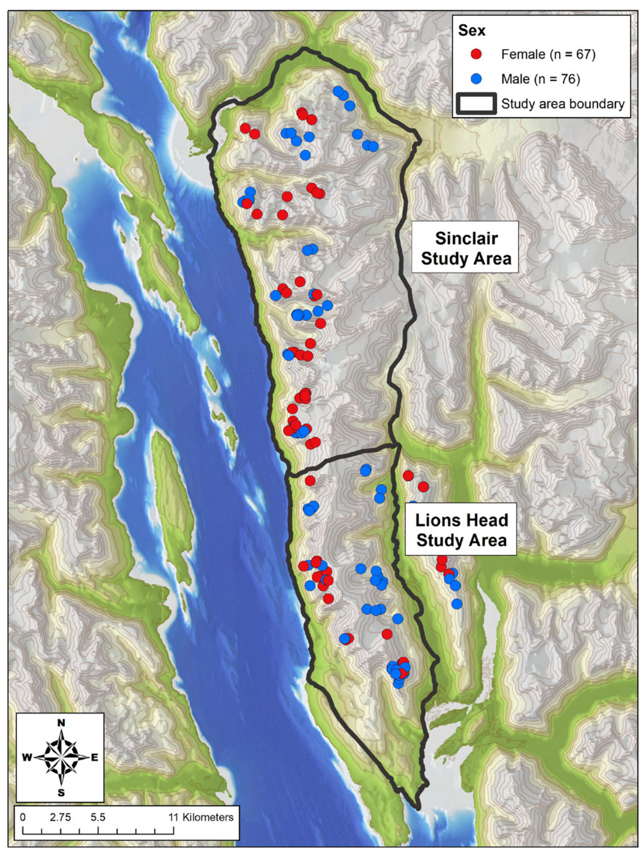

Figure 2: Locations of mountain goats captured and subsequently monitored in the Lynn Canal study area, 2005-2018.

muskeg and deciduous riparian forests. Mountain hemlock (Tsuga mertensiana) dominated 'krummholtz' forest comprises a subalpine, timberline band occupying elevations between ~460–760 meters. Alpine plant communities are composed of a mosaic of relatively dry ericaceous heathlands and moist meadows dominated by sedges, forbs and wet fens. Avalanche chutes are common in the study area and 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 - 2.4 mg 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 monitored 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). All capture procedures were approved by the State of Alaska Animal Care and Use Committee.

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 could be reasonably contained.

GPS Location Data

Telonics TGW-3590 or TGW-4590 GPS radio-collars (Telonics, Inc., Mesa, AZ) were deployed on most animals captured. Telonics MOD-500 VHF radio-collars were been deployed on a subset (n = 23) of animals to enable longer-term monitoring opportunities. During 2009-2016, animals were simultaneously marked with GPS and lightweight (Telonics MOD-410) VHF radio-collars (370 g). Double-collaring animals was conducted to extend the 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 that mountain goats must be captured. The combined weight of radio-collars attached to animals comprise 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.

GPS radio-collars were programmed to collect location data at 6-hour intervals (collar lifetime: 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, and/or manually downloaded. 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).

Resource Selection and Movement Patterns

Diet Composition.—Fresh fecal pellets were collected from live-captured animals during the summer-fall period (late-July to mid-October). Fecal pellet samples were also collected opportunistically during winter reconnaissance and snow surveys. Samples were sent to Washington State University (Wildlife Habitat Analysis Lab, Pullman, WA) for dietary analyses. Specifically, microhistological analyses of plant cell fragments in pellet samples were conducted to provide an estimate of diet composition for individual mountain goats and a composite winter sample. Results of these analyses were reported in White et al. (2012).

Activity, Movement Patterns and Resource Selection.—
Analyses of mountain goat GPS location data (i.e. data collected during 2005-2011) to characterize activity, movement and resource selection patterns were summarized in White (2006), Shafer et al. (2012) and White et al. (2012). More recently, White and Gregovich (2017) assessed relationships between mountain goat resource selection and proximity to mine development. In 2017, a collaboration was initiated with BUKO (Andre Fetzer) and Trent University (Joe Northrup) to analyze existing GPS location data to estimate timing of migration. Such analyses will ultimately be useful for quantitatively determining winter and summer range residency periods; information that is useful for determining site-specific "timing windows" relevant for managing industrial activities in the vicinity of mountain goat habitat. In 2018, a new analysis was initiated focused on utilizing mountain goat GPS radio-collar location data to characterize seasonal and sex-specific variation in home range size and site fidelity (sensu Shakeri et al. 2018).

Snow and Winter Severity Monitoring.—
Winter distribution of mountain goats is strongly influenced 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.

Standardized field surveys were conducted in order to estimate patterns of snow depth as it related to habitat type (i.e. forested/non-forested), altitude, and slope aspect. These efforts focused on four sites located in different mountain goat winter ranges in 2007 but consistent annual monitoring was conducted at only one site located on Echo Ridge, near Davies Creek. During surveys snow depth was measured at geo-referenced locations along an altitudinal gradient (beginning at sea level). Snow measurements were replicated at each sampling location (n = 5) and associated covariate information was collected. Sampling locations were spaced at regular (100-200 m) intervals, depending upon terrain complexity. Steep (>35 degrees), exposed slopes were, generally, not sampled due to safety considerations. In addition, daily climate information for reference weather stations was acquired from the National Weather Service (Haines COOP Weather Station).

Figure 3: Remains of a male mountain goat (LG157, 9 years old) that died in low elevation (300 ft.) old growth forest winter range, east of Lions Head Mountain. The animal appeared to have been scavenged by a wolverine and, based on bone marrow color and consistency, likely died of malnutrition.

Reproduction and Survival

Kidding rates and subsequent survival were estimated by monitoring individual study animals during monthly surveys using fixed-wing aircraft (usually a Piper PA-18 Super Cub) equipped for radio-telemetry tracking or via ground-based observations. During surveys, radio-collared adult female mountain goats were observed (typically using 14X image stabilizing binoculars) to determine whether they gave birth to kids and, if so, how long individual kids survived (Figure 3). 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

Aerial Surveys.—Population abundance and composition surveys were conducted using fixed-wing aircraft (Helioocourier and PA-18 Super Cub) and helicopter (Hughes 500) during August-October, 2005-2017. 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)

Figure 4: A group of seven mountain goats, including a GPS radio-collared adult female and attendent kid, seen during an aerial survey in the Yeldagalga Creek Valley during September 2018.

or kids (Figure 4). In addition, each mountain group observed was checked (via 14X image stabilizing binoculars) to determine whether radio-collared animals were present.

Sightability Data Collection.—During aerial surveys, data were simultaneously collected to evaluate group-level sighting probabilities. These data were used to parameterize aerial survey "sightability" models which were subsequently used to convert minimum counts to actual population size (i.e. White et al. 2016). Specifically, we characterized behavioral, environmental and climatic conditions for each radio-collared animal seen and not seen (i.e. missed) during surveys. In cases where radio-collared animals were missed, it was necessary to back-track and use radio-telemetry techniques to locate animals and gather associated covariate information. Since observers had general knowledge of where specific individual radio-collared animals were likely to be found (i.e. ridge systems, canyon complexes, etc.), it was typically possible to locate missed animals within 5-15 minutes after an area was originally surveyed. In most cases, it was possible to completely characterize behavioral and site conditions with minimal apparent bias, however in some cases this was not possible (i.e. animals not seen in forested habitats, steep ravines, turbulent canyons) and incomplete covariate information was collected resulting in missing data.

Evaluation of Population Trends.—In order to assess how mountain goat abundance changed over space and time we delineated nine geographically distinct survey areas and summarized the maximum number of adult and kid mountain goats seen in each area, by year (Appendix 4 and 5). The number of animals seen during aerial surveys is a commonly used metric of mountain goat population abundance; termed the "minimum count". Since the quantity does not account animals "missed" during surveys, the minimum count underestimates actual population size (i.e. by 35-50%). In order to account for variation in survey conditions and mountain goat aerial survey sighting probabilities we used a "sightability" model to derive population estimates based on aerial survey observations and associated covariate values (White et al. 2016). Specifically, the model is based on aerial survey mark-resight data collated in Lynn Canal and other areas of southeastern Alaska. The model accounts for variation in sky condition, group size, terrain and habitat type and converts minimum counts to actual population size (White et al. 2016). To assess population trends, we used simple linear regression to fit equations and determine proportional change in population size and density over time, for each area. We determined the amount of summer range habitat in each area (km^2; based on RSF models in White and Gregovich 2017) in order to convert population size to density; a standardized quantity useful for geographic comparisons and inference.

RESULTS AND DISCUSSION

Mountain Goat Capture and Handling

Capture Activities.—During August 2018, 6 animals (males, n = 3; females, n = 3) were captured in the Lions Head-Mt. Sinclair areas. All animals were simultaneously marked with GPS (TGW-4590) and lightweight VHF (Telonics MOD-410) radio-collars. Since 2005, 142 mountain goats have been radio-marked in the Lions Head and Sinclair Mountain study areas; GPS location data has been compiled for 87 animals within this area. Currently (as of 2/21/2018), 23 animals are marked in these two areas; all other previously deployed collars have either remotely released or animals have died. Annual capture activities are important for maintaining adequate sample sizes and compensating for natural or scheduled collar losses.

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 (8 mL), 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 and trace mineral screening or archived at ADFG facilities in Douglas, AK. During 2010 and 2014, nasal and pharyngeal swab samples were collected from 12 animals to index prevalence of respiratory bacteria.

Disease Surveillance.—In 2010 and 2014, a subset of captured animals were tested (Washington Animal Disease Diagnostic Laboratory, Pullman, WA) for prevalence of respiratory bacteria associated with incidence of pneumonia (specifically *Mycoplasma ovipneumoniae*). Results of these analyses were summarized in White et al. (2012) and Lowrey et al. (2018). Further surveillance testing for *Mycoplasma ovipneumoniae* was conducted in 2016, 2017 and 2018 but laboratory results are not yet available.

During 2005-2015, blood serum samples collected from captured animals have been tested each year for a suite of 15 different diseases relevant to ungulates (Appendix 1). Of particular interest was contagious ecthyma (CE), a viral disease previously documented among mountain goats in Juneau, Haines and other areas of southeastern Alaska. Common symptoms of CE include presence of grotesque lesions on the face, ears, and nose which can lead to death of animals, primarily those in young or old age classes; healthy adults commonly survive the disease. Of the 65 animals successfully tested for CE in the Lions Head and Mt Sinclair areas, three animals (5%) tested positive for CE-specific antibodies; a level of prevalence comparable to other southeastern Alaska populations tested.

Trace Mineral Testing.—In 2010-2014, whole blood and serum samples were analyzed to determine trace mineral concentration for 31 mountain goats in order to examine whether mineral deficiencies were prevalent in our study population (Appendix 2a). While experimental data is limited to assess deficiency threshold values for Selenium, a trace mineral that can influence pregnancy, values less than 0.10 ppm are generally considered low. In the Lion Head/Sinclair study areas 32% of animals had blood Selenium values below this threshold (Appendix 2b); a high proportion of deficiencies relative to other mountain goat research study areas in southeastern Alaska. Presumably, deficiencies are related to site productivity and geologic substrate and can provide some level of insight relative to inherent productivity of mountain goat summer range in this area.

Genetic Analyses.—Tissue samples from all mountain goats captured between 2005-2018 have been genotyped by Aaron Shafer (Trent University/University of Alberta). (Duplicate samples are archived at ADFG, Douglas, AK). A subset of these data were analyzed and included in continent-wide analyses of mountain goat population genetics (Shafer et al. 2010). Shafer et al. (2010) indicated that substantial genetic structuring exists among mountain goats in southeastern Alaska (and across the western North American range of the species). More recent analyses indicated that three genetically distinct mountain goat populations occur in our study area [east Berners mountains, Kakuhan range (including Lions Head and Sinclair Mountain), and Mt. Villard]; population boundaries generally

Table 1: Proportion of radio-marked adult female mountain goats observed with kids at heel during parturition in the Lynn Canal study area, 2005-2018. Data are also presented from other study areas, for comparative purposes.

Area	Year	Kids	AdF	Prop	SE
Baranof					
	2010	**4**	**4**	**1.00**	**0.00**
	2011	**5**	**6**	**0.83**	**0.15**
	2012	**3**	**5**	**0.60**	**0.22**
	2013	**5**	**10**	**0.50**	**0.16**
	2014	**9**	**12**	**0.75**	**0.13**
	2015	**7**	**14**	**0.50**	**0.13**
	2016	**8**	**12**	**0.67**	**0.14**
	2017	**4**	**11**	**0.36**	**0.15**
	2018	**8**	**12**	**0.67**	**0.14**
	Total	**53**	**86**	**0.62**	**0.05**
Haines-Skagway					
	2010	**5**	**10**	**0.50**	**0.16**
	2011	**8**	**10**	**0.80**	**0.13**
	2012	**8**	**11**	**0.73**	**0.13**
	2013	**10**	**12**	**0.83**	**0.11**
	2014	**10**	**17**	**0.59**	**0.12**
	2015	**14**	**18**	**0.78**	**0.10**
	2016	**11**	**15**	**0.73**	**0.11**
	2017	**6**	**11**	**0.55**	**0.15**
	2018	**8**	**14**	**0.57**	**0.13**
	Total	**80**	**118**	**0.68**	**0.04**
Lynn Canal					
	2005	**8**	**12**	**0.67**	**0.14**
	2006	**16**	**25**	**0.64**	**0.10**
	2007	**20**	**32**	**0.63**	**0.09**
	2008	**19**	**33**	**0.58**	**0.09**
	2009	**15**	**25**	**0.60**	**0.10**
	2010	**18**	**26**	**0.69**	**0.09**
	2011	**18**	**27**	**0.67**	**0.09**
	2012	**9**	**15**	**0.60**	**0.13**
	2013	**9**	**13**	**0.69**	**0.13**
	2014	**8**	**14**	**0.57**	**0.13**
	2015	**15**	**17**	**0.88**	**0.08**
	2016	**14**	**17**	**0.82**	**0.09**
	2017	**13**	**17**	**0.76**	**0.10**
	2018	**11**	**14**	**0.79**	**0.11**
	Total	**193**	**287**	**0.67**	**0.03**

Table 2: Estimates of mountain goat survival for different sex classes during 2005-2018, Lynn Canal, AK. Data are also presented from other study areas, for comparative purposes.

	Males				Females				Total			
	At Risk	Died	Ŝ	SE	At Risk	Died	Ŝ	SE	At Risk	Died	Ŝ	SE
Baranof Island												
2010/2011	8	1	0.88	0.11	4	0	1.00	0.00	12	1	0.92	0.08
2011/2012	12	0	1.00	0.00	6	0	1.00	0.00	18	0	1.00	0.00
2012/2013	17	3	0.82	0.09	6	0	1.00	0.00	23	3	0.87	0.07
2013/2014	17	3	0.82	0.09	10	0	1.00	0.00	27	3	0.89	0.06
2014/2015	17	3	0.82	0.09	12	1	0.92	0.08	29	4	0.86	0.06
2015/2016	14	0	1.00	0.00	13	2	0.84	0.11	27	2	0.92	0.06
2016/2017	23	3	0.85	0.08	13	2	0.82	0.12	36	5	0.84	0.06
2017/2018	21	5	0.76	0.09	11	2	0.80	0.13	32	7	0.77	0.07
All years	127	18	0.85	0.03	75	7	0.90	0.036	202	25	0.87	0.02
Cleveland Pen.												
2009/2010	5	0	1.00	0.00	2	0	1.00	0.00	7	0	1.00	0.00
2010/2011	6	2	0.67	0.16	6	0	1.00	0.00	12	2	0.83	0.10
2011/2012	4	2	0.50	0.18	6	0	1.00	0.00	10	2	0.80	0.11
2012/2013	2	1	0.50	0.35	6	0	1.00	0.00	8	1	0.88	0.12
2013/2014	1	0	1.00	0.00	6	2	0.67	0.19	7	2	0.71	0.17
All years	18	5	0.72	0.09	26	2	0.92	0.05	44	7	0.84	0.05
Haines-Skagway												
2010/2011	13	4	0.69	0.13	10	3	0.70	0.14	23	7	0.70	0.10
2011/2012	16	2	0.87	0.09	10	1	0.90	0.09	26	3	0.88	0.06
2012/2013	18	2	0.89	0.07	11	1	0.91	0.08	29	3	0.90	0.06
2013/2014	22	2	0.91	0.06	12	1	0.92	0.08	34	3	0.91	0.05
2014/2015	19	2	0.89	0.07	16	2	0.85	0.08	35	4	0.88	0.05
2015/2016	18	5	0.72	0.10	16	3	0.79	0.10	34	8	0.75	0.07
2016/2017	13	6	0.56	0.13	14	4	0.71	0.11	26	10	0.64	0.09
2017/2018	12	3	0.73	0.12	11	0	1.00	0.00	23	3	0.86	0.07
All years	128	26	0.79	0.03	96	15	0.84	0.04	224	41	0.81	0.03
Lynn Canal												
2005/2006	11	2	0.82	0.12	11	1	0.91	0.09	22	3	0.86	0.07
2006/2007	33	11	0.67	0.08	25	4	0.84	0.07	58	15	0.74	0.05
2007/2008	36	7	0.77	0.08	31	4	0.83	0.08	67	11	0.80	0.05
2008/2009	36	10	0.66	0.09	34	6	0.73	0.09	70	16	0.69	0.06
2009/2010	28	4	0.86	0.07	26	4	0.85	0.07	54	8	0.85	0.05
2010/2011	25	3	0.88	0.06	24	2	0.91	0.06	49	5	0.90	0.04
2011/2012	23	6	0.72	0.10	23	3	0.85	0.08	46	9	0.77	0.07
2012/2013	19	8	0.59	0.10	16	7	0.60	0.11	34	15	0.59	0.07
2013/2014	13	3	0.75	0.13	11	2	0.83	0.11	24	5	0.79	0.08
2014/2015	11	5	0.57	0.14	14	1	0.93	0.07	25	6	0.76	0.08
2015/2016	8	1	0.86	0.11	17	2	0.88	0.08	25	3	0.87	0.07
2016/2017	13	6	0.54	0.14	17	3	0.82	0.09	30	9	0.70	0.08
2017/2018	11	1	0.91	0.09	18	6	0.67	0.11	29	7	0.76	0.08
All years	243	67	0.73	0.03	233	45	0.81	0.02	474	112	0.77	0.02

At Risk = maximum number of animals monitored per month (per time period) coincide with our specific study area boundaries (Shafer et al. 2012). These findings indicate that gene flow between our study areas (with the exception of the Lion Head and Sinclair study areas, which are genetically indistinct) is limited. Additional analyses examined the extent to which mountain goat habitat selection characteristics and landscape configuration are linked to genetic relatedness across the study area (Shafer et al. 2012). Results from this analyses indicated that small- (i.e. distance to cliffs, heat load) and large-scale (i.e. river valleys and marine waterways) landscape features are key determinants of mountain goat gene flow across our study area (Shafer et al. 2012). In 2016, a new state-wide mountain goat population genetics project was initiated and will include more spatially extensive analyses that utilize both microsatelite and genomic techniques. This project is funded by ADFG and Trent University but will benefit our knowledge of mountain goat genetics in this study area as well.

GPS Location Data

GPS System Performance.—The performance of GPS radio-collars (Telonics TGW-3590) was evaluated for 124 collars deployed since the beginning of the study (see White et al. 2012). In general, the remote GPS data collection system used in this study worked as expected. Specifically, we did not encounter any significant problems with GPS collar performance, nor did any notable problems occur with remote data download attempts.

Winter Severity and Snow Modeling

Snow Surveys.—Field-based snow surveys were conducted within 5 days of April 1 during 2007-2008, 2010-2018 on Echo Ridge. Analyses of these data quantified the degree to which snow depth differs with increasing elevation between forested and non-forested sites (White et al. 2012). Overall, these data quantify the extent to which snow depth varied relative to elevation and habitat type (i.e. open vs. forest). Specifically, snow depth was 30-40 inches deeper in open relative to forested habitats, on average. Further, snow depth increased 2.3-2.7 inches per 100 foot gain in elevation, on average (White et al. 2012). Importantly, these data provide quantitative information about winter severity in areas representative of where mountain goats in our study area are wintering. Such data will be able to be used as covariates in future analyses of survival, reproduction and resource selection.

Climate Data.—Daily climate data were archived from the National Weather Service database to characterize broader scale climate patterns. Total annual snowfall, average daily temperature during July-August, and total precipitation (summer and annual) were summarized from data collected at the National Weather Service station in Haines, AK (Appendix 3). Total annual snowfall and average temperature during July-August are important predictors of mountain goat survival (White et al. 2011). Mean snowfall in Haines during the study period (2005-2018) was 114% of the long-term normal (i.e. 1950-2018). Overall, snowfall in Haines during 5 of the 7 initial winters of the study was above normal (including 5 of the 10 highest snowfall winters on record; 39 years of data). However, 5 of the last 6 winters have been below average, and included the winter of 2014/2015 which was exceptionally mild (54 inches of total snowfall, or 34% of normal). During the winter of 2017/2018, a total 109 inches (71% of normal) of snowfall was recorded in Haines.

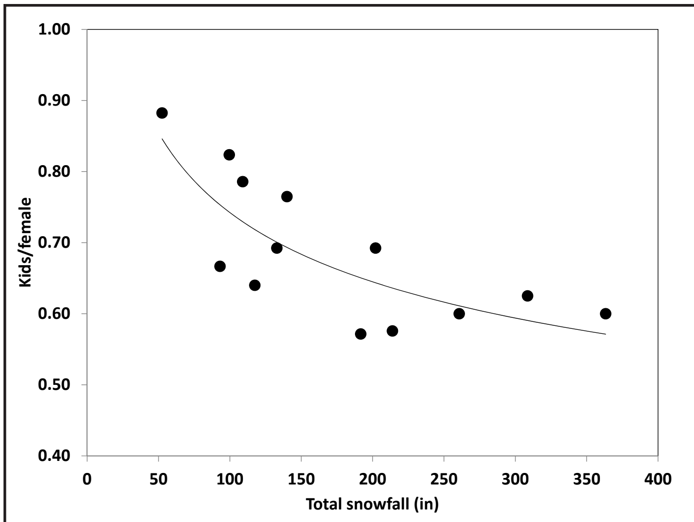

Figure 5. Relationship between total annual snowfall (Haines, AK) and the proportion of radio-marked females with kids during the parturition period during 2006-2018 in Lynn Canal, AK.

Reproduction and Survival

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 (Table 1). 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).

Annual estimates of kid production in Lynn Canal ranged from 57-88% between 2005-2018 (Table 1). During 2017, 79% of radio-marked females (n = 14) had a kid at heel; 12 percent above average (Table 1). As described above, the previous four winters have been particularly mild and likely contributed to the observed increase in reproduction; preliminary analyses suggest that reproduction is negatively related to total snowfall during the preceding winter (Figure 5).

Table 3: Causes of mortality for mountain goats in southeastern Alaska, 2005-2018, with specific emphasis on avalanche caused mortalities. Data are based on field investigations of radio-marked mountain goat mortality events in four study areas.

	Lynn Canal		Haines-Skagway		Baranof		Cleveland Pen		Total	
Cause of death	**n**	**prop**	**n**	**prop**	**n**	**prop**	**n**	**prop**	**n**	**prop**
Avalanche	**27**	**0.24**	**17**	**0.40**	**17**	**0.68**	**4**	**0.57**	**65**	**0.35**
Non-avalanche[1]	**50**	**0.44**	**4**	**0.10**	**1**	**0.04**	**1**	**0.14**	**56**	**0.30**
Unknown	**37**	**0.32**	**21**	**0.50**	**7**	**0.28**	**2**	**0.29**	**67**	**0.36**
All	**114**	**1.00**	**42**	**1.00**	**25**	**1.00**	**7**	**1.00**	**188**	**1.00**

[1]Non-avalanche includes predation (black bear, brown bear and wolf), malnutrition and falls

Survival.—Mountain goats were monitored monthly during fixed-wing aerial telemetry flights and/or via GPS-telemetry. During 2017/2018 biological year, 7 radio-marked animals died. Overall, 76±8% of animals survived during 2017/2018; a relatively low proportion (i.e. 1% lower than the long term average) given that winter snowfall, an important determinant of winter survival (White et al. 2011), was only 71% of average. Interestingly, avalanches were the cause of death in 3 of 7 mortality cases, and an additional animal died from a presumed fall during winter (the remaining 3 radiocollared animals died of unknown, but non-avalanche related, causes). Conditions leading to winter avalanches or falls can be somewhat independent of total winter snowfall amounts and instead more strongly linked to persistent weak layers in the snowpack. The ontogeny and stability of snowpacks can be complex and related to storm cycle sequences and, sometimes, anomalous events such as rain-on-snow and hard freezes. Overall, the higher than usual occurrence of avalanche related mortalities in the study area resulted in lower survival of mountain goats than would be expected based on total winter snowfall. Typically, we would expect relatively shallow snowpacks to improve availability of food resources, reduce costs of locomotion and depletion nutritional reserves leading to increased probabilities of survival. While avalanches represent an important source of mortality in our study area, the overall proportion of mountain goats dying in avalanches is lower than in other areas of southeastern Alaska (Table 3).

Population Abundance and Composition

Aerial Surveys.—During early-October 2018, we conducted three aerial surveys in the Lions Head and Sinclair Mountain study areas and the Berners-Lace ridge area (Appendix 4). The Berners-Lace ridge was surveyed because seasonal movement (albeit limited) by male mountain goats has been documented from the Lions Head study area to this site in past years.

Evaluation of Population Trends.— Geographic and temporal trends were calculated for eight survey areas within the Lions Head and Sinclair study areas, and Berners-Lace ridge (Appendix 4, 5a-c). Analyses were based on population estimates derived using the White et al. (2016) aerial survey sightability model and aerial survey data collected during 2005-2018.

Population densities declined substantially in most areas since 2005/2006 (Table 4). In the Lions Head area, the strongest decline occurred in the Kensington (i.e. -14% per year) and neighboring Met (-21% per year) survey areas, while the lower density West Berners area was largely stable (-1% per year) areas; similar to Berners-Lace Ridge (-3% per year). In the more northerly Sinclair study area, mountain goat populations exhibited stronger declines (Table 4). The peripheral, low density populations adjacent to the icefield appeared stable (but should be interpreted cautiously due to very low total number of animals seen in each areas). Population densities also varied substantially among areas with the highest initial densities occurring on the south and west side of the Kakuhan range (i.e. Kensington, Met, Yeldagalga and S Katzehin). Areas on the east side of the Kakuhan Range, generally had lower densities (and closer proximity to icefields and glaciers).

The general decline in mountain goat populations coincided with succession of severe winters between 2006-2014; total annual snowfall in Haines was greater than average in 6 of the 8 winters during this period (Appendix 3). Winter snowfall can exert strong negative effects of mountain

Table 4: Estimated change in minimum count densities, based on mountain goats observed during aerial surveys during 2005-2018, Lynn Canal, Alaska.

Area	Slope (change/yr)	r^2	Density (est total/km^2) Mean	Max	Min	Area (km^2)	# years
Lions Head							
W Berners	-0.01	0.01	1.4	2.3	0.6	22.0	14
Kensington	-0.14	0.28	2.3	5.9	1.2	19.9	14
Met	-0.21	0.32	5.4	8.2	2.6	15.4	13
Sinclair							
Yeldagalga	-0.19	0.22	4.5	8.2	1.8	25.1	13
S Katzehin	-0.19	0.44	2.6	5.1	1.3	41.6	13
Katzehin Lk	-0.13	0.55	1.1	2.2	0.2	21.2	12
Icefield							
S Meade	0.06	0.14	1.2	2.7	0.4	18.2	13
U Lace	<0.01	<0.01	0.7	1.3	0.2	16.9	13
BL Ridge	-0.03	0.09	1.5	2.0	0.9	30.0	11

goat survival (White et al. 2011) by increasing energetic costs of locomotion and burial of food resources. It is not immediately clear why declines appear to be strongest in the northwestern Kakuhan Range (i.e. Yeldagalga, South Katzehin and Katzehin Lake) and Kensington survey areas. It is possible that snow depths are greater in the northwestern areas; an observation supported by anecdotal information. The northwestern survey areas also had the highest initial population densities and may have been closer to nutritional carrying capacity (and thus more vulnerable to population declines) prior to the severe winters. In the Kensington area, declines appeared stronger than in surrounding areas to the east suggesting that factors other than local variation in winter conditions were important. Recent analyses suggested that mountain goat avoidance of winter range habitats within 1.8 km of Kensington Mine developments has reduced the functional winter range carrying capacity by 42% in the local area (White and Gregovich 2017). Thus, mine related disturbance may have indirectly exacerbated the effects of severe winters in the local mountain goat population. Nonetheless, the analyses and interpretation of the causes of population declines should be considered preliminary.

Population estimates derived from aerial survey data collected in 2016 - 2018 indicated that the mountain goat sub-populations in the Met, Yeldagalga and S Katzehin survey areas may be recovering, following the previously described multi-year decline. In other areas, populations appear to have remained stable over the last four mild (i.e. below average snowfall) winters. Under such winter conditions, population growth is expected and its currently unclear why a stronger population recovery has not occurred. Overall, results should be considered cautiously until additional data are collected in future years and confirm the apparent recovery trend.

Sightability Modeling and Population Estimates.—During all surveys, data were collected for purposes of developing group-level aerial survey sighting probability models (2018, n = 25 trials). In addition, complementary aerial surveys were conducted in areas outside of the study area (Haines, Baranof Island) where mountain goats were marked as part of independent studies. Collection of data in other areas has enabled acquisition of additional sightability data resulting in opportunity to more accurately parameterize sightability models; however, a majority of the data used to develop models was collected in the Lynn Canal/Berners Bay study areas. Details of this modeling effort are summarized in White et al. (2016) however newly acquired data continue to used to further refine models on a annual basis.

FUTURE WORK

The mountain goat population monitoring and assessment work in the vicinity of the Kensington Mine is planned to continue during the operational phase on mining operations. The project area for ongoing mine-related monitoring work encompasses the area between Slate cove and the Katzehin River (i.e. the “Lions Head” and “Sinclair” study areas). In this area study animals (2018/19, n = 28) will continue to be monitored monthly to assess reproductive status and survival. Mortalities will be investigated during April - October, or as conditions allow. GPS location data will be downloaded from radio-collars following field recovery efforts; GPS radio collars automatically release 3 years after capture/deployment (or at the time or mortality). GPS data will be post-processed and appended to the existing GPS location database. During late-summer, 6-8 mountain goats will be captured to ensure scientifically defensible sample sizes are maintained. Three replicate aerial surveys will be conducted in early-fall 2019, weather permitting, in order to estimate mountain goat sightability, population abundance and composition. During 2019-2020, efforts will continue to refine mountain goat aerial survey sightability models and, ultimately, derive population estimates. Results of project activities will be summarized and submitted to Coeur Alaska, Inc. and associated stakeholders as an annual research project report in spring 2020.

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PROJECT PUBLICATIONS

White, K. S., N. L. Barten and D. Larsen. 2006. Mountain goat assessment and monitoring along the Juneau Access road corridor and near the Kensington Mine, Southeast Alaska. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK. 65pp.

White, K. S. 2006. Seasonal and sex-specific variation in terrain use and movement patterns of mountain goats in southeastern Alaska. Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council, 15: 183-193.

White, K. S., N. L. Barten and D. Larsen. 2007. Mountain goat assessment and monitoring along the Juneau Access road corridor and near the Kensington Mine, southeast Alaska. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK. 16pp.

White, K. S. and N. L. Barten. 2008. Mountain goat assessment and monitoring along the Juneau Access road corridor and near the Kensington Mine, southeast Alaska. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK. 15pp.

White, K. S. and N. L. Barten. 2009. Mountain goat assessment and monitoring along the Juneau Access road corridor and near the Kensington Mine, southeast Alaska. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK. 16pp.

White, K. S. and G. Pendleton. 2009. Mountain goat population monitoring and survey technique development. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK. 4pp.

White, K. S. 2010. Nutrition and reproduction of mountain goats in coastal Alaska. Proceedings of the 17th Biennial Symposium of the Northern Wild Sheep and Goat Council, 17: 78.

White, K. S. 2010. Mountain goat data summary: East Berners study area. Unpublished report. Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S. and G. Pendleton. 2010. Mountain goat population monitoring and survey technique development. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S. and N. L. Barten. 2010. Mountain goat assessment and monitoring along the Juneau Access road corridor and near the Kensington Mine, southeast Alaska. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S., G. W. Pendleton, D. Crowley, H. Griese, K. J. Hundertmark, T. McDonough, L. Nichols, M. Robus, C. A.Smith and J. W. Schoen. 2011. Mountain goat survival in coastal Alaska: effects of age, sex and climate. Journal of Wildlife Management, 75: 1731-1744.

White, K. S. and G. Pendleton. 2011. Mountain goat population monitoring and survey technique development. Research Progress Report, Alaska Department of Fish and

Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S. and N. L. Barten. 2011. Mountain goat assessment and monitoring along the Juneau Access road corridor and near the Kensington Mine, southeast Alaska. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

Shafer, A. B. A., K. S. White, S. D. Cote and D. W. Coltman. 2011. Deciphering translocations from relicts in Baranof Island mountain goats: is an endemic genetic lineage at risk? Conservation Genetics, 12: 1261-1268.

Shafer, A. B. A., J. M. Northrup, K. S. White, M. S. Boyce, S. D. Cote and D. W. Coltman. 2012. Habitat selection predicts genetic relatedness in an alpine ungulate. Ecology, 93:1317-1329.

White, K. S. and G. Pendleton. 2012. Mountain goat population monitoring and survey technique development. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K.S., D. P. Gregovich, G. W. Pendleton, N. L. Barten, R. Scott, A. Crupi and D. N. Larsen. 2012. Moose population ecology and habitat use along the Juneau Access road corridor, Alaska. Research Final Report. Alaska Department of Fish and Game, Juneau, AK

White, K. S., D. P. Gregovich, G. W. Pendleton, N. L. Barten, A. Crupi, R. Scott and D. N. Larsen. 2012. Modeling resource selection of mountain goats in southeastern Alaska: applications for population management and highway development planning. Proceedings of the Northern Wild Sheep and Goat Council, 18: 32-42.

White, K. S., N. L. Barten, R. Scott and A. Crupi. 2013. Mountain goat population monitoring and movement patterns near the Kensington Mine, AK. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

Richard, J. H., K. S. White and S. D. Cote. 2014. Mating effort and space use of an alpine ungulate during the rut. Behavioral Ecology and Sociobiology, 68: 1639-1648.

White, K. S., N. L. Barten, R. Scott and A. Crupi. 2014. Mountain goat population monitoring and movement patterns near the Kensington Mine, AK. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S., N. L. Barten, R. Scott and A. Crupi. 2015. Mountain goat population monitoring and movement patterns near the Kensington Mine, AK. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S. and D. P. Gregovich. 2016. Mountain goat resource selection and habitat use in relation to mining related disturbance, near the Kensington Mine, Alaska.Research Final Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S. 2016. Mountain goat population monitoring and movement patterns near the Kensington Mine, AK. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S., G. W. Pendleton and J. N. Waite. 2016. Development of an aerial survey population estimation technique for mountain goats in Alaska. Final Wildlife Research Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S. and D. P. Gregovich. 2017. Mountain goat resource selection and habitat use in relation to mining related disturbance. Wildlife Biology, doi: 10.2981/wlb.00277.

White, K. S. 2017. Mountain goat population monitoring and movement patterns near the Kensington Mine, AK. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S., D. P. Gregovich and T. Levi. 2018. Projecting the future of an alpine ungulate under climate change scenarios. Global Change Biology, 24: 1136-1149.

Lowrey, B., C. J. Butler, W. H. Edwards, M. E. Wood, S. R. Dewey, G. L. Fralick, J. Jenings-Gaines, H. Killion, D. E. McWhirther, H. M. Miyasaki, S. T. Stewart, K. S. White, P. J. White, and R. A. Garrott. 2018. A survey of bacterial respiratory pathogens in native and introduced mountain goats (*Oreamnos americanus*). Journal of Wildlife Diseases, 54: 852-858.

White, K. S. 2018. Mountain goat population monitoring and movement patterns near the Kensington Mine, AK. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

Shakeri, Y. N. and K. S. White. 2018. Seasonal and sex-specific variation in space use and site fidelity of mountain goats in coastal Alaska. Conference Abstract. Northern Wild Sheep and Goat Council, Whitefish, MT.

REFERENCES

Chadwick, D.H. 1973. Mountain goat ecology: logging relationships in the Bunker creek drainage of western Montana. Montana Fish and Game Dept., P-R Project Report W-120-R-3,4. Helena, MT. Pp. 262.

Cote, S. D. 1996. Mountain goat response to helicopter disturbance. Wildlife Society Bulletin, 24: 681-685.

Cote, S. D., S. Hamel, A. St-Louis, and J. Mainguy. 2013. Do mountain goats habituate to helicopter disturbance? Journal of Wildlife Management, 77:1244-1248.

D'Eon, R. G. and D. Delaparte. 2005. Effects of radio-collar position and orientation on GPS radio-collar performance, and implications of PDOP in data screening. Journal of Applied Ecology, 42: 383-388.

D'Eon, R. G., R. Serrouya, G. Smith and C. O. Kochanny. 2002. GPS radiotelemetry error and bias in mountainous terrain. Wildlife Society Bulletin, 30: 430-439.

Festa-Bianchet, M. and S. D. Cote. 2007. Mountain goats: ecology, behavior, and conservation of an alpine ungulate. Island Press. Covelo, CA.

Foster, B.R. and E.Y Rahs. 1983. Mountain goat response to hydroelectric exploration in northwestern British Columbia. Environmental Management, 7:189-197.

Hamel, S., S. D. Côté, K. G. Smith, and M. Festa-Bianchet. 2006. Population dynamics and harvest potential of mountain goat herds in Alberta. Journal of Wildlife Management, 70:1044-1053.

Joslin, G. 1986. Mountain goat population changes in relation to energy exploration along Montana's Rocky Mountain Front. Proceedings of the Fifth Biennial Northern Wild Sheep and Goat Council, 5:253-271.

Lowrey, B., C. J. Butler, W. H. Edwards, M. E. Wood, S. R. Dewey, G. L. Fralick, J. Jenings-Gaines, H. Killion, D. E. McWhirther, H. M. Miyasaki, S. T. Stewart, K. S. White, P. J. White, and R. A. Garrott. 2018. A survey of bacterial respiratory pathogens in native and introduced mountain goats (*Oreamnos americanus*). Journal of Wildlife Diseases, 54: 852-858.

Pollock, K. H., S. R. Winterstein, C. M. Bunck and P. D. Curtis. 1989. Survival analysis in telemetry studies: the staggered entry design. Journal of Wildlife Management, 53: 7-15.

Robus, M. H. and B. L. Carney. 1995. Effects of Kensington mine development on black bears and mountain goats. Wildlife baseline studies and monitoring plan. Final report. Alaska Department of Fish and Game, Douglas, AK.

Schoen, J. W. and M. D. Kirchhoff. 1982. Habitat use by mountain goats in Southeast Alaska. Research Final Report. Alaska Department of Fish and Game, Juneau, AK. 67pp.

Shafer, A.B.A., S. D. Cote and D. W. Coltman. 2010. Hot spots of genetic diversity descended from multiple Pleistocene refugia in an alpine ungulate. Evolution, doi: 10.1111/j.1558-5646.2010.01109.x

Shafer, A. B. A., J. M. Northrup, K. S. White, M. S. Boyce, S. D. Cote and D. W. Coltman. 2012. Habitat selection predicts genetic relatedness in an alpine ungulate. Ecology, 93:1317-1329.

Taylor, W.P. 2000. Wildlife capture and restraint manual. Alaska Department of Fish and Game, Anchorage, AK.

White, K. S. 2006. Seasonal and sex-specific variation in terrain use and movement patterns of mountain goats in southeastern Alaska. Proceedings of the Biennial Symposium of the Northern Wild Sheep and Goat Council, 15: 183-193.

Stowell, H. H. 2006. Geology of Alaska: rock and ice in motion. University of Alaska Press. Fairbanks, AK.

White, K. S., G. W. Pendleton, D. Crowley, H. Griese, K. J. Hundertmark, T. McDonough, L. Nichols, M. Robus, C. A.Smith and J. W. Schoen. 2011. Mountain goat survival in coastal Alaska: effects of age, sex and climate. Journal of Wildlife Management, 75: 1731-1744.

White, K. S. and G. Pendleton. 2012. Mountain goat population monitoring and survey technique development. Research Progress Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K.S., D. P. Gregovich, G. W. Pendleton, N. L. Barten, R. Scott, A. Crupi and D. N. Larsen. 2012. Moose population ecology and habitat use along the Juneau Access road corridor, Alaska. Research Final Report. Alaska Department of Fish and Game, Juneau, AK

White, K. S. and D. P. Gregovich. 2016. Mountain goat resource selection and habitat use in relation to mining related disturbance, near the Kensington Mine, Alaska.Research Final Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S., G. W. Pendleton and J. N. Waite. 2016. Development of an aerial survey population estimation technique for mountain goats in Alaska. Final Wildlife Research Report, Alaska Department of Fish and Game, Division of Wildlife Conservation, Juneau, AK.

White, K. S. and D. P. Gregovich. 2017. Mountain goat resource selection and habitat use in relation to mining related disturbance. Wildlife Biology, doi: 10.2981/wlb.00277.

Appendix 1: Incidence of disease prevalence of mountain goats in the Lions Head, Sinclair, Villard and East Berners study areas, 2010-2015. Results are also provided for three other populations in southeastern Alaska in 2010-2015, for comparison. (Kakuhan includes the Lions Head and Sinclair study areas combined).

	Baranof			Cleveland			Haines			Berners			Kakuhan			Villard			Total		
Disease	**n**	**Pos.**	**Prop**	**n**	**Pos.**	**Prop**	**n**	**Pos.**	**Prop**	**n**	**Pos.**	**Prop**	**n**	**Pos.**	**Prop**	**n**	**Pos.**	**Prop**	**n**	**Pos.**	**Prop**
Contagious Ecthyma	40	2	0.05	10	1	0.10	44	3	0.07	20	1	0.05	65	3	0.05	24	0	0.00	203	10	0.05
Chlamydia	16	0	0.00	12	0	0.00	28	1	0.04	27	0	0.00	34	0	0.00	30	1	0.03	147	2	0.01
Q Fever	36	0	0.00	11	0	0.00	50	0	0.00	29	0	0.00	65	3	0.05	32	1	0.03	223	4	0.02
Bluetongue	17	0	0.00	10	0	0.00	20	0	0.00	20	0	0.00	17	0	0.00	18	0	0.00	102	0	0.00
Bovine respiratory synctial virus (BRSV)	17	0	0.00	10	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	16	0	0.00	101	0	0.00
Infectious bovine rhinotrachetis (IBR)	17	0	0.00	10	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	102	0	0.00
Parainfluenza-3 (PI-3)	17	0	0.00	10	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	102	0	0.00
Epizootic hemorrhagic disease (EHD)	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00
Caprinae arthritis encephalitis (CAE)	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	16	0	0.00	100	0	0.00
Malignant cataharral fever-ovine (MCF)	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	16	0	0.00	100	0	0.00
Leptospirosis cannicola	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00
Leptospirosis grippo	17	0	0.00	9	0	0.00	20	1	0.05	21	0	0.00	17	1	0.06	17	1	0.06	101	3	0.03
Leptospirosis hardjo	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00
Leptospirosis ictero	17	0	0.00	9	0	0.00	20	3	0.15	21	2	0.10	17	3	0.18	17	3	0.18	101	11	0.11
Leptospirosis pomona	17	0	0.00	9	0	0.00	20	0	0.00	21	0	0.00	17	0	0.00	17	0	0.00	101	0	0.00

Positive titers: PI3>1:120, IBR> 1:64, BRSV >1:32, Leptospirosis sp.>1:100

Appendix 2a: Trace mineral concentration documented for mountain goats in the Lions Head and Sinclair study areas, 2010-2013. Results are also provided for three other populations in southeastern Alaska in 2010-2014, for comparison. (Kakuhan includes the Lions Head and Sinclair study areas combined).

	Se			Mo			Mn			Fe			Cu			Zn		
Area	mean	SE	n	mean	SE	n	mean	SE	n	mean	SE	n	mean	SE	n	mean	SE	n
Baranof	0.31	0.01	36	0.05	0.00	36	0.006	0.000	36	1.64	0.07	36	1.07	0.02	36	0.81	0.03	36
Cleveland	0.26	0.01	5	0.05	0.00	5	0.006	0.000	5	1.71	0.09	5	0.81	0.03	5	0.70	0.04	5
Kakuhan	0.17	0.02	31	0.05	0.00	31	0.006	0.000	31	1.58	0.09	31	1.01	0.05	31	0.81	0.03	31
Haines	0.24	0.02	52	0.05	0.00	51	0.006	0.000	51	1.82	0.07	51	1.06	0.03	51	0.83	0.03	51
Average	0.24	0.01	126	0.05	0.00	125	0.006	0.000	125	1.72	0.04	125	1.04	0.02	125	0.82	0.02	125

Appendix 2b: Selenium concentration for mountain goats in the Lions Head and Sinclair study areas, 2010-2013. Results are also provided for three other populations in southeastern Alaska in 2010-2014, for comparison. (Kakuhan includes the Lions Head and Sinclair study areas combined).

Selenium (ppm)

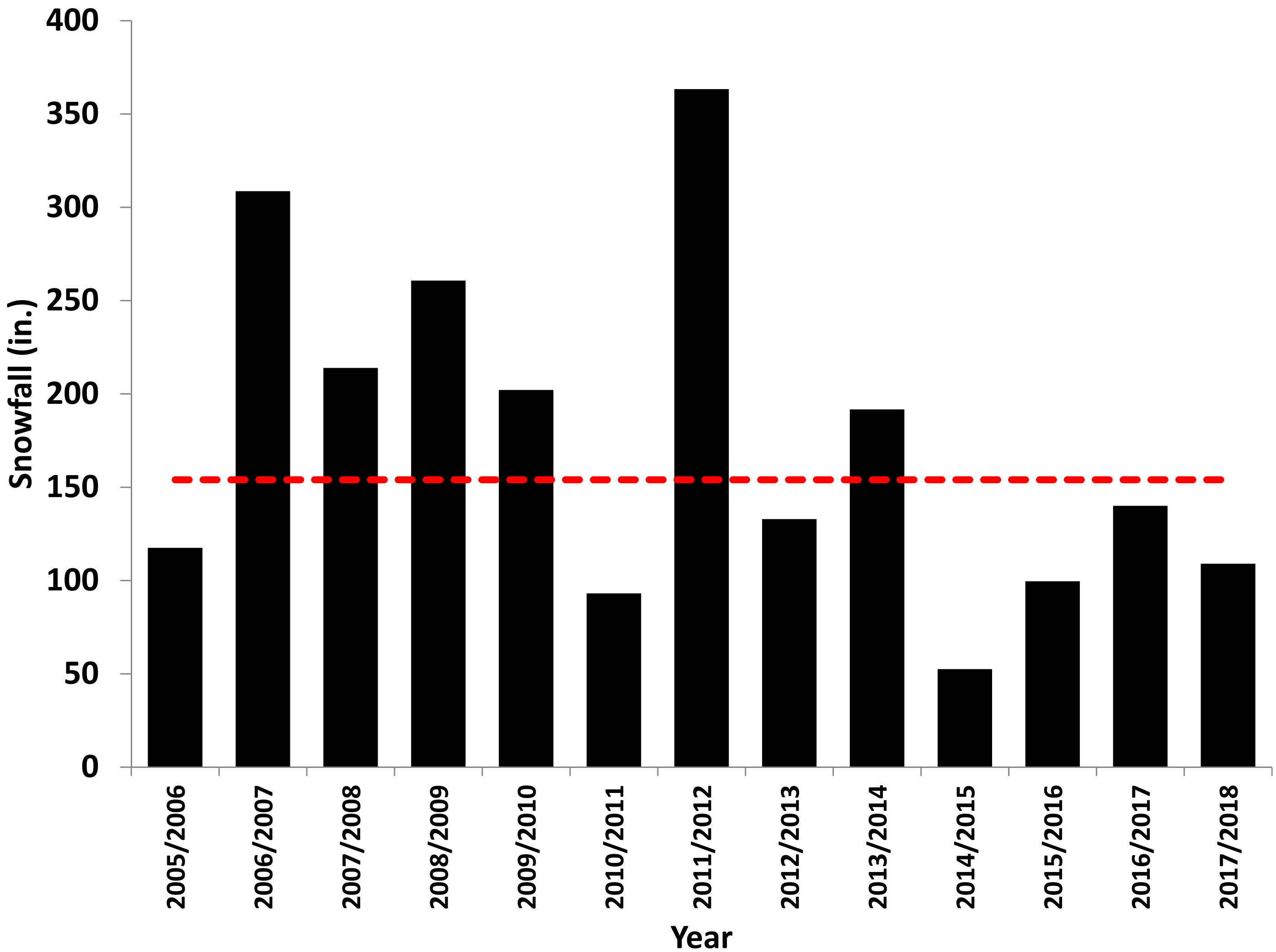
Area	mean	SE	n	Min	Max	# < 0.10	Prop < 0.10
Baranof	0.31	0.01	36	0.19	0.41	0	0.00
Cleveland	0.26	0.01	5	0.22	0.29	0	0.00
Kakuhan	0.17	0.02	31	0.05	0.37	10	0.32
Haines	0.24	0.02	52	0.03	0.73	9	0.17
Average	0.24	0.01	126	0.03	0.73	19	0.15

Appendix 3a: Monthly snowfall (in.) recorded at the Haines 2 COOP NWS Station in Haines, AK between 2005-2018.

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total	% of normal
2005/2006	0	30	9	40	22	16	0	0	118	76%
2006/2007	0	42	78	81	28	78	3	0	309	200%
2007/2008	0	6	56	78	41	31	3	0	214	139%
2008/2009	22	24	56	62	45	43	9	0	261	169%
2009/2010	0	48	19	68	8	59	0	0	202	131%
2010/2011	0	24	25	19	20	3	3	0	93	60%
2011/2012	0	126	40	121	20	56	0	0	363	236%
2012/2013	4	20	41	21	23	10	14	1	133	86%
2013/2014	0	20	92	22	23	35	1	0	192	124%
2014/2015	0	0	5	14	18	16	0	0	53	34%
2015/2016	0	21	43	18	16	2	0	0	100	65%
2016/2017	13	11	43	22	19	33	0	0	140	91%
2017/2018	0	28	2	27	17	34	0	0	109	71%
Average, Study period	3	31	39	46	23	32	3	0	176	114%
Average, Long-term[1]	3	22	38	38	28	21	3	0	154	100%

[1]Haines Airport (1950-1955, 1973-1998) and Haines COOP NWS Station (1999-2018)

Appendix 3a: Total annual snowfall (in.) recorded at the Haines 2 COOP NWS Station in Haines, AK between 2005-2018. The red dashed line designates the long-term average [Haines Airport (1950-1955, 1973-1998) and Haines 2 COOP NWS Station (1999-2018)].



Appendix 3b: Summer temperature and precipitation (in.) recorded at the Haines 2 COOP NWS Station in Haines, AK between 2005-2018.

	Temperature - July/August						Precipitation				
	Farenheit			Celcius			Inches				
Year	Mean - 0 ft.	Mean - 3000 ft.[1]	Departure	Mean - 0 ft.	Mean - 3000 ft.[1]	Departure	May/ June	July/ Aug	May- Aug	MA Dep	Annual
2005/2006	58.30	47.61	1.05	14.61	8.67	0.59	3.2	3.8	7.0	-3.6	66.7
2006/2007	55.95	45.26	-1.30	13.31	7.36	-0.72	6.4	3.6	10.0	-0.6	59.2
2007/2008	57.40	46.71	0.15	14.11	8.17	0.09	1.9	5.9	7.7	-2.8	58.3
2008/2009	54.65	43.96	-2.60	12.58	6.64	-1.44	4.6	9.3	13.9	3.3	69.4
2009/2010	59.10	48.41	1.85	15.06	9.11	1.03	0.7	8.3	9.0	-1.6	62.9
2010/2011	56.40	45.71	-0.85	13.56	7.61	-0.47	5.1	3.5	8.7	-1.9	67.9
2011/2012	56.10	45.41	-1.15	13.39	7.45	-0.64	1.3	5.9	7.2	-3.3	65.9
2012/2013	55.75	45.06	-1.50	13.19	7.25	-0.83	8.6	6.4	15.0	4.4	61.9
2013/2014	58.95	48.26	1.70	14.97	9.03	0.95	4.9	2.7	7.6	-3.0	57.1
2014/2015	56.80	46.11	-0.45	13.78	7.84	-0.25	6.6	11.8	18.4	7.8	64.5
2015/2016	57.35	46.66	0.10	14.08	8.14	0.06	3.0	9.0	11.9	1.4	68.7
2016/2017	58.85	48.16	1.60	14.92	8.98	0.89	6.8	3.4	10.2	-0.3	65.1
2017/2018	56.20	45.51	-1.05	13.44	7.50	-0.58	5.4	6.3	11.7	1.1	58.8
2018/2019	59.65	48.96	2.40	15.36	9.42	1.34	6.0	3.6	9.6	-0.9	53.5
Average, Study period	57.25	46.55	0.00	14.03	8.08	0.00	4.6	6.0	10.6	0.0	62.8

[1]Temperature adjusted based on standard lapse rate (-5.941 C/3000 ft)

Appendix 3a: Departure from normal average temperature (F) during July-August recorded at the Haines 2 COOP NWS Station in Haines, AK between 2005-2018.

Appendix 3a: Departure from normal precipitation (in.) during May-August recorded at the Haines 2 COOP NWS Station in Haines, AK between 2005-2018.

Appendix 4: Mountain goat aerial survey areas in the Kakuhan Range (Lions Head, Sinclair and Berners-Lace Ridge study areas). Each area was surveyed by fixed- and/or rotor-wing aircraft during August-October, 2005-2018. Summer range population size and density (mountain goats/km^2) estimates were derived using sightability and RSF modeling and described in associated figures.

Appendix 5a: Summary of mountain goat population composition, minimum count and population estimates based on data collected during aerial surveys on the Lions Head study area (and associated survey areas), 2005-2018. “Minimum counts” represent the number of mountain goats seen during aerial surveys and do not account for variation in sighting probabilities between surveys/years. Population estimates explicitly account for variation in group-level sighting probabilities among surveys/years.

			Minimum Count				Population Estimate					
Study Area	Survey Area	Year	Adults	Kids	Total	Prop. kids	Total	LCI	UCI	Density	# of surveys	Area (km^2)
Lions Head	W Berners	2005	9	0	9	0.00	21	11	20	1.0	2	22.0
Lions Head	W Berners	2006	16	2	16	0.13	47	20	27	2.1	4	22.0
Lions Head	W Berners	2007	18	7	25	0.28	50	17	24	2.3	4	22.0
Lions Head	W Berners	2008	15	1	16	0.06	26	9	15	1.2	2	22.0
Lions Head	W Berners	2009	12	3	15	0.20	23	8	13	1.0	1	22.0
Lions Head	W Berners	2010	9	1	10	0.10	26	13	20	1.2	2	22.0
Lions Head	W Berners	2011	17	4	21	0.19	39	13	18	1.8	1	22.0
Lions Head	W Berners	2012	11	2	13	0.15	25	10	16	1.1	1	22.0
Lions Head	W Berners	2013	16	2	18	0.11	42	17	25	1.9	1	22.0
Lions Head	W Berners	2014	6	1	7	0.14	15	8	13	0.7	1	22.0
Lions Head	W Berners	2015	5	1	6	0.17	14	8	14	0.6	1	22.0
Lions Head	W Berners	2016	7	1	8	0.13	30	18	29	1.3	1	22.0
Lions Head	W Berners	2017	14	1	15	0.07	42	21	32	1.9	1	22.0
Lions Head	W Berners	2018	13	3	16	0.19	39	20	31	1.8	1	22.0
Lions Head	Kensington	2005	21	5	26	0.19	51	17	24	2.5	2	19.9
Lions Head	Kensington	2006	48	8	54	0.15	118	29	36	5.9	4	19.9
Lions Head	Kensington	2007	24	4	27	0.15	43	12	18	2.2	4	19.9
Lions Head	Kensington	2008	17	4	21	0.19	46	17	25	2.3	2	19.9
Lions Head	Kensington	2009	15	5	19	0.26	31	10	15	1.5	2	19.9
Lions Head	Kensington	2010	18	7	25	0.28	45	15	22	2.3	2	19.9
Lions Head	Kensington	2011	25	7	32	0.22	50	13	18	2.5	1	19.9
Lions Head	Kensington	2012	20	3	23	0.13	38	11	17	1.9	1	19.9
Lions Head	Kensington	2013	17	5	22	0.23	53	21	31	2.7	1	19.9
Lions Head	Kensington	2014	16	1	17	0.06	34	13	19	1.7	1	19.9
Lions Head	Kensington	2015	7	2	9	0.22	25	14	21	1.2	1	19.9
Lions Head	Kensington	2016	13	4	17	0.24	47	23	36	2.4	1	19.9
Lions Head	Kensington	2017	10	2	12	0.17	36	19	31	1.8	1	19.9
Lions Head	Kensington	2018	8	1	9	0.11	26	16	26	1.3	1	19.9
Lions Head	Met	2005	35	7	42	0.17	80	22	31	5.2	2	15.4
Lions Head	Met	2006	47	14	61	0.23	125	30	37	8.2	5	15.4
Lions Head	Met	2007	48	5	53	0.09	117	30	37	7.6	4	15.4
Lions Head	Met	2008	39	13	51	0.25	102	26	33	6.6	2	15.4
Lions Head	Met	2009	30	9	39	0.23	56	13	19	3.6	2	15.4
Lions Head	Met	2010	32	14	46	0.30	91	24	32	5.9	2	15.4
Lions Head	Met	2011	42	15	57	0.26	84	16	22	5.5	1	15.4
Lions Head	Met	2012	37	7	44	0.16	74	17	24	4.8	1	15.4
Lions Head	Met	2013	31	11	42	0.26	81	24	34	5.3	1	15.4
Lions Head	Met	2014	30	10	40	0.25	63	15	21	4.1	1	15.4
Lions Head	Met	2015	--	--	--	--	--	--	--	--	0	15.4
Lions Head	Met	2016	17	7	24	0.29	65	27	39	4.2	1	15.4
Lions Head	Met	2017	12	4	16	0.25	39	19	32	2.6	1	15.4
Lions Head	Met	2018	26	8	34	0.24	94	35	45	6.1	1	15.4

Appendix 5b: Summary of mountain goat population composition, minimum count and population estimates based on data collected during aerial surveys on the Mt. Sinclair study area (and associated survey areas), 2005-2018. “Minimum counts” represent the number of mountain goats seen during aerial surveys and do not account for variation in sighting probabilities between surveys/years. Population estimates explicitly account for variation in group-level sighting probabilities among surveys/years.

			Minimum Count				Population Estimate					
Study Area	Survey Area	Year	Adults	Kids	Total	Prop. kids	Total	LCI	UCI	Density	# of surveys	Area (km^2)
Sinclair	Yeldagalga	2005	67	16	83	0.19	134	26	35	5.4	2	25.1
Sinclair	Yeldagalga	2006	95	22	112	0.20	206	36	41	8.2	6	25.1
Sinclair	Yeldagalga	2007	69	15	84	0.18	153	31	38	6.1	3	25.1
Sinclair	Yeldagalga	2008	50	12	62	0.19	114	26	34	4.6	2	25.1
Sinclair	Yeldagalga	2009	--	--	--	--	--	--	--	--	0	25.1
Sinclair	Yeldagalga	2010	25	9	31	0.29	69	22	29	2.7	2	25.1
Sinclair	Yeldagalga	2011	57	15	72	0.21	107	20	26	4.3	1	25.1
Sinclair	Yeldagalga	2012	59	9	68	0.13	95	17	23	3.8	1	25.1
Sinclair	Yeldagalga	2013	34	8	42	0.19	92	29	40	3.7	1	25.1
Sinclair	Yeldagalga	2014	31	9	40	0.23	63	14	20	2.5	1	25.1
Sinclair	Yeldagalga	2015	15	7	22	0.32	45	17	25	1.8	1	25.1
Sinclair	Yeldagalga	2016	49	15	64	0.23	158	43	54	6.3	1	25.1
Sinclair	Yeldagalga	2017	31	11	42	0.26	117	40	51	4.7	1	25.1
Sinclair	Yeldagalga	2018	31	10	41	0.24	97	34	45	3.9	1	25.1
Sinclair	S Katzehin	2005	72	13	85	0.15	155	32	38	3.7	2	41.6
Sinclair	S Katzehin	2006	94	19	113	0.17	211	38	43	5.1	4	41.6
Sinclair	S Katzehin	2007	84	20	104	0.19	184	33	40	4.4	3	41.6
Sinclair	S Katzehin	2008	70	19	89	0.21	131	21	27	3.2	2	41.6
Sinclair	S Katzehin	2009	--	--	--	--	--	--	--	--	0	41.6
Sinclair	S Katzehin	2010	29	7	36	0.19	79	24	31	1.9	2	41.6
Sinclair	S Katzehin	2011	53	14	67	0.21	105	20	26	2.5	1	41.6
Sinclair	S Katzehin	2012	42	6	48	0.13	80	18	25	1.9	1	41.6
Sinclair	S Katzehin	2013	21	4	25	0.16	55	20	31	1.3	1	41.6
Sinclair	S Katzehin	2014	27	6	33	0.18	57	15	21	1.4	1	41.6
Sinclair	S Katzehin	2015	27	8	35	0.23	75	23	31	1.8	1	41.6
Sinclair	S Katzehin	2016	21	6	27	0.22	75	30	41	1.8	1	41.6
Sinclair	S Katzehin	2017	24	2	26	0.08	76	31	42	1.8	1	41.6
Sinclair	S Katzehin	2018	40	13	53	0.25	139	42	53	3.3	1	41.6
Sinclair	Katzehin Lk	2005	23	8	31	0.26	47	13	21	2.2	2	21.2
Sinclair	Katzehin Lk	2006	25	3	27	0.11	44	13	18	2.1	4	21.2
Sinclair	Katzehin Lk	2007	16	2	18	0.11	37	14	22	1.8	3	21.2
Sinclair	Katzehin Lk	2008	15	4	19	0.21	41	16	23	1.9	2	21.2
Sinclair	Katzehin Lk	2009	--	--	--	--	--	--	--	--	0	21.2
Sinclair	Katzehin Lk	2010	14	5	19	0.26	42	17	25	2.0	2	21.2
Sinclair	Katzehin Lk	2011	7	2	9	0.22	16	7	13	0.8	1	21.2
Sinclair	Katzehin Lk	2012	3	0	3	0.00	6	3	8	0.3	1	21.2
Sinclair	Katzehin Lk	2013	2	1	3	0.33	8	5	14	0.4	1	21.2
Sinclair	Katzehin Lk	2014	3	1	4	0.25	7	3	10	0.3	1	21.2
Sinclair	Katzehin Lk	2015	2	0	2	0.00	4	2	10	0.2	1	21.2
Sinclair	Katzehin Lk	2016	7	1	8	0.13	26	16	29	1.2	1	21.2
Sinclair	Katzehin Lk	2017	8	1	9	0.11	25	14	26	1.2	1	21.2
Sinclair	Katzehin Lk	2018	2	0	2	0.00	8	6	18	0.4	1	21.2

Appendix 5c: Summary of mountain goat population composition, minimum count and population estimates based on data collected during aerial surveys on the Meade Icefield and Berners-Lace Ridge study areas (and associated survey areas), 2005-2018. "Minimum counts" represent the number of mountain goats seen during aerial surveys and do not account for variation in sighting probabilities between surveys/years. Population estimates explicitly account for variation in group-level sighting probabilities among surveys/years.

			Minimum Count				Population Estimate					
Study Area	**Survey Area**	**Year**	**Adults**	**Kids**	**Total**	**Prop. kids**	**Total**	**LCI**	**UCI**	**Density**	**# of surveys**	**Area (km^2)**
Icefield	S Meade	2005	6	1	6	0.17	10	4	11	0.5	2	18.2
Icefield	S Meade	2006	19	3	22	0.14	43	14	21	2.4	2	18.2
Icefield	S Meade	2007	3	1	4	0.25	8	4	10	0.4	1	18.2
Icefield	S Meade	2008	5	1	5	0.20	9	4	10	0.5	2	18.2
Icefield	S Meade	2009	--	--	--	--	--	--	--	--	0	18.2
Icefield	S Meade	2010	4	2	6	0.33	14	8	15	0.8	2	18.2
Icefield	S Meade	2011	10	3	13	0.23	24	10	15	1.3	1	18.2
Icefield	S Meade	2012	7	0	7	0.00	15	8	14	0.8	1	18.2
Icefield	S Meade	2013	10	1	11	0.09	25	12	20	1.4	1	18.2
Icefield	S Meade	2014	5	3	8	0.38	14	6	11	0.7	1	18.2
Icefield	S Meade	2015	5	2	7	0.29	16	9	16	0.9	1	18.2
Icefield	S Meade	2016	12	2	14	0.14	49	26	39	2.7	1	18.2
Icefield	S Meade	2017	9	1	10	0.10	32	18	29	1.7	1	18.2
Icefield	S Meade	2018	8	1	9	0.11	27	16	26	1.5	1	18.2
Icefield	U Lace	2005	9	0	9	0.00	22	12	18	1.3	1	16.9
Icefield	U Lace	2006	1	0	1	0.00	3	2	9	0.2	1	16.9
Icefield	U Lace	2007	8	1	9	0.11	16	7	12	1.0	1	16.9
Icefield	U Lace	2008	6	1	6	0.17	10	4	11	0.6	2	16.9
Icefield	U Lace	2009	--	--	--	--	--	--	--	--	0	16.9
Icefield	U Lace	2010	2	1	2	0.50	4	2	8	0.2	2	16.9
Icefield	U Lace	2011	6	4	10	0.40	14	4	10	0.8	1	16.9
Icefield	U Lace	2012	9	3	12	0.25	19	7	14	1.1	1	16.9
Icefield	U Lace	2013	2	0	2	0.00	6	4	12	0.4	1	16.9
Icefield	U Lace	2014	6	3	9	0.33	12	3	9	0.7	1	16.9
Icefield	U Lace	2015	7	1	8	0.13	17	9	16	1.0	1	16.9
Icefield	U Lace	2016	3	0	3	0.00	13	10	22	0.8	1	16.9
Icefield	U Lace	2017	3	2	5	0.40	12	7	19	0.7	1	16.9
Icefield	U Lace	2018	4	2	6	0.33	13	7	19	0.8	1	16.9
BL Ridge	BL Ridge	2005	10	0	10	0.00	33	17	25	1.1	1	30.0
BL Ridge	BL Ridge	2006	--	--	--	--	--	--	--	--	0	30.0
BL Ridge	BL Ridge	2007	25	4	29	0.14	57	18	26	1.9	1	30.0
BL Ridge	BL Ridge	2008	19	3	22	0.14	49	18	26	1.6	1	30.0
BL Ridge	BL Ridge	2009	--	--	--	--	--	--	--	--	0	30.0
BL Ridge	BL Ridge	2010	--	--	--	--	--	--	--	--	0	30.0
BL Ridge	BL Ridge	2011	26	9	35	0.26	60	16	23	2.0	2	30.0
BL Ridge	BL Ridge	2012	24	3	27	0.11	43	12	17	1.4	1	30.0
BL Ridge	BL Ridge	2013	13	2	15	0.13	40	18	27	1.3	1	30.0
BL Ridge	BL Ridge	2014	16	3	19	0.16	36	13	18	1.2	1	30.0
BL Ridge	BL Ridge	2015	18	4	22	0.18	54	20	28	1.8	1	30.0
BL Ridge	BL Ridge	2016	13	2	15	0.13	31	14	22	1.0	1	30.0
BL Ridge	BL Ridge	2017	17	5	22	0.23	49	21	33	1.7	1	30.0
BL Ridge	BL Ridge	2018	11	2	13	0.15	27	16	26	0.9	1	30.0

Appendix 6: Summary of mountain goats captured and monitored in the Lions Head and Mt. Sinclair study areas during 2005-2018, Lynn Canal, AK.

Mtn Goat ID	Date - Capture	Year	Sex	Est. Age	Kid	Weight (lbs.)	Fate	Date - Fate	Days Monitored
LG001	9/26/05	2005	M	9	--	308	Died	4/17/06	203
LG002	9/26/05	2005	F	11	1	140	Died	4/16/06	202
LG003	9/26/05	2005	F	7	1	180	Died	4/10/07	561
LG004	9/26/05	2005	F	7	1	196	Release	8/15/07	688
LG005	9/26/05	2005	M	9	--		Died	5/9/07	590
LG006	10/2/05	2005	M	8	--	347	Died	2/10/06	131
LG007	10/2/05	2005	M	2	--	163	Release	8/15/07	682
LG008	10/2/05	2005	F	5	0	171	Died	7/8/13	2836
LG008	8/15/10	2010	F	7	1	172	Died	7/8/13	1058
LG009	10/2/05	2005	F	10	0		Release	8/15/07	682
LG010	10/3/05	2005	F	7	?	187	Release	8/15/07	681
LG011	10/3/05	2005	M	9	--	335	Died	2/11/07	496
LG016	10/14/05	2005	M	5	--	273	Release	8/15/07	670
LG019	10/15/05	2005	M	5	--	273	Died	6/26/06	254
LG020	10/15/05	2005	M	8	--	285	Release	8/15/07	669
LG021	10/15/05	2005	F	4	0	194	Release	8/15/07	669
LG022	10/15/05	2005	F	8	?		Release	8/15/07	669
LG023	10/15/05	2005	M	9	--	221	Release	8/15/07	669
LG024	7/28/06	2006	M	3	--	134	Died	7/13/08	716
LG025	7/28/06	2006	F	6	?	130	Died	5/11/07	287
LG026	7/28/06	2006	M	6	--	251	Died	11/17/06	112
LG027	7/28/06	2006	M	10	--	274	Died	12/31/07	521
LG028	7/28/06	2006	M	8	--		Died	7/18/07	355
LG029	7/28/06	2006	F	7	?	160	Release	9/11/08	776
LG030	7/28/06	2006	F	8	?		Died	4/25/07	271
LG036	7/29/06	2006	M	6	--	308	Release	9/11/08	775
LG037	7/29/06	2006	M	4	--	216	Died	2/18/08	569
LG038	7/29/06	2006	F	4	?	141	Release	9/11/08	775
LG039	8/29/06	2006	F	10	0	165	Died	5/10/07	254
LG040	8/29/06	2006	M	8	--		Died	4/24/12	2065
LG040	9/24/08	2008	M	10	--	309	Died	4/24/12	1308
LG041	8/29/06	2006	F	5	1		Release	9/11/08	744
LG045	9/25/06	2006	F	6	0	185	Release	9/11/08	717
LG050	10/7/06	2006	M	8	--	250	Died	4/17/07	192
LG051	10/7/06	2006	F	2	0	145	Release	9/11/08	705
LG052	10/7/06	2006	F	3	0	160	Release	9/11/08	705
LG053	10/7/06	2006	M	3	--	171	Release	9/11/08	705
LG060	10/13/06	2006	M	5	--	287	Release	9/1/08	689
LG061	10/13/06	2006	M	10	--	350	Died	5/15/09	945
LG061	8/18/08	2008	M	12	--	301	Died	5/15/09	270
LG062	10/13/06	2006	M	10	--	310	Release	9/1/08	689

Appendix 6 (continued): Summary of mountain goats captured and monitored in the Lions Head and Mt. Sinclair study areas during 2005-2018, Lynn Canal, AK.

Mtn Goat ID	Date - Capture	Year	Sex	Est. Age	Kid	Weight (lbs.)	Fate	Date - Fate	Days Monitored
LG078	8/2/07	2007	F	9	1	175	Release	9/11/08	406
LG079	8/2/07	2007	M	11	--	269	Died	8/24/07	22
LG080	8/2/07	2007	M	6	--	281	Release	9/11/08	406
LG081	8/2/07	2007	M	4	--	217	Release	9/11/08	406
LG083	8/3/07	2007	M	5	--	258	Died	6/11/11	1408
LG084	8/3/07	2007	M	4	--	180	Died	4/12/11	1348
LG086	8/11/07	2007	M	4	--	223	Died	10/7/08	423
LG087	8/11/07	2007	M	5	--	233	Died	2/21/10	925
LG088	8/11/07	2007	F	8	0	160	Died	11/1/09	813
LG089	8/11/07	2007	M	4	--	240	Died	11/1/09	813
LG090	8/11/07	2007	F	3	0	157	Release	9/11/08	397
LG097	8/16/08	2008	F	5	1	151	Release	6/7/11	1025
LG098	8/16/08	2008	M	6	--	279	Died	2/15/14	2009
LG098	8/16/12	2012	M	10	--	302	Died	2/15/14	548
LG099	8/18/08	2008	M	6	--	266	Release	6/7/11	1023
LG100	8/18/08	2008	F	10	1	163	Died	10/6/08	49
LG101	8/18/08	2008	M	5	--	277	Died	10/8/09	416
LG102	8/18/08	2008	M	7	--	328	Died	4/3/13	1689
LG103	8/18/08	2008	F	7	0	185	Died	10/14/12	1518
LG103	9/10/11	2011	F	10	0		Died	10/14/12	400
LG104	8/18/08	2008	F	6	0	192	Release	6/7/11	1023
LG106	8/19/08	2008	M	5	--	242	Died	4/17/10	606
LG112	9/21/08	2008	F	11	1	199	Died	2/4/09	136
LG117	9/24/08	2008	F	3	0	170	Release	6/7/11	986
LG118	9/24/08	2008	F	3	0	166	Release	6/7/11	986
LG119	9/24/08	2008	M	4	--	237	Release	10/31/18	3689
LG120	9/24/08	2008	F	5	1	175	Died	3/22/09	179
LG124	8/5/09	2009	M	5	--	291	Died	3/2/12	940
LG125	8/5/09	2009	F	4	0	150	Died	4/11/14	1710
LG126	8/5/09	2009	F	6	1	175	Died	10/15/12	1167
LG127	8/5/09	2009	F	11	1	182	Died	3/9/10	216
LG128	8/5/09	2009	F	6	0	170	Died	7/27/10	356
LG136	9/1/09	2009	F	2	0	131	Died	10/18/09	47
LG137	9/1/09	2009	M	9	--	342	Died	6/19/12	1022
LG141	8/15/10	2010	M	7	--	307	Died	1/15/15	1614
LG143	8/15/10	2010	F	6	1	175	Died	5/7/13	996
LG144	8/15/10	2010	F	6	1	163	Died	6/14/11	303
LG145	8/15/10	2010	F	6	1	192	Release	9/20/17	2593
LG146	8/15/10	2010	M	2	--	134	Died	7/12/12	697
LG147	9/10/11	2011	F	3	0	145	Died	10/11/12	397
LG148	9/10/11	2011	F	6	0	182	Died	9/11/17	2193
LG149	9/10/11	2011	F	6	0	164	Died	8/28/12	353
LG150	9/10/11	2011	M	5	--	234	Died	5/19/13	617
LG151	9/10/11	2011	F	5	1	180	Died	6/24/12	288
LG152	9/10/11	2011	M	11	--	296	Died	5/21/12	254
LG153	9/10/11	2011	M	5	--	243	Died	11/8/16	1886
LG154	8/16/12	2012	F	2	0	151	Died	8/7/17	1817

Appendix 6 (continued): Summary of mountain goats captured and monitored in the Lions Head and Mt. Sinclair study areas during 2005-2018, Lynn Canal, AK.

Mtn Goat ID	Date - Capture	Year	Sex	Est. Age	Kid	Weight (lbs.)	Fate	Date - Fate	Days Monitored
LG155	8/16/12	2012	F	12	0	186	Died	5/8/13	265
LG156	8/16/12	2012	M	6	--	265	Died	1/24/14	526
LG157	8/16/12	2012	M	4	--	282	Died	1/18/18	1981
LG158	8/16/12	2012	M	4	--	192	Died	1/5/14	507
LG159	8/16/12	2012	M	3	--		Died	10/11/14	786
LG160	10/10/12	2012	F	2	0	172	Alive	2/11/19	2315
LG161	10/10/12	2012	F	3	0	160	Alive	2/11/19	2315
LG162	8/15/13	2013	M	8	--	325	Died	1/7/17	1241
LG163	8/15/13	2013	M	3	--	170	Died	7/7/15	691
LG164	8/15/13	2013	F	7	1	180	Died	2/10/17	1275
LG166	8/15/13	2013	M	2	--		Died	6/29/14	318
LG167	8/20/14	2014	F	11	0	208	Died	1/17/17	881
LG168	8/20/14	2014	F	5	1	193	Alive	2/11/19	1636
LG169	8/20/14	2014	F	9	0	155	Died	10/15/16	787
LG170	8/20/14	2014	M	7	--	254	Died	11/7/14	79
LG172	8/20/14	2014	M	3	--	174	Died	8/3/18	1444
LG173	8/20/14	2014	M	6	--	268	Died	11/19/16	822
LG174	8/20/14	2014	F	10	1		Died	11/7/17	1175
LG175	8/25/15	2015	F	4	0	202	Alive	2/11/19	1266
LG176	8/25/15	2015	M	6	--		Alive	2/11/19	1266
LG177	8/25/15	2015	F	11	1	211	Alive	2/11/19	1266
LG178	8/25/15	2015	M	6	--	300	Alive	2/11/19	1266
LG179	8/25/15	2015	F	4	1		Release	7/5/18	1045
LG180	8/25/15	2015	F	1	0		Died	4/15/16	234
LG181	9/2/16	2016	M	7	--	295	Died	12/28/16	117
LG182	9/2/16	2016	M	6	--	331	Died	4/5/17	215
LG183	9/2/16	2016	F	9	1	191	Died	10/10/17	403
LG184	9/2/16	2016	M	5	--	321	Died	12/2/18	821
LG185	9/2/16	2016	F	5	0	193	Died	8/7/17	339
LG186	9/2/16	2016	F	7	1	200	Alive	2/11/19	892
LG187	9/2/16	2016	M	5	--		Died	10/23/16	51
LG188	9/2/16	2016	M	4	--		Alive	2/11/19	892
LG189	8/10/17	2017	M	4	--	321	Alive	2/11/19	550
LG190	8/10/17	2017	M	3	--		Alive	2/11/19	550
LG191	8/10/17	2017	F	6	1	170	Alive	2/11/19	550
LG192	8/10/17	2017	F	6	1	172	Alive	2/11/19	550
LG193	8/10/17	2017	M	9	--		Alive	2/11/19	550
LG194	8/10/17	2017	F	8	1	179	Alive	2/11/19	550
LG195	8/10/17	2017	F	3	0	156	Alive	2/11/19	550
LG196	8/10/17	2017	M	4	--	209	Alive	2/11/19	550
LG197	7/31/18	2018	M	4	--	261	Alive	2/11/19	195
LG198	7/31/18	2018	F	4	0		Alive	2/11/19	195
LG199	7/31/18	2018	M	2	--		Alive	2/11/19	195
LG200	7/31/18	2018	F	5	1	172	Alive	2/11/19	195
LG201	8/1/18	2018	M	2	--	168	Alive	2/11/19	194
LG202	8/1/18	2018	F	7	0	170	Alive	2/11/19	194