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Review of factors in public and agency predator control for Mulchatna caribou, 2012–2023

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Alaska Department of Fish and Game Division of Wildlife Conservation

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Review of factors in public and agency predator control for Mulchatna caribou, 2012–2023

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Abstract

We reviewed factors that were considered in the decision for agency staff to conduct lethal reduction of 3 predator species on the calving grounds of the Mulchatna caribou herd (MCH) in spring 2023. Historical abundance of MCH is hard to understand because of limited data and changes in survey techniques before the 1980s. The herd had peaked at approximately 200,000 caribou in the mid-1990s and declined to approximately 30,000 by 2009, with a second decline to approximately 13,000 caribou by 2019. Due to low abundance, hunting has been closed since fall 2021. Poor nutritional condition of caribou from food competition and heavy range use as the herd reached its peak abundance in the 1990s was the likely driver of rapid population decline into the early 2000s. Public wolf control during 2011–2022 was likely of ineffective magnitude, frequency (successive years), and spatial concentration to improve calf survival. Preliminary research findings on calf survival from birth to 2-months old found overall bear predation twice as common as wolf predation and suggested that bear predation was increasing on the western MCH group after it had shifted its calving range in the mid-2010s, when minimum counts of the western group and its fall calf-to-cow ratio began declining. Abundance estimates and incidental observations in nearby areas suggest that brown bear abundance may have increased over the last 2 decades near the present calving area of the western group. The estimated birth rate of 3-year-old female caribou increased as MCH initially declined from peak abundance and has remained moderately high, but recent research suggests suboptimal nutrition that has potential to reduce calf fitness and could slow caribou population response to reduced predation. An increased exposure to brucellosis has occurred in MCH since at least 2015 with implications for reduced fitness of both sexes; how long the disease incidence may persist and its effect on herd growth is uncertain. Unreported harvest and wounding loss complicate historical assessments of herd dynamics and present management.

Key words: Black bear, brown bear, brucellosis, density dependence, hunting, nutrition, wolf.

Introduction

In May and June 2023 staff from the Alaska Department of Fish and Game (department) conducted lethal removal of 94 brown bears, 5 black bears, and 5 wolves from the calving grounds of the western group of caribou presently considered part of the Mulchatna caribou herd (MCH; Fig. 1) as part of an intensive management (IM) program. The rationale and plan for the agency predator control options during 2023–2028 are described in a February 2023 IM Operational Plan (ADF&G 2023a) that was referenced in the March 2023 Alaska Board of Game meeting.

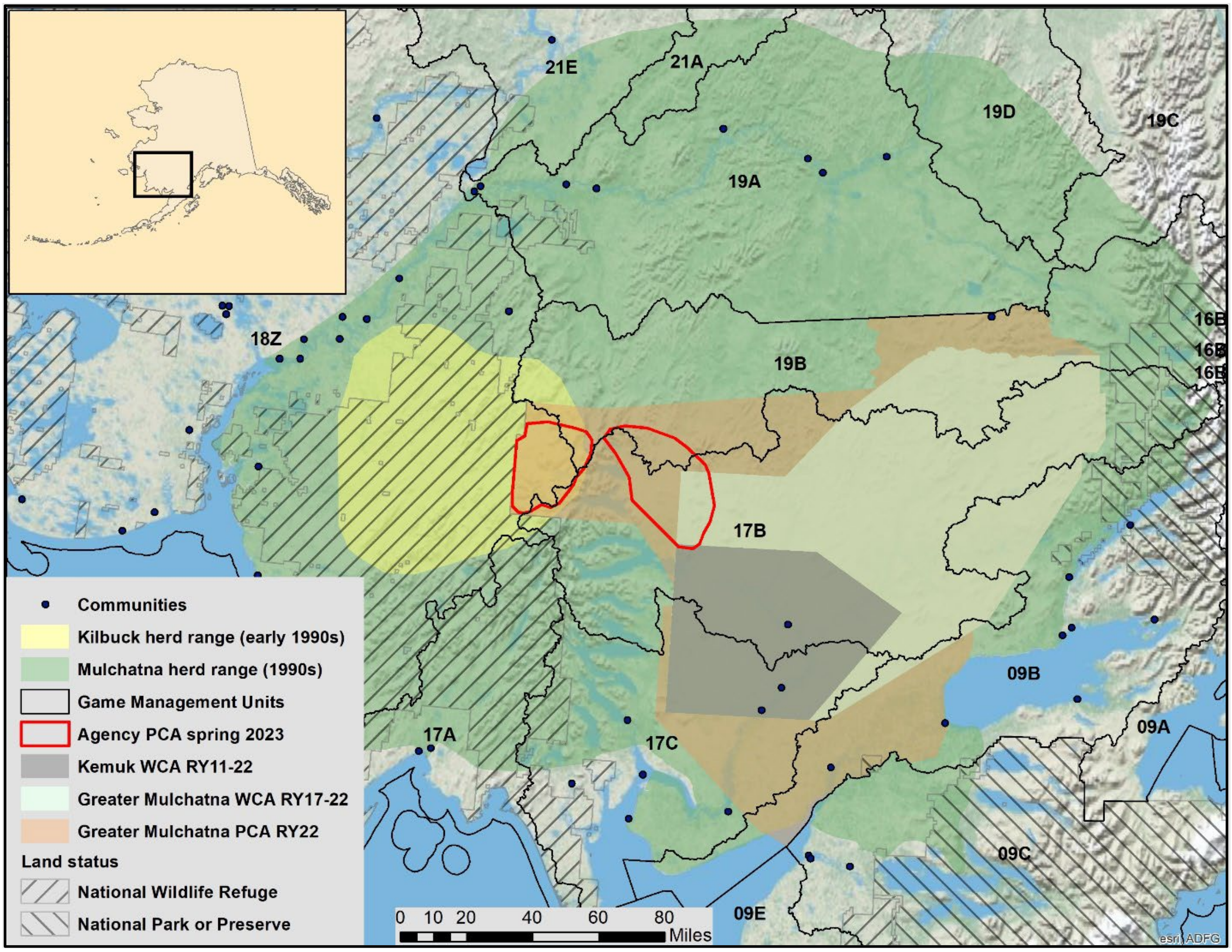

Figure 1. Community locations, periods of activity for areas of wolf control (WCA) or wolf and bear control (PCA), caribou herd ranges, and federal conservation areas relevant to intensive management of the Mulchatna caribou herd. A regulatory year (RY) begins 1 July and ends 30 June (e.g., RY22 = 1 July 2022 to 30 June 2023).

Predator management is controversial and generates substantial public debate. For this report, we (the authors) reviewed the scientific information and context for predator management that was considered by the department and the Alaska Board of Game (board) in the 2023 effort towards recovery of MCH from low abundance. In addition, some topics below address perceptions expressed through public comment or stories portrayed in the media. We included some figures from a staff report (ADF&G 2022a) on preliminary research, a Dillingham area overview (ADF&G 2022b), supplemental information from the acting area wildlife manager (ADF&G 2022c), and Proposal 21 (ADF&G 2022d) that was submitted to the board in January 2022 (image numbers referenced in online versions sometimes differ from higher resolution images used in this report). We also briefly describe the brown bear removal for context of magnitude and scale of estimated reduction. More program data exists in the most recent annual IM report for MCH (ADF&G 2023b). Note that biological data are often more relevant to show in calendar years for the birth estimates, postcalving counts, and fall composition surveys that pertain to cohorts, but span regulatory years, which pertain to harvest of prey and predators from fall through spring.

Background to actions taken in 2023

MCH grew rapidly in the 1980s and early 1990s to a peak abundance of approximately 200,000 caribou in 1996. After 1996, the herd rapidly decreased in size, which was likely due to overgrazing and poor nutritional condition (low birth rate), not overharvest (reviewed in Section 6). During the increase to peak abundance, the calving range shifted geographically (Woolington 1999), plausibly in response to heavy range use. MCH then declined to an initial low of approximately 30,000 caribou in 2009, a size the herd maintained for several years until a recent decline to approximately 13,000 caribou by 2019.

By the early 2000s the declining MCH began aggregating in 2 geographically distinct groups that remain today: 1) a western group in the Wood-Tikchik mountains area with a winter range in Unit 18 (previously used by the Kilbuck caribou herd; Fig. 1), and 2) an eastern group that uses an area across the middle Mulchatna drainage and a winter range in the lower Nushagak and Kvichak drainages (Fig. 2).

Initially, IM population objectives were set by the Alaska Board of Game in 2001 at 80,000–150,000 Mulchatna caribou, based on information provided by the department using criteria in 5 AAC 92.106 and input from the public. The board revised the IM objectives in 2009 to 30,000–80,000 caribou based on a proposal from the department. The initial IM plan in 2011 (5 AAC 92.125(o), Register 198) described biological and management factors, including research from 2 smaller herds on the Alaska Peninsula. This research indicated that wolves were a major predator of caribou calves in southwest Alaska despite high densities of brown bears (Sellers et al. 2003).

Valkenburg et al. (2016:211) summarized the history of MCH through 2008:

> The Mulchatna herd grew at the highest sustained rate of increase (about 17% annually during 1981–1996) of any herd in Alaska during the last 50+ years. The herd numbered about 190,000 caribou at its peak ([Valkenburg et al. 2016:] Fig. 12, Appendix A). Its subsequent decline was equally impressive, and it was down to 20,000 by 2008. The limited data on nutritional condition that we collected during the 1990s indicated that its 1990s peak herd size was unsustainable. The herd had access to extensive winter ranges with abundant lichens, but in many of these areas casual observations indicate that lichens were noticeably depleted by the late 1990s. Further, there is evidence that the summer range was probably also overgrazed.

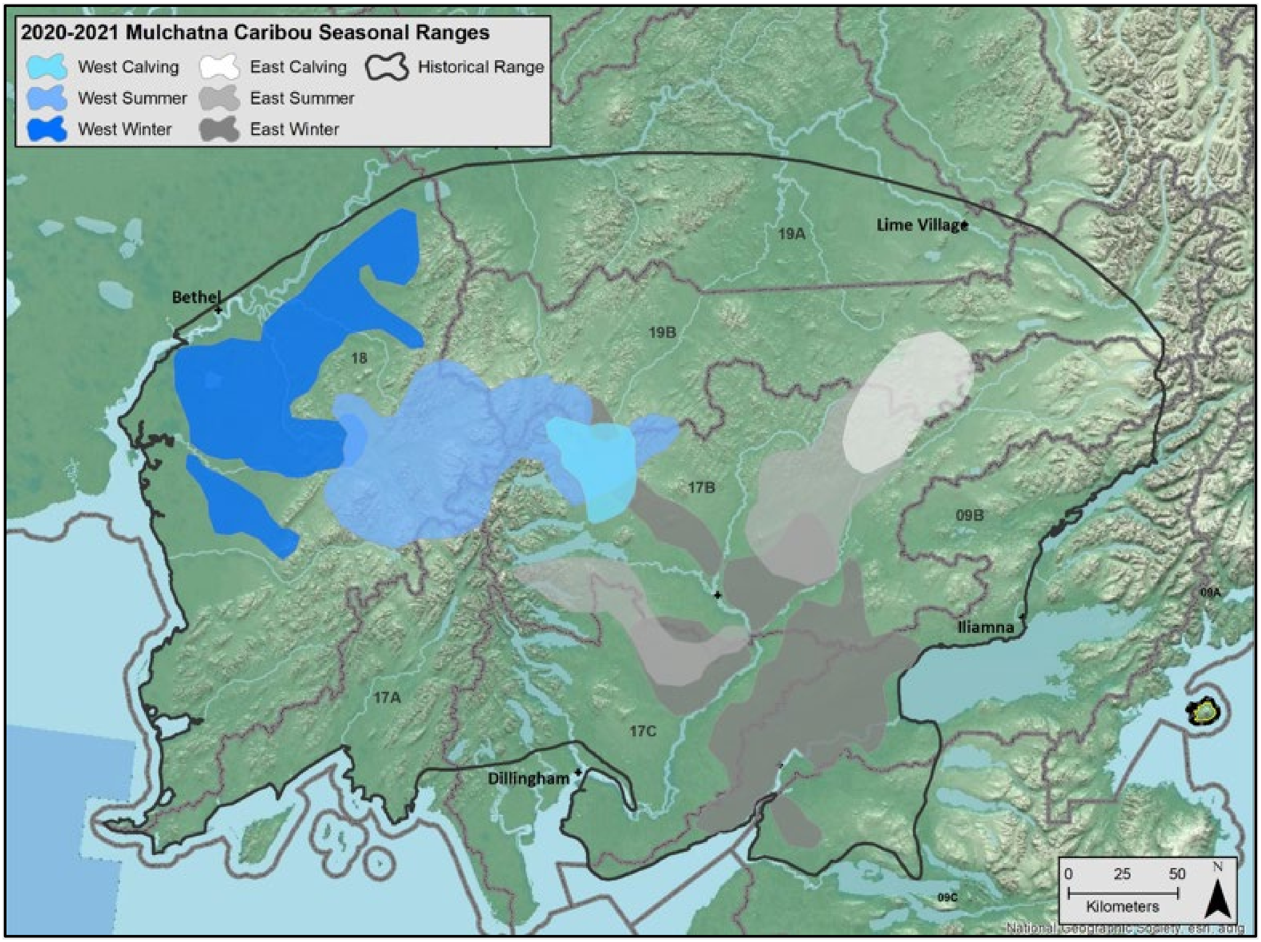

Figure 2. Mulchatna caribou seasonal ranges from 2020–2021, southwest Alaska, as presented to the Alaska Board of Game (ADF&G 2022a: image 2).

The recommendation for reducing predator abundance was based in part on modeling of caribou demographics. Staff briefed the Alaska Board of Game (BOG) at the March 2007 meeting in Anchorage (presentation images in Record Copy 179, available from Boards Support or the authors of this report) with a population modeling exercise to illustrate how a few years of exceptionally large female cohorts (year-specific effect on calf production and survival) in MCH likely affected population dynamics in successive years. The Nushagak Peninsula caribou herd was an example where an introduced population of primarily adult females from the Northern Alaska Peninsula caribou herd (Johnson and Sellers 1989:18, Hinkes and Van Daele 1996) and its population dynamics were monitored (Collins et al. 2003). Large cohorts eventually become older age classes with inherently lower fecundity and survival rates, which results in inevitable population decline even when other age-specific vital rates indicate population growth (e.g., nearly all females pregnant and high calf production and survival in MCH near peak abundance; Van Daele 1997a:29). The purpose of modeling was to illustrate how such transient dynamic effects can complicate interpretation of limiting factors (harvest, nutrition, predation, weather) if the female age structure and age-specific fecundity of a herd is not known, which is uncommon even in closely monitored herds (B. Dale, former caribou research biologist, email to T. Paragi, 13 June 2022).

Large calf cohorts were observed during the very rapid growth phases of MCH. This informed modeling of the age structure of the female segment of the herd. As the large cohorts reached old age, population declines were likely inevitable regardless of management actions because a significant portion of the breeding population was entering senescence. This knowledge justified pausing predator control until it was likely the transient large cohorts were gone, which the models predicted would be around 2011 (B. Dale email to T. Paragi, 13 June 2022).

Valkenburg et al. (2016) characterized predation as a more important factor affecting the dynamics of smaller, relatively nonmigratory herds than on larger, relatively migratory herds. IM actions that began in spring 2012 (Regulatory year [RY] 2011 is from 1 July 2011 to 30 June 2012) were focused on the 2 smaller MCH groups after parturition had rebounded to rates normally associated with herd growth (reviewed below in Section 3).

Aerial wolf control (shooting from aircraft or landing and shooting the same day airborne [SDA]) by permitted members of the public was focused on what was then the "southern" calving area (Kemuk control area; Fig. 1). Between initiation of calf mortality research in 2011–2014 and its resumption in 2017–2021, this calving area in the Nushagak drainage had shifted approximately 50 miles northwest to the Tikchik Mountains (now "western"), whereas the "northern" calving area had shifted approximately 25 miles south into the upper Mulchatna drainage (now "eastern," Fig. 3). In response to the calving range shifts, the wolf control area was expanded to a "Greater Mulchatna area" in RY17 to include the eastern calving range.

Despite the expansion of the wolf control area in RY17 (Fig. 1), numbers of caribou did not increase. Even with observed parturition rates (see Section 3), Mulchatna caribou declined by 2019 (Alaska Department of Fish and Game 2023b:Table 1). In fall 2021 (RY21) caribou harvest was closed entirely for both federal subsistence and state hunts. In RY22 the wolf control area was expanded northwest and southeast to include the recent calving range of the western group (upper Aniak and Holitna drainages, Unit 19B) and eastern group winter range (Kvichak drainage, Unit 9B), respectively (Fig. 1). Harvest of Mulchatna caribou presently remains closed. In the following sections we review factors that affect prey population dynamics to understand their relative potential to limit caribou herd growth from the present low abundance.

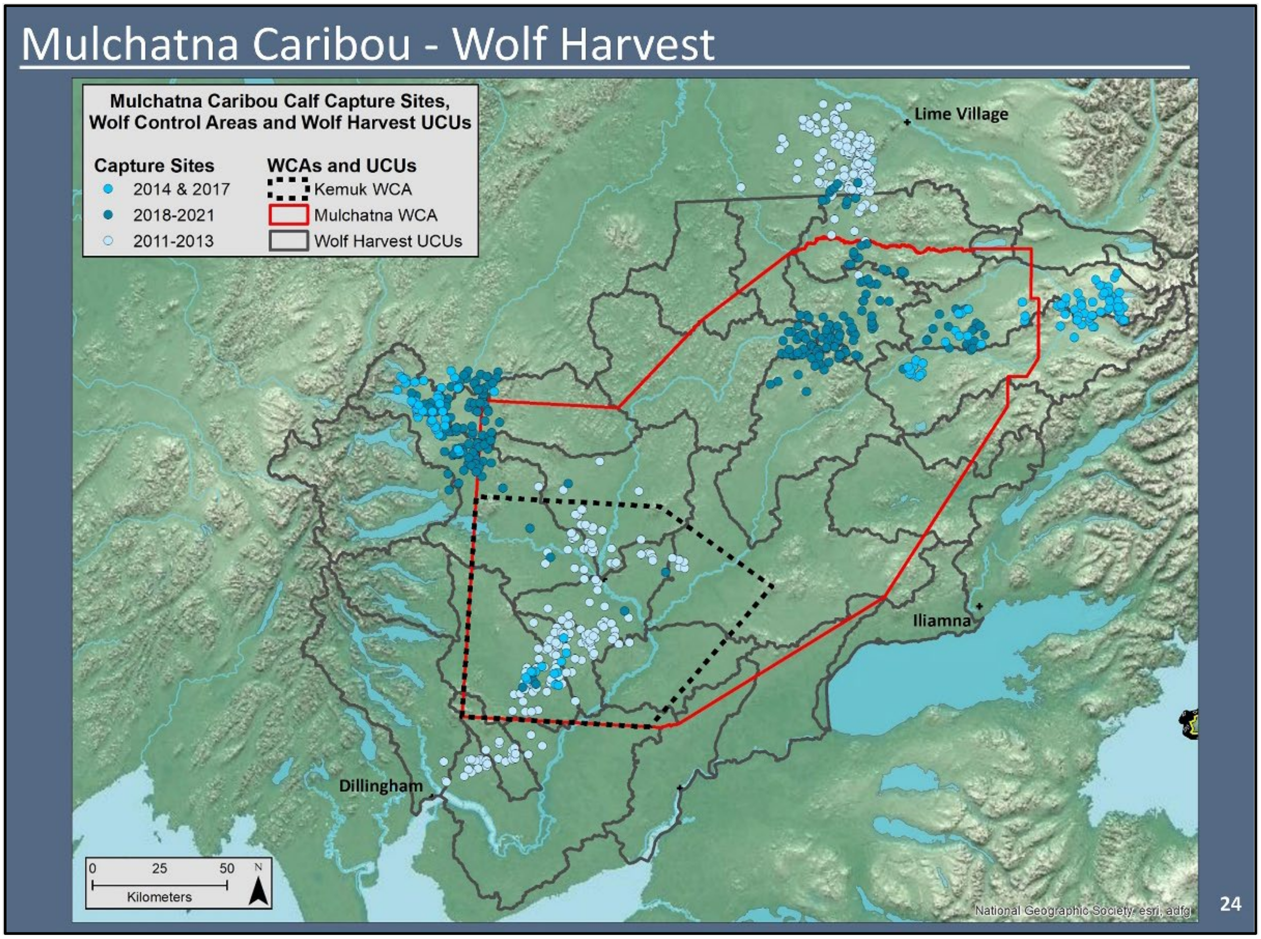

Figure 3. Mulchatna caribou calf capture sites, wolf control areas (WCAs), and wolf harvest uniform coding units (UCUs) in southwest Alaska during 2014 and 2017, 2018–2021, and 2011–2013 as presented to the Alaska Board of Game (ADF&G 2022a: image 10).

Key factors informing the 2023–2028 Intensive Management Operational Plan

1. Low effectiveness of public wolf control during 2011–2021

Winter conditions for tracking wolves from aircraft (for biological surveys or predator control activities) or ground travel by snowmachine for harvest are highly variable among years in Units 17 and 18 because of coastal weather conditions that often limit snow cover. Wolf control started 1 February in the Kemuk control area (allowing local residents hunting and trapping opportunity in early winter) and started 1 December in the Greater Mulchatna control area; most wolf take is in February and March. Pilot participation in MCH wolf control has been highly variable among years, and wolf control exceeded harvest only in 2020 (Figs. 4 and 5). Aside from variation in public efforts, it is unknown how much variation in total removal among years in the control area (Fig. 4) may reflect a high degree of transient wolves during the breeding season as young disperse (e.g., Adams et al. 2008:16–17).

Unit 17 Intensive Management

Wolf Removal from 9B,17B&C and 19B Predation Control Area

Period	RY	SDA Permitted Pilots	SDA Participants	SDA Removal	Non-SDA Harvest	Total Removal Control Area	Total Removal In Units 9B, 17 B/C & 19B
Year 1	2011	33		11	66	77	102
Year 2	2012	31	1	0	17	17	35
Year 3	2013	28	1	0	19	19	26
Year 4	2014			0	0	0	6
Year 5	2015			0	25	25	27
Year 6	2016			3	53	56	67
Year 7	2017	18	8	30	40	70	86
Year 8	2018	33	4	11	12	23	29
Year 9	2019	31	2	10	48	76	82
Year 10	2020	30	14	28	24	52	104

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Figure 4. Wolf removal by aerial shooting the same day airborne (SDA) from the Units 9B, 17B, 17C, and 19B predation control area during regulatory years (RY) 2011–2020, southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022b: image 22). Red numbers highlight years of high removal.

Since 2011 it is likely that the wolf reductions in Units 17B and 17C have been of an insufficient duration of successive years (≥4) to sustain an improvement in caribou survival (National Research Council 1997:184). Since the late 1990s overall prey biomass in Units 17B and 17C has declined. While moose density in Units 17B and 17C has remained relatively stable in survey areas the last 2 decades (harvest peaked in late 1990s; Woolington 2012:256–257, Barten 2018:5), the number of Mulchatna caribou on the landscape has declined substantially. Fewer available prey may have resulted in fewer wolves in the MCH wolf control area.

Despite 2 efforts to assess wolf density within the MCH calving area prior to years of initial implementation and subsequent expansion of wolf control, the number of wolves continues to be unknown. Wolf density in fall 2007 was approximated as 28–32 wolves/1,000 mi^2 in Unit 17B and 25–34 wolves/1,000 mi^2 in Unit 17C based on harvest data, incidental observations, and trapper questionnaires (Woolington 2009; see also 2011 IM Plan, 5 AAC 92.125(o), Register 198). In the mid-2000s there were approximately 30,000 Mulchatna caribou (see Section 6) and

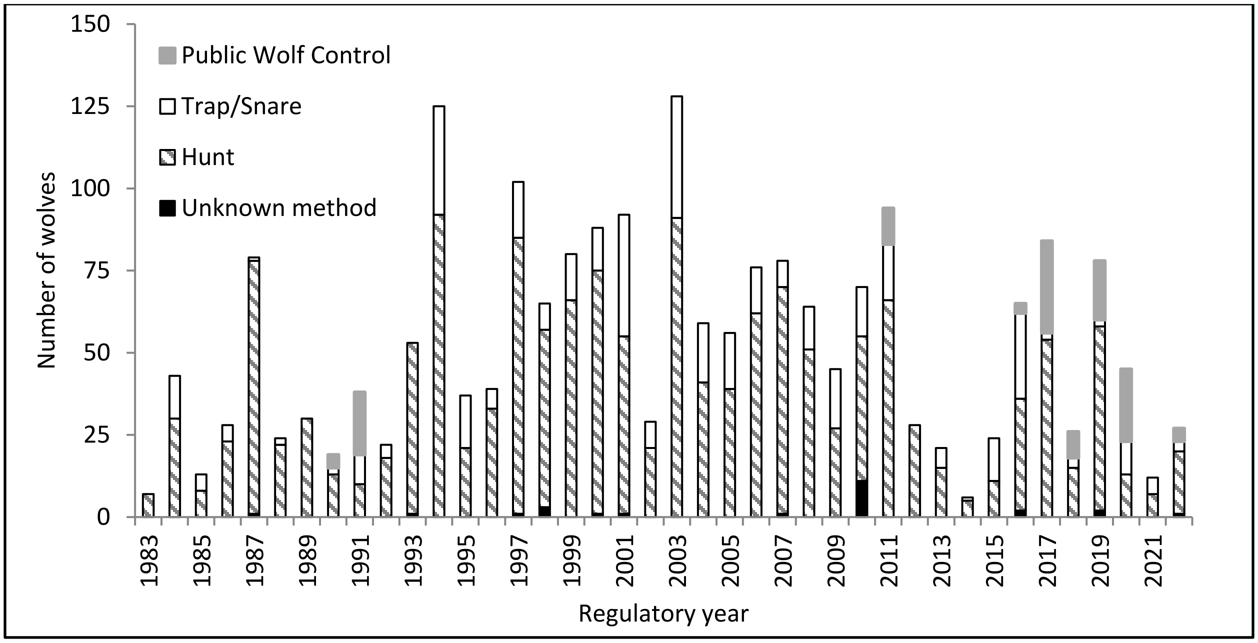

Figure 5. Harvest and control of wolves by method for Units 17B and 17C combined, the central portion of the MCH range, during regulatory years 1983–2018, southwest Alaska. Wolf control, active since 2011, occurred in a maximum of 50% of the combined unit area by 2017 with expansion to the Greater Mulchatna wolf control area (WCA; Fig. 1).

approximately 6,000 moose (0.2–0.6/mi^2) in Units 17B and 17C (Woolington 2012:256). The IM Operation Plan (ADF&G 2023a:12) described wolf density in late winter from intensive aerial surveys (February–March 2012) and radiocollaring 5 packs (2016). In both years densities ranged from approximately 5.5–7.5 wolves/1,000 mi^2; however, these were underestimates due to poor survey conditions in 2012 (ADF&G 2023a:12) and legal public take of collared wolves in 2017 (ADF&G 2023b:9) that hindered mapping of pack territories. These density estimates are low compared with other wolf populations in caribou-moose systems of Alaska with comparable prey biomass (Keith 1983, Fuller et al. 2003, Adams et al. 2008). The removal of 77 wolves from Units 17B and 17C over the RY07 winter corresponds to 20–29 wolves/1,000 mi^2 in spring from a pretreatment fall density of 25–34 wolves/1,000 mi^2, without corrections for natural mortality or emigration (potentially biased high) or immigration. Removal of 94 wolves from Units 17B and 17C in RY11 corresponds to a 21–30% reduction, and a removal of 65 wolves in RY17 corresponds to a 14–20% reduction. Both of these reduction estimates, even if biased low, are far below the ≥55% reduction threshold associated with prey numeric response (National Research Council 1997:184). Other years of wolf removal during RY12–RY22 were far lower (Fig. 5).

Without a robust precontrol estimate, the level of wolf reduction (control plus harvest) is uncertain. However, given what information is known and a spatial mismatch between the MCH calving grounds and where the bulk of wolf removals occurred by harvest (Fig. 6) and control (Fig. 7), these efforts have likely been insufficient to reduce predation adequately to stimulate prey population growth. With few communities near the calving ranges for hunter and trapper access (Fig. 1), sporadic take of wolves (Fig. 5), and irregular distribution of take by control efforts (Fig. 4), there was likely only low levels of wolf predation reduction in most years during

2011–2022. The responses in the fall 2012 calf-to-cow ratio for the western MCH group (38:100) and fall 2018 for the eastern MCH group (39:100; Fig. 8) were modest, unlike substantial responses in calf survival observed in case studies on multiple years of effective wolf control from Alaska and Yukon (typically >50:100 calves-to-cows; studies listed in ADF&G 2023a:14). During the irruptive phase of the MCH in the 1980s (prior to heavy range utilization), the calf-to-cow ratio was 40–60:100 (Valkenburg et al. 2016: Fig. 18). A sustained increase in calf-to-cow ratio (i.e., calf summer survival) was not observed after the start of wolf control. With lack of annual survival estimates and timing of cause-specific mortality for calves, we cannot evaluate from existing data whether wolf predation was a major limiting factor of calf survival to 1 year of age during this period. Regardless, wolf predation was likely not reduced effectively to elicit a response if it was a limiting factor.

a. (RY99–RY10)

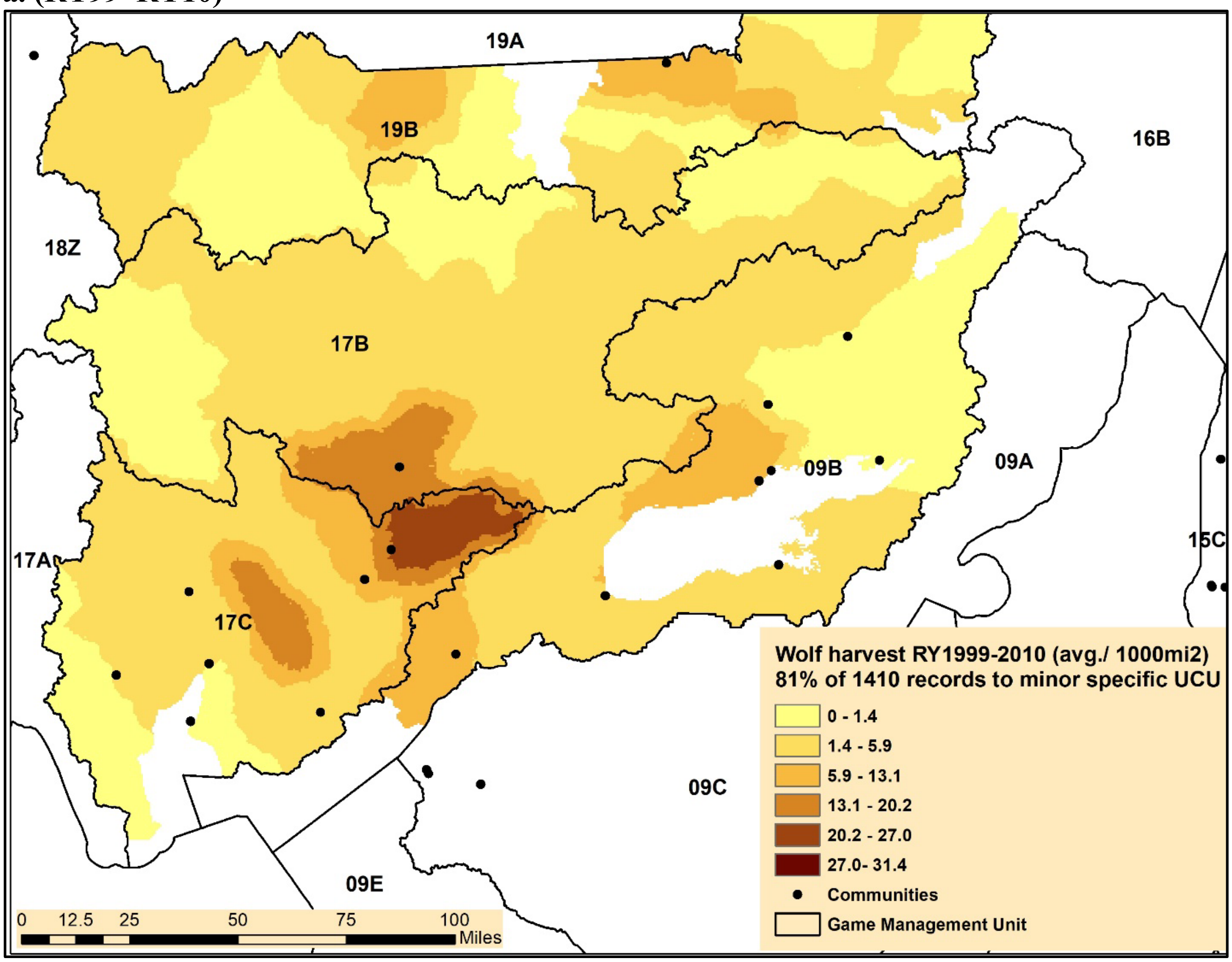

Fig. 6. (1 of 4). -continued-

b. (RY11–RY16)

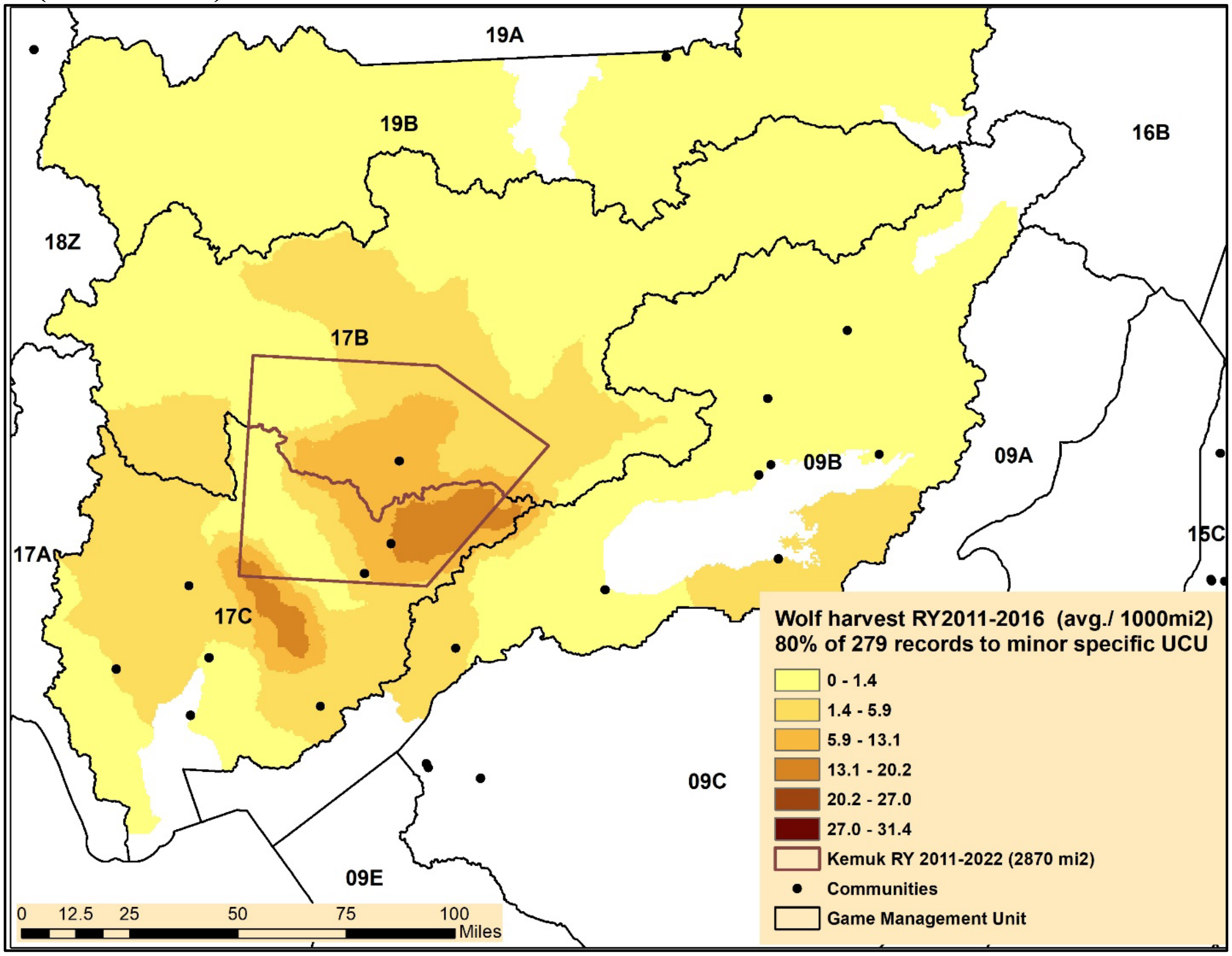

Fig. 6. (2 of 4). -continued-

c. (RY17–RY21)

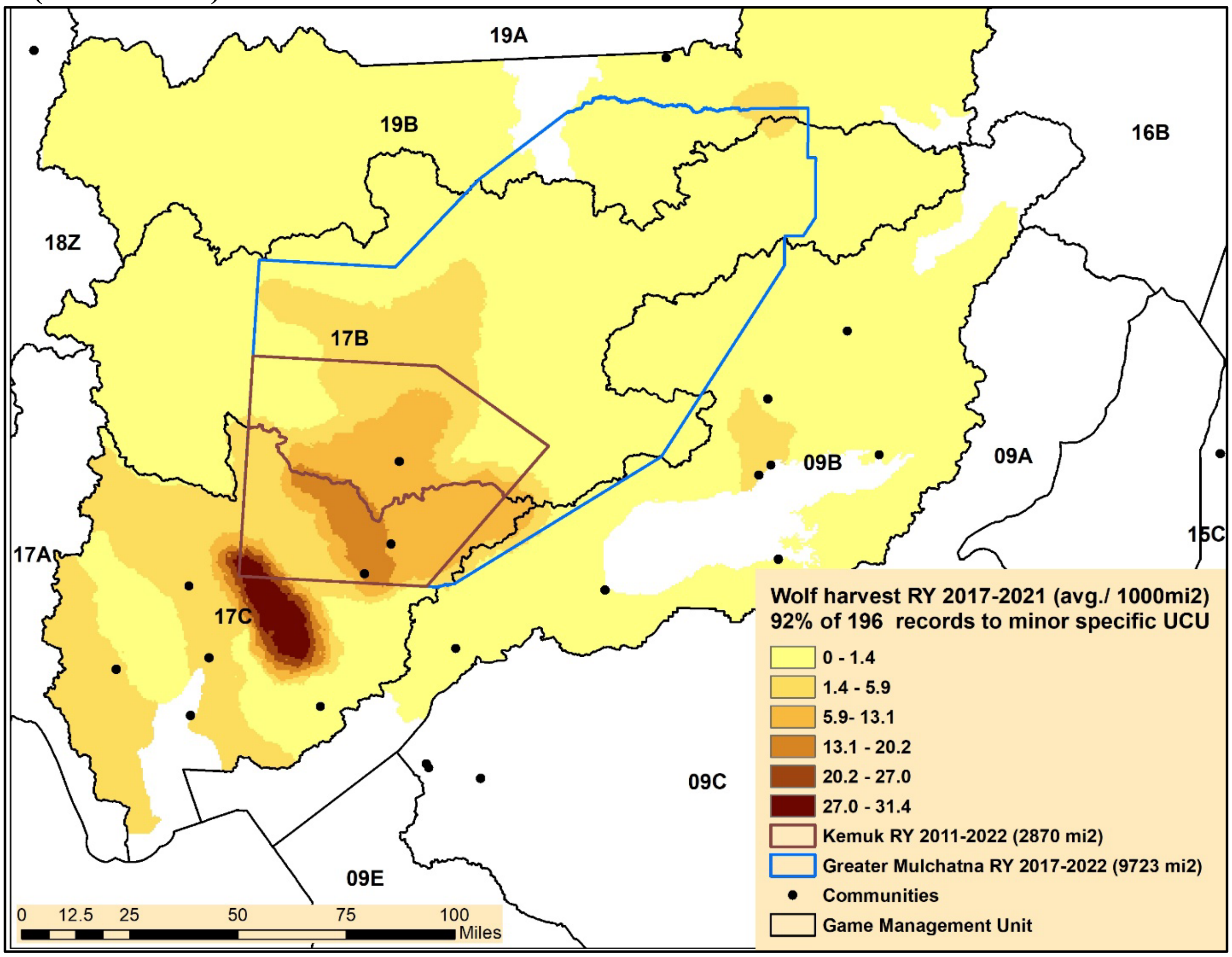

Fig. 6. (3 of 4). -continued-

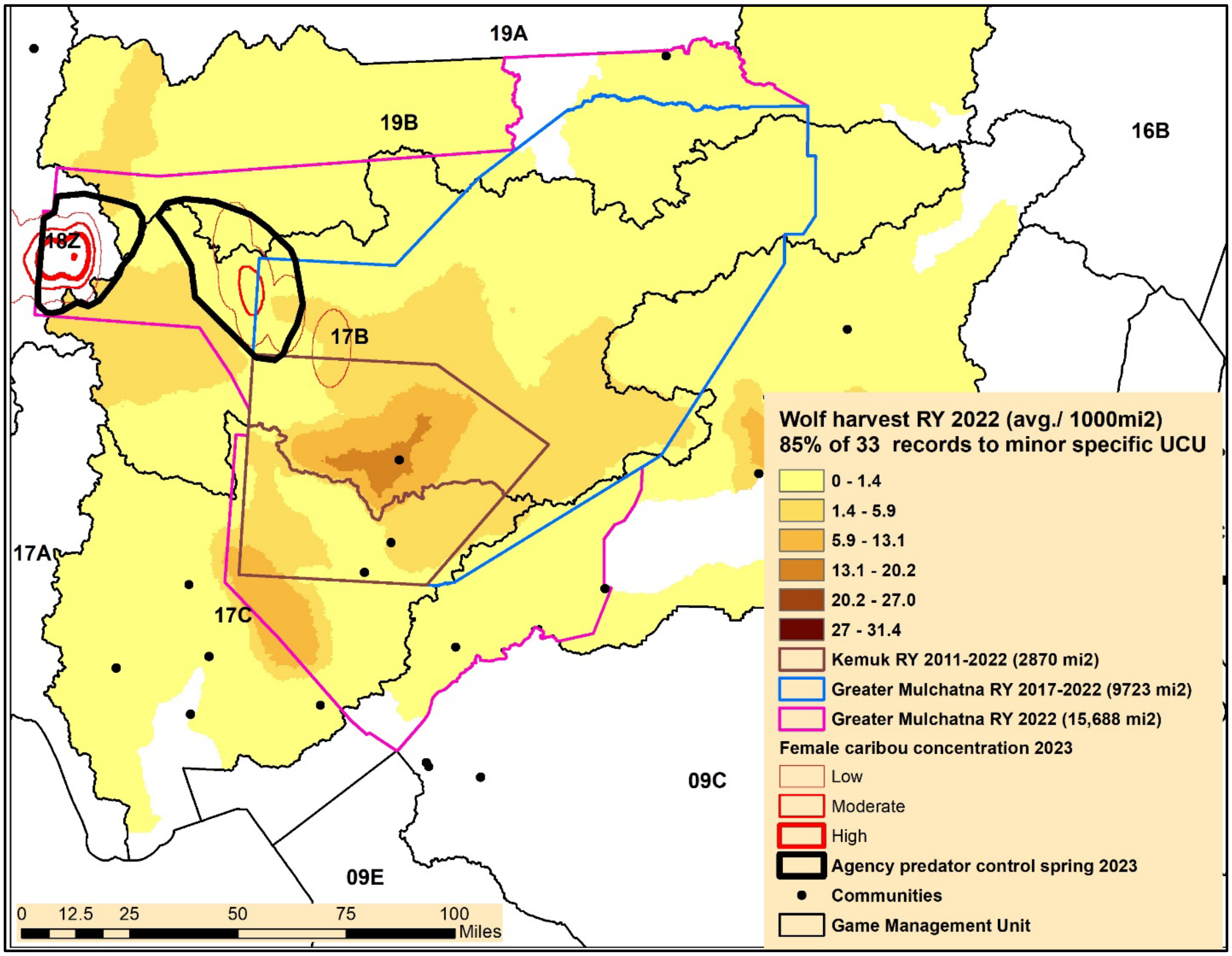

Figure 6. Spatial pattern of wolf harvest (no. taken per 1,000 mi^2) before wolf control (a) and in 3 periods of control area expansion (b–d) focused in Units 17B and 17C, regulatory years (RY) 1999–2022. Smoothed raster categories of wolf harvest density and mean kernel densities of 34 adult (3–13 years old) female caribou locations during May and early June 2023 are Jenks natural breaks. *Note*: UCU stands for uniform coding unit.

a (RY11–RY16)

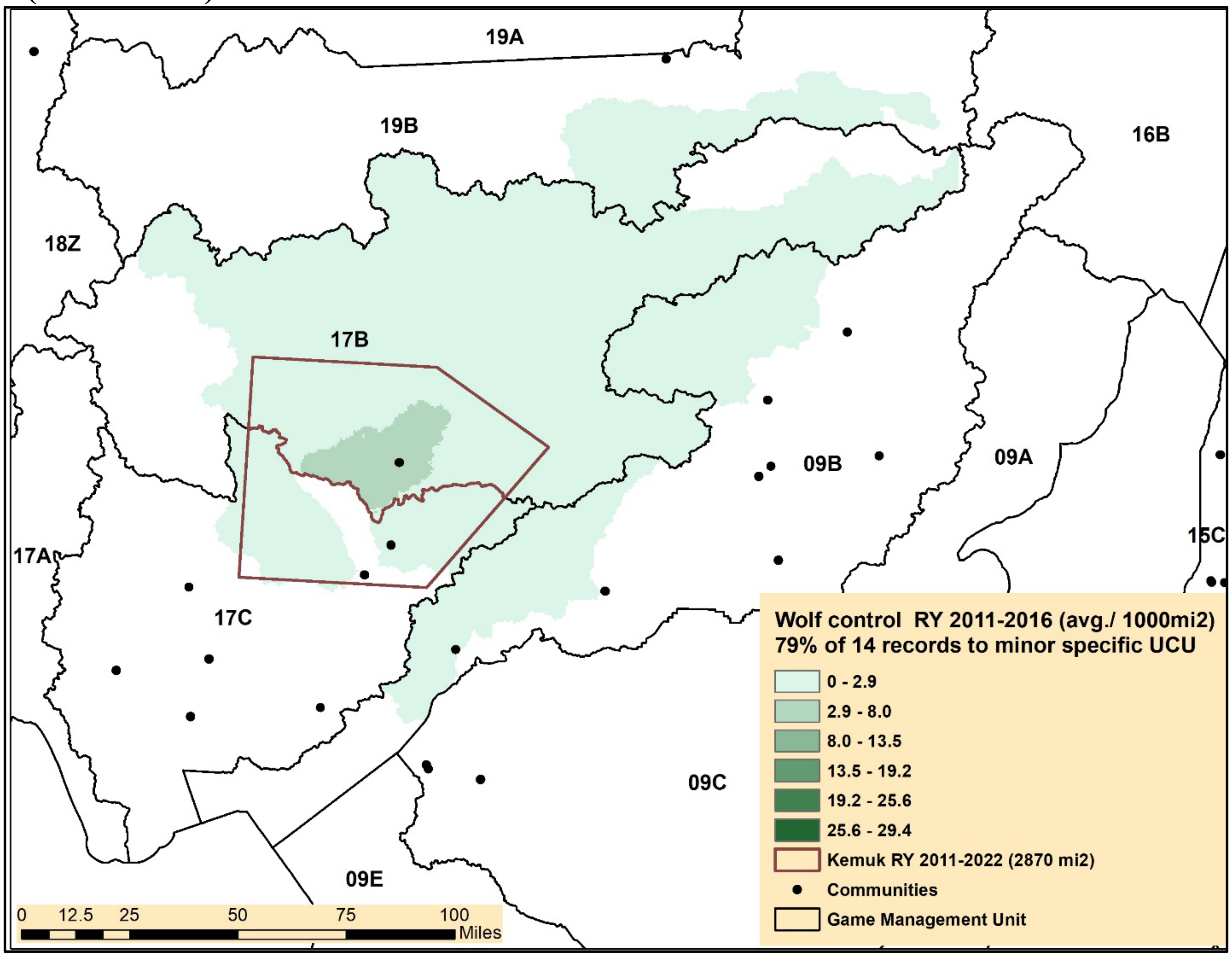

Fig. 7. (1 of 3). -continued-

b (RY10–RY21)

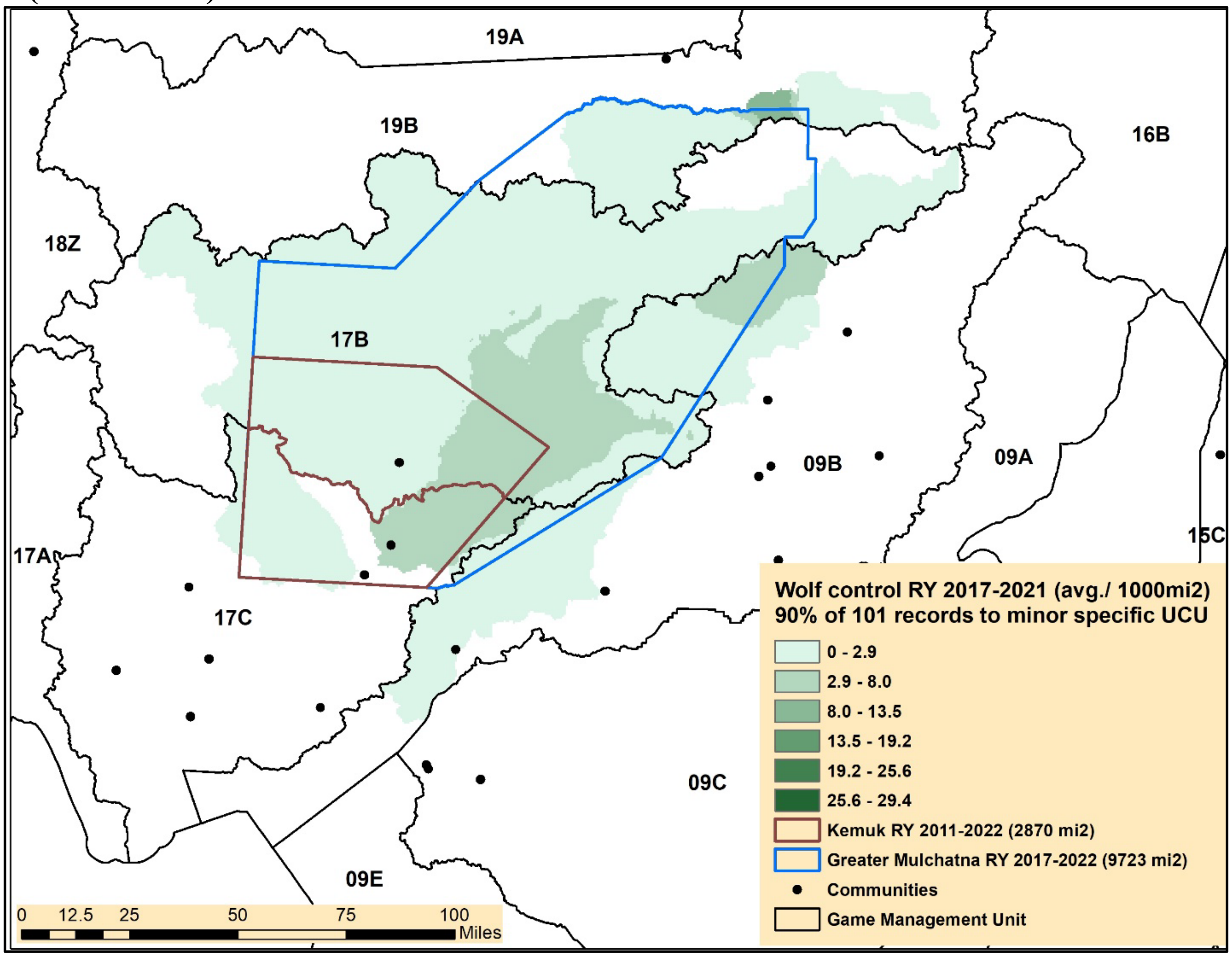

Fig. 7. (2 of 3). -continued-

c. (RY22)

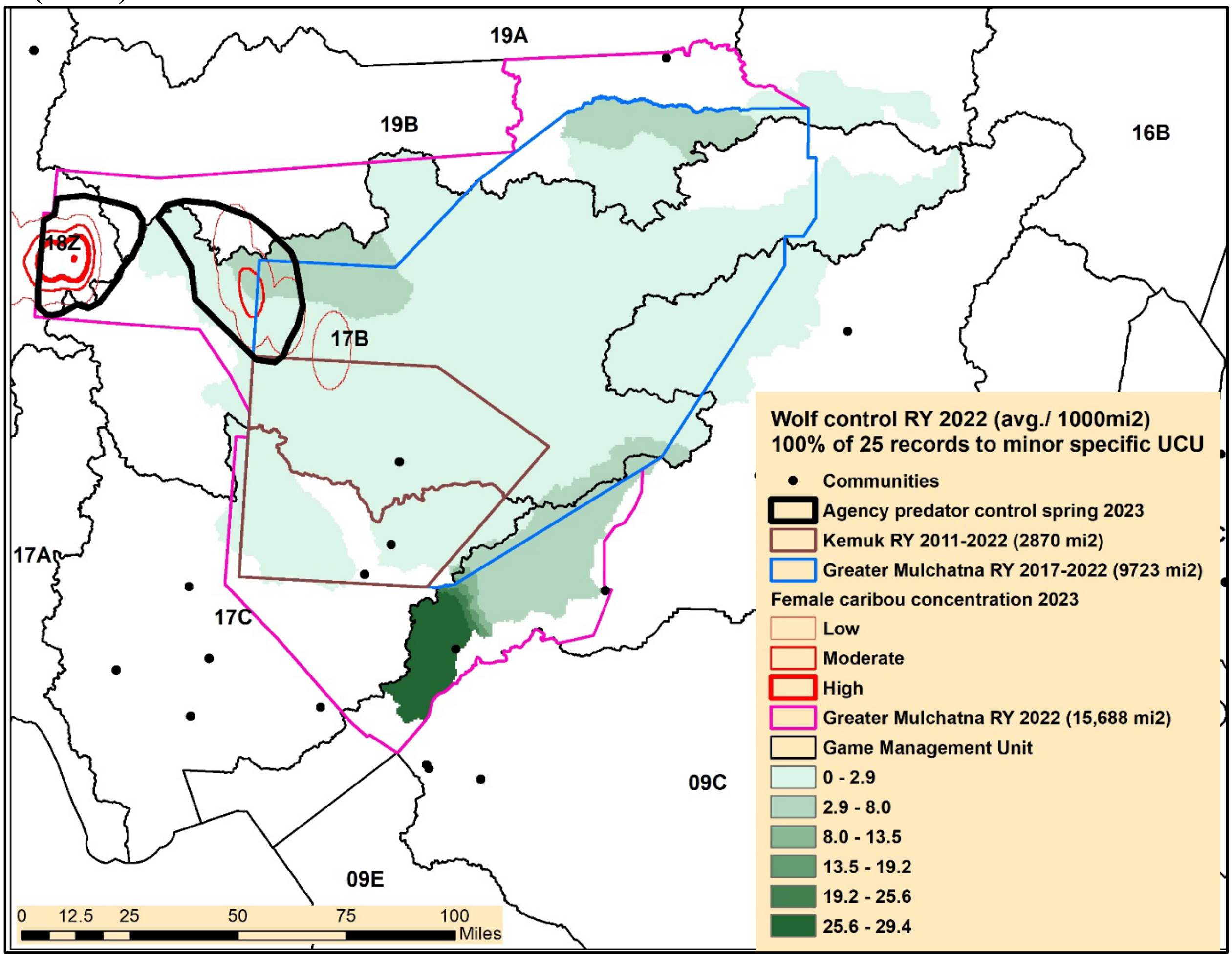

Figure 7. Spatial pattern of wolf control (no. taken per 1,000 mi^2) in 3 periods of control area expansion (a–c) focused in Units 17B and 17C, regulatory years (RY) 1999–2022. Smoothed raster categories of wolf control density and mean kernel densities of 34 adult (3–13 years old) female caribou locations during May and early June 2023 are Jenks natural breaks. *Note*: Wolf control density is calculated on drainage boundaries used in coding kill locations; control only occurred within the legally authorized control areas. UCU stands for uniform coding unit.

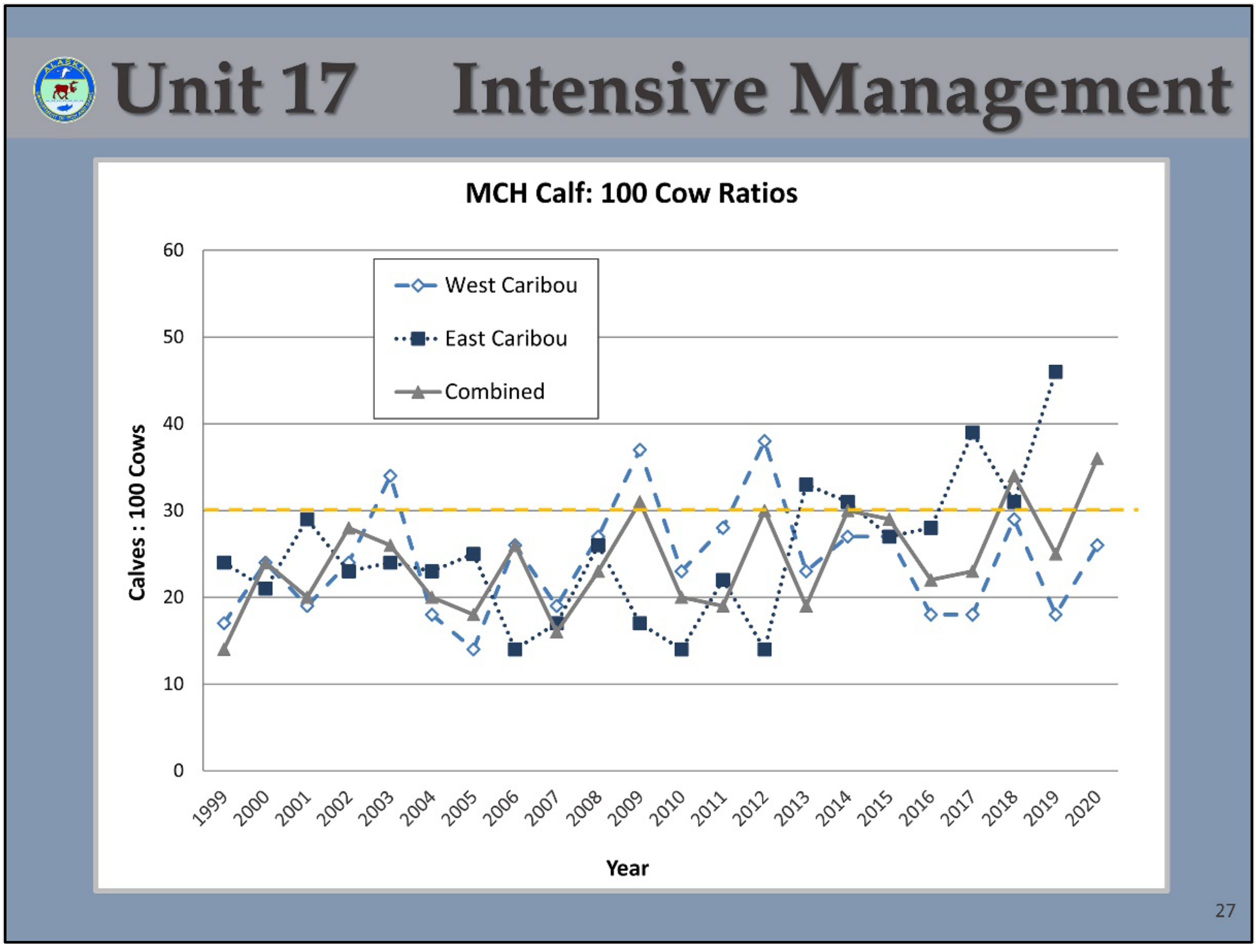

Figure 8. Mulchatna caribou herd (MCH) calf-to-cow ratios for the western and eastern groups during 1999–2020, southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022b: image 27). The yellow line is the management objective of 30 calves per 100 cows, above which represents higher potential for herd growth.

2. Importance of bear predation on Mulchatna caribou herd calves

Valkenburg et al. (2016:161) cited studies documenting how brown bear predation on caribou calves in summer can be as important as wolf predation on calves in summer, depending on the herds, but they also cautioned that predator management programs for caribou should be considered experimental (Valkenburg et al. 2016:viii). Earlier research on small caribou herds on the Alaska Peninsula indicated high neonatal survival with little brown bear predation (Sellers et al. 2003). In contrast, research that began in 2011 on the 2 MCH groups (ADF&G 2022a) identified 89% of mortality during the first 2 weeks of life as predation, with 46% from bears (Fig. 9). The level of nonpredation perinatal mortality in MCH (11%; Fig. 9) was similar to that of the Fortymile caribou herd during a period of increase (9% over 6 years, n = 353; Boertje et al. 2017:435–436). Mortality causes differed between MCH groups and changed over time as the locations of caribou calving ranges shifted, with bear predation becoming more important relative to wolves in the western group after 2014, somewhat opposite the situation in the eastern group (Fig. 10). Calf predation by brown bears is subject to being underestimated because of short handling times (Brockman et al. 2017).

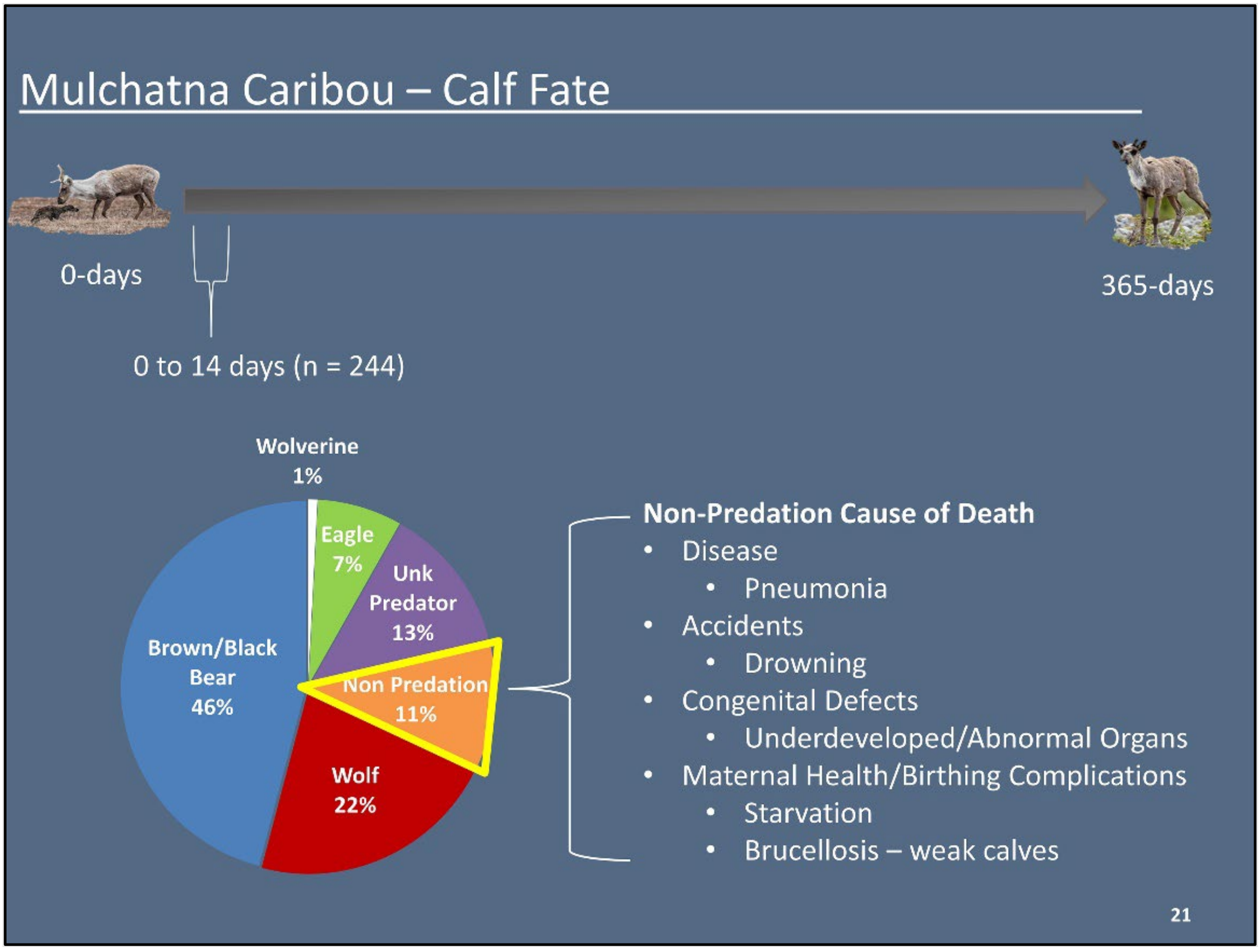

Figure 9. Mulchatna caribou calf mortality by cause during the first 2 weeks of life in southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022a: image 8).

The degree to which bear predation in spring and summer contributes to annual MCH calf mortality is unknown. However, there were shifts in the source of neonatal mortality after 2014 that seemed to affect calf survival to fall differently in the eastern group than the western group (Figs. 8 and 11). Circumstantially, the 2 highest fall calf-to-cow ratios of the eastern group occurred after its shift in calving area around 2014 (and seeming divergence from calf-to-cow ratios in the western group) and reduced mortality from bears. By 2022, wolf control did not appear to improve calf summer survival, particularly for the western group (Figs. 8 and 11). Since 2014, bear predation has been a larger contributor to calf mortality in the western group (Fig. 10).

The western Mulchatna caribou group appears to have declined substantially since 2014 and has remained low despite that harvest has been closed since 2021 (Fig. 12; Alaska Department of Fish and Game 2024:image 8). This led department staff to identify that agency predator control would be prudent for the western group in addition to wolf control by public permittees to temporarily reduce relevant predator species as low as possible on the calving grounds during the calving period. This was the only remaining option for improving summer survival of calves, particularly those not infected by brucellosis (see Section 4).

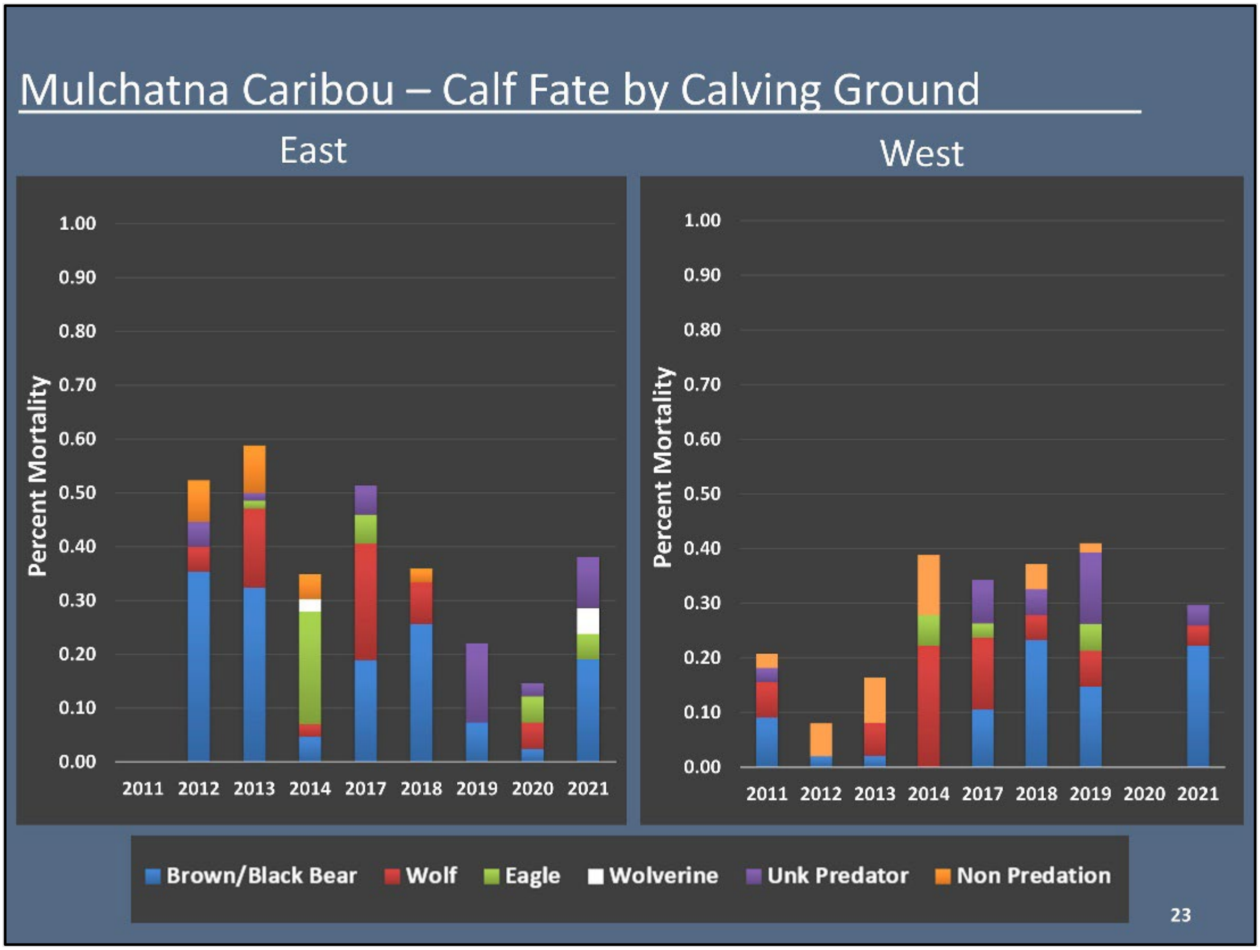

Figure 10. Mulchatna caribou calf mortality during the first 2 weeks of life in the eastern and western calving grounds during 2011–2021, southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022a: image 9).

Agency bear control has only occurred twice before under IM in Alaska, once nonlethally (96% reduction; Keech et al. 2011) and once lethally (89% reduction; ADF&G 2023c). For 2 consecutive years, each instance of bear control was concurrent with public wolf control and restriction or closure of prey harvest. Both programs reduced both black bears and brown bears and were effective at improving summer calf survival for moose. In both of these programs the bear reductions were followed by a subsequent increase in fall calf-to-cow ratio and eventually moose density, with black bears in Unit 19D returning to pretreatment levels 3–5 years after the 96% reduction (Keech et al. 2014).

To gauge pretreatment bear density for the 2023 effort, we considered 2 abundance estimates of brown bears in overlapping portions of Unit 17 that included use of radio collars to derive a correction factor for bears not seen during intensive aerial surveys. Van Daele et al. (2001) reported a minimum density of 47 adult brown bears/1,000 mi^2 from a 1993 survey but speculated that the actual density might have been double the minimum estimate.

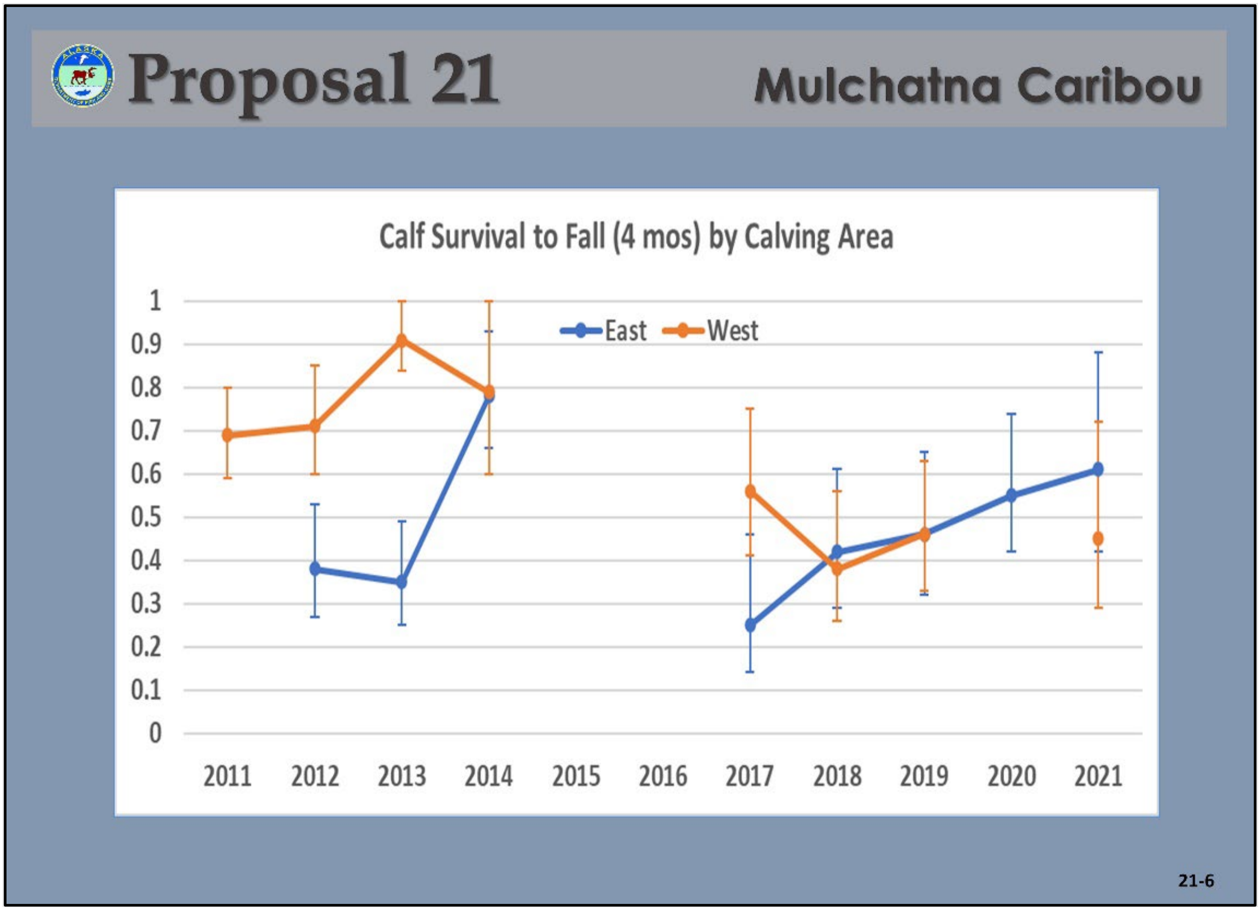

Figure 11. Mulchatna caribou calf survival to fall season or approximately 4-months old by calving area during 2011–2015, southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022d: image 73).

Walsh et al. (2010) estimated 70 independent brown bears/1,000 mi^2 (95% confidence interval [CI] = 55–88) or 103 brown bears/1,000 mi^2 (95% CI = 80–140) from a 2003–2004 survey. The latter survey area overlapped but was much larger than the 1993 survey area, and it was immediately adjacent to the southern edge of the 2023 removal area for the western group.

Walsh et al. (2010:48) described the impetus for the 2005 survey: "In recent years, concerns have been regularly voiced during local village meetings, Alaska Department of Fish and Game (ADF&G) meetings, and Federal Subsistence Regional Advisory Council meetings that brown bear populations are increasing, and this increase has adversely affected wildlife populations targeted by subsistence hunters. The lack of quantitative information on bear abundance has prevented resource managers from adequately addressing these concerns." These concerns were potentially at odds with findings of Kovach et al. (2006) for brown bears in the southwestern Kuskokwim Mountains (Units 17A, 17B and 18) during 1993–2002, where the estimated population trend suggested an increase in brown bear abundance (lambda of 1.04–1.05) for the first half of the study period and a decrease (lambda of 0.96–1.0) for the second half of the study period, trends which were attributed to changes in salmon availability (Collins et al. 2005).

Whether public observations characterized the landscape or were focused in areas of human use (fish camps on salmon streams, hunting camps, vicinity of communities, etc.) is unknown.

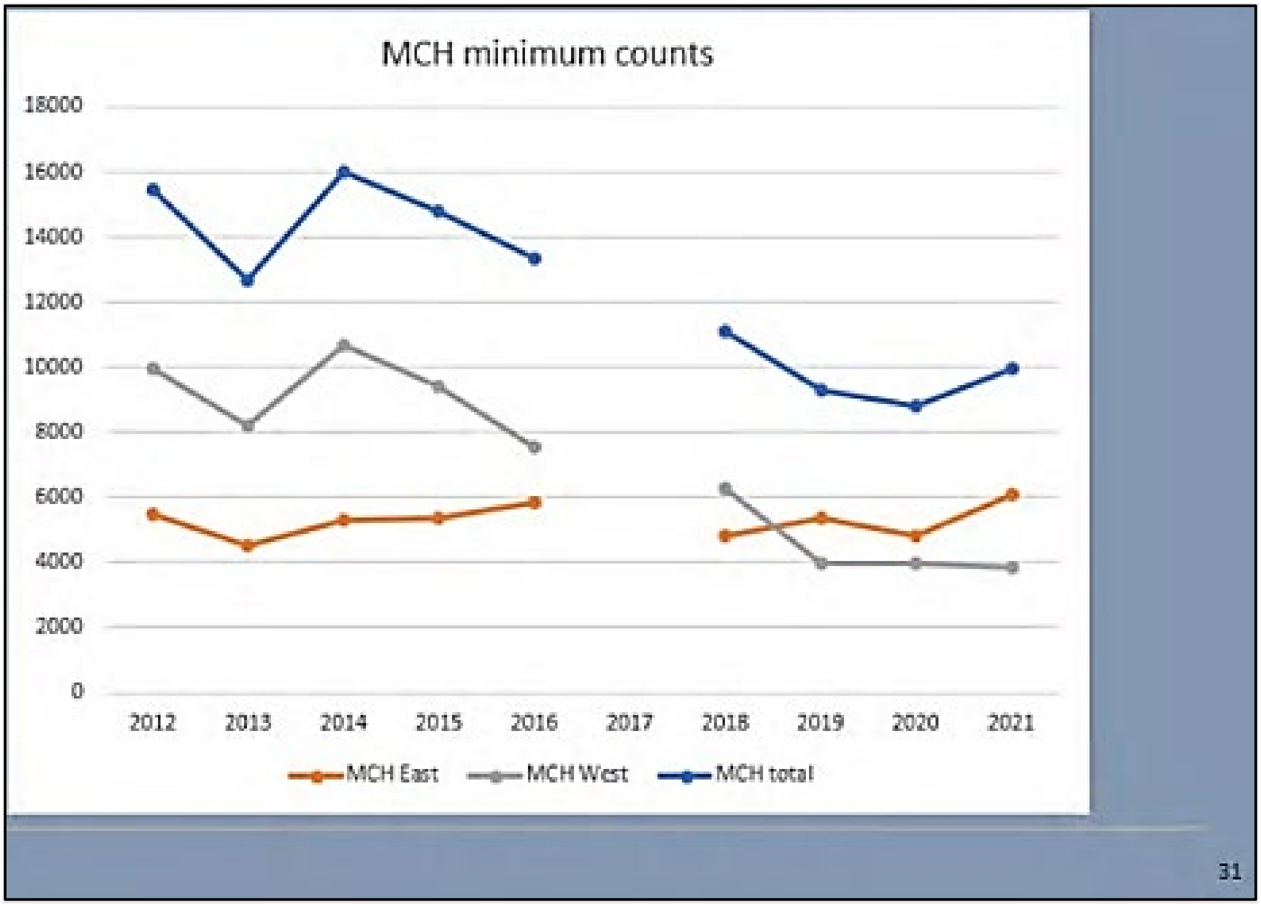

Figure 12. Screen capture of a presentation on Mulchatna caribou herd (MCH) minimum counts by area during 2012–2021, southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022c).

In 2021 and 2022 biologists and bear hunting guides in Unit 17 have observed litters with 3 or more brown bear cubs, and there were 2 sets of triplet cubs of the year taken during the 2023 predator removal. Record sockeye salmon returns to Bristol Bay since 2015 (Elison et al. 2022: Table 1) likely have enhanced brown bear fitness and abundance. Whether the bear population has increased since the 2003–2004 survey estimate is unknown; however, it is plausible given a greater food supply and the decline in brown bear harvest in this area during 2011–2019 (Fig. 13). The predator removal was planned for western Unit 17B based on history of calving locations (Figs. 2 and 3), but field staff split the search area between western Unit 17B and eastern Unit 18 (Fig. 1) based on observations of calving in spring 2023.

We are not aware of research on the effectiveness of predator reduction where brown bears are the primary predators of caribou calves. Ballard and Miller (1990) documented that a 60% minimum brown bear reduction (nonlethal, 1 year) had positive effects on moose calf survival in Unit 13E at a density of 1.8 moose per mi^2. In contrast, a subsequent 36% reduction in brown bears through elevated harvest over a 7-year period did not produce an increase in moose abundance. This might be due to compensatory mortality after moose increased to ≥2 moose per mi^2 (Ballard 1992, Miller and Ballard 1992). In the 2023 IM operational plan for MCH (ADF&G 2023a:18), the 1993 minimum estimate of 47 adult brown bears/1,000 mi^2 in Van Daele et al. (2001) and the 2003–2004 estimate of 103 brown bears/1,000 mi^2 (Walsh et al. 2010) were extrapolated to 54–118 brown bears in the approximate 1,150 mi^2 search area used in planning, which was split between 2 polygons (Fig. 1).

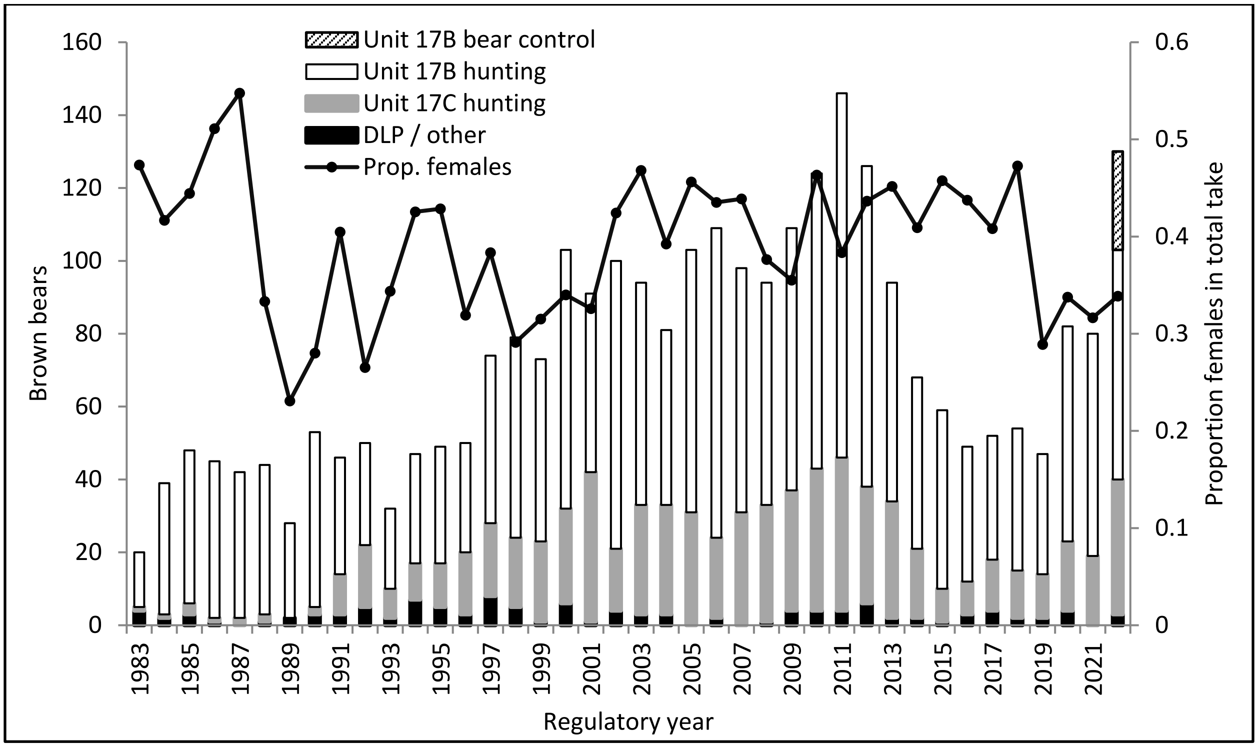

Figure 13. Harvest and predator control of brown bears in Units 17B and 17C, southwest Alaska, regulatory years 1983–2022. Control take of 27 individuals occurred on approximately 600 mi^2 (6%) of Unit 17B (9,906 mi^2). ***Note*****: DLP stands for defense of life or property.**

When questioned at the March 2023 BOG meeting about the number of bears estimated to be taken, the area management biologist reply was "up to 20," which was based on observations relayed to him by fixed-wing pilots and caribou researchers (up to 15 was noted in ADF&G 2023a:18). A precise reduction level was not specified in the IM Plan (5 AAC 92.111I(2) (D)): "the bear population objective for the MCH Predation Management Area is to annually reduce the number of bears in the predator control areas to a level that results in increased calf survival and recruitment." The objective for bear control in the IM Operational Plan was to "remove all bears within the Bear Predation Control Area" (ADF&G 2023a:18) that at 1,150 mi^2 composed 1.8% of affected subunits (Units 17B, 18, and 19B; 63,620 mi^2). During removals in May and June 2023, brown bears were spotted with focused searching at a low level from both a fixed-wing aircraft and helicopter, which affords an even lower oblique angle to aid in the detection of bears in open vegetation.

Brown bear harvest in Units 17B and 17C combined peaked in RY11 and then sharply declined through RY19 despite increased harvest opportunity starting in RY16, when a 2-bear bag limit allowing the sale of hides with claws and skulls was authorized (Fig. 13). Few hunters (2–4 per year during RY18–RY22) sealed 2 brown bears in Units 17B and 17C. Harvest of cubs ≥2-years old or associated adult females has been prohibited since 1957. Declining participation or hunt success could result in declining harvest, even if the bear population was increasing. Bear control take in the Unit 18 portion of the treatment area was substantially more than take from hunter harvest in RY22 (Fig. 14). Brown bear harvest in the 3 harvest reporting areas of eastern Unit 18 (5,700 mi^2) ranged from 0 to 6 annually during RY18–RY22, with 61 additional bears (44% female) removed through control efforts from the western search area portion of Unit 18 (Fig. 14). For context, the average annual brown bear harvest in the 2023 control area during RY18–RY22 was approximately 15 bears. The 2023 control area is within a remote region where average annual harvest of brown bears is relatively low in adjacent drainages used for coding harvest location (Fig. 15). Low harvest in surrounding area increases potential for brown bear emigration to the calving area from surrounding areas of natural bear density to ensure sustainability of bear population at GMU scale, even if bears are reduced substantially on the calving areas.

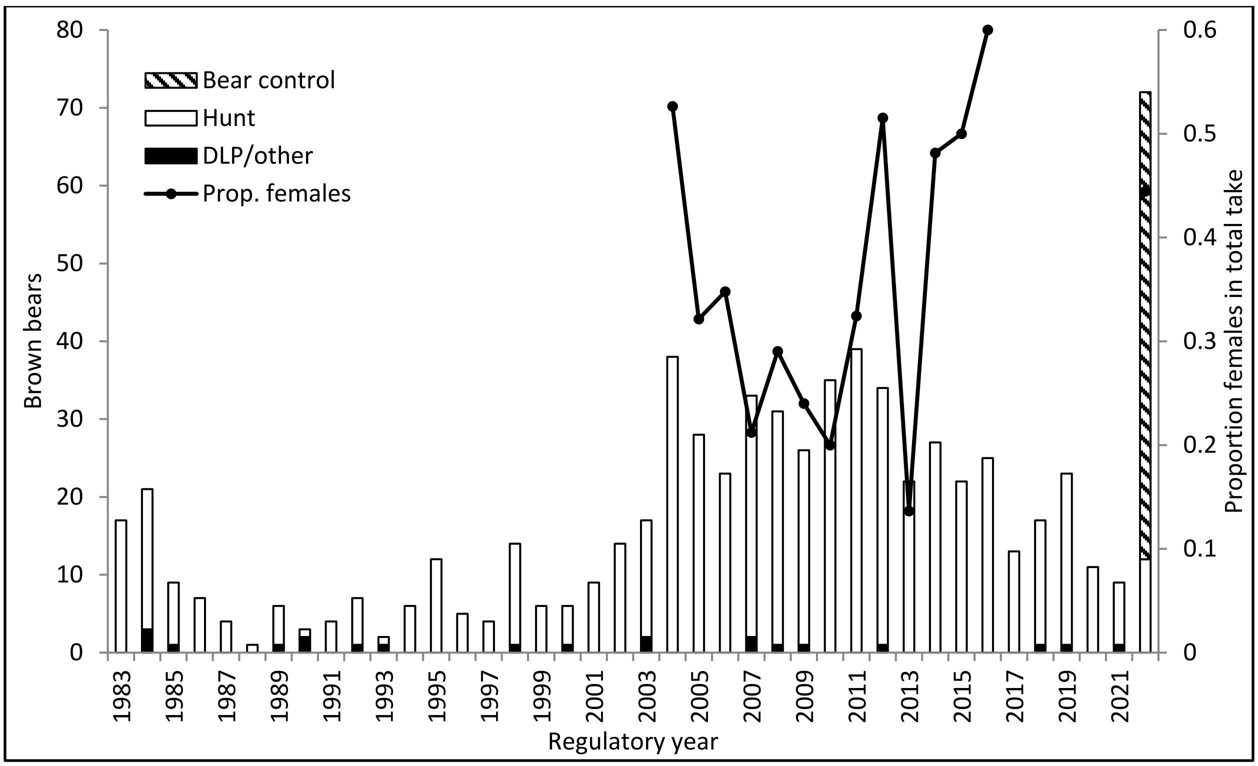

Figure 14. Harvest and predator control of brown bears in Unit 18, regulatory years 1983–2022. Control take of 61 individuals occurred on approximately 500 mi^2 (1%) of Unit 18 (45,913 mi^2). Sample sizes <30 for estimating the proportion females in the harvest are statistically unreliable. *Note*: DLP stands for defense of life or property.

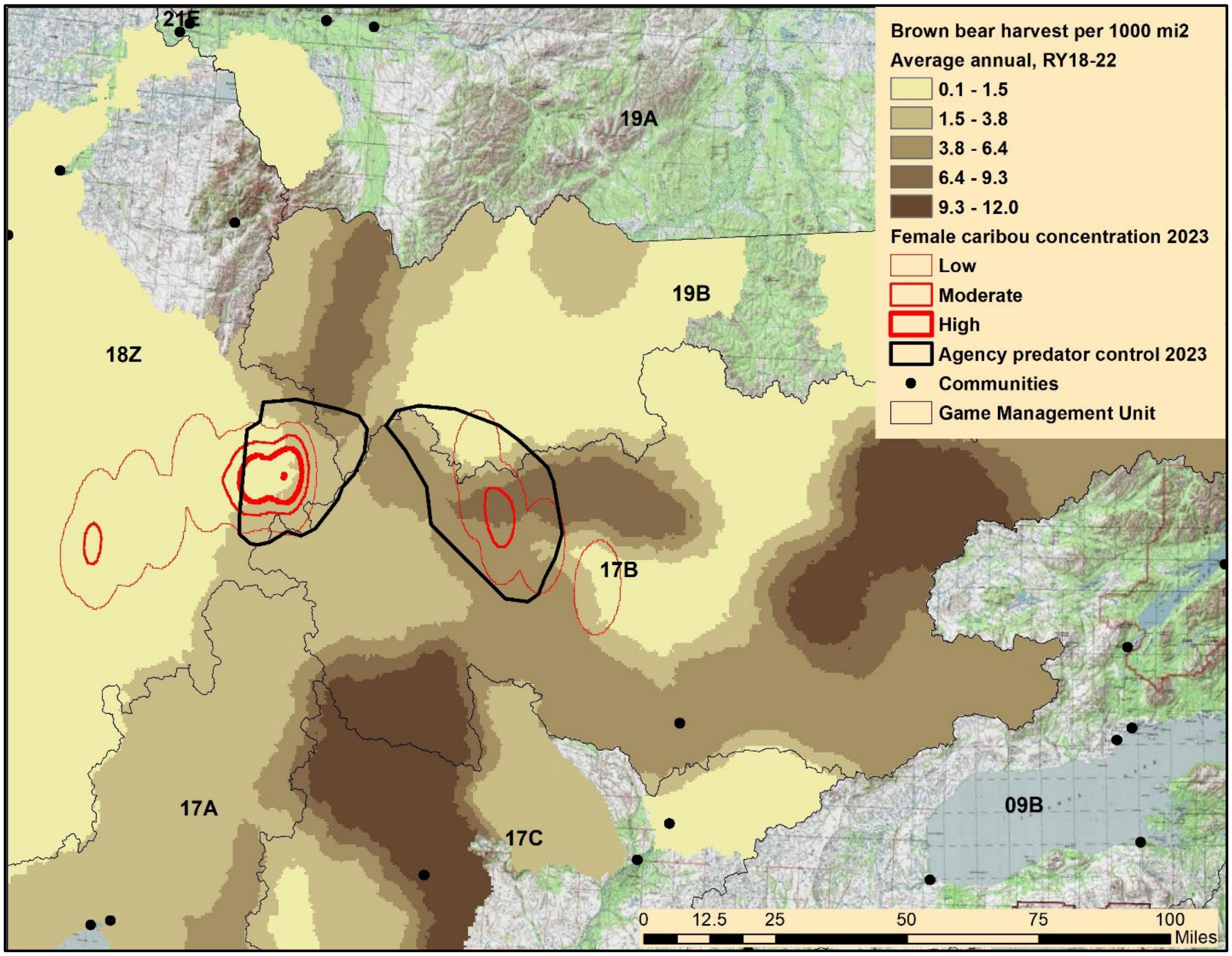

Figure 15. Spatial pattern of brown bear harvest (no. taken per 1,000 mi²) during regulatory years 2018–2022 in and near the agency predator control on the 2023 calving grounds of the western group of the Mulchatna caribou herd. Smoothed raster categories of bear harvest density and mean kernel densities of 34 adult (3- to 13-years old) female caribou locations during May and early June 2023 are Jenks natural breaks.

A harvest of 15 bears equates to 2.3 bears per 1,000 mi² within the 6 harvest reporting areas (6,476 mi²) including or intersecting the 2 predator control search areas, where these 6 harvest reporting areas combined would presumably contain 695 brown bears (103 bears per 1,000 mi²). This harvest from an estimated 695 brown bears is an approximate 2.2% harvest rate. Miller (1993) reviewed research from multiple areas of Alaska and conservatively judged 5% of the population as a sustainable harvest rate for brown bears (although more recent estimates of sustainable yield for brown bears are substantially higher; see Brockman et al. 2020). In addition to 27 brown bears removed from Unit 17B (Fig. 13) and 61 brown bears removed from Unit 18 (Fig. 14) in spring 2023, department staff also removed 6 brown bears in Unit 19B, where 15 were taken by hunting in RY22.

Whether the reduction of brown bear density in spring 2023 (along with 5 black bears and 5 wolves) was sufficient to improve caribou calf survival from birth to the fall season (approximately 4-months old) in the western MCH group will be discerned by assessing the magnitude of change in the fall 2023 calf-to-cow ratio derived from composition surveys.

3. High birth rate of caribou since herd declined to approximately 30,000 but uncertain nutritional condition

When calf survival to breeding age is strongly constrained by predation, reducing the relevant predators can allow prey populations to increase if prey reproduction is not constrained by poor nutrition. Range quality, as represented by forage plant abundance and its food value, can influence ungulate nutrition, which in turn influences fitness (reproduction and survival) and potential for herd growth (e.g., Monteith et al. 2014: Fig. 1). Valkenburg et al. (2003:134) noted that "by the mid-1990s casual aerial observations indicated that lichen biomass was reduced" on the MCH range around the peak of herd abundance. Historic measures of nutrition were not available for MCH, other than estimates of birth rate, nor were range quality data. Other observations indicating reduced caribou fitness (density dependence) shortly after peak abundance in the 1990s were clinical evidence of disease (Valkenburg et al. 2003) and low percent fat in femurs of fall caribou (Valkenburg et al. 2016:85).

Parturition surveys are a proxy measure for pregnancy or birth rates. Parturition rates are obtained by monitoring radiomarked females of known age over several days. This is typically done prior to peak of calving to verify a calf at heel (definitive of birth) or the presence of antlers or distended udders that indicate advanced pregnancy or nursing of calves that may have been lost to natural mortality before or soon after birth, respectively (Whitten 1995). Boertje et al. (2012:35–36) demonstrated how the parturition rate for 3-year-old caribou is sensitive to caribou density and had varying effect on population trend in 8 Alaska caribou herds, including MCH. Sellers et al. (2003:162, 164) reported 33% (n = 18) of 3-year-old females were parturient in the "chronically undernourished" Northern Alaska Peninsula caribou herd 3 years after its population decline began, compared with 100% (n = 8) parturient in the Southern Alaska Peninsula caribou herd 3 years after it had declined to a low abundance.

Mulchatna caribou parturition data since 2000 suggest density-dependent changes over time. The parturition rate for 3-year-old caribou in the mid-2000s was approximately 0–40% during MCH herd decline (Fig. 16). After the decline stabilized near 30,000 caribou by 2009, the parturition rate increased rapidly to approximately 60–100%. Survival of subadult females also declined in the early 2000s, likely due to nutritional limitation, then increased after 2006 (Fig. 17). Beyond parturition rates, key factors in herd growth rate are whether young females born at a given nutritional condition are capable of surviving to reproductive age and in turn having female calves, and how much a given nutritional condition at birth predisposes calves of both sexes to natural mortality from predation, accidents, or malnutrition. Research began in 2020 to assess the summer nutritional condition of adult female caribou during mid-October using indices validated in captive caribou (Cook et al. 2021). Staff used ultrasonography to measure rump fat, loin, and loin fat thickness; measured body mass; and evaluated each sampled caribou using a body condition score. They calculated ingesta-free body fat (%) and protein (kg) using equations with strong predictive ability. The January 2022 staff report includes preliminary research results from 2020 that body fat levels were indicative of at least moderate summer nutritional limitation (Alaska Department of Fish and Game 2022a:image 17). This is the first application of ultrasound in wild Alaska caribou for this purpose. Whether this level of nutritional condition is

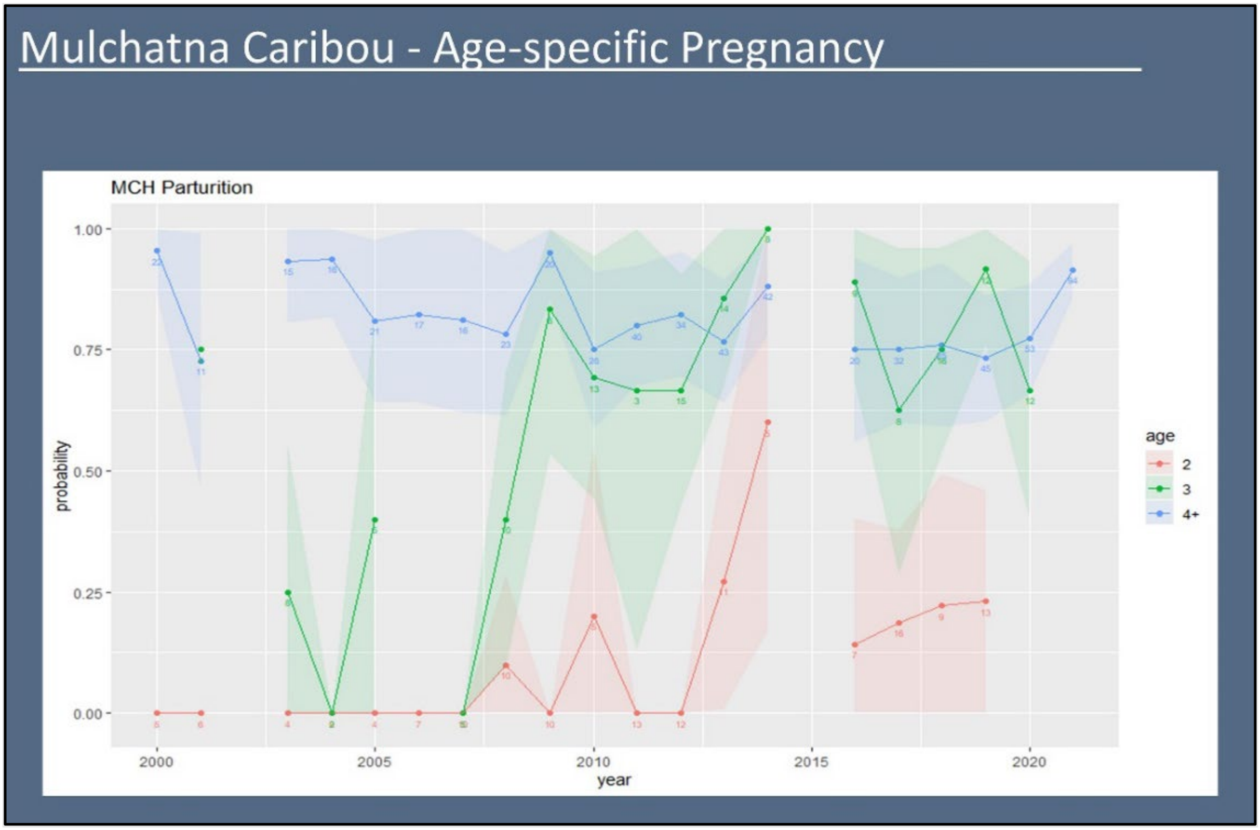

Figure 16. Mulchatna caribou herd (MCH) parturition probability by age during 2000–2020, southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022a: image 7). Sample sizes are near data points.

poor enough to constrain population growth in the Mulchatna caribou herd is unknown. Considering that parturition rates are moderately high, potential limitation to herd growth would likely be through the demographic parameters of cow and calf survival. Adult female survival has generally been good in the last decade, except in 2016 and 2017. The relationships between fall body condition, parturition the following spring, and calf recruitment multiple years later to breeding age is complex, largely because of the interacting factors that influence individuals between the time of the initial collection of body condition data and the subsequent events months to years later (personal communication [email], J. A. Crouse, Wildlife Physiologist, ADF&G, Soldotna, 5 September 2023). How nutrition relates to fitness measures and herd growth may be specific to unique circumstances of each herd and depend on changing conditions of range quality, weather (annual effect on forage biomass and nutritional quality, winter severity, and interactions with predators).

The 2 sources of data on the nutritional condition of MCH caribou (several years of birth rates and 1 year of ingesta-free body fat presented in January 2022) are subject to conflicting interpretations. Moderately high parturition cows indicate potential for the herd to grow. However, fall measurements of the body condition of cows was indicative of moderate nutritional limitation over summer, which indicate that limited forage could hinder population growth. Uncertainty in the nutritional condition of MCH caribou was an important consideration

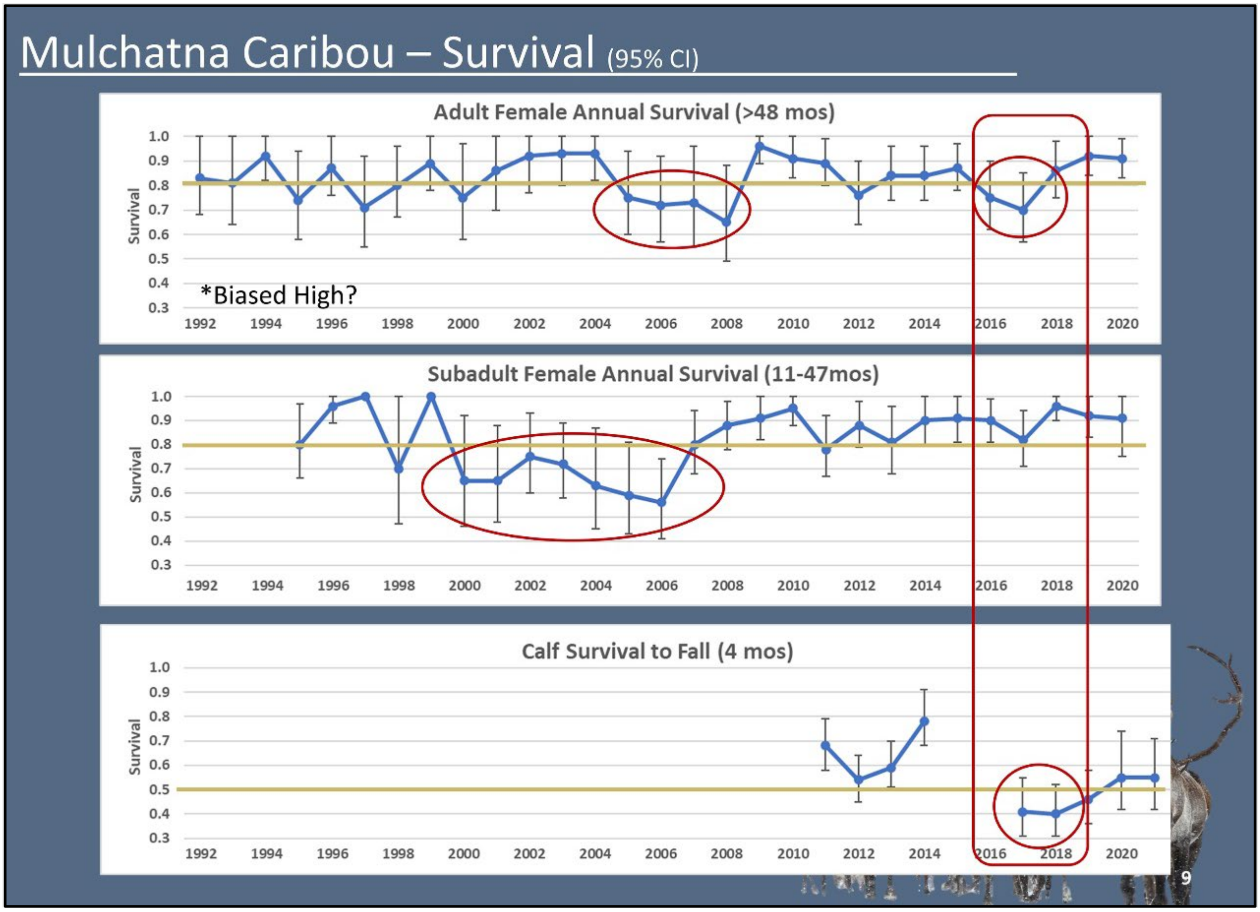

Figure 17. Mulchatna caribou survival with 95% confidence intervals (CI), southwest Alaska, as presented to the Alaska Board of Game (ADF&G 2022a: image 4). Red circles highlighted years of lower than average survival for the age classes indicated. Yellow lines indicate 80% survival for adults and 50% survival for calves, thresholds below which there is greater potential for herd decline. Failure of collars deployed on 10-month-old calves means these adult survival rates may be biased high because of older adults being censored.

by both the Alaska Board of Game and ADF&G in considering whether to proceed with adding bears to the intensive management (IM) Plan renewal in 2022 for 2023–2028 period (5 AAC 92.111, Register 242).

The decision to proceed in 2023 with predator control, including bears on the calving grounds, was based in part on the moderately high parturition rate for caribou that indicates potential for the herd to grow within constraints of nutrition that is potentially limiting calf fitness. The Mulchatna caribou herd is at its lowest abundance in the last 40 years despite high birth rates, and harvest has been closed for the last 3 hunting seasons. Predation is the only practical factor presently subject to management for increasing potential of modest herd growth.

A key factor that the department will consider in assessing the potential for nutritional limitation moving forward is the relationships of nutritional condition with reproduction, calf fitness, and herd growth rate. If after the spring 2023 predator control effort calves that survived in greater numbers fail to survive over winter, then the poor survival rate is likely a product of either poor nutrition or severe winter conditions, which in turn can predispose calves to a higher rate of predation (see discussion of compensatory mortality in Section 4).

4. Epizootic prevalence of brucellosis complicates management for herd recovery

Brucellosis occurs at enzootic levels (consistent with a 1–3% seroprevalence) in several Alaska caribou herds. Infection with *Brucella suis biovar 4* can cause in utero fetal death, abortions, still births, retained placentas, and calves of reduced weight and fitness particularly during the first pregnancy after infection. During parturition surveys (see Section 3), observations of females infected with brucellosis can give a positive bias to parturition rate based on presence of antlers or distended udders if calves were lost prepartum. Infections with *Brucella* spp. can also cause lameness, sterility, and increased susceptibility to other diseases. Clinical signs consistent with brucellosis infections in adults (carpal hygroma) were first observed in MCH during fall composition surveys in 2014, and in 2015 *Brucella suis biovar 4* was isolated from a harvested caribou.

Sampling of adult females occurred for the first time in the fall of 2020 (Fig. 18). Results from this sampling showed an antibody response indicating previous exposure to *Brucella* bacteria at a prevalence rate of >35% for the caribou samples subjected to standard screening tests. Subsequent sampling and testing revealed potentially increased and continuing exposure in the western group based on a small sample size (n = 57; Fig. 18). A retrospective analysis of serum that was collected from adult males for the first time in the fall of 2015 and later analyzed in 2021 confirmed the presence of elevated antibodies, indicating that exposure of >33% in adult males was present prior to 2015 (Beckmen 2021). These serum tests for antibodies indicate past exposure to the pathogen and an immunity response. Serum antibodies do not reveal exactly how long ago the exposure occurred, or if the exposure resulted in any disease in the animal (i.e., potential effect on fitness).

The 2 case studies of brucellosis reaching epizootic levels in Alaska caribou herds first exposed decades ago suggest that it can take 1–2 decades before the antibody prevalence decreases to an enzootic level (Beckmen 2021). There was little to no sampling of adult Mulchatna caribou prior to 2015, nor public or anecdotal reports of clinical signs, so it is not possible to determine when the outbreak and increased prevalence of exposure occurred in MCH (personal communication, Dr. K. B. Beckmen, Wildlife Veterinarian, ADF&G, August 2023, Fairbanks). Caribou with clinical signs were excluded from captures and collaring, thus the department cannot estimate a disease incidence rate (new infections), and the exposure rates extrapolated from positive antibody tests with increasing titers to date may be biased low.

Brucellosis infections in caribou and reindeer have the greatest negative impact on the female's first reproductive cycle after infection. This would be reflected in an increasing age at first reproduction, reduced parturition rates (especially in 2- or 3-year-old animals, which are the largest cohorts of breeding-age females), and poor calf survival. Pregnancies of *Brucella*-infected animals typically fail in the third trimester of the pregnancy resulting in abortions and still births. Note that the third trimester occurs before peak calving; thus, before biologists are in the field determining parturition rates. Those having stillbirths may still retain their antlers, or

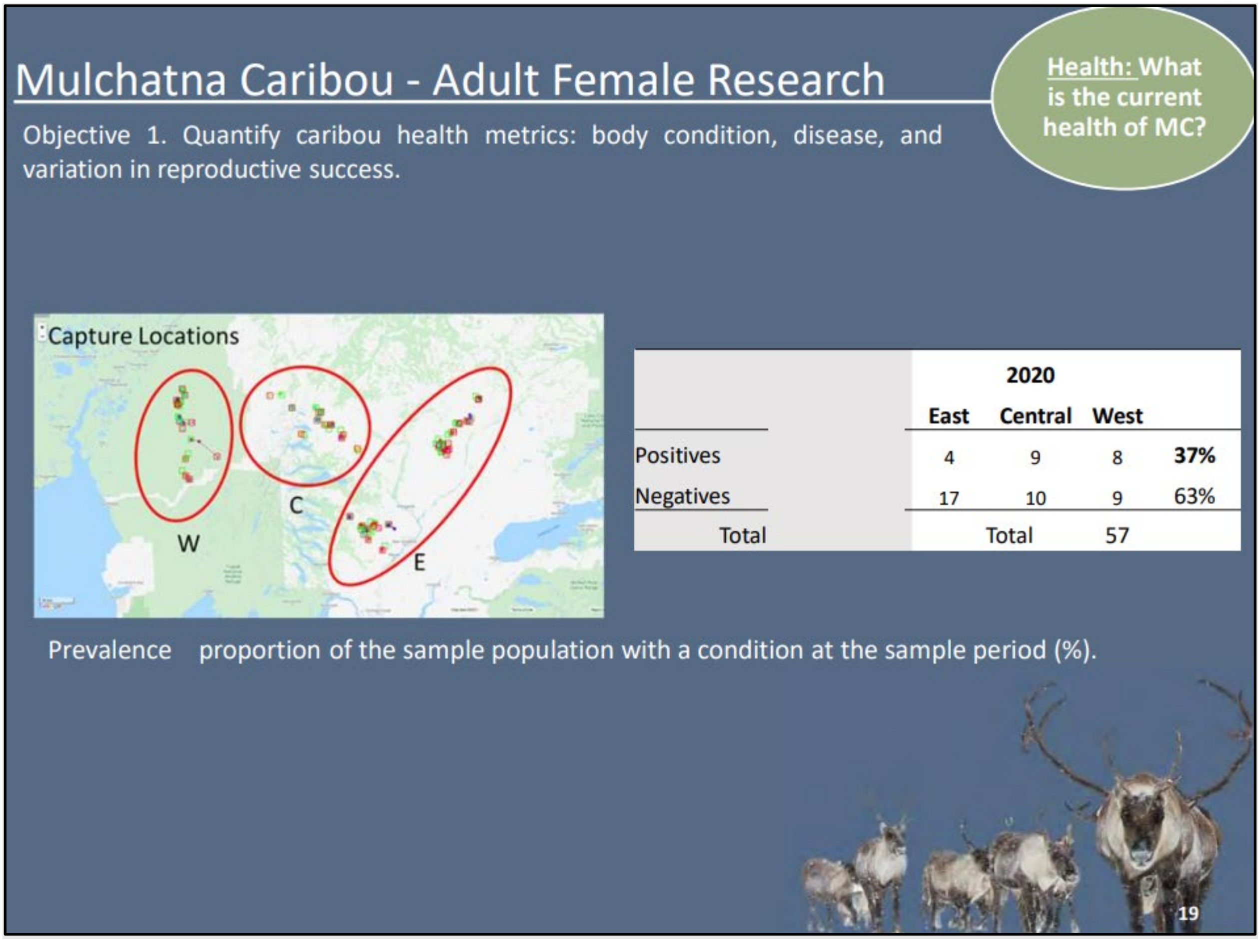

Figure 18. Health metrics for adult female Mulchatna caribou in 2020, southwest Alaska as presented to the Alaska Board of Game (ADF&G 2022a: image 19).

have visible udders, and may be counted as parturient in some surveys even though a calf at heel was not present. Scavenging would prevent the detection of aborted fetuses, still births, and weak calves that die shortly after birth. Thus, the suggested high birth rates implied by the parturition surveys of recent years (Section 3) are higher than what occurs in the population experiencing pregnancy losses due to high transmission and incidence of *Brucella* infections. If birth rates are high, then brucellosis is unlikely to reduce the potential for herd growth, although it could reduce survival of infected animals through other mechanisms (personal communication, Dr. K. B. Beckmen, Wildlife Veterinarian, ADF&G, November 2023, Fairbanks).

It is unknown if predator reduction to improve survival of noninfected calves during a brucellosis outbreak will offset compensatory mortality of infected calves to improve recruitment sufficiently for herd growth. Predation control in 2023 is an empirical test of a response in calf survival in the western group. However, the department lacks pretreatment data and the monitoring design needed to distinguish additive versus compensatory mortality (i.e., whether calves protected against predation will survive to reach breeding age and improve herd growth potential or will be more susceptible to another proximate source of mortality such as illness, malnourishment, winter starvation, or wolf predation). Understanding the role of disease in population dynamics is complex, requiring consideration of the mechanism for how prey regulation of abundance may be occurring. We can observe proximate causes of predation, but ultimate causes related to factors that make prey susceptible to predation (e.g., poor nutrition, disease, severe winters) can be harder to discern (e.g., McLellan et al. 2012), particularly in a remote area.

5. Uncertain historical size of the Mulchatna caribou herd relative to intensive management objectives

We considered whether the IM objectives for MCH are within the range of historic abundance. Early accounts of trade in hides and meat and landscape observations (e.g., incised migration trails) reviewed in management reports, ADF&G Subsistence Section reports, and other sources (e.g., Skoog 1968: 226–233, Hinkes et al. 2005) suggest that the maximum range occupied by MCH during its peak abundance in the 1990s had also contained abundant caribou in the mid-19th century, although multiple small herds may have occupied this large area rather than one large herd. When aerial minimum counts began in the late 1940s, MCH was considered small (approximately 1,000 caribou) and the ranges of other, smaller herds in the area were less defined. Increasing estimates of MCH numbers were reported with the use of systematic aerial surveys (approximately 14,000 caribou in 1974). In the early 1980s radio collars were first used to find groups during postcalving aggregations (approximately 20,000 caribou). This was prior to the documentation of the substantial increase in the herd over the following decade (late 1980s and early 1990s) as it expanded its range into areas that had likely not been grazed by caribou or reindeer for several decades or possibly over a century (Seavoy 2001:110). Changes in survey methods preclude inference on whether herd growth or better detection of existing caribou was responsible for the increase in estimated numbers of caribou up to the early 1980s.

Unlike peaks in abundance of other caribou herds in Alaska during the 1960s following effective federal wolf control in the 1950s (Valkenburg et al. 2016), the MCH did not increase until the 1980s. Federal agents conducted aerial shooting and used poison on wolves to benefit caribou on the Alaska Peninsula, but there is no evidence[1] it was done to any degree or extent in the Mulchatna range. Rabies epizootics in canids have been described for southwest Alaska. Van Daele (1997b) described perceived wolf declines in the 1970s and 1980s during periods of suspected rabies outbreaks among canids in Unit 17, as did Sellers et al. (2003) on the Alaska Peninsula (Units 9D and 9E). Whether low wolf abundance following a rabies epizootic allowed the irruption of the Mulchatna caribou herd to 200,000 animals by the 1990s is unknown.

6. Overharvest did not cause the decline of the Mulchatna caribou herd from its peak abundance

Section 3 reviewed how survival of subadult females and parturition rate of young females declined to low levels in the decade following peak herd abundance in the 1990s, which would affect population trend. Another factor to evaluate is harvest, which increased with herd size and as regulations (season lengths, bag limits, methods and means; e.g., Woolington 2001, Barten and Watine 2020) changed to allow more opportunity for harvest before subsequent harvest restriction as the herd declined (Fig. 19). Reported harvest by both residents and nonresidents

[1] Annual reports of the Alaska Game Commission to the U.S. Secretary of the Interior, 1948–1958

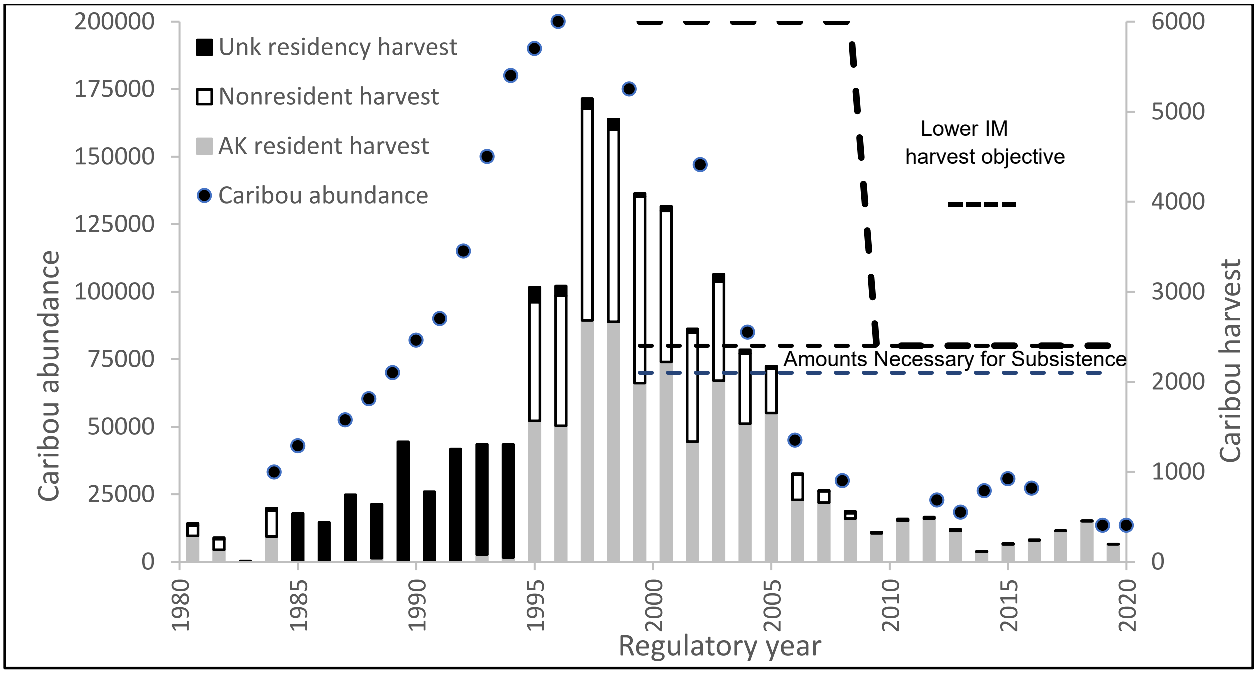

Figure 19. Abundance and reported harvest of Mulchatna caribou by hunter residency in southwest Alaska regulatory years 1980–2020. Amounts reasonably necessary for subsistence (ANS) are shown. Refer to text in this section (Section 6) for citations on regulatory changes in bag limit and hunt methods.

began to be consistently coded in 1996, at the peak of herd abundance. Reported resident harvest has consistently been more than reported nonresident harvest (Fig. 19), with the latter lower than expected during fall 1996 and fall 1997 because of caribou distribution (Woolington 1999).

To gauge the proportion of males and females harvested, we used fall composition data to estimate sex composition of the postcalving population in the 13 instances (years) when a photocensus was conducted between 1986 and 2017. Harvest rate averaged 0.6% (maximum of 1.5% in 2005) of the female population and 4.5% (maximum 10.0% in 2005) of the male population. Peak proportional harvest in 2005 occurred when the herd decline was slowly approaching 30,000 caribou around 2009. In theory, these rates should be sustainable, even during a decline, indicating other factors were driving the decline (e.g., nutrition and disease). Note that these are minimum estimates due to an unknown amount of unreported harvest and wounding loss. Since 2006 reported harvest has been far below the amounts reasonably necessary for subsistence uses (ANS) and almost entirely by residents of Alaska (Fig. 16).

Harvest reporting for MCH has been low, which can negatively bias annual estimates of yield rate (harvest versus prehunt population). Harvest data in the early 1980s suggested a reporting rate of only 16% among all MCH permits issued (additional unreported harvest outside of permits or hunters without licenses was not assessed). Most unreported harvest was believed to be during the December–March hunt, which is mostly utilized by residents (Woolington 1999). The proportion of reported female harvest in both fall and winter tended to be higher during the herd decrease phase after 1998 (23% of total harvest in fall, 43% in winter) than in the herd increase phase up to 1998 (12% in fall, 37% in winter). In general, harvest reporting has increased for ungulates over time, but it cannot be evaluated for harvest tickets that can be used on any caribou herd in the state. Most MCH harvest was by harvest tickets until 2013.

Wounding loss was noted during periods of abundant caribou and bag limits of multiple animals. Woolington (2001:39) described local resident concerns with caribou wounding during RY92 and RY93, when the Northern Alaska Peninsula herd and MCH were first observed to mix on winter range that neither herd had occupied before near the road and trail system by King Salmon. Wounding loss and unreported kill may have been 50% of total human-caused mortality for the MCH during the 1990s (personal communication [email], L. J. Van Daele, former board member, Alaska Board of Game, 18 January 2021); this level corresponds to estimates of unreported harvest in subsequent reports (Woolington 1999:26). Wounding loss cannot be objectively scored by residency category using the available data.

Unreported female harvest during the present hunting closure is a potentially important factor in herd recovery from current low abundance after the second decline in 2019. Harvest was restricted to bulls only in RY19, and to fall only in RY20 with a bag limit of 1 bull before a hunting closure starting in fall 2021. There were 57 collars deployed on adult (≥16-month old) females in fall 2020. Five of 10 subsequent mortalities were human caused, 2 were from bear predation (e.g., adult caribou predation noted in Boertje et al. 1988:2496, Table 3), and 3 were unknown but not predation (Alaska Department of Fish and Game 2022a:image20). This small sample size has high uncertainty but implies a potentially high rate of unreported female harvest, largely in the western group. Even if there is no trend in magnitude of unreported harvest, it can become a proportionally greater effect in hindering herd growth as population size decreases, particularly during a disease epidemic. Law enforcement authorities are aware of the issue, and data collection surrounding adult female survival and cause of mortality is ongoing.

Initial response to spring 2023 predator reduction and considerations for next steps

Removing 94 brown bears (82/1,000 mi^2) on the calving grounds of the MCH western group in spring 2023 represents an 80% reduction from the plausible 103 brown bears per 1,000 mi^2 in this localized area (Walsh et al. 2010). The actual reduction rate may be lower if bear density in 2023 was greater than in 2003–2004. Brown bear reduction in the spring 2023 predator control area (PCA; Fig. 1) was targeted on the active calving area where the recent bear harvest rate has been relatively low, including and surrounding the 2023 predator control area. A lack of decline in catch over time for brown bears in the 2023 western calving area during the spring 2023 predation control (Alaska Department of Fish and Game 2024:image 7) suggests that additional bears may have been temporarily immigrating to the calving grounds from immediately surrounding areas with potentially higher bear densities that are typical of coastal habitats with spawning salmon (e.g., Miller et al. 1997:Fig. 8).

Monitoring after the department's predation control provided evidence consistent with the control effort having a positive effect on MCH calf survival. In October 2023, fall composition surveys indicated 44 calves:100 cows in the western group (*n* = 1,840 caribou classified), the highest ratio for that group since data collection began in 1999 (average ratio 1999–2022 = 24:100; see Fig. 6 in Section 1; also Alaska Department of Fish and Game 2014:image 10). In comparison, the 2023 surveys indicated 32 calves:100 cows in the eastern group (n = 1,808) with the average ratio during 1999–2022 at 25:100. Whether this apparent improvement in summer calf survival for the western group that received predator control on the calving grounds in 2023 leads to higher annual survival to breeding age and caribou population growth remains to be seen.

As part of brucellosis surveillance for females known to be ≥30-months old in October 2023, staff handled a sample of 28 out of 60 total collared females in the western group and 27 out of 50 total collars in the eastern group. The ratio of lactating to nonlactating females in the western group was 16:12, which was not different from a ratio of 11:16 in the eastern group (chi-square = 1.48, *P-val* = 0.22).

Under present conditions of low caribou abundance, a moderately high apparent parturition rate for young females, high *Brucella* prevalence, and an apparent low calf recruitment to breeding age; passive management (i.e., without predation control) might require a continued harvest closure for several years in an effort towards herd recovery. Low female calf recruitment to breeding age during and after the lower adult female survival of 2016 and 2017 may have shifted the female segment to an older age structure where senescing individuals are inadequately replaced by young females. Where predation appears to be an important factor in limiting caribou herd growth for animals in good nutritional condition, research case studies have shown that improving survival of multiple, successive ungulate calf cohorts can allow population growth in the absence of multiple severe winters and disease (Gasaway et al. 1983, National Research Council 1997, Hayes et al. 2003). How the current prevalence of brucellosis and its trend may affect numeric response time and magnitude in the Mulchatna caribou herd is uncertain.

Sufficiently reducing the abundance of relevant predators (those affecting calf and adult survival of healthy caribou) for ≥2 years may stimulate modest growth of MCH during a prey-harvest closure. A short-term goal is to resume a limited subsistence harvest of bull caribou as progress toward reaching ANS (Fig. 19). Improved calf survival and herd growth are metrics for when to suspend predator control (5 AAC 92.111; Alaska Department of Fish and Game 2023a). If MCH begins to show continued growth potential after modest recovery (e.g., meeting the lower IM objective), then female harvest can be used to meet subsistence needs while slowing or stopping herd growth to reduce forage competition. Biological samples from harvested animals can complement research underway to better understand current habitat capacity for supporting caribou on seasonal ranges as climate trends affect changes in plant distributions (e.g., shrubs and trees invading tundra; Van Lanen et al. 2018:136–160, Macander et al. 2022). Habitat research will complement understanding of the relationship between caribou nutrition and parturition rate and how climate change may be affecting habitat suitability for caribou in the MCH range.

Additional Resources

Reports or publications of agency staff and board information are commonly available online:

- Management: http://www.adfg.alaska.gov/index.cfm?adfg=librarypublications.wildlifemanagement
- Research: http://www.adfg.alaska.gov/index.cfm?adfg=librarypublications.wildlifepublications
- Board of Game meeting information: http://www.adfg.alaska.gov/index.cfm?adfg=gameboard.meetinginfo
- Board of Game findings and policy: http://www.adfg.alaska.gov/index.cfm?adfg=gameboard.findings
- Intensive management: http://www.adfg.alaska.gov/index.cfm?adfg=intensivemanagement.main
- Subsistence (select by report type): http://www.adfg.alaska.gov/sf/publications/
- Habitat: https://www.adfg.alaska.gov/index.cfm?adfg=habitat_publications.main

Other reports or publications can often be found online through author and title searches in Google Scholar (https://scholar.google.com/) or the Alaska Resources Library and Information Service (https://www.arlis.org/).

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