Species Management Report and Plan ADF&G/DWC/SMR&P–2021–2

Central Arctic Caribou Management Report and Plan, Game Management Unit 26B:

Report Period 1 July 2012–30 June 2017, and

Plan Period 1 July 2017–30 June 2022

Elizabeth A. Lenart

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Alaska Department of Fish and Game Division of Wildlife Conservation

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PREPARED BY:

Elizabeth A. Lenart
Area Wildlife Biologist

APPROVED BY:

Doreen Parker McNeill
Management Coordinator

REVIEWED BY :

Ryan Klimstra
Regional Wildlife Biologist

Alyssa Crawford
Biometrician II

John Merickel
Biometrician III

PUBLISHED BY:

Sky Guritz
Technical Reports Editor

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Alaska Department of Fish and Game
Division of Wildlife Conservation
PO Box 115526
Juneau, AK 99811-5526

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Species management reports and plans provide information about species that are hunted or trapped and management actions, goals, recommendations for those species, and plans for data collection. Detailed information is prepared for each species every 5 years by the area management biologist for game management units in their areas, who also develops a plan for data collection and species management for the next 5 years. This type of report is not produced for species that are not managed for hunting or trapping or for areas where there is no current or anticipated activity. Unit reports are reviewed and approved for publication by regional management coordinators and are available to the public via the Alaska Department of Fish and Game's public website.

This species management report and plan was reviewed and approved for publication by Doreen Parker McNeill, Management Coordinator for the Division of Wildlife Conservation.

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Cover Photo: A group of Central Arctic caribou photographed during the July 2017 photocensus. ©2017 ADF&G. Photo by Nate Pamperin.

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Purpose of this Report

This report provides a record of survey and inventory management activities for Central Arctic caribou in Unit 26B for the 5 regulatory years 2012–2016 and plans for survey and inventory management activities in the following 5 regulatory years, 2017–2021. A regulatory year (RY) begins 1 July and ends 30 June (e.g., RY14 = 1 July 2014–30 June 2015). This report is produced primarily to provide agency staff with data and analysis to help guide and record agency efforts but is also provided to the public to inform it of wildlife management activities. In 2016 the Alaska Department of Fish and Game's (ADF&G, the department) Division of Wildlife Conservation (DWC) launched this 5-year report to more efficiently report on trends and to describe potential changes in data collection activities over the next 5 years. It replaces the caribou management report of survey and inventory activities that was previously produced every 2 years and supersedes the 1976 draft management plans (Alaska Department of Fish and Game 1976).

I. RY12–RY16 Management Report

Management Area

The management area for the Central Arctic caribou herd includes eastern portions of the Arctic Slope, Brooks Range, and northeastern Interior Alaska, including all or portions of Game Management Units 24A, 24B, 25A, 26A, 26B, and 26C (52,191 mi^2).

Summary of Status, Trend, Management Activities, and History of Central Arctic Caribou in Unit 26B

In the mid-1970s the Central Arctic caribou herd (CAH) was recognized as a discrete herd, and in 1975, the population was estimated to be 5,000 caribou (Cameron and Whitten 1979). By 1983, the CAH increased to approximately 13,000 caribou. The herd continued to grow and by 2000, the herd size increased substantially and was estimated to be more than 29,000 animals. In 2010, the herd peaked at an estimated 68,500 caribou (Fig. 1). The growth in herd size during 2000–2010 was due to low adult mortality, high parturition rates ($\geq$ 91%), and good fall calf recruitment.

The Central Arctic caribou range encompasses the eastern North Slope coastal plain from just west of the Colville River to the Canadian border, the north side of the Brooks Range from the Itkillik River to the Canadian border, the south side of the Brooks Range from approximately the North Fork Koyukuk River to the East Fork Chandalar River, and as far south as the Chandalar River valley (Fig. 2). The Central Arctic caribou herd (CAH) traditionally calves between the Colville and Kuparuk rivers on the west side of the Sagavanirktok River and between the Sagavanirktok and the Canning rivers on the east side (Fig. 2). During the early 1990s, the greatest concentration of caribou that calved in western Unit 26B shifted southwest as development of infrastructure related to oil production occurred in what was originally a major calving area (Lawhead and Johnson 2000; Wolfe 2000). No directional shift in the distribution of caribou that calved east of the Sagavanirktok River was noted (Wolfe 2000). The CAH summer range extends from just west of the Colville River, eastward along the coast (and inland approximately 30 miles) to the Canadian border (Fig. 2). The CAH winters mostly in the northern and southern foothills and mountains of the Brooks Range with some caribou wintering on the coastal plain (Fig. 2). The herd's range often overlaps with the Porcupine caribou herd (PCH) on summer and winter range to the east, and with the Western Arctic (WAH) and Teshekpuk (TCH) herds on summer and winter range to the west (Fig. 3).

Within the range of CAH, oil exploration and development began in the late 1960s and remains active today. Beginning in the late 1970s, the Alaska Department of Fish and Game (ADF&G) implemented long-term studies on population dynamics, distribution, movements, and effects of development on CAH. During the 1980s, calving activity was rare in the Prudhoe Bay oil field, where it was known to occur before development (Whitten and Cameron 1983). By the mid-1980s, major movements of CAH caribou through the Prudhoe Bay oil field in summer had ceased, and caribou distribution and movements within the Kuparuk oil field were altered substantially (Smith and Cameron 1983, 1985a, 1985b; Whitten and Cameron 1983, 1985; Curatolo and Murphy 1986). In addition, cows and newborn calves were underrepresented along the trans-Alaska pipeline corridor and around oil production facilities in the early 1990s (Cameron and Smith 1992; Cameron et al. 1992). In the mid-1990s, research on CAH was reduced substantially, and efforts were focused on monitoring population parameters and their relationship to management objectives. During the mid-1990s, some of CAH management goals and objectives were developed in response to concerns arising from research conducted during 1978–1993. Based on the hypothesis that displacement of enough magnitude would be harmful to CAH (Cameron 1983), ADF&G biologists worked with the oil industry to minimize disturbance to caribou movement due to physical barriers created by oil development. In addition, given that stress is cumulative, the Alaska Board of Game reduced hunting activity in areas adjacent to the oil field and the Dalton Highway and restricted cow harvest through the late 2000s. The population grew substantially during the mid-1990s through 2010. In 2010 the cow season was liberalized and the bag limit was increased for both resident and nonresident hunters.

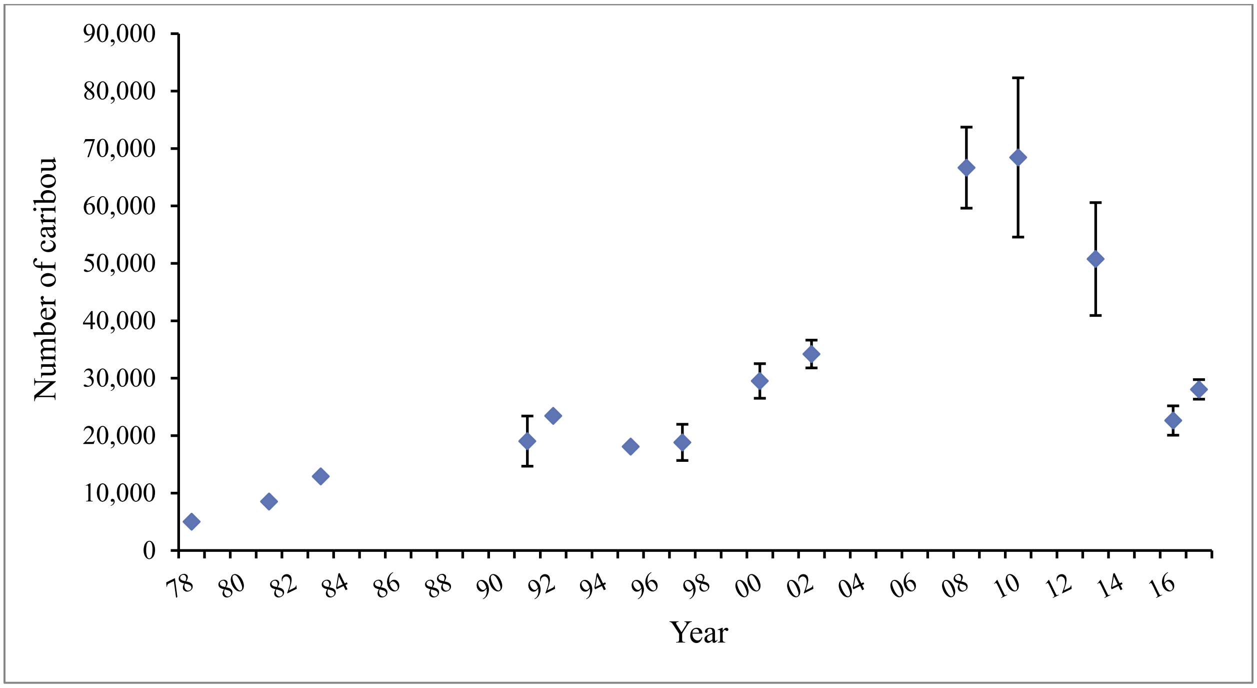
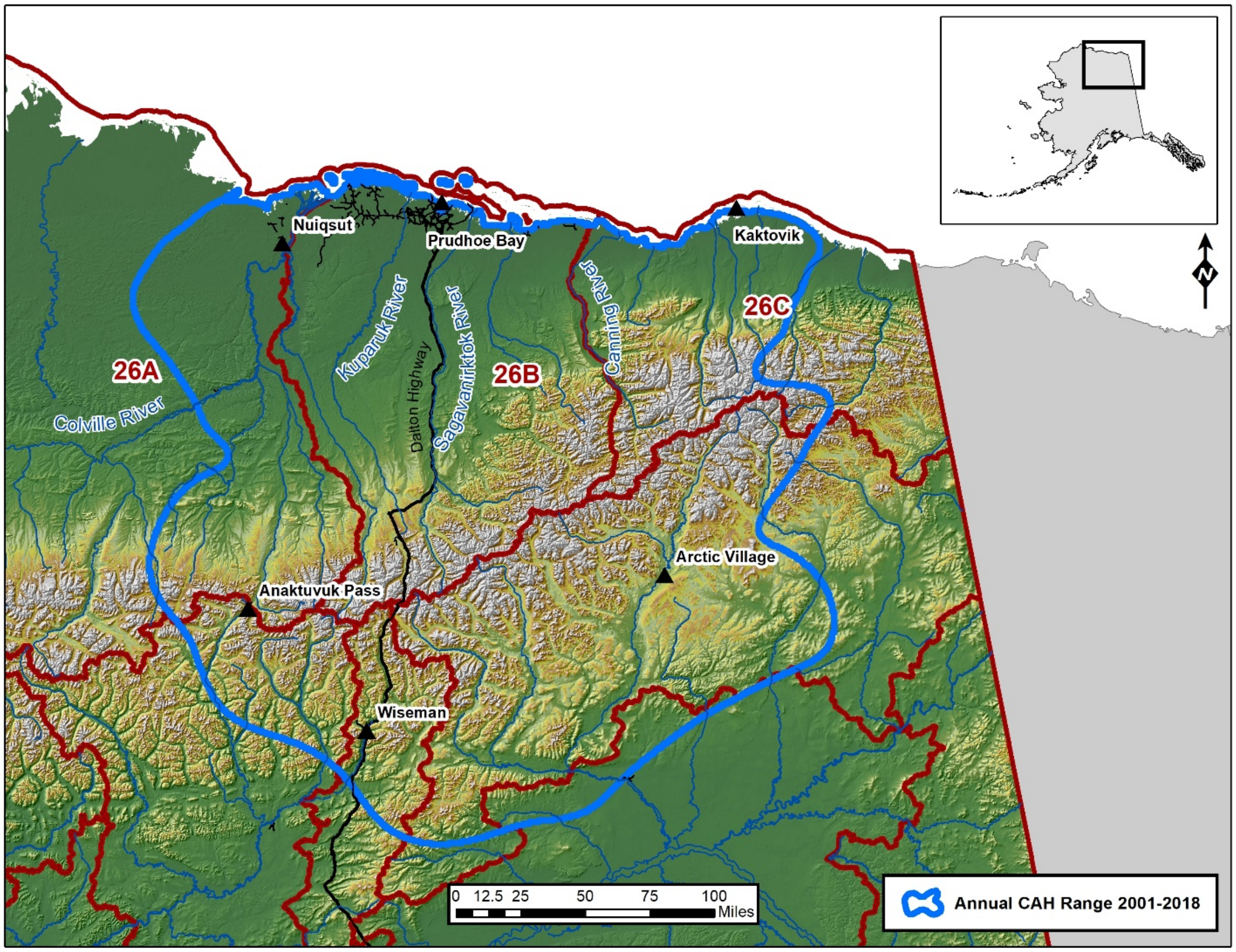
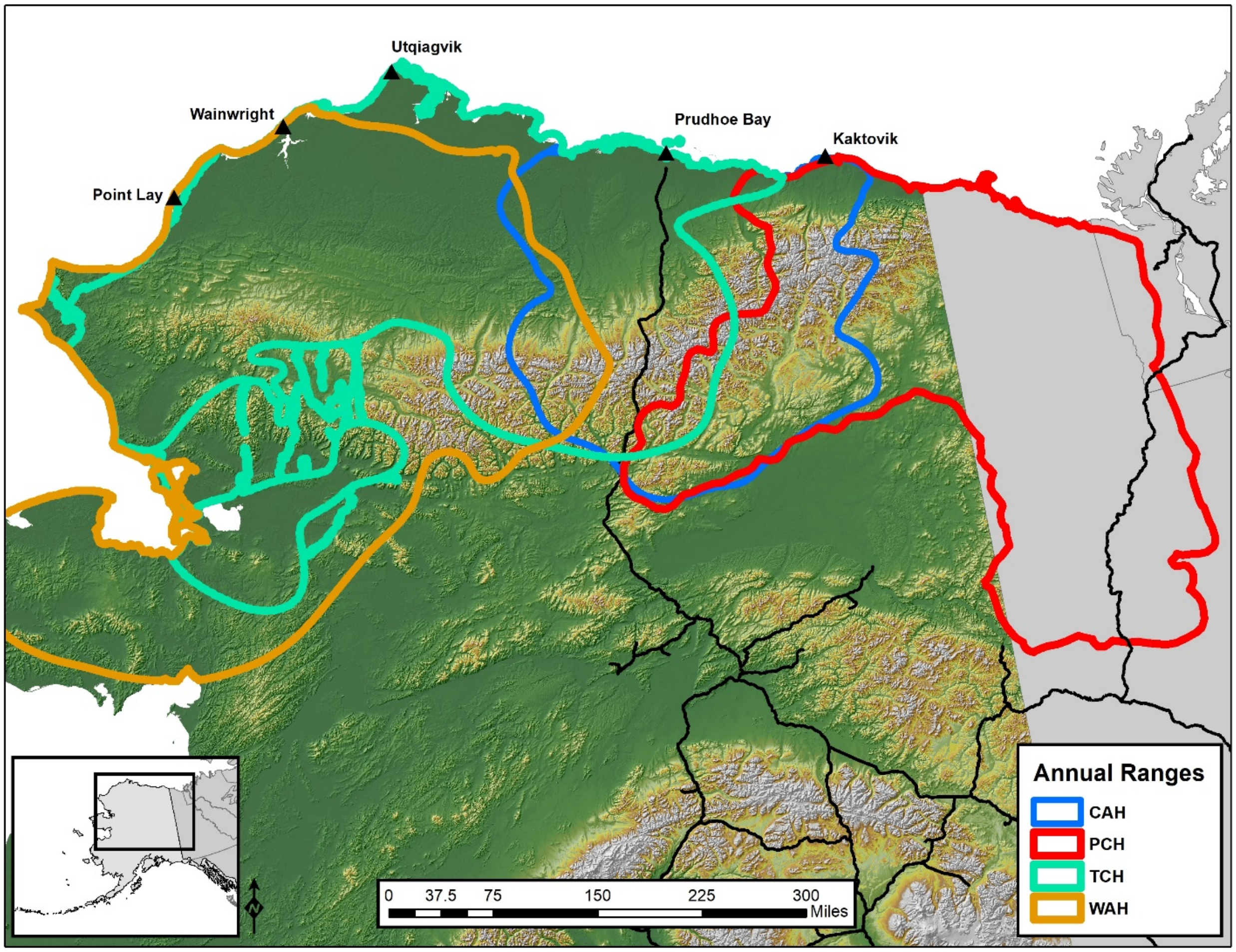


Figure 1. Central Arctic caribou population size, 1979–2017. Blue diamonds for years 1997–2017 represent Rivest population estimates with 95% confidence intervals represented by the solid error bars. For 1991, the point estimate is from a random stratified quadrat survey with 95% confidence interval (CI). All other years represent minimum counts of caribou observed from a photocensus.



Data source: ADF&G, ABR Inc., AKDOT, ESRI, USGS

Figure 2. Annual range of the Central Arctic Caribou herd, 2001–2018. Data is from fixed kernel analysis of locations of satellite radio collard females, at the 99% utilization distribution contour.



Data source: ADF&G, AKDOT, ESRI, USGS.

Figure 3. Annual ranges of the Western Arctic (WAH), Teshekpuk (TCH), Central Arctic (CAH), and Porcupine caribou herds (PCH), Alaska.

Management Direction

Existing Wildlife Management Plans

This document outlines the current plan for the CAH in Units 24A, 24B, 25A, 26A, 26B, and 26C. Previous management direction has been documented in the Central Arctic caribou management reports of survey and inventory activities (Lenart 2015).

Goals

G1. Minimize the adverse effects of development on CAH caribou.

G2. Provide the opportunity for a subsistence harvest of CAH caribou.

G3. Maintain opportunities to view and photograph CAH caribou.

Codified Objectives

Amounts Reasonably Necessary for Subsistence Uses

C1. The Central Arctic caribou herd has a positive finding by the Board of Game for customary and traditional uses of game populations (5 AAC 99.025) as a population that has been taken or used for subsistence with the amounts reasonably necessary for subsistence (ANS) set at 250–450 caribou.

Intensive Management

C2. The intensive management (IM) population objective for CAH is 28,000–32,000 caribou.

C3. The IM harvest objective for CAH is 1,400–1,600 caribou.

Management Objectives

M1. Maintain a population of at least 28,000–32,000 caribou (G1, G2, and G3).

M2. Maintain accessibility of seasonal ranges for CAH caribou (G1, G2, and G3).

M3. Maintain a harvest of at least 1,400 caribou if the population is ≥ 28,000 caribou (G2).

M4. Maintain a ratio of at least 40 bulls:100 cows (G1, G2, and G3).

M5. Reduce conflicts between consumptive and nonconsumptive uses of caribou along the Dalton Highway (G2 and G3).

Management Activities

1. Population Status and Trend

Activity 1.1. Capture and deploy 10–20 radio collars on yearling females, and 10–20 radio collars on both adult females and males combined annually. Maintain at least 30 radio collars on adult females and 10 radio collars on adult males. Conduct disease assessment. (M1, M2, M3, M4, C1, C2, and C3)

Data Needs

To maintain a population of at least 28,000–32,000 caribou, accessibility of seasonal ranges, and a bull-to-cow ratio of at least 40:100, it was necessary to deploy radio collars on CAH. Radiocollaring these caribou enabled ADF&G area management staff to monitor the herd; determine mortality/survival rates; map seasonal distribution of caribou; and locate caribou for photocensuses, parturition surveys, and fall composition surveys. Capturing CAH caribou provides the opportunity to collect blood and feces which aid in developing a disease monitoring program for CAH in the future.

Methods

CAPTURES

Caribou were captured using a handheld netgun operated from an R-44 helicopter, and manually restrained with hobbles and a blindfold-hood while we collected measurements and fitted the radio collars. During 2013–2016 caribou were captured in late April; during 2013–2015, 11-month-old female calves were weighed. Only adult females were captured in April 2016. In 2016 and 2017, caribou were captured in late June, and yearling female calves were only weighed in 2017. ADF&G staff assessed general body condition on all caribou as either very poor, poor, average, good, or very good. We recorded sex (male or female) and age as 11-month-old calf (short yearling), yearling, or adult. We recorded latitude, longitude, and general location of capture. We weighed short yearlings and yearlings. A classic linear regression model was used to test for trend on annual mean weights of 11-month-old female calves weighed during 2009–2015.

PATHOGEN AND MINERAL ANALYSES

In 2015 and 2017, blood was drawn from a total of 46 adult female caribou in April. Serum samples were screened for Influenza A (IAV) antibodies using a commercially available blocking enzyme-linked immunosorbent assay (IDDEX Laboratories, Westbrook, Maine; Van Hemert et al. 2019).

ADF&G staff drew blood from 25 adult females in April 2017, and 22 females (12 yearlings and 10 adults) in late June. Blood samples were submitted to several laboratories for pathogen and mineral analysis across the country. Serum was tested for Brucella suis biovar 4, *Chlamydophila* spp., contagious ecthyma virus, and *Coxiella burnetii* antibodies at USDA National Veterinary Services Laboratories (Ames, Iowa). Serum (in Serum Separator Tubes (SST®)) was tested for Bovine respiratory disease complex viruses and Leptospirosis antibodies at Wyoming State Veterinary Laboratory (WSVL; Laramie, Wyoming). Serum analysis for trace elements as well as whole blood testing for selenium was also conducted at WSVL. Serum was tested for vitamin B12/cobalamin at Cornell University Animal Health Diagnostic Center (Ithaca, New York). Both the Gastrointestinal Laboratory at Texas A & M Veterinary Medicine and Biomedical Sciences (College Station, Texas) were used to test for methylmalonic acid (MMA) to aid in determining and interpreting if there were trace element impacts resulting from heavy parasitic loads. Serum and plasma haptoglobins (a nonspecific biomarker of inflammation) and ceruloplasmin (biomarker associated with low copper status) were sent to Kansas State Veterinary Diagnostic Laboratory (Manhattan, Kansas). Serum was also tested at the Acute Phase Protein Laboratory at the University of Miami (Miami, Florida) for haptoglobins and serum amyloid A using gel electrophoresis, a process which extracts and separates proteins, to further identify the course of inflammatory conditions and to determine associations with pregnancy and other conditions.

In 2017, nasal swabs in phosphate buffered saline (PBS) and universal transport media (UTM) were collected and vagina swabs in Viral-Chlamydial-Mycoplasma (VCM) and UTM were collected from 23 (PBS) and 24 (VCM) adult females captured in April and from 19 females (11 yearlings and 8 adults) captured in late June. Samples were submitted to USDA Agricultural Research Service (Pullman, WA) to test for *Mycoplasma ovipneumoniae*, and to Wyoming State Veterinary Laboratory (WSVL; Laramie, Wyoming) to test for cervid adenovirus via PCR.

Results and Discussion

CAPTURES

2013—During 21–23 April, ADF&G staff deployed 35 radio collars on CAH, including 12 Global Positioning System (GPS) satellite radio collars with very high frequency (VHF) deployed on adult females ≥ 2-years old, 3 VHF-only radio collars deployed on males ≥ 2-years old, and 20 VHF-only radio collars deployed on 11-month-old females. Radio collars were deployed on the south side of the Brooks Range between the Dalton Highway and the East Fork Chandalar River, north of the North Fork Chandalar valley. Eighteen caribou were reported in average condition, 17 in good condition, and 1 in very good condition. On 29 June 2013, 3 VHF radio collars were deployed on adult females ≥ 2-years old near Badami oil field. Condition of caribou was not recorded in June.

2014—During 17–19 April, ADF&G staff deployed 51 radio collars on CAH including 13 GPS satellite radio collars with VHF on adult females ≥ 2-years old, and VHF-only radio collars on 2 males ≥ 2-years old, 2 female yearlings who were almost 2-years old, 21 on 11-month-old females (short yearlings), and 13 on adult females. Radio collars were deployed on the south side of the Brooks Range between the Dalton Highway and the East Fork Chandalar River, north of the North Fork Chandalar valley. Twenty-four of these caribou were reported in good condition. In addition, on 28 June 2014, we deployed 10 GPS satellite radio collars on adult females ≥ 2-years old south of Badami-Bullen Point and on the Kadleroshilik pingo. Condition of caribou was not recorded.

2015—During 20–26 April, we deployed 56 radio collars on CAH caribou. Thirty-three GPS satellite radio collars were deployed on adult females ≥ 3 years old. Twenty VHF-only radio collars were deployed on short yearling females (approximately 11 months old) and 3 were deployed adult males ≥ 2 years old. Ten caribou were reported in poor condition, 9 as average, and 32 in good condition.

All the radio collars were deployed on the south side of the Brooks Range between Twin Lakes and the Middle Fork Chandalar River. Because the PCH had been wintering in the same vicinity, we focused on groups that had only Central Arctic radio collars to minimize deploying radio collars on Porcupine caribou. By 20 April 2015, most of the PCH radio collars had moved to the East Fork Chandalar River and some further east into the Sheenjek River. Subsequent radiotracking during calving indicated that our strategy to collar caribou from groups with only CAH radio collars did not work. We estimated approximately 37% (n = 52; 4 mortalities occurred prior to calving) of the caribou that we radiocollared went with the PCH during spring migration. These were either originally PCH caribou or CAH caribou that followed PCH because there were so many more Porcupine caribou than Central Arctic caribou.

2016—During 25–28 June, we deployed 47 radio collars on CAH caribou (22 GPS satellite with VHF, and 25 VHF-only). Twenty-two GPS satellite radio collars were deployed on adult females ≥ 3 years old, 20 VHF-only radio collars were deployed on yearling females, and 5 VHF-only radio collars were deployed on adult males ≥ 2-years old. All radio collars were deployed in Unit 26B near the Kuparuk and Kadleroshilik rivers, and the Sagavanirktok River Delta, except for 1 recapture which was in the Sadlerochit Mountains. Condition of caribou was not recorded in 2016.

2017—During 18–19 April, we deployed 25 GPS satellite radio collars with VHF on adult CAH females ≥ 3 years old throughout Unit 26B. Fourteen caribou were reported in average condition and 11 in good condition.

During 27–29 June, we deployed 50 GPS radio collars on CAH caribou. Nineteen were deployed on adult females ≥ 3 years old, 13 were deployed on adult males ≥ 2 years old, and 18 radio collars were deployed on yearling females. All radio collars were deployed in Unit 26B near Kuparuk, White Hills, Itkillik Hills, Sagavanirktok River Delta, Bullen Point, and the Canning River. Twenty-four caribou were reported in average condition and 23 in good condition.

ELEVEN-MONTH-OLD CALF AND YEARLING WEIGHTS DURING 2013–2017

The mean weight of 11-month female calves taken in April of each year was 41.1 kg (90.7 lbs, *n* = 22, range = 34.4–60.0 kg (75.8–132.3 lbs)) in 2013, 43.0 kg (94.7 lbs, *n* = 22, range = 33.4–56.6 (73.6–124.8 lbs)) in 2014, and 41.4 kg (91.3 lbs, *n* = 20, 31.6–52.1 kg (69.6–114.9 lbs)) in 2015. Extensive mixing with the Teshekpuk (TCH) and Porcupine (PCH) caribou herds occurred in April during these years, making it impossible to determine if the weighed animal was CAH, PCH, or TCH; although we attempted to capture animals that were with other radiocollared CAH.

Even though we were unable to truly identify if the weighed caribou was a Central Arctic herd animal, and recognizing that the annual sample sizes were small (< 25), we tested for a trend in annual mean weights of 11-month-old female calves during 2009–2015. Results of the linear regression model indicated that there was a nonsignificant trend (-0.28 kg/year (-0.62 lbs/year), standard error (SE) = 0.285, *P*-value = 0.33; Fig. 4).

The mean weight of yearling (approximately 13-month-old) females in June 2017 was 45.7 kg (100.8 lbs; *n* = 20; range = 36.1–51.9 kg (79.5–114.5 lbs)).

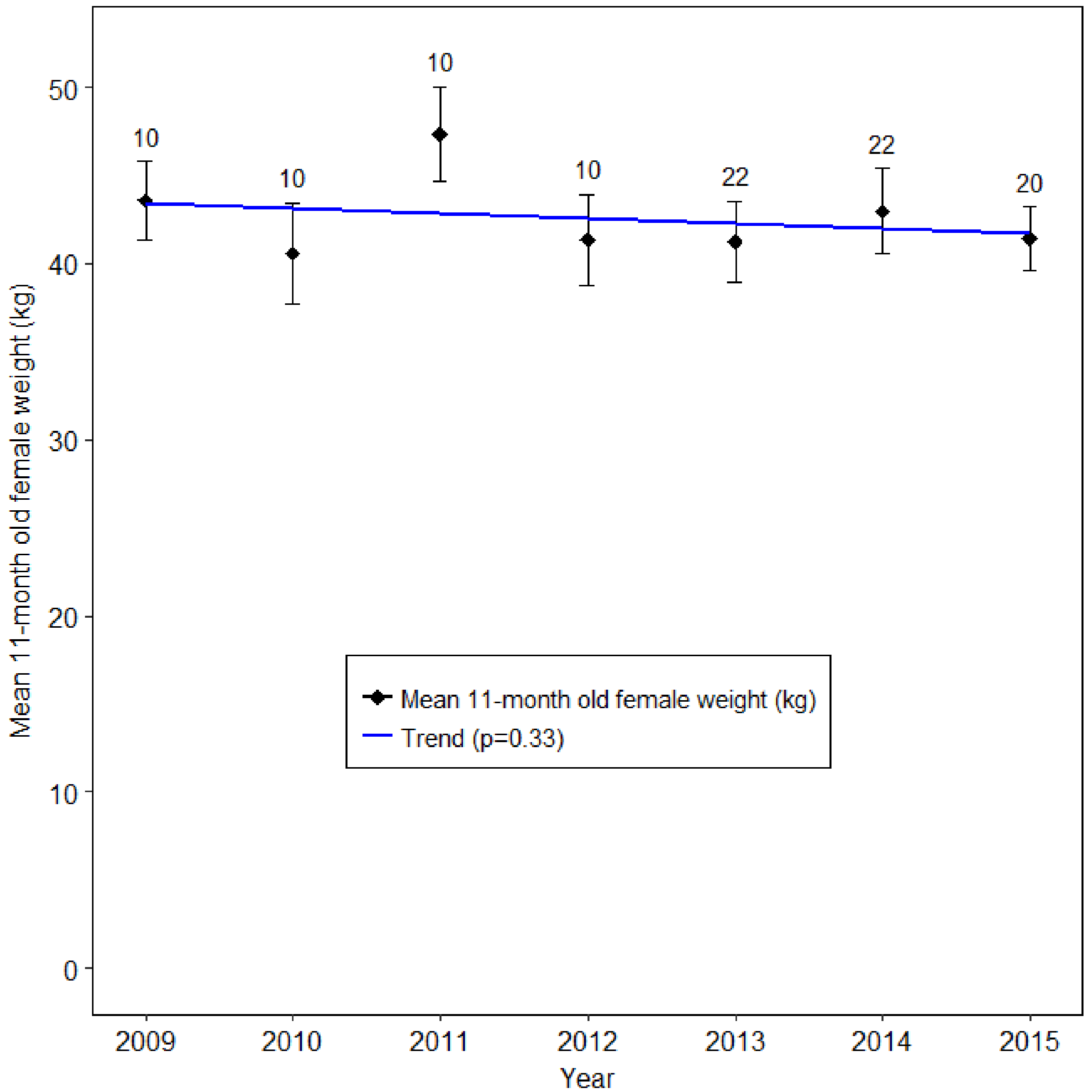


Figure 4. Mean weights and 95% confidence interval (CI) for 11-month-old females in Central Arctic caribou herd, 2009–2015 using a linear regression model to test for trend. Number above black diamonds indicate sample size for that year. Trend is nonsignificant.

PATHOGEN EXPOSURE AND MINERAL ANALYSES:

To investigate the health status of the CAH population, ADF&G monitored potential exposure to viruses by measuring antibodies with accredited veterinary diagnostic laboratory tests that were validated for cattle. We recognized that we did not have validated tests for caribou, and some of the assays were detecting cross reacting antibodies for other potential pathogens, however, this will serve as baseline data which is important to acquire when assessing wildlife disease or pathogen exposure to domestic animal or wildlife pathogens. With this baseline data, it will be possible to follow through time and investigate disease events or population changes, determine if the specific pathogen is involved, and evaluate new and specific biomarkers which are useful indicators of health. Once a baseline is established, it will then be possible to examine the tests for significant changes in the prevalence of antibodies, the introduction of pathogens not previously detected, or increasing inflammatory indicators. From there, it would be possible to compare CAH data with data from other caribou herds that are known to be increasing in size or have known health issues. In the future we will evaluate trends and changes in prevalence or health status over time to determine if a pathogen or disease is having a population level effect. Overall, results indicated that in 2017 there was not a significant change in the parameters and antibodies measured that was significant enough to explain a negative population level effect on the Central Arctic caribou herd.

Chlamydiophila spp., Contagious Ecthyma, and *Coxiella burnetii*—40 female caribou captured in April (21 adults) and in June (11 yearlings and 8 adults) were tested for antibodies against *Chlamydiophila* spp., contagious ecthyma, and *Coxiella burnetii.* Two females (1 adult female captured in April and 1 yearling female captured in June) tested positive (7.5%) for *Chlamydiophila* (positive at 1:16 for both). No caribou tested positive for contagious ecthyma. One adult female captured in April tested positive (2.5%) for *Coxiella* (positive at 1:10). The prevalence of antibodies found for *Chlamydiophila* spp. and C. *burnetii* were within the expected range for caribou in Alaska monitored previously (K. Beckmen, ADF&G Wildlife Veterinarian, DVM, personal communication). These diseases can affect reproduction by causing abortion or predisposing the cow to mastitis.

Leptospirosis—Thirty-eight female caribou captured in April (20 adults) and in June (10 yearlings and 8 adults) were tested for *Leptospira* serovars: *L. canicola*, *L. grippo*, *L. hardjo*, *L. ictero*, and *L. Pomona*. All test results (< 1:100) were within the expected range (> 1:5 is considered positive; K. Beckmen, ADF&G Wildlife Veterinarian, DVM, personal communication). These bacteria can cause kidney and liver disease, and abortion.

Respiratory Viruses— Thirty-nine female caribou captured in April (19 adults) and in June (12 yearlings and 8 adults) were tested for antibodies against bovine viral diarrhea virus (BVDV) type 1 and BVDV type 2 (*Pestivirus A* and *Pestivirus B,* respectively), infectious bovine rhinotracheitis (documented to be a cross reaction detecting an alpha herpes virus, cervid herpesvirus 2 (CvHV2)), parainfluenza 3 (PI3), and respiratory syncytial virus (RSV)). A positive antibody titer indicates an exposure and an immune reaction to an antigen but does not necessarily indicate disease occurred. These assays have not been validated in caribou, so it is not known which virus exposure is causing the immune response except for CvHV2. Therefore, linear trends in prevalence of exposure have been traditionally monitored.

- *Pestivirus A* by Serum Neutralization (SN)—Of the 39 caribou tested, 4 caribou (10.3%) had antibody titers indicative of exposure to this virus (≥ 1:128 is considered positive). It is unknown which *Pestivirus* is being detected, but it is a *Pestivirus* that is most similar to Border disease virus (BDV) which is now referred to as *Pestivirus C*. The prevalence rate found in this survey was half the rate of the last survey (26.8%; *n* = 41; 2008–2010), and therefore was not an issue for this herd during this reporting period. Wildlife Health and Disease Surveillance Program staff at ADF&G have indicated that there was an increased exposure to *Pestivirus* during 2007–2010, and possibly a disease outbreak just prior to 2007 (K. Beckmen, ADF&G Wildlife Veterinarian, DVM and C. Lieske, DVM, MPVM, personal communication).

- *Pestivirus B* by Serum Neutralization (SN)—Of the 39 caribou tested, 1 individual (2.6%) had antibody titers (≥ 1:128 is considered positive). We do not know which *Pestivirus* is being detected, but it appears to be similar to BVDV type 2 SN. The number falls within the expected range of prevalence (K. Beckmen, ADF&G Wildlife Veterinarian, DVM, and C. Lieske, DVM, MPVM, personal communication).

- Cervid Herpesvirus 2 (CvHV2)—Of the 39 caribou tested, 2 individuals (5.1%) were ≥ 1:64, indicating some presence of antibodies, but the prevalence rate falls well below the historic prevalence (8–18%; 1975–1982) and is now indicative of a low-level enzootic pathogen (K. Beckmen, ADF&G Wildlife Veterinarian, DVM, personal communication).

- P13 by Serum Neutralization— Of the 39 caribou tested, 4 individuals (10.3%) had titers ≥ 1:128 and fell within the range of prevalence found in 1988, when antibodies were first detected (n = 38; 10.5%). The herd had been negative from 1975 until 1988. The prevalence dropped dramatically in 1989 and 1990, to 1.6% and 2.4%, respectively. This increase in exposure or susceptible animals is indicative of a disease outbreak which likely occurred in 1988. This virus was probably introduced from cattle, and is now enzootic in most Alaska bison, caribou, and moose populations; it is likely a contributing factor to disease when stressors increase, or additional pathogens or parasites are introduced. The current increase in seroprevalence is a concern, but it does not directly explain depressed population recruitment (K. Beckmen, ADF&G Wildlife Veterinarian, DVM, personal communication).

- BRSV by Serum Neutralization— Of the 39 caribou tested, 4 individuals (10.2%) had a positive antibody titer (≥ 1:32 is considered positive). We do not know which virus is being detected but is likely a virus that causes syncytial cells to be formed. Given that all immunohistochemical (IHC) and PCR tests are negative, BRSV does not appear to be the virus responsible for the positive titer. The prevalence has been much lower in the past. From 1975 to 2010 there were 240 negative tests with only 2 positive tests (6%) in 1987 and 1 positive test (2.4%) in 1990. This indicates that the exposure to the pathogen occurred in 1987. However, it is not enzootic and the current 10.2% prevalence is above the expected range, indicating a potential recent outbreak. (K. Beckmen, ADF&G Wildlife Veterinarian, DVM and C. Lieske, DVM, MPVM, personal communication).

Further work in the wildlife disease arena is needed to be able to determine which virus is being detected in diagnostic lab tests.

Brucella Suis Biovar 4— There were 43 total female caribou captured and tested for Brucella in April (22 adults) and in June (12 yearlings and 7 adults); all tested negative. Brucella can cause a decrease in reproduction.

Trace Minerals—Thirty-six female caribou that were captured in April (17 adults) and June (7 adults and 12 yearlings) and serology from these animals were tested for the following trace minerals: selenium, iron, copper, zinc, manganese, and molybdenum. Normal reference ranges were not available.

- Selenium—ranged 0.142–0.351 ppm.

- Iron—ranged 0.68–3.04 ppm.

- Copper—ranged 0.231–0.737 ppm.

- Zinc—ranged 0.003–0.94 ppm.

- Manganese was < 0.006 ppm for all 36 females.

- Molybdenum was < 0.05 ppm for all 36 caribou.

Haptoglobin, Ceruloplasmin—In April and June, 35 female caribou were captured. Blood plasma samples were sent to Kansas State Veterinary Diagnostic Laboratory (KSVDL) where they were tested for haptoglobin and plasma ceruloplasmin. Results from the plasma haptoglobin test indicated that 7 caribou (20%) had elevated levels of haptoglobins (> 60 mg/dL); however, 2 were known to be pregnant, 2 were of unknown pregnancy, and 3 were yearlings. Results from the ceruloplasmin indicated that 1 caribou (2.9%) had elevated numbers (>8 mg/dl); this caribou was pregnant. Pregnancy can elevate numbers in both haptoglobins and ceruloplasmin. (K. Beckmen, ADF&G Wildlife Veterinarian, DVM, and C. Lieske, DVM, MPVM, personal communication).

Forty-one female caribou captured in April and June had serum haptoglobins assayed at the Acute Phase Protein Laboratory, University of Miami, Florida. Results from this test indicated that 11 caribou (27%) had elevated numbers for haptoglobin (> 0.60 mg/ml); however, 9 caribou were pregnant, 1 was nonparturient, and 1 was a yearling. Note that it was not the same caribou that had elevated haptoglobin in both tests. The Division of Wildlife Conservation veterinarian, Dr. Kimberlee Beckmen, is conducting an ongoing project to compare results between different laboratories (K. Beckmen, ADF&G Wildlife Veterinarian, DVM, personal communication).

Serum Amyloid A, and Total Protein—Forty-one and 40 adult female caribou were captured in both April and June, respectively. Protein was extracted from serum samples at the Acute Phase Protein Laboratory, University of Miami, to determine serum amyloid A (SAA; an acute protein) and total protein. Results from the SAA assay indicated that 2 caribou (5%) had an acute inflammatory process occurring within the expected range (C. Lieske, DVM, MPVM, personal communication).

Results from the total protein assay indicated that 5 caribou had low total protein (12%; < 4.4 g/dL). Eleven caribou (27%) had elevated total protein (> 7.5 g/dL). Note that it is an ongoing process of determining which values indicate low and high protein values in caribou. Although 27% of the caribou appeared to have high total protein values, ADF&G biologists and the ADF&G Wildlife Health and Disease Veterinarian are still determining what the range is and what it is that high protein values indicate. Values could be related to dehydration and severe inflammation or immune stimulation (C. Lieske, DVM, MPVM, personal communication).

Vitamin B12 and Methylmalonic Acid (MMA)—Twenty-one female caribou that were captured in April and June were tested for Vitamin B12/cobalamin (nutritional indicator) and 20 were tested for MMA. One caribou (5%) was considered potentially low in vitamin B12 (≥ 200–875) and high in MMA (> 2000 nmol/L) indicating that this animal was likely deficient in vitamin B12 (high MMA indicates that animal may not have enough of vitamin B12 for it to adequately function). This prevalence is considered within the normal range (C. Lieske, DVM, MPVM, personal communication).

Mycoplasma ovipneumoniae—Forty-one female caribou captured in April (25 adults) and June (10 yearlings and 6 adults) were tested for *M. ovipneumoniae* and all were negative. There is serologic evidence and also positive PCR tests that have confirmed that this herd has been exposed to *Mycoplasma ovipneumoniae* during 2007–2010. It is not a major health concern; but can be an additive stressor.

Cervid Adenovirus—Nine adult female caribou captured in April were tested for cervid adenovirus and there were no detections. Adenovirus is a respiratory virus that has been known to cause high mortality in deer fawns and has been detected in moose calves (K. Beckmen, ADF&G Wildlife Veterinarian, DVM).

Influenza A (IAV)—Forty-six adult females captured in April 2015 and April 2017 were tested for IAV; no antibodies were detected.

Recommendations for Activity 1.1.

Continue.

Continue to deploy 20 radio collars on yearlings annually to determine 3-year-old parturition rates and maintain a representative age structure and sample size. It is unclear if 3-year-old parturition rates are an important measurement in North Slope caribou. If the total number of radio collars deployed on the herd approaches 140 collars, ADF&G should consider reducing the number of radio collars on yearlings annually to 10–15 before reducing the number of radio collars on other age groups. Managing 140 radio collars would be extremely difficult to keep up with, and more are not necessary to complete photocensus, composition, and parturition surveys.

In addition to the 20 yearling collars deployed, 10–20 GPS radio collars have been deployed annually on recaptured adult females. These radio collars are currently programmed to last 3 years to obtain frequent movement data. Area biologists should also consider reducing the total number of radio collars to < 100 even if funding and collaboration does not decrease; and collaborate with other organizations if sample sizes are inadequate. If funding and collaboration does decrease, ADF&G biologists should program the radio collars to last 5 years, and then investigate the sample size needed to obtain movement data; reduce the total number of radio collars from to 100 to 80 (including males) while maintaining approximately 60 radio collars on females ≥ 1 years old, and 10–20 radio collars on males, which is important for conducting photocensus and composition surveys.

All VHF-only radio collars should be replaced with radio collars that are GPS satellite with VHF to determine survival rates and map seasonal distribution. Captures should be conducted until the end of June if PCH and TCH caribou are wintering in same area as CAH caribou, to ensure that captured caribou are CAH animals. Although the utility of weights as a measurement to nutritional index is not yet clear, ADF&G biologists should continue to weigh yearling and 11-month-old females to obtain a larger data set for analyses.

Continue to work with the DWC wildlife health and disease veterinarian on an annual basis to implement an arctic caribou disease monitoring program.

ACTIVITY 1.2. Conduct a photocensus every 2–3 years (M1, M3, C1, C2, and C3).

Data Needs

Estimating abundance (via a photocensus) is the primary metric used for monitoring herd status and is also important for evaluating IM and ANS objectives. Estimates of population size provide regulatory boards and advisory committees information to make informed decisions or recommendations regarding regulatory actions.

Methods

SURVEY AND ENUMERATION METHODS

2013 and 2016— ADF&G staff conducted a photocensus on the Central Arctic caribou herd on 4 and 5 July 2013 (E. Lenart, ADF&G, 2013 Central Arctic Caribou Photocensus Results Memorandum, 8 August 2014, Fairbanks, AK) and on 12 July 2016 (E. Lenart, ADF&G, 2016 Central Arctic Caribou Photocensus Results Memorandum, 20 March 2017, Fairbanks, AK). We used the modified aerial photo direct count technique (Davis et al. 1979) whereby postcalving aggregations of caribou were located by radiotracking radiocollared animals. Groups of caribou were photographed with a Zeiss RMK-A aerial film camera mounted in a DeHavilland DHC-2 Beaver aircraft and individuals or smaller groups of caribou were also counted directly from the Beaver or radiotracking airplane. Target altitude for film photography was 1,000 ft above ground level (AGL). We used a custom-made computer program, "PHOTOMAN (version 3.0.12)", which was developed within ADF&G, to assist in real-time assessment of photographic coverage and postphotography delineation of overlap lines for transects and photo layouts when caribou were counted from photographs. Groups of caribou were captured photographically within 1 to 6 transects. Caribou groups were radiotracked and located in either a Cessna 182 or a Piper Super Cub aircraft.

Postphotography activities included the following: black and white 9 × 9-inch photographs were developed and printed (HAS Images, Dayton, Ohio), photos were laid out and overlap lines were drawn on photos (by hand), and caribou were enumerated in photos. One ADF&G staff member laid out the photos and drew overlap lines on each photo to determine which photos and which parts of the photo were to be counted. Most of the time, topographic features in the photo were used to delineate overlap. Occasionally, groups of caribou were used to determine the overlap and to account for movement. This effort helps to eliminate double-counting caribou between the overlap lines and transects.

Caribou were enumerated by laying a 14 × 14 mm or 5 × 5 mm mylar grid (0.55 × 0.55 inch or 0.197 × 0.197 inch) over the photo to keep track of which caribou were counted; the photograph was not marked with which caribou were counted (Fig. 1). The photo was placed on a light table and/or table lamps were pointed at the photograph. ADF&G staff then used a 10× loupe to better see the caribou and a tally counter to keep track of caribou enumerated. The process of enumerating caribou was completed by 4 ADF&G staff in 2013 and 2 in 2016. The quality of photos and layout were considered good in 2013 and 2016.

2017—ADF&G staff conducted a photocensus on the Central Arctic caribou herd on 7 July 2017 (E. Lenart, ADF&G, 2017 Central Arctic Caribou Digital Camera System Photocensus Results Memorandum, 2 February 2018, Fairbanks, AK). We used the modified aerial photo-direct count technique (Davis et al. 1979; Valkenburg et al. 1985) whereby post-calving aggregations of caribou were located by radiotracking radiocollared animals. Groups of caribou were photographed from a DeHavilland DHC-2 Beaver aircraft with a customized digital-aerial-camera system composed of 3 medium-format, 100-megapixel cameras on a gyrostabilized mount. Two cameras were oriented partially oblique (50mm) and one was oriented at nadir (90mm). Target altitude for photography was 1,500 feet above ground level (AGL). All cameras were contained within a rigid insert which was attached to a gyrostabilized mount. The system was instrumented with a differential GPS and inertial measurement unit (IMU) to record position and attitude (pitch, roll, and yaw). Customized flight management software running on a laptop computer controlled the cameras and navigation system and allowed the pilot and camera operator to see footprints of the imagery in real time as well as inspect thumbnails of each image as they were captured. Groups of caribou were captured photographically in one transect. Caribou were radiotracked via a Cessna 182 (Tundra Air).

Post-photography activities included the following: flight data from the GPS and IMU were post processed using differential correction or precise point positioning (PPP) depending on the proximity to continually operating reference stations (CORS). Images were individually inspected and adjusted for exposure before being exported from raw format. Exterior orientation information (position, elevation, and altitude) and imagery were then processed through photogrammetry software using automated tie point extraction and bundle adjustment to produce digital terrain models which were then used to orthorectify individual images. Once orthorectification was completed, the oblique and nadir orthophotos were mosaicked separately. This process replaced the physical layout of film photos and hand drawn overlap lines. Note that all the groups photographed were captured in 1 transect, eliminating potential duplication of caribou or missing caribou due to movement between transects.

Caribou were enumerated from image mosaics within geographic information system (GIS) software using a customized tool which allowed users to count and classify caribou by placing colored points on the image where each animal was identified. A 10 × 10-meter grid was placed on the image to aid in keeping track of caribou when counting which is particularly helpful when reviewing a photo for missed caribou. Point data were stored in file geodatabases and archived. Most of the groups were counted from the 90mm imagery, the highest resolution available. Photo quality was rated on a scale of good to excellent by counters.

An error rate was calculated in 2017 with 5 counters who had enumerated caribou from photographic images. Two of the counters enumerated caribou from all groups (n = 10), 1 of the counters enumerated caribou from 4 of the largest groups, 1 counter enumerated 2 caribou groups, and 1 counter enumerated 1 caribou group. Counts were then compared, and an algorithm was developed to identify the differences in counts from one counter to another. The algorithm did not identify any caribou that were missed by all counters. A new geodatabase was created that included the reconciled differences between counts; this reconciled photo was considered the final count.

Population Estimate Methods

<u>2013, 2016, and 2017 Rivest Population Estimation Method</u>—We used a method described by Rivest et al. (1998) to estimate herd size and provide a measure of uncertainty. The estimator is a summation of group sizes divided by their probability of having at least 1 radiocollared caribou. The estimator is based on a 2-phase sampling design. Phase 1 sampling considers how collared caribou distribute among groups of known size and assumes that the collared caribou randomly distribute themselves. Phase 2 is the detection of those groups by radiotelemetry. Rivest et al. (1998) describes 3 detection models for use in phase 2. Of these models, the homogeneity method has been most frequently applied (Couturier 1996; Patterson et al. 2004) and is best suited for CAH caribou data. In the homogeneity model, each group has the same probability of being detected in the survey. This model assumes that all active collars are identified in observed groups and that unobserved groups with collared caribou are missed because they are outside of the surveyed area. It is important to note that phase 2 calculations are not necessary if all collars

are located and associated groups are counted. Also, the consequences of not meeting the assumptions of phase 2 are greatly mitigated when a high proportion of the active collars are detected, and associated groups counted. Finally, this estimator assumes a random distribution of collars among caribou. It is possible to test this assumption by relating the group size and associated number of radiocollared caribou in a graph. A statistical test of the assumption is suggested by Rivest et al. (1998) where the numbers of collars in each group are approximately Poisson distributed. Specifically, a score test to evaluate overdispersion in a Poisson model is provided to assess this assumption (Dean and Lawless 1989).

In 2013, we made 2 adjustments to the Rivest estimate to account for PCH caribou that may have been mixed with CAH caribou: 1) we removed PCH caribou estimated to be represented by the 10 PCH radio collars, and 2) we removed the number of PCH caribou that Rivest's method added by multiplying these additional caribou by the proportion of PCH caribou in the total caribou counted (E. Lenart, ADF&G, 2013 Central Arctic Caribou Photocensus Results Memorandum, 8 August 2014, Fairbanks, AK). Each radiocollared PCH caribou represented 2,191 caribou based on the 2013 PCH photocensus estimate of 197,228 caribou and 90 radio collars (J. Caikoski, ADF&G, Memorandum, 5 February 2014, Fairbanks, AK). We also accounted for the uncertainty associated with these adjustments.

Results and Discussion

2013 Rivest's Population Estimate—We estimated the CAH population at 50,753 caribou (SE = 4,345; 95% confidence interval (CI) = 40,924–60,582) using the Rivest et al. (1998) estimator and adjusting for the PCH caribou in the count (Tables 1 and 2; E. Lenart, ADF&G, 2013 Central Arctic Caribou Photocensus Results Memorandum, 8 August 2014, Fairbanks, AK). The variance associated with this estimate is the sum of the variances associated with the Rivest estimate, the estimate of the number of PCH caribou that are not associated with radio collars, and the estimate of the number of PCH caribou represented by the 10 PCH radio collars. Our assumption of a random distribution of radio collars in the survey was supported (*P*-value = 0.15; Table 1).

Note that Rivest's method includes those groups of caribou that have been radio collared (10 groups) only, which resulted in a count of 69,509 caribou, including the caribou counted from photos and visuals. Using Rivest's method, we estimated an abundance of 74,121 caribou, which accounted for an additional 4,612 caribou not found in groups with radio collars. However, this estimate included PCH caribou.

We estimated the number of PCH caribou represented by the 10 PCH radio collars to be 21,914 caribou. We also estimated that 1,454 of the 4,612 additional caribou estimated as part of uncollared groups were PCH caribou. Finally, we estimated the uncertainty associated with each of these 3 estimates to arrive at the population estimate of 50,753 caribou (SE = 4,345, 95% CI = 40,924–60,582 caribou; Table 1).

The population declined from an estimated 68,442 ± 13,870 caribou in 2010 to 50,753 ± 9,829 in 2013 (Table 2; Fig. 1). The decline was likely related to the very late spring that occurred in 2013. Adult and yearling females experienced high mortality during this period, and this was likely reflected in the 2013 photocensus estimate.

Table 1. Abundance-estimate statistics from the 2013 Central Arctic caribou herd (CAH photocensus survey).

Statistic or Number	Value	(SE)
a) CAH radio collars located and photographed	54	(NA)
b) Missing CAH radio collars	0	(NA)
c) Minimum count of all caribou from 11 groups	70,364	(NA)
d) Count of all caribou from the 10 groups with radio collars	69,509	(NA)
e) Abundance estimate using Rivest's Method (including PCH caribou)	74,12	(3,240)
f) Number of caribou added via Rivest's method to account for those not associated with radio collars (= e – d) [1]	4,612	(–)
g) Number of PCH represented by the 10 radio collars (= 10 × 197,228 PCH caribou / 90 PCH radio collars)	21,914	(1,530)
h) Number of PCH caribou added by Rivest's method (= g / d × f)	1,454	(2,458)
Abundance Estimate for CAH[2,3]	50,753 ± 9,829	
i) Standard error	4,345	
j) t value	2.26	
k) 95% confidence interval	(40,924–60,582)	
l) Test of randomness (*P*-value > 0.05 fails to reject randomness)	0.15	

Note: NA refers to not applicable.

[1] Result from item value "e)" minus result from item "d)" in the "Statistic or Number" column.
[2] Excluding PCH caribou.
[3] Point estimate = e - g - h; variance = var(e) + var(g) + var(h); SE = variance ^ 0.5.

2016 Rivest Population Estimate—We estimated the CAH population at 22,630 (SE = 1,081; 95%, CI = 20,074–25,186; Tables 1 and 3; E. Lenart, ADF&G, 2016 Central Arctic Caribou Photocensus Results Memorandum, 20 March 2017, Fairbanks, AK). Our assumption of a random distribution of radio collars in the survey was supported (*P*-value = 0.73; Table 3).

Note that Rivest's method uses only those groups of caribou with radio collars (8 groups) which resulted in a count of 20,476 caribou including caribou counted from photos and visuals. Using Rivest's method, we estimated an abundance of 22,630 caribou, which accounted for an additional 2,154 caribou not found in groups with radio collars. No TCH or PCH radio collars were present in the photocensus.

Results of the 2016 population estimate for the CAH (22,630 caribou; 95% CI = 20,074–25,186; Table 3) indicated there was a substantial decline in the population size from 2010 (68,442, 95% CI = 54,571–82,312; Table 2) and 2013 (50,753; 95% CI = 40,924–60,582; Table 2; Fig. 1). Mortality rates of radiocollared female caribou ≥ 1 -year old were higher during regulatory years 2012–2015 (mean = 25%; range = 20–33%) compared to the previous 10 years (mean = 12%; range = 7–20%). High mortality rates were also indicated by examining the fate of CAH radio collars from the 2013 CAH photocensus to the 2016 photocensus. Of the 54 CAH radio collars located from the 2013 CAH photocensus, 54% (29) had died before the 2016 CAH photocensus.

The second most important factor in the decline was related to emigration or herd switching whereby 19% (10) of the radiocollared caribou located in 2013 were found with a different herd in 2016 (7 with the Porcupine caribou herd and 3 with the Teshekpuk caribou herd). It is possible that other factors such as range quality, predation, and disease played a role. Prior studies indicated that predation on calves had not played a major role in calf mortality and predation was not considered to be a major factor for adults, although no predation studies were conducted during the decline. Disease was not implicated but monitoring of disease at the time was minimal. The impact of oil infrastructure on the CAH was considered but was not thought to be a contributing factor to the decline since the herd grew substantially during peak oil development.

2017 Rivest Population Estimator—We estimated the CAH population at 28,051 (SE = 765.4, 95% CI = 26,346–29,757) using the Rivest et al. (1998) method (Tables 1 and 4; E. Lenart, ADF&G, 2017 Central Arctic Caribou Digital Camera System Photocensus Results Memorandum, 9 February 2018, Fairbanks, AK). Our assumption of a random distribution of radio collars in the survey was supported (*P*-value = 0.09; Table 4).

Note that Rivest's method uses only those groups of caribou with radio collars (11 groups) which resulted in a count of 27,115 caribou including caribou counted from photos and visuals. Using Rivest's method, we estimated an abundance of 28,051 caribou, which accounted for an additional 936 caribou not found in groups with radio collars. One PCH radio collar was in a group of CAH caribou, but we determined that it was most likely CAH caribou because 8 other CAH radio collars were in the same group of approximately 2,700 caribou. No TCH radio collars were heard during the photocensus.

Directly comparing results of the 2016 population estimate to the 2017 population estimate indicated that there was an increase in the population size from 2016 (22,630; 95% CI = 20,074–25,186) to 2017 (28,051; 95% CI = 26,346–29,757) for the Central Arctic caribou herd (Fig. 1).

However, due to a change in technique (using a digital photography system in 2017 compared to a film system in 2016), results are not directly comparable. Although more caribou were counted in 2017, other demographic metrics collected (e.g., parturition rates, mortality rates, calf-to-cow ratios) during 1 July 2016 through 30 June 2017 indicated the herd likely did not grow by 24%. The differences in the population estimates between 2016 and 2017 are more likely a result of a change in technique. We expected improved accuracy in the digital photography system because the system supports higher flight altitudes and larger photo footprints. Larger photo footprints result in fewer transects to capture each group. In addition, it is likely that the digital system allowed us to count a higher proportion of the caribou captured on digital photographs compared to what would have been counted using the old film system due to improved image quality and the ability to identify caribou counted with a mark on the computer. The demographic data collected indicated that the herd may be closer to stability than increasing.

In 2017, we calculated the difference in caribou enumerated on photographs by individual counters with the reconciled final count and determined that the difference ranged from 0.2% to 1.5%. When there were 2 counters, the difference was 0.7% and 1.5%.

Recommendations for Activity 1.2

Continue.

Table 2. Central Arctic caribou herd estimated population size, Alaska, 1978–2017.

Year	Date	Method[a]	CAH[b] radio collars located (missing)	Groups photographed (located)[c]	Groups w/radio collars	PCH[b] or TCH[b] radio collars (est. # caribou)	Minimum count[d]	Estimated population size (SE)[e]	Confidence interval (population range)
1978	Jul	STS	–[f]	unk	unk	unk	5,000		
1981	Jul	AC	–[f]	unk	unk	unk	8,537		
1983	21 Jul	APDCE	–[f]	unk	unk	unk	12,905		
1991	18–20 Jun	RSQS	unk	unk	unk	unk	n/a	19,046 (n/a)	90% (14,667–23,414)
1992	8–9 Jul	APDCE	unk	9 (10)	unk	unk	23,444		
1995	13 Jul	APDCE	unk	12 (42)	unk	unk	18,100		
1997	19–20 Jul	APDCE	41 (3)	22 (22)	12	0	19,730	18,824 (1,431)	95% (15,674–21,974)
2000	21 Jul	APDCE	81 (4)	22 (24)	22	0	27,128	29,519 (1,449)	95% (26,504–32,533)
2002	16 Jul	APDCE	76 (4)	9 (9)	9	0	31,857	34,211 (1,050)	95% (31,790–36,361)
2008	2–3 Jul	APDCE	62 (0)	14 (18)	12	2 PCH (3,379)	66,772	66,666 (3,206)	95% (59,609–73,722)
2010	9 Jul	APDCE	57 (2)	16 (18)	14	2 PCH (3,379) 2 TCH (1,916)	70,034	68,442 (6,420)	95% (54,571–82,312)
2013	4–5 Jul	APDCE	54 (0)	10 (12)	10	10 PCH (21,914)	70,364[g]	50,753 (4,345)[g]	95% (40,924–60,582)
2016	12 Jul	APDCE	49 (2)	7 (10)	8	0	21,186	22,630 (2,556)	95% (20,074–25,186)
2017[h]	7 Jul	APDCE	82 (1)	10 (11)	11	1 PCH (0)	27,115	28,051 (765.4)	95% (26,346–29,757)

[a] STS = systematic transect surveys; AC = aerial count; APDCE = aerial photo direct count extrapolation (Davis et al. 1979); RSQS = random stratified quadrat survey (Valkenburg 1993).

[b] CAH = Central Arctic herd; PCH = Porcupine caribou herd; TCH = Teshekpuk caribou herd.

[c] Groups located include single caribou.

[d] Minimum number of caribou observed during survey; may include caribou from other herds.

[e] In 1991, the analysis used was from Gasaway et al. 1986. During 1997–2013, the analysis used was from Rivest et al. 1998. In years that PCH or TCH caribou radio collars were present, we adjusted the “Rivest” estimate to account for PCH or TCH radio collars (E. A. Lenart, Wildlife Biologist, ADF&G Memorandum, 2013 Central Arctic Caribou Photocensus Results, 8 Aug 2014, Fairbanks); SE = standard error.

[f] No radio collars were deployed.

[g] Minimum count includes approximately estimated 20,000 Porcupine caribou and were excluded for the estimated population size.

[h] Digital camera used in 2017, where film camera was used in previous years. The 2017 survey occurred after the reporting period which ended on 30 June 2017.

Table 3. Abundance-estimate statistics from the 2016 CAH photocensus survey.

Statistic or Number	Value	(SE)
a) CAH radio collars located and photographed	49	(NA)
b) Missing CAH radio collars	2	(NA)
c) Minimum count of all caribou from 10 groups	21,186	(NA)
d) Count of all caribou from the 8 groups with radio collars	20,476[a]	(NA)
e) Population estimate using Rivest's method (homogeneity model)	22,630	(1,081)
f) Number of caribou added via Rivest's method to account for those not associated with radio collars (= e – d)[b]	2,154	(–)
Abundance Estimate for CAH	22,630 ± 2,556	
g) Standard error	1,081	
h) t value (df based on 8 groups minus 1)	2.364	
i) 95% Confidence Interval	(20,074–25,186)	
j) Test of randomness (*P*-value > 0.05 fails to reject randomness)	0.73	

Note: NA refers to Not applicable.

[a] Four caribou were inadvertently duplicated during the Rivest analysis.
[b] meaning result from item "e)" minus result from item "d)."

Table 4. Abundance-estimate statistics from the 2017 CAH photocensus survey.

Statistic	Value
a) CAH radio collars located	82
b) Missing CAH radio collars	1
c) Minimum count	27,115
d) Count of all caribou from the 11 groups with radio collars	27,115
e) Population estimate using Rivest's method (homogeneity model)	28,051
f) Number of caribou added via Rivest's method to account for those not associated with radio collars (= e – d)[a]	936
Abundance Estimate for CAH	28,051 ± 1,706
g) Standard error	765.4
h) t-value (Degrees of freedom is based on 11 groups minus 1)	2.228
i) 95% Confidence interval	(26,346–29,757)
j) Test of randomness (*P*-value > 0.05 fails to reject randomness)	0.09

[a] Result from item "e)" minus result from item "d)."

ACTIVITY 1.3. Estimate growth rate (lambda (λ); M1, M3, C1, C2, and C3).

Data Needs

Estimates of trends in abundance are important for evaluating IM and ANS objectives. Rates of population increase and decrease helps to inform the regulatory process.

Methods

Using the adjusted Rivest population estimates and their associated variances, the growth rate for the CAH was estimated for the growing and declining phases during 1997–2017. A nonlinear model was fitted to estimate the average multiplicative annual growth rate (lambda; λ), using Bayesian methods and the software OpenBUGS (Lunn et al. 2009), to incorporate within year variation. Because the data indicated that the population peaked between 2008 and 2010, we used years 1997, 2000, 2002, 2008, and 2010 for one growth phase, and years 2010, 2013, 2016, and 2017 for another growth (actually declining) phase to achieve 2 bounded estimates of lambda. Posterior means were used as point estimates for lambda, and 95% credible intervals were calculated. Note that a 95% credible interval is interpreted slightly different than a confidence interval (CI) in that there is a 95% probability that the interval contains the true value of lambda.

Results and Discussion

Using the adjusted Rivest population estimates for years 1997–2010, we estimated that there was a 95% probability that lambda was between 1.10 and 1.12 (95% credible interval), with a point estimate (posterior mean) of lambda of 1.11 (11% annual growth rate). The 95% credible interval for lambda did not contain 1 and was greater than 1; therefore, we can conclude that there is a 95% probability that the population was increasing (Table 5; Fig. 5). A histogram of the posterior distribution of lambda is shown to help depict the uncertainty of lambda (Fig. 6). High parturition rates, good calf survival, and low adult mortality since 1997 contributed to the increase in population size. We determined that immigration from PCH and TCH likely played a minor role in contributing to the increase during those years. High annual rates of increase similar to those reported here have been reported for other arctic caribou herds (1.12), although minimum count estimates were used as well as a different method to calculate the annual rate of increase (Carroll 2007; Dau 2007).

Using the adjusted Rivest population estimates for years 2010–2017, we estimated that there was a 95% probability that lambda was between 0.86 and 0.91 (95% credible interval) with a point estimate (posterior mean) of 0.88 (12% annual decline; Table 5; Fig. 7). The 95% credible interval for lambda did not contain 1 and was less than 1; therefore, we can conclude that there was a 95% probability that the population was declining. A histogram of the posterior distribution of lambda is shown to help depict the uncertainty of lambda (Fig. 8).

Recommendations for Activity 1.3

Continue to estimate trends in abundance to evaluate IM and ANS objectives and provide regulatory boards and advisory committees additional biological information to make informed decisions or recommendations regarding regulatory actions.

When estimating lambda, models that best fit the data should be used.

Table 5. Central Arctic caribou estimates of the 95% credible intervals for lambda derived from a multiplicative growth model using Bayesian methods on adjusted Rivest population estimates and their associated variances for years 1997–2010 and 2010–2017.

Time period (year)	Point estimate of lambda (λ)	LCI[a] 95%	UCI[b] 95%
1997–2010	1.11	1.10	1.12
2010–2017	0.88	0.86	0.91

[a] LCI stands for lower credible interval.
[b] UCI stands for upper credible interval.

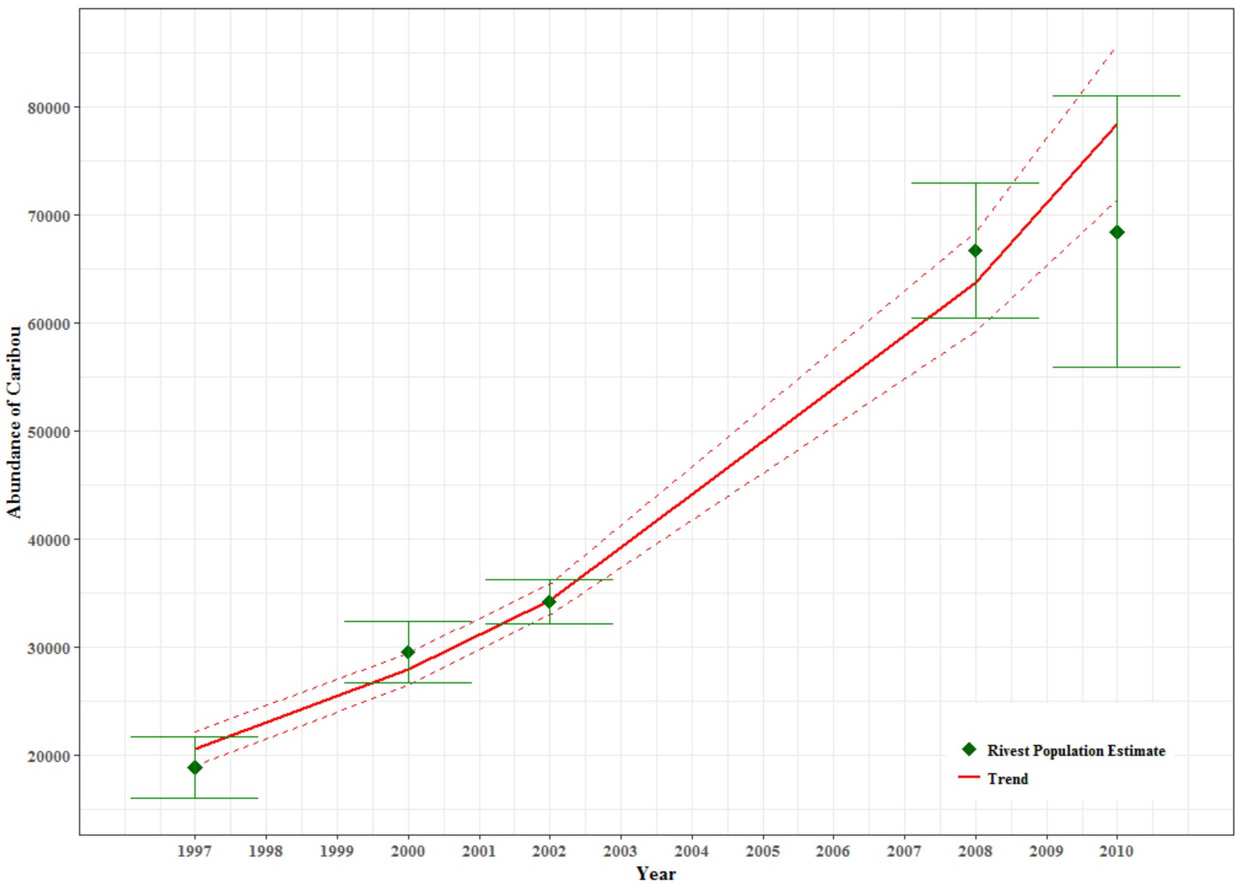


Figure 5. Central Arctic caribou population trend estimated from a Bayesian multiplicative population growth model during a growth phase (1997–2010). Lambda is depicted by the trend line (solid thick line). The dashed error bar along the trend line represents a 95% credible interval. The 95% credible interval for lambda was 1.10–1.12 (point estimate = 1.11). The solid diamonds represent the CAH population estimate calculated using the Rivest (1998) method. The error bars around the Rivest population estimates represents a 95% confidence interval.

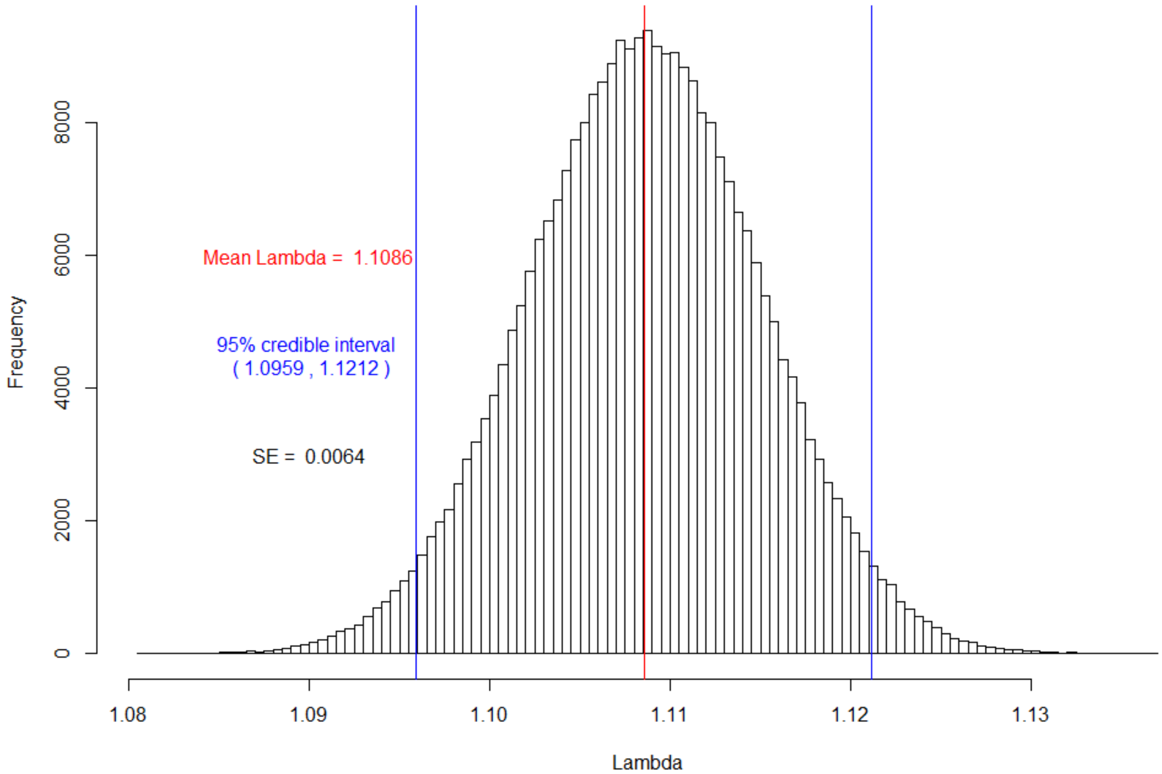


Figure 6. A histogram of the posterior distribution of lambda for years 1997–2010. The posterior mean (point estimate) is 1.11 with a 95% credible interval (1.10, 1.12), indicating that there is at least a 95% probability that the growth rate is positive because lambda is > 1.

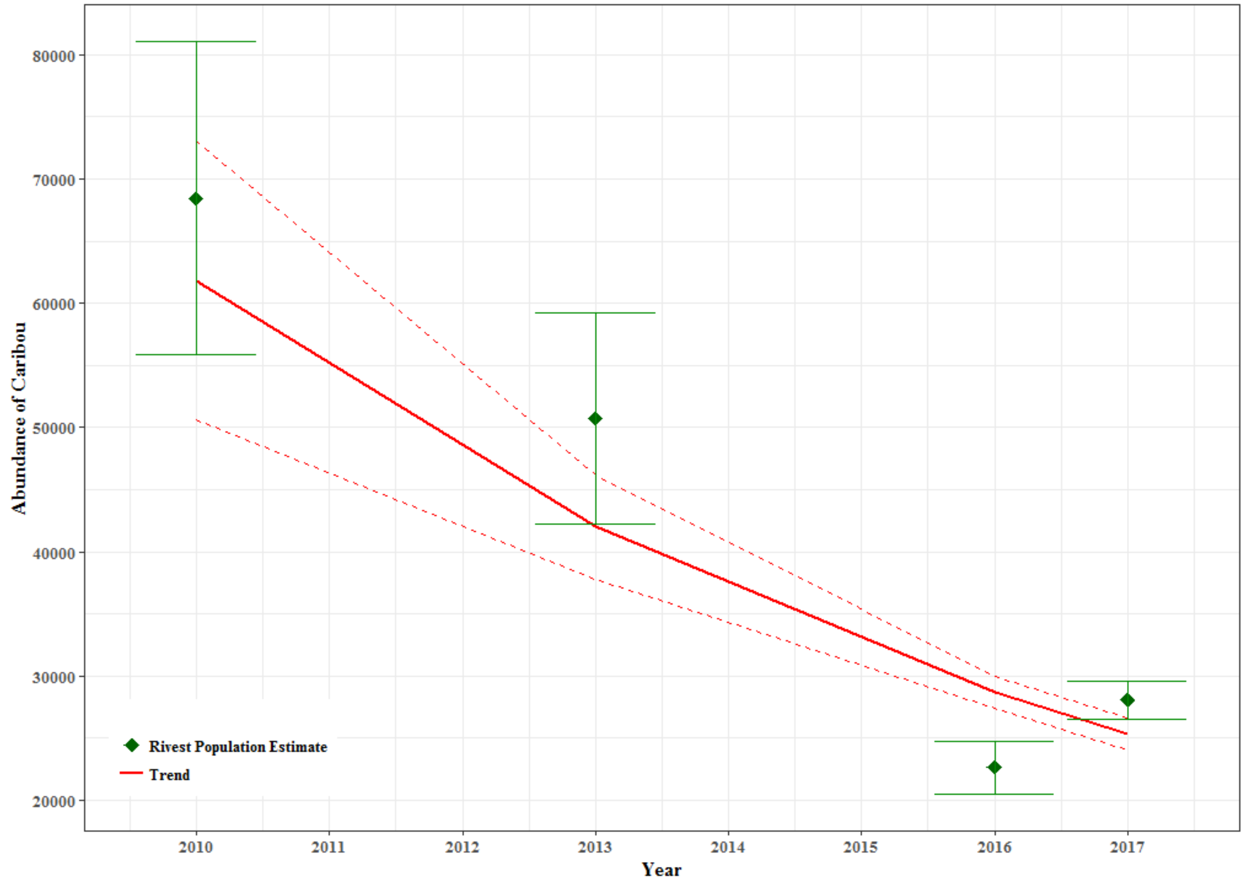


Figure 7. Central Arctic caribou population trend estimated from trend of Bayesian multiplicative population growth model during a declining phase (2010–2017). Lambda is depicted by the trend line (solid thick line). The dashed error bar along the trend line represents a 95% credible interval. The 95% credible interval for lambda was 0.86–0.91 (point estimate = 0.88). The solid circles represent the CAH population estimate calculated using the Rivest (1998) method. The error bars around the Rivest population estimates represents a 95% confidence interval.

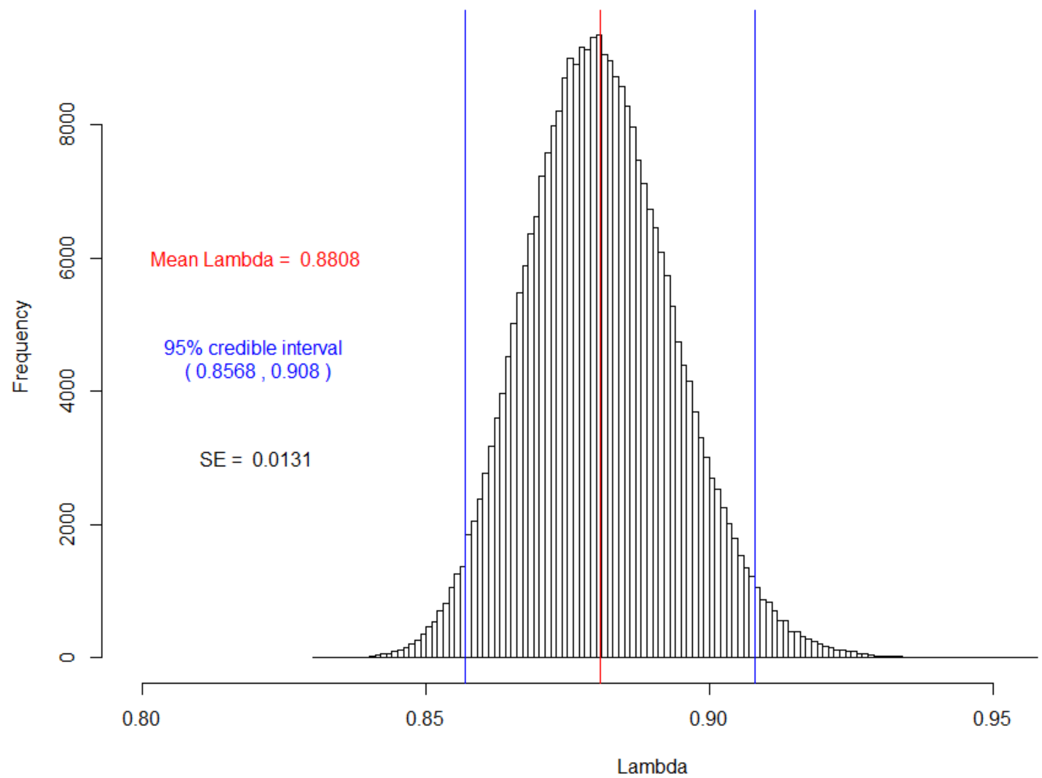


Figure 8. A histogram of the posterior distribution of lambda for years 2010–2017. The posterior mean (point estimate) is 0.88 with the growth rate between 0.86 and 0.91 at the 95% credible interval, indicating that there is at least a 95% probability that the growth rate is negative because lambda is < 1.

ACTIVITY 1.4. Estimate annual mortality rates from radiocollared female caribou (M1, M3, C1, C2, C3).

Data Needs

Annual survival/mortality is a sensitive biological parameter to population growth or decline, particularly for adult females. Estimates of annual survival/mortality provide an important demographic parameter to evaluate population trajectory in years when abundance is not estimated and corroborates estimates in trends in abundance.

Methods

Annual adult female mortality rate for females ≥ 1-year old was estimated per regulatory year by determining the number of known mortalities in a regulatory year and dividing that number by the number of active radio collars beginning 1 July of that regulatory year.

Results and Discussion

RY12—The mortality rate was 33% for CAH females ≥ 1-year old (n = 49). Additional mortalities included 3 adult females. Of the 20 short yearlings (11-month-old calves) that were radiocollared in April 2013, 11 died by 30 June 2013, and 5 adult males died during RY12.

Spring 2013 persisted approximately 1 month later than usual and the CAH experienced high mortality in adult females and 11-month-old calves immediately following the spring.

RY13—The mortality rate was 23% for CAH females ≥ 1-year old (n = 44). Additional mortalities included 1 adult female during recaptures; of the 22 short yearlings (11-month-old calves) that were radiocollared in April 2014, 2 died by 30 June 2014, and 4 adult males died in RY13 (2 with TCH).

RY14— The mortality rate was 20% for radiocollared CAH females ≥ 1-year old (n = 60). Additional mortalities included 1 adult female during captures, 1 adult female found dead 1 month after captures, 2 of 20 short yearlings (11-month-old calves) that that died by 30 June 2015 which were radiocollared in April 2015, and 3 adult males that died during RY14.

RY15— The mortality rate was 19% for radiocollared CAH females ≥ 1-year old (n = 73). Additional mortalities during the regulatory year included 2 adult males and 1 yearling female that died between captures in April and calving surveys in early June.

RY16— The mortality rate was 19% for radiocollared CAH females ≥ 1-year old for regulatory year 2016 (n = 85). Additional mortalities during the regulatory year included 1 adult male, 1 adult female captured in April 2017 that died in May 2017, 2 capture mortalities in April 2017, and 1 capture mortality in June 2017. Of the 16 female caribou that died during RY16, 4 died during July and August, and another 6 were found dead in October. The caribou found on mortality mode in October had VHF radio collars and could have died earlier in the summer. The caribou that died in July and August had satellite radio collars, therefore, we were able to obtain accurate dates of death.

These mortality rates serve as a crude index to mortality. During RY12 through RY16, mortality rates of adult females ≥ 1-year old were considered high, ranging 19–33% (mean = 22.8; Table 6); the Central Arctic herd declined substantially during this period (Table 2; Fig. 1). Mortality rates during the previous 5 years, RY07–RY11, ranged 9–17% (mean = 12.6; Table 6). During a 10-year period the herd was increasing (RY02–RY11), mortality rates ranged 7–17%, except in 2004 when it was 20% (mean = 12.3; Table 6; Fig. 1).

Recommendations for Activity 1.4.

Continue. Consider exploring other methods of determining estimating annual survival such using known-fate models (logistic regression) and model fit, including evaluating using Akaike's Information Criterion values (Akaike 1973) adjusted for sample size (AIC_c; Burnham and Anderson 2002) or other analyses that may be a better fit for the data.

Table 6. Mortality rates of radiocollared female caribou greater than or equal to 1-year old, Central Arctic herd, Alaska, regulatory years 1997–2016.

Regulatory year	Number of mortalities	Number of radio collars[a]	Percent mortality
1997	2	44	4
1998	2	53	4
1999	7	53	13
2000	12	66	18
2001	4	64	6
2002	11	78	14
2003	7	75	9
2004	19	96	20
2005	8	77	10
2006	5	69	7
2007	7	64	11
2008	9	74	12
2009	9	65	14
2010	5	58	9
2011	10	58	17
2012	16	49	33
2013	10	44	23
2014	12	60	20
2015	14	73	19
2016	16	85	19

Note: Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 1997 = 1 July 1997–30 June 1998).
[a] Number of radiocollared cow caribou ≥ 1-year old known to be alive at the beginning of the regulatory year.

ACTIVITY 1.5. Estimate allowable harvest (M1, M3, M4, C2, and C4).

Data Needs

Estimates of annual allowable harvest inform the regulatory process. As population abundance fluctuates each year, it is necessary to adjust the allowable harvest to ensure the number of animals being harvested remains sustainable.

Methods

During the summers 2013, 2014, and 2015, when the population was considered high, allowable harvest was a minimum of 5% of the most recent population estimate.

Following the 2016 photocensus, allowable harvest was 3% of the most recent population estimate of which no more than 75 could be cows.

Results and Discussion

2013, 2014, and 2015—Based on the 2013 population estimate of 50,753 caribou, allowable harvest was set at a minimum of 2,500 caribou.

2016— Based on the 2016 population estimate of 22,630 caribou, allowable harvest was 680 caribou of which no more than 75 could be cows. Cow harvest was restricted to allow growth of the herd. The population was below the management objective of 28,000–32,000 caribou.

2017— Based on the 2017 population estimate of 28,051 caribou, allowable harvest was 840 caribou of which no more than 75 could be cows. Cow harvest was restricted to continue to allow growth of the herd. The population was estimated at the lower end of the management objective of 28,000–32,000 caribou.

Recommendations for Activity 1.5.

Continue to estimate annual allowable harvest because it is important when making recommendations to inform the regulatory process. Continue to apply a 3% harvest rate and limit cow harvest while the population is at or below management objectives. When the herd begins to grow again, consider applying a 4% or 5% harvest rate. If the herd is growing rapidly, a larger harvest rate can be applied; however, harvest is limited by access to the CAH, and historically has been much less than the 5% harvest rate.

ACTIVITY 1.6. Estimate annual parturition rate from radiocollared female caribou (M1 and C2).

Data Needs

Estimates of parturition rate provide a direct measure of productivity and may serve as an index to adult female body condition, particularly for 3-year-old caribou (Boertje et al. 2012). Parturition rate is one of the demographics used to aid in determining trends in population size in years that abundance is not estimated from a photocensus.

Methods

Parturition rate was estimated by observing radiocollared females ≥ 3-years old from a fixed-wing aircraft during the first half of June. Caribou observed with calves, hard antlers, or distended udders were classified as parturient (Whitten 1995). During 2013–2016, caribou were located once during 1–8 June. In 2017, caribou were relocated between 31 May and 7 June up to 7 times for each animal.

Parturition rate was calculated as the number of adult females classified as parturient divided by the total number of adult females observed. Parturition rates were calculated for females ≥ 4-years old, 3-years old, and ≥ 3-years old. Not all caribou observed had known ages; but we included unknown aged caribou in the females ≥ 4-years old and females ≥ 3-years old categories. A 95% binomial confidence interval was calculated for parturition rates for females ≥ 4-years old using a normal approximation method:

$$1.96\sqrt{\frac{(\hat{p}*(1-\hat{p}))}{n}} \text{ where } \hat{p} = \text{estimated parturition rate}$$

A binomial generalized linear model (GLM) regression was fitted to estimate the trend in parturition rates for the years 1997−2017 (all years of data), 2000−2010 (years population was increasing), and 2010−2017 (years population was declining).

Parturition data for females ≥ 4-years old were stratified between Unit 26B West (west of the west bank of the Sagavanirktok River) and Unit 26B East (east of the west bank of the Sagavanirktok River) because Arthur and Del Vecchio (2009) determined that CAH caribou maintained their fidelity to these calving areas from year to year (92%; $n = 46$ for radiocollared CAH cows with calving locations obtained in ≥ 5 calving seasons during 1997–2006). Because some overlap occurred, we arbitrarily chose the Sagavanirktok River as the line separating Unit 26B West (where there was substantial oil exploration and development) from Unit 26B East (where little exploration and development occurred). A binomial GLM with an intercept and categorical predictor for Unit 26B West versus Unit 26B East was fitted to estimate the difference in mean parturition rates between the 2 calving areas from 1997−2017 (all years of data), 2000−2010 (years population was increasing), and 2010−2017 (years population was declining). In addition, a quasi-binomial model was also fitted to the data to account for overdispersion in the data.

A 5-year moving weighted average parturition rate for 3-year-olds (95% CI) was estimated for years 2009–2017 using methods described in Boertje et al. 2012.

Results and Discussion

2013—Parturition rates of radiocollared females ≥ 4-years old were 80% ± 15.7 ($n = 25$; 95% CI; Table 7; Fig. 9). Of these 25 caribou, 5 had a calf present, 15 were determined to be parturient based on presence of udder and/or antlers, and 5 were barren. Parturition rates west of the west channel of the Sagavanirktok River were 100% ($n = 9$; 3 with a calf, 6 pregnant) and 69% east of the west channel of the Sagavanirktok River ($n = 16$; 2 with a calf; 11 pregnant, 5 barren). Spring in 2013 persisted approximately 1 month longer than normal.

Parturition rates for 3-year-olds were 75% ($n = 4$; 2 with calf, 2 barren). Parturition rates for females ≥ 3-years old were 76% ($n = 29$; 7 with a calf, 15 parturient based on presence of udder and/or antlers, 7 barren).

2014—Parturition rates of radiocollared females ≥ 4-years old were 77% ± 14.3 ($n = 34$; 95% CI; Table 7; Fig. 9). Of these 34 caribou, 3 had a calf present, 23 were determined to be parturient based on presence of udder and/or antlers, 8 were barren with 77% parturient west of the west channel of the Sagavanirktok River ($n = 26$), and 75% parturient east of the west channel of the Sagavanirktok River ($n = 8$; Table 7). No 3-year-olds were observed in 2014.

2015—Parturition rates of radiocollared females ≥ 4-years old were 87% ± 9.3 ($n = 52$; 95% CI; Table 7; Fig. 9). Of these 52 caribou, 31 had a calf present, 14 were determined to be parturient based on presence of udder and/or antlers, and 7 were barren. Parturition rates west of west channel of the Sagavanirktok River were 79% ($n = 34$; Table 7). The parturition rate east of the west channel of the Sagavanirktok River was 100% ($n = 18$; Table 7).

Parturition rates for 3-year-olds were 75% ($n = 4$; 3 with calf, 1 barren). Parturition rates for females ≥ 3 years old were 86% ($n = 56$, 34 with a calf, 14 parturient based on presence of udder and/or antlers, and 8 barren).

2016— Parturition rates of radiocollared females ≥ 4-years old were 95% ± 6.9 ($n = 38$; 95% CI, Table 7; Fig. 9). Of these 38 caribou, 22 had a calf present, 14 were determined to be parturient based on presence of udder and/or antlers, and 2 were barren. Parturition rates west of the west channel of the Sagavanirktok River were 96% ($n = 26$; Table 7). Parturition rates east of the west channel of the Sagavanirktok River were 92% ($n = 12$; Table 7).

Parturition rates for 3-year-old caribou were 67% (n = 3; 1 with calf, 1 parturient based on presence of udder and/or antlers, 1 barren). Parturition rates for females ≥ 3 years old were 93% (n = 41; 23 with a calf, 15 parturient based on presence of udder and/or antlers, and 3 barren).

2017— Parturition rates of radiocollared females ≥ 4-years old were 90% ± 7.6 (n = 59; 95% CI; Table 7; Fig. 9). Of these 59 caribou, 25 had a calf present, 28 were determined to be parturient based on presence of udder and/or antlers, and 6 were barren. Parturition rates west of west channel of the Sagavanirktok River were 94% (n = 47; Table 7). Parturition rates east of the west channel of the Sagavanirktok River were 77% (n = 13; Table 7).

Parturition rates for 3-year-olds were 100% (n = 6; 3 with calf, 3 parturient based on presence of udder and/or antlers). Parturition rates for females ≥ 3-years old were 91% (n = 65; 28 with a calf, 31 based on presence of udder and/or antlers, and 6 barren).

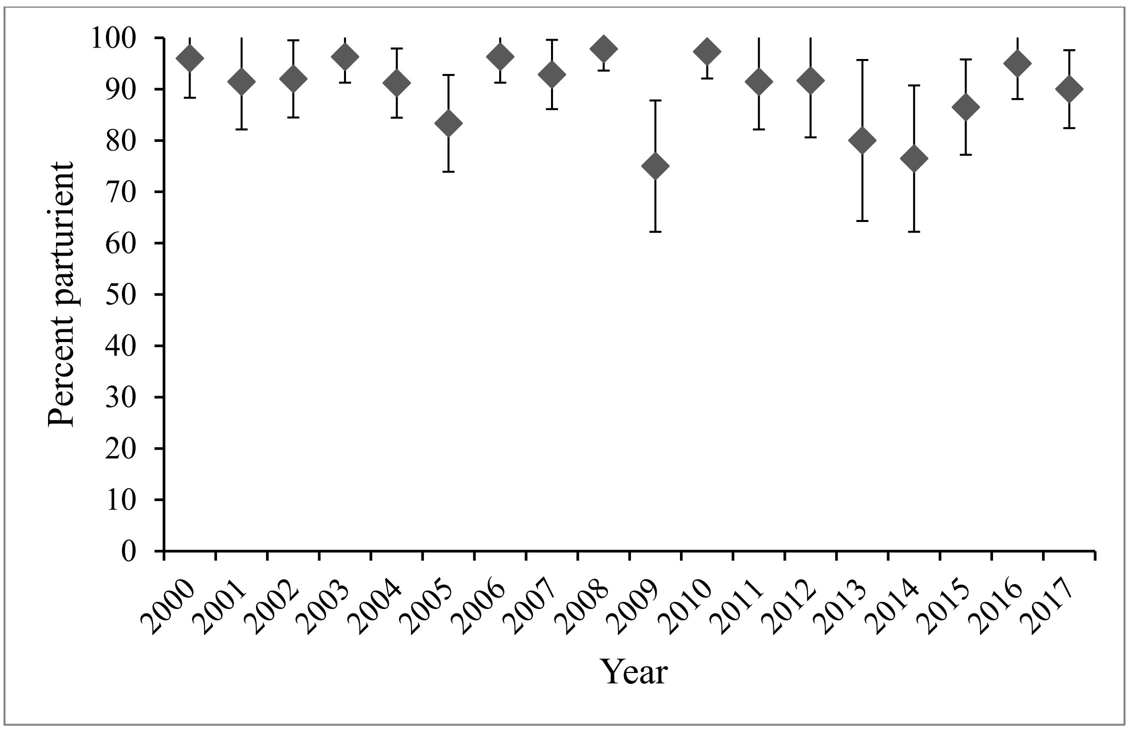


Figure 9. Parturition rates (± 95% confidence interval) of Central Arctic radiocollared female caribou ≥ 4 years old, Alaska, 2000–2017.

Table 7. Central Arctic herd caribou percent parturition of radiocollared females, Unit 26B Alaska, 1997–2017.

		Percent parturition ≥ 4-years old[a]			
Year	Date(s)	Unit 26B West (*n*)	Unit 26B East (*n*)	Unit 26B combined ± 95% CI	Total (*n*)
1997	6 Jun	77 (13)	46 (13)	61 ± 18.7	(26)
1998	3–4 Jun	93 (14)	83 (12)	88 ± 12.5	(26)
1999	5, 9 Jun	94 (16)	92 (12)	93 ± 9.5	(28)
2000	6–7 Jun	89 (9)	100 (16)	96 ± 7.7	(25)
2001	3–9 Jun	90 (20)	93 (15)	91 ± 9.3	(35)
2002	4–7 Jun	89 (27)	96 (23)	92 ± 7.5	(50)
2003	30 May–8 Jun	93 (29)	100 (25)	96 ± 5.0	(54)
2004	31 May–11 Jun	88 (40)	96 (28)	91 ± 6.7	(68)
2005	31 May–9 Jun	86 (35)	80 (25)	83 ± 9.4	(60)
2006	29 May–8 Jun	94 (32)	100 (22)	96 ± 4.9	(54)
2007	2–6 Jun	88 (32)	100 (24)	93 ± 6.7	(56)
2008	2–4 Jun	100 (26)	96 (20)	98 ± 4.2	(46)
2009	1–3 Jun	74 (19)	76 (25)	75 ± 12.8	(44)
2010	2–5 Jun	91 (11)	100 (26)	97 ± 5.2	(37)
2011	2–4 Jun	83 (12)	96 (23)	91 ± 9.3	(35)
2012	3, 7 Jun	83 (12)	100 (12)	92 ± 11.0	(24)
2013	2–6 Jun	100 (9)	69 (16)	80 ± 15.7	(25)
2014	2–3 Jun	77 (26)	75 (8)	77 ± 14.3	(34)
2015	1–8 Jun	79 (34)	100 (18)	87 ± 9.3	(52)
2016	2–4 Jun	96 (26)	92 (12)	95 ± 6.9	(38)
2017	31 May–7 Jun	93 (45)	77 (13)	90 ± 7.7	(58)

[a] Data for females ≥ 4-years old were stratified based on the location of caribou east and west of the Sagavanirktok River. In some years, we captured unknown-age adult females that were included in the ≥ 4-years old sample.
[b] Previous management and reports had slightly different rates; data was updated for this report.

Combined years—During 2014–2017, parturition rates for females ≥ 4-years old ranged 77–95%, similar to what was observed in previous years (Table 7; Fig. 9). It is unknown what the critical value for a parturition rate for the CAH is regarding its effect on population trend.

Despite that the population was increasing from 2000 to 2010, (*n* = 529, *P*-value = 0.5964), and declining from 2010 to 2017 (*n* = 305, *P*-value = 0.6470), no trend was detected (i.e., trend in parturition rate was not significantly different from zero) for parturition rates for females ≥ 4-years-old from 1997–2017, the years that data was available (*n* = 877; *P*-value = 0.9979).

Mean parturition rates for females ≥ 4-years-old were not significantly different between Unit 26B West and Unit 26B East during 1997–2017 (*n* = 877, *P*-value = 0.5547). The mean parturition rate in Unit 26B West was 0.89 (*n* = 489, lower limit (LL) = 0.83, upper limit (UL) = 0.92) and in Unit 26B East it was 0.90 (*n* = 388, LL = 0.85, UL = 0.94). During the years when the herd was increasing (2000–2010) mean parturition rates were not significantly different (*n* = 529, *P*-value = 0.1951): Unit 26B West = 0.89 (*n* = 249, LL = 0.82, UL = 0.94) and Unit 26B East = 0.94 (*n* = 280, LL = 0.88, UL = 0.97). Although the actual difference in mean parturition rates was approximately 0.05, the 95% confidence intervals overlapped significantly, resulting in little evidence to indicate a difference in parturition rates (*P*-value = 0.19). During the years when the herd was declining (2010–2017), mean parturition rates were not significantly different (n = 529, P-value = 0.5816): Unit 26B West = 0.88 (n = 177, LL = 0.77, UL = 0.94) and Unit 26B East = 0.91 (n = 128, LL = 0.79, UL = 0.96).

The 5-year (2013–2017) moving weighted average of the proportion of pregnant 3-year-old caribou was 82.4 ± 18.1 (n = 16; annual sample size ranged 0–6; CI = 95%; Table 8). The 5-year moving weighted average was higher for years 2013–2017 compared to the previous 5 years (2008–2012; 62 ± 21; n = 21; annual sample size ranged 0–7; CI = 95%; Table 8). However, the error bars overlap considerably which likely reflects annual low sample sizes. In addition, even the 5-year sample sizes were low (≤ 25). Boertje et al. (2012) considered 5-year moving weighted averages of 55–80% to be moderate parturition rates, although the utility of this measure for arctic caribou remains unknown (Valkenburg et al. 2000; Boertje et al. 2012). Moderate to high parturition rates in 3-year-old caribou can be indicative of good nutritional condition. If the utility of this metric were to be investigated for arctic caribou, annual sample sizes would need to be increased substantially.

Recommendations for Activity 1.6.

Continue. A minimum of 30 radio collars should remain deployed on females ≥ 4-years old to obtain parturition rates. In the future, area biologists should consider stopping reporting on parturition rates for Units 26B West and 26B East because this analysis has not been useful in recent years.

Investigate the potential to use movement rates analyzed from GPS radio collars to estimate parturition rate, particularly because our pool of capable pilots that are available to fly this type of survey is diminishing.

Table 8. Central Arctic caribou herd annual percent parturition of radiocollared females 36 months of age and 5-year moving weighted averages, Alaska, 1999–2017.

Year	%	*n*	5-year moving weighted average proportion pregnant ± 95% CI	Total *n* in fifth year
1999	100	7	–	–
2000	80	10	–	–
2001	77	13	–	–
2002	77	12	–	–
2003	–	0	82 ± 12	42
2004	88	8	80 ± 12	43
2005	86	7	81 ± 12	40
2006	71	7	80 ± 13	34
2007	100	4	85 ± 14	26
2008	–	0	85 ± 14	26
2009	60	5	78 ± 17	23
2010	60	5	71 ± 19	21
2011	50	4	67 ± 22	18
2012	71	7	62 ± 21	21
2013	75	4	64 ± 19	25
2014	–	0	65 ± 21	20
2015	75	4	68 ± 21	19
2016	67	3	72 ± 21	18
2017	100	6	82 ± 18	17

ACTIVITY 1.7. Estimate peak of calving from radiocollared female caribou (M1).

Data Needs

This data is a byproduct of estimating parturition rates and could be important information if the median calving dates change significantly and also coincide with changes in demographics, weather patterns, or habitat.

Methods

Peak of calving or the median date of calving was defined as the date at which 50% or more of the radiocollared parturient females ≥ 3-years old gave birth. In years when caribou were only located once, and the peak of calving had not occurred yet, we estimated the date of peak of calving using the following criteria which is based on a percentage calculated using the proportion of ≥ 3-year-old females with calves to the number of ≥ 3-year-old parturient females at the last date of radiotracking where if the result was:

1) ≤ 25%, a span of 3 days was added following the last radiotracking date.
2) 26–39%, 2 days were added.
3) 40–49%, 1 day was added.
4) 51–59%, 1 day was subtracted and included in the last day of radiotracking.
5) 60–74%, 2 days were subtracted.
6) ≥ 75%, a span of 3 days was subtracted.

(ADF&G unpublished data, Fairbanks; Arthur and Del Vecchio 2009; Lenart 2015; R. Cameron, retired ADF&G, person communication 2012). The date of the point estimate was determined by deriving the midpoint between the estimated dates for peak of calving.

Results and Discussion

2013—We determined the median date range of calving to be 7–8 June in 2013 (Table 9). At least 7 of 22 parturient females (32%) had a calf by 6 June. A span of 2 days was added to the last radiotracking date of 6 June because 26% to 39% of the parturient females ≥ 3-years old had a calf by 6 June.

2014—The median date range of calving was 4–6 June in 2014 (Table 9). At least 3 of 26 parturient females (11.5%) had a calf by 3 June. A span of 3 days was added to the last radiotracking date of 3 June because ≤ 25% of the parturient females ≥ 3-years old had a calf by 4 June.

2015—The median date of calving was 3 June in 2015 (Table 9). At least 24 of 46 parturient females (52%) had a calf by 3 June.

2016—The median date of calving was 2 June in 2016 (Table 9). Fifty percent of the parturient caribou had a calf by 2 June 2016, but less than half of the caribou were observed ($n = 18$). However, at least 23 of 38 parturient females (60%) had a calf by 3 June.

2017—The median date of calving was 7 June in 2017 (Table 9). At least 28 of the 52 parturient females (54%) had a calf by 7 June.

The estimated date of peak calving ranged from 2 to 8 June during 2013–2017 with the mean estimated date of peak of calving on 5 June (mean point estimate (4.9) ± SE (1.1)). These dates were similar to years before 2013 (range of 1–10 June during 1997–2012). During 1997–2017 the mean estimated date of peak calving was 5 June (mean point estimate (5.3) ± SE (0.50); Table 8; Arthur and Del Vecchio 2009; Lenart 2013, 2015; R. D. Cameron, Wildlife Biologist, ADF&G [retired], personal communication, 2012).

Recommendations for Activity 1.7.

Continue. If time allows, ADF&G area management staff should consider analyzing weather data and snow melt during calving to determine if it is related to peak of calving.

Table 9. Estimated date of peak of calving for Central Arctic caribou herd, Alaska, 1997–2017.

Year	Survey dates	Number of radiocollared parturient cows ≥ 3-years old	Estimated dates for peak of calving[a]	Point estimate for calving date[b]
1997	6 Jun	16	4–5 Jun	4.5
1998	3–4 Jun	25	1–3 Jun	2.0
1999	5, 9 Jun	33	8 Jun	8.5
2000	6–7 Jun	32	8–10 Jun	9.0
2001	3–8 Jun	43	9–10 Jun	9.5
2002	4–7 Jun	55	4–6 Jun	5.0
2003	30 May–8 Jun	52	4–6 Jun	5.0
2004	31 May–11 Jun	69	4–6 Jun	5.0
2005	31 May–9 Jun	56	4–6 Jun	5.0
2006	29 May–8 Jun	57	4–6 Jun	5.0
2007	2–6 Jun	56	7–8 Jun	7.5
2008	2–4 Jun	32	1–2 Jun	1.5
2009	1–3 Jun	36	4 Jun	4.0
2010	2–5 Jun	39	2–5 Jun	3.5
2011	2–3 Jun	34	4–5 Jun	4.5
2012	3, 7 Jun	27	6–7 Jun	6.5
2013	3–6 Jun	22	7–8 Jun	7.5
2014	2–3 Jun	26	4–6 Jun	5.0
2015	1–8 Jun	46	3 Jun	3.0
2016	2–4 Jun	38	2 Jun	2.0
2017	31 May–7 Jun	52	7 Jun	7.0

Note: Peak of calving was defined as the date when 50% or more of the radiocollared parturient cows ≥ 3-years old gave birth.

[a] For years 2002–2006 and 2017, radiocollared females were relocated daily or every 2–3 days until a calf was present (Arthur and Del Vecchio 2009). If observations of females that were determined to be parturient with no calf were followed by ones with a calf present, then the range of days between observations was determined as the estimated date that the females had calved. For years 1997–2000 and 2007–2016, the estimated date of peak of calving was determined using the following criteria based on the percentage calculated using the proportion of ≥ 3-year-old females with calves to parturient females ≥ 3-years old at the last date of radiotracking where if the result was: 1) ≤ 25%, a span of 3 days was added following the last radiotracking date; 2) 26–39%, 2 days were added; 3) 40–49%, 1 day was added; 4) 51–59%, 1 day was subtracted, and included the last radiotracking date; 5) 60–74%, 2 days were subtracted; and 6) ≥ 75%, a span of 3 days was subtracted (Lenart 2013).

[b] The date of the point estimate was determined by deriving the midpoint between the estimated dates for peak of calving.

ACTIVITY 1.8. Estimate 50% and 95% isopleths for radiocollared parturient females during calving (M1 and M2).

Data Needs

Estimating annual core calving ranges is important in identifying calving grounds, and in providing a foundation for collaboration with the oil industry to minimize disturbance to caribou movement during calving. This allows ADF&G management staff to monitor accessibility of seasonal ranges and minimize the adverse effects of development on CAH caribou.

Methods

To display areas of concentrated calving, 95% (home range) and 50% isopleth (core) polygons were calculated annually for years 2013–2017 using the "isopleth" command in Geospatial Modeling Environment (Beyer 2015; R Core Team 2018). Individual kernel density rasters were generated using the plugin bandwidth estimator. Individual year raster output was normalized with the following calculation: "raster" - "raster".minimum) / ("raster".maximum - "raster".minimum; and then summed for the 2013–2017 combined results (M. Spathelf, ADFG GIS Analyst, personal communication). Both cows with calves and cows considered parturient (based on antler and udder distension) were included in the sample.

Results and Discussion

2013— Distribution of calving in 2013 (includes females identified as pregnant and females observed with calves at heel; *n* = 22) during 2–6 June was different compared to previous and subsequent years with CAH caribou calving further south (Fig. 10A; E. Lenart, ADF&G, CAH Caribou 2009 Memorandum, 11 April 2010 Fairbanks, AK; E. Lenart, ADF&G, CAH Caribou 2010 Memorandum, 11 August 2011 Fairbanks, AK; E. Lenart, ADF&G, CAH Caribou 2011 Memorandum, 12 August 2012 Fairbanks, AK; E. Lenart, ADF&G, CAH Caribou 2012 Memorandum, 20 November 2012). Extent of calving encompassed a large area (south to north) as represented by the 95% isopleth (Fig. 10A). The 50% isopleth identified 2 distinct calving concentrations (Fig. 10A).

Spring persisted approximately 1 month longer in the eastern Brooks Range and on the eastern coastal plain, likely slowing the movement of caribou to the calving grounds. Peak of calving was estimated 2.5 days later compared to the overall mean for the previous 16 years (5 June; Table 9).

2014— Distribution of calving (includes females identified as pregnant and females observed with calves at heel, *n* = 26) during 2–3 June encompassed a large area (west to east) as represented by the 95% isopleth. The 50% isopleth again identified 2 distinct calving concentrations (Fig. 10B).

2015— In 2015, distribution of calving (includes females identified as pregnant and females observed with calves at heel, *n* = 48) during 1–8 June was similar to where CAH calved during 2009–2012 (E. Lenart, ADF&G, CAH Caribou 2009 Memorandum, 11 April 2010 Fairbanks, AK; E. Lenart, ADF&G, CAH Caribou 2010 Memorandum, 11 August 2011 Fairbanks, AK; E. Lenart, ADF&G, CAH Caribou 2011 Memorandum, 12 August 2012 Fairbanks, AK; E. Lenart, ADF&G, CAH Caribou 2012 Memorandum, 20 November 2012). The 50% isopleth identified 2 distinct calving concentrations occurred in 2015 (Fig. 11A).

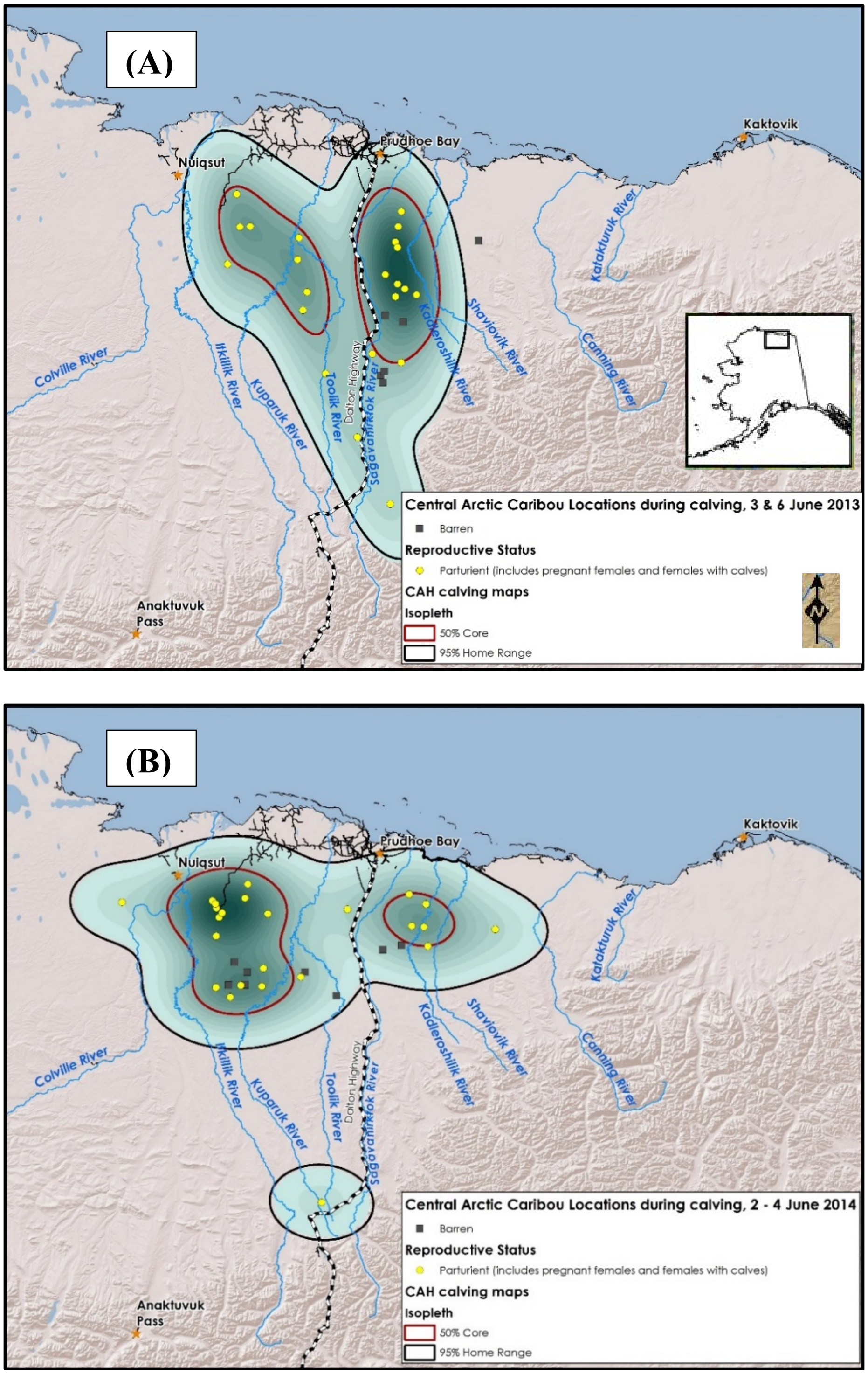
2016— In 2016, the distribution of calving (includes females identified as pregnant and females observed with calves at heel, n = 38) during 2–4 June was similar to 2015 with the 50% isopleth indicating 2 distinct calving concentrations (Fig. 11B).

2017— In 2017, distribution of calving (includes females identified as pregnant and females observed with calves at heel, n = 59) during 31 May–7 June was similar to where CAH calved during the previous 2 years. The 50% isopleth identified one calving concentration in 2017 compared to 2 concentrations during 2013–2016 (Fig. 12A). Calving did occur east of the Dalton Highway, and was captured in the 95% isopleth (Fig. 12A).

Combined Years 2013–2017—Distribution of calving during the previous 5 years, 2013–2017, is represented by the 95% isopleth in Fig. 12B. The 50% isopleth identified 2 distinct calving concentrations which occurred during 2013–2017 (Fig. 12B).

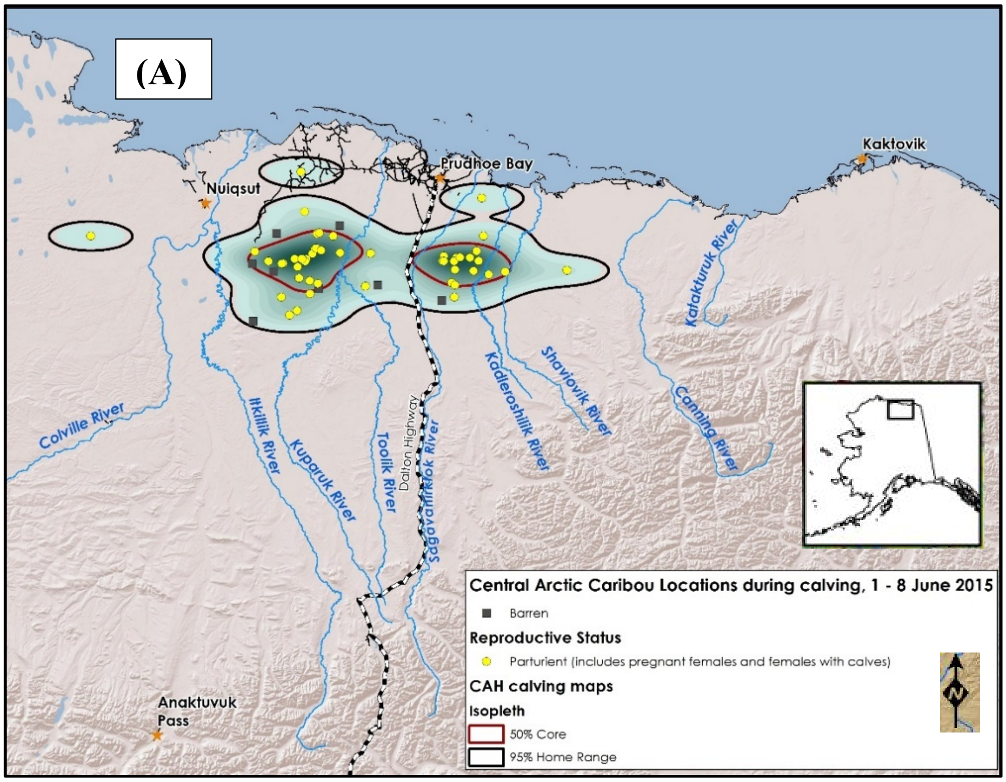
Recommendations for Activity 1.8.

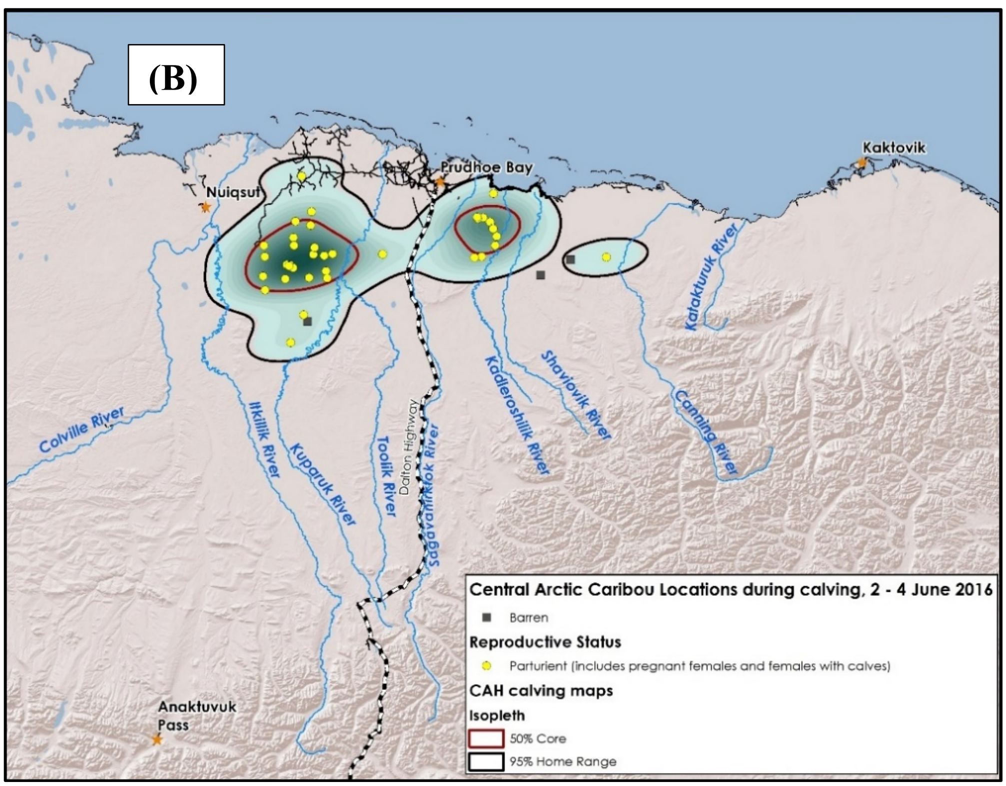
Continue. Investigate other methods of estimating calving ranges (e.g., core calving range, concentrated calving range) or use the kernel density method used to estimate calving distribution in Activity 1.11, seasonal distribution of Central Arctic caribou.



Data source: ADF&G, AKDOT, ESRI, USGS

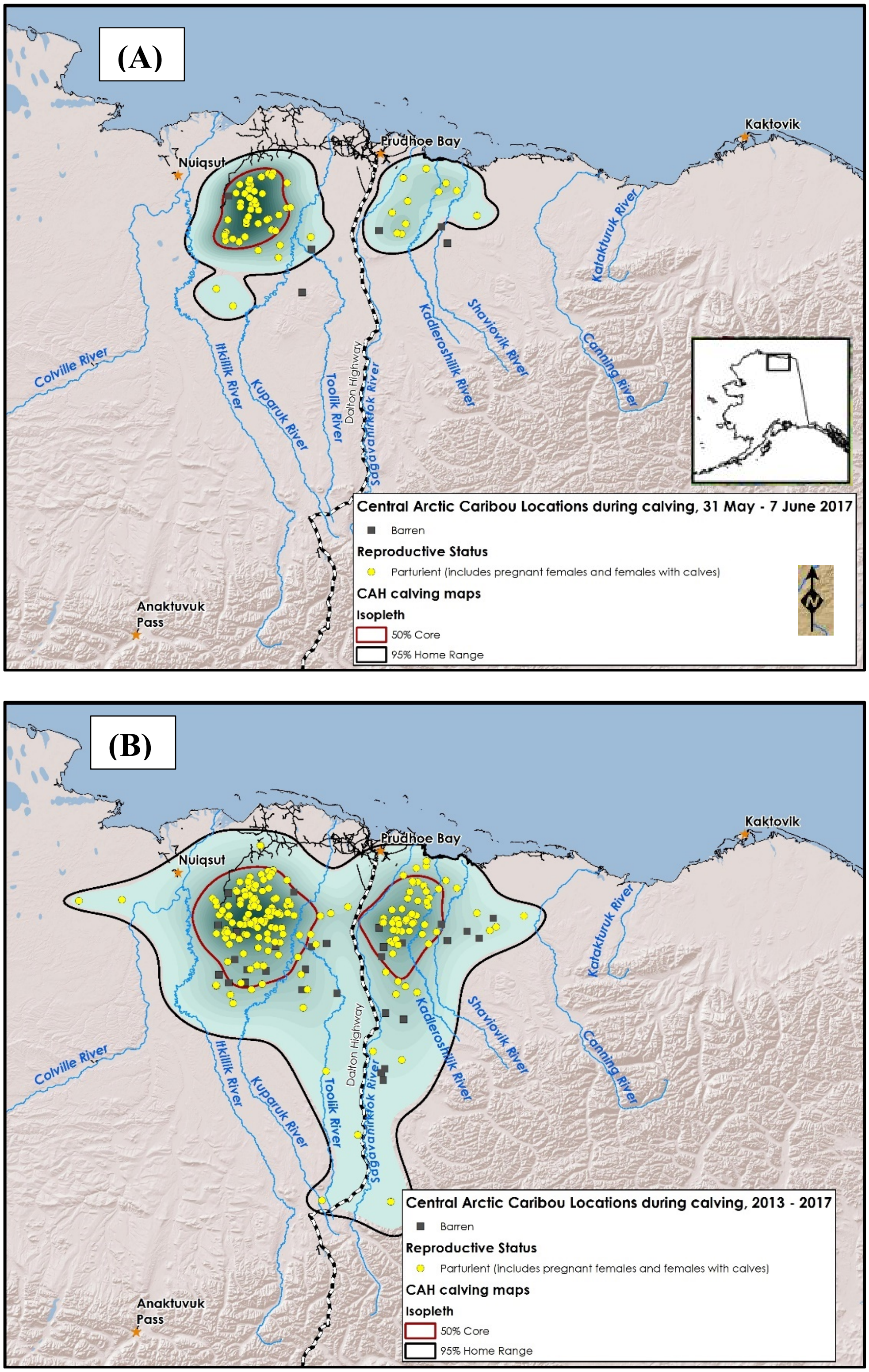
Figure 10. Map showing calving locations for Central Arctic caribou during 2–4 June 2014. Fifty percent (red outline polygon) and 95% (black outlined polygon) isopleths for radio collared Central Arctic female caribou considered parturient during calving in 2013 (A) and 2014 (B). Parturient females include pregnant females and females observed with a calf.





Data source: ADF&G, AKDOT, ESRI, USGS

Figure 11. Map showing calving locations for Central Arctic caribou during 1–8 June 2015(A) and 2–4 June 2016(B). Fifty percent (red outline polygon) and 95% (black outlined polygon) isopleths for radio collared Central Arctic female caribou considered parturient during calving in 2015(A) and 2016(B). Parturient females include pregnant females and females observed with a calf.



Data source: ADF&G, AKDOT, ESRI, USGS

Figure 12. Map showing calving locations for Central Arctic caribou during 2013–2017. Fifty percent (red outline polygon) and 95% (black outlined polygon) isopleths for radio collared Central Arctic female caribou are considered parturient during calving in 2017(A) and combined for 5 years, 2013–2017(B). Parturient females include pregnant females and females observed with a calf.

ACTIVITY 1.9. Estimate late June calf-to-cow ratios of radiocollared females and early calf survival (M1 and C2).

Data Needs

Estimates of late June calf-to-cow ratios and early summer calf survival provide an index of recruitment potential for that year. Estimates of early calf survival are one of the demographics used to aid in determining a trend in the population size when a photocensus is not completed.

Methods

The proportion of calves:100 cows was estimated by observing radiocollared females ≥ 3-years old from a fixed-wing aircraft during the third or fourth week of June after calving was most likely to have occurred. During 2013−2017, surveys were conducted during 21−27 June, except in 2015 and 2016 when caribou groups were too dense to identify a calf with a cow, mostly due to warm temperatures.

The ratio of the number of calves:100 cows was calculated as the number of adult female caribou observed with a calf at heel divided by the total number of adult females observed. This is referred to as "late June calf:cow ratios". Late June calf:cow ratios were calculated for females ≥ 4-years old, 3-years old, and ≥ 3-years old. Not all caribou observed had known ages; but we included unknown-aged caribou in the following categories: females ≥ 4-years old and females ≥ 3-years old. A 95% binomial confidence interval was calculated for late June calf:cow ratios for females ≥ 4-years old using a normal approximation method:

$$1.96\sqrt{\frac{(\hat{p}*(1-\hat{p}))}{n}} \text{ where } \hat{p} = \text{estimated proportion of calves: 100 cows}$$

A binomial GLM regression was fitted to estimate the trend in proportion of calves:100 cows for years 1997−2017 (all years of data), 2000−2010 (years population was increasing), and 2010−2017 (years population was declining). Data for females ≥ 4-years old were stratified based on the location of caribou east and west of the Sagavanirktok River, following the protocol for estimating parturition rates.

Early summer calf survival of radiocollared females ≥ 3-years old was estimated by comparing females identified as parturient in early June with the same females in late June to determine if their calf had survived.

Results and Discussion

<u>2013</u>— Late June calf:cow ratios of radiocollared females ≥ 4-years old were 56:100 ± 19.5 (*n* = 25; 95% CI; Table 10; Fig. 13). Of these 25 caribou, 14 had a calf present and 11 did not have a calf present. Ratios were 60:100 (*n* = 5) in Unit 26B West and 55:100 (*n* = 20) in Unit 26B East (Table 10).

Two of the four 3-year-old caribou that were located had a calf (50:100). The late June calf:cow ratio of radiocollared females ≥ 3-years old was 55:100 (*n* = 29).

Early calf survival of all radiocollared females (≥ 3-years old) in late June indicated that 73% of females that were determined to be parturient or had a calf in early June still had a calf in late

June (n = 22). Thus, 6 cows that were determined parturient or had a calf in early June did not have a calf in late June, including one of the two 3-year-olds.

2014— Late June calf:cow ratios of radiocollared females ≥ 4-years old were 65:100 ± 16.0 (n = 34; 95% CI; Table 10; Fig. 13). Of the 34 caribou located, 22 had a calf present and 12 did not have a calf present. Late June calf:cow ratios were 71:100 (n = 24) in Unit 26B West and 40:100 (n = 10) in Unit 26B East (Table 10).

We located one 3-year-old caribou and it did not have a calf. The late June calf:cow ratios of radiocollared females ≥ 3-years old was 63:100 (n = 35).

Early calf survival of all radiocollared females (≥ 3-years old) in late June indicated that 76% of females were determined to be parturient, had a calf in early June, or still had a calf in late June (n = 25). Thus, 6 females that were determined parturient or had a calf in early June did not have a calf in late June. One female that was determined barren in early June had a calf present in late June.

2015 and 2016—No surveys were conducted because caribou groups were too dense to identify a cow with a calf. The relatively tight grouping was likely due to warm temperatures.

2017— Late June calf:cow ratios for females ≥ 4-years old were 57:100 ± 12.5 (n = 60; 95% CI; Table 10; Fig. 13). Of the 60 caribou located, 34 had a calf present and 26 did not have a calf present. In Unit 26B West, the ratio was 60:100 (n = 47). The ratio in Unit 26B East was 46:100 (n = 13; Table 10).

The late June calf:cow ratio for 3-year-old females was 100:100 (n = 5). The late June calf:cow ratio of radiocollared females ≥ 3-years old was 60:100 (n = 65).

Early calf survival of all radiocollared females (≥ 3-years old) in late June indicated that 66% females that were determined parturient or had a calf in early June still had a calf in late June (n = 59). Thus, 20 females that were determined parturient or had a calf in early June did not have a calf in late June.

Combined years—During 2013–2017, late June calf:cow ratios for females ≥ 4-years old ranged from 57% to 65% which is lower than what was observed in previous years (Table 10, Fig. 13). Note that during this time-period, only 3 years of data were collected. It is unknown what the critical value for late June calf:cow ratios are for the CAH regarding its effect on population trend.

A declining trend was detected in late June calf:cow ratios for females ≥ 4-years-old during 1997–2017 (n = 760; P-value = 0.0207). On average, the decline was approximately 1% per year, although the rate of change model used was not linear. No trend was detected in years the herd was increasing, 2000–2010 (n = 507, P-value = 0.9061). A declining trend was detected in years the herd was declining, 2010–2017 (n = 214, P-value = 0.0323); however, only 6 years of data were collected during the 8 years. On average, the decline was approximately 3.5% per year, the rate of change model used was not linear.

Identifying a calf with the correct cow (i.e., its mother) can be challenging during late June. When a calf perceives a threat, it often runs to the nearest cow making it difficult for the observer and pilot to determine the correct calf-cow pair. Taking this into account and the 2 years of missing data during a critical period (when the herd was declining), it still appears that late June calf:cow ratios were lower in the years that the herd was declining, indicating that there may have been lower early-calf survival compared to previous years. However, calf-to-cow ratios observed from the fall composition surveys during 2010–2017 (Activity 1.10) indicated good calf survival. Note that these 2 surveys are not directly comparable because one survey was based on individual radiocollared females and the other survey was based on groups of caribou. One or both surveys may or may not represent what is actually happening in the population.

Recommendations for Activity 1.9.

Continue.

Table 10. Central Arctic herd caribou late June calf-to-cow ratios (calves per 100 cows) of radiocollared females greater than or equal to 4-years old, Unit 26B, Alaska, 1997–2017.

Year	Date(s)	Unit 26B West[a] (*n*)	Unit 26B East (*n*)	All Unit 26B ±95% CI	Total (*n*)
1997	29–30 Jun	85 (13)	64 (11)	75 ± 17.3	(24)
1998	29–30 Jun	79 (14)	80 (15)	79 ± 14.5	(29)
1999	22–24 Jun	92 (13)	67 (12)	80 ± 15.7	(25)
2000	17–19 Jun	79 (14)	72 (18)	75 ± 15.0	(32)
2001	23–25 Jun	78 (18)	81 (16)	79 ± 13.7	(34)
2002	23–25 Jun	78 (28)	83 (24)	81 ± 10.7	(52)
2003	24–26 Jun	77 (26)	78 (27)	77 ± 11.3	(53)
2004[b]	24 Jun	78 (27)	87 (17)	82 ± 11.3	(44)
2005	24 Jun	77 (35)	61 (23)	71 ± 11.7	(58)
2006	23–24 Jun	82 (22)	94 (33)	89 ± 8.3	(55)
2007	22–23 Jun	87 (32)	71 (21)	81 ± 10.5	(53)
2008	23–24 Jun	100 (3)	90 (42)	91 ± 8.4	(45)
2009	23–24 Jun	56 (17)	48 (25)	52 ± 15.1	(42)
2010	22–23 Jun	92 (12)	81 (27)	85 ± 11.2	(39)
2011	20–21 Jun	80 (10)	75 (20)	77 ± 15.0	(30)
2012	26–27 Jun	64 (11)	73 (15)	69 ± 17.8	(26)
2013	26–27 Jun	60 (5)	55 (20)	56 ± 19.5	(25)
2014	24–25 Jun	75 (24)	40 (10)	65 ± 16.0	(34)
2015[c]	–	– –	– –	–	–
2016[c]	–	– –	– –	–	–
2017	21–22 Jun	60 (47)	46 (13)	57 ± 12.5	(60)

Note: Data for females ≥ 4-years old were stratified based on the location of caribou east and west of the Sagavanirktok River. In some years, we captured unknown-age adult females and these were included in the ≥ 4-years old sample.

[a] Unit 26B West is west of the west bank of the Sagavanirktok River and Unit 26B East is east of the west bank of the Sagavanirktok River.
[b] Only GPS radiocollared females with radiocollared calves were relocated because the caribou were aggregated tightly, making identifying a calf with the correct cow impossible.
[c] Caribou were too grouped to identify a calf with a cow.

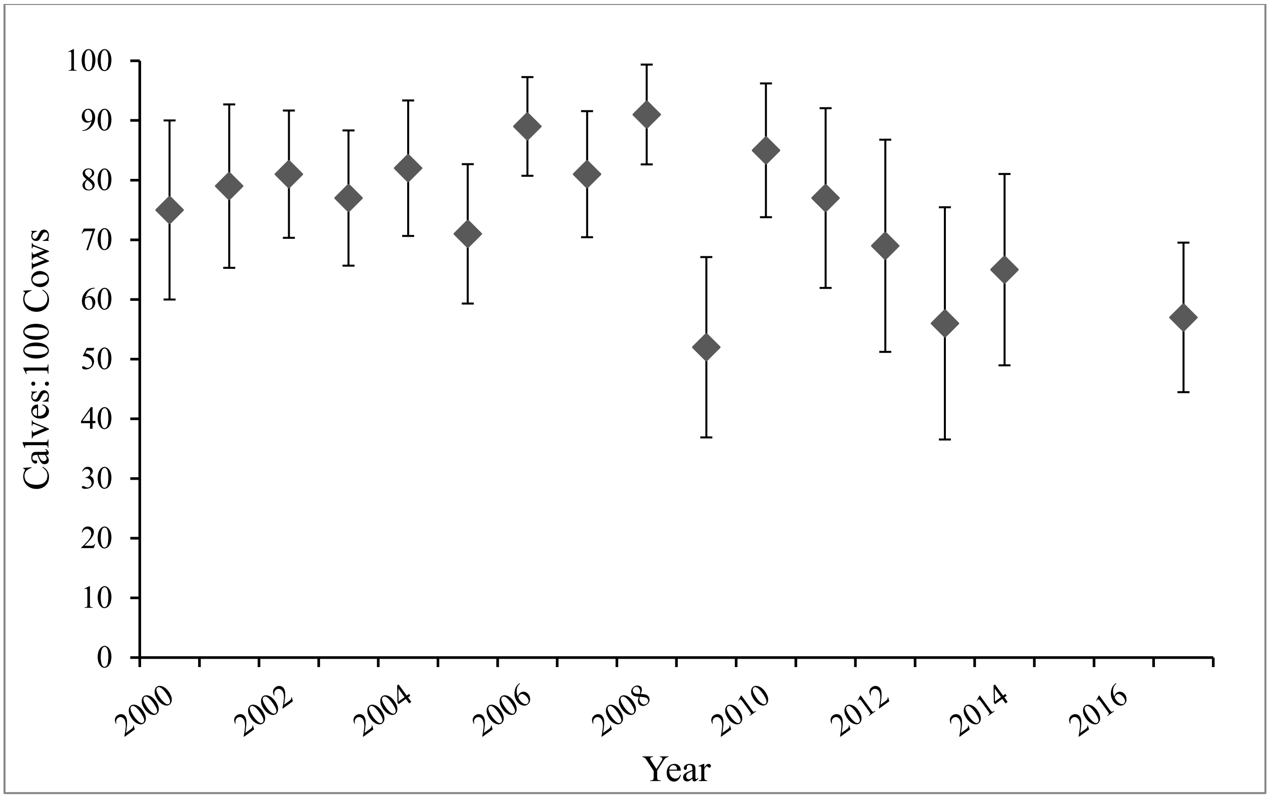


Figure 13. Late June calf:cow ratios (± 95% CI) of Central Arctic radiocollared female caribou ≥ 4-years old, Alaska, 2000–2017.

ACTIVITY 1.10. Conduct annual fall composition surveys to estimate bull-to-cow and calf-to-cow ratios (M1, M2, M3, M4, C1, C2, and C3).

Data Needs

This activity can provide demographic data to be used in determining population trends, information to determine if there is an adequate number of bulls available for breeding, an indication of bull survival, an indication of calf survival to fall; and may inform appropriate harvest rates when abundance if low and the harvestable surplus is near management objectives. These metrics are less informative when abundance estimates are regularly obtained but may help evaluate herd status and trend in periods when a photocensus cannot be obtained.

Methods

Fall sex and age composition were estimated by classifying caribou from an R-44 helicopter near the peak of rut to take advantage of the presumed mixing of bulls, cows, and calf caribou. Peak rut was estimated as the date 228 days (gestation period) prior to the median calving date (19 October) for CAH. Caribou groups were located by radiotracking collared caribou from a fixed-wing aircraft. Caribou were classified as cows; calves; and small, medium, or large bulls. Summary data were reported as ratios of bulls:100 cows and calves:100 cows.

In 2012 and 2014, for each radiocollared caribou, approximately 200 caribou were classified up to a 3-mile radius, using a cluster sampling scheme (Cochran 1977). If less than 200 caribou were present in a group, all, or most of the caribou in that group were classified. In addition, some groups without radio collars were sampled.

In 2016, caribou were located by radiocollar from a fixed-wing aircraft. On the coastal plain, caribou were not in large groups, but were scattered across the landscape in small groups of 6–20 caribou. Therefore, we classified caribou across the landscape within the boundaries of the collared caribou. The caribou that were located near Porcupine Lake (in the mountains) in large pre-rut groups were all classified.

In 2017, for each radiocollared caribou, approximately 50 were classified per our objective of classifying at least 10% of the herd to estimate both bull-to cow and calf-to-cow ratios. Based on the 2016 CAH population estimate of 22,630 caribou (the most current data available as the 2017 photos had not been counted yet), our objective was to classify at least 2,300 caribou. Sampling effort was allocated over the entire spatial distribution of the CAH by using GPS radiocollar location information that ADF&G had documented prior to the survey. The sample was distributed among sex and age classes of radiocollared caribou to capture a representative sample of the population to the extent that was logistically possible. While radiotracking, ADF&G staff listened for VHF radio collars which were also included in the number of caribou classified per radio collar.

Results and Discussion

During RY12–RY17, bull-to-cow ratios were close to the management objective of 40 bulls:100 cows and calf-to-cow ratios were considered good (≥ 42 calves:100 cows; Table 11).

2012— In October, we classified 4,016 caribou and observed bull-to-cow ratios of 56:100 and calf-to-cow ratios of 61:100 (Table 11). ADF&G staff sampled caribou from 11 groups with 31 radio collars in the upper Sagavanirktok, Accomplishment, Ribdon, and Lupine rivers north of the Brooks Range; in upper Your Creek; and near Chandalar Lake south of the Brooks Range (Fig. 14). Fifty percent of the active radio collars (n = 62) were distributed among the groups. The number of radio collars in a group ranged from 1 to 12 and the number of caribou classified in a group ranged from 48 to 1,156 (E. Lenart, ADF&G, CAH Caribou 2012 Memorandum, 20 November 2012).

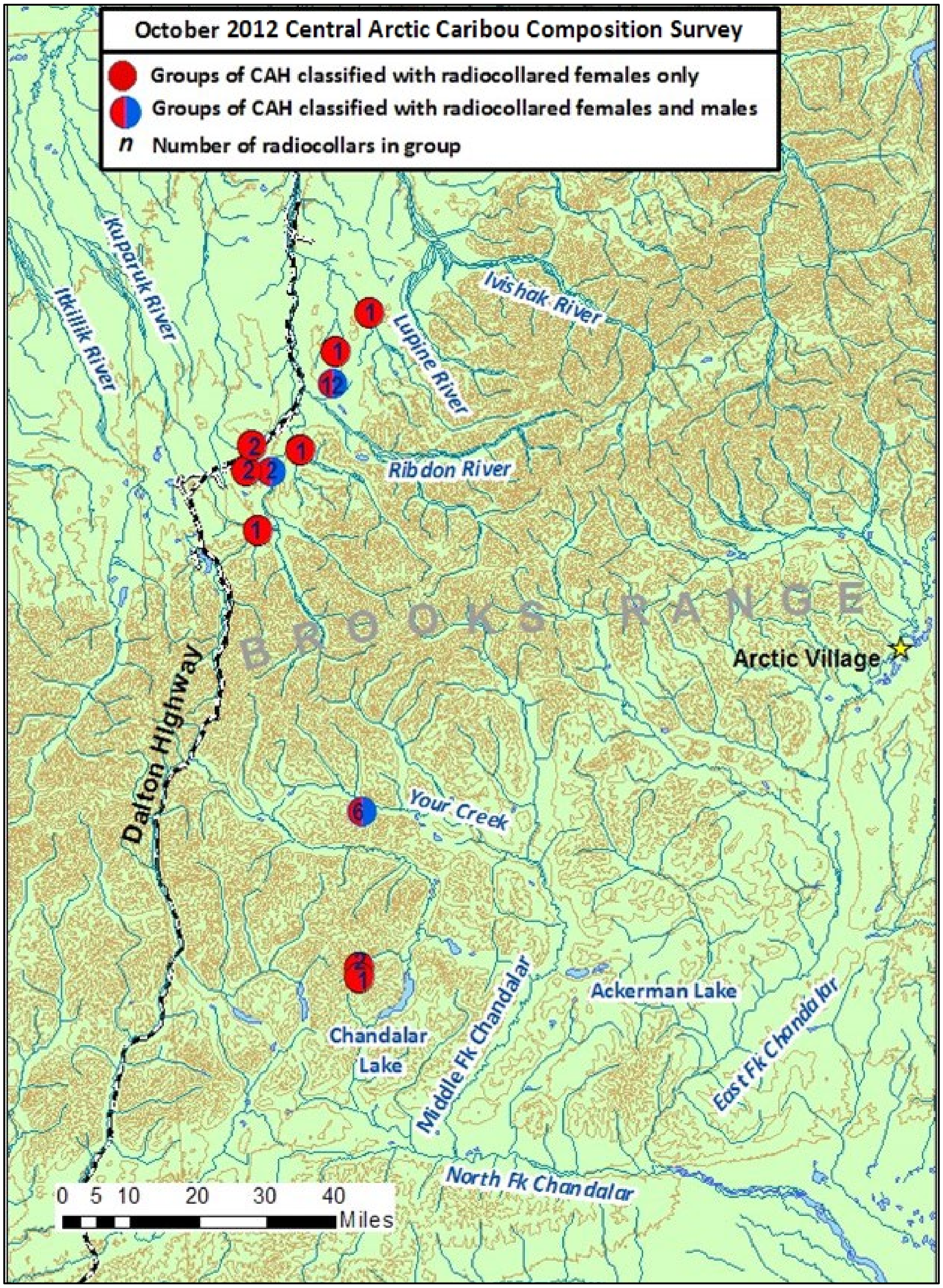


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Figure 14. Map showing the locations of groups of Central Arctic caribou classified by sex and age, during the composition survey that occurred in October 2012.

2014—During October, we classified 2,004 caribou and observed bull-to-cow ratios of 41:100 and calf-to-cow ratios of 42:100 (Table 11). We sampled caribou from 15 groups with 18 radio collars between Twin Lakes, Chandalar Lake, North Fork Chandalar River, Your Creek, and Middle Fork Chandalar River in Unit 25A (Fig. 15). This represented 19% of the active radio collars (n = 93) distributed among the 15 groups. Each group had no more than 2 radio collars in it. Group size ranged from 16 to 460 caribou (E. Lenart, ADF&G, Fall 2014 CAH Composition Memorandum, 15 September 2015, Fairbanks, AK).

The bull-to-cow ratio was lower compared to previous years; however, this number should be viewed with caution due to small sample size and potential mixing with PCH caribou (E. Lenart, ADF&G, Fall 2014 CAH Composition Memorandum, 15 September 2015, Fairbanks, AK). The calf-to-cow ratio was also lower, yet still met objectives. We expected a lower calf-to-cow ratio because parturition rates and late June calf:cow ratios of radiocollared females were lower in 2014 compared to 2010−2012; this ratio was also affected by small sample size and mixing and therefore it should also be viewed with caution.

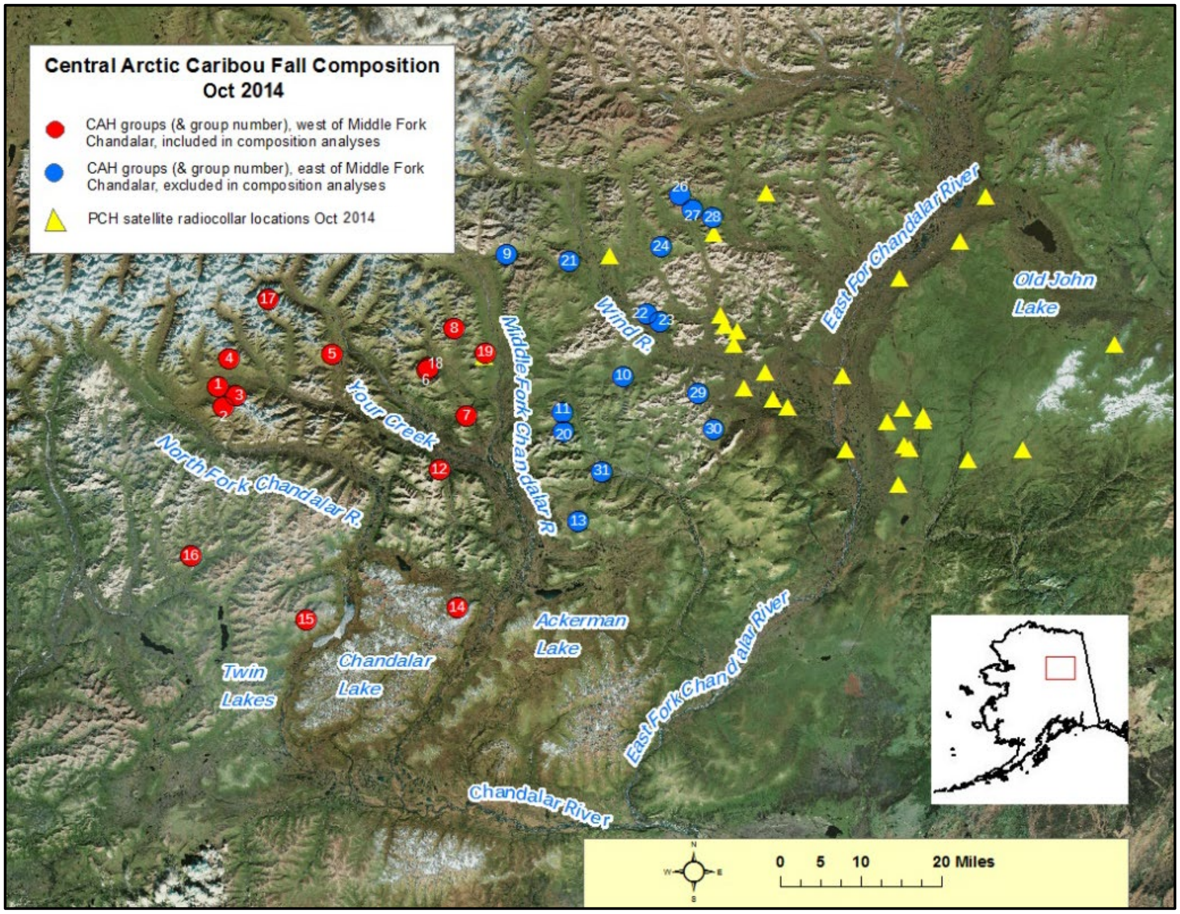


Figure 15. Locations of groups of Central Arctic caribou (CAH) classified by sex and age during the CAH composition survey in October 2014. West of Middle Fork Chandalar River are represented by red circles and included in composition results. The east of Middle Fork Chandalar River is represented by blue circles and is excluded from composition analyses due to potential mixing with the Porcupine caribou herd. Yellow triangles represent the Porcupine caribou satellite radio collar locations.

2016 —During October, we classified 2,944 caribou; the bull-to-cow ratio was 39:100 and the calf-to-cow ratio was 47:100 (Table 11). ADF&G staff sampled caribou from 12 groups west of the Dalton Highway and north of the White Hills in Unit 26B *(n* = 10) which mostly consisted of several small groups combined, however, caribou scattered between these small groups were also included (Fig. 16). Group size in this area ranged from 28 to 480 caribou. Groups of caribou near Porcupine Lake in Unit 26B (*n* = 2) were larger ranging from 144 to 661 caribou which is similar to rutting groups that were observed in previous years (E. Lenart, ADF&G, Fall 2016 CAH Composition Memorandum, 23 February 2018, Fairbanks, AK).

Although the radio collars could not be used to sample, we did locate 65% of the 63 total active radio collars (28 were located and 13 were heard in the vicinity) indicating that our sampling distribution was likely adequate. Thirty-seven of the radio collars were west of Dalton highway and north of the White Hills and 2,139 caribou were classified. Four radio collars were located near Porcupine lake, where 805 caribou were classified.

In 2016, the bull-to-cow ratio was similar to what was observed in 2014 (41:100), however, the sample size was small in 2014 and there was the issue of potential mixing with PCH. The calf-to-cow ratio in 2016 of 47:100 was similar to the average ratio observed during 2009–2012 (49:100) and slightly higher than in 2014 (42:100).

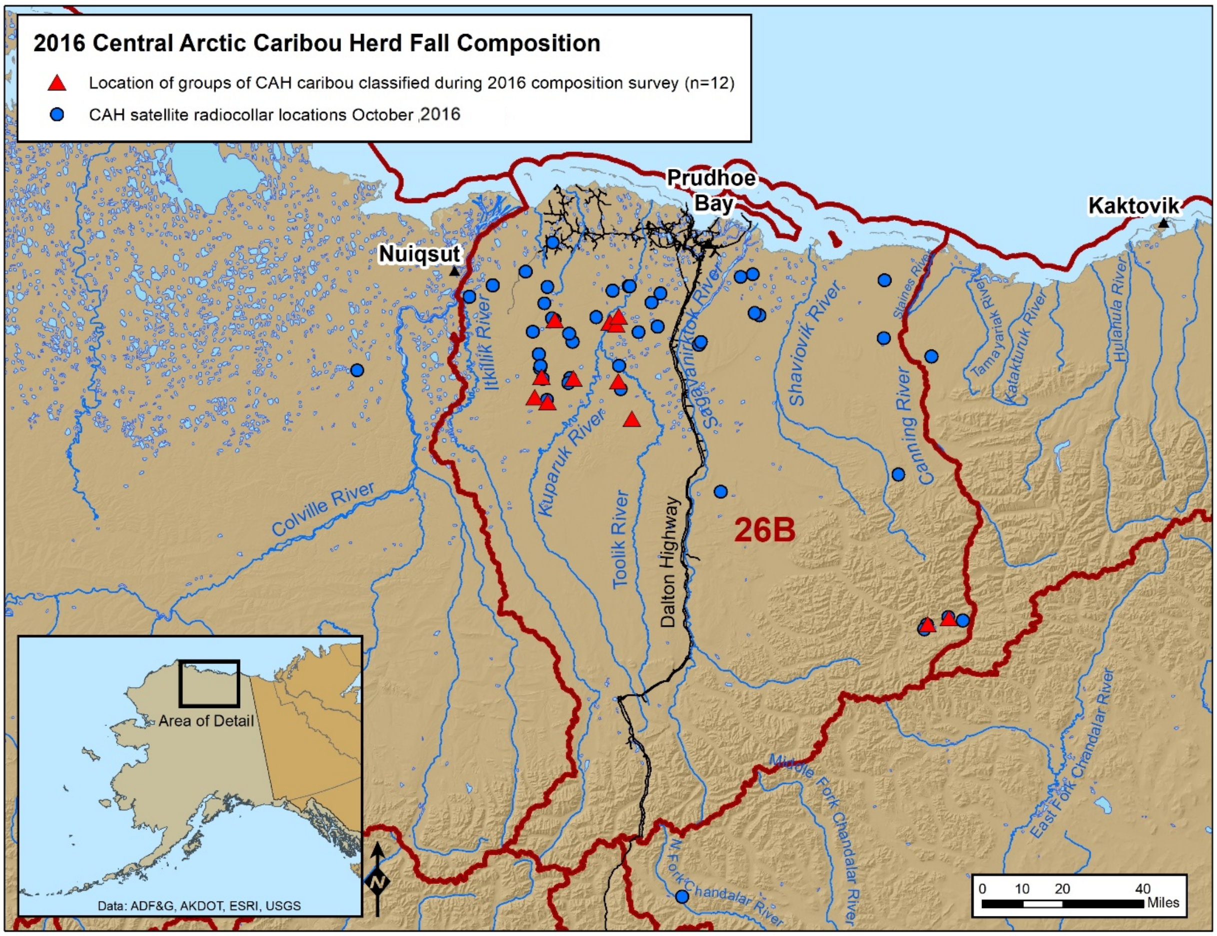


Figure 16. Distribution of Central Arctic caribou (CAH) satellite radio collar locations (blue circles) and groups of caribou classified by sex and age (red triangle) during CAH composition survey, October 2016.

2017— In October, we classified 2,962 caribou; the bull-to-cow ratio was 39:100 and the calf-to-cow ratio was 51:100 (Table 11). A total of 16 groups were classified, 12 groups had between 1 and 16 radio collars per group, and 4 had zero radio collars per group. The number of caribou classified in a group ranged from 10 to 947 caribou. Groups that ranged from Toolik Lake to Deadhorse in Unit 26B were sampled (Fig. 17).

In early-to-mid October, caribou were in large groups of 700–2,000 caribou, characteristic of traditional rutting groups. It appeared that rutting activity had taken place and caribou were moving southward. We classified 4 groups at this time (Fig. 17A). Weather prevented us from returning for a few days in mid-October. In mid-to-late October, the caribou that we classified were more scattered in smaller groups of 25–200 caribou (Fig. 17B).

We located a total of 51 radio collars in 12 groups out of a total of 110 active radio collars. In mid-to-early October, we located 40 radio collars and classified 2,224 caribou from 4 groups. In mid-to-late October, we located 11 radio collars in 8 groups and classified 585 caribou. We also classified 153 caribou from 4 groups with no radio collars present resulting in a total of 738 caribou classified from 12 groups in mid-to-late October (E. Lenart, ADF&G, Fall 2017 CAH Composition Memorandum, 20 July 2018, Fairbanks, AK). Radio collars located and sampled represented approximately 46% of the active CAH radio collars (n = 110).

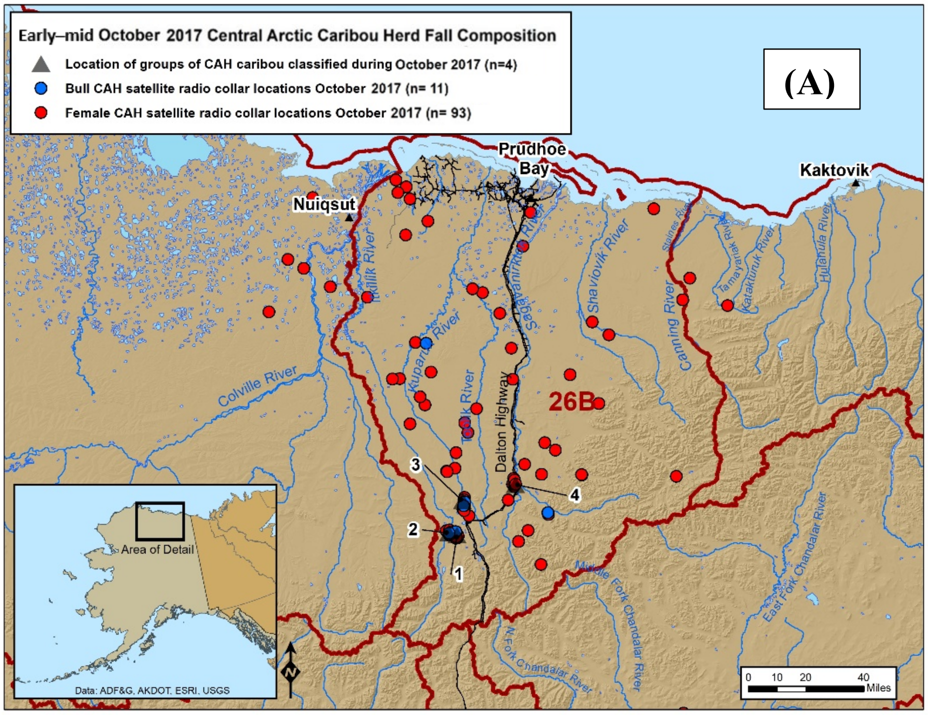
Recommendations for Activity 1.10

Continue. Potentially modify by working with a biometrician to investigate the utility of using proportions versus ratios to inform future management decisions and continue to explore ways to minimize bias in sampling distribution, classification, and segregation of sexes.

Table 11. Central Arctic caribou herd fall composition surveys, Unit 26B, Alaska, 2009–2017.

Date	Bulls: 100 cows	Calves: 100 cows	% Calves (# calves)	% Cows (# cows)	% Bulls (# bulls)	Sample size	# Groups	# Collars (# bull collars)
13–14 Oct 2009	50	33	18 (1,193)	55 (3,641)	27 (1,814)	6,648	19	37 (0)
23 Oct 2010	50	46	23 (889)	51 (1,930)	26 (968)	3,787	12	21 (0)
13 Oct 2011	69	56	25 (1,303)	44 (2,306)	31 (1,590)	5,199	22	33 (0)
14 Oct 2012	56	61	28 (1,132)	46 (1,845)	26 (1,039)	4,016	11	31 (5)
13–14 Oct 2014[a]	41	42	23 (462)	55 (1,097)	22 (445)	2,004	15	18 (0)
13–14 Oct 2016	39	47	25 (742)	54 (1,579)	21 (623)	2,944	12	28 (2)
16, 20 Oct 2017	39	51	27 (802)	53 (1,559)	20 (601)	2,962	16	51 (10)

[a] View data with caution. Originally, 3,903 caribou were classified in this survey, but ADF&G management staff determined that caribou may have been mixed with PCH caribou based on PCH satellite radio collar locations. Therefore, only groups sampled west of the Middle Fork Chandalar River were included, reducing overall sample size.



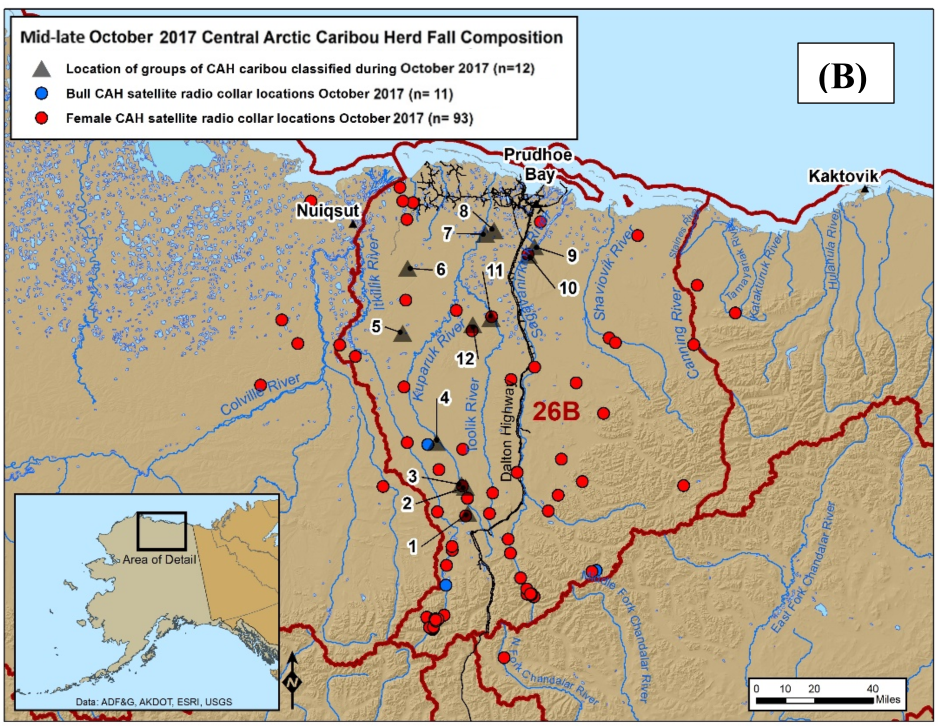


Figure 17. Map showing the distribution of Central Arctic (CAH) satellite radio collared caribou. Red circles represent female, blue circles represent male, and locations of groups of caribou classified by sex and age (grey triangles with group number), during CAH composition survey, early-to-mid October 2017 (A) and mid-to-late October 2017 (B).

ACTIVITY 1.11. Estimate seasonal distribution of Central Arctic caribou (M3).

Data Needs

Understanding the seasonal distribution of CAH is necessary to ensure accessibility of seasonal ranges for CAH caribou and minimize the adverse effects of development on the herd. Providing the opportunity for a subsistence harvest, viewing the herd, and photographing the herd requires reliable estimates of location and density of CAH caribou. Telemetry data obtained from satellite radio collars is needed to provide a basis for calculating these estimates.

Methods

SATELLITE RADIOCOLLAR DATA

Telemetry data (Platform Transmitter Terminal ((PTT) and GPS collars) were compiled for female caribou of the Central Arctic Herd (CAH) during 1 July 2012–30 June 2017. Data were screened to remove the following: locations prior to collaring, the first 14 days after initial collaring, after collar removal, after mortality, with poor quality (PTT quality score of A or 0), far offshore, and duplicates. Data were also removed based on a distance-rate-angle score that considered the angle and speed of 3 successive locations. Locations were also removed when caribou were with other herds.

KERNEL DENSITIES

For winter (1 Dec–15 Apr), calving (1–15 June), postcalving (16–30 June), mosquito season (1–15 July), oestrid fly season (16 July– 7 Aug), late summer seasons (8 Aug– 15 Sep), and annual range, we estimated kernel densities by calculating the mean location of each caribou for every 2-day period during the year using the ks package for R software (Duong 2017). Fixed-kernel density estimation was employed to create the utilization distribution contours of caribou distribution for every 2-day period throughout the year, for all years combined (1 July 2012–30 June 2017). An average utilization distribution for each season was calculated. By calculating the average of the utilization distribution based on the mean location for each animal, we were able to account for movements within a season while not biasing the calculation due to autocorrelation among locations for a single caribou, or due to unequal sample sizes among caribou. The plug-in method was used to calculate the bandwidth of the smoothing parameter. The 50%, 75%, and 95% isopleth were calculated from each seasonal utilization distribution and used to display the high-, medium-, and low-density contours, respectively.

DYNAMIC BROWNIAN BRIDGE MOVEMENT MODELS

To visualize caribou movements during spring and fall migration periods, dynamic Brownian Bridge Movement Models (dBBMM) was used to create utilization distribution maps of movements based on the locations of collared individuals (Kranstauber et al. 2014). These dBBMM models, a modification of earlier Brownian bridge models (Horne et al. 2007), use an animal's speed of movement and trajectory calculated from intermittent GPS locations to create a probability map describing relative use of the area traversed. A 95% isopleth of movements for each individual CAH caribou outfitted with a collar in the area was computed and then overlaid the isopleth layers for each season to calculate the proportion of collared caribou using each 100-meter pixel. This visualization displays the seasonal use of the area by CAH caribou as a function of both caribou distribution and movements. The dBBMM models were computed using the move package in R software (Kranstauber et al. 2017).

Results

Winter (1 Dec–15 Apr)—Distribution during 2012–2015, indicated that the highest density of caribou wintered on the south side of the Brooks Range between the Dalton Highway and west of Arctic Village and north of the Brooks Range, west of the Dalton Highway and south of the coast (Fig. 18A). Densities varied from year to year such that in some years more caribou wintered on the south side or the north side rather than caribou distributing equally on both sides of the range. In some years when the herd wintered south of the Brooks Range, substantial mixing with the PCH occurred. In the winter of 2016–2017, most of the caribou wintered on the north side.

Winter 2012–2013— During mid-March and early April 2013, distribution of CAH satellite and VHF radio collars (*n* = 63; 54 heard or located) indicated that 100% of the Central Arctic wintered on the south side of the Brooks Range between Twin Lakes and upper North Fork and Middle Fork Chandalar rivers with some caribou as far east as the East Fork Chandalar River between the Wind and Junjik rivers. A small portion of PCH mixed with CAH; but most of PCH caribou wintered in Canada. Some mixing with TCH did occur (E. Lenart , ADF&G, 2013 Central Arctic Caribou Winter Radiotracking & Capture, Parturition, Early survival, Photocensus Memorandum, 8 August 2014, Fairbanks, AK).

Winter 2013–2014—During mid-March 2014, distribution of CAH satellite radio collars (PTT and GPS, *n* = 17) indicated that 94% were on the south side of the Brooks Range, with most caribou distributed between Bob Johnson Lake and the Middle Fork Chandalar River, and some caribou in and south of the Hodzana Hills. Substantial mixing with both TCH and PCH herds occurred during winter 2013–2014 (E. Lenart , ADF&G, 2014 Central Arctic Caribou Winter radiotracking & capture, Parturition, Early survival, Fall Composition Memorandum, 01 September 2015, Fairbanks, AK).

Winter 2014–2015—During mid-March 2015, distribution of GPS satellite (*n* = 21) and VHF only radio collars (located on 19 March 2015; *n* = 35) indicated that 88% of the radio collars were on the south side of the Brooks Range. Most of the radio collars were distributed east of the Dalton Highway from the North Fork Chandalar River to the East Fork Chandalar River. Substantial mixing with the Porcupine caribou herd (PCH) occurred during the winter of 2014–2015. Most of the PCH wintered along the East Fork Chandalar River and lower Middle Fork Chandalar where some CAH also wintered. Some Central Arctic caribou also wintered with a portion of the Teshekpuk caribou (TCH) just west of the Dalton Hwy, south of the Brooks Range in the upper Hammond and Clear Rivers (E. Lenart, ADF&G, 2014 Central Arctic Caribou Field Summary Memorandum, 23 July 2018, Fairbanks, AK).

Winter 2015–2016—During mid-March 2016, distribution of Central Arctic herd GPS satellite radio collars indicated that 64% of the GPS satellite radio collars (*n* = 28) were on south side of the Brooks Range during mid-March. These caribou were distributed east of the Dalton Highway, from Wiseman to the East Fork Chandalar River and Arctic Village. The remaining collars were distributed throughout or just outside of Unit 26B into Unit 26C. Some mixing with both the Teshekpuk (TCH) and Porcupine (PCH) caribou herds occurred during mid-March (E. Lenart, ADF&G, 2016 Central Arctic Caribou Winter Distribution, Parturition, Captures, Photocensus, Fall Composition Memorandum; 1 August 2018, Fairbanks, AK). Note that most of TCH wintered in Unit 26A and most of PCH wintered in Canada.

VHF only radio collars were radiotracked on 15 April 2016. VHF-only and GPS satellite radio collars were in the same general location during mid-March of 2016; although 84% of the VHF radio collars (*n* = 31) were south of the Brooks Range, compared to 64% of the satellite GPS collars. However, we did not cover the entire area of Unit 26B, and 5 radio collars could have been in Unit 26B north of the Brooks Range but were not heard.

Winter 2016–2017— During mid-March of 2017, the distribution of GPS satellite radio collars (*n* = 37) on CAH caribou indicated that 92% were on north side of the Brooks Range throughout Unit 26B, with a few radio collars in Unit 26C, just east of the boundary between Units 26B and 26C. Very little mixing with the Teshekpuk (TCH) and Porcupine (PCH) caribou herds occurred (E. Lenart, ADF&G, 2016 Central Arctic Caribou Winter distribution, Parturition and Postcalving, Captures, Photocensus, and Fall Composition Memorandum, 6 September 2018, Fairbanks, AK).

Spring Migration 2013–2016 (16 Apr –31 May)—The area within their seasonal range that exhibited the highest density of use by CAH caribou occurred by way of departing their wintering grounds from the upper Chandalar country, to crossing the Continental Divide and then the Dalton Highway, traveling northeast of Toolik Lake then paralleling the highway, and continuing on to the calving grounds (Fig. 18B). Spring migration in 2017 was different compared to the previous 4 years because most of the caribou wintered north of the Brooks Range and west of the Dalton Highway which resulted in a much shorter migration distance because the caribou were closer to their calving grounds.

Calving (1–15 June)—During 2013–2017, there were 2 distinct calving concentrations: 1) west of the Dalton Highway and south of the oilfields, and 2) east of the Dalton Highway to the Shaviovik River (Fig. 18C). See Activity 1.7 for more detailed information on Central Arctic caribou calving distribution during 2013–2017.

Postcalving (15–30 June)—During postcalving in 2013–2017, caribou shifted north of the calving grounds toward the coastal plain and formed groups to prepare for when mosquitos hatched. In some years, temperatures were warm, and mosquitos hatched during the end of June and caribou were distributed along the coast (Fig. 18D). Postcalving and mosquito season frequently overlap.

Mosquito Season (1–15 July)— During the mosquito seasons in 2012–2016, caribou sought insect relief habitat along the coast on large gravel bars and deltas with more wind and open areas (Fig. 18E). Caribou aggregated in large tight groups when temperatures were warm (≥ 58° F), wind was low (< 10 mph), and mosquitos had hatched. In 2015 there were fewer mosquitos, they did not aggregate as tightly, and formed smaller groups. Caribou moved into the wind to avoid insects and frequently wind direction was from the northeast (NOAA n.d.).

Oestrid Fly Season (16 July–7 Aug)— Oestrid fly season directly follows mosquito season. During oestrid fly season in 2012–2016, caribou moved off the coastal plain (Fig. 18F), sought different habitat such as gravel bars further south and bands of willows, and were much more loosely aggregated.

Late Summer 2012–2016 (8 Aug–15 Sep)— Caribou mostly remained off the coast, were loosely distributed across the coastal plain, with more caribou distributed west of the Dalton Highway (Fig. 18G).

Fall Migration 2012–2015 (16 Sep–30 Nov)— The highest density of CAH seasonal range use was west of the Dalton highway along the Kuparuk River drainage, after caribou crossed the Dalton Highway north of Toolik Lake and then moved through the upper Sagavanirktok River drainage into the upper North Fork Chandalar River drainage. Caribou originating east of the Dalton Highway either followed the foothills to the upper Sagavanirktok River or crossed over the Continental Divide from the Canning River into the East Fork Chandalar River. Note the high density of CAH caribou in the upper Chandalar country; this was likely after most of the longer migration had already occurred because at that time caribou had reached the vicinity of their wintering grounds and movement distances were much smaller during the month of November. Fall migration distances in 2016 and 2017 were much shorter because caribou remained north of the Brooks Range (Figs. 16 and 17). In both years, more caribou were west of the Dalton Highway (Figs. 16 and 17).

Recommendations for Activity 1.11.

Continue.

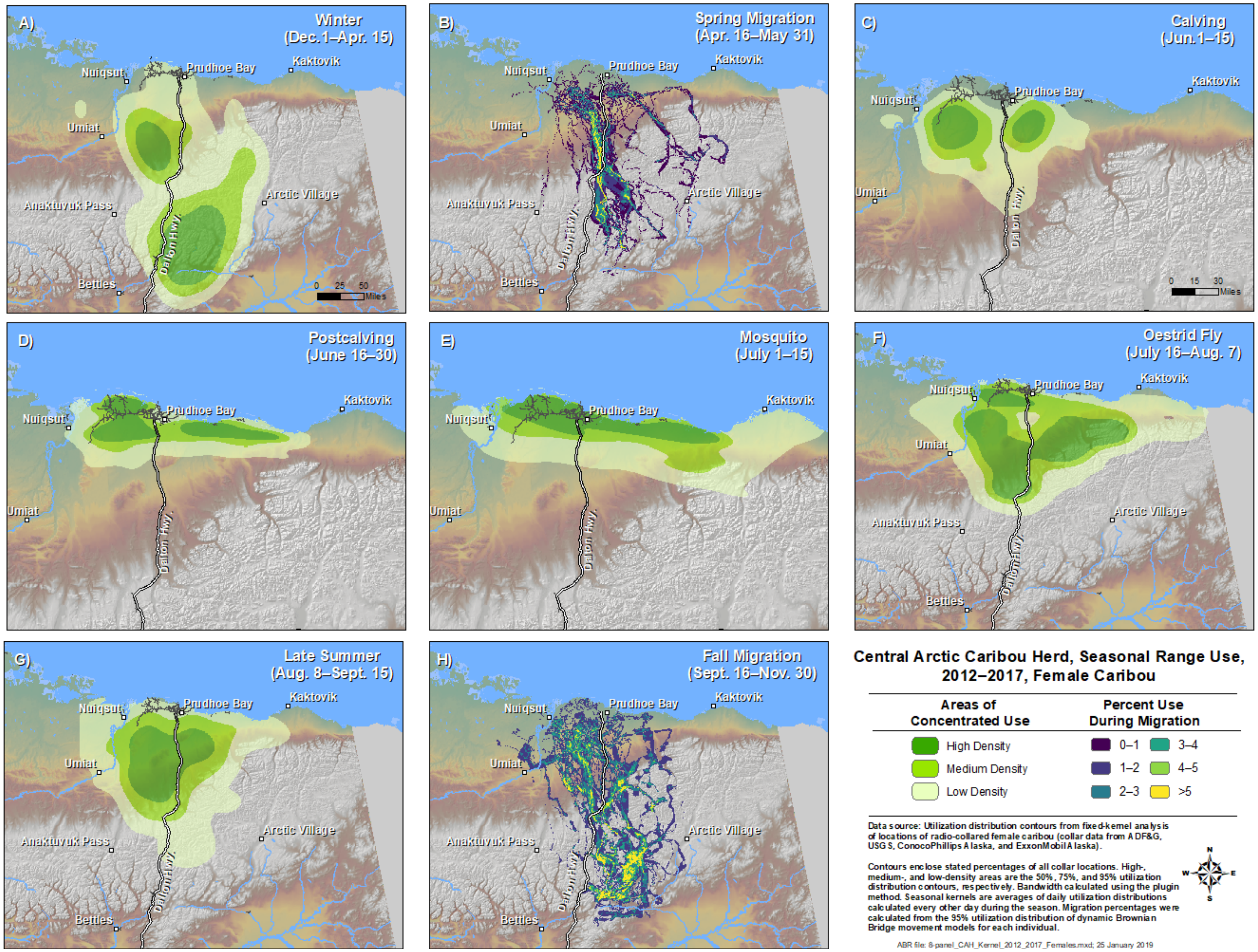


Figure 18. Central Arctic female caribou seasonal utilization distribution contours for years between 1 July 2012–30 June 2017. High, medium, low density are the 50%, 75%, and 95% utilization distribution contours, respectively.

2. Mortality-Harvest Monitoring and Regulations

ACTIVITY 2.1. Monitor harvest using harvest ticket reports and ADF&G Division of Subsistence household surveys.

Data Needs

Estimates of annual harvest are important to ensure that harvest is within sustainable limits and to evaluate IM objectives (C1, C2, C3, M1, M3, and M4).

Methods

Reported harvest was obtained from general harvest reports mailed or reported online. Data collected from both types of reporting were stored in ADF&G's Wildlife Information Network database (WinfoNet).

Season and Bag Limit

Seasons and bag limits for caribou in Units 24A, 24B, 25A, 26B, and 26C were established in 5AAC 85.025 editions 2012–2013, 2014–2015, 2015–2016, 2016–2017, 2017–2018 and are available in the Alaska hunting regulations numbers 53, 54, 55, 56, and 57. Additional state regulations affecting caribou hunting include special restrictions along the Dalton Highway which can be found in 5AAC 92.530 (7), Dalton Highway Corridor Management Area.

Results and Discussion

Harvest by Hunters

UNIT 26B HARVEST

Most harvest of CAH caribou (primarily nonlocal residents and nonresidents) occurs in Unit 26B, and all summaries related to harvest hereafter, unless otherwise noted, refer to reported harvest in Unit 26B.

RY12—Out of 1,430 total hunters (residents and nonresidents combined), 722 were successful, with a combined total harvest of 1,007 caribou (50% success rate; Tables 12 and 13). A total of 1,126 Alaska residents reported hunting, and 533 of those Alaska resident hunters were successful with a total harvest of 771 caribou (47% success rate; Table 13). There were 295 total nonresidents hunters, 188 were successful, with a total nonresident harvest of 235 caribou (64% success rate; Table 13).

RY13—Out of 1,463 total hunters (residents and nonresidents combined), 629 were successful, with a combined total harvest of 868 caribou (43% success rate; Tables 12 and 13). A total of 1,014 Alaska residents reported hunting, and 359 of those Alaska resident hunters were successful with a total harvest of 530 caribou (35% success rate; Table 13). There were 441 total nonresident hunters, 265 were successful, with a total nonresident harvest of 331 caribou (60% success rate; Table 13).

RY14— Out of 1,433 total hunters (residents and nonresidents combined), 666 hunters reported harvesting 916 caribou (46% success rate; Tables 12 and 13). A total of 987 Alaska residents reported hunting, and 384 of those Alaska resident hunters were successful with a total harvest of 555 caribou (39% success rate; Table 13). There were

442 total nonresident hunters, 279 were successful, with a total nonresident harvest of 358 caribou (63% success rate; Table 13).

RY15— Out of 1,256 total hunters (residents and nonresidents combined), 585 hunters reported harvesting 756 caribou (47% success rate; Tables 12 and 13). A total of 807 Alaska residents reported hunting, and 302 of those Alaska resident hunters were successful with a total harvest of 414 caribou (37% success rate; Table 13). There were 449 total nonresident hunters, 283 were successful, with a total nonresident harvest of 342 caribou (63% success rate; Table 13).

RY16— Out of 1,064 total hunters (residents and nonresidents combined), 449 hunters reported harvesting 586 caribou (42% success rate; Tables 12 and 13). A total of 705 Alaska residents reported hunting, and 286 of those Alaska resident hunters were successful with a total harvest of 403 caribou (41% success rate; Table 13). There were 358 total nonresident hunters, 163 were successful, with a total nonresident harvest of 183 caribou (46% success rate; Table 13).

RY17— Out of 619 total hunters (residents and nonresidents combined), 219 hunters reported harvesting 230 caribou (35% success rate; Tables 12 and 13). A total of 348 Alaska residents reported hunting, and 98 of those Alaska resident hunters were successful with a total harvest of 109 caribou (28% success rate; Table 13). There were 268 total nonresident hunters, 118 were successful, with a total nonresident harvest of 118 caribou (44% success rate; Table 13).

Table 12. Reported Central Arctic caribou herd harvest by sex and method of take, Alaska, regulatory years 2000–2017.

Regulatory year	Reported caribou harvest Male	Female	Unk	Total (by bow)[a]	Total hunters	Percent successful hunters[b]
2000	465	28	1	494 (214)	804	52
2001	496	16	4	516 (192)	918	47
2002	389	23	3	415 (96)	851	41
2003	389	11	4	404 (136)	717	48
2004	588	42	4	634 (228)	989	52
2005	635	45	7	687 (239)	1,104	52
2006	798	37	6	841 (301)	1,331	53
2007	620	68	2	690 (183)	1,380	42
2008	669	47	1	717 (180)	1,362	43
2009	757	45	13	815 (224)	1,317	49
2010	978	234	26	1,238 (296)	1,622	54
2011	814	346	12	1,172 (330)	1,401	57
2012	726	275	6	1,007 (285)	1,430	50
2013	730	135	3	869 (191)	1,463	43
2014	720	196	0	916 (200)	1,433	46
2015	530	225	1	756 (94)	1,256	47
2016	317	268	1	586 (145)	1,064	42
2017[c]	223	7	0	230 (64)	619	35

Note: Regulatory year (RY) begins 1 July and ends 30 June (e.g., regulatory year 2014 = 1 July 2014–30 June 2015). Most harvest of CAH caribou (primarily nonlocal residents and nonresidents) occurs in Unit 26B.
Source: Harvest ticket reports are from the Unit 26B caribou database in ADF&G's Wildlife Information Network (WinfoNet).

[a] Harvest by bow is also included in total harvest.
[b] The percent successful hunters is calculated by dividing the number of successful hunters by the number of total hunters and represents the percentage of hunters who hunted that harvested an animal.
[c] This reporting period includes RY12–RY16.

Table 13. Reported Central Arctic caribou herd hunter residency and success, Unit 26B, Alaska, regulatory years 2000–2017.

	Successful hunters				Unsuccessful hunters				
Regulatory year	Alaska resident	Nonresident	Unk	Total (%)	Alaska resident	Nonresident	Unk	Total (%)	Total hunters[a]
2000	339	74	3	416 (52)	354	32	2	388 (48)	804
2001	331	101	4	436 (47)	403	76	3	482 (53)	918
2002	247	103	2	352 (41)	428	70	1	499 (59)	851
2003	249	90	5	344 (48)	313	58	2	373 (52)	717
2004	381	127	9	517 (52)	385	78	9	472 (48)	989
2005	421	154	1	576 (52)	425	100	3	528 (48)	1,104
2006	476	213	20	709 (53)	498	98	26	622 (47)	1,331
2007	383	189	8	580 (42)	649	141	10	800 (58)	1,380
2008	411	157	12	580 (43)	603	163	16	782 (57)	1,362
2009	461	175	6	642 (49)	574	87	8	669 (51)	1,317
2010	633	234	4	871 (54)	600	142	4	746 (46)	1,622
2011	594	194	6	794 (57)	511	81	9	601 (43)	1,401
2012	533	188	1	722 (50)	593	107	5	705 (49)	1,430
2013	359	265	5	629 (43)	655	176	3	834 (57)	1,463
2014	384	279	3	666 (46)	603	163	1	767 (53)	1,433
2015	302	283	0	585 (47)	505	166	0	671 (53)	1,256
2016	286	163	0	449 (42)	419	195	1	615 (58)	1,064
2017[b]	98	118	3	219 (35)	250	150	0	400 (65)	619

Note: Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2000 = 1 July 2000–30 June 2001). Most harvest of CAH caribou (primarily nonlocal residents and nonresidents) occurs in Unit 26B. Source: Harvest ticket reports from Unit 26B in caribou database via ADF&G's Wildlife Information Network (WinfoNet).

[a] Includes both successful and unsuccessful permit holders who went hunting.
[b] This reporting period includes regulatory years 2012–2016.

HARVEST BY LOCAL RESIDENTS

During the reporting period (RY12–RY16) and also the following year (RY17), local resident harvest was estimated at approximately 100 caribou annually (Braem et al. 2011). The bulk of the harvest is attributed to Nuiqsut resident hunters which is likely due to accessibility of the herd near Nuiqsut. CAH caribou may have been accessible to residents of Kaktovik in summers 2013 and 2014, and inaccessible in 2015, 2016, and 2017.

BOWHUNTING

During the reporting period (RY12–RY16) and also the following year (RY17), bowhunter harvest ranged from 12% to 28% of the total harvest, which was similar to the previous 5 years when bowhunter harvest ranged from 24% to 28% (RY07–RY11; Table 12). Bowhunter success within the Dalton Highway Corridor Management Area (DHCMA) is related to caribou distribution.

Sex of Harvest

During the reporting period (RY12–RY16), and also the following year (RY17), the number of female caribou in the harvest ranged from 135 to 268 animals; the proportion of females increased each year from 16% in RY13, to 21% in RY14, 30% in RY15, and up to 46% in RY16 (Table 12). Most of the female harvest occurred in August and September. In RY17, most of Unit 26B was closed to cow harvest and only 7 cows were reported harvested. Most of these cows were illegally harvested and there were probably more cows harvested illegally that were not reported.

Harvest Chronology

During the reporting period (RY12–RY16) and also the following year (RY17), 54–76% of the harvest occurred in August, 18–28% occurred in September, and less than 10% of the caribou harvest occurred in spring (March, April, and May; WinfoNet database, Accessed 3 July 19).

Transport Methods

During the reporting period (RY12–RY16) and also the following year (RY17), 28–50% of the harvest was by airplane, and 28–43% by highway vehicles which were the most popular transport methods used to harvest caribou. The proportion of airboats and boats combined used as a transport method ranged from 17% to 27% (Table 14).

Alaska Board of Game Actions and Emergency Orders

2016 March— Beginning in 2016, regulation changed from requiring just Yukon River residents to obtain a harvest ticket to requiring residents from all of Units 24, 25, and 26B to obtain a harvest ticket (5 AAC 92.010(g)). This decision was made at the statewide March 2016 Board of Game meeting.

2017 March—During the March 2017 Board of Game meeting, the season and bag limit for caribou was changed in Unit 26B, making regulations more restrictive for RY18 (2017–2018 Alaska Hunting Regulations 58). In northwestern Unit 26B, the season was changed from 1

July–30 April to no closed season except cows could only be taken from 1 July to 15 May; the bag limit for resident hunters remained the same at 5 caribou per day.

For residents in the remainder of Unit 26B, the bag limit was changed from 5 caribou total to 2 bulls. The remainder of Unit 26B was previously separated into 3 areas for caribou, each with a different season: south of 69° 30′ and west of the Dalton highway was previously both 1 Jul–10 Oct and 16 May–30 June for bulls, and 1 July–10 Oct for cows; south of 69° 30′ and east of the Dalton Highway previously had no closed season for bulls, and 1 Jul–10 Oct for cows; and 26B remainder was 1 Jul–30 Apr. For all 3 of these areas, the season was changed to 1 Aug–30 Apr, and all 3 areas were grouped and referred to collectively as Unit 26B remainder.

In all of Unit 26B for nonresidents, the bag limit was changed to from 5 caribou total to 1 bull, and the season was changed to 1 Aug–15 Sep. Previously the seasons were 1 Jul–10 Oct and 16 May–30 June for bulls, and 1 July–10 Oct for cows in the area south of 69° 30′ and west of the Dalton highway; there was no closed season for bulls and the season was 1 Jul–10 Oct for cows in the area south of 69° 30′ and east of the Dalton Highway; and the season was 1 Jul–30 Apr in the remainder of Unit 26B.

The hunting regulations in the other Units that CAH inhabit reflect the needs of other caribou herds that are present rather than CAH (e.g., Unit 26A: TCH, Unit 24A, 25A, 26C: PCH, Unit 24B: WAH).

Recommendations for Activity 2.1.

Continue.

3. Habitat Assessment and-Enhancement

None.

Table 14. Reported Central Arctic caribou harvest by transport methods, Alaska, regulatory years 2000–2017.

Regulatory year	Harvest by transport methods (%)[a]								Total
	Airplane	Horse/dog	Boat	Airboat	Snowmachine	ORV[b]	Highway vehicle	Unk	
2000	91 (18)	17 (3)	57 (11)	17 (3)	4 (<1)	1 (<1)	302 (61)	5 (1)	494
2001	108 (21)	7 (1)	50 (10)	18 (4)	0 (0)	5 (1)	324 (63)	4 (<1)	516
2002	112 (27)	10 (2)	54 (13)	11 (3)	1 (<1)	14 (3)	206 (50)	7 (2)	415
2003	78 (19)	2 (<1)	61 (15)	36 (9)	0 (0)	3 (<1)	219 (54)	5 (1)	404
2004	97 (15)	10 (2)	101 (16)	82 (13)	1 (<1)	3 (<1)	335 (53)	5 (<1)	634
2005	120 (17)	7 (1)	119 (17)	60 (9)	0 (0)	2 (<1)	362 (53)	17 (2)	687
2006	191 (23)	10 (1)	133 (16)	56 (7)	0 (0)	1 (<1)	433 (51)	17 (2)	841
2007	205 (30)	22 (3)	72 (10)	40 (6)	3 (<1)	1 (<1)	333 (48)	14 (2)	690
2008	259 (36)	20 (3)	93 (13)	46 (6)	0 (0)	1 (<1)	287 (40)	11 (2)	717
2009	216 (26)	33 (4)	144 (18)	45 (5)	0 (0)	1 (<1)	364 (45)	12 (1)	815
2010	356 (29)	27 (2)	194 (16)	111 (9)	0 (0)	3 (<1)	517 (42)	30 (2)	1,238
2011	330 (28)	73 (6)	178 (15)	61 (5)	0 (0)	3 (<1)	505 (43)	22 (2)	1,172
2012	324 (32)	26 (3)	136 (14)	56 (6)	0 (0)	6 (<1)	436 (43)	23 (2)	1,007
2013	343 (40)	36 (4)	122 (14)	73 (9)	0 (0)	5 (<1)	279 (33)	11 (1)	869
2014	455 (50)	38 (4)	84 (9)	73 (8)	0 (0)	1 (<1)	261 (28)	4 (<1)	916
2015	315 (47)	24 (4)	110 (16)	65 (10)	0 (0)	7 (<1)	234 (35)	1 (<1)	756
2016	166 (28)	16 (3)	107 (18)	53 (9)	0 (0)	7 (1)	234 (40)	2 (<1)	585
2017	82 (36)	0 (0)	36 (16)	20 (9)	0 (0)	0 (0)	90 (39)	1 (<1)	229

Note: Regulatory year begins 1 July and ends 30 June (e.g., regulatory year 2000 = 1 July 2000–30 June 2001). Source: Harvest ticket reports from Unit 26B in caribou database via ADF&G's Wildlife Information Network (WinfoNet).

[a] Percentages were calculated using the total which includes unknown transport methods (Unk).

[b] ORV includes 4-wheelers and other off-road vehicles.

NONREGULATORY MANAGEMENT PROBLEMS OR NEEDS

Data Recording and Archiving

Original raw data forms can be found in Room 110, file cabinet CAH Caribou. Electronic copies of telemetry and capture scanned raw data, excel files, reports, and memoranda will be stored on an internal database housed in WinfoNet (under Data Archive/Northeast Alaska Area/Central Arctic Caribou). Project ID: Central Arctic Caribou. Primary Region: Region III (http:/winfonet.alaska.gov/index.cfm, under Data Archive). Harvest data are stored on an internal database housed on a server (http:/winfonet.alaska.gov/index.cfm, under Harvest Information).

Agreements

Data sharing agreements were developed with ConocoPhillips, Exxon Mobile, USGS, and Porcupine Caribou Technical Committee for use of satellite collar data.

Permitting

None.

Publications

Research conducted during this reporting period has resulted in external publications that are important to note for the Central Arctic caribou herd including:

- NDVI exhibits mixed success in predicting spatiotemporal variation in caribou summer forage quality and quantity (Johnson et al. 2018).
- Caribou use of habitat near energy development in Arctic Alaska (Johnson et al. 2020).
- Caribou distribution and movements in a northern Alaska oilfield (Prichard et al. 2020a).
- Interchange and overlap among four adjacent arctic caribou herds (Prichard et al. 2020b).

Conclusions and Management Recommendations

Amounts Reasonably Necessary for Subsistence Uses

C1. There is a positive finding for customary and traditional uses for the Central Arctic caribou herd which was set at 250–450 animals (5 AAC 99.025); this objective was met. Opportunity was available for this level of harvest with 250–450 caribou representing less than 2% of the 2013 and 2017 abundance estimates.

Intensive Management

C2. Population objective: 28,000–32,000 caribou. The population objective was met in all years except 2016 when the population was estimated at 22,630 caribou.

C3. Harvest objective: 1,400–1,600 caribou. This objective was not met because less than 1,400 caribou were harvested in all years during the reporting period (RY12–RY16) and also in RY17; mostly due to hunter access and a decline in the caribou population size and distribution of caribou.

Management Objectives:

M1. Maintain a population of at least 28,000–32,000 caribou. This objective was met in all years except 2016.

M2. Maintain accessibility of seasonal ranges for CAH caribou. This objective was met based on observations and analysis of satellite radio collar movements.

M3. Maintain a harvest of at least 1,400 caribou if the population is ≥ 28,000 caribou. This objective was not met when the population was ≥ 28,000 caribou, mostly due to hunter access and a decline in the population size and distribution of caribou.

M4. Maintain a bull-to-cow ratio of at least 40:100. This objective was mostly met because bull-to-cow ratios ranged from 39 to 56 bulls per 100 cows during the reporting period (RY12–RY16) and also RY17.

M5. Reduce conflicts between consumptive and nonconsumptive uses of caribou along the Dalton Highway. This objective was met because there appeared to be few conflicts between consumptive and nonconsumptive uses of caribou along the Dalton Highway during RY12–RY17. This objective it is not quantifiable and therefore will be discontinued.

II. Project Review and RY17–RY21 Plan

Review of Management Direction

The only change in the management direction for the Central Arctic caribou herd will be for the management objective that aims to reduce conflicts between consumptive and nonconsumptive uses of caribou along the Dalton Highway which has been removed because is not a quantifiable objective. In addition, conflicts between consumptive and nonconsumptive uses of caribou along the Dalton Highway has not been an issue in recent years. Goals have been slightly updated.

Management Direction

Goals

G1. Provide the opportunity for subsistence and other hunting opportunity on a sustained yield basis.

G2. Minimize the adverse effects of development on CAH caribou.

G3. Provide opportunity for viewing and other uses of CAH caribou.

CODIFIED OBJECTIVES

Amounts Reasonably Necessary for Subsistence Uses

C1. The Central Arctic caribou herd has a positive finding for customary and traditional uses of game populations (5 AAC 99.025) as a population that has been taken or used for subsistence with the amounts reasonably necessary for subsistence set at 250–450 caribou.

Intensive Management

C2. The IM population objective is 28,000–32,000 caribou.

C3. The IM harvest objective is 1,400–1,600 caribou.

MANAGEMENT OBJECTIVES

M1. Maintain a population of at least 28,000–32,000 caribou (G1, G2, and G3).

M2. Maintain a harvest of at least 1,400 caribou if the population is ≥ 28,000 caribou (G1).

M3. Maintain a bull-to-cow ratio of at least 40:100 (G1 and G3).

M4: Maintain accessibility of seasonal ranges for CAH caribou (G2).

REVIEW OF MANAGEMENT ACTIVITIES

1. Population Status and Trend

ACTIVITY 1.1. Capture and deploy 10–20 radio collars on yearling females annually, and 10–20 on both adult females and males combined annually. Maintain at least 30 radio collars on adult females and 10 radio collars on adult males. Conduct disease assessment (M1, M2, M3, M4, C1, C2, and C3).

Data Needs

To maintain a population of at least 28,000–32,000, accessibility of seasonal ranges, and a bull-to-cow ratio of at least 40:100 it will be necessary to deploy radio collars on CAH. Radiocollaring these caribou enables ADF&G biologists to monitor the herd; locate caribou for photocensuses, parturition surveys, and fall composition surveys; determine mortality and survival rates; and map seasonal distribution of these caribou. While animals are restrained, health monitoring and disease assessment can be conducted.

Methods

CAPTURES

Capture caribou using a handheld netgun from an R-44 helicopter, manually restrain them with hobbles, and use a blindfold-hood while collecting measurements, samples, and fitting a radio collar. Assess the general body condition on each caribou in the following categories: very poor, poor, average, good, or very good. Record sex (male or female) and age as 11-month-old calf (short yearling), yearling, or adult. Record latitude, longitude, and general location of capture. Weigh short yearlings and yearlings.

PATHOGEN EXPOSURE AND MINERAL ANALYSES

Collect whole blood and serum to test for Brucella suis biovar 4, *Chlamydophila* spp., contagious ecthyma virus, Q Fever, vitamin B12/cobalamin; analyze serum (in Serum Separator Tubes (SST®)) for serology for Bovine respiratory disease complex viruses and Leptospirosis antibodies, analyze serum to test for trace elements, adenovirus, and analyze serum haptoglobin to test for nonspecific inflammation. Collect nasal swabs to test for respiratory disease. Collect hair and feces to test for parasites. Continue working with the DWC Wildlife Health and Disease Veterinarian to determine appropriate disease and health monitoring of the herd.

ACTIVITY 1.2. Conduct a photocensus every 2–3 years (M1, M2, C1, C2, and C3).

Data Needs

This activity is associated with the management objectives to maintain a population of at least 28,000–32,000 caribou and to maintain a harvest of at least 1,400 caribou if the population is ≥ 28,000 caribou. Estimating abundance (via a photocensus) is the primary metric used for monitoring herd status and is also important for evaluating IM and ANS objectives. Estimates of population size provide regulatory boards and advisory committees information to make informed decisions or recommendations regarding regulatory actions.

Methods

SURVEY AND ENUMERATION METHODS

Employ the modified aerial photo-direct count technique (Davis et al. 1979; Valkenburg et al. 1985) whereby postcalving aggregations of caribou are located by radiotracking radiocollared animals. Groups of caribou will be photographed from a DeHavilland DHC-2 Beaver aircraft with a customized digital aerial camera system composed of 3-medium format, 100-megapixel cameras on a gyrostabilized mount. Two cameras will be oriented partially oblique (50 mm) and one will be oriented at nadir (90 mm). The target altitude for photography is 1,500 feet above ground level (AGL). All cameras will be contained within a rigid insert which is attached to a gyrostabilized mount. The system is instrumented with a differential GPS and inertial measurement unit (IMU) to record position and attitude (pitch, roll, and yaw). Customized flight management software running on a laptop computer controls the cameras and navigation system; and allows the pilot and camera operator to see footprints of the imagery in real time as well as inspect thumbnails of each image as they are captured. Groups of caribou will be captured photographically in one transect.

Postphotography activities will include the following: flight data from the GPS and IMU will be post processed using differential correction or precise point positioning (PPP) depending on the proximity to continually operating reference stations (CORS). Images will be individually inspected and adjusted for exposure before being exported from raw format. Exterior orientation information (position, elevation, and attitude) and imagery will then be processed through photogrammetry software using automated tie-point extraction and bundle adjustment to produce digital-terrain models which will then be used to orthorectify individual images. Once orthorectification is completed, the oblique and nadir orthophotos will be mosaicked separately.

Caribou will be enumerated from image mosaics within geographic information system (GIS) software utilizing a customized tool which allows users to count and classify caribou by placing colored points on top of each animal. A 10 × 10-meter grid will be placed on the image to help the counter keep track of caribou while counting, particularly when reviewing a photo for missed caribou. Point data will be stored in file geodatabases and archived.

POPULATION ESTIMATE METHODS

Employ a method described by Rivest et al. (1998) to estimate herd size and provide a measure of uncertainty. The estimator is a summation of group sizes divided by the probability of having at least 1 radiocollared caribou. It is based on a 2-phase sampling design. Phase 1 sampling considers how collared caribou distribute among groups of known size and assumes the collared caribou randomly distribute themselves. Phase 2 is the detection of those groups by radio telemetry. Rivest et al. (1998) describes 3 detection models for use in phase 2. Of these models, the homogeneity method has been most frequently applied (Couturier 1996; Patterson et al. 2004) and is best suited for our data. In the homogeneity model, each group has the same probability of being detected in the survey. This model assumes that all active collars are identified in observed groups and that unobserved groups with collared caribou are missed because they are outside of the surveyed area. It is important to note that phase 2 calculations are not necessary if all collars are located and associated groups are counted. Also, the consequences of not meeting the assumptions of phase 2 are greatly mitigated when a high proportion of the active collars are detected, and associated groups counted. Finally, this estimator assumes a random distribution of collars among caribou. It is possible to test this assumption by relating the group size and associated number of radiocollared caribou in a graph. A statistical test of the assumption is suggested by Rivest et al. (1998) where the numbers of collars in each group are approximately Poisson distributed. Specifically, a score test to evaluate overdispersion in a Poisson model is provided to assess this assumption (Dean and Lawless 1989).

ACTIVITY 1.3. Estimate growth rate (λ, lambda; M1, M2, C1, C2, and C3).

Data Needs

Estimates of trends in abundance are important for evaluating IM and ANS objectives. The rate of population increase or decrease provides regulatory boards and advisory committees additional biological information to make informed decisions or recommendations regarding regulatory actions.

Methods

Estimate the growth rate for CAH using the adjusted Rivest population estimates and their associated variances by fitting a nonlinear model to estimate the average multiplicative annual growth rate (lambda; λ) using Bayesian methods and the software OpenBUGS (Lunn et al. 2009) to incorporate within year variation.

ACTIVITY 1.4. Estimate annual mortality rates from radiocollared female caribou (M1, M2, C1, C2, and C3).

Data Needs

This activity is associated with the management objectives to maintain a population of at least 28,000–32,000 caribou and maintain a harvest of at least 1,400 caribou if the population is ≥ 28,000 caribou. Annual survival/mortality is a sensitive biological parameter to population growth or decline, particularly for adult females. Estimates of annual survival/mortality provide an important demographic parameter to evaluate population trajectory in years when abundance is not estimated and corroborates estimates in trends in abundance.

Methods

Estimate annual adult female mortality rate for females ≥ 1-year old per regulatory year by determining the number of known mortalities in a regulatory year and dividing that number by the number of active radio collars beginning 1 July of that regulatory year. Explore other methods.

ACTIVITY 1.5. Estimate allowable harvest (M1, M2, M3, M4, C2, and C3).

Data Needs

Estimates of annual allowable harvest are important when making recommendations to inform the regulatory process.

Methods

During years that the population is considered high, allowable harvest will be estimated at a minimum of 5% of the most recent population estimate. During years that the population is considered low and there is desire for growth, allowable harvest will be estimated at 3% of the population and cow harvest will be restricted.

ACTIVITY 1.6. Estimate annual parturition rate from radiocollared female caribou (M1 and C2).

Data Needs

This activity is associated with the management objective to maintain a population of at least 28,000–32,000 caribou. Estimates of parturition rate provide a direct measure of productivity and may serve as an index to adult female body condition, particularly for 3-year-old caribou (Boertje et al., 2012). Parturition rate is one of the demographics used to aid in determining trend in population size in years that abundance is not estimated.

Methods

Parturition rate is estimated by observing radiocollared females ≥ 3-years old from a fixed-wing aircraft during the first half of June. Caribou observed with calves, hard antlers, or distended udders will be classified as parturient (Whitten 1995).

Parturition rate is calculated as the number of adult females classified as parturient divided by the total number of adult females observed. Parturition rates are calculated for females ≥ 4-years

old, 3-years old, and females ≥ 3-years old. Include unknown aged caribou in the females ≥ 4-years and females ≥ 3-years old categories. A 95% binomial confidence interval will be calculated for parturition rates for females ≥ 4-years old using a normal approximation method:
for parturition rates for females ≥ 4-years old using a normal approximation method:

$$1.96\sqrt{\frac{(\hat{p}*(1-\hat{p}))}{n}} \text{ where } \hat{p} = \text{estimated parturition rate}$$

A binomial GLM regression will be fitted to estimate the trend in parturition rates for all years through 2021.

Historically parturition data for females ≥ 4-years old were stratified between Unit 26B West (west of the west bank of the Sagavanirktok River) and Unit 26B East (east of the west bank of the Sagavanirktok River) because Arthur and Del Vecchio (2009) determined that CAH caribou maintained their fidelity to these calving areas from year to year (92%, *n* = 46 for radiocollared CAH cows with calving locations obtained in ≥ 5 calving seasons during 1997–2006). However, the utility of this stratification should be examined because recently, fewer CAH caribou have been calving east of the Sagavanirktok River where there has been less oil exploration and development. If the stratification analysis is performed, then a binomial GLM with an intercept and categorical predictor for Unit 26B West versus Unit 26B East will be fitted to estimate the difference in mean parturition rates between the 2 calving areas for all years of data through 2021. In addition, a quasi-binomial model will also be fitted to account for overdispersion in the data.

A 5-year moving weighted average parturition rate for 3-year-olds (95% CI) will also be estimated (Boertje et al. 2012).

ACTIVITY 1.7. Estimate peak of calving from radiocollared female caribou (M1).

Data Needs

This data is a by-product of estimating parturition rates but could be important information if median calving dates changed significantly when other changes in demographics occur.

Methods

Peak of calving or the median date of calving is defined as the date at which 50% or more of the radiocollared parturient females ≥ 3-years old gave birth. In years when caribou are located only once, and peak of calving has not occurred yet, the date of peak of calving will continue to be estimated using the following criteria based on the proportion of ≥ 3-year-old females with calves to parturient ≥ 3-year-old females at the last date of radiotracking where each result will determine the adjustment. If the result is:

1) ≤ 25%, a span of 3 days will be added following the last radiotracking date.
2) 26–39%, 2 days will be added.
3) 40–49%, 1 day will be added.
4) 51–59%, 1 day will be subtracted and included in the last day of radiotracking.
5) 60–74%, 2 days will be subtracted.

6) ≥ 75%, a span of 3 days will be subtracted.

The date of the point estimate will be determined by deriving the midpoint between the estimated dates for peak of calving.

ACTIVITY 1.8. Estimate late June calf-to-cow ratios of radiocollared females and early calf survival (M1 and C2).

Data Needs

Estimates of late June calf-to-cow ratios and early summer calf survival provide an index of recruitment potential for the year. Estimates of early calf survival are one of the demographics used to aid in determining trend in population size when a photocensus is not completed.

Methods

The proportion of calves per 100 cows will be estimated by observing radiocollared females ≥ 3-years old from a fixed-wing aircraft during the third or fourth week of June, after calving has most likely occurred.

The proportion of calves per 100 cows will be calculated as the number of adult female caribou observed with a calf at heel divided by the total number of adult females observed. This is referred to as "Late June calf:cow ratios". Late June calf:cow ratios will be calculated for females ≥ 4-years old, 3-years old, and ≥3-years old. Not all caribou observed will have known ages; but we will include unknown-aged caribou in the females ≥ 4-years old and ≥ 3-years old categories. A 95% binomial confidence interval is calculated for late June calf:cow ratios for females ≥ 4-years old using a normal approximation method: for parturition rates for females ≥ 4-years old using a normal approximation method:

$$1.96\sqrt{\frac{(\hat{p}*(1-\hat{p}))}{n}} \text{ where } \hat{p} = \text{estimated proportion of calves: 100 cows}$$

A binomial GLM regression will be fitted to estimate the trend in parturition rates for all years of data through 2021. Data for females ≥ 4-years old will be stratified based on the location of caribou east and west of the Sagavanirktok River, following the protocol listed previously in the methods section for estimating parturition rates (Activity 1.6).

Early summer calf survival of radiocollared females ≥ 3-years old will continue to be estimated by comparing females identified as parturient in early June with the same females in late June to determine if their calf had survived.

ACTIVITY 1.9. Conduct annual fall composition surveys to estimate bull-to-cow and calf-to-cow ratios (M1, M2, M3, M4, C1, C2, and C3).

Data Needs

Demographic data is useful in determining population trend, if there are enough bulls available for breeding (which is an indication of bull survival), calf survival to fall; and may inform appropriate harvest rates when abundance is low and harvestable surplus is near management objectives. These metrics are less informative when abundance estimates are regularly obtained but may be helpful in evaluating herd status and trend in periods when a photocensus is not possible.

Methods

Fall sex and age composition is estimated by classifying caribou from an R-44 helicopter near peak of rut to take advantage of the presumed mixing of bulls, cows, and calf caribou. Peak rut will be estimated as the date 228 days (gestation period) prior to the median calving date of the CAH. Caribou groups will be located by radiotracking collared caribou from fixed-wing aircraft. Caribou will be classified as cows; calves; and small, medium, or large bulls.

Sampling effort is allocated over the entire spatial distribution of CAH by using GPS radiocollar-location information prior to the survey. The sample will be distributed across the sample among the different sex and age classes of the radiocollared animals to capture the most representative sample of the population composition to the extent that it is logistically possible.

Summary data will be reported as a ratio of the number of bulls per 100 cows and the number of calves per 100 cows.

Correspond with biometrician to determine best approach.

ACTIVITY 1.10. Estimate seasonal distribution of Central Arctic caribou (M4 and C1).

Data Needs

Understanding the seasonal distribution of CAH caribou is necessary to ensure accessibility of seasonal ranges for these caribou and minimize the adverse effects of development on the herd. Providing the opportunity for a subsistence harvest, viewing the herd, and photographing the herd requires reliable estimates of location and density of CAH caribou. Telemetry data obtained from satellite radio collars is needed to provide a basis for calculating these estimates.

Methods

SATELLITE RADIO COLLAR DATA

Telemetry data (PTT and GPS collars) are compiled for female caribou of the Central Arctic Herd (CAH). Data are screened to remove locations prior to collaring, first 14 days after the initial collaring, after collar removal, after mortality, with poor quality (PTT quality score A or 0), far offshore, and duplicate locations. Data are also removed based on a distance-rate-angle score that considered the angle and speed of 3 successive locations. Locations will also be removed when caribou were with other herds.

KERNEL DENSITIES

For winter (1 Dec–15 Apr), calving (1–15 June), postcalving (16–30 June), mosquito season (1–15 July), oestrid fly season (16 July– 7 Aug), late summer seasons (8 Aug–15 Sep), and annual range, kernel densities will be estimated by calculating the mean location from each caribou for every 2-day period during the year and using the ks package for R software (Duong 2017). Fixed-kernel density estimation will be employed to create the utilization distribution contours of caribou distribution for every 2-day period throughout the year (all years combined). An average utilization distribution for each season will be calculated. By calculating the average of utilization distribution based on the mean location for each animal we are able to account for movements within a season while not biasing the calculation due to autocorrelation among locations for a single caribou or due to unequal sample sizes among caribou. The plug-in method is used to calculate the bandwidth of the smoothing parameter. The 50%, 75%, and 95% isopleth is calculated from each seasonal utilization distribution and used to display the high, medium, and low-density contours, respectively.

DYNAMIC BROWNIAN BRIDGE MOVEMENT MODELS

To visualize caribou movements during spring and fall migration periods, use dynamic Brownian Bridge Movement Models (dBBMM) to create utilization distribution maps of movements based on the locations of collared individuals (Kranstauber et al. 2014). These dBBMM models, a modification of earlier Brownian bridge models (Horne et al. 2007), use an animal's speed of movement and trajectory calculated from intermittent GPS locations to create a probability map describing relative use of the area traversed. We will compute the 95% isopleth of movements for each individual CAH caribou outfitted with a collar in the area and then overlaid the isopleth layers for each season to calculate the proportion of collared caribou using each 100-meter pixel. This visualization displays the seasonal use of the area by CAH caribou as a function of both caribou distribution and movements. The dBBMM models are computed using the move package in R (Kranstauber et al. 2017).

2. Mortality-Harvest Monitoring

ACTIVITY 2.1. Monitor harvest through harvest ticket reports and ADG&G, Division of Subsistence household surveys.

Data Needs

Estimates of annual harvest are important to ensure that actual harvest is within sustainable limits and to evaluate IM objectives (C1, C2, C3, M1, M2, M3, and M4).

Methods

Reported harvest (primarily nonlocal residents and nonresidents) are obtained from general harvest reported via mail or reported online. Data collected from both types of reporting are stored in ADF&G's internal WinfoNet database.

3. Habitat Assessment-Enhancement

None.

NONREGULATORY MANAGEMENT PROBLEMS OR NEEDS

Data Recording and Archiving

Original raw data forms can be found in Room 110, file cabinet CAH Caribou. Electronic copies of telemetry and capture scanned raw data, excel files, reports, and memoranda will be stored on an internal database housed in WinfoNet (Data Archive/Northeast Alaska Area/Central Arctic

Caribou). Project ID: Central Arctic Caribou. Primary Region: Region III (http:/winfonet.alaska.gov/index.cfm, under Data Archive) once this project is entered into the database.

Harvest data are stored on an internal database housed on a server (http:/winfonet.alaska.gov/index.cfm, under Harvest Information).

Agreements

Data sharing agreements for use of satellite radio collar data analyses will be developed with ConocoPhillips, Exxon Mobile, USGS, and ABR, Inc.

Permitting

None.

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