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Mountain Goat Movement Patterns and Population Monitoring on Baranof Island

Kevin S. White, Phil Mooney and Kent Bovee

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Alaska Department of Fish and Game Division of Wildlife Conservation

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Brenda Bowers, Alaska Department of Fish & Game, P. O. Box 1100024, Juneau, AK 99811-0024, USA; Phone: 907-465-4272

Mountain Goat Movement Patterns and Population Monitoring on Baranof Island

Kevin S. White[1], Phil Mooney[2] and Kent Bovee[3]

[1]Alaska Department of Fish and Game, Division of Wildlife Conservation
P. O. Box 110024, Juneau, AK 99811,

[2]Alaska Department of Fish and Game, Division of Wildlife Conservation, 304 Lake Street, Room 103, Sitka, AK 99835-7671,

[3]601B Lincoln Street, Sitka, AK 99835

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Region 1, Division of Wildlife Conservation, Alaska Department of Fish and Game
P. O. Box 110024, Juneau, Alaska 99811

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[1]Correspondence author: Alaska Department of Fish and Game, Division of Wildlife Conservation
P. O. Box 110024, Juneau, AK 99811, kevin.white@alaska.gov, 907-465-4102

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INTRODUCTION

The City and Borough of Sitka is planning to conduct hydroelectric development activities on central Baranof Island, specifically in the vicinity of Blue and Takatz lakes. Among the key wildlife species potentially affected by this development project are mountain goats (City and Borough of Sitka Electric Department 2010). Specifically, mountain goat populations are expected to be sensitive to hydroelectric project activities associated with inundation of lakeshore winter habitat, construction activities, increased human access and cumulative effects of dual projects in both the Blue and Takatz lake watersheds.

In response to the above concerns, the City and Borough of Sitka (CBS) and the Alaska Department of Fish and Game (ADFG) have initiated cooperative mountain goat population monitoring activities to determine possible impacts of hydroelectric development on mountain goats and identify potential mitigative measures, to the extent feasible. Research activities include collection of movement and vital rate data on a sample of radio-marked mountain goats in addition to implementation of annual aerial population abundance and productivity surveys. These efforts are aimed at providing the ADFG and local stakeholder groups with information necessary to appropriately manage mountain goats in the vicinity of proposed development activities and beyond. The three objectives of the proposed assessment and monitoring work include:

Objectives:

1) Characterize seasonal movement and habitat selection patterns of mountain goats on central Baranof Island.

2) Assess reproductive success and survival of mountain goats on central Baranof Island.

3) Estimate and monitor mountain goat population abundance and composition on central Baranof Island.

Study Area:

Field research activities were concentrated in ca. 1360 km^2 area surrounding the Blue and Takatz lake hydroelectric project sites (Figure 1). This configuration was intended to enable collection of field data across an array of locally distinctive habitat complexes inhabited by mountain goats within the hydroelectric project areas (Figure 2). In addition, since mountain goats are capable of making routine annual movements of 10-15 km (and dispersal movements exceeding 35 km) it was considered necessary to delineate a study area large enough to encompass the area used by mountain goats potentially affected by development activities.

Figure 1: Map of the Baranof Island study area. The red shaded area depicts the study area boundary; the city of Sitka is shown for reference.

Figure 2: Photograph of Glacier Lake in the Blue Lake watershed depicting the rugged character of the landscape on the western side of the mountain goat study area, September 2013.

METHODS

Mountain Goat Capture

Mountain goats were captured using standard helicopter darting techniques and immobilized by injecting 2.4-3.0 mg of carfentanil citrate, depending on sex and time of year (Taylor 2000, White and Barten 2010), 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 were reversed with 100 mg of naltrexone hydrochloride per 1 mg of carfentanil citrate (Taylor 2000). All capture procedures were approved by the State of Alaska Animal Care and Use Committee.

Figure 3: Photograph of a 4-yr old female mountain goat (BG-31) deployed with Telonics GPS/VHF radio-collars, south of the Middle Arm of Kelp Bay, Baranof Island, September 2013.

GPS Location Data

Telonics TGW-3590, TGW-4500 and TGW-4590 GPS radio-collars (Telonics, Inc., Mesa, AZ) were deployed on all captured animals (Figure 3). In addition, lightweight Telonics MOD-400 VHF radio-collars were also simultaneously deployed on each animal to enable longer-term monitoring opportunities (collar lifespan: ~6 years). GPS radio-collars were programmed to collect location data at 6-hour intervals (collar lifetime: 3-4 years for TGW-3590 and TGW-4500, respectively). 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. For Telonics TGW-3590 collars (n = 9), GPS location data-sets were remotely downloaded (via fixed-wing aircraft) 2-3 times per year (pre-programmed download "windows" occur twice every 8 weeks). Telonics TGW-4500 radio-collars store all GPS data "on-board" and will not be downloaded until collars automatically release in June 2014 and annually thereafter (depending on deployment date). Location data will be 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).

Movement Patterns and Habitat Use

Complete analyses of GPS location data to characterize movement patterns and habitat use of mountain goats will not be conducted until data have been downloaded from all GPS collars (i.e., 2015).

Preliminary analyses of GPS location data downloaded from 9 TGW-3590 radio-collars was conducted to examine seasonal movement patterns and elevational migration. Specifically, we summarized the average elevation (ft.) per day in order to determine when elevational migrations occurred and the average elevation used during the summer and winter periods. We also estimated the average distance moved during a 6-hr period and examined how movement distances varied seasonally (using the Geospatial Modeling Environment software; http://www.spatialecology.com/gme/). These analyses were summarized in White et al. (2012).

Reproduction and Survival

Kidding rates and subsequent survival was estimated by monitoring individual study animals during 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 evaluating activity sensor data embedded in GPS location data and/or by detecting radio-frequency pulse rate changes during routine monitoring surveys. In cases where mortalities were detected, efforts were made to investigate sites as soon as possible via ground, helicopter or boat. To the extent possible, all mortalities were thoroughly investigated to ascertain the cause of death and relevant biological samples collected. Annual survival of radio-collared animals was estimated using the Kaplan-Meier methodology (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. 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 ancillary data were collected to characterize behavioral and habitat conditions expected, a priori, to influence sighting probabilities.

Preliminary estimates of mountain goat population size were calculated using standard Lincoln-Peterson mark-resight methods. In the future, estimates will be revised using more complex models (see White and Pendleton 2012). The entire study area was subdivided into geographically discrete survey areas (Appendix 1) in order to gain insight into patterns of spatial variability. However, preliminary population estimates were based on adjusting raw counts in accordance with the sighting probability (i.e., the ratio of the number of marked animals seen vs. present in the study area) estimates for the entire study area. This approach was used because the number of marked animals in any given survey area was too small for accurate estimates, and we did not feel that survey conditions during the day of survey varied markedly between survey areas.

Results and Discussion:

Mountain Goat Capture and Handling

Capture Activities.—Mountain goats were captured during five days in August-September 2010-2013. Overall, 31 animals (10 females and 21 males) were captured using standard helicopter darting methods (Figure 4, Appendix 2). Each animal was deployed with a Telonics TGW-3590 (n = 9), TGW-4500 (n = 15) or TGW-4590 (n = 7) GPS radio-collar and a lightweight Telonics MOD-400 VHF radio-collar (370g). Double-collaring animals was conducted to extend the time period individual animals could be monitored (lifespan, GPS: 3-4 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 had to 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.

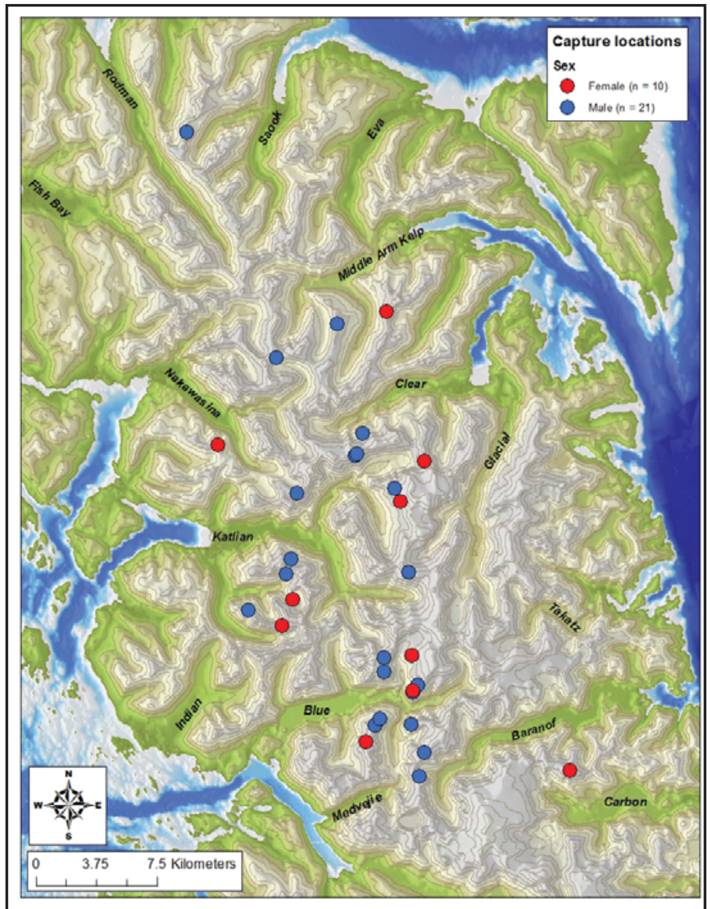

Figure 4: Location of mountain goat capture sites in central Baranof Island, September 2010-2013 (n = 31). Sex of animals captured and key geographic localities are identified.

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. While we were able to meet our annual sample size objectives, the difficulty of capturing mountain goats (due to terrain ruggedness and animal abundance and distribution) exceeds that of other areas in southeastern Alaska where mountain goats have been captured in recent years (i.e., Lynn Canal, Haines/Skagway, Cleveland Peninsula). Consequently, the distribution of collar deployments was less uniform than desired, with a majority of collar deployments being concentrated on the central and western side of the study area. Nonetheless, given seasonal movement patterns, capture locations are not necessarily a reliable indicator of the annual distribution of individual animals. Thus, the possibility remains that the apparent bias, described above, may not persist over time.

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 and trace mineral analyses, or archived at ADFG facilities in Douglas, AK.

Disease Testing.—Blood serum samples collected from captured animals were also tested for a suite of 15 different diseases relevant to ungulates (Appendix 3). 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 23 animals successfully tested for CE, only one animal tested positive for CE-specific antibodies; a comparable prevalence relative to other southeastern Alaska populations tested in 2005-2012 (Appendix 3). Otherwise, antibody prevalence of the remaining diseases tested for was virtually absent and indicates a general lack of disease exposure among Baranof mountain goats; yet, it is important to recognize that such conditions likewise suggest a high level of vulnerability should such diseases become prevalent in the future (i.e., due to a lack of a previous immune response). The general lack of positive antibody responses for the suite of diseases examined was also typical of the other southeastern Alaska populations tested.

Trace Mineral Testing.—In 2010-2012, whole blood and serum samples were analyzed to determine trace mineral concentration of 24 mountain goats in order to examine whether mineral deficiencies were prevalent in our study population (Appendix 4). Unfortunately, baseline mineral concentration values for healthy mountain goats are limited and constrain our ability to compare observed values

Figure 5: Photo of a 3-yr old female mountain goat (BG-30) captured on Slaughter Ridge in the Nakawasina watershed, Baranof Island, AK. Note the broken and deformed left horn, possibly caused by a fall earlier in life.

in our study population to established standards. Nonetheless, Selenium (Se) and Copper (Cu) deficiencies have been studied in northern ungulates (Fielder 1986, O'Hara et al. 2001) and the mountain goats sampled did not appear to have concentrations below reported deficiency thresholds for both of these minerals (i.e., Se > 0.05, Cu >0.8). In comparison to other southeastern Alaska populations, Baranof mountain goats appear to have comparable or higher values for the minerals tested, suggesting that equal or higher levels of mineral resources were available for animals in the Baranof population, relative to elsewhere.

Population Genetics.—Tissue samples from all mountain goats captured (and a majority of animals harvested via ADFG registration hunts) were sent to 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 southeastern Alaska. Interestingly, analyses suggest that mountain goats on Baranof Island are derived from two separate source populations (Shafer et al. 2010, Shafer et al. 2011). One source population consists of animals translocated from Tracy Arm in 1923 (Paul 2009). The other source population consists of animals originating from a population endemic to Baranof Island, putatively occurring on Baranof Island prior to the 1923 translocation and persisting in a coastal refugia during the last ice age (unbeknownst to contemporary historians). The conservation implications associated with the presence of two distinct genetic lineages (one introduced and one endemic) on Baranof Island are provocative.

Future analyses will focus on examining the spatial distribution of each lineage and determining the extent of overlap (relying primarily on data from harvested animals). Further, genotyping animals captured during this study will enable assignment to the appropriate genetic lineages and make possible more discrete linkages between genetic identity to spatial distribution (via GPS collar location data) and, potentially, vital rates. To accomplish the latter objectives, additional sample collection efforts have resulted in archival of 156 mountain goat samples (102 males, 54 females) from Baranof Island during 2003-2012. As of August 2012, laboratory analyses have been completed and further statistical analyses of genetic data are planned for the future.

Reproduction and Survival

Reproduction-In order to estimate reproductive productivity, we monitored radio-marked adult females to determine whether they had kids at heel. In 2010, our estimates were based on surveys beginning in August and thus likely represent an underestimate of kid production. However, in 2011-2013 surveys were conducted during the late-parturition period and are expected to more closely approximate actual parturition rates. Overall, we determined that 68% of marked females had kids at heel during 2010-2013 (Table 1). This baseline estimate is comparable to longer-term estimates calculated for mountain goats on the mainland (Table 1); however, sample sizes are small and estimates should be considered preliminary until more data is gathered in future years.

Table 1: Proportion of radio-marked adult female mountain goats seen with a kid at heel in the Baranof Island study area and, for comparison, Haines-Skagway and Lynn Canal areas, 2005-2013.

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
	Total	17	25	0.68	0.09
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
	Total	31	43	0.72	0.07
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	8	12	0.67	0.14
	Total	131	207	0.63	0.03

Survival-We estimated survival for 24 mountain goats monitored between August 2010-May 2013 (Table 2). Our estimates for 2010 did not include fates of animals during June-August 2010 (prior to initial captures) and thus do not span an entire biological year. Nonetheless, since mortality rates are typically low during these months (White et al. 2011) our estimates are expected to be similar to actual annual survival. Overall, we determined that 92±4% of animals survived (Table 2). Four animals have died during the monitoring period; all adult males that died during winter, including one that died in an avalanche in Baranof Pass (May 2013). Overall, estimated survival in the Baranof population was relatively high, but comparable to estimated survival in the Lynn Canal and Haines-Skagway populations during the equivalent time period. Winter snowfall, an important determinant of mountain goat survival, tends to be substantially lower in the Sitka area, due to the strong maritime influence, relative to the mainland and may account for higher survival rates. Alternatively, mountain goat survival may normally be high on Baranof, relative to mainland populations, due to the absence of wolves. Nonetheless, it is important to recognize that our sample size for the Baranof population is very small for the purposes of estimating survival, and chance events may result in our estimates not being representative of the local populations as a whole. Clearly, additional monitoring of an increased sample of marked mountain goats over multiple years will increase our ability to accurately characterize baseline survival rates for this population.

Population Abundance and Composition Estimation

Systematic aerial surveys were conducted in the study area each year between 2010-2013. However, mark-resight surveys were conducted only in 2011-2013 (Appendix 5); mark-resight surveys enable estimation of sighting prob-

Table 2: Mountain goat survival estimates, and associated winter climate data, for radio-marked mountain goats in the Baranof Island study area and, for comparison, Cleveland Peninsula, Haines-Skagway and Lynn Canal areas. Sample sizes in the Baranof Island, Cleveland Peninsula and Haines-Skagway area are small and estimates should be interpreted with caution.

	Males				Females				Total			
	At Risk	Died	$\hat{S}$	SE	At Risk	Died	$\hat{S}$	SE	At Risk	Died	$\hat{S}$	SE
Baranof Island												
2010/2011	6.0	1	0.88	0.11	3.0	0	1.00	0.00	9.0	1	0.92	0.08
2011/2012	10.8	0	1.00	0.00	5.5	0	1.00	0.00	16.3	0	1.00	0.00
2012/2013	15.0	3	0.82	0.09	6.0	0	1.00	0.00	21.0	3	0.87	0.07
All years	31.8	4	0.89	0.05	14.5	0	1.00	0.00	46.3	4	0.92	0.04
Cleveland Pen.												
2009/2010	5.0	0	1.00	0.00	2.0	0	1.00	0.00	7.0	0	1.00	0.00
2010/2011	5.8	2	0.67	0.16	5.0	0	1.00	0.00	10.8	2	0.83	0.10
2011/2012	4.0	2	0.50	0.18	6.0	0	1.00	0.00	10.0	2	0.80	0.11
2012/2013	1.6	1	0.50	0.35	6.0	0	1.00	0.00	7.6	1	0.88	0.12
All years	15.1	5	0.71	0.10	18.5	0	1.00	0.00	33.6	5	0.86	0.05
Haines-Skagway												
2010/2011	11.6	4	0.69	0.13	9.2	3	0.70	0.14	20.8	7	0.70	0.10
2011/2012	13.2	2	0.87	0.09	9.0	1	0.90	0.09	22.2	3	0.88	0.06
2012/2013	16.3	2	0.89	0.07	10.3	1	0.91	0.08	26.6	3	0.90	0.06
All years	39.1	8	0.83	0.06	27.0	5	0.84	0.06	66.1	13	0.83	0.04
Lynn Canal												
2005/2006	9.6	2	0.79	0.13	10.0	1	0.90	0.09	19.6	3	0.85	0.08
2006/2007	25.4	11	0.57	0.10	22.1	4	0.82	0.08	47.5	15	0.68	0.07
2007/2008	26.5	6	0.79	0.07	20.8	3	0.88	0.07	47.3	9	0.83	0.05
2008/2009	24.2	10	0.66	0.09	21.4	6	0.73	0.09	45.6	16	0.69	0.06
2009/2010	25.1	4	0.86	0.07	22.3	4	0.85	0.07	47.4	8	0.85	0.05
2010/2011	24.3	3	0.88	0.06	23.2	2	0.91	0.06	47.5	5	0.90	0.04
2011/2012	17.9	6	0.72	0.10	15.3	3	0.85	0.08	33.2	9	0.77	0.07
2012/2013	16.8	8	0.59	0.10	13.6	7	0.60	0.11	30.4	15	0.59	0.07
All years	167.5	51	0.73	0.03	146.1	31	0.81	0.03	313.6	82	0.77	0.02

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

Table 3: Summary of sighting probabilities detected during mountain goat aerial surveys conducted in 4 seperate study areas during 2010-2013 in southeastern Alaska.

Area	Seen	Total	Prop. seen	SE
Baranof				
2010	--	--	--	--
2011	12	18	0.67	0.11
2012	11	21	0.52	0.11
2013	16	22	0.73	0.09
Total	39	61	0.64	0.06
Cleveland Pen				
2010	--	--	--	--
2011	--	--	--	--
2012	3	16	0.19	0.10
2013	10	21	0.48	0.11
Total	13	37	0.35	0.08
Haines-Skagway				
2010	14	20	0.70	0.10
2011	20	32	0.63	0.09
2012	8	18	0.44	0.12
2013	24	31	0.77	0.08
Total	66	101	0.65	0.05
Lynn Canal				
2010	39	73	0.53	0.06
2011	19	28	0.68	0.09
2012	21	32	0.66	0.08
2013	13	22	0.59	0.10
Total	92	155	0.59	0.04
Overall total	210	354	0.59	0.03

ability and population size.

Sighting probabilities tended to be lower in 2012 as compared to 2011 and 2013 (Table 3, Appendix 5), but sample sizes were relatively small, resulting in a lack of statistical differences between years. Sighting probabilities observed during aerial surveys on Baranof Island were similar to sighting probabilities estimated during simultaneous studies conducted in Lynn Canal and the Haines-Skagway area (Table 3). Overall, we estimated that between 52-73% of mountain goats were seen during surveys on Baranof Island in 2011-2013. Preliminary analysis of environmental factors influencing the sighting probability of individual mountain goats during aerial surveys were summarized in White and Pendleton (2013).

Survey results were categorized based on watershed basin delineations to provide insight relative to spatial variation in abundance and kid production across the study area. In general, mountain goat abundance was higher on the west side of the island, relative to the east side (Appendix 1). However, within this context, areas on the west side of the island that were in close proximity to human access tended to have reduced abundance; though formal statistical analyses (including reference to historical survey data) are needed to confirm this preliminary assessment. The study area-wide estimate of mountain goat abundance was 13% lower in 2013 as compared to 2011, however preliminary confidence intervals overlapped between years. Likewise, the proportion of kids in the population was substantially lower in 2012 (10.2%) as compared to 2011 (17.9%) and 2013 (20.4%). While these preliminary results appear to suggest a marked population decline between 2011 and 2013, is it important to interpret these results with caution until further population monitoring data is collected in subsequent years. In addition, further statistical analysis is need to calculate the precision of annual estimates (sensu White and Pendleton 2012) and determine whether statistically significant differences have occurred between years of study. Regardless, these preliminary results suggest that management of the population should remain conservative.

Future Work/Recommendations:

During 2014/2015, efforts will be made to monitor fates of marked animals opportunistically from the ground or air. Specific efforts will be made to remotely download TGW-3590/4590 GPS collars (n = 11) and ascertain reproductive success of radio-marked female mountain goats (n = 10) in spring 2014; over-winter mortalities will be investigated from the ground, as applicable. In addition, monthly monitoring of animals with only VHF radio-collars (i.e. GPS collars already released) should be monitored to determine survival status. During June/July 2014, 8 TGW-4500 GPS radio-collars are scheduled to automatically release from mountain goats and will be recovered from the field with helicopter support. During August/September 2014, an additional 6 GPS radio-collars may be deployed via helicopter capture methods, contingent on sufficient funding. Annual fall aerial population estimation and composition surveys will be conducted in September/October 2014. Finally, an annual project progress report will be prepared and submitted by December 31, 2014.

Original project planning involved assessment of local mountain goat populations in the vicinity of planned or ongoing hydroelectric development activities. This aspect of the project was jointly funded by the City of Sitka, ADFG and USFS through 2013. In the meantime, significant concerns have arisen concerning mountain goat population management in areas outside the hydroelectric development area. Such concerns focus on the effects of chronic harvest of female mountain goats and associated population level effects (i.e. population decline). As a result of these concerns, ADFG has financially supported geographical expansion of field efforts to include additional high priority management areas. We recommend continuation of research and monitoring activities into the future in order to monitor population recovery. Specifically, collection of population vital rate and abundance/composition data is needed to gauge population response to recent regulatory changes. Completion of these goals will be contingent on continued funding from ADFG and the USFS.

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Project Publications:
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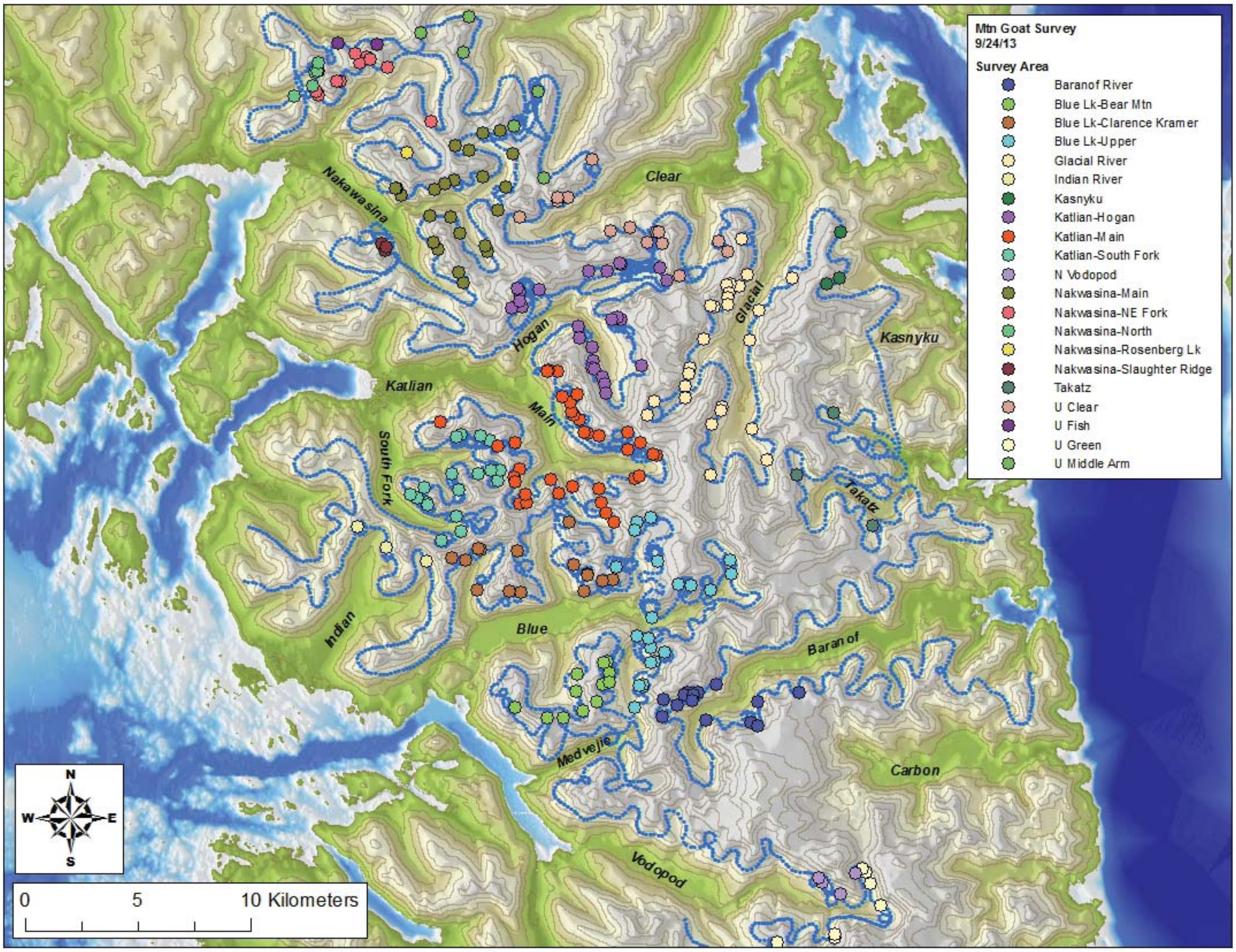
Appendix 1. Map depicting the route (i.e., light blue line) of the mountain goat aerial survey conducted in 2013 in the Baranof Island study area. The locations of each mountain goat group observed are color coded based on specific watershed-based geographic areas; survey results are reported in Appendix 5.



Appendix 2: Characteristics of mountain goats (n = 31) captured on central Baranof Island, 2010-2013. "Status" denotes fate as of September 24, 2013.

Mtn Goat ID	Date	Sex	Est. Age	Kid at Heel	Weight (lbs.)	Horns[1] Total Length	Horns[1] Basal Circum.	GPS Collar Type	Status	Location
BG001	9/7/10	M	3	--	--	--	--	TGW-3590	Alive	Blue Lk
BG002	9/7/10	M	1	--	134	7 1/16	4 11/16	TGW-3590	Alive	Blue Lk
BG003	9/7/10	F	6	1	196	7 3/16	3 9/16	TGW-3590	Alive	Blue Lk
BG004	9/7/10	M	2	--	150	8	4 12/16	TGW-3590	Alive	Blue Lk
BG005	9/7/10	M	8	--	290	7 0/16*	4 14/16	TGW-3590	Alive	Baranof R Pass
BG006	9/7/10	F	5	1	163	7 14/16	3 14/16	TGW-4500	Alive	Katlian
BG007	9/7/10	M	1	--	119	6 2/16	4 5/16	TGW-4500	Alive	Katlian
BG008	9/12/10	F	9	1	201	10 2/16	3 12/16	TGW-4500	Alive	Carbon
BG009	9/12/10	M	4	--	--	8 13/16	5 1/16	TGW-4500	Alive	Baranof R Pass
BG010	9/12/10	M	8	--	306	8 10/16	4 14/16	TGW-4500	Died	Katlian
BG011	9/12/10	M	8	--	--	9 7/16	--	TGW-4500	Alive	Katlian
BG012	9/12/10	F	5	1	179	8 13/16	4	TGW-4500	Alive	Katlian
BG013	9/11/11	M	3	--	229	8 1/16	4 14/16	TGW-3590	Alive	Blue Lk
BG014	9/11/11	M	4	--	275	8 9/16	5 1/16	TGW-3590	Alive	Blue Lk
BG015	9/11/11	F	4	1	175	8 11/16	4	TGW-3590	Alive	Blue Lk
BG016	9/11/11	F	5	1	203	8	3 15/16	TGW-3590	Alive	Katlian
BG017	9/11/11	M	7	--	340	8 8/16	5 3/16	TGW-4500	Alive	Hogan Lk
BG018	9/11/11	M	3	--	209	8 1/16	5	TGW-4500	Died	Hogan Lk
BG019	9/11/11	M	7	--	322	7 14/16*	5	TGW-4500	Alive	Nakwasina
BG020	8/20/12	M	6	--	285	9 1/16	5 4/16	GPS TGW-4500	Died	Blue Lk
BG021	8/20/12	M	6	--	267	8 10/16	5 4/16	TGW-4500	Alive	Katlian
BG022	8/20/12	M	14	--	227	10 2/16	5 15/16	TGW-4500	Died	Clear R
BG023	8/20/12	M	6	--	324	9 15/16	5 2/16	TGW-4500	Alive	MF Kelp Arm Ck
BG024	8/20/12	M	5	--	259	9 8/16	5 2/16	TGW-4500	Alive	Saook
BG025	9/15/13	F	3	0	186	8 4/16	3 15/16	TGW-4590	Alive	Blue Lk
BG026	9/15/13	M	3	--	193	8 7/16	5	TGW-4590	Alive	Blue Lk
BG027	9/15/13	M	1	--	142	6 8/16	4 9/16	TGW-4590	Alive	Katlian
BG028	9/15/13	F	8	1	211*	9 7/16	3 15/16	TGW-4590	Alive	Katlian
BG029	9/15/13	M	4	--	255	8 4/16	5	TGW-4590	Alive	Nakwasina
BG030	9/15/13	F	3	0	159	8 7/16	3 15/16	TGW-4590	Alive	Nakwasina
BG031	9/15/13	F	4	0	191	9 1/16	4 1/16	TGW-4590	Alive	MF Kelp Arm Ck

[1] Horn dimensions reflect length or circumference of the largest horn; an asterisk denotes the horn tip was broomed.

Appendix 3. Incidence of disease prevalence of mountain goats in the Baranof Island study area, 2010-2012. Results are also provided for three other populations in southeastern Alaska in 2005-2012, for comparison.

	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	23	1	0.04	10	1	0.10	26	3	0.12	20	1	0.05	49	3	0.06	24	0	0.00	152	9	0.06
Chlamydia	11	1	0.09	12	1	0.08	22	0	0.00	27	2	0.07	29	1	0.03	30	0	0.00	131	5	0.04
Q Fever	19	0	0.00	11	0	0.00	32	0	0.00	29	0	0.00	50	3	0.06	32	1	0.03	173	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 4. Trace mineral concentration (ppm) documented for mountain goats in the Baranof Island study area, 2010-2012. Results are also provided for three other populations in southeastern Alaska in 2010-2012, for comparison.

	Se			Fe			Cu			Zn			Mo			Mn		
Area	**mean**	**SE**	**n**	**mean**	**SE**	**n**	**mean**	**SE**	**n**	**mean**	**SE**	**n**	**mean**	**SE**	**n**	**mean**	**SE**	**n**
Baranof	0.32	0.01	24	1.78	0.09	24	1.08	0.03	24	0.82	0.03	24	0.05	0.00	24	0.01	0.00	24
Cleveland	0.26	0.01	5	1.71	0.09	5	0.81	0.03	5	0.70	0.04	5	0.05	0.00	5	0.01	0.00	5
Grandchild	0.27	0.08	2	2.86	0.03	2	1.07	0.05	2	0.77	0.06	2	0.05	0.00	2	0.01	0.00	2
Kakuhan	0.17	0.02	19	1.75	0.11	19	0.96	0.05	19	0.82	0.04	19	0.05	0.00	19	0.01	0.00	19
Haines	0.25	0.03	38	1.94	0.08	37	1.07	0.04	37	0.81	0.03	37	0.05	0.00	37	0.01	0.00	37
Average	0.25	0.01	88	1.86	0.05	87	1.04	0.02	87	0.81	0.02	87	0.05	0.00	87	0.01	0.00	87

Appendix 5. Summary of mountain goat aerial survey results, conducted from a fixed-wing aircraft (Piper Cub) during 2011-2013. Results for “adults”, “kids” and “total” represent the number of animals seen (i.e., not corrected for sighting probabilities) in specific watersheds on central Baranof Island, AK. The “estimated total” represents the estimated number of total animals in each survey area after accounting for year-specific aerial survey sighting probabilities (i.e., the proportion of marked animals seen during the study area-wide survey, by year).

Area	Year	Date	Adults	Kids	Total	% Kids	Sighting Prob[1]	Est. Total	CI
U Green	2011	9/25/11	--	--	--	--	--	--	--
	2012	10/2/12	10	0	10	0.0	0.52	19	--
	2013	9/24/13	9	2	11	18.2	0.73	15	--
N Vodopod	2011	9/25/11	21	2	23	8.7	0.67	34	7
	2012	10/2/12	8	0	8	0.0	0.52	16	--
	2013	9/24/13	5	1	6	16.7	0.73	8	--
Medvejie	2011	9/25/11	0	0	0	0.0	--	--	--
	2012	10/2/12	0	0	0	0.0	--	--	--
	2013	9/24/13	0	0	0	0.0	--	--	--
Blue Lake-Bear Mtn	2011	9/25/11	11	3	14	21.4	0.67	21	2
	2012	10/2/12	7	2	9	22.2	0.52	17	--
	2013	9/24/13	18	2	20	10.0	0.73	27	3
Blue Lake-Upper	2011	9/25/11	29	9	38	23.7	0.67	56	14
	2012	10/2/12	15	1	16	6.3	0.52	30	6
	2013	9/24/13	30	10	40	25.0	0.73	54	10
Blue Lake-Clarence Kramer	2011	9/25/11	20	4	24	16.7	0.67	36	7
	2012	10/2/12	11	2	13	15.4	0.52	25	4
	2013	9/24/13	22	7	29	24.1	0.73	40	6
Indian River	2011	9/25/11	3	1	4	25.0	--	--	--
	2012	10/2/12	3	1	4	25.0	--	--	--
	2013	9/24/13	3	0	3	0.0	--	--	--
Katlian-South Fork	2011	9/25/11	36	6	42	14.3	0.67	62	15
	2012	10/2/12	38	4	42	9.5	0.52	78	25
	2013	9/24/13	43	14	57	24.6	0.73	77	16
Katlian-Main	2011	9/25/11	58	10	68	14.7	0.67	100	27
	2012	10/2/12	48	4	52	7.7	0.52	96	31
	2013	9/24/13	53	16	69	23.2	0.73	94	19
Katlian-Hogan	2011	9/25/11	66	21	87	24.1	0.67	128	35
	2012	10/2/12	34	6	40	15.0	0.52	74	23
	2013	9/24/13	36	10	46	21.7	0.73	63	12
Nakwasina-Slaughter Ridge	2011	9/25/11	--	--	--	--	--	--	--
	2012	10/2/12	7	2	9	22.2	0.52	17	--
	2013	9/24/13	5	3	8	37.5	0.73	11	--
Nakwasina-Main	2011	9/25/11	50	9	59	15.3	0.67	87	23
	2012	10/2/12	34	4	38	10.5	0.52	71	22
	2013	9/24/13	47	10	57	17.5	0.73	77	16
Nakwasina-Rosenberg Lk	2011	9/25/11	--	--	--	--	--	--	--
	2012	10/2/12	0	0	0	0.0	0.52	0	--
	2013	9/24/13	2	0	2	0.0	0.73	3	--
Nakwasina-NE Fork	2011	9/25/11	31	5	36	13.9	0.67	53	13
	2012	10/2/12	12	3	15	20.0	0.52	28	5
	2013	9/24/13	22	6	28	21.4	0.73	38	6
Nakwasina-North	2011	9/25/11	--	--	--	--	--	--	--
	2012	10/2/12	4	1	5	20.0	0.52	10	
	2013	9/24/13	13	3	16	18.8	0.73	22	--
Glacial River	2011	9/25/11	40	13	53	24.5	0.67	78	20
	2012	10/2/12	18	3	21	14.3	0.52	39	10
	2013	9/24/13	56	10	66	15.2	0.73	90	18
Kasnyku	2011	9/25/11	7	0	7	0.0	--	--	--
	2012	10/2/12	12	0	12	0.0	--	--	--
	2013	9/24/13	5	2	7	28.6	--	--	--

[1]Total marked animals, 2011 = 18; 2012 = 21, 2013 = 22

Appendix 5 (continued). Summary of mountain goat aerial survey results, conducted from a fixed-wing aircraft (Piper Cub) during 2011-2013. Results for “adults”, “kids” and “total” represent the number of animals seen (i.e., not corrected for sighting probabilities) in specific watersheds on central Baranof Island, AK. The “estimated total” represents the estimated number of total animals in each survey area after accounting for year-specific aerial survey sighting probabilities (i.e., the proportion of marked animals seen during the study area-wide survey, by year).

Area	Year	Date	Adults	Kids	Total	% Kids	Sighting Prob[1]	Est. Total	CI
Takatz	2011	9/25/11	5	2	7	28.6	--	--	--
	2012	10/2/12	1	0	1	0.0	--	--	--
	2013	9/24/13	5	1	6	16.7	--	--	--
Baranof River	2011	9/25/11	23	3	26	11.5	0.67	38	8
	2012	10/2/12	13	0	13	0.0	0.52	25	4
	2013	9/24/13	19	5	24	20.8	0.73	33	5
N Carbon	2011	9/25/11	2	1	3	33.3	--	--	--
	2012	10/2/12	9	1	10	10.0	--	--	--
	2013	9/24/13	--	--	--	--	--	--	--
Total[2]	**2011**	**9/25/11**	**400**	**88**	**488**	**18.0**	**0.67**	**714**	**208**
	2012	**10/2/12**	**254**	**30**	**284**	**10.6**	**0.52**	**522**	**187**
	2013	**9/24/13**	**366**	**94**	**460**	**20.4**	**0.73**	**623**	**144**
% change			**-8.5**	**6.8**	**-5.7**			**-12.7**	

[1]Total marked animals, 2011 = 18; 2012 = 21, 2013 = 22

[2]Total calculated only for areas surveyed each year (2011-2013)