SUMMARY REPORT

The Role of Grizzly Bear Predation on Caribou Calf Survival in the Klinse-Za Herd

Feasibility Study

A.D. WOODS[1] AND R.S. MCNAY[2]

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[1] Ridgeline Wildlife Enhancement Inc., SS#2 Site 13 Comp 30, Fort St. John, BC, V1J 4M7, adwoods04@gmail.com
[2] Wildlife Infometrics Inc., PO Box 308, Mackenzie, BC, V0J 2C0, wild_info@wildlifeinfometrics.com

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EXECUTIVE SUMMARY

The Klinse-Za population of woodland caribou (*Rangifer tarandus*), located in northern British Columbia (BC), numbered only 36 animals in 2013 after undergoing a steep population decline during the previous two decades. Since 2013, emergency measures (wolf removal and caribou maternal penning) have been undertaken to prevent immediate extirpation of the Klinse-Za herd and have resulted in a caribou population that has now surpassed 100 animals. However, free-ranging calf survival continues to be unsustainable, which forced us to investigate other factors that may influence calf survival. Traditional knowledge and studies conducted elsewhere have indicated that grizzly bear predation may be a significant source of calf mortality.

The purpose of this project was to conduct a preliminary study to assess the feasibility of using collared grizzly bears to identify calf predation events, prior to implementing a full study to support the development of management recommendations. A late-spring and poor weather conditions precluded capture during the peak caribou calving window; however, four grizzly bears were successfully captured and fitted with GPS- and video camera-equipped collars in June 2021. Unfortunately, we experienced a high rate of collar failure; video cameras failed after seven to 10-days post-deployment and only two of the four collars collected GPS location data for the duration of collar deployment. A total of 282 minutes of video data was collected between June 5 and 16, prior to collar failure. Resting (33%), travelling (21%), and feeding (16%) were the most common activities recorded. Over the 25-day video collection period, six predation events were recorded: three from a young male bear and three from an adult female bear, for an average kill rate of 0.24 large-mammal kills/bear/day. Prey items were difficult to identify from the video footage, but are believed to be ungulate (moose, elk, deer, or caribou) and potentially a black bear. For the two bears where the GPS collars functioned correctly, bears and caribou overlapped intermittently from calving to the fall rut, with approximately 10% of bear locations at or above the average elevation of collared caribou.

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INTRODUCTION

Project Rationale

The Klinse-Za woodland caribou herd numbered only 36 animals in 2013. Maternal penning and wolf removal have helped to temporarily avert herd extirpation, as the population has now surpassed 100 animals (McNay et al. 2021). Together these management actions have contributed to an overall (penned plus free ranging) calf recruitment of 56 calves:100 cows[1]. However, calf recruitment in the free-ranging component of the Klinse-Za population is still unsustainable at only 23 calves:100 cows – much lower than recruitment in the neighbouring Quintette caribou herd (36 calves:100 cows) – compelling us to continue maternal penning and wolf removal in the Klinse-Za.

During the neonatal period, annual calf survival in other caribou herds has been observed to range between ~65-80% (Gustine et al. 2006, Walker et al. 2021, Unpublished data[2]), however, in the Chisana herd in southwest Yukon, calf survival was less than 25% during the neonatal period (Adams et al. 2019). The low free-ranging recruitment in the Klinse-Za and the disparity with the Quintette herd recruitment suggests there may be other factors contributing to calf mortality in Klinse-Za, given that both herds have received wolf reductions. Research suggests grizzly bears in other systems can have significant impact on caribou calf mortality (Brockman 2015, Egan 2019). However, the role of bears as a predator in northern caribou herds, their impact on calf survival, and the potential for compensatory predation is unknown (Leblond et al. 2016, McNay et al. 2021).

Based on the results from studies elsewhere, local traditional knowledge, and from our observations over eight years of field work in the area, we think the most likely explanation for the difference in calf survival between the herds is predation by alternate predators, which, if corroborated by empirical data, can lead to important implications for how caribou recovery initiatives are implemented, including both maternal penning and wolf removal. The purpose of our proposed project is to specifically investigate the role of grizzly bears, as a contributing factor to the relatively low calf recruitment observed in the free-ranging portion of Klinse-Za caribou herd. This work will directly contribute to the Shared Recovery Objectives as expressed within the Intergovernmental Partnership Agreement for the Conservation of the Central Group of the Southern Mountain Caribou – in particular, the expeditious growth of the herd to self-sustaining levels.

Background

The original concept of this project was to examine the role of grizzly bear predation on the disparity in calf survival between the Kline-Za and Quintette herds (Bridger 2019, McNay et al. 2021). To address the original purpose of the project, in December 2019 we applied for a permit for the capture and collaring of 60 grizzly bears in the Klinse-Za and Quintette caribou herds. This included fitting 10 video-equipped collars and 20 standard GPS-equipped collars on bears in each herd area. Video-equipped collars

[1] Unpublished Data: Integrated Population Model (in progress; Williams S., Martin H., and Lamb C.L. (2020)).
[2] Nîkanêse Wah tzee Stewardship Society - Klinse-Za Caribou Recovery Program (2013-2020) and Wildlife Infometrics Inc. - Omineca Northern Caribou Project (1999-2002).

were to be deployed for approximately 12 weeks during the neonatal period to record predation events. GPS collars were to be deployed for approximately 3-5 years to collect data on grizzly bear habitat use, movements, range overlap with caribou, and to be used to estimate grizzly bear density in caribou calving ranges. In collaboration with FLNRORD's Fish & Wildlife branch, 20 of the 40 GPS collars were to be supplied by FLNRORD to conduct a habitat use study on grizzly bears in the Hart GBPU, in addition to providing data on range overlap between bears and caribou in the Quintette herd.

Our original project scale was not supported by FLNRORD Northeast Region, and our initial permit application was rejected[3]. As a result, we reduced the scale of the project and refined project objectives to focus more directly on quantifying the number of calves killed by grizzly bears in the Klinse-Za herd only, which allowed us to reduce the number and type of collars to be deployed. After consultation with Northeast Region regional staff and the BC Caribou Science Team members, we proposed a feasibility study to be conducted in 2021. Implementing the project at a reduced scale would allow us to collect information regarding project feasibility prior to implementing a broader mechanistic study to support the development of management recommendations.

Project Feasibility

To initially assess feasibility of the study, we developed a hypothetical scenario of the outcome based on parameters estimated from observations taken over the past eight years (Unpublished data, Wildlife Infometrics Inc.). We estimated there were approximately 100 caribou in the Klinse-Za herd prior to the 2021 calving season, including 34 adult females, of which 17 would likely be left free-ranging after capture for the pen. Assuming a pregnancy rate of >95% and that 10% of the pregnancies will fail, we estimated 14 free-ranging calves born and 14 penned calves born. Average annual recruitment in the Klinse-Za is 26 and 57 calves:100 free-ranging and penned females, respectively, so only four of the 14 calves would survive to March in the free-ranging cohort (26%) and nine of the 14 calves (61%) in the pen would survive to March. The pen is successfully "saving" five calves from predation each year; however, 10 (or more) of the 18 calves produced (56%) are dying outside the pen. Based on our observations while conducting aerial surveys during calving, and on photo records taken from camera traps throughout the herd area, we estimate that there are at minimum of 10 to 15 grizzly bears in the Klinse-Za herd that appear to spend their time on calving grounds in the spring, which may contribute to the low calf survival observed in the free-ranging population.

Even though the number of calves that are dying in the free-ranging portion of the Klinse-Za herd, potentially from grizzly bear predation, is a relatively small number (four to 10 annually), this has conservation implications that far exceed its limited magnitude. Consistent with the Shared Recovery Objective of the Partnership Agreement for expeditious growth, and the BC Science Team's mandate to explore limiting factors to caribou, the loss of these four to 10 calves (when you have a population of approximately 100 animals) is significant and is limiting the expeditious growth of caribou in the Klinse-Za. So much so, that without the maternity pen, the Klinse-Za herd would be stable at best and more likely to be declining, instead of increasing.

[3] It was not sufficiently clear to the decision maker, that the information gained from the study would out-weigh the risk of collaring a large number of grizzly bears.

OBJECTIVES

To address the important question of the potential role of grizzly bear predation on low calf survival in the Klinse-Za herd, we identified five project objectives for this feasibility study:

a) Determine whether there are enough bears present in the Klinse-Za calving range to be captured and collared,
b) Capture and collar 10 adult grizzly bears,
c) Evaluate the effectiveness of video collars to document predation events by identifying if the amount and quality of data that can be collected from a small sample of collared bears is sufficient to detect a predation event,
d) Assess whether bears are pursuing caribou and if these pursuits are successful, and
e) Enumerate predation of calves by grizzly bears in the Klinse-za herd during the neonatal period.

STUDY AREA

The Klinse-Za caribou population extends across greater than 550,000 ha of land from ~15 km west of Moberly Lake to the eastern shore of Parsnip Arm of the Williston Reservoir, and from Highway 97 north to the southern shore of the Peace Arm of the Williston Reservoir. Overlapping with the Klinse-Za caribou herd is the Moberly Grizzly Bear Population Unit (GBPU; Figure 1). We focussed the project study area on high-elevation winter and summer ranges[4]; however, we recognized the large home ranges of grizzly bears and considered low-elevation matrix habitat during our capture efforts.

METHODS

To implement our feasibility study and address the project objectives, we proposed to capture and collar ten grizzly bears in the Klinse-Za herd area prior to and during the caribou neonatal period (May 1 to June 15).

Capture and Collaring

Using a Bell Jet Ranger helicopter and a crew of two experienced observers and a shooter, we located bears by flying known caribou calving ranges in the herd area. In transit to calving ranges, we also searched for bears in core and matrix caribou habitat (Figure 1). When a bear was spotted, the capture crew assessed the size and sex of the bear and whether a successful capture was possible (i.e., safe capture location and a sufficient forest opening for darting and for immobilization to take effect).

[4] Data BC: https://catalogue.data.gov.bc.ca/dataset/pncp-high-elevation-winter-range

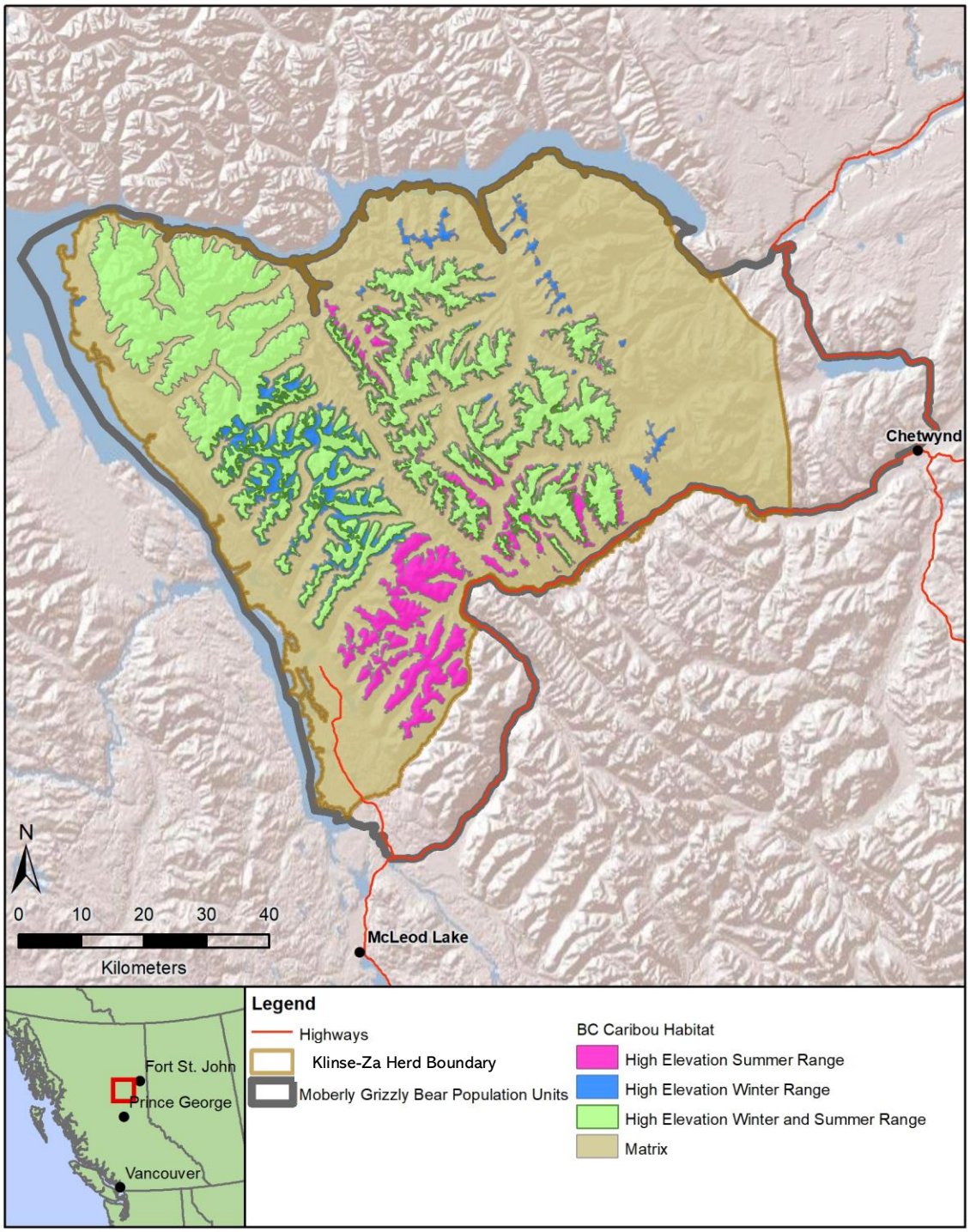

Figure 1. High-elevation winter and summer caribou habitat in the Klinse-Za caribou herd and boundaries of the Moberly Grizzly Bear Population Unit (GBPU), Klinse-Za Grizzly Bear Predation Project, 2021-22.

Using a PneuDart rifle equipped with velocity control setting to minimize dart related injuries, and appropriate doses of Zoletil (a 1:1 combination of tiletamine hydrochloride and zolazepam hydrochloride premixed in powdered form, Virbac, Carros, France), we

immobilized the animals by firing the dart from the helicopter into the bear's shoulder. Depending on the size of the bear, the drug dose ranged between 1,000- to 1,500-mg. Capture occurred when the ambient temperature was below 15 deg C, which is in accordance with the Northwest Territories Standard Operating Procedures[5] for handling and capture of bears (a reasonable standard). Using the helicopter, at a distance that would not cause high stress to the bear, we slowly moved the bear to suitable open terrain for darting and directed the bear uphill to slow them. Close, intense chase times were limited to less than 2 minutes in duration.

Once darted, we observed the bear from a distance, during the induction period, watching for the predictable changes observed with Zoletil immobilization. After the induction period, we assessed the depth of anesthetic remotely for reaction (i.e., with sound, calling the bear) and slowly approached the bear from behind, watching for movements of the head and ears and eye position. The bear was firmly prodded in the hind quarters to ensure a safe depth of anesthetic and then crews slowly moved around to the front of the animal. One crew member had a firearm for crew protection.

When it was determined that the bear was fully immobilized, crews approached the bear. After restraining the bear using hobbles and placing a blindfold over the eyes, we positioned the bear in a natural position, with the head and neck extended, and slightly elevated, to allow for unobstructed breathing. We fitted each bear with a Lotek™ Litetrack Iridium collar equipped with GPS and InSight video camera and an Advanced Telemetry Systems (ATS™) VHF ear tag transmitter. Biological samples (blood, hair, feces, tissue biopsy) and morphometric measurements (neck circumference and straight-line body length) were collected. During immobilization and processing, we monitored the bear, watching for signs of alertness including licking of lips and slight head movements. After processing, we left the bear in a natural position, safe from potential dangers such as water, cliffs, or steep slopes. We checked each immobilized bear the following day, either through remote monitoring of the GPS collar or by relocating the bear, to ensure the bear had fully recovered. Our capture and handling methods followed the recommended procedures by Canadian Association of Zoo and Wildlife Veterinarians (2009) and the Provincial Live Animal Capture and Handling Guidelines (BC MELP 1998).

Collar Programming and Data Analysis

The use of video collars to record and enumerate predation events by bears on ungulates has been used in Alaska (Brockman et al. 2017), Sweden (Egan 2019), and on polar bears in Alaska (Pagano et al. 2018). Using the successes and failures of these previous studies, as well as keeping our project objectives in mind, we programed the video camera-equipped GPS collars to record a 15-second-long video clip and a corresponding GPS location every 7-minutes. Video cameras were triggered by a light sensor, so videos were not recorded at night or at low-light levels. Video data was stored on the collar, which were to remain on the bear for approximately 12-16 weeks. We fitted each bear with a VHF ear tag and each collar was equipped with rot-off fabric attachments in the event of complete collar failure. The video collars were equipped with radio release drop-off mechanisms, which we released remotely in the field and immediately recovered.

[5] Northwest Territories Capture, Handling and Release of Bears Standard Operating Procedure: https://www.enr.gov.nt.ca/sites/enr/files/resources/bears_care_sop.pdf

When collars were recovered, we downloaded video and GPS location data and classified video clip data into activity classes (feeding, travelling, resting, alert, drinking, or pursuing). Feeding events were classified as either vegetation or mammal. Where discernable, we noted the plant species being foraged, and mammal prey items were identified to species using bone size and pelage colour and texture (Brockman et al. 2017). We classified and quantified each active predation event, as well as feeding on fresh or old carcasses (Brockman et al. 2017).

To describe the range overlap between bears and caribou during calving through the fall rut (Julian weeks 24-42; May 23rd to October 16th), we visually compared graphs of the average weekly elevation for all concurrently collared caribou locations and the 90th percentile of weekly location elevations for the two bears having collars that regularly obtained GPS fixes. We also compared spatial plots of one-third of the bear locations that were highest in elevation and all caribou locations. GPS fixes with an unreliable Dilution of Precision (DOP <3.0) were not used for either analysis.

RESULTS

Capture and Collaring

Over the course of 11 capture days, between May 5th and June 16th, we observed a total of 17 individual bears but not all in calving range (Table 1). Our first capture session on May 5th showed no sign of bear activity in the sub-alpine. The second capture session occurred May 14-16th and a total of nine bears were observed (including three <2-year-old bears); two of the nine bears were in calving range. We surveyed for bears concurrently during a caribou calf capture on May 28th but did not observe any bears. Three grizzly bears were observed during the fourth capture session (June 4-6th) and another five bears were observed during the final capture session (June 14-16th). We observed minimal sign of bear activity in the sub-alpine during the calving season this year. Where bear sign was evident, tracks showed these bears left dens and immediately moved to lower elevations, where new vegetation growth was occurring along roadsides and in cutblocks.

Between May 14th and June 15th, we captured five grizzly bears (Table 1, Figure 2). All immobilized bears were fitted with VHF ear tags and biological samples collected. Four of the five bears immobilized were fitted with collars, and one bear (captured in calving range) was too small for proper fit of a collar; however, a VHF ear tag was applied, and biological sampling was completed on this bear. Two of the collared bears were mature females and two were young (~4-5 years) males. One of the collared females had two one-year old cubs with her. An additional adult male bear was also darted; however, despite efforts to keep the bear in the open cutblock after darting, the bear went into dense pine regen adjacent to the cutblock prior to full immobilization. We deemed it unsafe to try to locate the bear in this habitat without confirmation of full immobilization.

Table 1. Capture events and bears observed between May 5-June 16, 2021, Klinse-Za Grizzly Bear Predation Project, 2021-22.

Date	Bears Observed	Bears Captured	General Habitat Description	Comments
May 5, 2021	None			
May 14, 2021	1 unclassified bear		Edge of cutblock	No suitable capture location
May 14, 2021	1 unclassified bear	1 young male	Sub-alpine	Two young bears; one immobilized but too small for collar
	1 female with 1 one-year old cub		Steep, north aspect slope in McAllister burn	Not enough daylight remaining for capture
May 16, 2021	1 female with 2 one-year old cubs		Edge of cutblock	No suitable capture location
	1 unclassified bear		Cutblock Road	No suitable capture location
June 4, 2021	1 adult male		Cutblock/pine regen	Darted, immobilization not confirmed, no collar applied
June 5, 2021		1 adult female	Cutblock	
June 6, 2021		1 sub-adult male	Cutblock	
June 14, 2021		1 sub-adult male	Sub-alpine	
June 15, 2021	1 adult female with 1 unclassified bear			In Bocock Park – we were not permitted to capture in a Park.
		1 adult female		With 2 one-year old cubs
June 16, 2021	1 adult male	None	Cutblock Road	No suitable capture location
Total Bears	**12**	**5**		

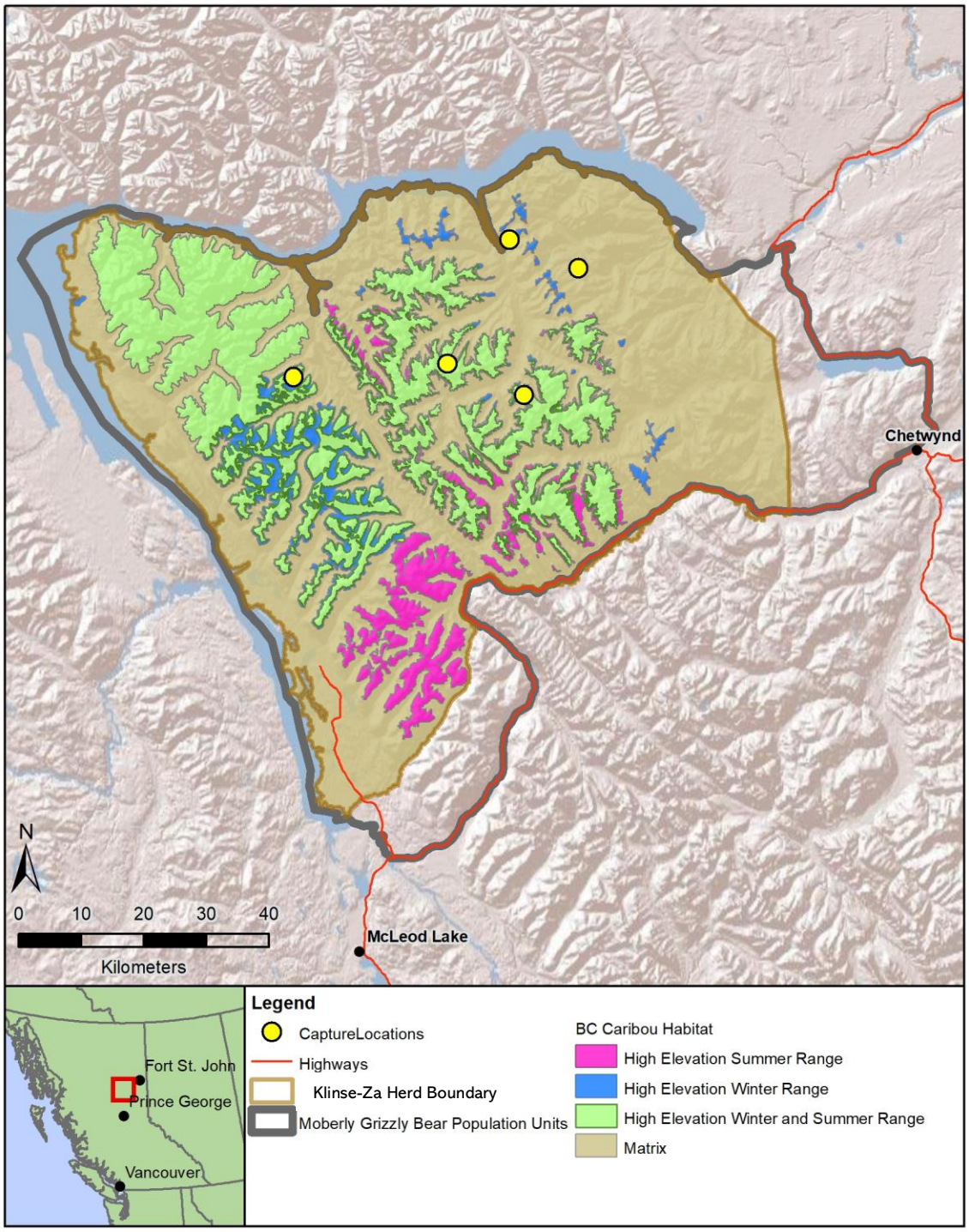

Figure 2. Capture locations of five grizzly bears, Klinse-Za Grizzly Bear Predation Project, 2021-22.

Unfortunately, a high rate of collar failure was experienced during the feasibility study and video cameras failed well before the 12-week video capture capability of the unit (Table 2). Of the four collars deployed, one collar (Monach male, captured in the sub-alpine adjacent to calving caribou) completely failed <1-day after deployment (no GPS data or video data collected). One collar failed to collect GPS data one-day post-capture and only recorded videos as per the set schedule for 11 days before it failed (Carbon female). The Rochfort male's collar collected GPS data for the duration of deployment (June to October) but only collected video data for a nine-day period following deployment. Similarly, the Clearwater female's collar collected GPS location data for the duration of collar deployment (June to October) but only collected video data for six days post-deployment (Table 2).

Table 2. Summary of GPS and video data collection for four grizzly bears collared in the Klinse-Za caribou herd, Klinse-Za Grizzly Bear Predation Project, 2021-22.

			GPS data		Video data	
Bear ID	**Collar Deployment**	**Collar Retrieval**	**Successful Collection Period**	**# of days**	**Successful Collection Period**	**# of days**
Carbon Female	June 5	August 11	June 5-6	1	June 5-16	12
Rochfort Male	June 6	October 7	June 6-October 7	123	June 7-15	9
Monach Male	June 14	September 3	Failed	0	Failed	0
Clearwater Female	June 15	October 11	June 15-October 11	128	June 15-20	6
Total Days of Successful Data Collection				**252**		**27**

Activity Budgets

A total of 282 minutes of video was recorded over 27 days of fully functioning video cameras. After removing videos recorded during bear capture/processing and videos <5 seconds long, a total of 265 mins was recorded. Approximately 36% (95 mins) of the videos recorded indicated resting activity, where the bear was asleep or laying down (Table 3). Travelling (23%), feeding (18%), and alert (16%; e.g., standing, looking around) activities were the next most common activities recorded. Of the approximately 48 mins of feeding activity recorded, 40.5 mins were feeding on vegetation. Approximately 5.3 mins of feeding on ungulates was captured and 1.5 mins of feeding on either a black bear or a moose. Vegetation species foraged upon was largely undiscernible (~50% of feeding events); however, where detectable, the most common vegetation species identified during feeding events were clover (*Trifolium* sp.), grass, dandelion (*Taraxacum* sp.), horsetail (*Equisetum* sp.) and cow parsnip (*Heracleum maximum*). Approximately 40% of feeding on vegetation occurred along linear features (roads, cutblock roads) and ~18% in cutblocks. The Clearwater female spent a lot of time feeding on new vegetation growth in and around avalanche shoots (Photo 1).

Table 3. Summary of bear activity data from video collars on three grizzly bears in the Klinse-Za caribou herd area, Klinse-Za Grizzly Bear Predation Project, 2021-22.

	Time (mins)			
Activity	**Carbon Female**	**Rochfort Male**	**Monach Male[1]**	**Clearwater Female**
Alert	25.2	10	-	8.3
Drinking	0.5	1	-	0.6
Feeding	28.5	13.4	-	6.5
Fleeing	0.3	-	-	-
Pursuit	0.5	-	-	-
Resting	62.4	15.2	-	18.1
Rolling/Scratching	-	0.3	-	-
Sniffing	0.5	2.3	-	-
Swimming	-	0.5	-	-
Travelling	33.2	19.5	-	8.6
Unknown	5.7	2.5	-	1.2
Vocalizing	-	-	-	0.3
Total	**157.0**	**64.7**	**0**	**43.6**

[1] Complete camera failure.

Predation Events

Feeding on large mammals accounted for 6.3 minutes of video footage. Over a collective period of 25 days (where cameras functioned as programmed), three bears killed and consumed six large-mammal prey items, for an average kill rate of 0.2 large-mammal kills/day (0-0.3). Over nine days of video collection, the Rochfort male killed three separate prey items (0.3 kills/day). Based on hair colour and texture of the prey item, as well as relative bone size, one of the feeding events was likely an elk, one was a deer or caribou (tan and white hide, smaller bone size; Photo 2), and one was likely a moose (dark hair and size of bone). The Carbon female consumed three separate prey items over 10 days of video collection (0.3 kills/day). The first predation event shows a pursuit through a cutblock, followed by feeding on either a moose or a bear (fineness of the fur suggested bear but we cannot deny that it could also be a moose). The second predation event occurred two days later. The pursuit was not captured on video but the killing of either a moose or elk calf was recorded (crying of the calf could be heard). Subsequent videos of feeding on this prey item were recorded for 24 hrs post-predation. Based on video evidence of this prey (i.e., bone size) and the duration of time spent feeding on the prey (>24 hours), we suspect that the bear killed the calf and likely the accompanying adult (Photo 3). The third predation event by this bear was presumed to be on an ungulate (Photo 4); however, due to malfunctioning of the collar, few videos

were captured before or after the feeding event was recorded. Over a six-day video-collection period, there was no evidence of predation events or feeding on large mammals by the Clearwater female or her two 1-year-old cubs (0 kills/day).

Photo 1. Clearwater female feeding on new vegetation growth in an avalanche shoot adjacent to calving range, Klinse-Za Grizzly Bear Predation Project, 2021-22.

Range Overlap

Two of the collared bears were captured in calving range (Clearwater female and Monach male) and two were captured in low-elevation cutblocks adjacent to high-elevation winter and summer range (Carbon female and Rochfort male; Figure 2).

Using the limited video footage recorded in June, the Carbon female appeared to utilize low-elevation habitat outside calving range including cutblocks and burned areas. However, due to the malfunctioning of the GPS collar shortly after deployment and camera failure by the end of June, we do not have video or GPS data to determine if she used high-elevation caribou range beyond June 30th.

Photo 2. Rochfort male feeding on a mammalian prey (second prey feeding event), June 10, Klinse-Za Grizzly Bear Predation Project, 2021-22.

Photo 3. Section of bone from a large mammal being consumed by the Carbon female (second prey feeding event), June 14, Klinse-Za Grizzly Bear Predation Project, 2021-22.

Photo 4. Carbon female feeding on a large mammal (third prey feeding event), June 30, Klinse-Za Grizzly Bear Predation Project, 2021-22.

The Rochfort male, caught outside calving range, utilized low-elevation habitats east of Carbon Creek and swam across the Carbon Creek inlet, moving into caribou winter, calving, and summer range on Rochfort Mtn. (Figure 3). Assessing the 90th percentile of weekly bear locations, the Rochfort male spent time at or above the average elevation of caribou during calving through the fall rut (Figure 4, Figure 5). The Rochfort male's recorded predation events occurred in low-elevation habitat and, unfortunately, the video collar failed shortly after he arrived in the sub-alpine and therefore any predation events at higher elevations were not captured.

The Clearwater female was caught in high-elevation calving range and post-capture she and her two one-year-old cubs primarily utilized avalanche shoots and riparian areas for foraging on new, green vegetation growth and resting in mid-elevation mature forest. Throughout collar deployment, the female made multiple east-west movements across the Clearwater River, using both high-elevation calving and summer range and low-elevation cutblocks and riparian areas (Figure 6). Like the Rochfort male, the Clearwater female spent time overlapping with, or above, the average weekly elevation of caribou, however, this was more pronounced later in the season (mid-August onwards; Figure 4, Figure 5). In mid-October, when her collar was dropped, the Clearwater female and her two one-year-old cubs had been actively using a potential den site in calving range, located approximately 4 km from her Spring 2021 capture site.

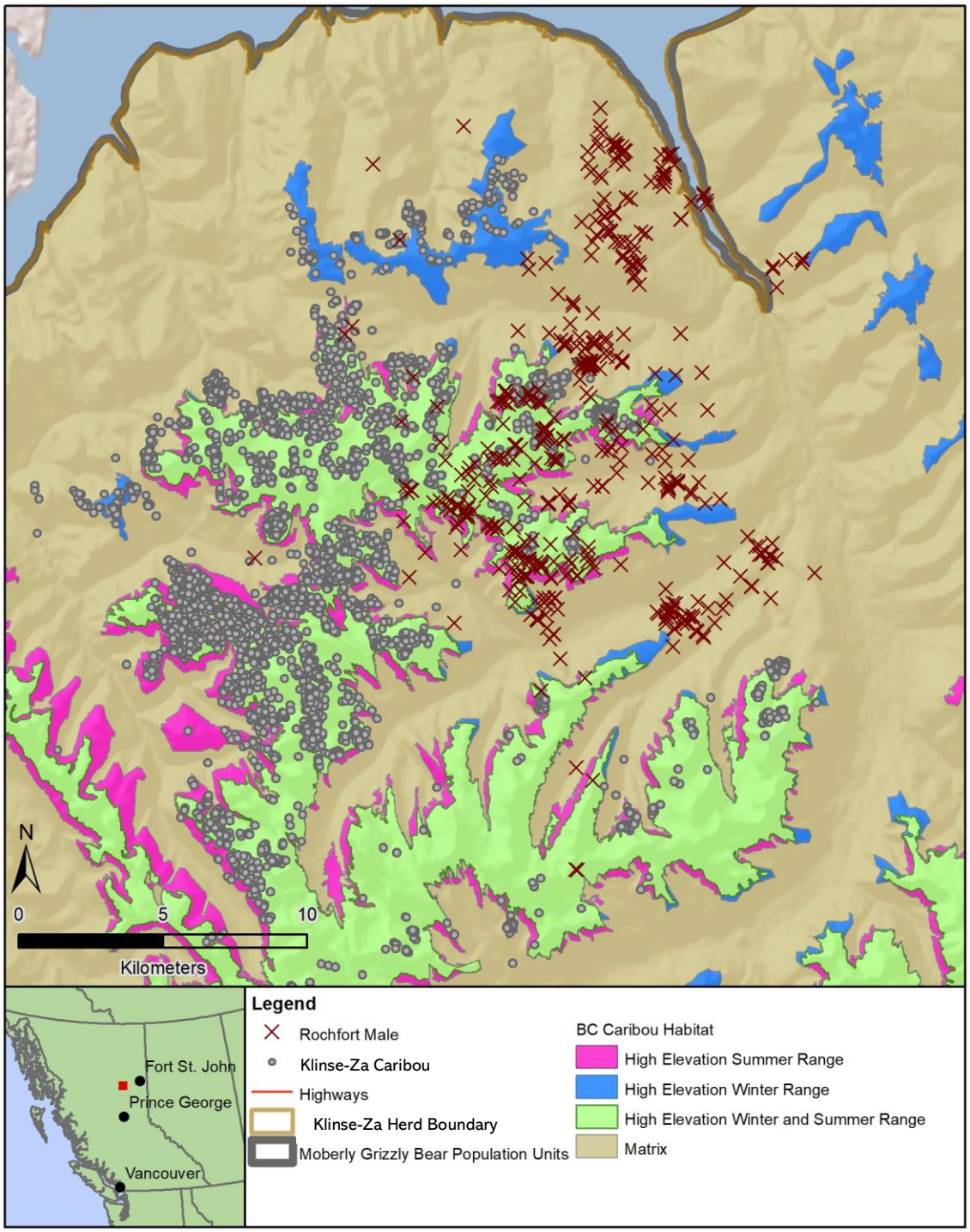

Figure 3. Locations of the collared Rochfort male during collar deployment (June 6-October 7, 2021), Klinse-Za Grizzly Bear Predation Project, 2021-22.

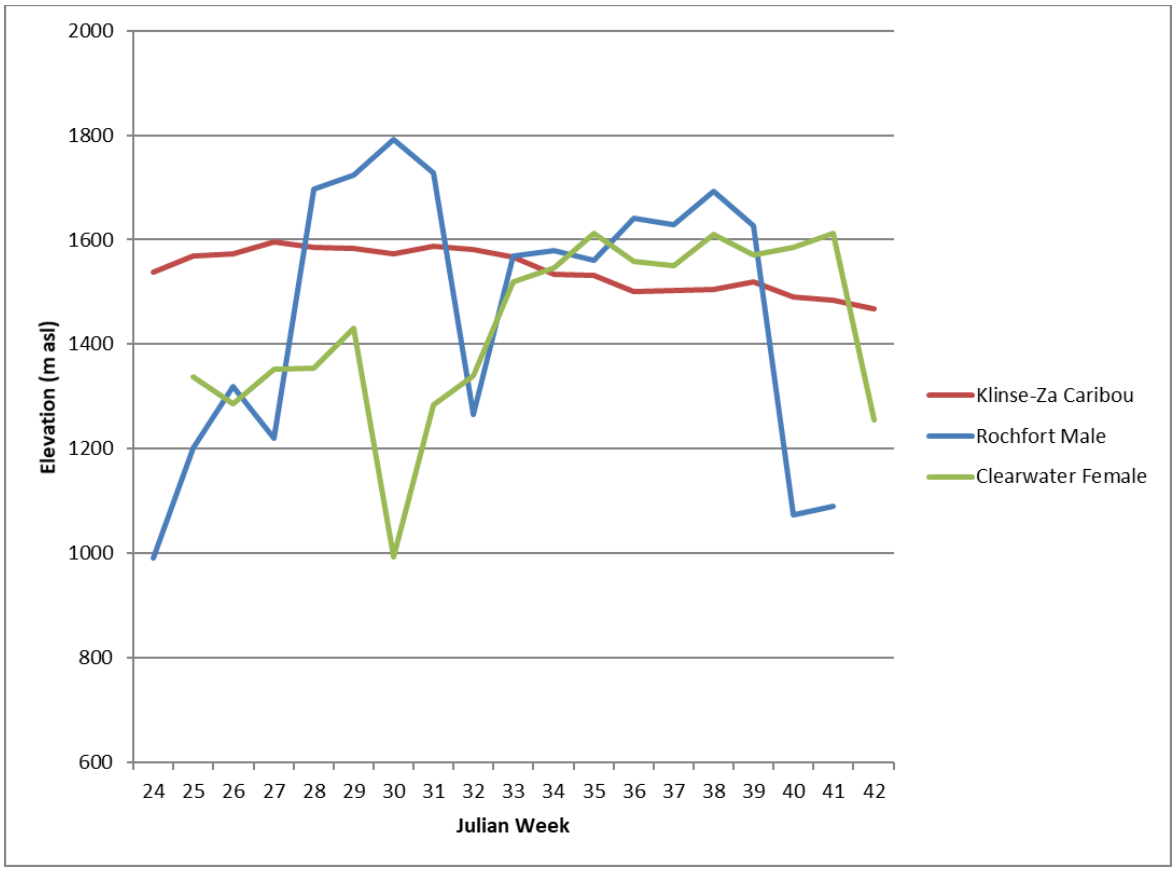

Figure 4. Average weekly elevation for all Klinse-Za caribou locations and the 90th percentile of weekly location elevations for the two bears having collars that regularly obtained GPS fixes, Klinse-Za Grizzly Bear Predation Project, 2021-22.

DISCUSSION

Due to an unseasonably late spring and a higher-than-average snow load in 2021, in contrast to other years with less snow, fewer bears were initially observed in calving range. During parturition and early in the neonatal period (mid-May), many bears observed were in low-elevation habitats, specifically in cutblocks and along linear corridors, where new vegetation growth was available as forage. However, later in the neonatal period (mid-June), when snow loads had receded to what would have been expected in mid-May, we observed that bears began to move to calving range and were available for capture. As a result, two of the five bears were captured in calving range at the end of our capture period.

Our surveys and capture efforts prior to and during the calving period showed a periodic use of the sub-alpine and alpine by grizzly bears during this time. However, over the past eight years of monitoring collared caribou, completing calf recruitment surveys, and conducting pellet collection during the calving period, we believe grizzly bears are pursuing caribou during the calving season and are contributing to the low free ranging

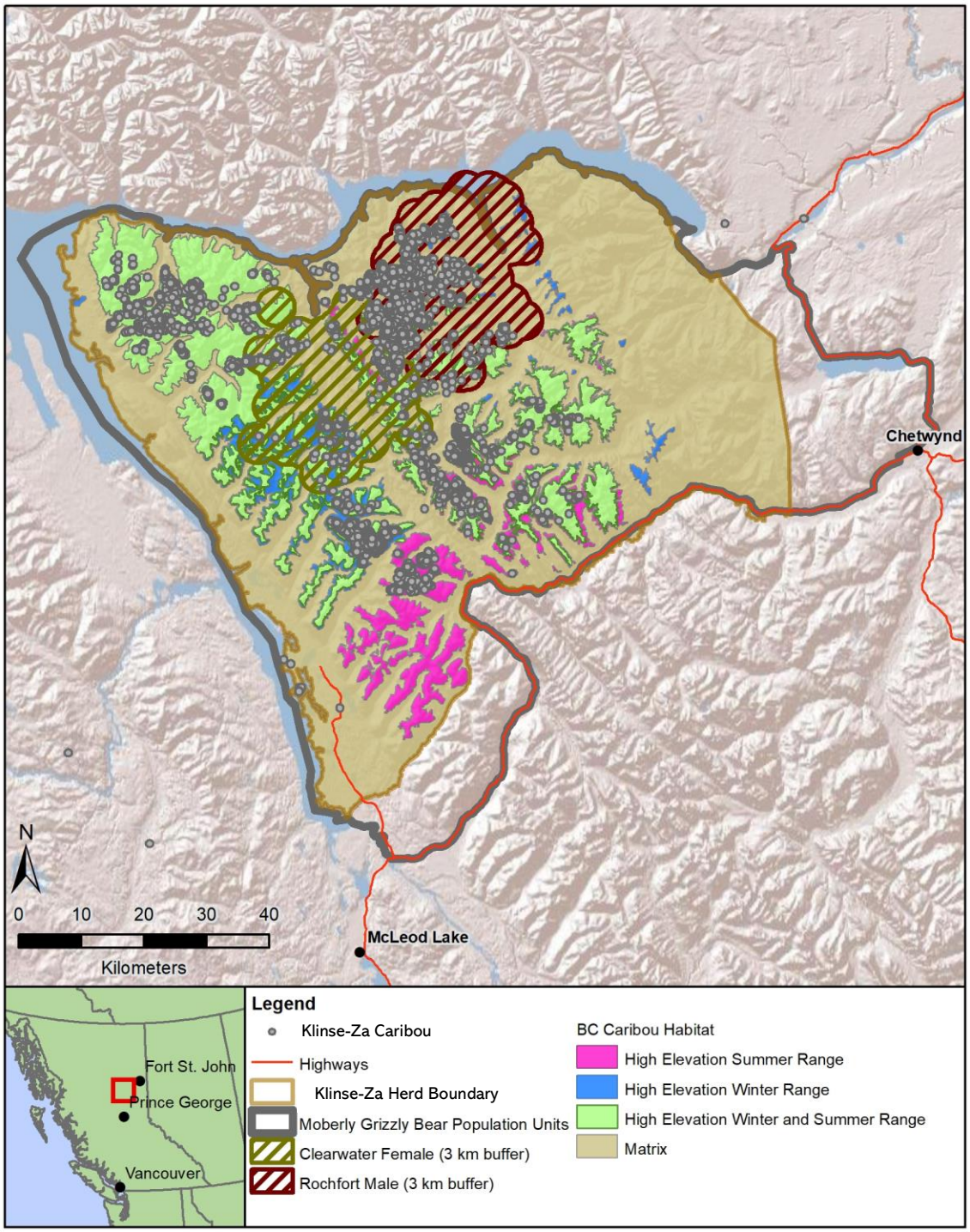

Figure 5. Overlap of caribou and grizzly ranges, using buffered (3 km) grizzly bear GPS locations and collared caribou locations collected over the same period (May 23rd to October 16th), Klinse-Za Grizzly Bear Predation Project, 2021-22.

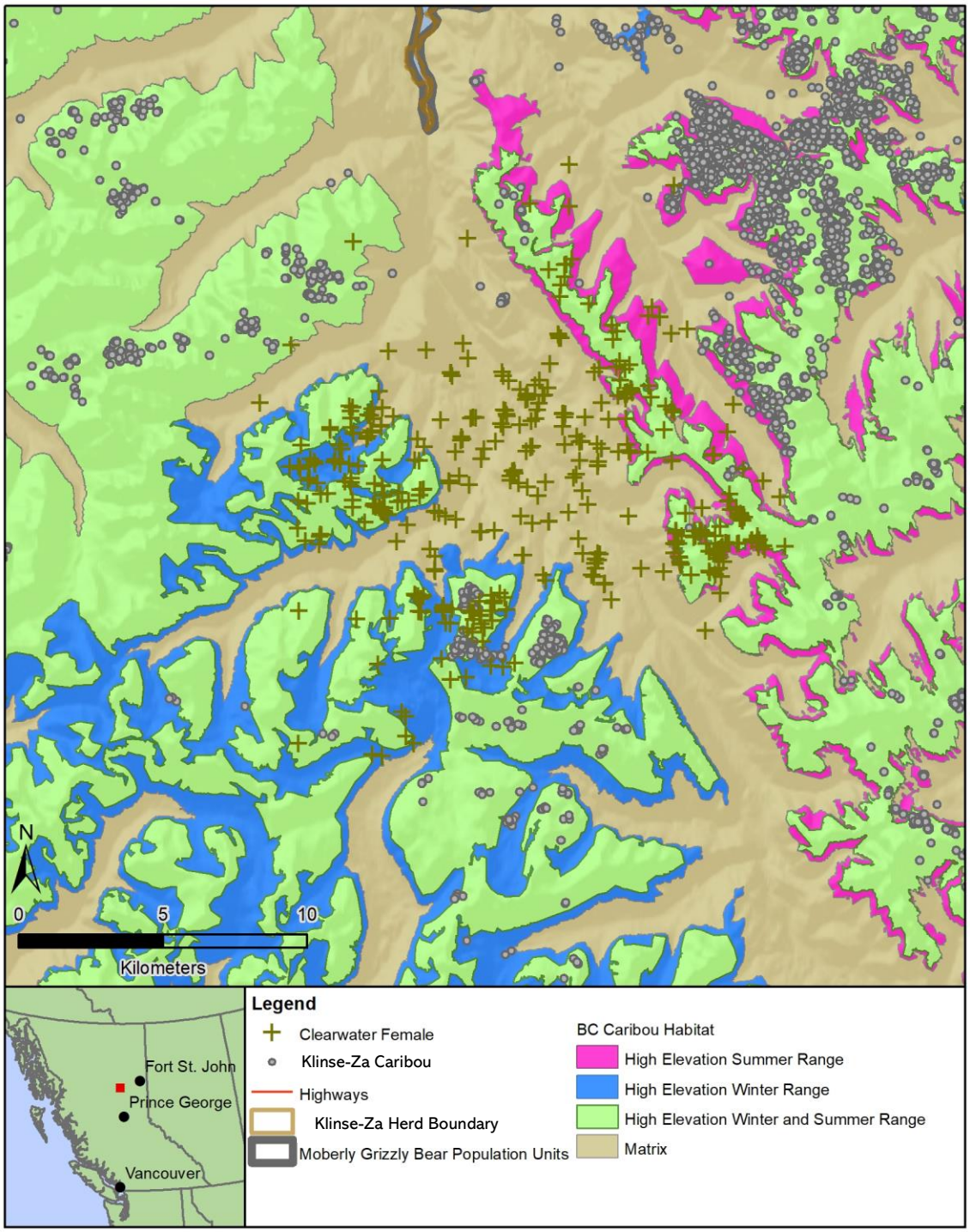

Figure 6. Locations of the collared Clearwater female during collar deployment (June 15-October 11, 2021), Klinse-Za Grizzly Bear Predation Project, 2021-22.

calf survival in the Klinse-Za herd[6] (McNay et al. 2021, Unpublished data, Wildlife Infometrics Inc.); this, however, may be dependent on annual variation in snow conditions and may be more opportunistic in nature. Increasing our sample size of collared bears during the calving season would further inform the degree of predation during parturition and the neonatal period and help us identify if pursuit of caribou during this time is targeted or opportunistic, as even opportunistic predation events have a significant impact on a small, recovering population such as the Klinse-Za caribou herd.

Unfortunately, due to a high collar failure rate, we were only able to collect video footage from three bears between June 5-June 20, for a total collection period of 25 days. During the period when the three collars performed well, collared bears in the Klinse-Za spent the majority of their time resting, travelling, and feeding, which was similar to that reported by Brockman et al. (2017) for seven collared brown bears in Alaska. Of the time spent feeding, greater than 50% was spent feeding on vegetation, which is comparable to that reported by Egan (2019) in Sweden. Conversely, Brockman et al. (2017) found that feeding on vegetation included only 18% of recorded feeding time.

Identifying large-mammal prey species was difficult because of the angle of the camera (camera was often obstructed by the chin and neck of the bear) and poor video quality (blurriness, obstructions). Predation events (actual killing of the prey) was recorded on one video (crying of a calf) and one pursuit was recorded but the prey was not visible. Based on the colour of the blood and tissue, and often blood dripping from the bear's chin, all feeding events on mammals appeared to be predation events, and not scavenging events.

The camera's schedule of capturing 15 second clips every seven minutes was an appropriate length of time to assess bear activity, where five- to 10-second-long video clips would have been too short and made it more difficult to make inferences of bear activity and identify predation events. We were surprised that pursuits/chases of prey were not captured more, as the video worked well when bears were travelling and their heads were up. This may be indicative, however, of relatively quick pursuit and chase times (<7 minutes), which would have been missed given the video capture interval.

Insufficient confirming evidence from video data, resulting from only half of our deployment objective being met and malfunctioning collars, meant we were unable to determine whether bears were actively pursuing caribou. This was further compounded due to the late spring season and bears not moving into calving season until later in the neonatal period. Three of the collared bears spent time in calving range during the neonatal period, however, at this point, cameras had malfunctioned, and we did not collect video evidence while bears were in calving range. Further, we speculate that variation in annual weather conditions may influence the source of predation on caribou calves, as this year wolverines seemed to be the primary source of predation (McNay et al., in prep).

Large-mammal kill rates of the collared Klinse-Za bears (2 kills/bear, n = 3 bears) was higher than that reported in Alaska (1.4 adult ungulate kills/bear, n = 7 bears; Brockman

[6] In 2020, a caribou calf was presumed to be lost to a grizzly bear that was observed at the calving location (McNay et al. 2021). In 2019, a grizzly bear was observed within 400 m of a group of caribou during calving (Unpublished Data, Wildlife Infometrics Inc.). Over the course of the Klinse-Za Caribou Health project, during spring pellet collection periods, grizzly bear tracks were often seen following caribou tracks during the calving period (Unpublished Data, Wildlife Infometrics Inc.).

et al. 2017). Overall, Klinse-Za bears had an average large-mammal kill rate of 0.24 large-mammal kills/bear/day, nearly four times greater than bears monitored in Alaska (0.06 adult ungulate kills/bear/day; Brockman et al. 2017) and six times greater than collared bears in another Alaskan study (0.04 adult moose or caribou kills/bear/day; Boertje et al. 1988). Removing the predation event on a potential black bear and only considering the calf and cow predation as one predation event, the Klinse-Za bear kill rate on adult ungulates (0.12 kills/bear/day) was still double that measured in Alaska.

Although we did not capture evidence of adult or calf caribou predation events by our collared bears in the Klinse-Za herd, our limited sample still shows a high rate of predation on adult ungulates during the neonatal period, similar to that observed by Boertje et al. (1988), where predation rates of grizzly bears was greatest during the neonatal period in Alaska. The risk of predation to Klinse-Za caribou may have increased as bears moved into caribou calving range later in the neonatal period. Caribou calf mortality was high in the Klinse-Za herd in 2021, with nine of 12 calves dying during the neonatal period. Five of these deaths were of unknown or unconfirmed causes. These five deaths could be attributed to grizzly bear predation, as predation and consumption of neonatal calves by grizzly bears are generally quick events (ranging from <12 hrs to 36 hours; Boertje et al. 1988, Ballard et al. 1990), which could preclude us from confirming predation by grizzly bear.

Of the two bears that had functioning GPS collars throughout collar deployment, neither bear showed an obvious elevational progression of movement into high-elevation caribou habitats as the season progressed (and snow retreated) but rather made occasional movements into caribou range during calving and through to the fall rut period (Figure 4). Although less than 10% of the bears' locations were at elevations overlapping with high-elevation caribou range, this overlap still presents the opportunity for grizzly bears to predate caribou calves. Although a predation event on a single caribou or caribou calf may be a negligible component of a bears' seasonal diet or range occupancy, for a recovering caribou population the overlap of ranges and the potential for a predation event has significant impacts on calf recruitment and population recovery. In grizzly bear populations in southeastern BC, McLellan and Hovey (2001) observed two habitat selection strategies that included mountain-resident bears and bears that made elevational migrations. This aligned with our original theory: bears that denned in the sub-alpine would remain in high-elevations (overlapping with caribou during the neonatal period) and feed on caribou neonates before moving down in elevation to alternative food sources; thereby having an impact on calf survival. However, based on our observations from the two bears collared in the Klinse-Za, we believe that the risk of predation by grizzly bears on caribou is not necessarily linked to mountain-dwelling bears; but rather the proximity of bears to caribou range and the ability of bears to access caribou range, which presents the opportunity for predation. Given the large home ranges of grizzly bears (100 to 1,300 km2; Mace and Waller 1997, Graham and Stenhouse 2014), the availability of linear corridors connecting low- to high-elevations in the Klinse-Za herd (Woods et al. 2021), and the known use of linear corridors by bears

in the Klinse-Za[7] (Woods et al. 2020, Woods et al. 2021) and elsewhere (Dickie et al. 2019), we feel the risk of predation by grizzly bears cannot be limited to bears occupying calving range.

Wolf reduction programs in the Klinse-Za caribou herd, and Quintette caribou herd, have maintained wolf populations at approximately 25% of pre-reduction population size (Bridger 2019). Although we did not record evidence of bear predation on caribou, the reduced wolf populations in the Klinse-Za herd may be creating opportunities for greater predation on caribou by grizzly bear, resulting from fewer predation events by wolves through compensatory predation (Gasaway et al. 1992). Boertje et al. (1988) observed approximately 3% of grizzly bear consumption of adult moose was a result of scavenging on wolf kills, and that the higher rate of carcass consumption may have been related to higher grizzly bear (16 grizzly bears/100 km^2) than wolf densities (5 wolves/1000 km^2; Boertje et al. 1987, as cited in Boertje et al. 1988). In the Klinse-Za, with the reduction of wolf kills available to grizzly bears to scavenge, bears may be increasing their consumption of adult ungulates through direct predation. Further evidence of compensatory predation is observed in the Klinse-Za caribou herd area as moose calf recruitment was found to be low concurrently with low caribou calf recruitment and during the wolf reduction program (Sittler 2020, M. Bridger, pers. comm.[8]). Sittler (2020) also found more bear predation on adult moose in our study area compared to an adjacent area where wolvers were not being removed. In multi-predator ecosystems, compensatory mortality has shown to increase as more predator species are present (Griffin et al. 2011). In a predator-prey system where both wolves and bears are present, predation by bears was the most important source of predation on neonate elk calves and this mortality was greatest in the first 30 days post-parturition (Griffin et al. 2011). This may apply to the Klinze-Za, which is a multi-predator ecosystem including populations of grizzly and black bears, cougar, wolverine, coyote, lynx, and wolves – all of which have been detected in or adjacent to caribou calving range (Woods et al. 2021).

CONCLUSION & RECOMMENDATIONS

An unseasonably late spring and high collar failure precluded our ability to fully assess the feasibility of conducting a full study to quantify grizzly bear predation on caribou calves in the Klinse-Za herd. However, we can confirm there are as many, or even more, bears (17 individual bears observed over 9 survey days) as we predicted (10-15 bears) to facilitate our capture and collaring objectives, had weather conditions been different. We would have reached our goal of capture and collaring 10 grizzly bears if our collaring schedule was better aligned with the current year's weather conditions and/or if we had more budget.

[7] Throughout collar deployment, both the Rochfort male and Clearwater female made use of linear corridors that are proposed for restoration. Specifically, the Rochfort male foraged and travelled along cutblock access and inblock roads in the 7-Mile and 10-Mile Road areas, adjacent to the Rochfort maternity pen, and the Clearwater female used the 4000 Road in the Clearwater valley. Functional habitat restoration of the 4000 Road completed this past fall (Woods et al. in prep) and proposed restoration of linear corridors in the 7-Mile and 10-Mile areas over the next few years (Woods et al. 2021) may decrease the use of these corridors by grizzly bears, impacting their access to caribou range.

[8] Mike Bridger, Wildlife Biologist, Ministry of Forests, Lands, Natural Resource Operations and Rural Development. Unpublished results, January 2022.

Although the technology of video camera-equipped wildlife collars has advanced since Brockman et al. (2017), we had poor reliability and success with the Lotek™ Litetrack Iridium GPS collars and InSight video camera. Deployed and undeployed collars have been sent back to Lotek for inspection to determine the cause of such high failure rate. The effectiveness of the collars to detect predation events was confounded by our poor sample size that resulted from high collar failure. In the predation events that were documented, it was difficult to identify prey items to species due to obstructions to the camera, poor video quality, and a narrow field of view. We recommend that changes to the collar design should be made to improve video quality and identification of prey species including: a) use of a wide-angled or fish-eye lens and b) angle the camera downwards to reduce obstruction of the camera from the bear's chin and neck, to enable a clearer view of the prey item below.

Due to collar failure and a delay in bears moving into calving range, our results are inconclusive to be able to assess whether bears are pursuing caribou during the calving season and to what extent grizzly bear predation on caribou is contributing to low calf survival in the free-ranging Klinse-Za herd. To properly address both these objectives, we would need replicate years of sampling (to account for seasonal variation in snow conditions during calving) and more reliable collars with improved video quality. To investigate reasons for the disparity in calf survival between the free-ranging Klinse-Za herd and the Quintette herds, we would need to conduct replicate sampling in the Quintette herd as well, which may reveal additional information on the unsustainable levels of calf survival the Klinse-Za herd.

Although the data we collected during this feasibility study was limited to only three bears over a short period of time at the end of the neonatal period, a high rate of predation on adult ungulates may have implications for caribou recovery efforts in the Klinse-Za herd. If bears require, and are consuming, a significant biomass of ungulates during the neonatal period, this predation effort may occur on caribou (adults and/or calves) in years where snow loads are reduced, and bears remain in calving range after den emergence. Additionally, given the consumption of large biomass prey during the neonatal periods of other ungulates (moose, elk, and deer), predation by grizzly bears on young of these species may also have implications for alternative prey management and the role that plays in caribou recovery efforts. Information gained from this feasibility study suggests that further work is required to address the role of grizzly bear predation on caribou calf survival in the Klinse-Za herd.

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APPENDIX A. EXAMPLE PHOTOS CAPTURED FROM VIDEO COLLARS

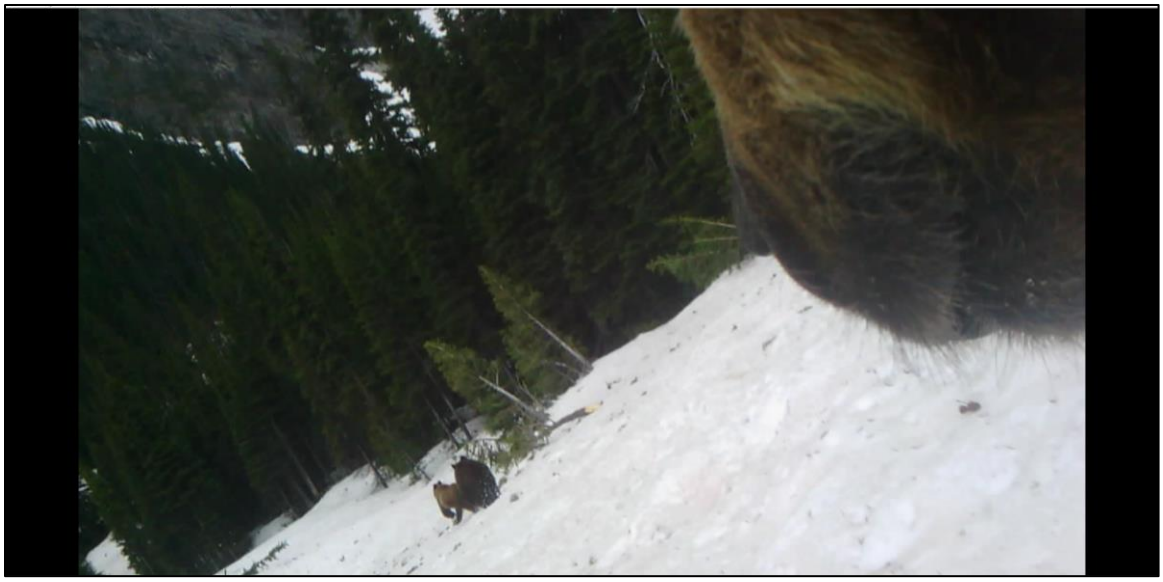

Photo 5. Clearwater female and two 1-year old cubs in an avalanche shoot, June 16, Klinse-Za Grizzly Bear Predation Project, 2021-22.

Photo 6. Photo capture of one of the Clearwater female's 1-year old cubs foraging in dense shrubs, June 17, Klinse-Za Grizzly Bear Predation Project, 2021-22.

Photo 7. Photo capture of the Clearwater female foraging on dandelion, June 18, Klinse-Za Grizzly Bear Predation Project, 2021-22.