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CHAPTER 14: CARIBOU MANAGEMENT REPORT

From: 1 July 2012
To: 30 June 2014[1]

LOCATION

GAME MANAGEMENT UNIT: 21D, 22A, 22B, 22C, 22D, 22E, 23, 24A, 24B, 24C, 24D and 26A

HERD: Western Arctic

GEOGRAPHIC DESCRIPTION: Northwest Alaska

BACKGROUND

The Western Arctic caribou herd (WAH) ranges over approximately 157,000 mi^2 (363,000 km^2) of northwestern Alaska (Figs. 1 and 2). During spring, most parturient cows travel as directly toward the calving grounds as possible; in contrast, bulls and nonmaternal cows lag behind pregnant cows and move toward the Wulik Peaks and Lisburne Hills (Figs. 3 and 4). Cows give birth in the Utukok Hills (Figs. 5 and 6). During the post-calving period, maternal cows and neonates travel southwest toward the Lisburne Hills, where they mix with bulls and nonmaternal cows (Figs. 7 and 8). During summer, WAH caribou move east through the Brooks Range (Figs. 9 and 10); this is the most rapid, concentrated (in terms of space and time), and predictable seasonal movement of the year. In late summer, most bulls become relatively sedentary in the upper Noatak–Nigu river area while most cows slowly disperse back onto the coastal plain (Figs. 11 and 12). Caribou from this herd are more dispersed during fall than at any other time of year as they move south and southwest toward winter range (Figs. 13 and 14). Rut occurs in late October during the fall migration: there is no specific 'rutting ground' for this herd (unlike other ungulates, e.g. moose and Dall sheep). In most years during the mid-1980s through 1995 much of the WAH wintered in the Nulato Hills as far south as the Unalakleet River drainage. Since 1996 few WAH caribou have wintered in the southern portion of the Nulato Hills, shifting instead to either the Seward Peninsula or upper Kobuk and Koyukuk drainages (Figs. 15 and 16). In many years a small portion of the WAH has wintered on the North Slope in the Point Lay-Atqasuk-Umiat area.

In 1970 the WAH numbered approximately 242,000 caribou (Fig. 17) and was thought to be declining (P. Valkenburg, ADF&G, personal communication). By 1976 it had declined to about

[1] Data and analysis from a broader period are included to provide a more comprehensive overview in this report of the status of the herd.

75,000 animals (Table 1, Fig. 17). From 1976 to 1990 the WAH grew at an average rate of 13% annually, and from 1990 to 2003 it grew an average of 1–3% annually. In 2003 the WAH numbered ≥490,000 caribou but from that time until 2011 it declined at an average of 4–6% annually, and from 2011 to 2013 it declined an average of 15% annually, to reach a population size of 235,000 caribou.

At its peak in 2003, density of the WAH over its total range was 3.1 caribou/mi^2 (1.2 caribou/km^2). Density estimates for the herd are misleading, though, because caribou exhibit a "clumped" distribution in space and time. Seasonal densities provide a more useful measure to evaluate the effects of caribou on their range and on each other but only reduce rather than correct for the effects of clumping. For example, although almost all of the WAH was on its summer range during the first 2 weeks of July 2007 for a density of 11.2 caribou/mi^2, caribou occupied less than 25% of this total area. Additionally, the ranges of the WAH and Teshekpuk Herd (TCH) overlap, and caribou from these herds regularly comingle on some seasonal ranges annually. Occasionally, caribou from the Central Arctic Herd (CAH) also move onto WAH range. Additionally, WAH caribou mix with reindeer on the Seward Peninsula. For example, during the winter of 2013–2014, caribou from the WAH, TCH, and CAH all wintered in or near the Goodhope River drainage, an area that probably contained remnants of several reindeer herds.

In 1995 the department took the lead to establish a group of public citizens who use the WAH, representatives of environmental groups, transporters, guides, and agency staff who manage caribou. Although federal management of wildlife in Alaska for subsistence users was still a new development at that time, it was obvious that some type of group representing a broad spectrum of users was needed to bridge the state and federal systems. It was also clear that users and managers needed to work together outside of the politically charged forums of the Board of Game and Federal Subsistence Board to share information in the interest of conserving this herd. The Western Arctic Caribou Herd Working Group (WG) became established as an interim group in 1997 and adopted its current structure in 2000. The purpose of the group is to facilitate communication and cooperation among people who use, value and manage this herd, and to promote its conservation for the future. A technical committee consisting of agency staff was subsequently established in 2004 to advise the WG about biological and regulatory issues. These groups now meet once each year to discuss the status of the herd, share information, and discuss issues that affect caribou and the people who rely on or value them.

MANAGEMENT DIRECTION

MANAGEMENT GOALS

- Protect and maintain the WAH and its habitat.
- Provide for subsistence and general season hunting on a sustained yield basis.
- Provide for viewing and other uses of caribou.
- Perpetuate associated wildlife populations, including carnivores.

MANAGEMENT OBJECTIVES

The following management objectives compose the seven basic elements of the Western Arctic Caribou Herd Cooperative Management Plan (Western Arctic Caribou Herd Working Group 2011):

- Encourage cooperative management of the herd and its habitats among state, federal, and local entities and all users of the herd.
- Manage for a healthy population using strategies adapted to population levels and trends while recognizing that caribou numbers naturally fluctuate.
- Assess and protect important habitats of the WAH.
- Promote consistent, understandable, and effective state and federal regulations for the conservation of the WAH.
- Seek to minimize conflict between reindeer herders and the WAH.
- Integrate scientific information, traditional ecological knowledge of Alaska Native users, and knowledge of all users into management of the herd.
- Increase understanding and appreciation of the WAH through use of scientific information, traditional ecological knowledge of Alaska Native users, and knowledge of all other users.

TERMS

Terms used in this report are defined as follows:

"ADF&G" is the Alaska Department of Fish and Game.

"ARGOS" is a world-wide satellite-based system that collects, processes, and transmits environmental data (in this report, from caribou satellite radio collars) to the individuals, organizations and agencies that own them.

"Adult caribou" is any caribou ≥12 months old.

"BLM" is the Bureau of Land Management.

"BOG" refers to the Alaska Board of Game.

"Calf" is any caribou <12 months old.

"Caribou" in the generic sense refers to individuals belonging to the WAH. Acronyms used for other caribou herds are as follows: TCH for Teshekpuk caribou herd and CAH for Central Arctic caribou herd.

"CARMA" is the CircumArctic Rangifer Monitoring and Assessment, a network organization with the mission to monitor and assess the impacts of global change on the Human-Rangifer System across the CircumArctic, through cooperation, both geographically and across disciplines. This network has not been funded since about 2013 and has not met since 2012.

"c.i." is the abbreviation for "confidence interval."

"Collar year" or "CY" is the 12-month period from 1 October through the following 30 September, abbreviated as CY (e g., 1 October 2010 through 30 September 2011 is abbreviated as CY10). It is defined based on the time when radio collars are deployed on WAH caribou.

"Conventional telemetry" refers to techniques using radio collars with very high frequency (VHF) transmitters and antennas mounted on airplanes to locate caribou. When referring to radio collars, the terms "VHF" and "conventional" are used interchangeably.

"Department" or "department" refers to the Alaska Department of Fish and Game.

"DMTS" is the De Long Mountains Transportation System, erroneously referred to as the "Red Dog road" in previous reports. This is the 53-mi-long road that connects the Red Dog mine to its Port Site.

"DOI" refers to the Department of Interior. The U.S. Fish and Wildlife Service, National Park Service, and Bureau of Land Management are all administered under the DOI.

"FSB" refers to the Federal Subsistence Board.

"FWS" or "USFWS" is the U.S. Fish and Wildlife Service.

"GPS" is Global Positioning System, a satellite-based system that provides latitude and longitude of location information.

"Guide" is a licensed commercial operator who accompanies a hunter in the field and provides professional services to assist in the taking of trophy wildlife.

"High quality" telemetry data refers to: 1) VHF location data with the latitude and longitude recorded directly over the group of caribou that contained the collared individual; 2) PTT location data with a location quality index (LQI) of 1, 2, or 3 (or 10, 20 or 30, depending on the year a collar was deployed); or 3) all GPS location data.

"Intensive management" means management of an identified big game prey population consistent with sustained yield through active management measures to enhance, extend, and develop the population to maintain high levels or provide for higher levels of human harvest, including control of predation and prescribed or planned use of fire and other habitat improvement techniques (AS 16.05.255(e)).

"Light weight satellite collar" refers to models ST-10, ST-18, ST-20, and TAW-4610 PTT collars and TGW-4680 GPS collars manufactured by Telonics, Inc. (Mesa, AZ). Model ST-3 or ST-14 PTT collars are not light weight collars.

"Local hunter" is a hunter that resides within the range of the WAH.

"LQI" refers to location quality index, an ARGOS ranking level applied to satellite collar locations.

"Maternal cow" refers to a female caribou accompanied by a calf or having ≥1 hard antler during June.

"NPS" is the National Park Service.

"Nonlocal hunters" are hunters that live outside the range of the WAH, including Alaska residents, nonresidents, and aliens.

"Photo census" is the aerial direct count photo extrapolation technique (Davis et al. 1979).

"Potentially active" radio collars refer to VHF transmitters that have been located within the previous 2 years.

"Recruitment survey" is used interchangeably with "short yearling survey." These surveys are conducted during late March through May to estimate the ratio of short yearlings:100 adult caribou.

"Regulatory year" or "RY" is the 12-month period from 1 July through 30 June, abbreviated as RY (e. g., RY10=1 July 2010–30 June 2011)

"Rivest population estimate," "Rivest technique" or simply "Rivest" refers to an estimate of population size based on the homogeneity model reported by Rivest et al. (1998).

"Satellite collar" is a radio collar that contains both a VHF transmitter and either a PTT or a GPS transmitter.

"Short yearling" or "SY" is any caribou 10–11 months old.

"SNWR" is the Selawik National Wildlife Refuge.

"Successful hunter" is applied only to nonlocal hunters and is defined as anyone who reported taking at least 1 caribou of either sex during the regulatory year. With regard to hunter success, the distinction between 'local' and 'nonlocal' hunter stems from how WAH harvest data are collected from each group. Harvest data for local hunters are collected through community harvest surveys where 'household' is the sample unit. For nonlocal hunters, harvest data are collected through reports that individual hunters must submit; thus, 'hunter' is the sample unit.

"Teck Alaska, Incorporated" is the company that operates the Red Dog Mine, road, and port site in partnership with NANA Regional Native Corporation. In past reports, it has been referred to by its previous names, including TecCominco and NANA-TecCominco.

“Transporter” is a commercial operator who provides only transportation services to hunters.

“WACH WG” or “WG” refers to the Western Arctic Caribou Herd Working Group.

METHODS

Population Status and Trend. Our understanding of WAH population status and trend is based on conventional, PTT, and GPS telemetry information; opportunistic observations of caribou by department staff located in Nome, Barrow, Kotzebue, and Fairbanks, and reports from the public. Implementation and early objectives of the conventional radiotelemetry program in the WAH were previously reported (Dau 2005).

The first PTTs deployed in the WAH were attached to 2 cows in May 1984 by a private organization (Craighead Wildlife-Wildlands Institute, Missoula, MT) to test the feasibility of this technology for monitoring caribou movements (Craighead and Craighead 1987). Data from these collars were not made available to the department. The department began deploying PTTs in the WAH in 1987 primarily to assist with locating conventionally collared caribou during VHF telemetry flights. As the PTT database expanded through time and the number of satellite-collared WAH caribou increased, we increasingly used this information to evaluate seasonal movements and distribution of this herd. Now, we also use satellite telemetry to more accurately determine time of death and assess the influence of roads on movement patterns. Although we rely heavily on telemetry information to monitor the WAH, we have only collared approximately 0.02–0.03% of the herd annually. This small sample of collars relative to population size has limited our understanding of the complexity or variability of movements and distribution of the herd. Similarly, low sampling intensity has affected confidence intervals associated with estimates of annual mortality (Fig. 18) and other collar-based population metrics. Since the late 1980s we have typically conducted at least 15 to 20 VHF relocation flights annually in part to monitor characteristics of caribou (e.g., body condition and sex-age distribution), and in part to assess environmental conditions (e.g., snow conditions and the prevalence of predators). In 1995, 2000, and 2012, VHF telemetry flights enabled us to identify localized mortality events that were not apparent from satellite telemetry data.

During this reporting period, VHF and satellite telemetry techniques were used to estimate population size, adult mortality, calf production and recruitment, sex and age composition, movement patterns, and distribution. Telonics Inc. (Mesa, AZ) manufactured all radio collars deployed in the WAH during this (and previous) reporting periods. Configuration of conventional and satellite collars, PTT duty cycles, VHF relocation techniques, types of data collected, allocation of collars between bulls and cows, and sources of error in telemetry data have been previously described (Dau 1997).

We have not attempted to radiocollar a representative cross-section of ages and sexes in the WAH. This is partly because the age structure of the WAH is unknown, yearlings are generally too small to be collared with adult collars, it would be difficult to humanely pull a tooth while collaring caribou from boats, we prefer to not remove a tooth for health reasons, and the specific age of adult caribou cannot be determined from samples collected at the time of collaring. Since the late 1980s we have attempted to maintain about 15 collared bulls in the total marked sample primarily to aid in conducting censuses; unfortunately, we have rarely achieved that goal.

Mortality rates for mature bulls have exceeded 60% in some years, bulls are sometimes scarce during the collaring project, and we do not compete with local hunters for bulls. Although we've usually managed to begin each CY with ≥15 collared bulls in the WAH, we've rarely met the objective by retaining a minimum of 15 collared bulls at the end of each CY because of losses to mortalities, slipped collars, and harvests of collared bulls. We do not deploy collars on bulls less than 3 years old to avoid choking them from skeletal growth and seasonal enlargement of their neck during rut. Collars are randomly deployed on cows ≥1 year old annually irrespective of age or maternal status. Only cows in very poor physical condition are not collared.

We began CY12 with 100 potentially active collars on living caribou (86 cows and 14 bulls). Of these collared caribou, 76 cows and 3 bulls were equipped with a functional PTT or GPS collar. We began CY13 with 103 potentially active collars on living caribou (93 cows and 10 bulls). Of these caribou, 87 cows and 10 bulls had an active PTT or GPS collar. The number of radiocollared caribou reported for each year, regardless of collar type, is inconsistent between consecutive management reports because individuals are retroactively removed from initial sample sizes as we determine that their batteries were likely exhausted or that a caribou died prior to the start of a collar year.

During the reporting period all new radio collars were deployed during September in Unit 23 at Onion Portage on the Kobuk River. The rationale and methods for this technique have been previously described (Dau 1997). Many residents of northwest Alaska object to chemical immobilization and helicopter capture techniques. Therefore, to avoid using these techniques, we have not removed or replaced previously deployed radio collars on WAH caribou since at least the mid-1980s. Since beginning the WAH telemetry program in 1979, we have collared 1,151 caribou, and the batteries in the transmitters on up to 151 of these individuals (10%) were likely exhausted before the animals died (the last time this occurred was in 2009). The Onion Portage project is broadly supported by people who reside within the range of this herd. Even so, we limit the duration of the collaring project and the number of agency staff present at Onion Portage to minimize our impact on local hunters.

We have deployed no VHF collars on adult WAH caribou since 2010. In 2012 we deployed 1 GPS and 19 PTT collars for the department, and 12 GPS collars for NPS. In 2013 we deployed 16 GPS and 3 PTT collars for the department, and 10 GPS collars for NPS. To maintain a minimum 36-month VHF transmitter life expectancy in PTT and GPS collars, we specified a 12-hr ON/12-hr OFF duty cycle in VHF transmitters contained in department satellite collars (ON 8:00 a.m.–8:00 p.m. daily); the NPS specified this VHF duty cycle as well. All NPS collars were fitted with a Cr-2a breakaway device programmed to release in 5 years (most of the 2009 collars released in early June 2013).

Satellite and GPS Collars. The objectives and limitations of the WAH satellite collar program were previously described (Dau 2007). Both ADF&G and NPS purchase collars for WAH caribou and, during this reporting period, data sharing was negotiated. This report includes data that the NPS had withheld from ADF&G during November 2013 through March 2015, but was later appended to the department data files following completion of a data sharing agreement.

The 1 April 2015 agreement covers only GPS and PTT locations from GPS-collared WAH caribou. It does not include VHF observations of GPS-collared caribou, or any location data from VHF- or PTT-collared caribou. Data covered by this agreement date from 1 September 2009 and the agreement applies to the incoming data stream. This agreement will remain in effect 5 years from the date it was signed (1 April 2015 through 1 April 2020).

Population Size and Composition. Since 1986 we have determined population size using the aerial photo-direct count extrapolation (photo census) technique (Davis et al. 1979). We photographed the entire WAH twice in 2013, once on 7 July and a second time on 8 July (i.e., the entire herd was completely photographed each day). We treated each day as a separate census for comparison. All overlap lines were completed by 2 department staff (J. Dau and B. Saito) during December 2013, and Don Williams completed counting all of the photos by 12 March 2014.

In this report I present both minimum population counts of census photographs as well as population estimates based on radiocollared caribou following Rivest et al. (1998). Also, I report the higher of the Rivest point estimate or the minimum count. The rationale and effects of this change in reporting population size on other aspects of this report were previously described (Dau 2011).

Population composition for the WAH was estimated from annual calving surveys during June, fall composition counts during October 2012 and 2014, and annual short yearling surveys during April–May. We conduct calving surveys to delineate calving areas, monitor initial calf production, and contribute to our annual estimate of adult caribou mortality. Additionally, the neonate:cow ratio provides an indirect way to assess body condition of mature cows during the previous fall (Cameron and Ver Hoef 1994), a parameter that is difficult to directly measure.

Calving survey techniques for this herd have been previously described (Dau 1997, Dau 2011). During 2013, calving surveys were conducted using a PA-18 airplane during 5, 7, and 11–14 June. During 2014, they were conducted during 8 and 10–14 June. During 2015 (after this reporting period) calving surveys were conducted during 5–7 and 11–12 June. In this report I arbitrarily used the 95% kernel isopleth to show the extent of the calving area, and a Bayesian model (Wilson et al. 2010) to identify core areas.

During this reporting period we continued to relocate collared cows multiple times during calving surveys to better determine maternal status and improve the accuracy of parturition sites. We tried to locate cows until they were observed with a calf at heel or grew visible velvet antlers. However, each year some cows initially having at least 1 hard antler and no calf were not observed with a neonate by the end of the survey. For kernel analyses, I approximated parturition sites by filtering survey data by two criteria: 1) the first observed location of a cow with a neonate; and 2) the last observed location of a cow with at least 1 hard antler and not accompanied by a neonate. During this reporting period no collared cows were observed >4 times.

Caribou collared at Onion Portage are not randomly mixed throughout the herd until the following June. Therefore, we exclude location data for these individuals from the time of collar deployment through May 31 of the subsequent calendar year from analyses that describe the distribution of this herd.

Fall composition surveys were conducted on 24, 26, and 27 October 2012 and on October 20–22 2014 using techniques previously described (Dau 1997). Survey dates were determined by our estimates of seasonal dates for rut, the availability of an R-44 helicopter, and weather.

In 2013 spring composition (short yearling or recruitment) surveys were conducted on 3, 8, 14, 20 and 25 April. In 2014 recruitment surveys were conducted on 7, 10, 17, and 28 April, and on 2 May. Recruitment survey techniques as well as the strengths and limitations of data collected by these methods have been previously described (Dau 1997, Dau 2005).

The period over which we monitor recruitment (June through the following May) does not directly correspond with the period over which we estimate adult mortality (October through the following September). As a result, recruitment is graphed differently in Figures 19 and 26. In Figure 19 recruitment is plotted on the year it was estimated (i.e., the year following the birth year) to best correspond with estimates of adult mortality. The purpose of Figure 26 is to show the ratio of calves to cows through their first year of life; therefore, the spring recruitment estimate for any specific year is shifted 1 year earlier to track its year of birth. For example, we observed 86 neonate calves:100 cows during June 1992, 52 calves:100 cows during October 1992, and 28 calves:100 cows during April 1993. The 28 calves:100 cows would be attributed to 1993 (time of collection) in Figure 11, and 1992 (birth year) in Figure 17.

I estimated size of total annual range using an arbitrary 95% fixed kernel (using ArcGIS Spatial Analyst). All PTT and GPS location data were standardized using the first best location every 6 days throughout each year. Only high quality (LQI values of 1–3) PTT records were used in addition to GPS locations and visual VHF observations.

I used the mean annual growth rate ($N=e^r$) to estimate population size for years between censuses where

N=caribou population estimate

e=2.7183

$r=[\ln(N_{t2})-\ln(N_{t1})]/t_2-t_1$

t=year of census.

Distribution and Movements. Distribution and movements of the herd were monitored through rangewide conventional telemetry surveys, and through PTT and GPS locations. Rangewide VHF surveys were conducted throughout the year, often in conjunction with composition surveys. Flights were based out of Barrow, Kotzebue, Nome, and Fairbanks using survey techniques previously described (Dau 1997).

Mortality. Mortality rates for adult WAH caribou were estimated from cows with conventional, PTT, or GPS collars on a collar-year basis. Estimated mortality includes all causes of death, including hunting, with the exception of caribou killed, purposely or accidently, by department staff. Department-caused deaths are unique to the sample of collared caribou and do not reflect the overall population. Portions of 3 collar years (CY11, CY12, and CY13) span this reporting period. Mortality rates are estimated separately for cows and bulls because we do not collar bulls less than 3 years old, and sample sizes of collared bulls historically have been small. We began using expandable collar sections on bulls in 2001, which appears to have reduced the number of collars that slip over a caribou's head during winter and are lost.

Mortality rates reported in consecutive management reports are inconsistent because sample sizes are continually adjusted as we determine the fate of collared individuals. For example, radiocollared caribou not located for 2 years are retroactively dropped from the sample of active collars going back to the year they were last located. Also, when a hunter returns a collar to ADF&G that was harvested years earlier we adjust our annual sample sizes accordingly. Inconsistencies in mortality estimates are most pronounced for the previous 1–3 years.

I examined seasonal patterns of mortality for bulls and cows separately. Annual sample sizes for bulls were consistently much smaller than for cows, and I was able to use only CY94 through CY13 data for bulls. For cows, I used CY83 through CY13. To compare differences between sexes I standardized initial sample sizes to 100 individuals separately for each sex. For cows, this was of little consequence because initial sample sizes usually approximated 100 individuals for all years after and including CY89 (for CY83 through CY88, the multiplier to normalize the sample to 100 individuals was 2.3). For bulls the multiplier used for individual years ranged 5–11. Therefore, conclusions regarding seasonal patterns of mortality for bulls should be viewed with caution. Because the duration of individual seasons varied, I standardized all estimates of mortality to number of deaths per week.

I reviewed archived telemetry data to evaluate causes of WAH mortality. There is little information regarding cause of death for collared individuals before CY88. This is partly attributable to small sample sizes of collared caribou and our complete dependence on VHF collars during the early years of the telemetry program. We often were unable to visit mortality sites to determine cause of death during the early years of the program and, when we did, staff often did not record cause of death even when it could be determined. We increased our efforts to determine cause of death for collared caribou after this herd began declining around 2003. Given this change in effort, temporal trends in causes of mortality should be viewed with caution. Department staff continued to invest heavily in determining cause of death for radio collared caribou during this reporting period.

I used a latent bloodstain reagent (Bluestar Forensic Reagent, Monte Carlo, Monaco) to detect dried blood on retrieved collars to help determine whether caribou had been killed by predators or merely scavenged by them. When using the bloodstain reagent, I focused on the inside of the brass hardware that holds the 2 ends of the collar together, and on the inside of the 2 overlapping ends of the collar. Bloodstains in these areas would occur only if the collar had been drenched in blood during a predation event. If there was only a small amount of blood on other portions of the collar, I assumed that the caribou had not been killed by a predator and was scavenged. Each collar was individually placed in a plastic bag at the time of retrieval from the field to prevent transfer of blood residue from collar to collar.

Most collars were retrieved during the snow-free period so that we could examine mortality sites to determine cause of death and collect a mandible for aging. Caribou that died from an unknown cause far from a community or in a location inaccessible to people (e.g. extremely steep terrain) were classified as 'unknown natural mortality.' Caribou that died from an unknown cause in proximity to a village or a transportation corridor (i.e., winter staked trails or major rivers) were classified as 'unknown mortality.' Mortalities attributed to human harvest were based on the collar being returned to the department, or on characteristics of the mortality site (e.g., an obvious butchering site, collar material having been cut with a knife, or removal of collar hardware). I used characteristics observed at the mortality site to determine causes of natural mortality, for example, presence of hair and hide, presence of various bones, whether the collar was buried under a rock or land slide, amount of disarticulation of bones, degree to which bones had been consumed, pattern of bone consumption (e.g., complete shattering of large bones versus gnawed articulating surfaces of large bones), presence of predator scat in the immediate area, presence of bear hair on bones or antlers (bears often lay on top of carcasses), time of death (bears rarely kill caribou during the denning period), and whether the carcass had been buried in a mound of vegetation. I was conservative and specified "unknown cause of death" when the evidence was inconclusive.

<u>Harvest</u>. Harvest data were summarized by regulatory year (RY), which begins 1 July and ends 30 June (e.g., RY10 = 1 July 2010–30 June 2011). We collected harvest information using statewide harvest tickets for nonlocal hunters; these data are available from RY98 through the present time. We also collected harvest information from local hunters using community-based harvest assessments for communities within the range of the WAH. During RY14, the department administered hunt RC900 in Nome which had a harvest report requirement. During that RY all other communities received harvest registration RC901 that did not include a hunt report requirement. During RY15, the department eliminated RC901 and issued RC900 registrations throughout the range of the WAH. This reporting method requires hunters to submit a harvest report, as Nome residents did during RY14, indicating how many bulls and how many cows they harvested during each of 2 hunting periods, fall and winter/spring. When a nonlocal hunter reported taking >1 caribou, I used the earliest date reported as an index of temporal trends in effort.

Community-based harvest assessments have been conducted in selected communities within the range of the WAH since 1985. The communities composing the sample have changed from year to year. As a result, no single village has a complete record of harvest surveys for the 1996–2014 period. These gaps in harvest data for communities necessitate estimating harvest with a model that uses variables correlated with harvest. The 2 variables for which we have data are village population size and the spatial proximity of WAH caribou to each community. The linear model that we used in the past to estimate caribou harvests by hunters who live within the range of the WAH (Sutherland 2005) had not been updated with additional community harvest data since its development. In February–March 2015 we replaced Sutherland's model with a new analysis of covariance (ANCOVA) model developed by the department's Division of Wildlife Conservation Region V (Arctic and Western Alaska) biometrician A. Craig. The new model differs from Sutherland's original model in several ways:

1. It includes community harvest data for the period 1996–2014 (the Sutherland model used community harvest data collected during 1987–2000).
2. It uses annual estimates of human population size for individual communities from the Alaska Department of Labor (the Sutherland model referenced only 2 years of community population data from the Alaska Department of Community and Economic Development).

3. It considers only 2 classes of availability of caribou: average and far (the Sutherland model identified 3 classes of availability). Caribou availability was determined from caribou telemetry location data.
4. The new model includes an interaction parameter between availability and human population size.

The linear model was fit to the updated harvest data. Proximity of caribou to each community in a given year was defined as the categorical variable 'availability' with 2 possibilities: average or far. We investigated using 3 categories of availability but the data supported using only 2. We also investigated 2 models to estimate harvest: one with an interaction term between availability and community population size, and one without this interaction term. A likelihood ratio test showed that the former model that included the interaction term was a better fit to the data (P<0.001). This indicates that harvest increases with community population size differently for the 2 availability classes.

A total annual (i.e., regulatory year) caribou harvest by local residents is estimated with a linear combination of the model parameter estimates ($\boldsymbol{\beta}$). A matrix was assembled wherein each row contained the correct linear combination (**c**) of model parameters to provide an estimate of total harvest for a particular year. For example, the first row of this matrix for 1996 is a vector comprising 4 quantities:

$\mathbf{c}$ =(Total Villages$_{1996}$, Total Human Pop.$_{1996}$, Total 'Far' Villages$_{1996}$, Total Human Pop. 'Far' Villages$_{1996}$)

An estimate of the total caribou harvest for 1996 can then be calculated by the dot or scalar product of $\mathbf{c}^{\mathbf{T}}\boldsymbol{\beta}$.

Body Condition and Disease. During each year of the reporting period we collected blood samples from caribou while deploying radio collars at Onion Portage. Blood was collected from all caribou that were radiocollared as well as from additional individuals. Caribou were captured, restrained, and released as previously reported (Dau 1997). We collected blood from 20 bulls and 25 cows in 2012, 2 bulls and 14 cows in 2013, and 6 bulls and 21 cows in 2014. Body condition (very skinny, skinny, average, fat, very fat), abnormalities, and presence of a calf were recorded for caribou from which a blood sample was collected. Since 2001, serum samples have been analyzed mainly to assess haptoglobin levels, which indicate inflammation (Dau 2001), and exposure to *Brucella suis* bacteria. However, in 2014 no tests were conducted on WAH serum because veterinary staff in Fairbanks did not have time to submit the samples.

Calf weights. Since 2008 we've recorded the live weight of calves each year during the Onion Portage collaring project. Most calves weighed accompany cows that we radio collar or sample for blood. Occasionally, we weigh an orphan calf that is not with an adult cow.

It takes 3 individuals to weigh a calf from a small boat. A cow-calf pair is separated from the rest of the group while swimming the Kobuk River. Once by themselves, the cow and calf are separated and the cow is captured by the "collar boat." Calves are grabbed around the neck by staff in a second boat. As soon as the calf is caught, the anchor is set. One person, the 'grabber,' holds the calf around the neck and a second person holds the tail. The third person, usually the boat driver, slips 2 nylon belt slings around the calf's torso, one just behind the front legs and one in front of the hind legs. A carabiner is used to close each loop around the calf. The top eye of each sling is fitted over a hook on the bottom of the scale (we used a 250 lb mechanical spring scale until 2010 when we transitioned to a 440 lb digital scale: Pesola PHS200, China). An 8-foot-long, 2-inch diameter straight aluminum pole is balanced on the shoulders of the 2 individuals holding the calf. The scale is attached to the center of this pole. The 2 individuals holding the calf release it while simultaneously standing up to lift it out of the water and over the side of the boat. The third person, who attached the slings, helps guide the calf over the side of the boat as it is being lifted and then reads its weight on the scale. After reading the scale the process is reversed and the calf is immediately returned to the water. The weighing equipment is removed, the anchor is pulled, and the calf is held while the boat slowly maneuvers close to the boat that is holding its mother. The mother and calf are simultaneously released and, if necessary, gently herded to the south side of the river. The process of weighing a calf is often completed within several minutes by an experienced crew.

Calf weights are corrected for water weight that is held in their fur. We determined water weight by weighing calves held at the University of Alaska Large Animal Research Center when they were dry and again after soaking them with a hose. The correction factor is 2 lb (1 kg).

Mandible collections. Mandibles of harvested WAH caribou have been collected episodically since the late 1950s. During this reporting period we continued to collect jaws during the collaring project and intensified our efforts to collect a jaw from mortality sites of collared individuals. Additionally, we have opportunistically collected jaws from all caribou mortality sites we have encountered in the field. In this report I used total ramus length as an indicator of body size. All mandibles were measured following the CARMA protocol (Gunn and Nixon 2008). There are no tooth cementum age data for this herd prior to 1997. All age estimates for caribou collected before that time are based on tooth eruption and wear patterns by department staff. All teeth collected since 1990 and aged by counting cementum annuli were processed by Matson's Laboratory, Inc. (Milltown, MT). Most caribou were aged from a first incisor tooth (I-1); however, when an incisor or canine tooth was not available, I usually substituted a first molar tooth (M-1) for aging. The sex of the caribou, tooth type, and approximate time of death were provided to Matson's at the time of sample submission. The WAH mandible collection program has been previously described (Dau 2014).

RESULTS AND DISCUSSION

POPULATION STATUS AND TREND

Population Size

Differences between minimum counts and Rivest estimates have been small relative to the size of the WAH (Fig. 17, Table 1).

We completely photographed the WAH on 7 July 2013 and again on 8 July 2013. There were rain showers over some groups photographed on 7 July which had the potential to affect the quality of the photos. Conditions were optimal on 8 July and we had adequate film to photograph the herd a second time for comparison to the 7 July census.

The Rivest estimate for 7 July was 234,757 caribou (SE = 3,871) and for 8 July was 220,549 caribou (SE = 3,997). The collars were randomly distributed among groups on both days (P =

0.80 and 0.78, respectively). The ranges of the upper and lower 95% confidence intervals for the 2 estimates overlapped. The official estimate of herd size in 2013 released to the public was 235,000 caribou (7 July estimate rounded up). The difference between these estimates was likely attributable to difficulty establishing overlap lines on one of the largest groups photographed on 8 July. Other factors that most often affect the quality of caribou census estimates were inconsequential. For example, 1) we found 77 of 78 collared caribou on each day of the photography; 2) the herd was highly aggregated into few groups (7 groups on 7 July of which 6 groups contained a collared caribou, and 5 groups on 8 July all of which contained at least 1 collared individual); 3) there was little movement of caribou during the photography; and 4) light was good. I recounted 8 photographs from the 7 July census, ~10% of the total number, originally counted by Don Williams. There was no statistical difference between our mean counts (paired T test, t = 1.47, $P = 0.19$).

We found 8 collared TCH caribou in the WAH aggregations during both the 7 and 8 July photography. The 8 collared individuals could mean that ~8,000 TCH caribou were present during the 2013 WAH censuses. This is of little importance to the WAH estimate but could comprise almost 20% of the 2013 TCH estimate. I did not use collared TCH caribou for the Rivest WAH population estimate, and I did not adjust the WAH estimate down to account for a possible influx of caribou from the TCH.

In addition to completely censusing the WAH twice in 2013, we also photographed 3 groups twice on 7 July, and 1 group twice on 8 July. Differences between counts of these groups were 10%, 5%, and 5% on 7 July, and 23% on 8 July (this was the group for which we had difficulty establishing overlap lines). The Rivest technique assumes that groups containing collared caribou are counted accurately. This source of variability is not included in Rivest estimates of standard error.

The decline from an estimated 325,000 caribou in 2011 to an estimated 235,000 caribou in 2013 represents a 15% average annual rate of decline (Table 1, Fig. 17). This is substantially higher than the 4–6% rate of decline experienced from 2003 to 2011, and it approaches the 18% average annual decline experienced during the 1970s population crash (Table 1, Fig. 17). However, the adult WAH cow mortality rate (Table 2, Fig. 18) suggests that the rate of decline from 2011 to 2013 was likely not a constant 15% over those 2 years. Instead, mortality was very high during the CY11 (33%) and lower (20%) during CY12 (Table 2, Fig. 18). The CY11 cow mortality estimate is among the highest recorded for the WAH. Adult cow mortality was 36% during CY83 but that was based on a sample of only 21 VHF-collared caribou during an era when radiotracking flights were conducted infrequently. In addition to high mortality during CY11, recruitment was relatively low during 2012 and 2013 (Table 3, Fig. 19). The 2013 census estimate is consistent with these estimates of adult cow mortality and recruitment.

As of 2013, the WAH had slipped from the 'liberal' to the 'conservative' management level identified in the WAH cooperative management plan (See Table 2, Western Arctic Caribou Herd Working Group 2011). Additionally, Appendix II of the cooperative plan recommends several regulatory restrictions under the conservative management level: 1) no harvest of calves, 2) no cow harvest by nonresidents, and 3) restriction of bull harvests by nonresidents. If the WAH continues to decline even just 4–6% annually as it did during 2003–2011, and if mortality and recruitment do not change, this herd could enter the 'preservative' management level within 2–3 years. The plan recommends increasingly restrictive regulations as the population level and trend decline.

My observations of snow conditions, caribou carcasses, and the body condition of live caribou during spring suggest that fall and winter icing events were probably a primary factor that initiated this population decline around 2003. Additionally, although we have little quantitative information regarding densities of brown bears or wolves throughout the range of this herd, opportunistic observations by department staff and many reports from residents of this area, long-term guides, and transporters all indicate that predator numbers are high compared to previous years. I have seen substantially more wolf-killed caribou during the last 3–5 winters than prior to that time. Although BLM (Joly et al. 2007) has documented a decline in lichen cover with a concomitant increase in shrub and grass cover on portions of WAH winter range, the generally good body condition of WAH caribou suggests that density dependent habitat degradation is probably not driving this population decline (although it could be contributing to it).

The department has supplemented biennial and triennial census data with annual estimates of adult cow mortality (Table 2, Fig. 18) and recruitment (Table 3, Fig. 19) to fill data gaps between years when censuses are conducted, and to help understand factors that could be driving population size and trend. Trends of increased adult female caribou mortality and decreased recruitment (Fig. 20) are consistent with the decline in population size shown by census data.

Although census data for this herd date back to 1970, satellite location data adequate to calculate total range extends back only to CY99. Since 2000 there has been no correlation between total estimated population size (using average annual growth rates to estimate herd size for years between censuses) and either of 1) total annual range size (Pearson correlation coefficient = 0.66, $P = 0.23$; Fig. 21), or 2) the annual extent of calving (Pearson correlation = -0.19, $P = 0.76$; Fig. 22) or the core calving area (Pearson correlation = -0.44, $P = 0.46$; Fig. 22).

Population Composition

Calf production and survival. Rate and direction of travel of satellite-collared cows during 1988–2012 indicates that peak calving has generally occurred during 9–13 June (Dau and Sutherland, ADF&G unpublished data archived in the Kotzebue ADF&G office WAH files; Fig. 23). However, peak calving can occur before or after these dates in some years. For example, calving probably peaked early during 1987 and 1990, based on the western distribution of collared cows, their uniformly rapid and western direction of travel, and the absence of hard antlers on cows. The earliest reported peak calving date for the WAH is 26 May 1960 (Lent 1966). During calving surveys conducted since 1989, the median date of observation to determine the maternal status of collared cows occurred before 9 June during 10 years, and after 13 June during 2 years. This was partly attributable to weather conditions that affected the timing of calving surveys. During 1987–2015 there was no correlation between median annual date when calving surveys were conducted and the June calf:cow ratio (Pearson rank correlation = -0.21, $P = 0.29$, $n = 28$).

During June calving surveys, we observed 62 calves:100 cows in 2012, 63 calves:100 cows in 2013, and 69 calves:100 cows in 2014 (Table 4, Fig. 24). Historical estimates of calf production suggest parturition rates were more variable 1960–1970 than in recent years (Fig. 24). However, sampling approaches varied prior to 1987 when conventional telemetry techniques were adopted to locate calving caribou. Therefore, measurement error may have contributed to this early variability.

Our estimates of parturition are probably conservative because we do not record udder status for collared cows (Whitten 1995) and undoubtedly misclassify some cows that produced a calf as nonmaternal if they lost their antlers and their neonate before we observed them. In 2010 we began relocating individual collared cows multiple times to more accurately determine their maternal status and parturition site. This had little effect on our annual estimate of parturition because, during 2010–2015, only 5 of 20 cows (25%) initially observed without antlers or a neonate eventually had a calf. This sounds like a sizeable proportion until you consider that during this time we observed 433 collared cows during calving surveys. The 20 no calf-no antler cows comprise <5% of the total number of cows observed, and the 5 that eventually had a calf comprise only 1% of the total sample.

Although collecting multiple locations of potentially maternal cows had little effect on our estimates of initial productivity, this approach provided more accurate information regarding their parturition site during the 2010–2015 calving surveys. We looked at 45 cows from 2 to 6 times during 2010–2015 to identify calving sites (this includes only cows that we eventually observed with a calf; some cows, although relocated multiple times, were never observed with a calf). For cows with at least 1 hard antler and no calf that were first observed north of 68.65° N Latitude (i.e., cows that would have had their first observation used to denote parturition site prior to 2010), the median distance between the first observation to where we first saw them with a calf was 10.8 mi (range = 0.8–39.0 mi; 17 km, range = 1–63 km). In 2013, 3 cows first observed with a hard antler and no calf south of 68.65° N Latitude were later found with a calf. These individuals traveled 23.5, 119.0 and 40.9 mi (37.8, 191.5 and 65.8 km), respectively, from their initial location to where we first saw them with a neonate. This supports our long-held policy of not using the location of hard antlered-no calf cows to denote parturition site when first observed south of the De Long Mountains crest. Pregnant cows can rapidly move long distances to reach the calving grounds before giving birth. During 2010–2015, the median distance traveled by cows that were observed multiple times before giving birth, excluding those initially observed south of the De Long Mountains crest, was 2.2 mi/day (n_i = 42, range = 0.4–7.8 mi/day).

The negative linear relationship between the calf:cow ratio and the proportion of cows with velvet antlers during calving (F = 13.16, P = 0.001, R^2 = 0.34) continued through this reporting period (1988–2015, Spearman rank correlation = –0.58, P < 0.0001, n = 28 years). The mean rank of cows with velvet antlers during years when the calf:cow ratio was ≥70:100 (n = 13) was significantly lower than the median for years when this ratio was <70:100 (n = 15; Kruskal–Wallis test statistic 20.17, P <0.001). This suggests low WAH parturition rates are real and not artifacts of sampling error.

The fall calf:cow ratio generally increased during 1976–1982, a period of rapid population growth. In contrast, this ratio declined 1992–2014, a period of slow growth or decline (Table 5, Fig. 25).

We observed 25 short-yearlings:100 cows in spring 2013, 21:100 in spring 2014 and 20:100 in spring 2015 (Table 3, Fig. 26). Recruitment, as reflected in April–May surveys, has slowly declined since the early 1980s (Table 3, Figs. 19 and 26). The persistent, declining trend in recruitment would not be evident without this long-term data set (Fig. 19).

Least squares linear regression indicates that there has been no trend in the June calf:cow ratio during 1982–2015 (F = 0.00, P = 0.97, n = 28, Fig. 24). The fall calf:cow ratio declined linearly during 1982–2015 (correlation coefficient = -0.55, R^2 = 0.41, F = 7.67, P = 0.02, n = 13) as did the spring calf:cow ratio (correlation coefficient = -0.62, R^2 = 0.45, F = 20.88, P<0.0001, n = 28; Fig. 26).

Calf:cow ratios were estimated during June, the following fall, and the following spring in 13 years between 1992 and 2015 (Fig. 26). During 1982–2013 there has been no correlation between the June calf:cow ratio and subsequent fall ratio (Spearman rank correlation = -0.10, P = 0.77), or with the following spring ratio (Spearman rank correlation = -0.14, P = 0.64). In contrast, the fall and subsequent spring ratios were correlated (Spearman rank correlation = 0.63, P = 0.02). Calf production has likely had little influence on the population trajectory of the WAH; however, declining calf survival through the summer of their birth year may have contributed to the current decline.

Bull:cow ratios. The fall bull:cow ratio was 39:100 during October 2014. During 1992–2014 the fall bull:cow ratio declined linearly (correlation coefficient = -0.81, F = 15.23, P = 0.002, n = 13, Fig. 27). During this time the median was 49 bulls:100 cows (Table 5, Fig. 27). The bull:cow ratio now appears to have reached the minimum acceptable level identified in the 2011 cooperative management plan (WACH WG 2011).

Sexual segregation and our inability to sample the entire population during fall probably account for more annual variability in the estimated bull:cow ratio than actual changes in population composition. The low value of 38 bulls:100 cows in 2001 was probably a result of spatial segregation and incomplete sampling of the entire herd rather than an actual short-term drop in the proportion of bulls in the population. Because of this measurement error, the bull:cow ratio data reported here should be viewed with caution. We think these data probably reflect trends in bull:cow ratios reasonably accurately; however, the actual values could be higher or lower.

Distribution and Movements

Historical Summary. Our historical understanding of WAH distribution has been previously described (Dau 2001). In recent years we have replaced VHF collars with PTT and GPS collars. This has reduced the need to conduct range-wide VHF telemetry relocation surveys to determine the mortality rate and monitor the distribution of this herd. It has also provided a larger volume of higher quality location data compared to the era of VHF telemetry.

General Movement Pattern: The general movement pattern of this herd was previously reported (Dau 2009). Season dates were determined from rate and direction of travel for male and female caribou (Figs. 23 and 28, Table 6, Dau 2013). Since about 2000, fall movements have appeared to be less predictable and generally later than during the 1980s and 1990s. Despite the increased variability in the timing of movements during recent years, the WAH has exhibited the same general movement pattern among seasonal ranges for at least 50 years.

Spring. It appears that the onset of spring migratory movement is temperature dependent. When average daily ambient air temperature rises to 0°C (32°F), cows begin migrating north (Sutherland and Dau, ADG&G unpublished data archived in the ADF&G Kotzebue office WAH files). From my observations, difficult traveling conditions (e.g., extensive overflow on river ice, open water, deep or rotten snow, etc.) have little effect on the northward migration of either cows or bulls. The only exception occurs when ice pans flowing down rivers during freeze-up and break-up seasons temporarily halt migrating caribou. In these situations caribou accumulate along river banks for up to several days until ice bridges form, allowing them to pass, or the ice pans disappear.

Based on location data collected during 1988–2012 (all years combined), bulls and cows exhibit strikingly different movement patterns following the winter season. Pregnant cows, many accompanied by their 10-month-old calf, generally begin migrating toward the calving grounds around 6 May. In contrast, bulls and many nonmaternal cows don't begin migrating north until roughly 16 May. Pregnant cows head directly toward the calving grounds from wherever they spent the winter. Bulls that winter in the Nulato Hills or on the Seward Peninsula initially follow the same movement corridors traveled by pregnant cows; however, as they cross the Noatak drainage, bulls bypass the calving grounds and head northwest through the De Long Mountains toward the Red Dog–Lisburne Hills area. The 'spring' season for bulls encompasses 3 seasons for cows: 'spring,' 'calving,' and 'post-calving.'

Movements by bulls and cows followed the typical WAH spring movement pattern during 2013 and 2014; however, the timing of spring movements was unusually late during 2013.

Calving grounds. The WAH has exhibited strong fidelity to its calving grounds in the Utukok hills since the late 1950s. For example, the areas identified by Lent (1966) as calving areas in 1960 and 1961 are within the 95% calving kernel for 1988–2012.

The distribution of maternal cows extended unusually far south during the calving season in 2013. This was the first time we had documented a 'core' calving area that extended south of the crest of the De Long Mountains since we began recording parturition sites in 1987. As in 2000 and 2001, when cows were late getting to the calving grounds, breakup was late in spring 2013.

Calving was unusually concentrated during 2014 and 2015 for reasons that are not clear. We have observed relatively few wolves on the calving grounds since around 2005. Brown bears are commonly observed on the calving grounds during June surveys but are only infrequently observed on carcasses of adult or neonate caribou at this time. It seems unlikely that the concentrated calving during 2014 and 2015 was caused by predators.

One GPS-collared cow gave birth to a calf near the mouth of the Buckland River during calving 2015. This is only the second time since the mid-1980s that a collared WAH cow gave birth on the Seward Peninsula. This cow was severely crippled and could travel only with obvious difficulty. She was accompanied by an unusually large calf that survived until at least mid-July. Other than her calf, there were no other caribou seen in this area during numerous flights in June or July. In late August 2015, this cow began migrating west toward Cape Espenberg along heavy trails established since 1996. She is still alive at the time of this report (December 2015) and is wintering on the eastern side of Shishmaref Inlet with tens of thousands of WAH caribou.

Post-calving. The post-calving movement by maternal cows and their neonates from the calving grounds southwest to the Lisburne Hills is one of the most concentrated and predictable movements exhibited by WAH caribou. Rate of travel during this season is second only to that exhibited during summer movements. Post-calving movements were typical during 2013 and 2014 (Figs. 7 and 8).

Summer. The WAH uses the western North Slope and central to western Brooks Range during summer. The importance of summer range to the WAH has been previously discussed (Dau 2003). Small numbers of WAH caribou, mostly bulls and nonmaternal cows, were observed on the Seward and Baldwin peninsulas by department staff during both summers of this reporting period. Summer movements by WAH caribou are more predictable than any other season, and movement rates during summer greatly exceed those of any other season.

No collared caribou summered on the Seward Peninsula during the summer of 2013. One PTT-collared bull spent the summer of 2014 in the vicinity of Serpentine Hot Springs during the summer of 2014. This bull was harvested on 14 October 2014 near Deering as he was moving west, possibly in search of caribou moving onto the Seward Peninsula as rut approached. We have no evidence to suggest that a nonmigratory caribou herd has established itself on the Seward Peninsula.

Caribou followed the typical WAH summer movement pattern in 2013 and 2014 (Figs. 9 and 10).

Late summer. Following the summer period bulls and cows disperse through the De Long and Schwatka mountains or move slowly north and west back onto the coastal plain. The small percentage of WAH caribou (mostly bulls) on the Seward Peninsula near Serpentine Hot Springs, Cape Espenberg, and Mount Bendeleben remain there during late summer.

In 2012, caribou were widely dispersed throughout the northeastern portion of their range but exhibited 2 areas of weak clustering in the vicinity of Howard Pass and southwest of Umiat (Fig. 11). In 2013, caribou were again widely dispersed throughout the northern portion of their range and showed no evidence of clustering (Fig. 12).

Fall. Caribou from this herd have historically been more widely distributed during fall than at any other time of year. In many years the vanguard of the fall migration will reach the southernmost portions of winter range before some caribou even depart areas occupied during late summer. However, in recent years the migration has been different in both space and time. During autumn of 2012, 2013, and 2014, relatively few WAH caribou migrated through the western portion of Unit 23. During these years the most heavily used fall movement area was within a relatively narrow east–west corridor between the Anisak and Aniuk rivers, through Ivishak Pass, and into the Purcell Mountains or Nulato Hills. As a result, Noatak, Kivalina, and Kotzebue hunters experienced difficulty harvesting caribou in the fall during 2012, 2013, and 2014.

In addition to changes in the fall distribution of migrating WAH caribou, the timing of fall movements has also affected local subsistence and nonlocal recreational hunters. In 2013 and 2014, a segment of the WAH moved through the upper Nigu–middle Noatak area and crossed the middle Kobuk River for 7–10 days during early September. Following that spike in caribou availability, very few caribou appeared along the Noatak, Kobuk, Selawik, or Buckland rivers for the next several weeks. When caribou did resume crossing the Kobuk River, they did so in large numbers just above Kiana. These caribou were heavily harvested by hunters from Kotzebue, Noorvik, Kiana, and even Noatak. We received reports from local residents of poor behavior by some hunters during this brief period of super abundance.

In 2013 and 2014, the delayed fall migration also affected the collaring project at Onion Portage. In 2013, the lack of caribou crossing the Kobuk River allowed us to deploy only 28 of 33 collars, and in 2014 we deployed only 40 of 49 collars. As a result, in 2014 and 2015 we extended the duration of the collaring project to 2 weeks; however, in 2014 even that extended time was insufficient to get all of the collars deployed. In 2015, although department staff planned to conduct the project for 2 weeks if necessary, an abundance of caribou allowed them to deploy 78 collars in just 3 days.

During this reporting period, residents of Unit 23 continued to express concerns about guides and transporters placing large numbers of nonlocal hunters in fall movement corridors and deflecting caribou from traditional subsistence hunting areas. This has been a serious, recurrent issue dating to the early 1980s. Incomplete camp location information has precluded quantitative assessment of deflection or displacement of caribou by activities associated with commercial operators and their clients (hunters). Even so, despite virtually complete saturation of access points in the Anisak drainage by transporters each year during 2009–2015, caribou from the WAH migrated through this area during each successive year, and in no year did caribou divert away from the Anisak drainage despite persistent hunting and transporter activity. My speculation is that the long-held Inupiaq hunting tradition founded on the understanding that once the 'lead' caribou in the fall migration establish trails, those caribou behind them will continue to use these trails even in the face of hunting applies equally to other disturbance stimuli (e.g., commercial airplane activity, nonlocal hunters, and even trucks or human activity along the DMTS).

<u>Winter Range</u>. Most WAH caribou wintered on the Seward Peninsula or in the Kobuk, Selawik, and Buckland drainages during the winter of 2012–2013 (Fig. 15; subareas 7 and 4, respectively, in Fig. 29; Tables 7 and 8). During the winter of 2013–2014 (Fig. 16), most WAH caribou again wintered on the Seward Peninsula (subarea 7 in Tables 7 and 8 and Fig. 29) with a much lower number wintering in the central Brooks Range (subarea 5 in Tables 7 and 8 and Fig. 29).

The estimates of caribou density on winter ranges reported in Table 8 represent minimum values because they do not include reindeer or caribou from the TCH or CAH that also use WAH winter range. This would primarily affect densities reported for the central Brooks Range, the foothills of the Brooks Range east of the Utukok River, and the Seward Peninsula. Before the winter of 1996–1997, few WAH caribou wintered on the Seward Peninsula west of the Kugruk River drainage. Since that time a large proportion of the herd has wintered there during most years (Tables 7 and 8).

MORTALITY AND RECRUITMENT

Survival rates in relation to collar type and sex have been previously reported (Dau 2009). In past reports I estimated adult caribou mortality separately for bulls and cows based solely on radiocollared individuals. There are a number of limitations for this data. Mortality estimates for cows are conservative because collaring efforts exclude emaciated, injured, or clinically diseased individuals even though they compose part of the population. Additionally, we collar few yearling cows. Mortality estimates for bulls are biased high because we do not collar bulls younger than 3 years old, and some are substantially older than that when we collar them. Our selection of old bulls was more pronounced during the late 1980s through early 2000s; since 2006, we have selected bulls 3–4 years old to collar. Age related bias in our sample of collared caribou has been previously reported (Dau 2011; Prichard et al. 2012). The WAH telemetry program was based almost solely on VHF observations during the 1970s through 1990s. During this period we sometimes could not determine time of death to year much less season. This introduced uncertainty into early estimates of adult caribou mortality.

For this report I examined survival by sex and age using data from the WAH mandible collection. This greatly increased the sample size for cows and especially for bulls. It also eliminated some of the limitations with age data noted above for radiocollared caribou. Survival for male caribou exceeds survival for females through age 4. At age 5 this switches and female survival consistently exceeds that for males for the remainder of their lifespan. The difference in probability of survival between males and females is greatest during ages 5–11, with the greatest difference occurring at age 7 (Fig. 30).

There is also error associated with our estimates of recruitment. We undoubtedly misclassify some 10- and 22-month-old caribou during spring composition surveys because we conduct them from a Piper Cub PA-18 airplane. This provides a briefer view of the animals compared to observations made from a helicopter. However, conducting recruitment surveys from a Cub has been cost effective and has allowed us to consistently collect this data every year since 1982. Given the limited availability of helicopters in northwest Alaska, the vagaries of weather, and limited funding, fewer surveys would likely have been completed had we insisted on using helicopters to conduct these surveys.

The 33% adult cow mortality rate for 2011–2012 was second only to 1983–1984 (Table 2, Fig. 18). The 1983–1984 estimate (36%) is likely inaccurate because no satellite collars were deployed then to facilitate VHF telemetry surveys, few VHF tracking flights were made, and mortalities could go undiscovered for 1–2 years only to be discovered during a year of relatively high search effort. Given that the WAH was in a phase of rapid growth that spanned the 1983–1984 mortality period, the actual mortality rate during 1983–1984 was probably much lower than estimated from VHF-collared caribou. In contrast, the 2011–2012 mortality estimate is probably reasonably accurate. Snow depth was relatively high in many portions of WAH winter range during the winter of 2011–2012, and both wolves and brown bears were abundant. I observed many wolf-killed caribou while flying aerial surveys and while traveling in WAH winter range via snow machine. My observations of high caribou mortality were consistent with many reports I received from the public, and with similar comments almost universally made during recent WG round table discussions. I suspect that caribou weakened and/or impeded by deep snow were easy prey for wolves during the winter of 2011–2012. Many wolf-killed caribou carcasses I observed that winter were only partially eaten. Wolves may have found it easier to kill fresh caribou than to gnaw on what remained of a frozen caribou carcass they had killed earlier. I saw less snow on WAH range during the winter of 2012–2013 than in any winter since 1988–1989. The 20% adult cow mortality rate for 2012–2013 was lower than for 2011–2012 but, despite a relatively easy winter, was still substantially higher that the 15% average annual mortality rate during 1985–1986 through 2002–2003 (i.e., prior to the initiation of the current population decline). If predation by brown bears and wolves is a primary driving force behind the high adult caribou mortality, and if numbers of large predators remained high during 2012–2013 as reported by the public, caribou mortality could remain elevated even under favorable winter conditions. Notably, the caribou carcasses I visited during the easy winter of 2012–2013 were consistently more completely consumed than those I observed during the hard winter of 2011–2012. This was particularly evident while retrieving radio collars from mortality sites during July 2012 compared to July 2013. In 2012 skeletal remains were readily apparent at most sites while in 2013, the bones of many carcasses had been crushed and apparently consumed (it was hard to find any bones at some 2012–2013 mortality sites). One explanation for this inter-annual difference is that wolverines, which often crush and consume bones when scavenging carcasses, visited a higher proportion of collared caribou carcasses during 2012–2013 than in the previous years. Alternatively, the effects of deep snow or otherwise harsh winter conditions during 2011–2012 may have made caribou vulnerable to wolf predation, and wolves did not have to consume bones to meet their nutritional needs as perhaps happened during the easy winter of 2012–2013. Adult cow mortality was relatively low during 2013–2014 (15%) and 2014–2015 (17%), both years of light snow that came late in the winter (at least in those areas where caribou were wintering).

Adult mortality has slowly increased while recruitment has slowly decreased since the mid-1980s (Figs. 19 and 20). These trends are consistent with census results (Fig. 17). As noted above, age-related bias in our sample of collared cows causes us to overestimate mortality and recruitment (Prichard et al. 2012). However, the opposing trends in these relationships are more important than their annual values. There has been a significant negative correlation between recruitment and adult cow mortality during 1985–2015 (Spearman rank correlation = -0.57, $P < 0.0005$, $n_i = 31$).

Collared bulls exhibited higher seasonal mortality rates (deaths/week) than cows throughout the year, and seasonal differences in natural mortality and harvest rates were less pronounced for cows than bulls (Fig. 31). Little harvest of cows or bulls occurred during summer, and few bulls were harvested during spring. In contrast, natural mortality and harvests of bulls both spiked during fall.

A number of factors may have contributed to higher mortality. Possible effects of winter thaws and rain-on-snow events on caribou mortality have been previously reported (Dau 2009). Additionally, our opportunistic observations and many reports from the public indicate that wolf numbers have been high and increasing during recent years. During the 2012, 2013, and 2014 WG meetings, every representative of communities within WAH range reported very high numbers of wolves in their respective areas. Most representatives also reported high numbers of brown bears as well. My opportunistic observations during winter suggest that wolf predation on caribou has been higher since about 2008 than in previous years.

Habitat changes are probably not yet limiting the size of the WAH. Not surprisingly, given the large size of this herd since the mid-1980s, BLM has documented substantial declines in percent lichen cover with concomitant increases in grasses and shrubs on some WAH winter range (Joly et al. 2007). However, despite these changes in winter range, body condition of caribou has remained good based on the 2007 and 2010 health assessments, on our subjective index of caribou body condition during the September collaring project, and from many comments received from caribou hunters. This suggests that range limitation is not yet a primary driver of high mortality or the current population decline.

Despite the limitations of WAH mortality data, it is clear that far more WAH collared caribou have died of natural causes than were killed by hunters since the mid-1980s (Table 9, Fig. 32). Hunters often report being surprised when they approach a caribou they've just killed to find that it was wearing a collar; therefore, we do not think that hunters introduce bias into this data by avoiding taking collared individuals. Of those caribou that perished of natural causes, the majority were killed by predators (Table 9, Fig. 33). Wolves, brown bears, wolverines, lynx, golden eagles, and even coyotes are known to kill WAH caribou but I was only able to identify wolves and brown bears as predators causing deaths based on evidence present at the mortality sites. Of 152 collared caribou likely killed by predators, I could not identify the type of predator that killed 81 of them (53%). For collared caribou killed by a predator or predators that I could distinguish as either wolves or bear, wolves killed at least 3 to 4 times more caribou than bears. A characteristic of wolf kills is that often very few bones are left (only the skull plate, upper and lower tooth rows, pelvis and vertebrae are usually not completely consumed by wolves), and the collar is often moved away from the carcass. In contrast, with adult caribou, brown bears often chew only the ends off large bones but do not crush and eat them, and they bury the carcass and collar under a midden of dirt and vegetation. Therefore, I probably classify a higher proportion of wolf kills that have little material at the site as "unknown natural mortality" or "unknown predator" than I do grizzly kills that tend to contain intact bones and the collar. Undoubtedly, some kills I attribute to wolves or bears were actually killed by other predators; however, I think this error is small. Additionally, I probably erroneously attributed some deaths to predators that were caused by other factors (e.g., disease or starvation) and then later scavenged by predators. To minimize these sources of error I was conservative when assigning cause of death, and classified many mortalities as 'unknown cause of death,' 'unknown natural mortality,' or 'unknown predator.'

Harvest

Season and Bag Limit. On state-managed lands the following seasons and bag limits were in effect throughout the reporting period.

RY12 and RY13 Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Units 21D, 22A, and 22B remainder		
Resident Hunters: 5 caribou per day		
Bulls	No closed season	
Cows	1 Jul–15 May	
Nonresident Hunters: 5 caribou total per year		

RY12 and RY13 Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Bulls		No closed season
Cows		1 Jul–15 May
Unit 22B west of Golovnin Bay and west of Fish and Niukluk rivers excluding Libby River		
Resident Hunters: 5 caribou per day (Season may be announced 1 May–Sep 30; however, cows may not be taken 16 May–June 30)	1 Oct–30 Apr	
Nonresident Hunters: 5 caribou per year		1 Oct–30 Apr
Unit 22C Resident Hunters: 5 caribou per day	May be announced	
Nonresident Hunters: 5 caribou per year		May be announced
Unit 22D that portion in the Pilgrim River Resident Hunters: 5 caribou per day (Season may be announced 1 May–Sep 30; however, cows may not be taken 16 May-June 30)	1 Oct–30 Apr	
Nonresident Hunters: 5 caribou per year		1 Oct–30 Apr
Unit 22D that portion in the Kougarok, Kuzitrin, American, Agiapuk River drainages Resident Hunters: 5 caribou per day		

RY12 and RY13 Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Bulls	No closed season	
Cows	1 July–15 May	
Nonresident Hunters:		
5 caribou per year		
Bulls		No closed season
Cows		1 July–15 May
Unit 22D Remainder		
Resident Hunters:		
5 caribou per day	May be announced	
Nonresident Hunters:		
5 caribou per year		May be announced
Unit 22E that portion east of and including the Sanaguich River		
Resident Hunters:		
5 caribou per day		
Bulls	No closed season	
Cows	1 July–15 May	
Nonresident Hunters:		
5 caribou per year		
Bulls		No closed season
Cows		1 July–15 May
Unit 22E remainder		
Resident Hunters:		
5 caribou per day	May be announced	
Nonresident Hunters:		
5 caribou per year		May be announced
Unit 23		
Resident Hunters:		
5 caribou per day		
Bulls	No closed season	
Cows	1 July–15 May	

RY12 and RY13 Unit and Bag Limits	Resident Open Season (Subsistence and General Hunts)	Nonresident Open Season
Nonresident Hunters:		
1 caribou total per year[a]		
Bulls		No closed season
Cows		1 July–15 May
Units 24A excluding that portion south of the south bank of the Kanuti River (24 remainder), 24B excluding that portion south of the south bank of the Kanuti River upstream from and including the Kanuti-Kilolitna River drainage (24B remainder), 24C, 24D, and 26A		
Resident Hunters:		
5 caribou per day		
Bulls	No closed season	
Cows	1 Jul–15 May	
Nonresident Hunters:		
5 caribou total per year		
Bulls		No closed season
Cows		1 Jul–15 May

Federal hunting seasons were identical to state seasons during this reporting period. However, the bag limits under federal subsistence regulations were 15 caribou per day in Unit 23, 10 caribou per day in Unit 26A, and 5 caribou per day in other units used by the WAH.

Board of Game (BOG) Actions and Emergency Orders. During this reporting period no emergency orders (EOs) were issued for caribou hunting within the range of the WAH.

The BOG met in Kotzebue 10–13 January 2014 and considered Proposal 23 to review customary and traditional use of the TCH, and to establish amounts reasonably necessary for subsistence. The board passed an amended version of this proposal which clarified that the ANS range of 8,000–12,000 caribou that had been previously established for the WAH also includes the TCH. The board did not increase the existing ANS levels after formally recognizing that it will apply to both herds. In the future, the combined harvestable surplus for both the WAH and the TCH will be used to assess whether these herds should be managed under general hunt, Tier I, or Tier II status. This board action does not affect implementation of intensive management law for either the WAH or the TCH. Thus, the WAH and TCH are now combined with regard to ANS decisions under subsistence law, but each herd will be considered separately with regard to intensive management. At the January 2014 meeting the BOG also passed an amended version of Proposal 177 allowing hunters to use a snowmachine to position a caribou, wolf, or wolverine for harvest, and to shoot caribou, wolves, and wolverines from a stationary snowmachine.

During the March 2015 BOG meeting, a number of actions restricting caribou regulations were taken in response to the current WAH and TCH population declines. These actions constitute the first restrictions to caribou hunting in northwest Alaska in more than 30 years. Proposal 202, submitted by the department to the BOG, was the vehicle for these actions. As submitted, Proposal 202 would mainly have made state hunting regulations consistent with recommendations identified in the WAH cooperative management plan (WACH WG 2011). The only regulatory action recommended in Proposal 202 that went beyond recommendations in the plan was to eliminate the same-day-airborne caribou hunt in Unit 22.

During the year prior to the March 2015 BOG meeting, department staff visited almost every community within Units 22, 23, 26A and Anaktuvuk Pass (located in Unit 24) to present population overviews for the WAH and TCH. Department staff also met with all state fish and game advisory committees (ACs) within Units 22, 23 and 26A, several federal regional subsistence advisory councils (RACs), 2 NPS subsistence resource councils, the Red Dog Subsistence Resource committee, the Northwest Arctic Borough Planning Commission, and the WACH Working Group. Members of the public who attended these meetings quickly deduced that the actions put forth in Proposal 202 would do little to actually conserve caribou. Therefore, over 20 amendments to Proposal 202 for additional restrictions to caribou seasons and bag limits were submitted to the BOG prior to the meeting. The evening before Proposal 202 was scheduled to be considered, all AC representatives present in Anchorage to testify on this proposal met for several hours to discuss Proposal 202. The outcome of this meeting was to recommend a single, unified amendment to the original proposal that created closed seasons separately for bulls and cows. The board accepted this amendment from the combined ACs, added minor changes to seasons in Unit 26A, and passed an amended version of Proposal 202. These regulatory changes went into effect on 1 July 2015 and will be covered in detail during the next reporting period. In short, the changes passed during the March 2015 BOG meeting were as follows:

1. Create closed resident hunting seasons separately for bulls and cows throughout the range of the WAH. Specific season dates vary by GMU because of seasonal differences in caribou availability and hunting patterns. Despite these closures, during no time of the year is caribou hunting completely closed. That is, throughout the year hunters can take either bulls or cows, and during some portions of the year may take a caribou of either sex. The resident bag limit of 5 caribou/day was maintained throughout most WAH range.
2. Prohibit the take of calves by all hunters throughout the range of the WAH.
3. Prohibit the harvest of cows by nonresident hunters.
4. Reduce the nonresident bag limit to 1 bull/year throughout WAH range.
5. Shorten the nonresident caribou season to 1 August–30 September throughout most WAH range (the nonresident season opens 15 July in Unit 26A).

6. Eliminate the SDA winter caribou hunt in Unit 22.

Human-Induced Harvest. The total harvest of WAH caribou was approximately 13,352 caribou in RY12 and 12,713 caribou in RY13 (Table 10). We assumed that 95% of all caribou harvested by nonlocal hunters in Unit 26A were from the WAH and the remainder from the TCH. These levels are within the range of harvest levels reported in previous years (Fig. 34). Total annual harvest during each regulatory year was roughly 4–5% of the population using the 2011 and 2013 population estimates.

Our harvest data do not include wounding losses or caribou killed but not salvaged. My opportunistic observations made while conducting aerial surveys over the past several years and numerous reports from the public suggest that levels of caribou mortality attributable to wounding and failure to salvage, although unknown, may be substantial (at least hundreds of caribou). Caribou movements and distribution combined with the critical importance of caribou as a subsistence food item, as well as the still high abundance of the WAH, all likely contributed to wounding and failure to salvage losses.

The new ANCOVA model to estimate caribou harvests by local residents likely provides reasonably accurate trend information for total harvests but almost certainly does not accurately reflect annual harvest levels, or harvest levels by game management unit. Even though community harvest assessments provide very accurate data regarding caribou harvests for the communities that were surveyed during those specific years, available funding and staff time to conduct these surveys limits them to a handful of communities each year (especially when large communities, e.g., Kotzebue or Barrow, are surveyed). Therefore, we were forced to use 18 years of community harvest data to have an adequate sample to develop this model. As a result, a large change in harvest over a significant amount of time will be necessary for the model to identify a change in harvest level. For example, an estimated average of any parameter that is based on a sample of 1,000 measurements is unlikely to substantially change with the addition of 5 new measurements unless they are extremely different. We examined the sensitivity of this model to changes in harvest levels by manipulating harvest values for Kotzebue and Barrow. By virtue of their large human populations and consistently good access to caribou, these 2 communities take more caribou than any other communities within WAH range. A significant decrease in the estimated harvest did not occur until a hypothetical 70% reduction in harvest for these 2 large communities occurred. Thus, although this model likely reflects long-term trends in annual local harvests reasonably accurately, it is too insensitive to detect short term changes in harvest levels to enable real time management decisions to regulate harvests.

Although we think harvest levels have been relatively stable since 1998, the decline of this herd since 2003 has resulted in hunters taking a higher proportion of the herd in recent years (Fig. 35). During RY99 through RY10, hunters took an average 2.8% of the WAH annually. During RY11 through RY13, this increased to 4.6% annually. Although we don't think that hunting precipitated the current decline of this herd, if these trends continue (i.e., a stable harvest level with decreasing population size) harvests will increasingly affect the sex and age structure of this herd, and possibly its size and trend as well. This is apparent when harvests are evaluated separately for bulls and cows (Fig. 36). Currently, we consider the WAH harvestable surplus to be 15% of all bulls in the population, and 2% of all cows. These percentages may be modified if this herd continues to decline, or if the population sex ratio changes.

The increasing proportion of bulls being harvested from this herd (Fig. 36) will likely have little effect on the population trajectory of this herd other than through the direct numeric removal of bulls from the herd. This is because caribou are polygynous (males mate with >1 female) and because hunters generally prefer to take large bulls for their trophy value or for the high quality of their meat. Thus, many harvested bulls are probably near the end of their natural life (i.e., many of these bulls would soon die anyway if not harvested). The primary effect of maintaining proportionally high annual bull harvests (e.g., 15% of all bulls in the population) will be a rapid skewing of the sex structure. This, in turn, will quickly reduce the total annual harvestable surplus because bulls compose such a high proportion of it (Fig. 37). As the WAH declines, delaying protection of bulls to meet short-term human demand does not promote long-term recovery of the population. Instead, it creates problems with low bull:cow ratios and precludes shifting harvest pressure onto bulls should herd size drastically decline in the future.

In contrast to bulls, even modest increases in the cow harvest above sustainable levels could have a significant effect on the population trajectory of the WAH. This is because of compounding effects with each cow taken: all of her female descendants with their reproductive potential are eliminated from the population when the cow is taken. This effect increases through time if cow harvests are not managed appropriately.

Even though there are considerable uncertainties in our estimates of bull:cow ratios, sex ratio of harvested caribou, and total harvest, it is clear that sustainable harvest will soon be exceeded if current trends continue. Based on declines in herd size and the bull:cow ratio (Fig. 27), and considering uncertainties in harvest and caribou population survey data, current harvest levels of bulls may have exceeded their harvestable surplus during RY14 and, if not, will likely exceed it soon (Fig. 37). Additional negative pressure on population trend has come from recent cow harvest levels that have probably exceeded the harvestable surplus of cows since RY10 (Fig. 37). This is why the BOG and FSB began restricting harvest opportunity during RY15. If current trends in harvest levels, bull:cow ratios, and population size continue, the state will probably have to consider intensive management for this herd within the next several years, and will likely manage harvests under either Tier I or Tier II regulations (Fig. 38).

All caribou hunting by residents that live north of the Yukon River and within the range of the WAH is administered through a registration requirement (RC900) that replaces mandatory harvest tickets. Only nonresidents and residents of Alaska who live south of the Yukon River are required to use statewide caribou harvest tickets. Registration overlays are free, there is no annual quota limiting harvest or the number of people who can register, and the permits are available at license vendors throughout the range of this herd. During the late 1980s and early 1990s, comparisons of registration harvest data and community harvest assessments indicated that only about 10% of the actual harvest was reported through the registration system (Georgette 1994). This disparity prevailed even though: 1) vendors were paid twice as much to issue caribou registrations as they were to issue caribou harvest tickets; 2) the department relieved the public of the responsibility to send in harvest reports and, instead, sent them self-addressed questionnaires that requested only minimal information; and 3) substantial outreach efforts by Department of Public Safety (DPS) and department staff were used to educate hunters about the need for accurate harvest data. The exception to the generally poor compliance with RC900 reporting requirements has been the community of Nome, where compliance is thought to have been good (K. Persons and T. Gorn, ADF&G area biologists, personal communication).

Permit Hunts. There are no registration permit hunts or drawing permit hunts in current regulations. The RC900 registration requirement is often misidentified as a permit hunt, but it is actually a harvest registration option governed by harvest ticket regulations.

Hunter Residency and Success. Hunters living within the range of the WAH have taken roughly 95% of the total harvest since the late 1990s (Fig. 39, Table 10). Local WAH harvest has been relatively stable since the late 1990s. Even though this herd has declined by >50% since 2003, caribou were still abundant enough during this reporting period that local users could still harvest as many caribou as they did in the past. Granted, residents of some communities have had to greatly increase their expenditure of money and effort to maintain these harvest levels, they've had to switch from taking bulls to cows because of temporal shifts in availability, and some communities (e.g., Unalakleet and Noatak), have not met their subsistence needs in many recent years. Using population growth rate to estimate herd size for non-census years, during 1999–2013, estimated harvest by local residents has not been correlated with WAH population size (Pearson correlation coefficient = -0.17, $P = 0.54$, $n_i = 15$).

There has been no clear change in numbers of nonlocal WAH caribou hunters during the fall hunting season since RY98 (Table 11). Since RY98, numbers of nonlocal Alaska residents hunters have been similar to numbers of nonresident hunters who reported hunting the WAH. During this reporting period, numbers of nonlocal hunters were slightly lower than during previous years. This is partly because transporters have reportedly had to fly longer distances to find caribou for their clients so cannot book as many hunters as in years past when caribou could be reliably found close to Kotzebue. It may also be partly because lower success rates during recent years have discouraged some nonlocal hunters from pursuing WAH caribou. Mean nonlocal hunter success during RY98–RY09 was 65% while in RY10–RY14 it was 55%. "Success" was defined as any hunter who harvested ≥1 caribou of either sex. For some hunters, being forced to make the best of a bad situation and take either a cow or a small bull would not be considered successful, so this metric may be an insensitive indicator of hunter satisfaction. As in the past, most WAH caribou taken by nonlocal hunters were harvested in Unit 23 (74% in RY12 and 68% in RY13). Unlike local harvest levels, using population growth rate to estimate herd size for non-census years, there has been a marginal positive correlation between WAH population size and nonlocal harvest levels during 1999–2013 (Pearson correlation coefficient = 0.50, $P = 0.06$, $n_i = 15$).

Communities within the range of the WAH harvest caribou year-round whenever they are available, and cow caribou have always been an important component of the subsistence harvest. Bulls enter rut around 7–12 October and their meat takes on a strong odor and flavor that most people consider unpalatable. From the onset of rut through roughly the end of December, subsistence hunters shift harvests from bulls to cows. Some communities, especially those in the southern portion of WAH range, have had little opportunity to harvest bulls before the onset of rut given the late timing of fall migrations in recent years. These communities have taken proportionately more cows during recent years compared to the 1980s and 1990s (Nikki Braem, Subsistence Resource Specialist, Subsistence Division., Fairbanks, personal communication).

Nonlocal hunters take few caribou after the first week of October, and generally take few cows (roughly 40–80 cows annually). As reported previously (Dau 2013), nonlocal hunters took a higher proportion of cows (15% of their total harvest) during RY12, a year when caribou were not readily available until late September, than in previous years. As the need to protect cows to ensure the conservation of this herd increases, demand for cows by all hunters may also increase.

Harvest Chronology. Seasonal subsistence harvest patterns have been previously described (Dau 2009). Subsistence hunters throughout WAH range take caribou whenever they are available. Seasonal movements of caribou drive seasonal harvest patterns among communities within the range of this herd.

Despite no closed season on bulls, 85–90% of all caribou taken by nonlocal hunters are harvested between 25 August and 7 October. This temporal concentration of nonlocal hunters in Unit 23 combined with intense subsistence hunting during the same period has created conflicts between these groups, as well as guides and transporters, since at least the early 1980s.

Transport Methods. Most subsistence hunters harvest WAH caribou using snowmachines during late October–early May, and boats or 4-wheelers during the rest of the year. Few local hunters use aircraft to hunt caribou. Transport methods used by nonlocal caribou hunters have been surprisingly consistent through time (Table 12). During this reporting period, 76% of nonlocal hunters accessed hunting areas by airplane in each of RY12 and RY13.

Mandible Collections

I resumed collecting mandibles from WAH caribou in 2009 to monitor body size of individual caribou and the age structure of the population. Most WAH jaws have come from harvested caribou. Samples from harvested animals often do not reflect the overall population in terms of age, size, or sex ratios because hunters select for various characteristics of individual caribou, such as body size, trophy size, or meat quality.

To assess the potential for sampling bias in age data attributable to hunter selectivity I compared the median age of harvested caribou with that of natural mortalities for mandibles collected during 2005–spring 2014. There was no difference in the median age of harvested bulls (6 yrs, range = 0.5–19 yrs, n_i = 807) compared to bulls that died of natural causes (5 yrs, range = 0.5–16 yrs, n_i = 45; Kruskal-Wallis F = 0.02, P = 0.88). In contrast, the median age of cows that died of natural causes (7 yrs, range = 0.5–20 yrs, n_i = 150) was significantly older than those harvested by hunters (6 yrs, range = 0.5–19 yrs, n_i = 214, Kruskal–Wallis F = 5.94, P = 0.01). The statistical significance of this 1-yr difference for cows probably does not reflect a significant biological difference.

Analyses of body size can be affected by the proportion of immature individuals in the sample. This requires some understanding of when skeletal growth ends in WAH caribou (i.e., when growth through time approaches the upper asymptote of size). Skeletal growth of WAH cows appears to last well beyond age 3 when most cows begin consistently producing a calf (Fig. 40). Median ramus length for cows 3 yrs old was significantly shorter than for cows >3 yrs old (257 mm vs. 264 mm, n_i = 30 and 171 cows, respectively; Kruskal–Wallis F = 11.82, P = 0.0004). This was true for cows at age 4 yrs and even 5 yrs (all Kruskal–Wallis P values <0.008). The youngest cohort at which there was no difference in cow median ramus length occurred at age 6 yrs vs. >6 yrs (265 mm vs. 266 mm, n_i = 20 and 103 cows respectively, Kruskal–Wallis F = 0.01, P = 0.92). For bulls (Fig. 41), the youngest cohort at which there was no statistically significant difference in median ramus length occurred at age 7 yrs vs.. >7 yrs old (292 mm vs. 293 mm, n_i = 108 and 136 bulls, respectively; Kruskal–Wallis F = 0.37, P = 0.54). Despite these statistical differences, it appears that the majority of skeletal growth for cows occurs by age 4 (Fig. 40) and for bulls by age 5 (Fig. 41) so I respectively excluded individuals younger than these ages from analyses of temporal changes in size.

Caribou age determined from cementum annuli is superior to age determined from tooth wear and eruption but still has an element of uncertainty associated with it. We submitted, in the blind, an incisor from 13 known-age reindeer or caribou to be aged by cementum annuli (Table 13). For 8 of these individuals we submitted a second incisor also in the blind (teeth were collected from euthanized individuals). There was no difference in the known median age and median cementum age (Wilcoxon signed rank test Z = 1.44, normal approximation of 2-tailed test P = 0.15, n_i = 13). However, the cementum age equaled the known age for only 5 of the 13 individuals although the difference between known and cementum ages was only ±1 year for 9 of the 13 individuals (69%). The greatest differences between known and cementum ages were for 2 old individuals aged 14 and 19 years old (Table 13). Thus, although cementum age is an unbiased indicator of caribou age, 31% of the time it was off by >1 year. Error in cementum age may have been attributable to tooth characteristics rather than from tooth slide interpretation errors because, for the 8 teeth aged twice, the 2 ages were the same for 5 individuals (63%) and varied by only up to ±1 year for the other 3 individuals.

Given the small sample of known-age animals, I also submitted, in the blind, 2 incisors from 40 caribou of unknown age to evaluate the potential for error in cementum age estimates (Fig. 42). There was no difference in the median age of the 2 samples (median=7 vs. 6.5 yrs, Wilcoxon signed rank test Z = 1.17, normal approximation of 2-tailed test P = 0.24, n_i = 40), but the 2 age determinations agreed only 14 times (35%, Fig. 42). Similar to the known age sample, the difference between the replicate cementum ages differed by ≤1 yr 68% of the time. Although cementum age estimates are not 100% accurate, they are unbiased and appear to be within ±1 yr roughly two thirds of the time. For most applications of caribou age data, a 1-yr error in age is not biologically significant. For this report, I assume cementum ages are accurate while recognizing the limitations noted above.

Age estimates from tooth eruption/wear were significantly correlated with cementum annuli (Pearson correlation coefficient = 0.69, P = 0.00, n_i = 1,151). There was no significant difference between median age based on tooth wear and cementum age (Wilcoxon signed rank test Z = 0.18, 2-tailed normal approximation P = 0.86, n_i = 1,151). Tooth-wear age equaled cementum age only 20% of the time; it exceeded cementum age 43% of the time, and was less than cementum age 37% of the time. Thus, although estimates of age based on tooth wear are unbiased, they usually differ from the cementum age of individual caribou by 1–3 years and occasionally much more. Thus, age estimates based on tooth wear may allow comparisons of gross temporal changes at the population level but are of less value for accurately determining the age of individual caribou than cementum ages. Of 90 caribou mandibles independently aged using tooth wear by 2 Kotzebue staff (Dau and Hutchins), the 2 estimates were within ±1 yr of each other 76 times (84%). This includes caribou where both wear estimates differed substantially from the cementum age. This suggests that variation in tooth wear among individual caribou of the same age in terms of total wear, and in terms of wear patterns among incisors/canines, premolars, and molars, confounds our ability to accurately age caribou using tooth wear alone. During this reporting period we completed an exhibit of caribou mandibles by age and wear (light, average, and heavy wear) that is displayed in the Kotzebue ADF&G office. We also completed an electronic file (PDF format) showing photos of these mandibles to help people age caribou by tooth wear.

Mandibles have been collected from WAH caribou during 5 periods:

1. 1959 – 1961: Population trend unknown, size 160,000–200,000 caribou (Lent 1966).
2. 1975: Population at the end of a sustained 18% average annual decline, size 75,000 caribou.
3. 1985–1990: Population increasing 13% annually, size 229,000–417,000 caribou.
4. 1991–2003: Population growing 1–3% annually, size 437,000–490,000 caribou.
5. 2004–2015: Population declining 4–15% annually, size 460,000–235,000 caribou; during this period annual sample sizes before 2009 are too small to characterize by year.

Sample sizes are inadequate to assess long-term differences in age among all of these time periods for bulls or for cows.

During recent years (2009–2015) there is no difference among years in the median age of cows (Fig. 43). Although significant annual differences exist in median annual age of bulls during 2009 to 2015, there has been no clear trend in bull age structure (Fig. 44). The statistical significance of pairwise annual differences in age for bulls may be attributable to large sample sizes rather than an indication of biological significance, because the differences are generally <1 year.

Sample sizes for cows are adequate to assess differences in size only for l959–1961 and 2009–2015. Sample sizes for bulls are adequate to assess differences in size only for l959–1961, 1985–1990, and 2009–2015. Adult cows were significantly smaller during 1959–1961 than during 2009–2015 (255 mm vs. 264 mm, n_i = 219 and 174 caribou, respectively; Kruskal–Wallis statistic = 40.45, P<0.0001). Differences in mandible lengths among periods were even more striking for bulls. Median ramus lengths were 272 mm, 295 mm, and 290 mm during 1959–1961, 1985–1990, and 2009–2015, respectively, and each period was significantly different from the others (Dunn's all-pairwise comparisons test, P<0.05).

Calf Weights

During 2008–2015 (all years combined), median live weight of male calves (94 lb, n_i = 93) was significantly heavier than for female calves (90 lb, n_i = 102; Kruskal–Wallis F = 5.93, P = 0.01). Median male calf weight was significantly different among years (Kruskal–Wallis statistic = 19.22, P = 0.004, Table 14) with weight being significantly heavier in 2015 than during 2008, 2009, and 2011 (Dunn's all-pairwise comparisons, P<0.05). Similarly, median weight for female calves was significantly different among years (Kruskal–Wallis statistic = 15.94, P = 0.02) with weight being significantly heavier in 2015 than during 2008 (Dunn's all-pairwise comparisons, P<0.05). There was a marginal difference in calf weight among the 3 body condition categories of the calves' mothers (below average, average, or above average, Table 15) for female calves (Kruskal–Wallis statistic= 4.97, P = 0.08; all years combined, n_i = 6, 43, and 50, respectively), and for male calves (Kruskal–Wallis statistic = 5.53, P = 0.06; all years combined, n_i = 9, 48, and 33, respectively).

Other Management Issues

User conflicts. Many residents of Unit 23 think that the state is generally unwilling to try to reduce user conflicts. This criticism is not wholly deserved. For example, the original Noatak Controlled Use Area (CUA) was established by the BOG in 1988 to reduce hunting-related airplane activity along the main stem of the Noatak River and thus reduce disturbance of subsistence hunters in boats. This CUA was later substantially expanded in both space and time to increase its effectiveness. Additionally, the department has led two Unit 23 user conflict planning processes, the last of which continued to function throughout this reporting period. The BOG passed a mandatory Unit 23 pilot orientation requirement which was developed by department staff. Additionally, the department has developed and distributed extensive public outreach products that focus on reducing user conflicts, including posters and brochures that are available on the department's website and as printed copies. Despite these efforts by the state, user conflicts have continued in Unit 23 and subsistence users have increasingly looked to federal agencies to address their concerns.

To try to reduce user conflicts and facilitate caribou hunting by residents of Noatak, around 2012, the NPS effectively created a federal CUA through a concessionaire requirement that prohibited transporters from dropping caribou hunters in the Kelly, Kugururuk, and lower Agashashok river drainages before 15 September. This restriction could be suspended by special action of the Western Area Parklands superintendent during years when caribou migrated through the middle Noatak drainage prior to 15 September and subsistence hunters had met their demand for meat. Even without this special action, transporters can still drop moose, bear, or sheep hunters as well as floaters, hikers, and fishermen in these areas even while the restriction is in effect. This requirement applies only to transporters such that hunters flying their personal planes and guides could still hunt caribou in these areas prior to 15 September. This NPS requirement has probably had minimal effect on numbers or the distribution of nonlocal caribou hunters because few caribou have migrated through the affected area and transporters dropped most of their clients east of the closed area.

Failure to salvage meat. The issue of 'waste' should be addressed soon by the department, federal agencies, fish and game advisory committees, the Alaska Department of Public Safety, and Alaska Department of Law. Everyone agrees that waste is wrong. But while salvage requirements provide guidance regarding what must be salvaged from harvested wildlife, it is by no means definitive with regard to animals affected by disease or trauma and is of little value to hunters who cannot understand technical jargon. Additionally, there are strongly held differences among subsistence users, agency staff, and recreational hunters regarding what is fit for human consumption. Allegation of waste was a contentious issue during the last decline of this herd during the 1970s. If the WAH again declines to a level where it becomes necessary to restrict hunting, it will be critical for agencies and users to agree on a mutually acceptable definition of waste. Managers, enforcement staff, and users should try to address this issue now before the population declines further. The WG could be an effective body to facilitate this discussion. Unfortunately, given sensitivities surrounding this topic, agency staff and the public, are reluctant to discuss it. Failure to address waste could be a disservice to users, managers, and the WAH.

Habitat

Assessment

The department did not monitor WAH range condition during this reporting period.

Enhancement

There were no WAH habitat enhancement activities during the reporting period.

Nonregulatory Management Problems/Needs

WAH Cooperative Management

The history, organization, and accomplishments of the WG have been previously reported (Dau 2011). This group continues to receive funding from state and federal agencies. During the 2014 meeting the WG began to focus on regulatory actions to reduce caribou harvests so that human harvests will not accelerate the current population decline or skew sex and age ratios.

Resource Development

The WAH has one of the most intact ranges of any large caribou herd in North America. Currently, the Red Dog mine, road, and port site comprise the only large development complex within the range of this herd. These facilities are located wholly within the northwestern portion of WAH range.

The 'Ambler Road' is a major development project still under consideration. This project was described in the last WAH management report (Dau 2013). In 2012 the Alaska Industrial Development and Export Authority (AIDEA) assumed leadership of this project from the Alaska Department of Transportation. Along with several other large capital improvement projects, this road was put on hold in January 2015 after the administration of the current governor, Bill Walker, replaced that of the former governor, Sean Parnell. However, in November 2015, the Walker administration announced that it would resume funding the Ambler Road project. The objective of this project is to build an access road into the Ambler Mining District to open the upper Kobuk region to mineral development. This road could have profound impacts on WAH movements, on the distribution and harvest of other wildlife species, especially resident species (e.g., moose, brown bears, black bears, furbearers, and wolves), and on subsistence users. Under the Parnell administration, AIDEA intended to minimize these impacts to wildlife and local users by requiring industry to ultimately finance construction of this road, thus making it privately owned. That would allow industry to control, and presumably limit, access to this road. Of course, private ownership of the road would not guarantee in perpetuity that the road would never be open to the public. For example, although the DMTS was initially closed to all uses outside of the mine's commercial use, managers of this mine eventually conceded to demands from Kivalina to allow them to use four-wheelers to hunt from the road.

During the previous reporting period I described movements of WAH caribou near the DMTS (Dau 2013). During the fall 2011 migration, approximately 80,000 WAH caribou (roughly 28% of the WAH, Table 16) experienced a 2–6-week delay crossing this road while being deflected as far north as Cape Thompson and the Tigara Peninsula. Although most of these deflected caribou eventually crossed the road, the 4 collared caribou that did not cross it wintered in the western De Long Mountains or Lisburne Hills north or northwest of the road. All 4 of these collared individuals subsequently died the following winter or spring during an icing event. This suggests that the consequences of preventing caribou from reaching their preferred winter range can be severe.

The relatively high proportion of the WAH (28%) that migrated within 30 mi of the DMTS and mine in 2011 was not unprecedented (Table 16). Prior to 2000 sample sizes of satellite-collared caribou were too small to evaluate herd-scale movements near the road. However, during 2001, 2004, and 2005 (all years with $\geq$15 satellite-collared caribou in the WAH), an even higher proportion of the herd migrated through this area. What was unique in 2011 was the high proportion of the herd (28%) that grossly modified its rate or direction of travel as the caribou approached the 30-mile road zone. During the 2013 and 2014 fall migrations, only 8% and 7% of the WAH migrated within 30 miles of the DMTS, and only 5% and 3% of the herd modified its rate or direction of travel, respectively.

During 2015, 14 of 81 satellite-collared caribou (17% of the herd) approached within 30 miles of the DMTS. One of these 14 collars malfunctioned which made it impossible to track the movements of this caribou near the road. Nine of the remaining 13 collared caribou (69%) grossly changed their direction or rate of travel as they approach the road, and 2 of them did not cross it. Four additional collared caribou that moved from Point Lay to the Lisburne Hills never came within 30 miles of the road but joined the 2 collared caribou that had changed their direction at the road. All of these caribou moved back to the vicinity of Point Lay by mid December 2015 and had approached Wainwright by early January 2016.

Given the typically small proportion of the WAH that has migrated near Red Dog during fall (Table 16), this road has had relatively little effect on overall fall movements of the WAH since at least 2000. However, of those caribou that have approached within 30 miles of this road, more than 50% of them have changed their speed or direction of travel as they approached it.

The significance of caribou movements observed near Red Dog is that caribou approaching other roads developed in the future will probably react to them as they have to the DMTS. Indeed, the potential of the DMTS to affect caribou movements is probably much less than for most other roads with higher traffic and use patterns. If new roads are built in areas heavily used by WAH caribou, overall impacts to this herd could be much greater. Movements of caribou near the Red Dog mine should be carefully considered when attempting to predict impacts of new development projects, such as the Ambler Road, on this caribou herd.

Distribution of satellite-collared WAH caribou during winter suggests they may have avoided areas near the Kougarok and Council road systems (near Nome) despite no traffic (other than snowmachines) and little human activity along it during that time (Dau 2013). However, it is not clear whether caribou were actually displaced by these roads or whether they merely selected areas having lower snow depths or better food that were not in proximity to the roads.

School Programs

In September 2012 the Kobuk and Kivalina schools participated in the Onion Portage caribou collaring project. In 2013 the Nome and Unalakleet schools were scheduled to participate in the project but each school cancelled due to the lack of caribou. Each of these schools participated in the project during 2014. In 2015, the Noorvik school participated in the project. In each year all students were high school level. In addition to working with agency staff, the students learned subsistence skills from their chaperones. This project has been a positive experience for students, school district staff, and agency staff since its inception in 1991.

Conflicts Between WAH Caribou and the Reindeer Industry

A small proportion of WAH caribou have summered on the Seward Peninsula in recent years (Dau 2011, 2013). In response to this, in 2010 some NPS staff began promoting a helicopter collaring program for this area which the Kawerak Reindeer Herder's Association (RHA) has supported. The department has opposed the proposed NPS collaring project because: 1) no one knows the relative proportions of caribou, reindeer and hybrids that compose these over-summering animals; 2) many residents of Game Management Units 23 and 26A oppose helicopter capture methods; and 3) caribou collared at Onion Portage use the Seward Peninsula during summer and winter, thus negating the need to conduct an expensive and potentially controversial helicopter collaring project there. In place of a helicopter capture project, the department has agreed to help collect tissue samples and fund genetic analyses to determine relative numbers of caribou and reindeer that summer on the Seward Peninsula.

Even if most of the *Rangifer* on the Seward Peninsula during summer are caribou, telemetry data indicates that they remain in the area near Taylor, Serpentine Hot Springs, and Cape Espenberg. The primary threat to Seward Peninsula reindeer herds is not from the few thousand caribou that summer in this area; rather, it is from the tens or hundreds of thousands of caribou that winter over extensive portions of the eastern half to two thirds of the Seward Peninsula. These wintering caribou sweep away reindeer as they emigrate from the Seward Peninsula on their northward migration each spring.

If the *Rangifer* that summer near Serpentine are primarily reindeer, NPS, RHA, and the University of Alaska Reindeer Research Project may proceed with telemetry as they see fit. However, if the animals are mostly caribou, then the department will have to decide how to proceed given limited staffing and funding. Additionally, the department will have to consider how this modification of the WAH caribou collaring program will affect the overall caribou survey and inventory program and data interpretation. The department will not conduct helicopter capture operations without first assessing public support for this project.

WAH serology program

The WAH serology program was discontinued after September 2014. The primary objective of this project was to provide a red flag approach for identifying when disease(s) might affect the population dynamics of this herd. Additionally, caribou sera were tested for antigens in response to public concerns regarding the safety of eating caribou meat. The recent lack of caribou at Onion Portage during the collaring project now requires staff to spend up to 2 weeks deploying radio collars. Although serum can be chilled for up to a week without compromising its quality for serological tests, longer periods require freezing to retain sample quality. It is logistically impracticable to bring enough dry ice to this field project to freeze caribou sera for up to 2 weeks. Additionally, the department's veterinary staff does not have the time or storage capability to process and archive WAH sera. For the first time since the early 1990s, no blood was collected from WAH caribou during the collaring project in September 2015.

User Conflicts

Conflicts among nonlocal hunters, guides, transporters and local hunters continued in portions of WAH range during this reporting period. These conflicts were most pronounced in Unit 23 but also occurred near Anaktuvuk Pass. This complex issue involves all hunters, not just caribou hunters, and is affected by a variety of factors (Dau 2005). Factors that contribute to these conflicts in Unit 23 include limited access points for guides and transporters, and the perception among residents of Unit 23 that commercial hunting activities and drop off hunters 'upstream' in the migration deflect caribou from traditional hunting areas. The Unit 23 User Conflict Working Group held meetings in Kotzebue during May 2013 and May 2014 to share information among agencies and users regarding user conflicts.

CONCLUSIONS AND RECOMMENDATIONS

The WAH is still very large despite its decline since 2003. There is no evidence that any single factor (e.g., human harvests, predation, environmental contaminants, range degradation, or disease) is currently limiting the size of this herd. Icing events likely caused high mortality in some years and may have initiated this population decline. Long-term declines in recruitment and the proportion of bulls in the population might suggest that density dependent factors have subtly affected the population dynamics of this herd; however, this is inconsistent with the consistently good body condition of caribou during recent years. Opportunistic observations by department staff and numerous reports from local residents and long-term commercial operators suggest that brown bears and, especially, wolves have been abundant and taking many caribou in recent years. Predators are almost certainly affecting the population dynamics of this herd to a greater degree now than in the previous 30 years.

Despite the continued large size of this herd, local and visiting hunters have experienced difficulty harvesting caribou during recent fall hunting seasons due to delays in the onset of the fall migration, and to caribou moving through relatively narrow migration corridors. Limited availability of caribou appears to intensify conflicts among user groups even when local and nonlocal hunters are spatially separated. User conflicts will likely intensify if this herd continues to decline and hunting becomes more difficult.

The need for accurate and complete caribou harvest data is becoming increasingly important to the management of this herd (Dau 2013) and the TCH. Without substantial increases in funding and staffing levels or a substantial change in methodology, it is unlikely that ADF&G's Division of Subsistence will be able to conduct an adequate number of community harvest assessments annually to be able to detect short-term changes in harvest levels. A statistically-based, comprehensive sampling approach for the community harvest assessment program is one of the greatest management needs for the WAH and TCH. Paper-based harvest report systems have never worked well within the range of the WAH. If the department hopes to change this, it will be necessary to spend substantial staff time visiting communities within the range of this herd to convey the importance of collecting this information for the management of this herd. With adequate compliance with reporting requirements by hunters, a harvest report system could provide accurate caribou harvest information annually throughout the range of this herd, and it could do so at relatively little expense. The greatest obstacle to this has been the lack of participation in voluntary harvest reporting systems by local hunters. This likely will not change without a substantial public outreach program describing why managers need harvest data.

The department should continue to monitor the health of caribou in this herd through health assessments conducted at least once every 5 years. Health assessments should be conducted during spring as well as fall. Analysis of caribou health assessment data should be expanded to include trends and the biological significance of pathogens to caribou at the population level.

A number of large-scale resource development projects are being considered for northwest Alaska. Potential impacts of individual projects on caribou and users should not be evaluated individually. Instead, the cumulative effects of all existing and proposed development should be collectively considered over the short- and long-term to predict impacts on caribou. Additionally, social impacts from expanding roads into historically remote, traditional subsistence areas must be considered. Preliminary analyses strongly suggest that roads significantly alter WAH movements at least during some years. The mechanisms for this and their biological impacts on caribou are still not understood. Even so, the impact to subsistence users and other hunters from delayed or diverted caribou migrations could be serious. Additionally, it has long been clear that subsistence harvests are significantly lower near road systems than away from them (Wolf and Walker 1987). The social impacts of establishing new roads into previously remote areas should be a primary consideration when deciding whether to build new roads within the range of the WAH.

The department should continue to support the Western Arctic Caribou Herd Working Group. The 2011 *Western Arctic Herd Cooperative Management Plan* recommends an incremental approach for monitoring activities and regulatory restrictions that is linked to WAH population size and trend. There are many things agencies and users might voluntarily do to try to minimize human impacts on this herd that would not necessarily require regulatory action by the BOG or FSB. The WG would be a good forum for discussing these types of voluntary responses, as well as regulatory actions, to address the current population decline.

Despite efforts to keep caribou regulations as simple, consistent, and, understandable as possible during the March 2015 BOG meeting, the FSB subsequently created federal caribou regulations that differ substantially from those of the state. The complexity of inconsistent state and federal regulations will probably confuse many hunters and could lead to citations when they unknowingly break state or federal laws. Ultimately, this will not facilitate a spirit of cooperation between managers and the public, nor will it help conserve caribou. It should be possible to promulgate at least very similar – if not completely consistent – state and federal caribou regulations: both sides are dealing with the same caribou herd on adjoining lands used by the same people. A major challenge now facing managers is to reconcile differences in state and federal regulations to make them fair, effective, and understandable to the hunting public. Following the BOG and FSB meetings in 2015, the overall suite of state and federal regulations were unclear even to professional biologists and enforcement officers working within the range of this herd.

During 2014 and early 2015, department staff conducted an extensive and intensive public outreach campaign in GMUs 22, 23, 26A, and Anaktuvuk Pass to inform people of the population status of the WAH and TCH, and to begin discussing how to begin reducing harvests from these herds. If the WAH continues to decline, this level of outreach is going to become a necessity, perhaps on an annual basis, if managers hope to have public support for and compliance with regulatory restrictions and harvest reporting requirements. Throughout these public meetings, a comment frequently repeated was that managers cannot simply reduce harvests to stop or reverse the decline in WAH caribou numbers: they *have* to reduce numbers of wolves and brown bears as well. Given the size and remoteness of WAH range, the presence of large tracts of NPS and FWS lands where predator control is prohibited, the difficulty of finding wolves in areas occupied by large numbers of caribou, and the dismal budget outlook for the State of Alaska as oil revenues decline, it is unlikely that a state-administered predator control program could have a measureable impact on reversing the WAH decline. Even so, if the state hopes to work cooperatively with the public in addressing this WAH population decline, a meaningful attempt to at least reduce the impact of predators on this herd may be necessary even if the intensive management review process deems it infeasible. There is no terrestrial wildlife population in northwest Alaska more important to subsistence users, nonlocal hunters, or commercial operators than the WAH. It will be imperative that managers work with the public in managing this herd through this decline. Failure to do so in such a remote area having limited enforcement capabilities could result in anarchy regarding caribou management.

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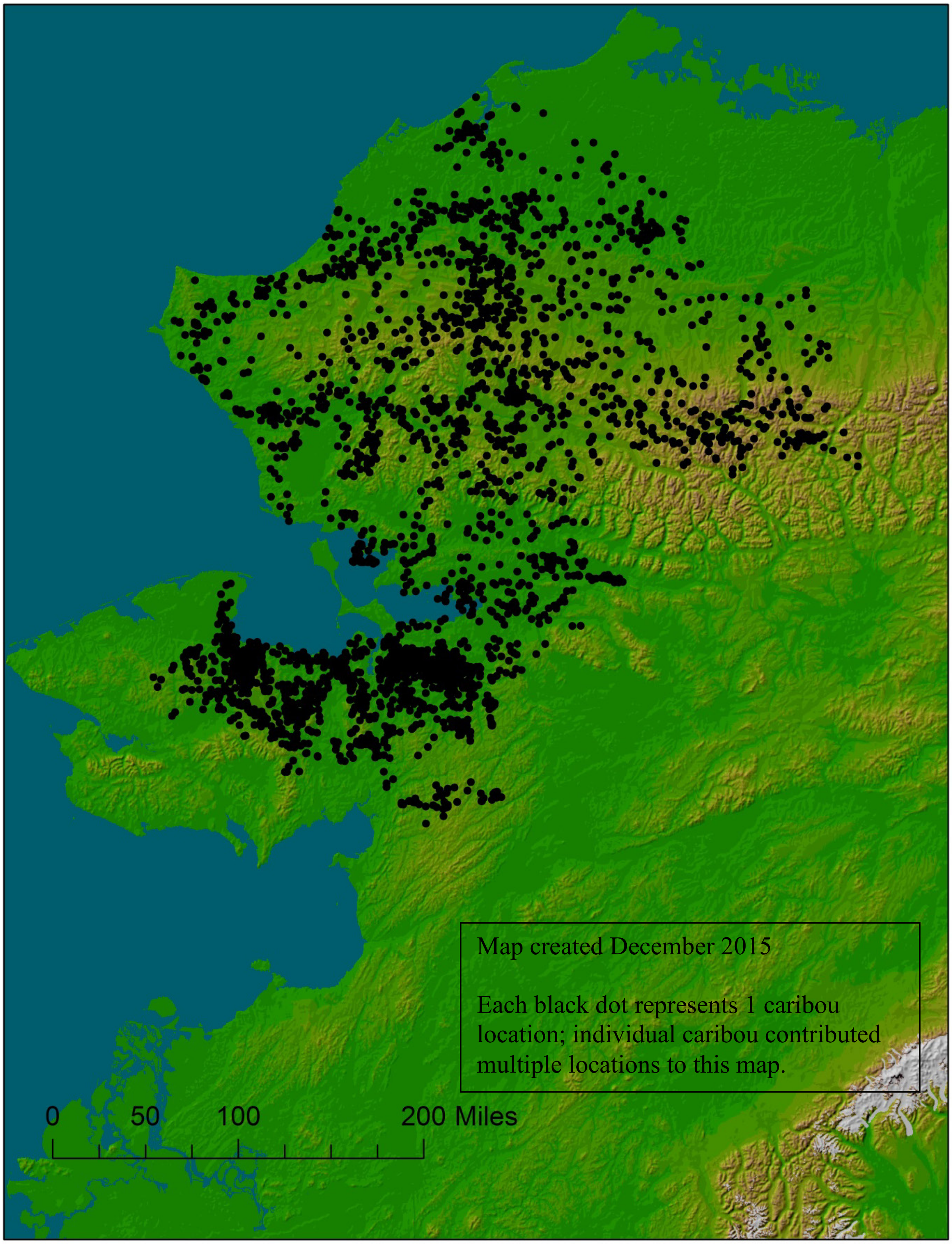

Figure 1. Locations of 105 radiocollared caribou (15 bulls, 90 cows), Western Arctic caribou herd, RY12. Data excludes first 8 months after collaring. All collar duty cycles standardized to 1 location every 6 days (n_i = 4,146 locations).

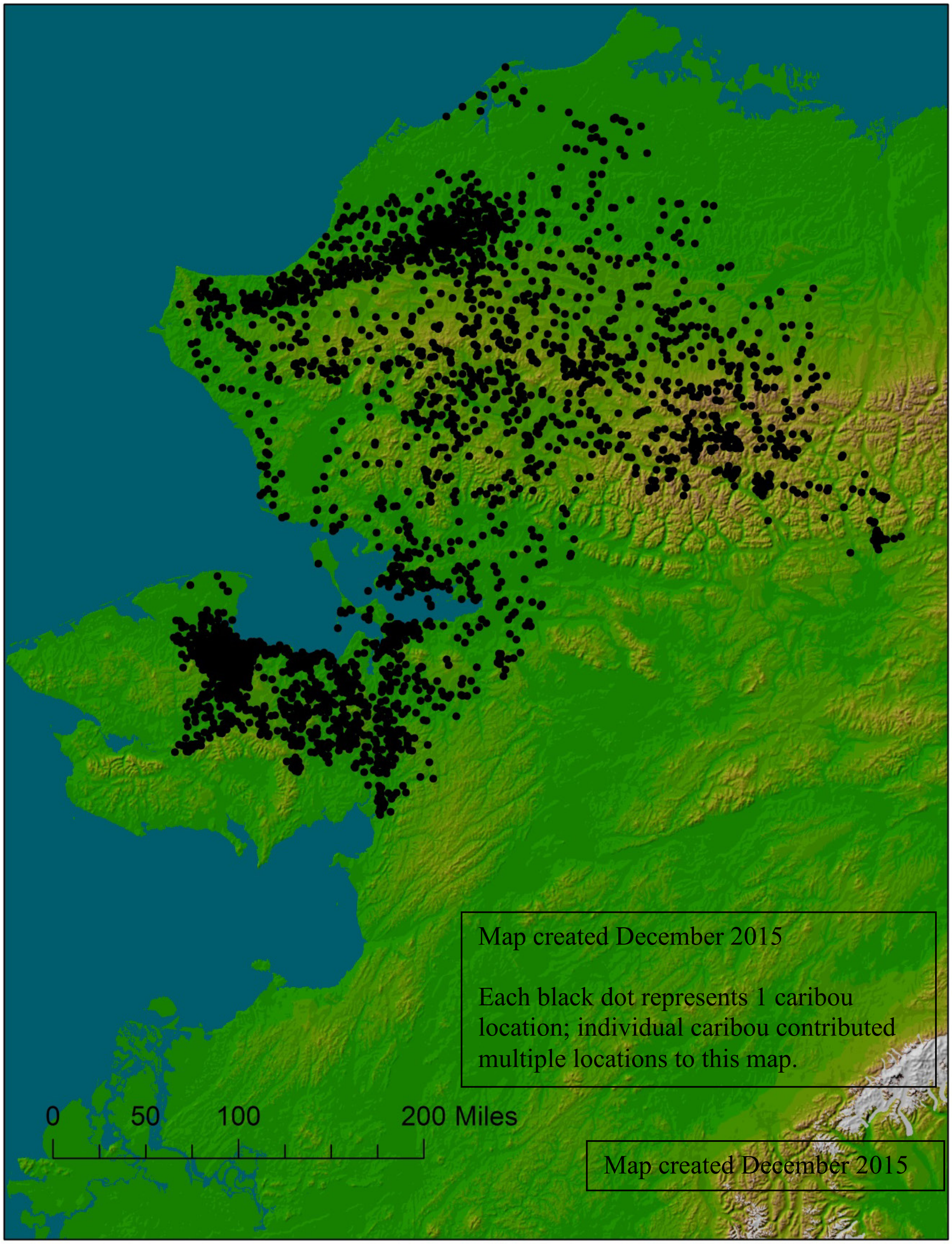

Figure 2. Locations of 108 radiocollared caribou (12 bulls, 96 cows), Western Arctic caribou herd, RY13. Data excludes first 8 months after collaring. All collar duty cycles standardized to 1 location every 6 days (n_i = 4,172 locations).

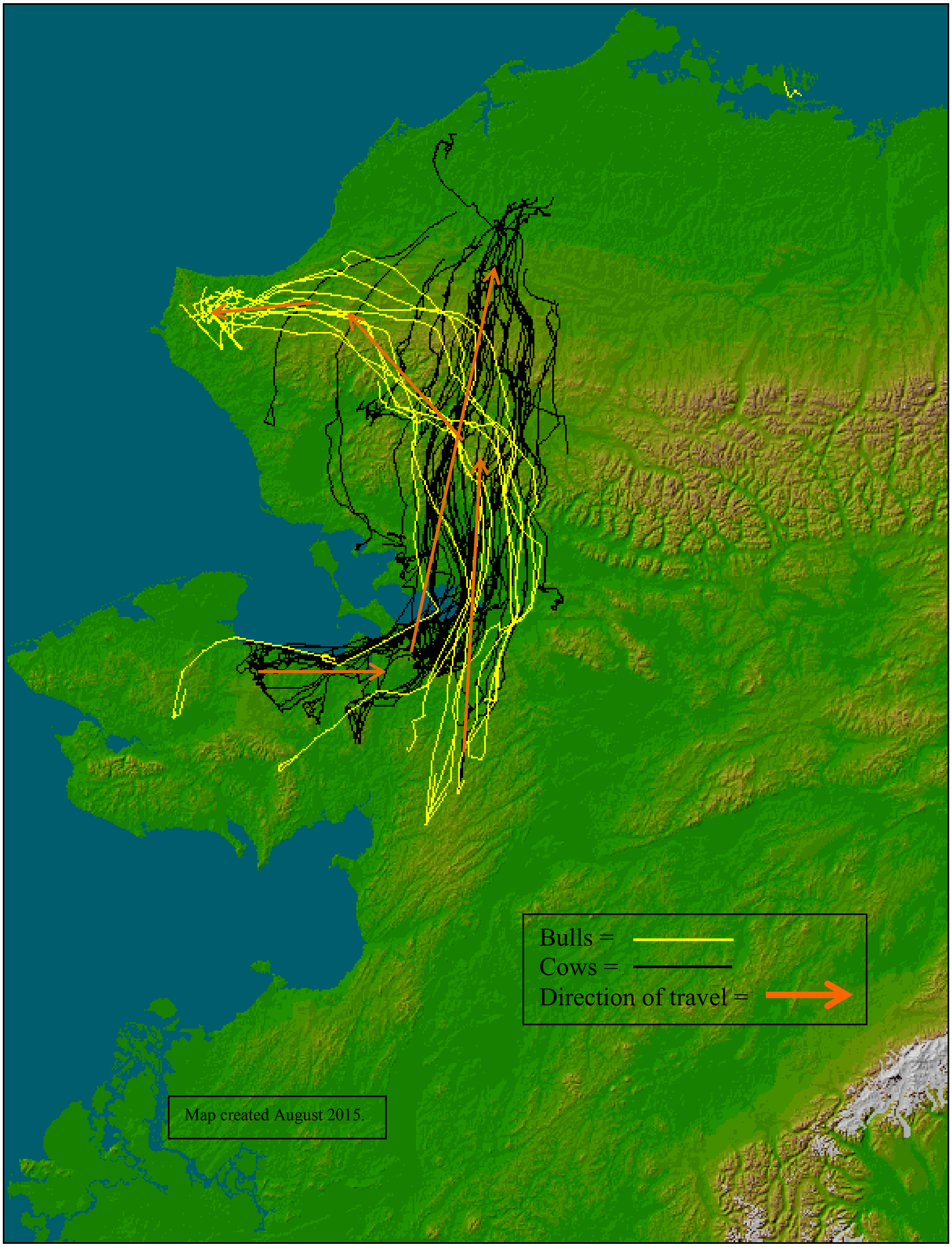

Figure 3. Spring 2013 movements from south to north of satellite-collared caribou; 11 bulls (yellow lines, 16 May–4 July) and 72 cows (black lines, 6 May–8 June), Western Arctic caribou herd (season dates determined from speed and direction of travel, see Table 6).

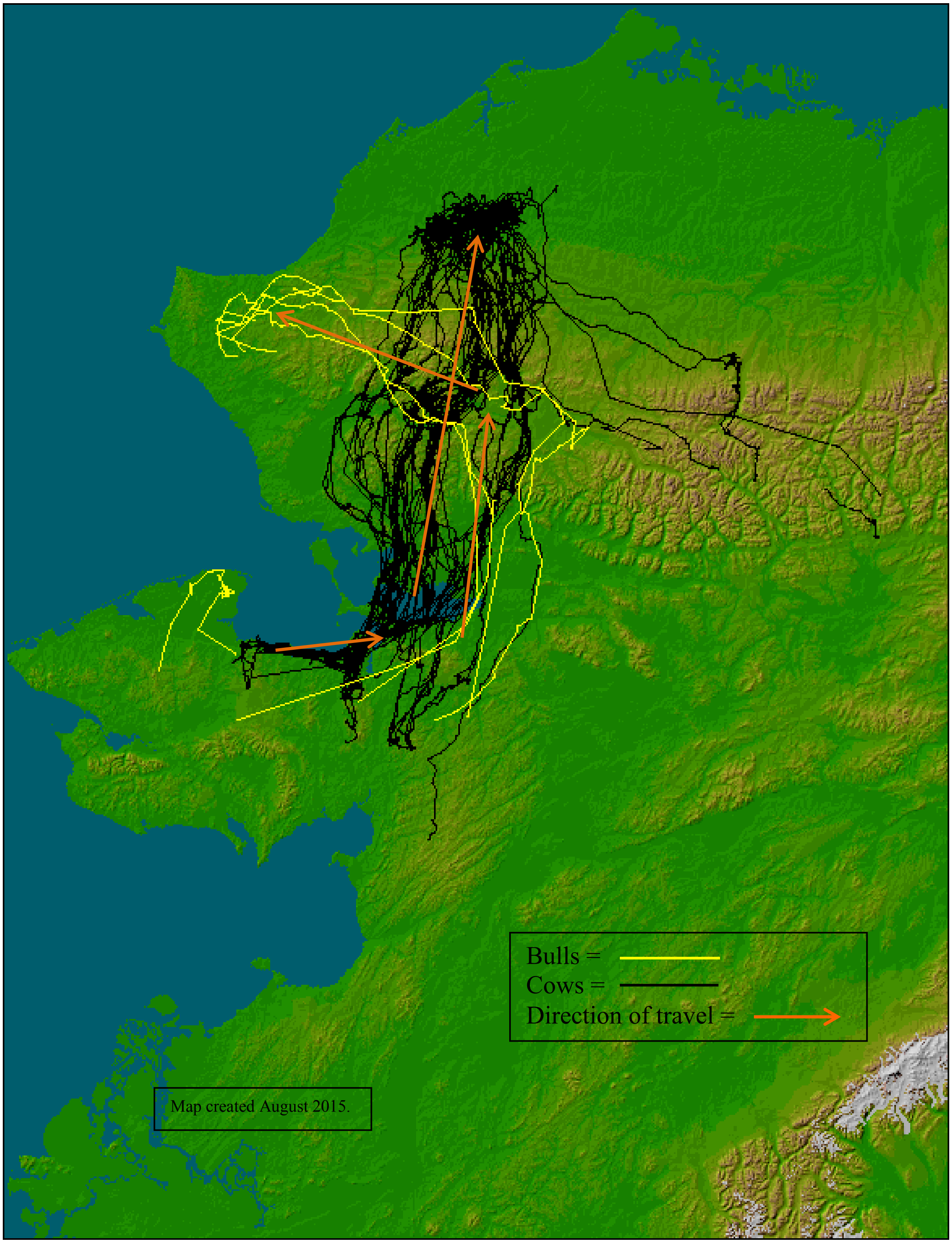

Figure 4. Spring 2014 movements from south to north of satellite-collared caribou; 5 bulls (yellow lines, 16 May–4 July) and 77 cows (black lines, 6 May–8 June), Western Arctic caribou herd (season dates determined from speed and direction of travel, see Table 6).

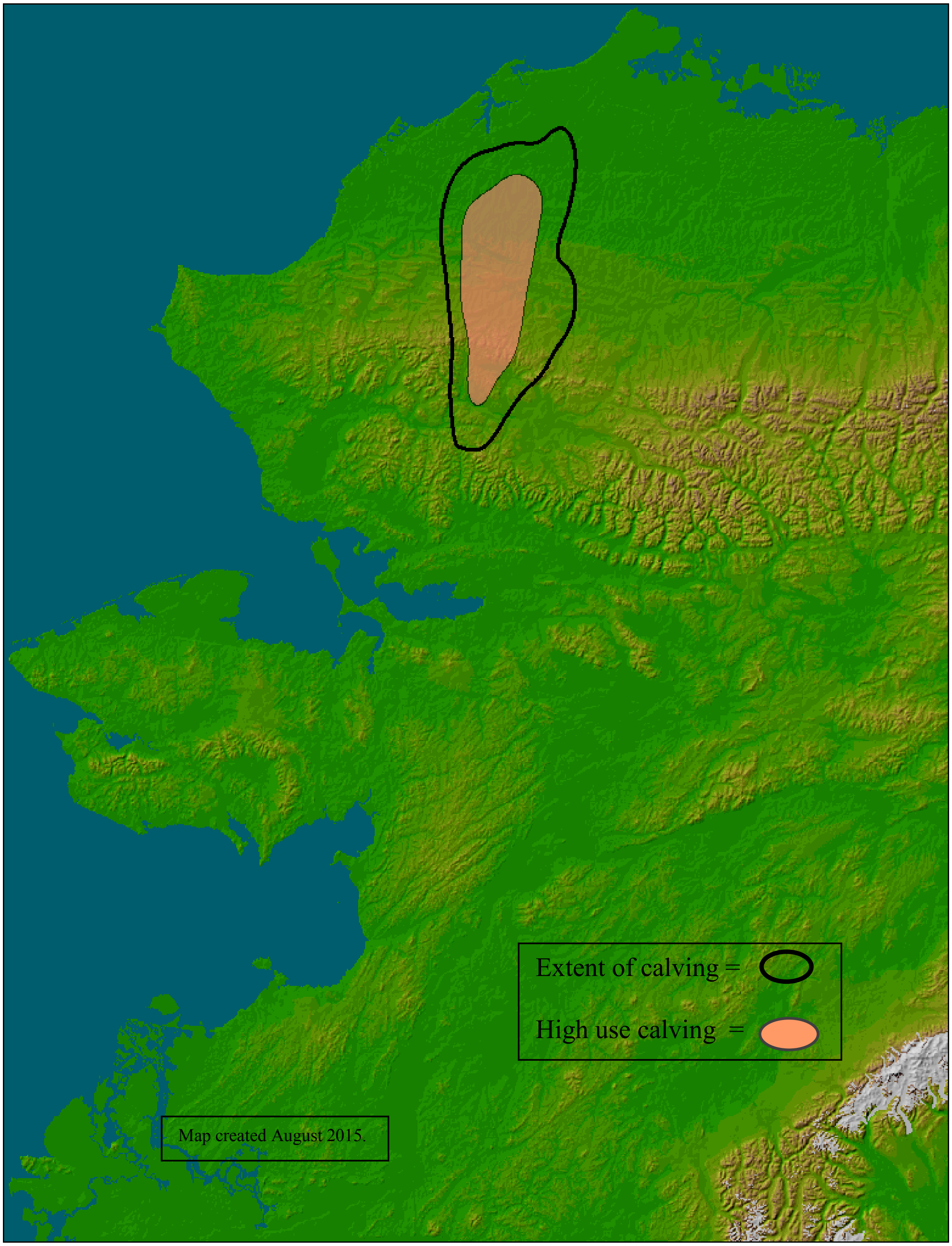

Figure 5. Kernel depiction of calving distribution during June 2013 based on locations of 45 maternal cows, Western Arctic caribou herd. Calving period is 9–13 June (season dates determined from speed and direction of travel, see Table 6). Outer black boundaries represent the 95% isopleth to show the extent of calving. Shaded area (67% isopleth) was selected by a Bayesian model to reflect high use.

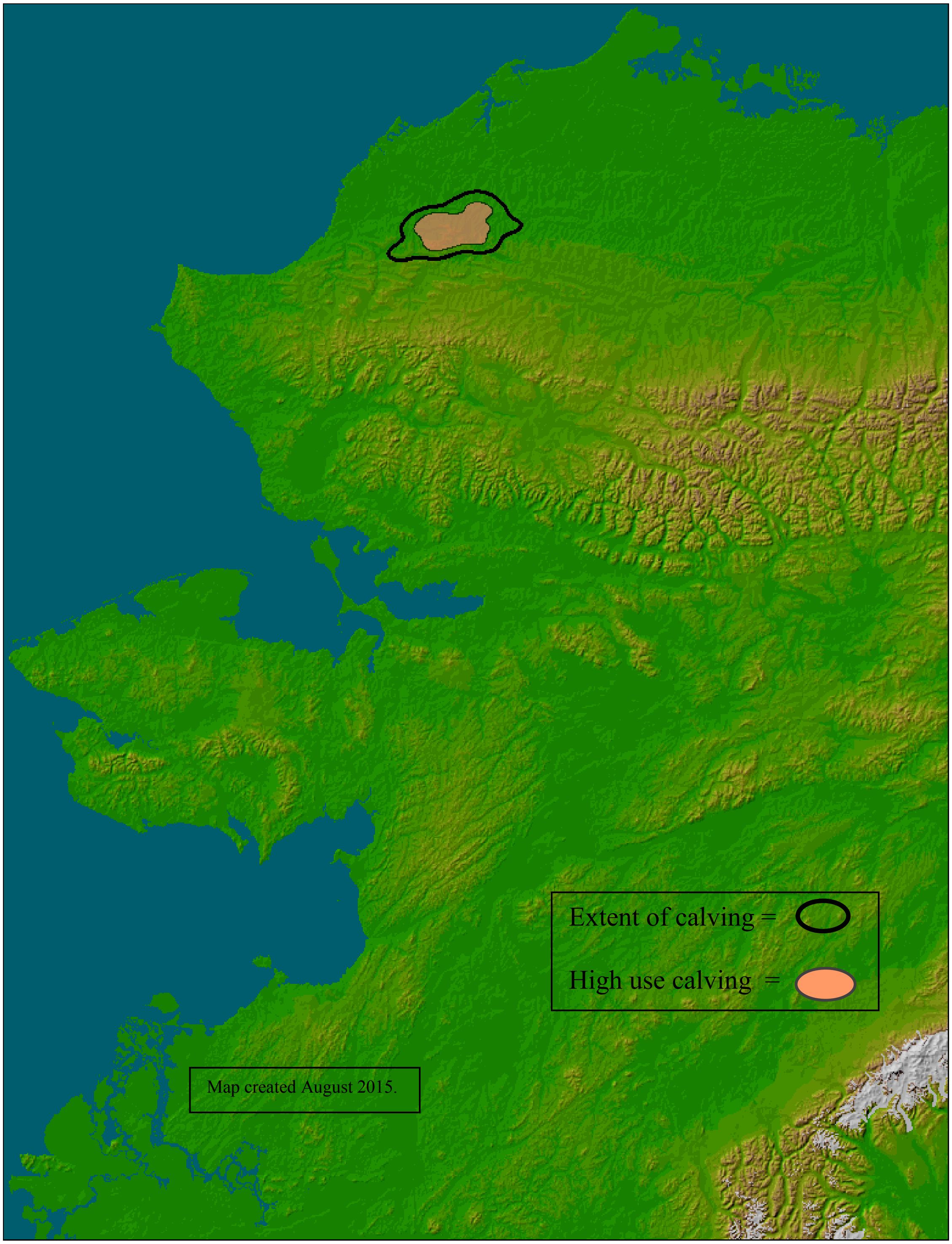

Figure 6. Kernel depiction of calving distribution during June 2014 based on locations of 47 maternal cows, Western Arctic caribou herd. Calving period is 9–13 June (season dates determined from speed and direction of travel, see Table 6). Outer black boundaries represent the 95% isopleth to show the extent of calving. Shaded area (69% isopleth) was selected by a Bayesian model to reflect high use.

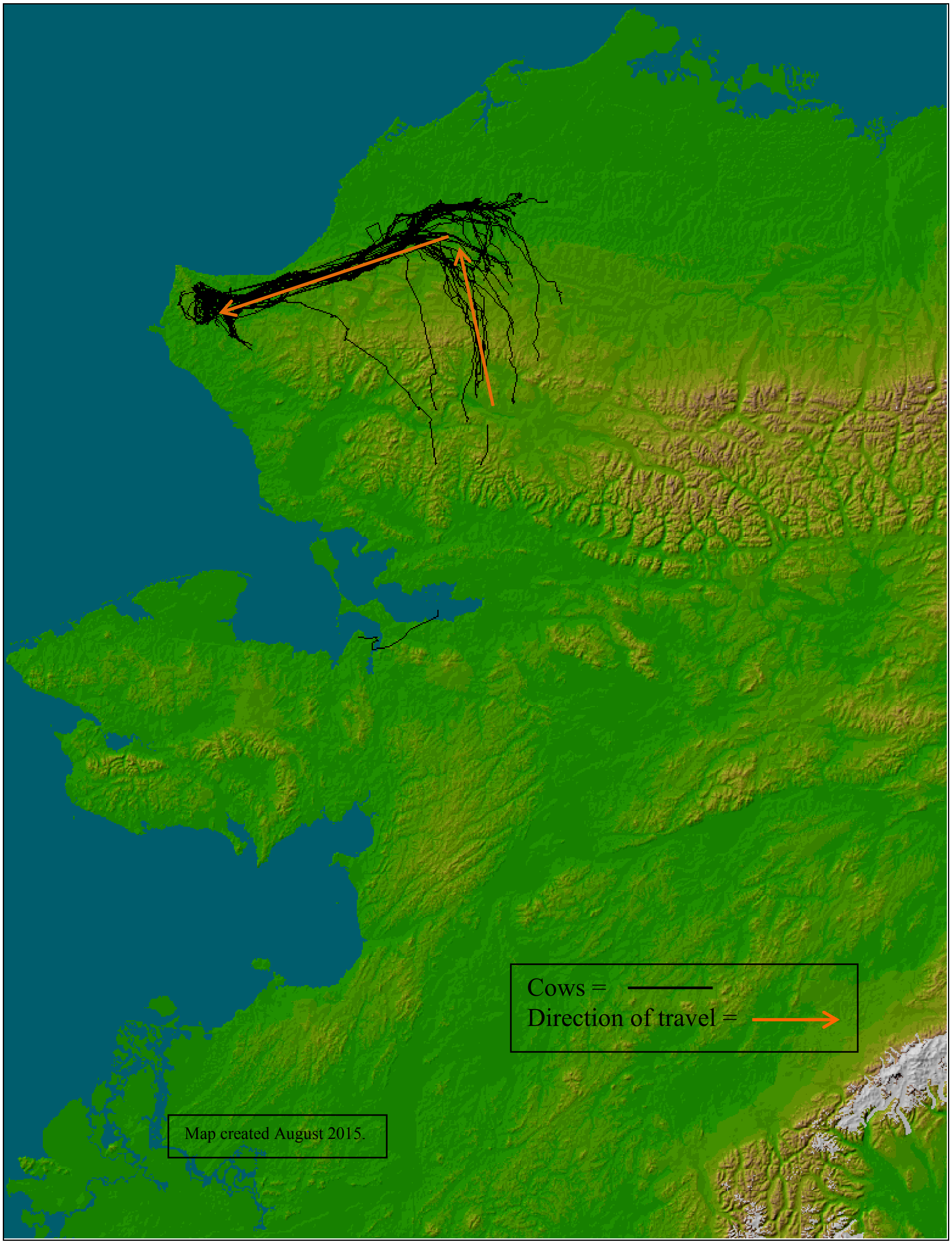

Figure 7. Post-calving movements from east to west of 65 satellite-collared cows, 2013, Western Arctic caribou herd (movement is northward toward the calving grounds, or from the calving grounds southwest toward the Lisburne Hills). Movement period is 14 June–5 July (season dates determined from speed and direction of travel, see Table 6).

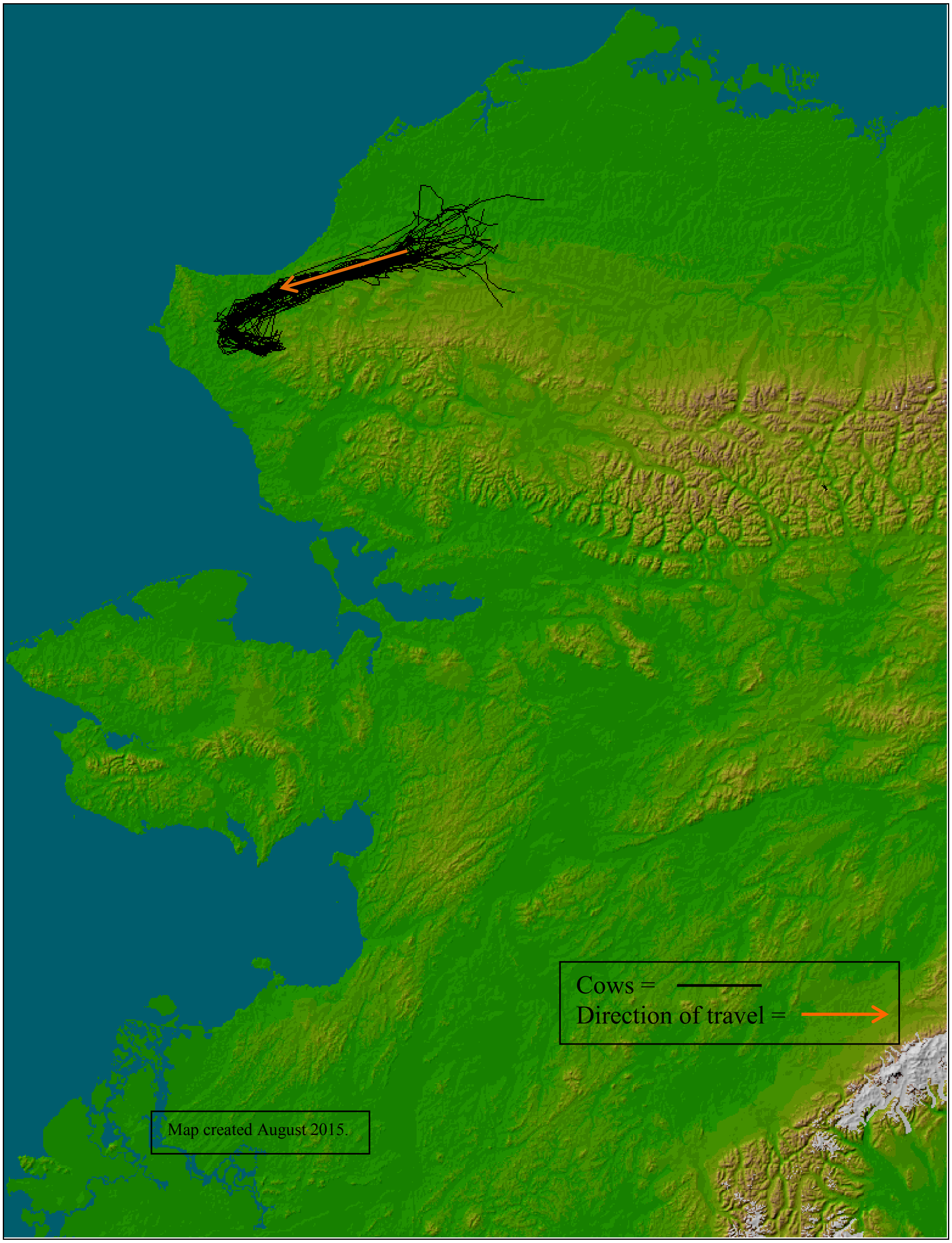

Figure 8. Post-calving movements from east to west of 67 satellite-collared cows, 2014, Western Arctic caribou herd (movement is from the calving grounds southwest toward the Lisburne Hills). Movement period is 14 June–5 July (season dates determined from speed and direction of travel, see Table 6).

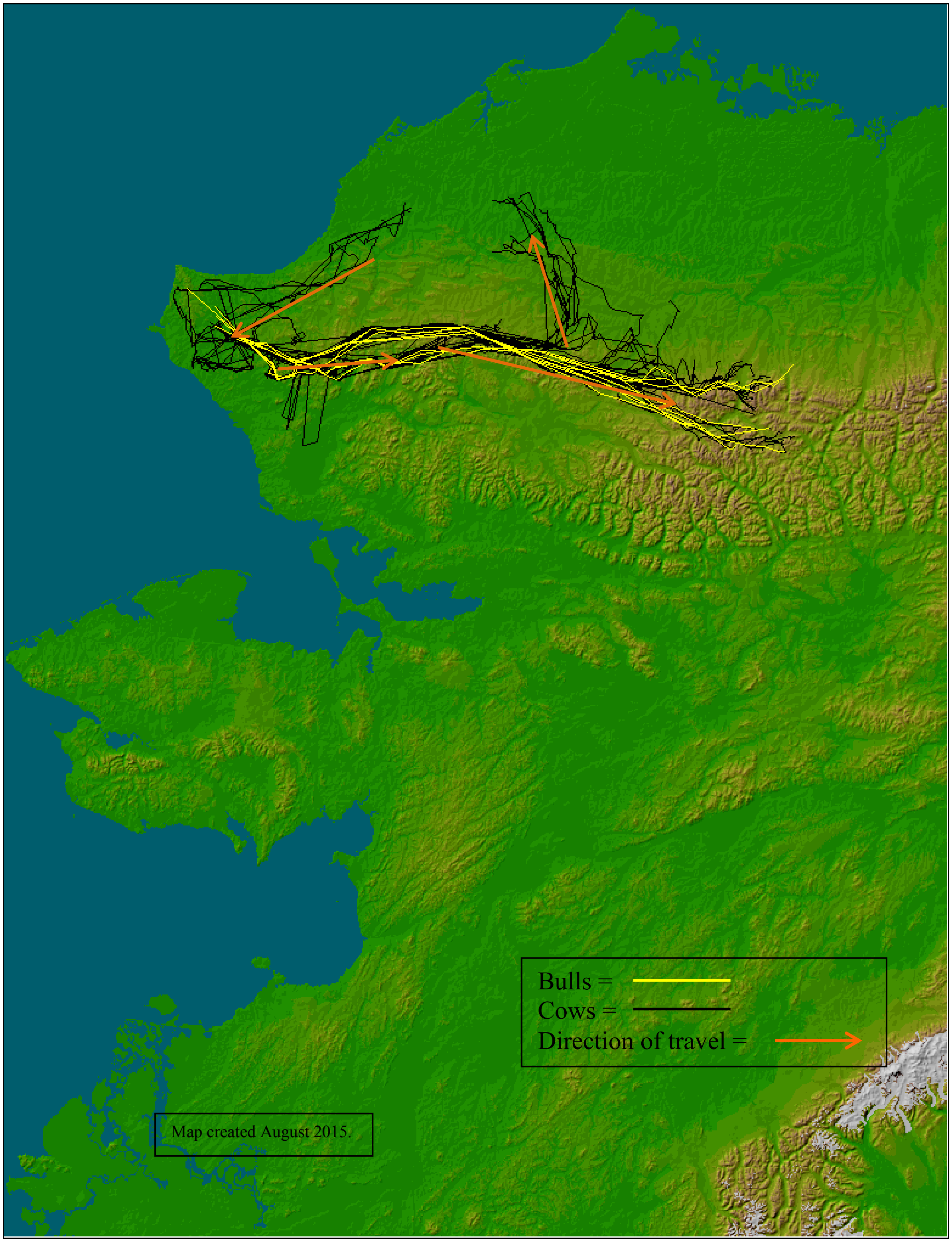

Figure 9. Summer 2013 movements from west to east of 64 satellite-collared cows (6 July–30 July, black lines) and 10 bulls (5 July-2 August, yellow lines), Western Arctic caribou herd (season dates determined from speed and direction of travel, see Table 6).

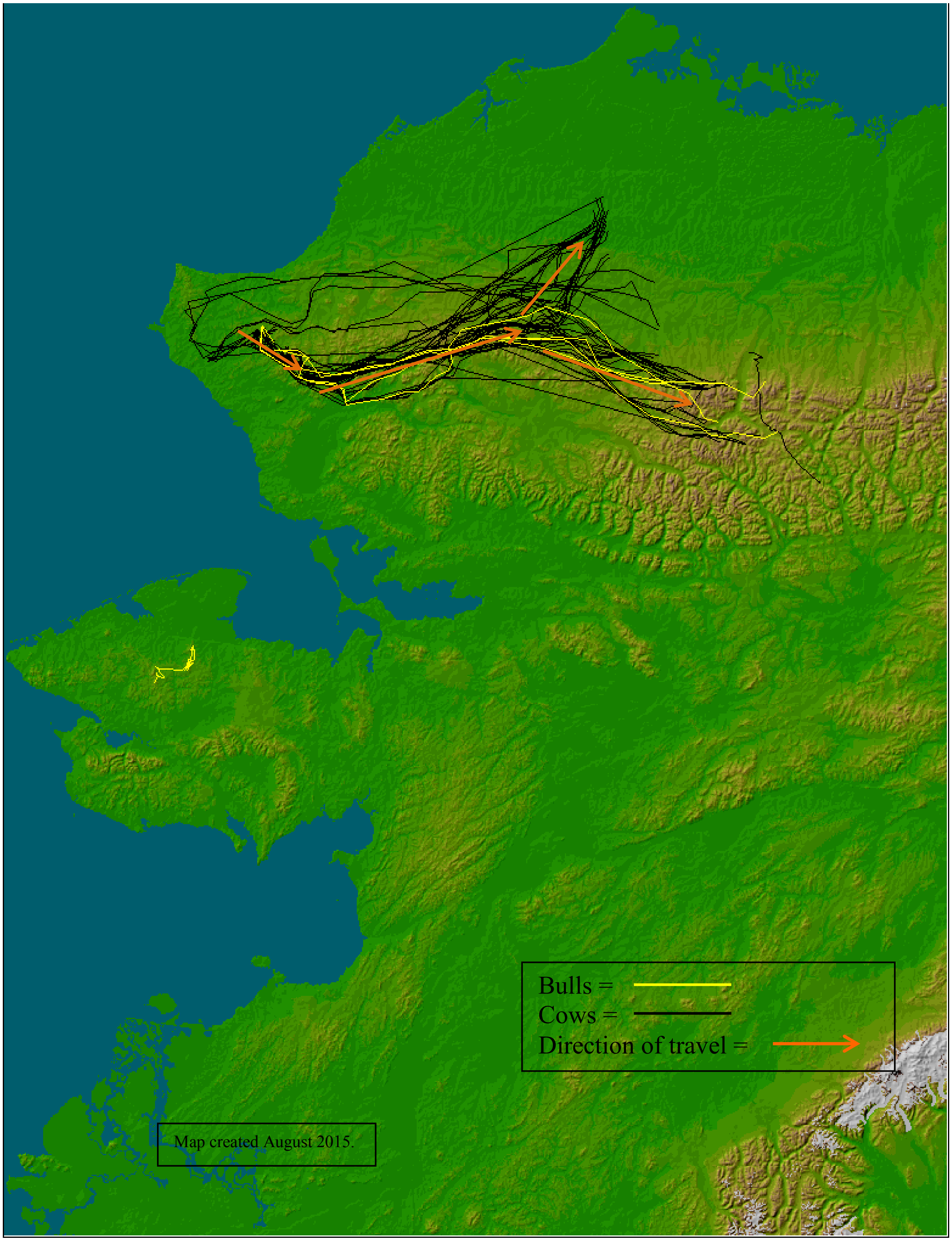

Figure 10. Summer 2014 movements from west to east of 64 satellite-collared cows (6 July–30 July, black lines) and 5 bulls (5 July–2 August, yellow lines), Western Arctic caribou herd (season dates determined from speed and direction of travel, see Table 6).

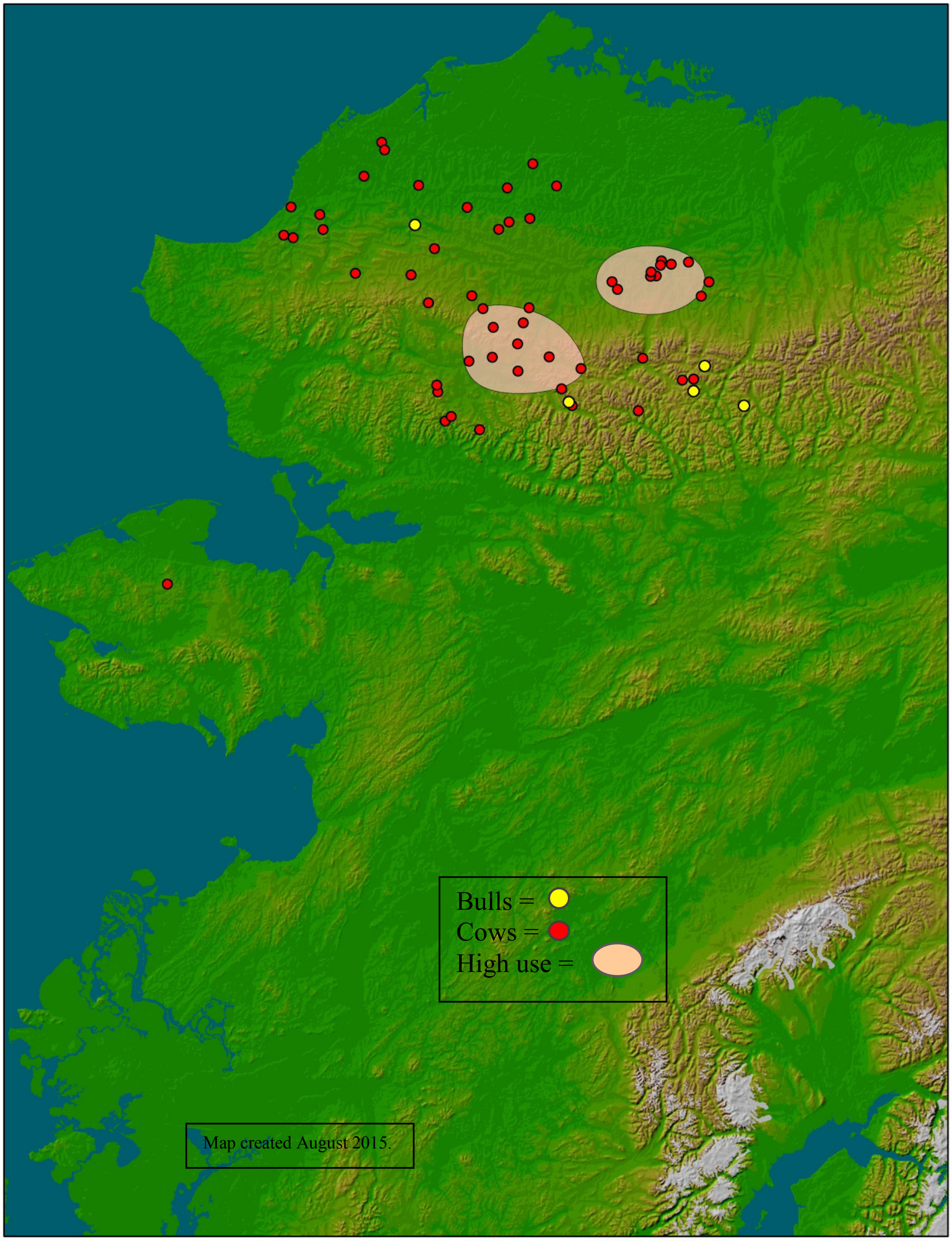

Figure 11. Point locations and kernel areas of late summer (31 July–17 September) distribution for 5 bulls and 55 cows (yellow and red symbols, respectively), Western Arctic caribou herd, 2012 (season dates determined from movement data, see Table 6). Isopleth (15%) was selected by a Bayesian model. The location closest in time to the midpoint date of late summer was selected for each collared caribou.

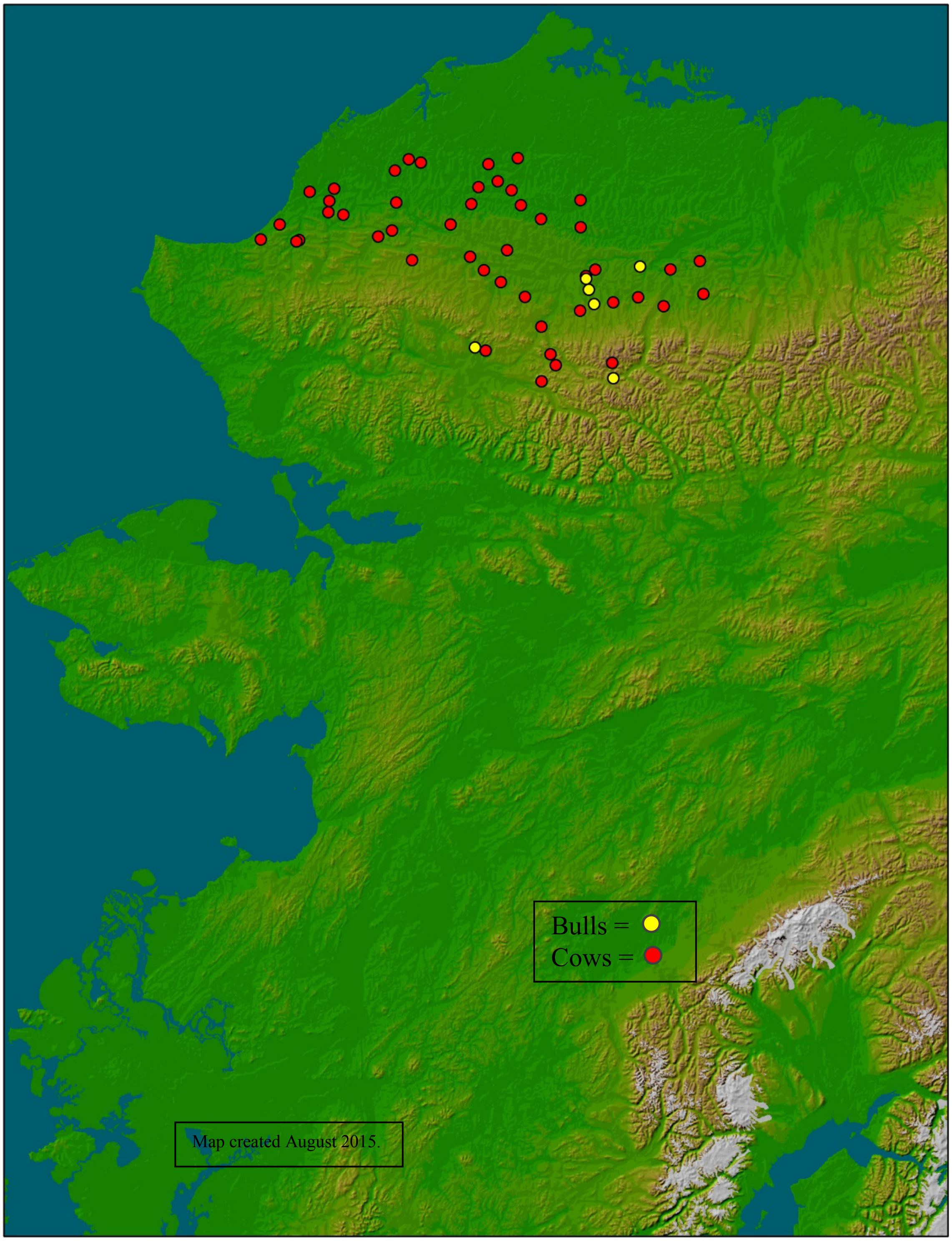

Figure 12. Point locations and kernel areas of late summer (31 July–17 September) distribution for 6 bulls and 47 cows (yellow and red symbols, respectively), Western Arctic caribou herd, 2013 (season dates determined from movement data, see Table 6). There was no evidence of clustering by caribou in late summer 2013. The location closest in time to the midpoint date of late summer season was selected for each collared caribou.

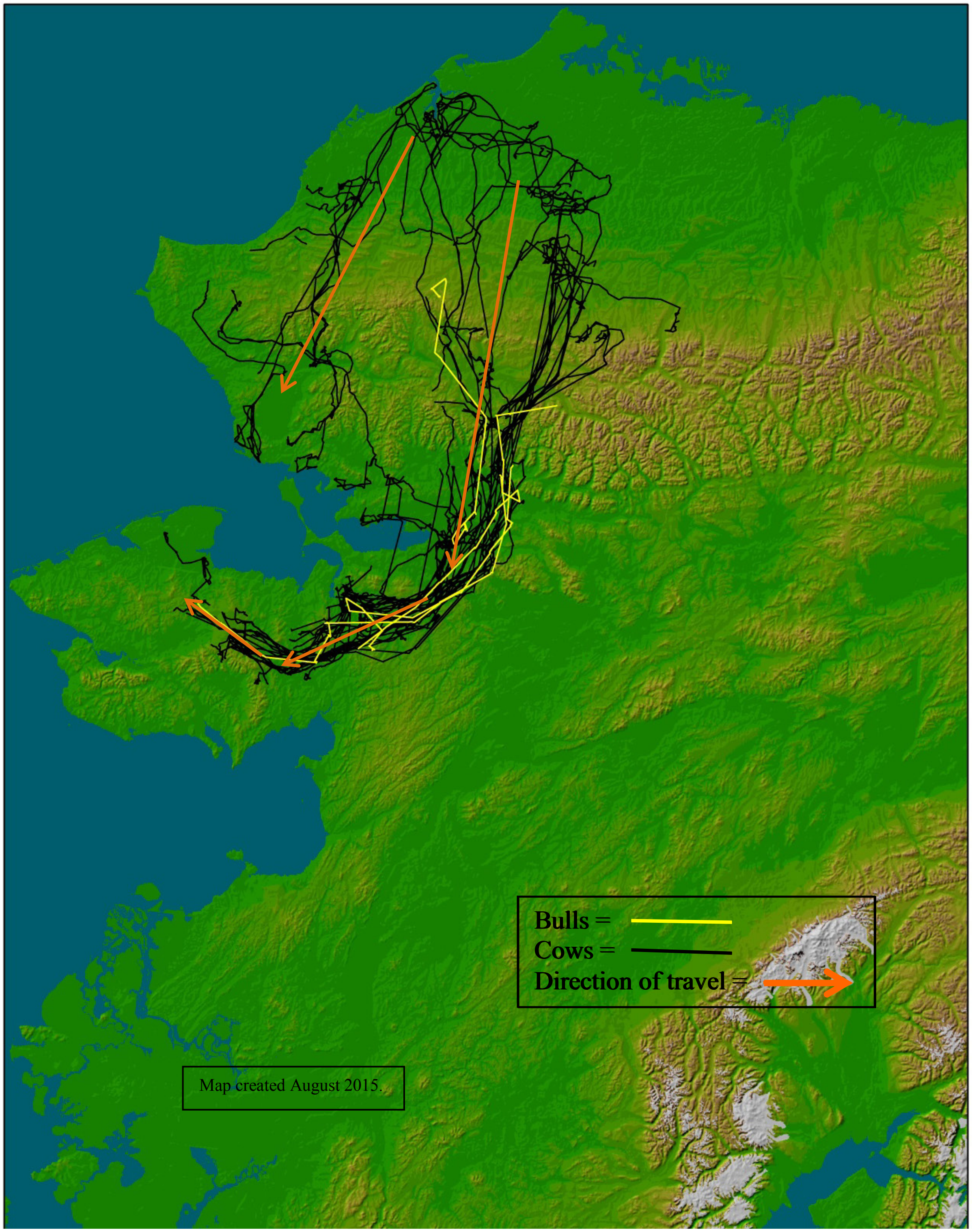

Figure 13. Fall (18 September–7 November) movements from north to south of satellite-collared caribou (4 bulls = yellow lines, 57 cows = black lines), Western Arctic caribou herd, 2012 (season dates determined from movement data, see Table 6). Data through 8 months after collaring are excluded.

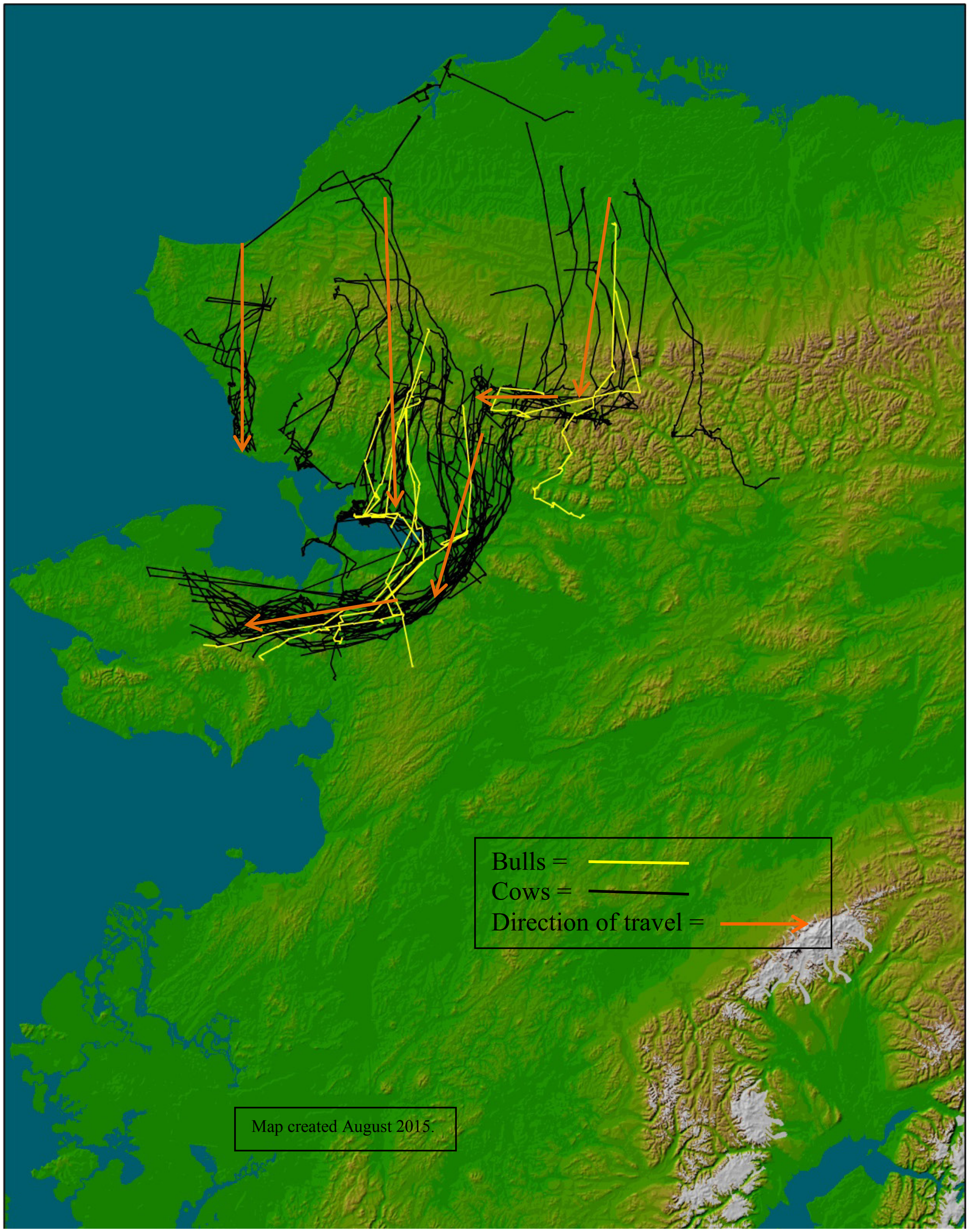

Figure 14. Fall (18 September–7 November) movements of satellite-collared caribou (8 bulls=yellow lines, 61 cows=black lines), Western Arctic caribou herd, 2013 (season dates determined from movement data, see Table 6). Data through 8 months after collaring are excluded.

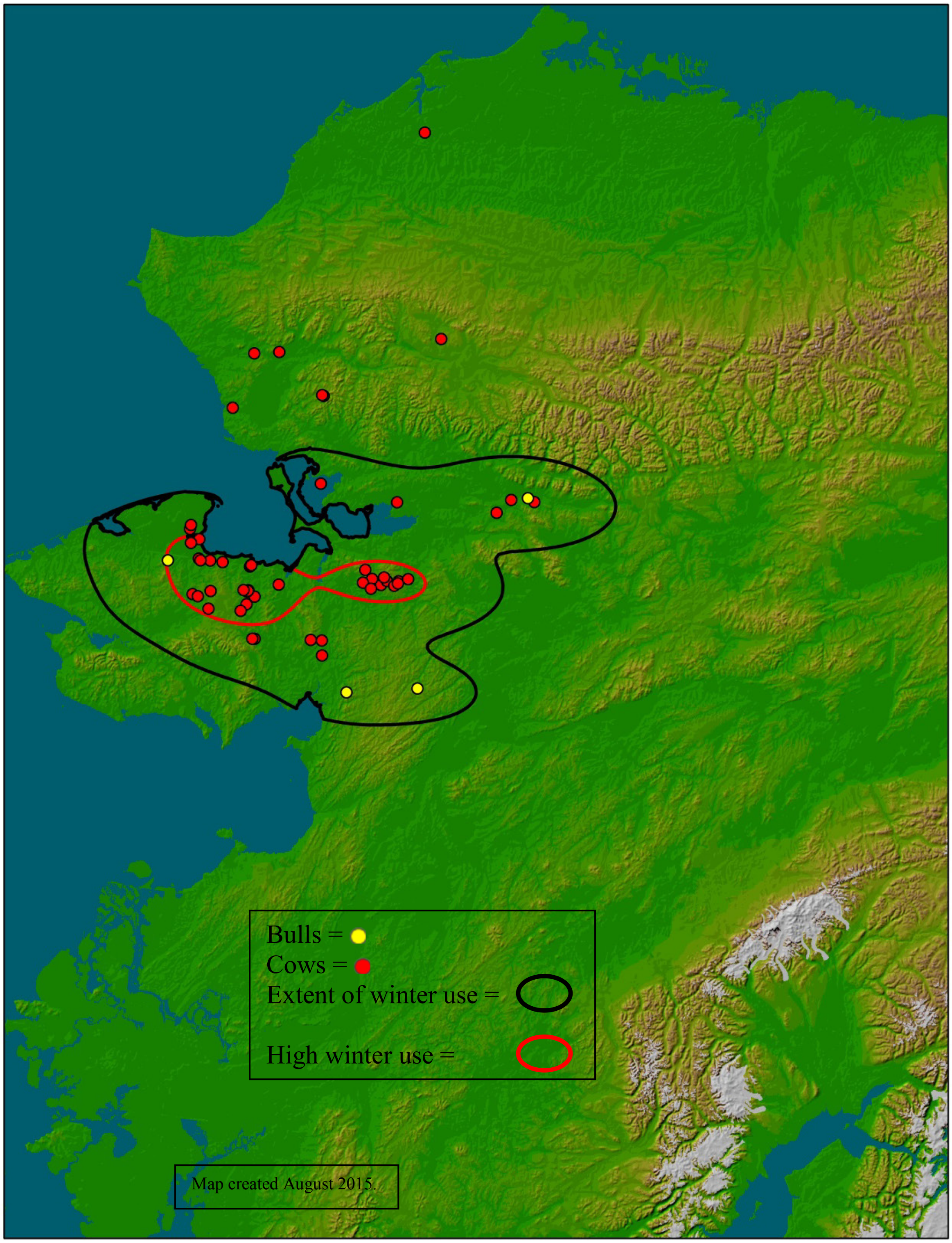

Figure 15. Kernel densities showing winter (8 November–5 May) distribution of satellite-collared caribou, Western Arctic caribou herd, 2012–2013. Points shown are the locations closest to 1 January 2013. Black line = 95% kernel; red line = high use area (34% kernel); yellow dots = bulls ($n_i = 4$); red dots = cows ($n_i = 51$).

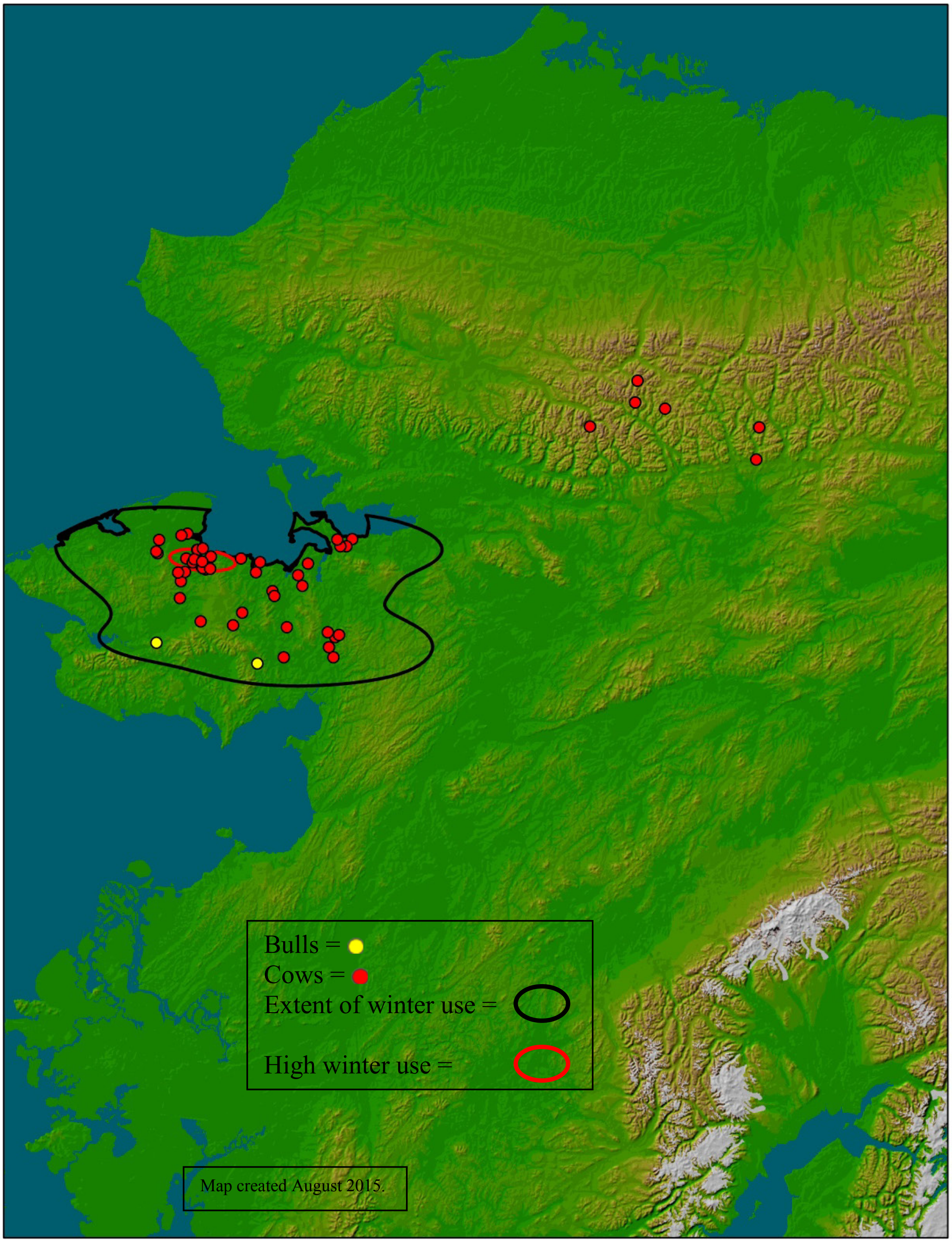

Figure 16. Kernel densities showing winter distribution of satellite-collared caribou, Western Arctic caribou herd, 2013–2014. Points shown are the locations closest to 1 January 2014. Black line = 95% kernel; red line = high use area (85% kernel); yellow dots = bulls ($n_i = 2$); red dots = cows ($n_i = 53$).

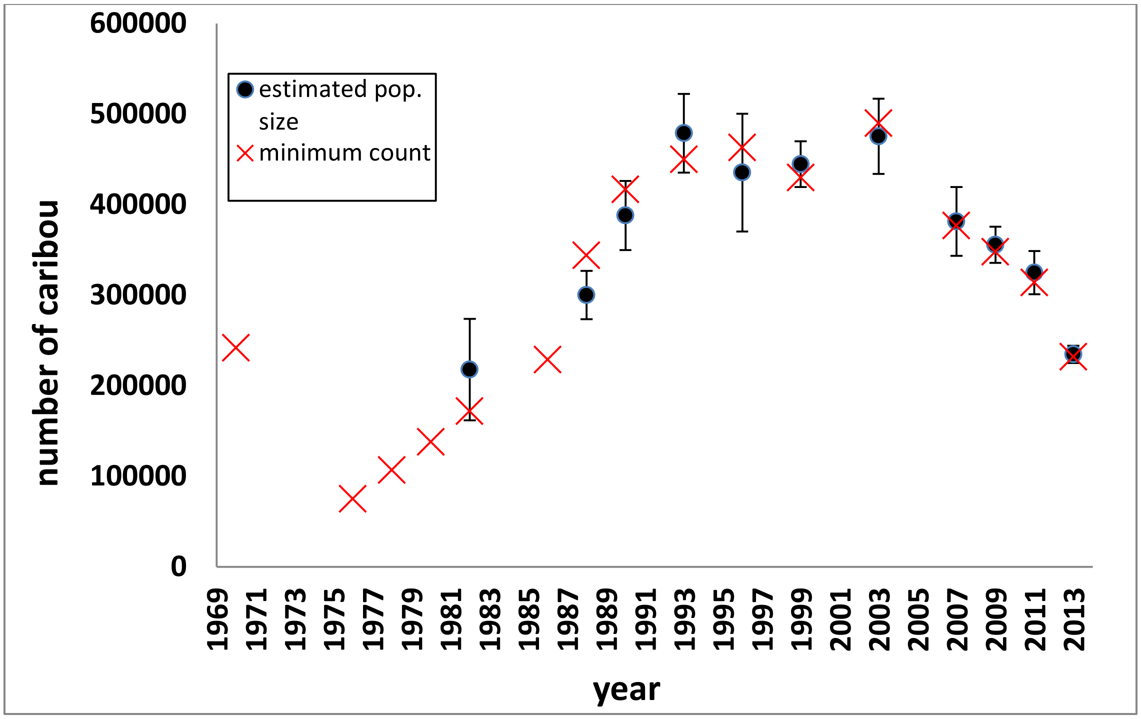

Figure 17. Western Arctic caribou herd photo census results, 1970–2013. Brackets around the open circles represent 95% confidence intervals for Rivest population estimates.

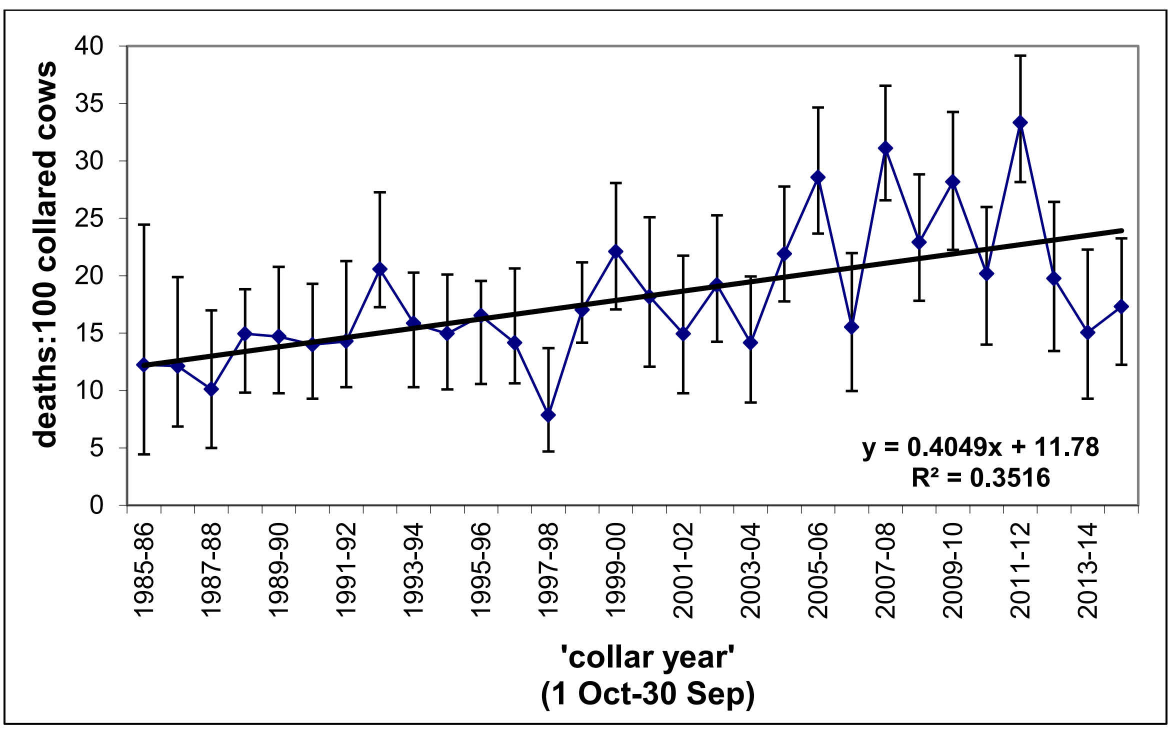

Figure 18. Adult cow mortality, Western Arctic caribou herd, CY85 through CY12 (brackets indicate 80% binomial c. i.; estimates based on radiocollared cows excluding ST-3 and ST-14 satellite collars; estimates not corrected for age bias in sample of collared cows).

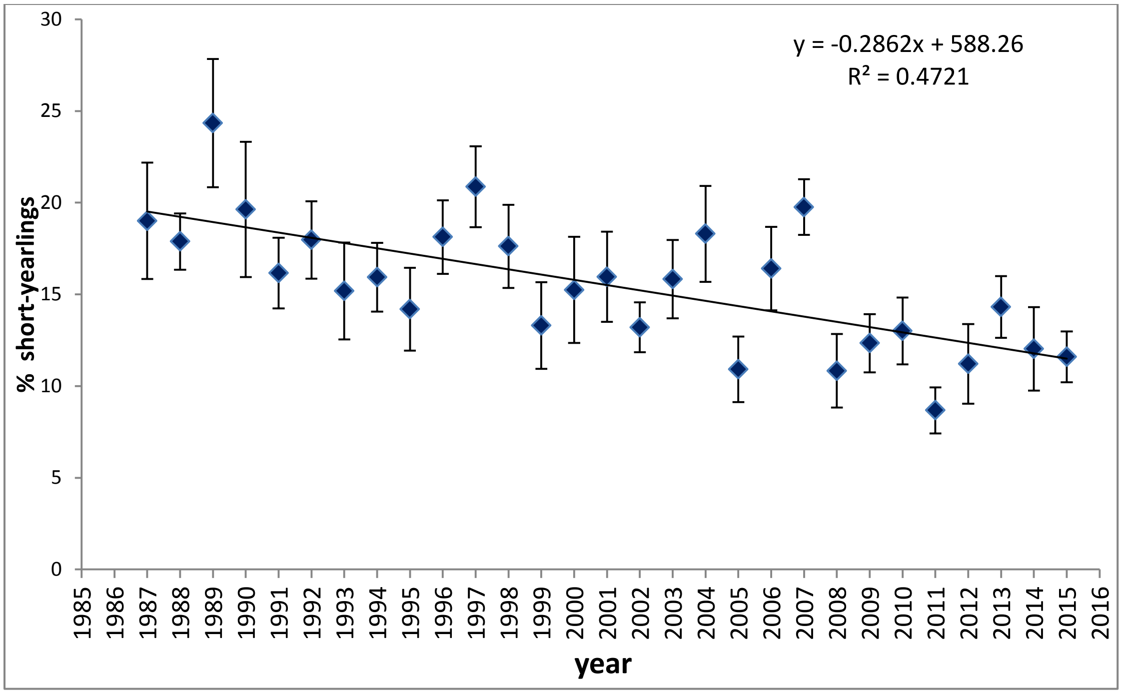

Figure 19. Percent short yearling recruitment for the Western Arctic caribou herd (brackets indicate 80% binomial confidence intervals), 1987–2015.

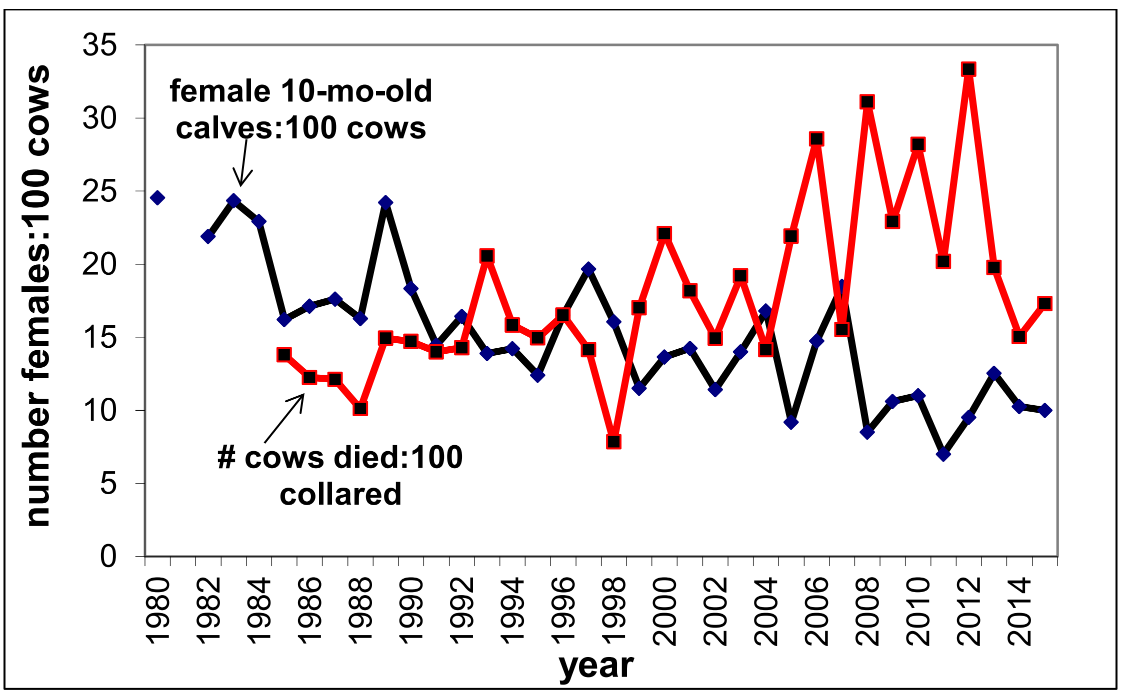

Figure 20. Indices of adult cow mortality and female calf recruitment for the Western Arctic caribou herd, 1980–2015. The spring calf:adult ratio is transformed to female calf:cow ratio based on fall composition data assuming equal male–female sex ratio at birth. Female calf recruitment is adjusted 3.3% down and adult cow mortality is adjusted 3.4% down to correct for age bias in the sample of collared adult cows.

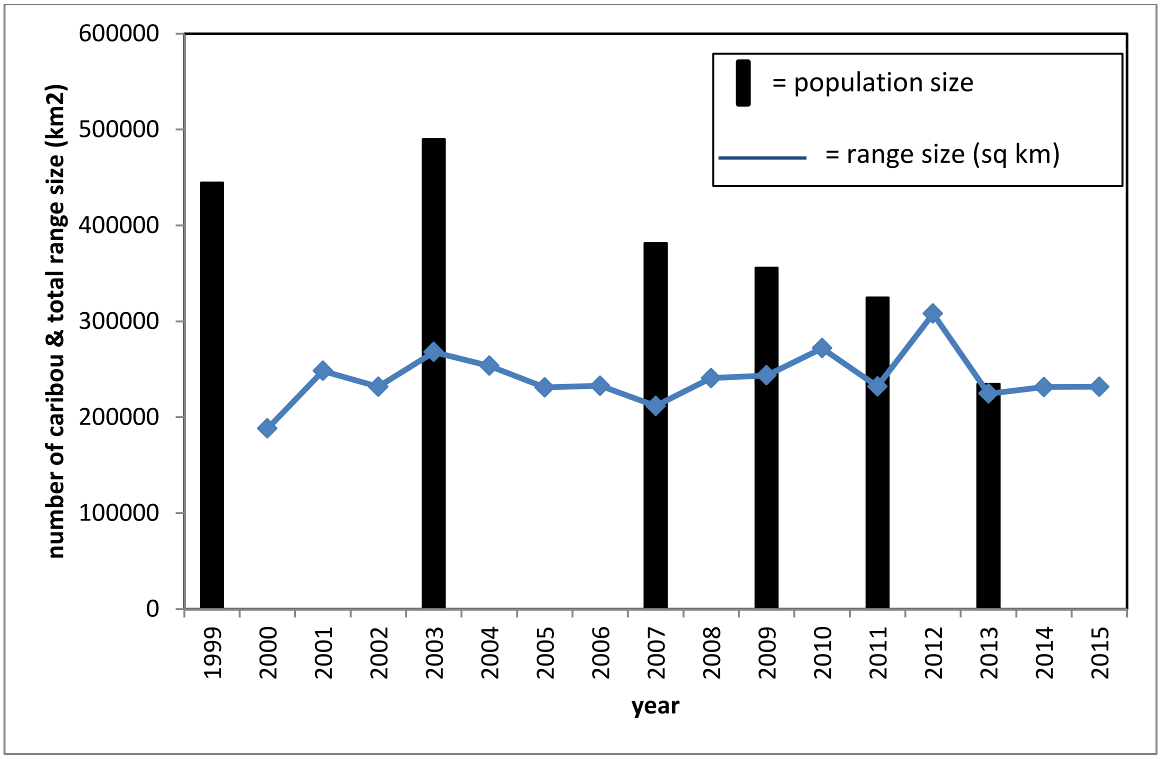

Figure 21. Annual range size (blue line; km^2) in relation to estimated population size (black bars) of the Western Arctic caribou herd, 1999–2015.

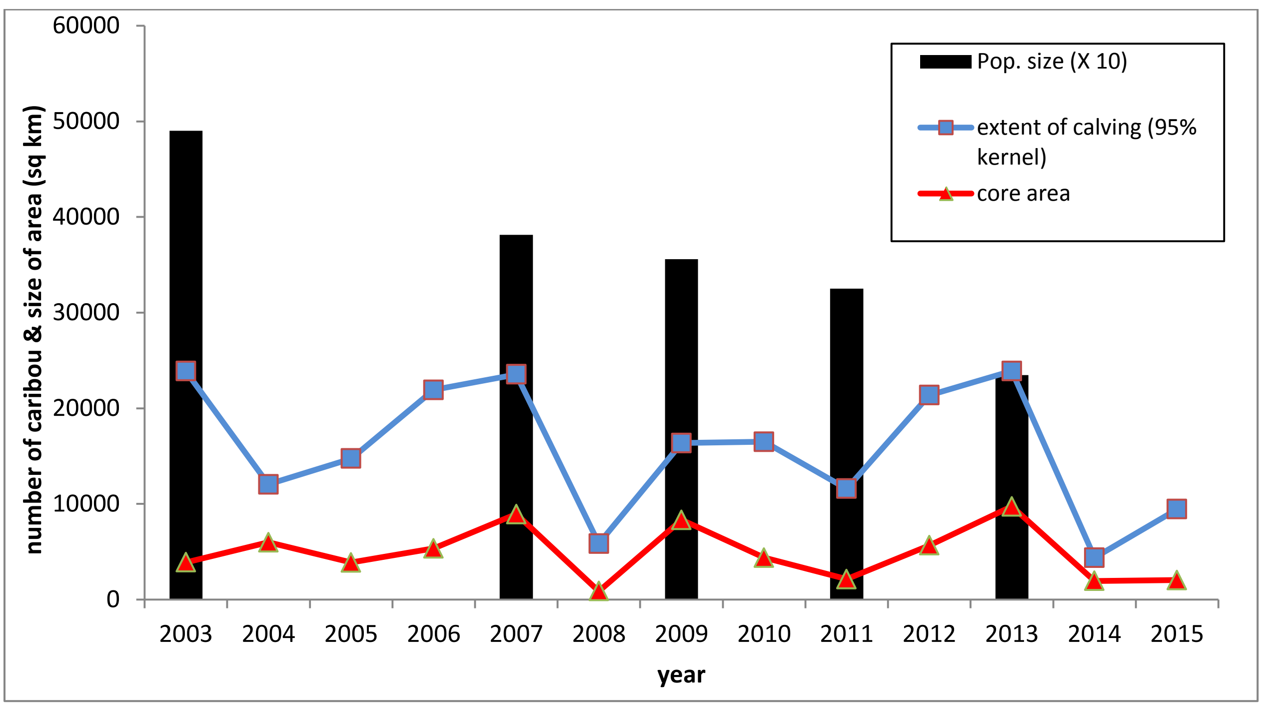

Figure 22. Size (km^2) of calving area extent (blue line, 95% kernel) and core kernel areas (red line, kernel isopleth determined annually) in relation to estimated population size (black bars) of the Western Arctic caribou herd, 1988–2015.

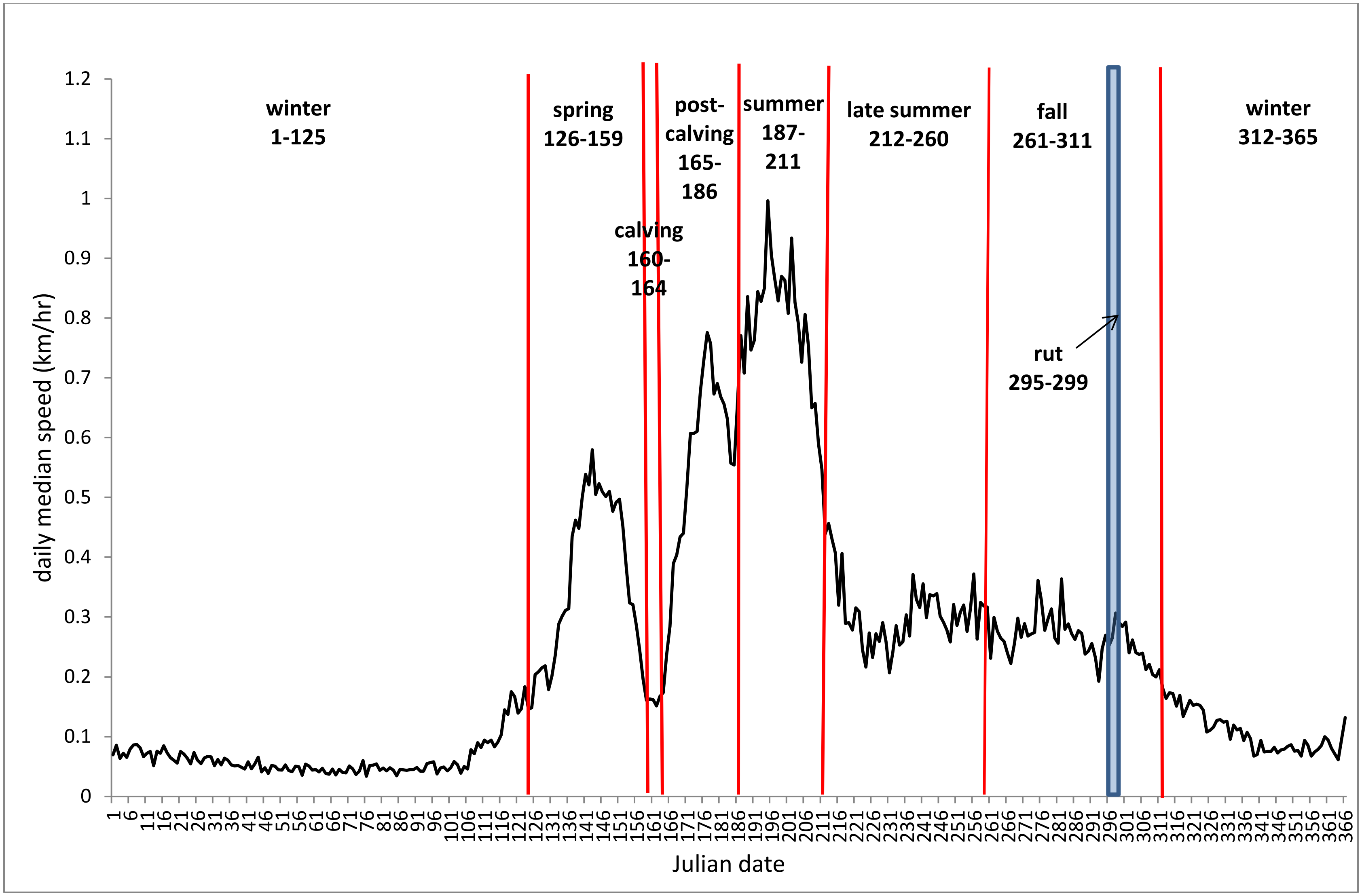

Figure 23. Median daily rate of travel and seasonal periods determined from rate and direction of travel for satellite-collared cow caribou, Western Arctic caribou herd, 1 June 1988 through 20 November 2012 (all years combined).

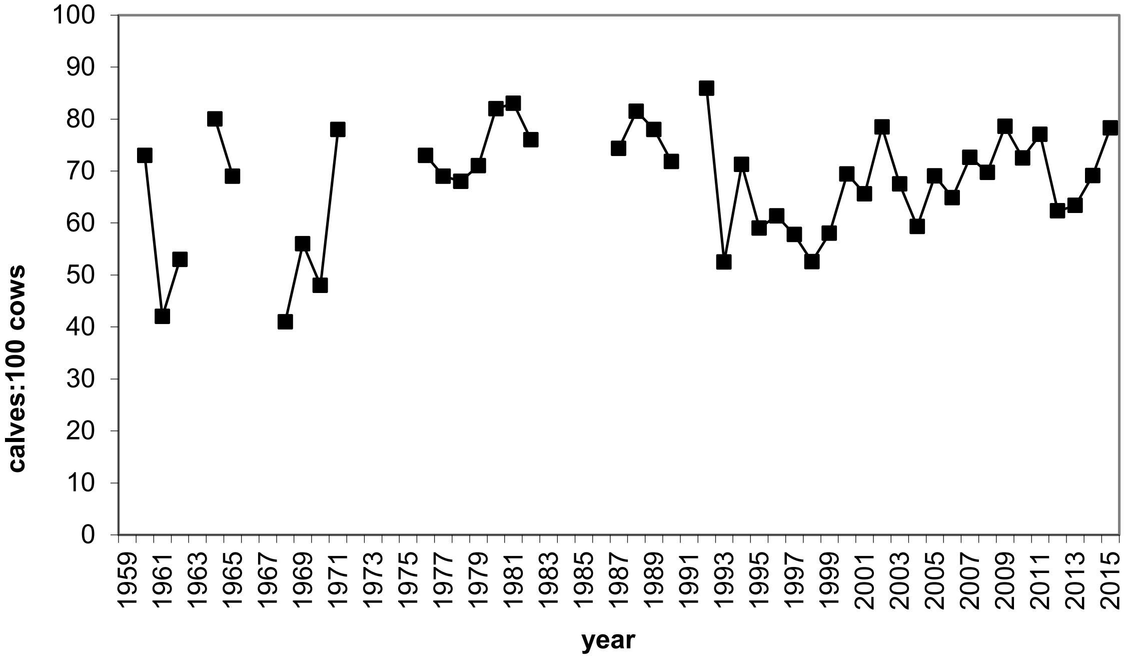

Figure 24. Calving survey results (calf: cow ratio), Western Arctic caribou herd, 1960–2015. Telemetry-based surveys were initiated in 1987. Gaps reflect years when no data were collected.

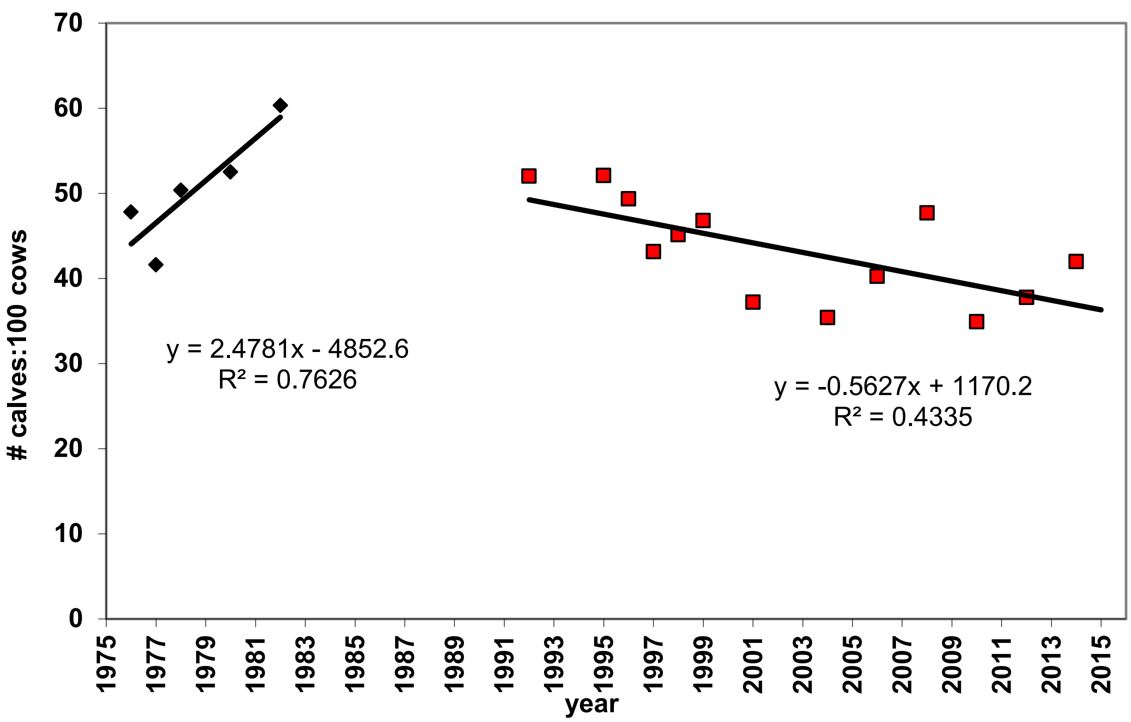

Figure 25. Fall calf:cow ratios with trend lines for the Western Arctic caribou herd, 1976–1982 and 1992–2014. Composition data from 2001 may be biased low due to survey conditions.

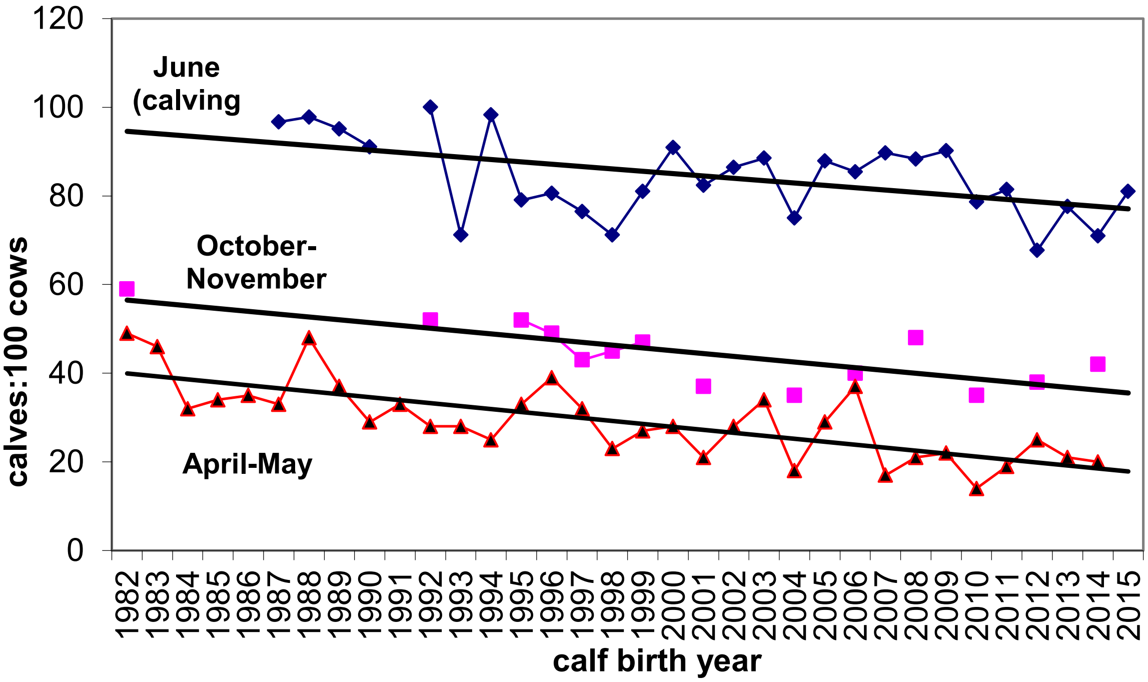

Figure 26. Unweighted least squares linear regression of calf:cow ratios during June (calving), the subsequent fall (Oct–Nov) and following spring (Apr–May, short yearling recruitment), Western Arctic caribou herd, 1982–2013. In this graph the April–May ratio for any specific year is shifted 1 year earlier to reflect year of birth. In contrast, in Figures 12 and 13, recruitment is plotted in the year the estimate was made to correspond with the period over which adult mortality is monitored. The April–May calf:cow ratio in this figure was calculated from the recorded calf:adult ratio using fall composition data from the closest point in time.

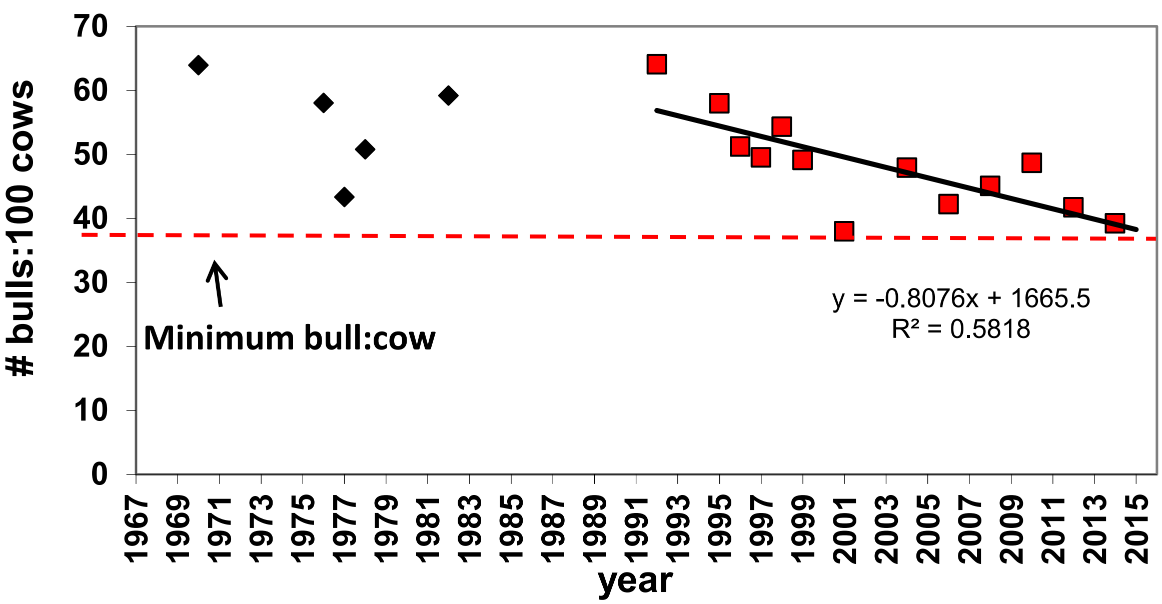

Figure 27. Fall bull:cow ratios, Western Arctic caribou herd, 1976–2014. No trend line shown for 1970–1982 because yearly survey methods varied.

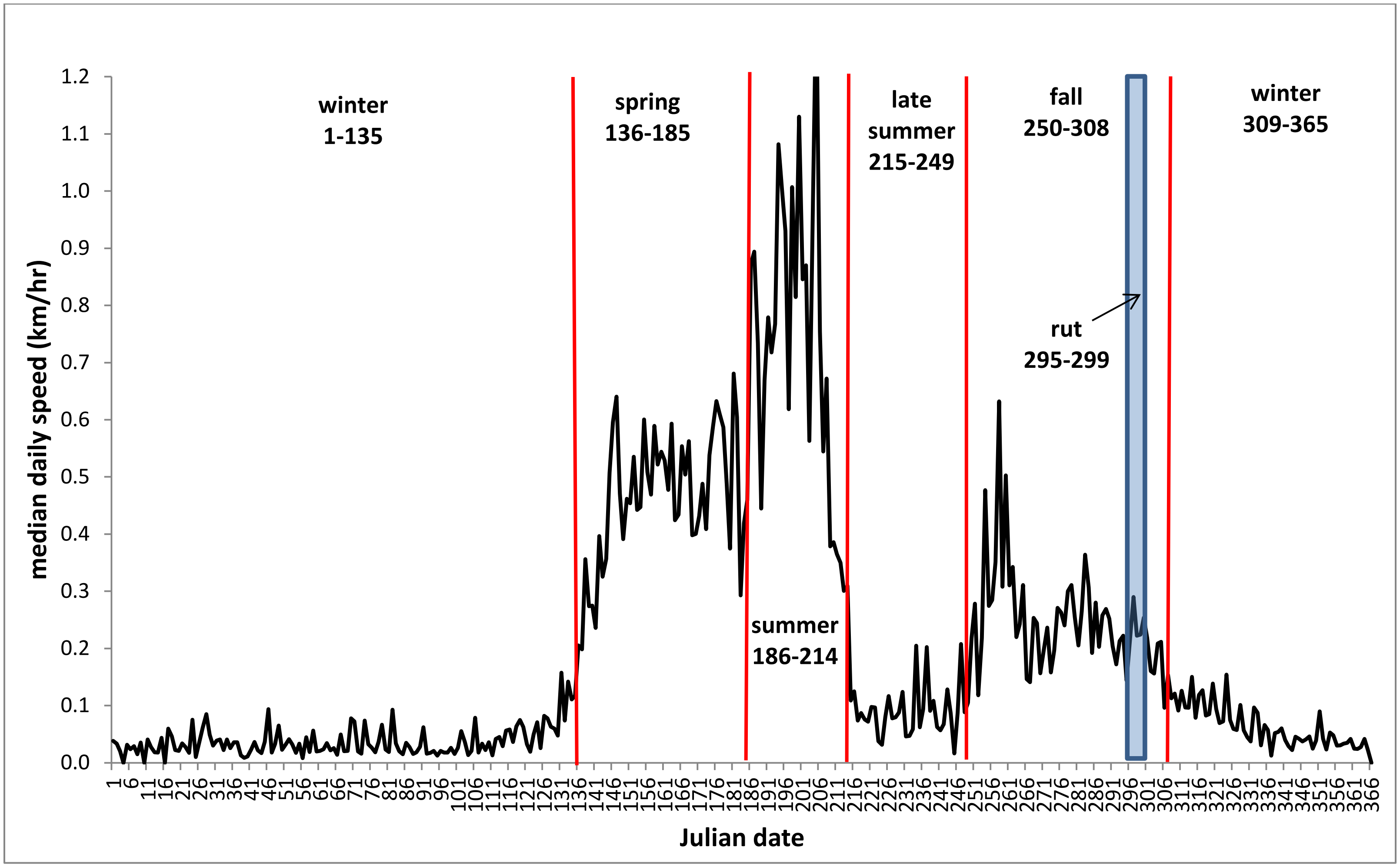

Figure 28. Median daily rate of travel and seasonal period determined from rate and direction of travel of satellite-collared bull caribou, Western Arctic caribou herd, 1 June 1988 through 20 November 2012 (all years combined).

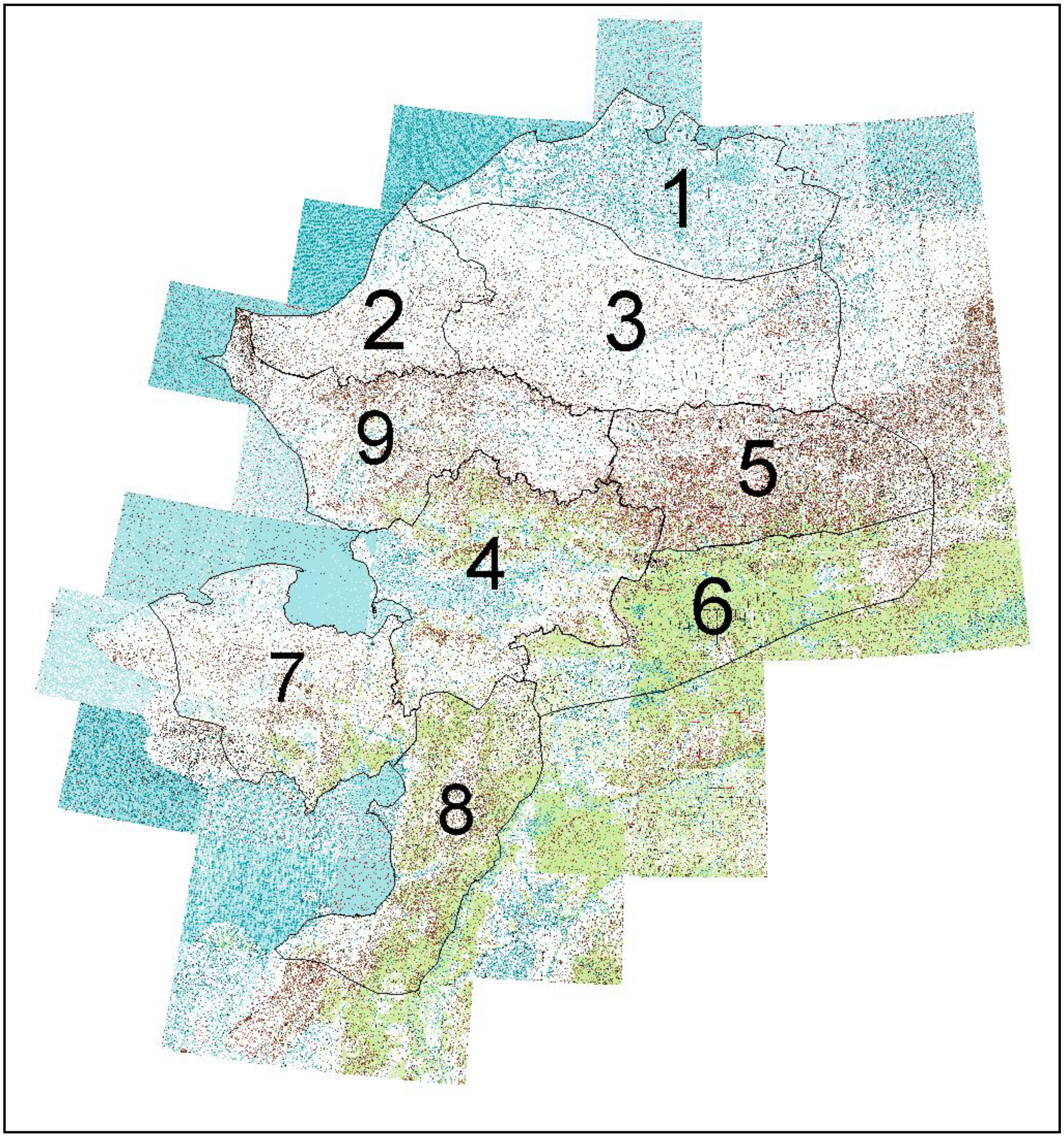

Figure 29. Subareas of Western Arctic herd range used to assess winter distribution (see Table 7 for geographic descriptions).

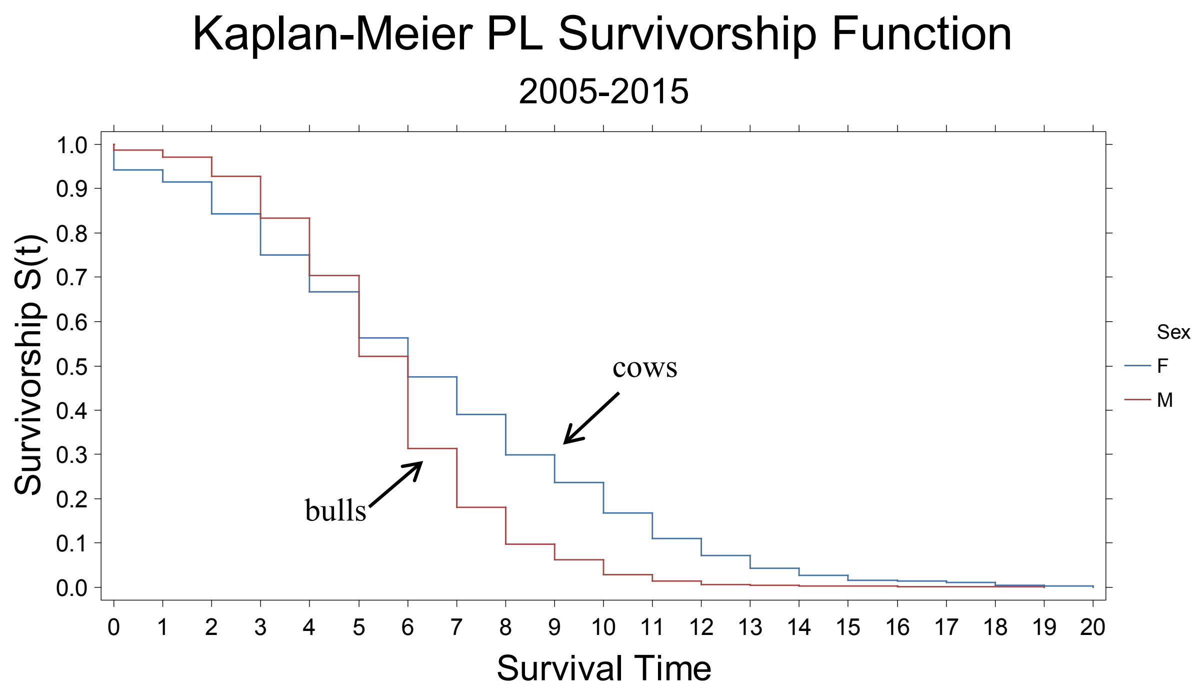

Figure 30. Kaplan-Meier product-limit survival functions for 856 bulls (red line) vs. 364 cows (blue line), 2005–2015. Estimates are based on mandible collections from hunter harvests and natural mortalities.

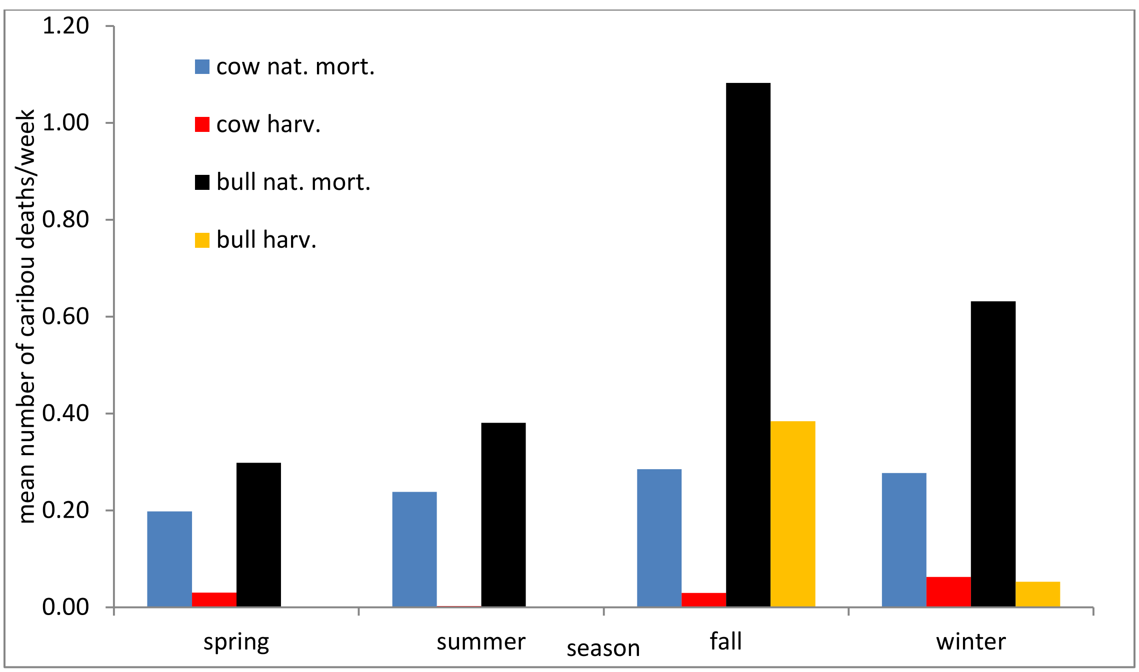

Figure 31. Seasonal mortality of radiocollared caribou by sex, CY92 through CY14 (all years combined); sample sizes for each sex standardized to 100 individuals/yr to compensate for annual differences in the total number of collared individuals and variable sample sizes between bulls and cows.

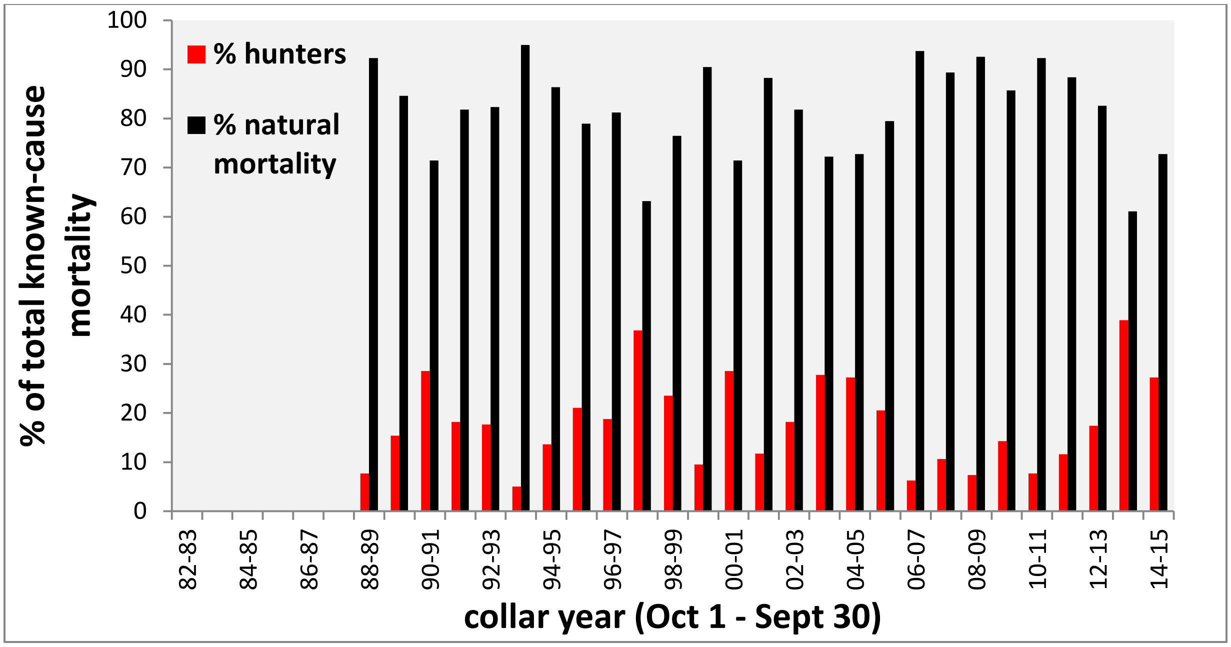

Figure 32. Percentage of total known-cause caribou mortality attributed to hunters (red bars) vs. natural factors (black bars), Western Arctic caribou herd, CY83–CY15. Data based on radiocollared bulls and cows, and excludes all unknown-cause mortalities. Years with <10 known-cause mortalities are excluded.

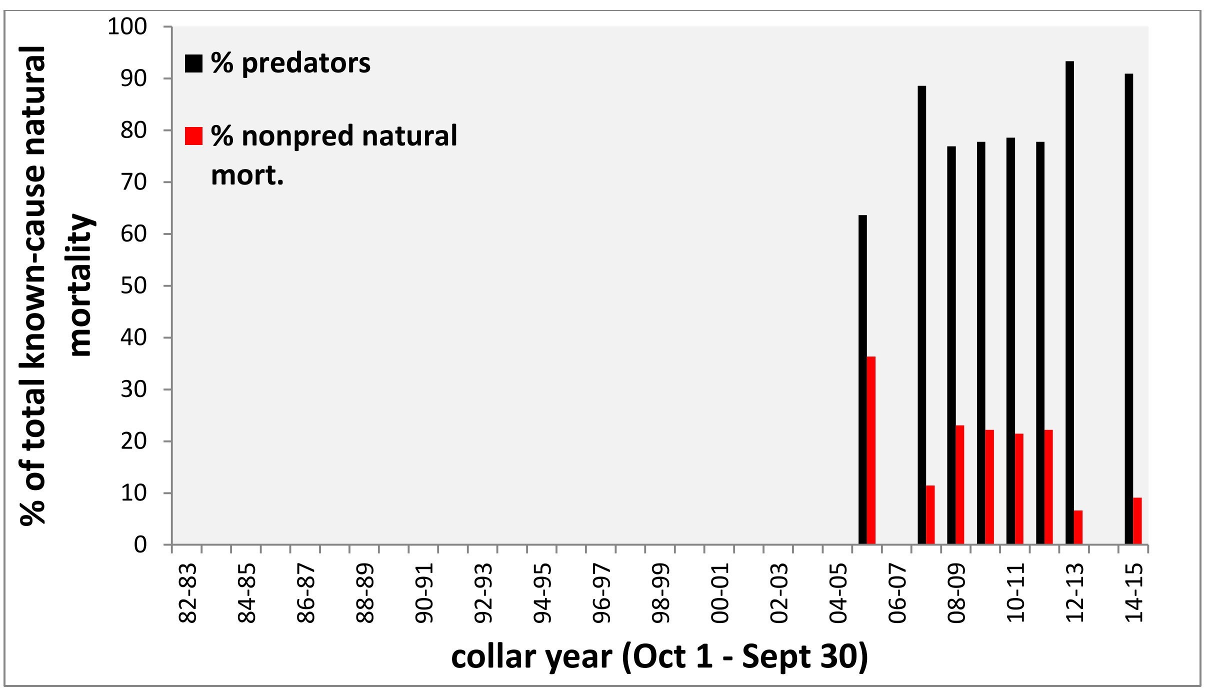

Figure 33. Percentage of total known-cause natural mortality attributed to predators (black bars) vs. other natural causes (red bars), Western Arctic caribou herd, CY83–CY15. Data based on radiocollared bulls and cows, and excludes all unknown-cause mortalities as well as natural mortalities for which cause of death was uncertain. Years with <10 known-cause natural mortalities are excluded.

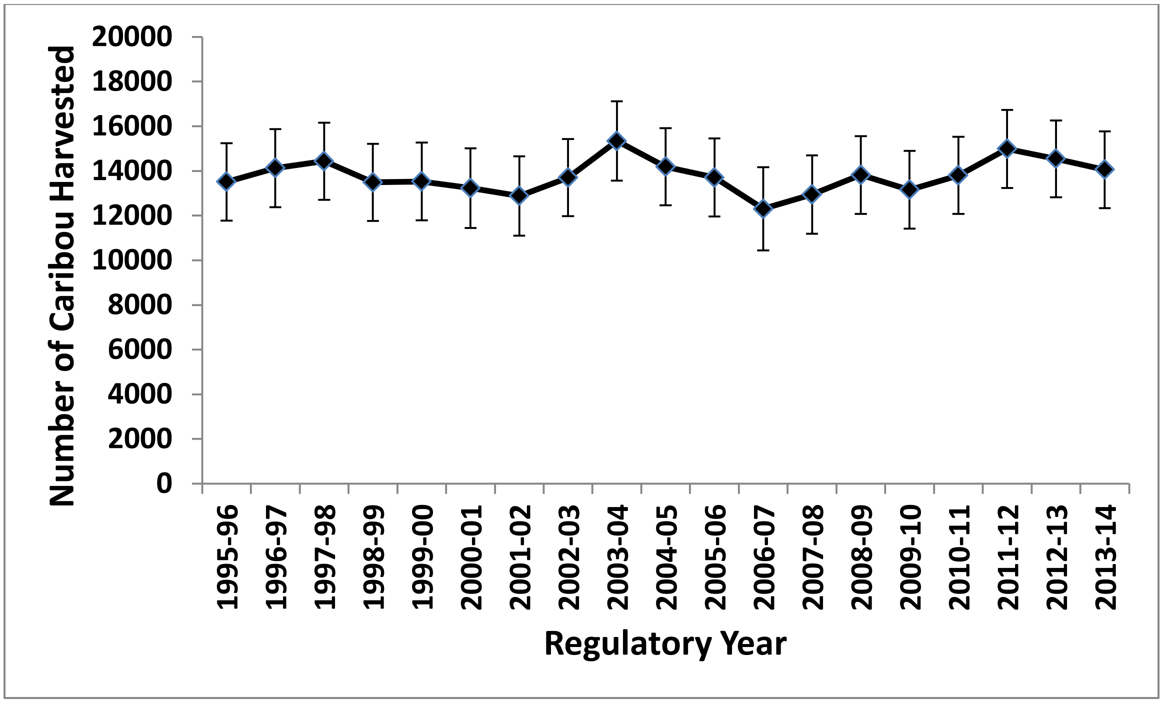

Figure 34. Estimated annual caribou harvest and 95% confidence intervals (vertical lines) by hunters living within the range of the Western Arctic caribou herd, RY95–RY13.

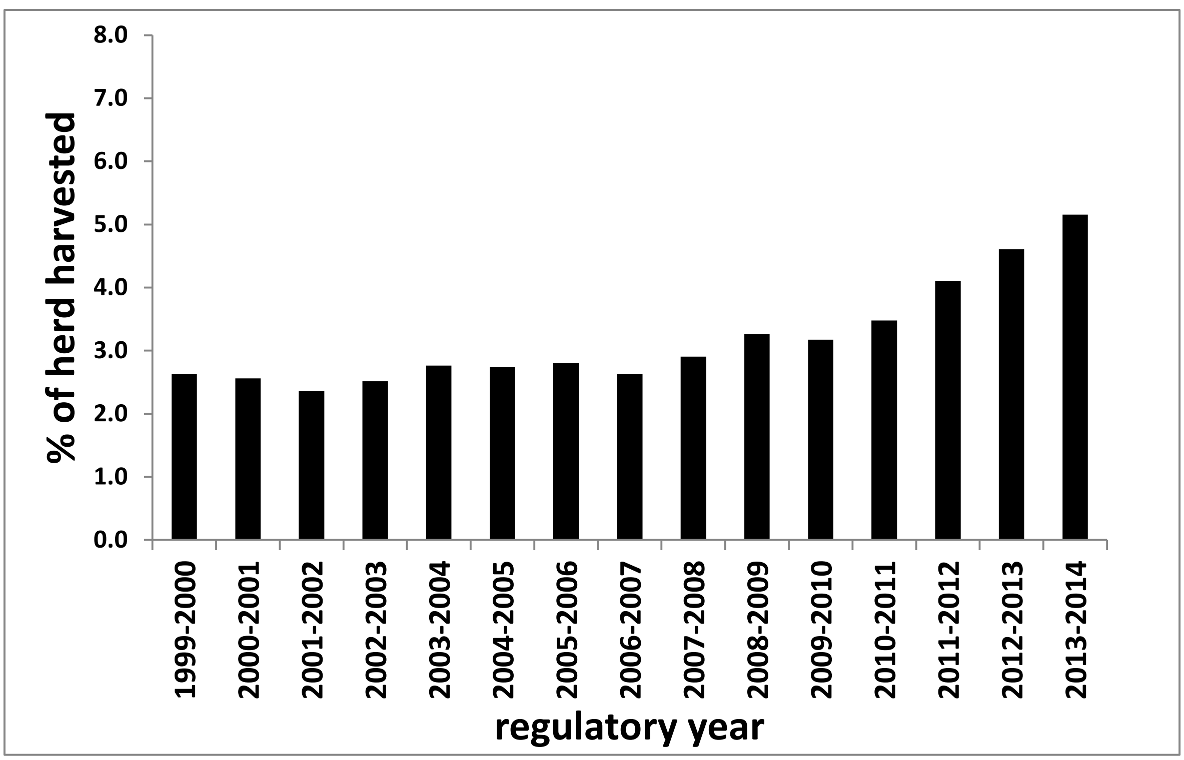

Figure 35. Percentage of the WAH harvested annually, RY99–RY13.

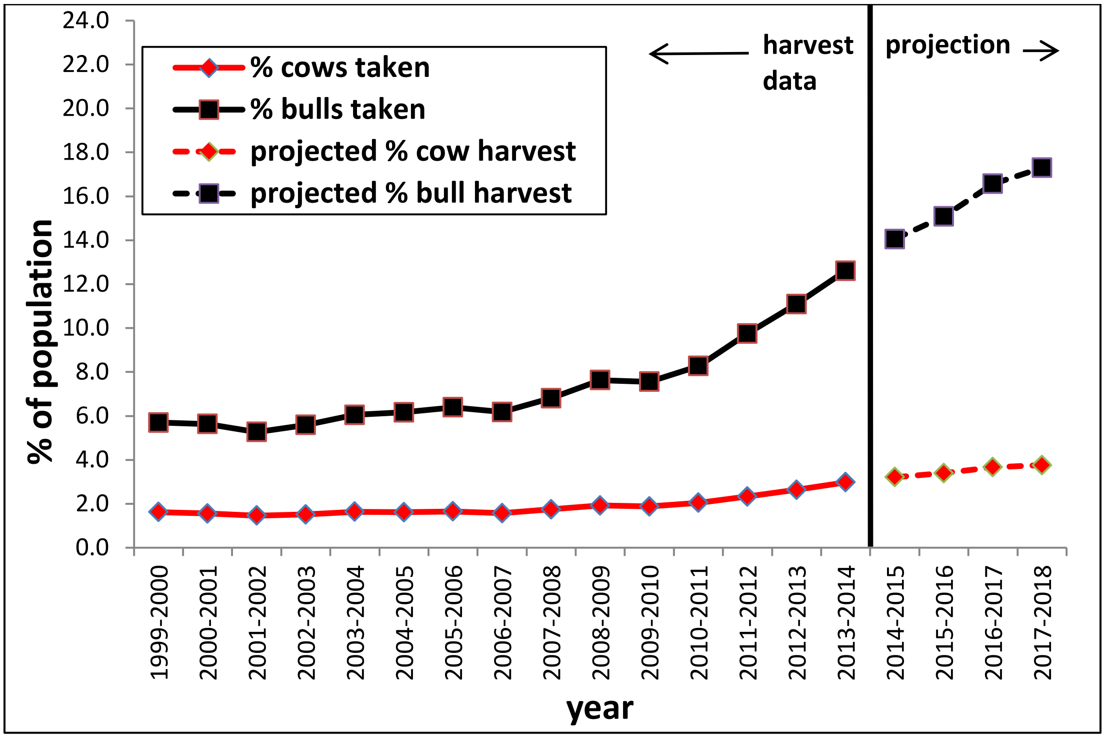

Figure 36. Observed and projected percentage of bulls and cows being harvested annually, Western Arctic caribou herd, RY99–RY17.

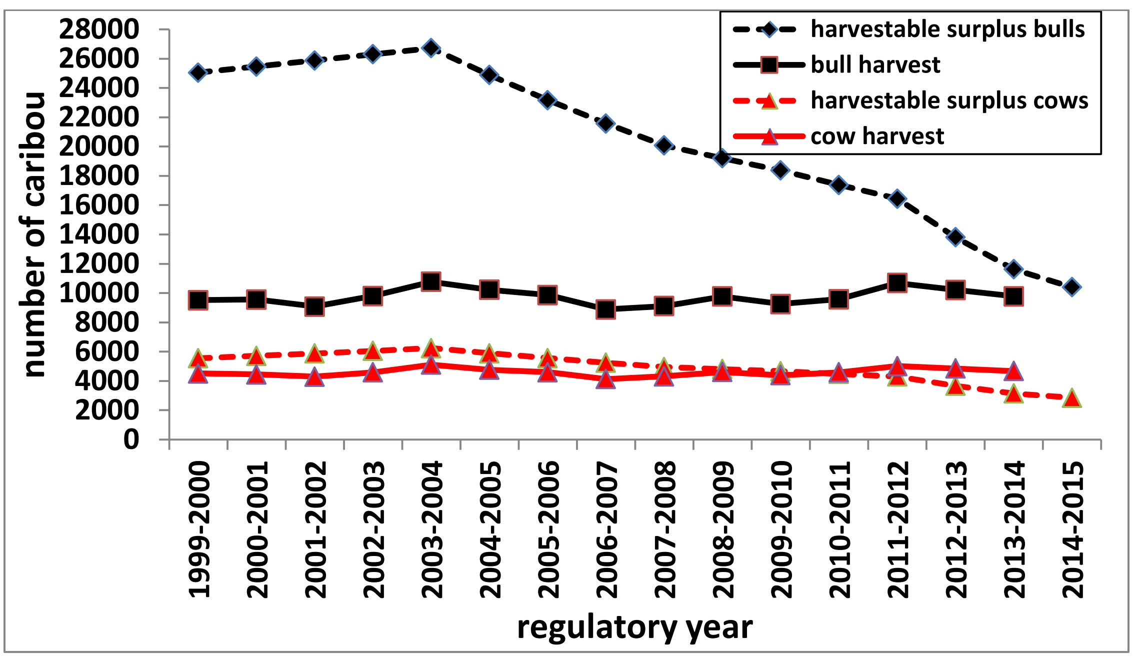

Figure 37. Annual bull and cow harvest relative to their respective harvestable surplus levels (harvestable surplus=15% of bulls and 2% of cows in the population; calves apportioned equally between bulls and cows), Western Arctic caribou herd, RY99–RY14.

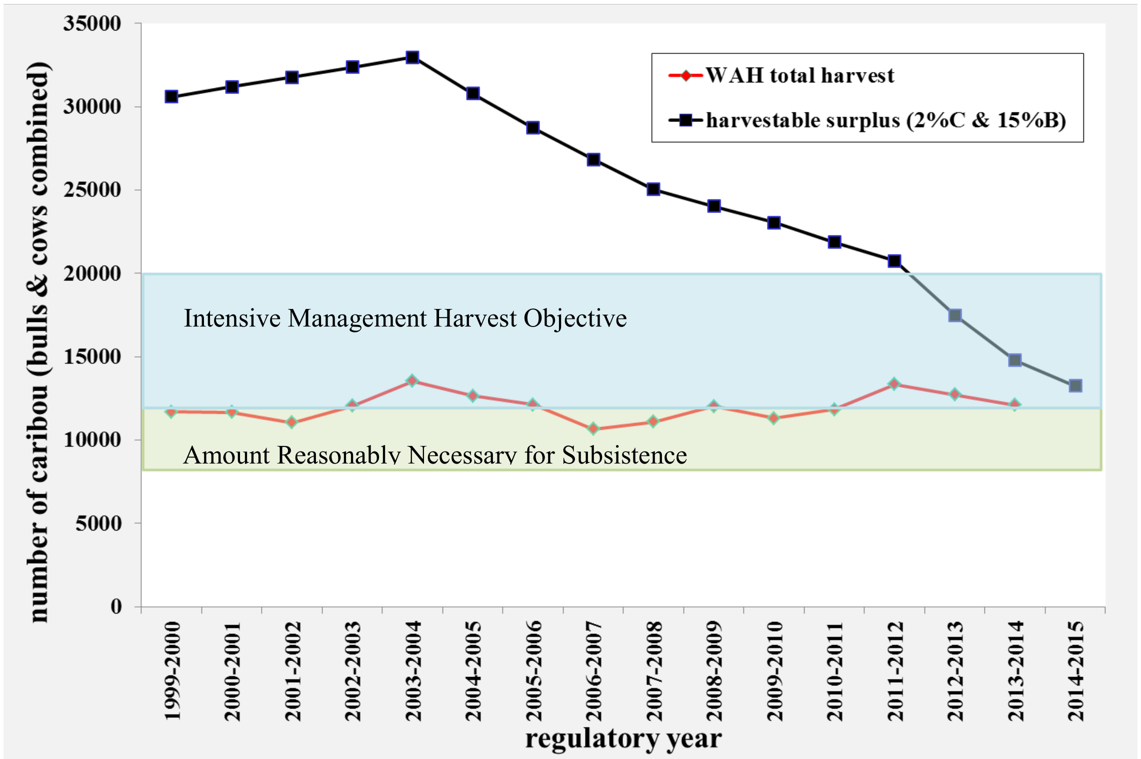

Figure 38. Harvestable surplus (bulls & cows combined) relative to harvest levels, Intensive Management Harvest Objective (12,000–20,000 caribou; blue box), and the Amount Reasonably Necessary for Subsistence range (8,000–12,000 caribou; green box), Western Arctic caribou herd, RY99–RY14.

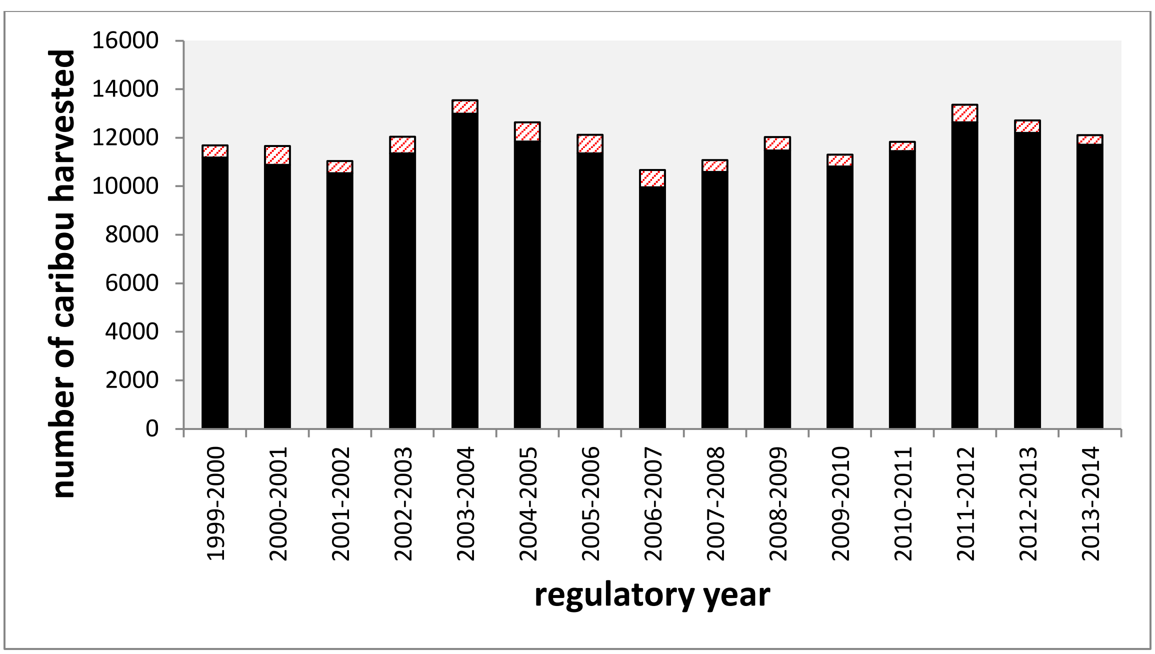

Figure 39. Total harvest by local (black bars) and nonlocal (red patterned bars) hunters, Western Arctic caribou herd, RY99–RY13.

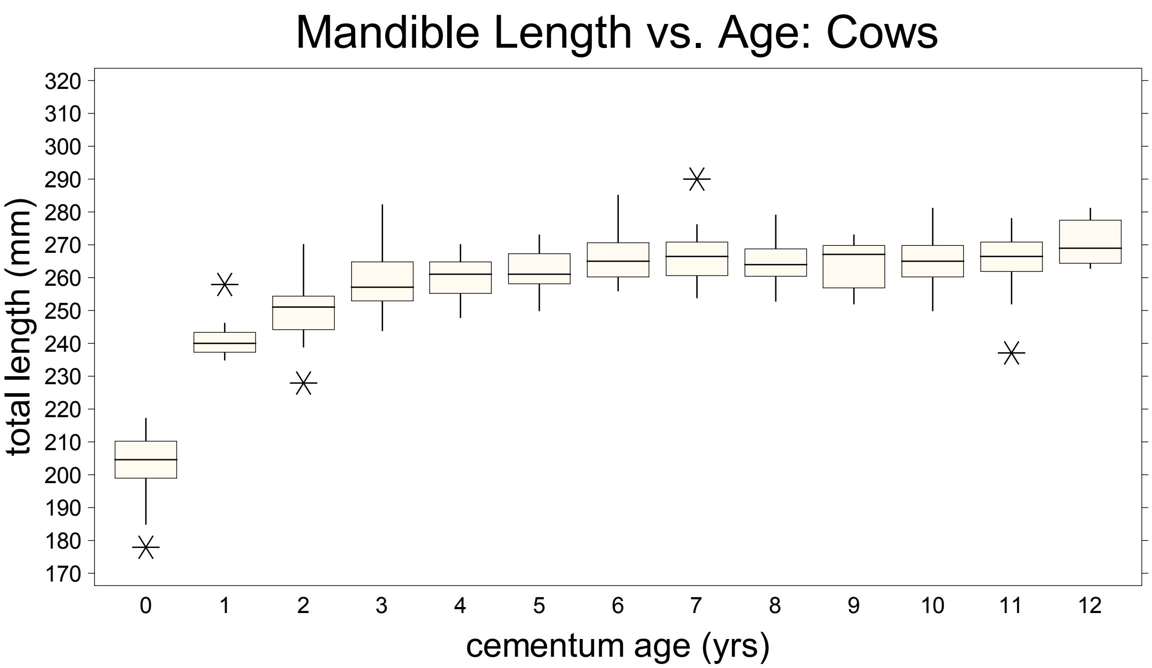

Figure 40. Box and whisker plot of cow mandible length as a function of tooth cementum age, Western Arctic caribou herd, 1997–2015 (n_i=245 cows; all years combined; asterisks=possible outliers).

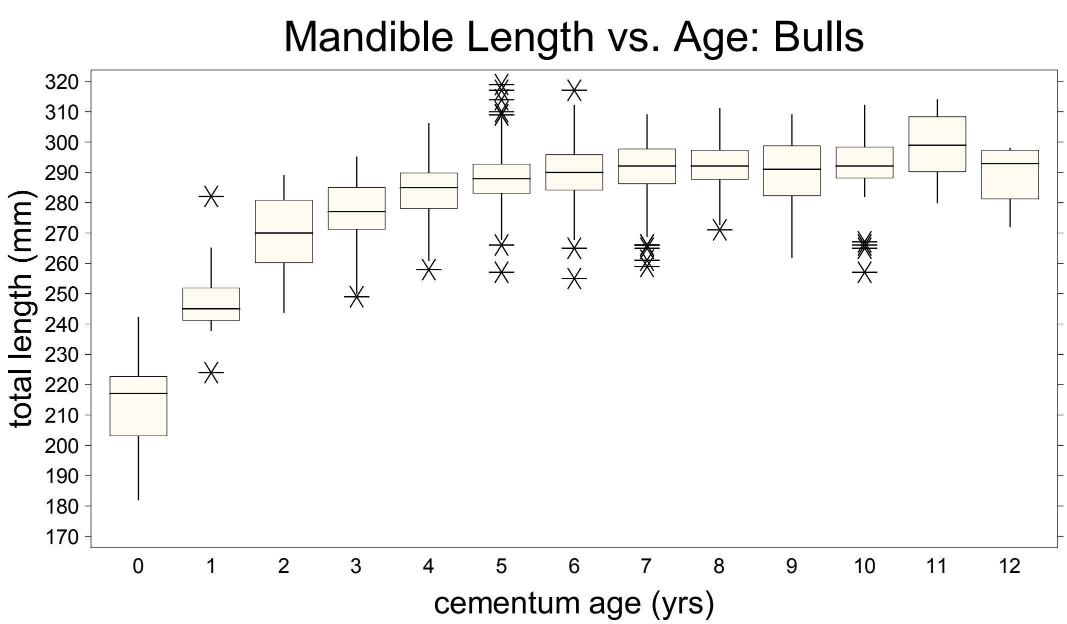

Figure 41. Box and whisker plot of bull mandible length as a function of tooth cementum age, Western Arctic caribou herd, 1997–2015 (n_i=695 bulls; all years combined; asterisks=possible outliers).

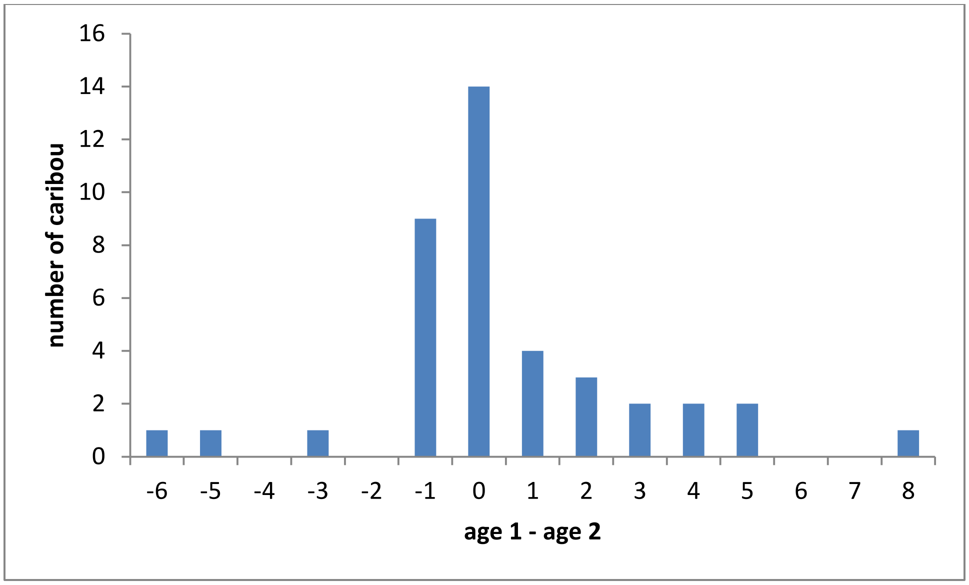

Figure 42. Difference between 2 blind samples in caribou tooth cementum ages, Western Arctic caribou herd (n_{i} = 40 caribou).

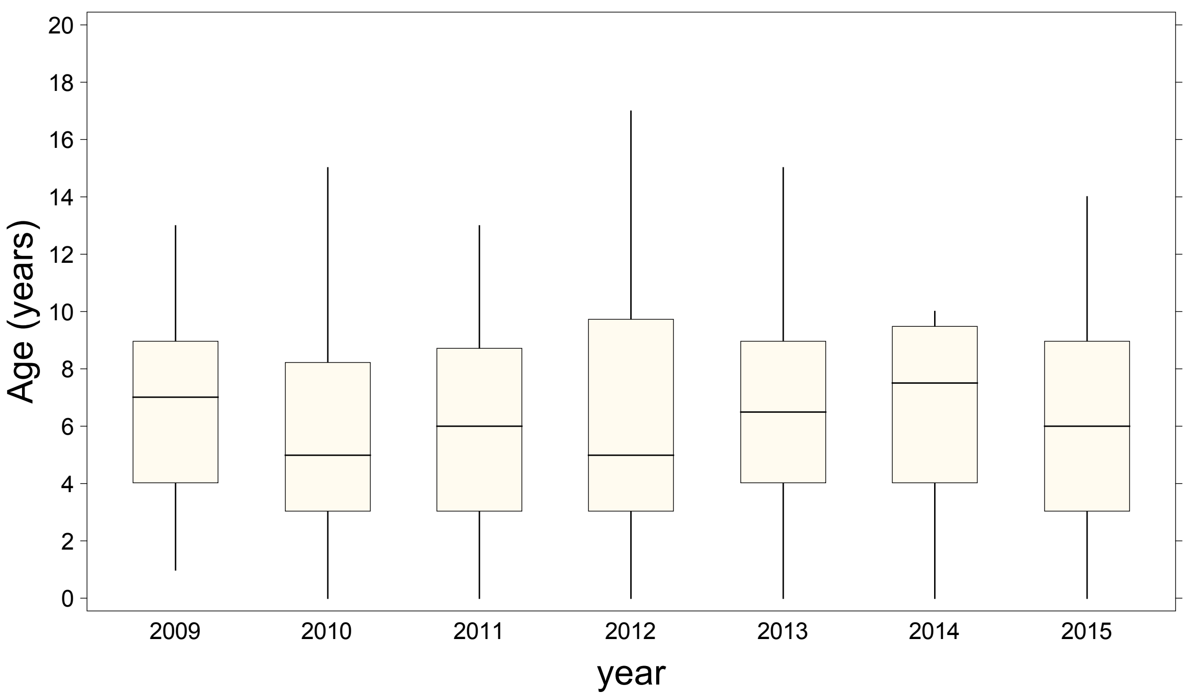

Figure 43. Box and whisker plot of cow tooth cementum age, Western Arctic caribou herd, 2009–2015 (n_i = 316 cows with no outliers; NOTE: n_i = 8 individuals in 2014).

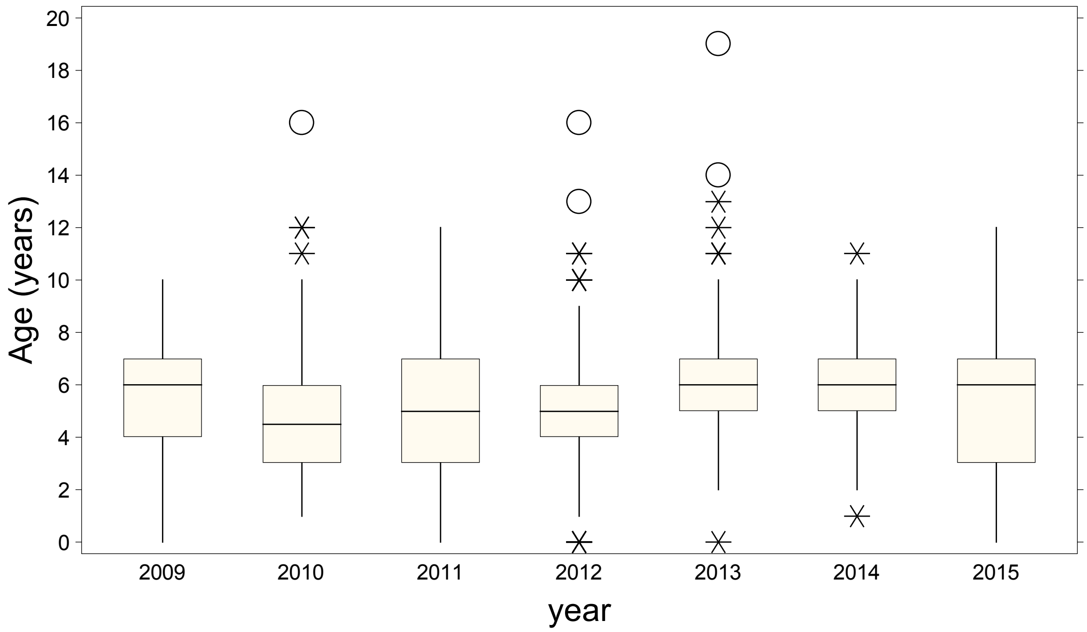

Figure 44. Box and whisker plot of bull tooth cementum age, Western Arctic caribou herd, 2009–2015 (n_i=843 bulls; asterisks=possible outliers; open dots=probable outliers).

Table 1. Photo census population estimates of the Western Arctic caribou herd, 1970–2013.

Census year	Min. count pop. est.	Rivest estimated population size	Population size[a]	Mean annual rate of change[b]	Estimated population size between censuses
1970	242,000		242,000		
1971				-18	199,000
1972				-18	164,000
1973				-18	135,000
1974				-18	111,000
1975				-18	91,000
1976	75,000		75,000		
1977				19	90,000
1978	107,000		107,000		
1979				14	122,000
1980	138,000		138,000		
1981				26	173,000
1982	172,000	217,863	217,863		
1983				1	221,000
1984				1	223,000
1985				1	226,000
1986	229,000		229,000		
1987				22	280,000
1988	343,000	300,299	343,000		
1989				10	378,000
1990	417,000	388,105	417,000		
1991				5	437,000
1992				5	457,000
1993	450,000	478,822	478,822		
1994				-1	473,000
1995				-1	468,000
1996	463,000	435,363	463,000		
1997				-1	458,000
1998				-1	453,000
1999	430,000	444,597	444,597		
2000				2	455,000
2001				2	466,000
2002				2	478,000
2003	490,000	475,391	490,000		
2004				-6	460,000
2005				-6	432,000
2006				-6	406,000
2007	377,000	381,501	381,501		
2008				-3	368,000
2009	348,000	355,828	355,828		
2010				-4	340,000
2011	314,000	324,963	324,963		
2012				-15	276,000
2013	232,000	234,757	234,757		

[a] Maximum value of minimum count or Rivest estimate.

[b] Mean annual rate of change=e^r where e=2.7183; $r=[\ln(N_{t2})-\ln(N_{t1})]/t$; t=number of years between censuses; N_{t1}=population estimate at $time_1$; N_{t2}=pop. estimate at $time_2$.

Table 2. Annual mortality rate and binomial confidence intervals for cows of the Western Arctic caribou herd collared with conventional or lightweight satellite radio collars[a] for collar years[b] 1987 through 2014.

Collar year	Sample size[a]	No. died	Mortality rate[c] (%)	Binomial Confidence Intervals 80%	90%	95%
CY87	88	8	9	5–14	5–16	4–17
CY88	87	13	15	10–21	9–23	8–24
CY89	102	15	15	10–20	9–22	8–23
CY90	100	15	15	10–21	9–22	9–24
CY91	104	16	15	11–21	10–22	9–24
CY92	107	21	20	15–25	14–27	13–28
CY93	102	16	16	11–21	10–23	9–24
CY94	108	14	13	9–18	8–20	7–21
CY95	112	20	18	13–23	12–25	11–26
CY96	107	16	15	11–20	10–22	9–23
CY97	102	8	8	5–12	4–14	3–15
CY98	94	16	17	12–23	11–25	10–26
CY99	86	19	22	16–29	15–31	14–32
CY00	77	14	18	13–25	11–27	10–29
CY01	87	13	15	10–21	9–23	8–24
CY02	99	19	19	14–25	13–27	12–28
CY03	99	14	14	10–20	9–21	8–23
CY04	104	23	22	17–28	16–30	15–31
CY05	111	32	29	23–35	22–37	21–38
CY06	102	16	16	11–21	10–23	9–24
CY07	118	36	31	25–37	24–38	22–40
CY08	96	22	23	17–29	16–31	15–33
CY09	110	31	28	22–34	21–36	20–37
CY10	114	23	20	15–26	14–27	13–29
CY11	108	36	33	27–40	26–42	25–43
CY12	86	17	20	14–26	13–28	12–30
CY13	93	14	15	10–21	9–23	8–24
CY14	104	18	17	13–23	12–25	11–26

[a] Sample size=number of potentially active conventional or lightweight satellite radio collars active on adult cows at the beginning of the collar year.
[b] Collar year=12 month period beginning 1 October (e. g. CY87 = 1 Oct 1987–30 Sep 1988).
[c] Mortality rate=(Number caribou died/Sample size)100.

Table 3. Short yearling[a] survey results of the Western Arctic caribou herd, 1984–2015.

Year	Number of caribou			Number			
	Adults	SY[a]	Total	Groups	Radio-collared cows	SY[a]:100 adults	3-yr moving average SY[a]:100 adults
1984	1,646	503	2,149			31	28
1985	2,776	600	3,376			22	25
1986	5,372	1,227	6,599			23	23
1987	4,272	1,003	5,275			23	23
1988	6,047	1,312	7,359	31	45	22	26
1989	5,321	1,718	7,039	29	37	32	26
1990	5,231	1,278	6,509	25	36	24	25
1991	7,111	1,371	8,482	47	48	19	22
1992	7,660	1,678	9,338	49	52	22	20
1993	4,396	814	5,210	19	33	19	20
1994	8,369	1,587	9,956	44	53	19	18
1995	13,283	2,196	15,479	53	86	17	19
1996	4,876	1,073	5,949	32	36	22	22
1997	9,298	2,438	11,736	40	56	26	23
1998	7,409	1,585	8,994	34	46	21	21
1999	6,354	975	7,329	34	36	15	18
2000	8,398	1,513	9,911	41	47	18	17
2001	6,814	1,294	8,108	32	33	19	17
2002	8,268	1,258	9,526	38	42	15	18
2003	8,518	1,602	10,120	42	49	19	19
2004	7,078	1,599	8,677	33	42	23	18
2005	8,376	1,026	9,402	35	40	12	18
2006	7,528	1,479	9,007	36	41	20	19
2007	10,570	2,603	13,173	44	57	25	19
2008	9,550	1,084	10,634	43	54	11	17
2009	13,873	1,963	15,836	59	71	14	13
2010	9,890	1,479	11,369	47	53	15	13
2011	11,316	1,058	12,374	52	58	9	12
2012	8,015	1,012	9,027	40	41	13	13
2013	9,584	1,601	11,185	36	53	17	14
2014	10,423	1,425	11,848	27	57	14	14
2015	12,659	1,661	14,320	33	66	13	14

[a] Short yearlings (SY) are defined as 10- to 11-month-old caribou.

Table 4. Aerial calving survey results from observations of radiocollared cows in the Western Arctic caribou herd, 1992–2015.

Year	Median June survey date	With Calf	No Calf ≥1 hard antler	No Calf soft antlers	No Calf no antlers	Total	Maternal	Non-Maternal	Calves: 100 Cows
1992	12	55	6	0	10	71	61	10	86
1993	14	39	3	17	21	80	42	39	53
1994	11	42	15	2	21	80	57	23	71
1995	11	47	2	13	21	83	49	34	59
1996	6	38	16	13	21	88	54	34	61
1997	5	39	13	16	22	90	52	38	58
1998	13	36	5	16	21	78	41	37	53
1999	12	47	0	11	23	81	47	34	58
2000	13	39	11	5	17	72	50	22	69
2001	16	8	34	9	13	64	42	22	66
2002	2	13	38	8	6	65	51	14	78
2003	6	16	38	7	19	80	54	26	68
2004	6	38	13	17	18	86	51	35	59
2005	10	45	13	8	18	84	58	26	69
2006	10	37	11	8	18	74	48	26	65
2007	6	36	25	7	16	84	61	23	73
2008	12	48	5	7	16	76	53	23	70
2009	6	35	20	6	9	70	55	15	79
2010	7	49	9	17	5	80	58	22	73
2011	9	47	10	13	4	74	57	17	77
2012	7	41	3	21	6	71	44	27	62
2013	12	37	8	13	13	71	45	26	63
2014	11	45	2	19	2	68	47	21	69
2015	7	46	7	13	2	68	53	15	78

Table 5. Fall population composition of the Western Arctic caribou herd, 1961–2014.

Year	Bulls	Cows	Calves	Total	Calves: 100 Cows	Calves: 100 Adults	Bulls: 100 Cows
1961	276	501	187	964	37	24	55
1970	1,748	2,732	1,198	5,678	44	27	64
1975	720	2,330	1,116	4,166	48	37	31
1976	273	431	222	926	52	32	63
1980	715	1,354	711	2,780	53	34	53
1982	1,896	3,285	1,923	7,104	59	37	58
1992	1,600	2,498	1,299	5,397	52	32	64
1995	1,176	2,029	1,057	4,262	52	33	58
1996	2,621	5,119	2,525	10,265	49	33	51
1997	2,588	5,229	2,255	10,072	43	29	49
1998	2,298	4,231	1,909	8,438	45	29	54
1999	2,059	4,191	1,960	8,210	47	31	49
2001[a]	1,117	2,943	1,095	5,155	37	27	38
2004	2,916	6,087	2,154	11,157	35	24	48
2006	1,900	4,501	1,811	8,212	40	28	42
2008	2,981	6,618	3,156	12,755	48	33	45
2010	2,419	4,973	1,735	9,127	35	23	49
2012	2,119	5,082	1,919	9,120	38	27	42
2014	2,384	6,082	2,553	11,019	42	30	39

[a] Sample from Mulgrave Hills only and based on 25 radiocollared caribou in the area. Survey was conducted on 14 Nov and segregation between bulls and cows was apparent. The bull:cow ratio is probably biased low.

Table 6. Season dates for Western Arctic Herd bulls and cows, 1 June 1988–20 November 2012, determined from rate and direction of travel (excludes records for caribou movements that were affected by Red Dog mine operations during 15 August through 20 November).

Sex	Season	Julian dates	Calendar dates
Cows			
	Spring	126–159	6 May–8 Jun
	Calving	160–164	9 Jun–13 Jun
	Post-calving	165–186	14 Jun–5 Jul
	Summer	187–211	6 Jul–30 Jul
	Late summer	212–260	31 Jul–17 Sep
	Fall	261–311	18 Sep–7 Nov
	(Rut)	(295–299)	(22 Oct–26 Oct)
	Winter	312–125	8 Nov–5 May
Bulls			
	Spring	136–185	16 May–4 Jul
	Summer	186–214	5 Jul–2 Aug
	Late summer	215–249	3 Aug–6 Sep
	Fall	250–308	7 Sep–4 Nov
	(Rut)	(295–299)	(22 Oct–26 Oct)
	Winter	309–135	5 Nov–15 May

Table 7. Percent[a] winter distribution of radiocollared caribou in 9 geographic subareas[b] of total range, Western Arctic caribou herd, 1991–1992 through 2014–2015 (winter=1 Nov–31 Mar; bottom row (n_i) is number of radiocollared caribou found during each winter; subareas are shown in Figure 29).

	Year																							
	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Area	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1	5	9	0	1	10	4	6	9	0	5	5	4	2	0	1	0	0	0	5	1	1	1	2	3
2	1	0	0	1	0	0	0	0	9	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
3	1	2	4	0	5	0	5	1	1	5	0	4	0	0	2	1	8	0	1	0	0	1	0	4
4	52	6	1	26	33	12	5	11	42	12	22	23	12	16	48	33	38	31	26	17	8	38	10	8
5	9	6	8	3	26	4	25	31	5	6	9	16	31	5	10	8	28	6	3	20	24	0	8	4
6	6	19	4	1	2	2	0	2	12	0	3	8	20	0	13	0	10	2	19	33	16	0	2	0
7	4	4	7	6	9	59	29	24	17	42	31	38	14	19	5	16	13	43	13	6	25	42	73	77
8	20	54	75	54	16	20	29	20	5	29	5	0	20	53	18	42	2	15	25	23	20	4	5	2
9	2	0	0	9	1	0	1	1	9	2	25	7	1	6	2	0	1	3	9	0	6	15	0	1
n_i[c]	61	70	90	78	63	81	88	67	72	63	58	69	86	78	70	69	90	78	68	81	83	67	65	69

[a] Percent of total radiocollared caribou observed each winter, by subarea during each winter period; column totals include rounding error of ±2%.

[b] Areas: 1 North Slope coastal plain west of Colville drainage; 17,322 mi^2
2 Foothills of Brooks Range west of Utukok River; 8,817 mi^2
3 Foothills of Brooks Range east of Utukok River and west of Dalton Highway; 28,875 mi^2
4 Kobuk drainage below Selby River; Squirrel drainage below North Fork; Selawik drainage; Buckland drainage; 18,928 mi^2
5 Kobuk drainage above Selby R; central Brooks Range north of Koyukuk R & west of Dalton Hwy; Noatak drainage above Douglas Creek; 16,281 mi^2
6 Koyukuk drainage south of Brook Range mountains, including Kanuti Flats, Galena Flats; 20,945 mi^2
7 Seward Peninsula west of Buckland and Koyukuk villages; 15,436 mi^2
8 Nulato Hills; 14,126 mi^2
9 Noatak drainage below Douglas Creek; Squirrel drainage above North Fork; Wulik and Kivalina drainages; Lisburne Hills; 16,541 mi^2

[c] n_i = number of radiocollared caribou found during each winter; excludes the year of collar deployment; when collared caribou wintered in >1 subarea, we proportioned equal time among subareas and included fractions of use.

Table 8. Winter density (number/mi^2) of caribou in 9 geographic subareas of total range, Western Arctic caribou herd, 1991–1992 through 2014–2015 (winter=1 Nov–31 Mar; subareas are shown in Figure 22).

Area[a]	91 92	92 93	93 94	94 95	95 96	96 97	97 98	98 99	99 00	00 01	01 02	02 03	03 04	04 05	05 06	06 07	07 08	08 09	09 10	10 11	11 12	12 13	13 14	14 15
1	1.2	2.4	0.0	0.2	2.6	1.0	1.5	2.3	0.0	1.3	1.4	1.2	0.7	0.0	0.1	0.0	0.0	0.0	1.1	0.2	0.2	0.1	0.2	0.3
2	0.4	0.0	0.0	0.3	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1
3	0.1	0.3	0.6	0.0	0.8	0.0	0.7	0.2	0.2	0.8	0.0	0.6	0.0	0.0	0.1	0.0	1.0	0.0	0.1	0.0	0.0	0.1	0.0	0.3
4	12.1	1.5	0.3	6.4	8.1	2.8	1.3	2.7	9.8	2.9	5.3	5.7	3.0	3.7	4.3	2.8	7.7	6.1	4.9	3.0	1.3	5.5	1.2	0.9
5	2.4	2.0	2.5	0.7	7.5	1.0	7.0	8.5	1.3	1.6	2.5	4.6	9.5	1.5	1.1	0.8	6.6	1.3	0.6	4.3	4.8	0.0	1.2	0.6
6	1.2	4.0	1.0	0.3	0.4	0.5	0.0	0.5	2.5	0.0	0.8	1.8	4.6	0.0	1.0	0.0	1.8	0.3	3.2	5.4	2.4	0.0	0.3	0.0
7	1.2	1.3	2.2	2.0	2.7	17.2	8.5	7.0	5.0	12.4	9.4	11.8	4.5	5.7	0.5	1.6	3.2	10.3	2.9	1.2	5.2	7.5	11.1	10.6
8	6.3	17.1	25.4	18.0	5.3	6.8	9.5	6.4	1.5	9.2	1.7	0.2	6.9	17.5	2.1	4.7	0.6	4.0	6.2	5.5	4.7	0.8	0.8	0.0
9	0.4	0.0	0.00	2.6	0.2	0.0	0.3	0.4	2.4	0.7	7.0	2.1	0.3	1.8	0.2	0.0	0.3	0.6	1.9	0.0	1.2	2.5	0.0	0.2
N[b]	*437*	*457*	**479**	*473*	*468*	**463**	*458*	*453*	*445*	*455*	*466*	*478*	**490**	*460*	*432*	*406*	**382**	*368*	**355**	*340*	**325**	*276*	**235**	*212*

[a] Areas: 1 North Slope coastal plain west of Colville drainage; 17,322 mi^2

2 Foothills of Brooks Range west of Utukok River; 8,817 m

3 Foothills of Brooks Range east of Utukok River and west of Dalton Highway; 28,875 mi^2

4 Kobuk drainage below Selby River; Squirrel drainage below North Fork; Selawik drainage; Buckland drainage; 18,928 mi^2

5 Kobuk drainage above Selby R; central Brooks Range north of Koyukuk R & west of Dalton Hwy; Noatak drainage above Douglas Creek; 16,281 mi^2

6 Koyukuk drainage south of Brook Range mountains, including Kanuti Flats, Galena Flats; 20,945 mi^2

7 Seward Peninsula west of Buckland and Koyukuk villages; 15,436 mi^2

8 Nulato Hills; 14,126 mi^2

9 Noatak drainage below Douglas Creek; Squirrel drainage above North Fork; Wulik and Kivalina drainages; Lisburne Hills; 16,541 mi^2

[b] Estimated Western Arctic caribou herd population size in thousands from Table 1. Numbers in **bold** are census results; numbers in *italics* are estimated using average annual rate of population change.

Table 9. Number of radiocollared caribou mortalities (morts) by source and year, Western Arctic caribou herd, collar years 1979–2014. (All categories are mutually exclusive; collar year = 1 Oct–30 Sep).

Collar year	Initial n_i collared caribou	Total morts	Known-cause morts	Harvested by hunter	Wolf	Bear	Unknown predator	Starved	Non-predator natural mortality	Unknown natural morts
CY80	33	3	0	–	–	–	–	–	–	–
CY81	50	9	3	2	1	0	0	0	0	0
CY82	43	2	1	0	0	0	0	0	0	1
CY83	46	17	10	2	1	0	0	0	0	7
CY84	29	5	1	1	0	0	0	0	0	0
CY85	49	6	3	3	0	0	0	0	0	0
CY86	66	8	6	3	0	0	0	0	0	3
CY87	95	7	7	3	0	0	0	0	1	3
CY88	93	16	13	1	2	0	0	0	1	9
CY89	107	17	14	2	2	0	0	0	0	10
CY90	104	16	14	4	0	0	0	0	1	9
CY91	112	16	12	1	0	0	0	0	1	11
CY92	128	26	18	3	1	0	0	0	0	14
CY93	116	24	19	1	0	0	1	0	0	17
CY94	116	23	22	3	0	0	1	1	0	17
CY95	121	25	19	4	2	1	1	0	0	11
CY96	118	18	16	3	1	0	0	0	0	12
CY97	114	20	17	6	1	1	1	0	0	8
CY98	107	19	17	4	0	0	0	0	0	13
CY99	100	27	21	2	2	0	4	0	3	10
CY00	86	20	14	4	0	0	0	0	1	9
CY01	98	21	17	2	0	0	3	0	1	11
CY02	115	26	21	4	0	0	0	0	2	15
CY03	113	27	21	5	0	0	1	0	0	15
CY04	115	25	22	6	3	1	1	0	3	8
CY05	129	47	38	8	0	0	6	0	3	21
CY06	115	17	16	1	0	0	6	0	3	6
CY07	139	46	46	4	7	2	22	0	3	8
CY08	114	28	27	2	1	0	9	0	3	12
CY09	130	38	36	5	5	1	7	0	4	14
CY10	128	29	26	2	9	2	0	0	4	10
CY11	122	47	43	5	12	5	11	4	4	2
CY12	100	23	23	4	4	3	7	0	1	4
CY13	103	19	18	7	6	2	1	0	0	2
CY14	113	23	22	6	2	3	5	0	1	5

Table 10. Annual WAH-TCH caribou harvest levels by sex and hunter residence, RY99 through RY14.

Regulatory year (RY)	WAH-TCH harvest by local hunters[a]	WAH harvest by local hunters[b]	WAH harvest by nonlocal hunters[c]	Total WAH harvest[d]	Approximate WAH-TCH cow harvest[e]	Approximate WAH-TCH bull harvest[f]
RY99	13,525	11,175	509	11,684	4,514	9,520
RY00	13,232	10,882	775	11,657	4,444	9,563
RY01	12,879	10,529	505	11,034	4,300	9,083
RY02	13,699	11,349	689	12,038	4,590	9,799
RY03	15,338	12,988	549	13,537	5,116	10,771
RY04	14,186	11,836	799	12,635	4,761	10,224
RY05	13,703	11,353	762	12,115	4,598	9,867
RY06	12,302	9,952	714	10,666	4,131	8,885
RY07	12,943	10,593	488	11,081	4,320	9,111
RY08	13,818	11,468	563	12,031	4,616	9,764
RY10	13,155	10,805	491	11,296	4,390	9,256
RY11	13,797	11,447	374	11,821	4,590	9,581
RY12	14,986	12,636	716	13,352	5,017	10,685
RY13	14,543	12,193	520	12,713	4,851	10,212
RY14	14,058	11,708	397	12,105	4,679	9,776

[a] Community harvest data (ADF&G 2000).
[b] This subtracts a constant 2,350 caribou (the estimated total TCH harvest) from the combined WAH–TCH annual harvest estimate.
[c] Statewide caribou harvest report data: this assumes that 95% of the caribou harvest by nonlocal hunters in Unit 26A were from the WAH.
[d] Total WAH harvest = (WAH harvest by local hunters)+(WAH harvest by nonlocal hunters).
[e] WAH–TCH cow harvest = (0.33*WAH-TCH harvest by local hunters)+(0.10*WAH harvest by nonlocal hunters).
[f] WAH–TCH bull harvest = (0.67*WAH-TCH harvest by local hunters)+(0.90*WAH harvest by nonlocal hunters).

Table 11. Number of hunters, success rates and caribou harvest[a] by sex for hunters residing outside the range of the Western Arctic caribou herd (WAH) per regulatory year and unit, RY09 through RY13.

Reg.		Number of hunters			Success	Caribou harvest			
Year	Unit	Successful	Unsuccessful	Total	rate (%)	Bulls	Cows	Unk	Total
RY09	21	0	1	1	0	0	0	0	0
	22	15	29	44	34	23	3	0	26
	23	276	163	439	63	324	60	9	393
	24	18	63	81	22	13	6	0	19
	26A	58	22	80	72	60	12	2	74
	Total	367	278	645	57	420	81	11	512
RY10	21	1	1	2	50	1	0	1	2
	22	29	29	58	50	37	1	0	38
	23	178	243	421	42	222	25	1	248
	24	10	38	48	21	16	4	0	20
	26A	46	31	77	60	51	12	3	66
	Total	264	342	606	44	327	42	5	374
RY11	21	0	1	1	0	0	0	0	0
	22	31	23	54	57	43	5	0	48
	23	315	142	457	69	452	55	14	521
	24	32	14	46	70	39	7	0	46
	26A	70	21	91	77	80	10	8	98
	Total	448	201	649	69	614	77	22	713
RY12	21	0	0	0		0	0	0	0
	22	23	20	43	53	38	3	1	42
	23	259	189	448	58	323	63	5	391
	24	4	43	47	9	4	1	0	5
	26A	70	30	100	70	78	12	0	90
	Total	356	282	638	56	443	79	6	528
RY13	21	0	0	0		0	0	0	0
	22	16	24	40	40	23	2	0	25
	23	186	187	373	50	180	36	46	262
	24	9	38	47	19	14	3	0	17
	26A	85	41	126	67	97	6	14	117
	Total	296	290	586	51	314	47	60	421

[a] This table likely overestimates the number of WAH caribou taken by hunters residing outside the range of the WAH because it includes a small number of Teshekpuk caribou herd taken in Unit 26A.

Table 12. Numbers and percent of nonlocal hunters by transport methods and year for the Western Arctic caribou herd, RY99–RY13 (all Units combined; annual % in parentheses).

Reg. Year (RY)	Plane	Horse-Dog team	Boat	4-wheeler	Snow machine	Off road vehicle	Highway vehicle	Airboat	No transp.	Total
RY99	414 (72)	3 (1)	83 (14)	20 (3)	14 (2)	4 (1)	32 (6)	3 (1)	0 (0)	573
RY00	426 (65)	0 (0)	139 (21)	23 (3)	19 (3)	1 (0)	51 (8)	0 (0)	0 (0)	659
RY01	410 (69)	3 (1)	88 (15)	19 (3)	12 (2)	3 (1)	59 (10)	2 (0)	0 (0)	596
RY02	460 (67)	1 (0)	122 (18)	31 (5)	14 (2)	2 (0)	50 (7)	3 (0)	0 (0)	683
RY03	377 (67)	0 (0)	99 (17)	28 (5)	9 (2)	5 (1)	48 (8)	0 (0)	0 (0)	566
RY04	470 (73)	3 (0)	90 (14)	17 (3)	18 (3)	2 (0)	47 (7)	0 (0)	0 (0)	647
RY05	510 (74)	1 (0)	112 (16)	11 (2)	12 (2)	6 (1)	33 (5)	1 (0)	0 (0)	686
RY06	522 (76)	4 (1)	102 (15)	20 (3)	4 (1)	7 (1)	26 (4)	0 (0)	1 (0)	686
RY07	370 (76)	2 (1)	57 (12)	18 (4)	4 (1)	3 (1)	16 (5)	1 (0)	0 (0)	471
RY08	396 (79)	2 (0)	60 (12)	25 (5)	5 (1)	3 (1)	13 (3)	0 (0)	0 (0)	504
RY09	400 (65)	5 (1)	90 (15)	29 (5)	8 (2)	8 (1)	71 (12)	0 (0)	4 (1)	615
RY10	431 (74)	5 (1)	55 (9)	32 (6)	11 (2)	13 (2)	35 (6)	0 (0)	0 (0)	582
RY11	442 (69)	3 (1)	71 (11)	31 (5)	31 (5)	11 (2)	49 (8)	3 (0)	1 (0)	642
RY12	476 (76)	1 (0)	54 (9)	18 (3)	27 (4)	10 (2)	39 (6)	2 (0)	1 (0)	628
RY13	427 (76)	0 (0)	43 (8)	12 (2)	13 (2)	10 (2)	57 (10)	1 (0)	2 (0)	565

Table 13. Comparative and differential incisor (I-1) cementum ages (years) for 13 known-age reindeer or caribou.

Known age (yrs)	Cementum age 1	Sample quality 1	Difference 1	Cementum age 2	Sample quality 2	Difference 2
4	6	A	-2	6	A	-2
3	4	B	-1	3	A	0
13	12	A	1	13.5	A	-0.5
14	10	B	4	11	B	3
19	14	A	5			
1	1	A	0			
10	10	A	0	10	A	0
2	2	B	0			
3	2	A	1			
2	1	A	1	1	A	1
8	8	A	0	8	A	0
4	4	A	0	4	A	0
10	7	B	3			

Table 14. Median fall calf weights (lb) by year and sex (weights corrected for water saturation), Western Arctic caribou herd, 2008–2015.

	Number of calves			Median Weight, lb		
Year	Male	Female	Total	Male	Female	All Calves
2008	9	13	22	83	82	82
2009	20	16	36	90	89	90
2010	22	7	29	94	90	93
2011	9	14	23	86	90	90
2012	4	10	14	97	85	88
2013	4	9	13	94	93	93
2014	12	11	23	94	86	89
2015	13	12	25	110	100	101

Table 15. Median fall calf weights (lb) by sex and body condition of mother (sample size in parentheses), Western Arctic caribou herd, 2008–2015.

	Median calf weight (lb)					
Year	Female calf, mother <avg condition	Female calf, mother =avg condition	Female calf: mother >avg condition	Male calf, mother <avg condition	Male calf, mother =avg condition	Male calf, mother >avg condition
2008	77 (2)	84 (8)	90 (3)	96 (1)	80 (6)	89 (2)
2009		85 (8)	92 (8)	92 (2)	91 (14)	89 (4)
2010	96 (1)	93 (3)	88 (3)	80 (3)	96 (14)	95 (4)
2011	90 (1)	91 (8)	90 (5)	86 (1)	100 (3)	83 (4)
2012	89 (1)	86 (6)	84 (3)		97 (3)	97 (1)
2013	99 (1)	78 (1)	93 (5)	95 (1)		94 (2)
2014		83 (4)	86 (7)	68 (1)	81 (4)	95 (7)
2015		89 (5)	101 (16)		102 (4)	111 (9)

Table 16. Numbers (and percentages) of satellite-collared caribou that grossly changed their speed and/or direction of travel within 30 mi of the Red Dog road during August-December, Western Arctic caribou herd, 1994–2015.

Year	Total no. of satellite collars in herd, n_i	No. of collared caribou within 30 mi of Red Dog road, *n* (% total collars)	No. of collared caribou that changed speed or direction of travel, *n* (% total collars)	Estimated no. of caribou that changed speed or direction of travel[a]	Percent of collared caribou within 30 mi of Red Dog road that changed speed or direction of travel	No. of collared caribou that did not cross Red Dog road to south or southeast, *n* (% total collars)
1994	8	2 (25)	1 (12)		50	0
1995	5	2 (40)	1 (20)		50	1 (20)
1996	3	3 (100)	1 (33)		33	0
1997	6	1 (17)	1 (17)		100	1 (17)
1998	3	0 (0)	-		-	-
1999	11	2 (18)	2 (18)		100	2 (18)
2000	20	0 (0)	-	0	-	-
2001	18	5 (28)	2 (11)	51,000	40	1 (6)
2002	22	2 (9)	1 (5)	24,000	50	0
2003	28	4 (14)	1 (4)	20,000	25	1 (4)
2004	22	7 (32)	3 (14)	64,000	43	0
2005	15	4 (27)	2 (13)	56,000	50	0
2006	26	1 (4)	0	0	0	0
2007	22	1 (5)	0	0	0	0
2008	35	5 (14)	1 (3)	11,000	20	0
2009	41	1 (2)	1 (2)	7,000	100	1 (2)
2010	62	0 (0)	-	0	-	-
2011	74	21 (28)	18 (24)	78,000	86	4 (5)
2012	69	7 (10)	4 (6)	17,000	57	1 (1)
2013	73	6 (8)	4 (5)	12,000	66	0
2014	75	5 (7)	2 (3)	6,000	40	0
2015	81	12 (15)	8 (10)	22,000	83	2 (2)

[a] Estimated number of caribou that changed speed/direction = (WAH herd size) X (% of WAH that changed speed/direction).