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Teshekpuk Caribou Herd Management Report and Plan, Game Management Units 23, 24, and 26:

Report Period 1 July 2012–30 June 2017, and

Plan Period 1 July 2017–30 June 2022

Lincoln S. Parrett

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Alaska Department of Fish and Game Division of Wildlife Conservation

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

This species management report and plan was reviewed and approved for publication by Phillip L. Perry, Management Coordinator for the Division of Wildlife Conservation.

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Purpose of this Report

This report provides a record of survey and inventory management activities for Teshekpuk caribou in Units 23, 24, and 26 for the 5 regulatory years 2012–2016 and plans for survey and inventory management activities in the following 5 regulatory years, 2017–2021. A regulatory year (RY) begins 1 July and ends 30 June (e.g., RY14 = 1 July 2014–30 June 2015). This report is produced primarily to provide agency staff with data and analysis to help guide and record agency efforts but is also provided to the public to inform it of wildlife management activities. In 2016 the Alaska Department of Fish and Game's (ADF&G, the department) Division of Wildlife Conservation (DWC) launched this 5-year report to more efficiently report on trends and to describe potential changes in data collection activities over the next 5 years. It replaces the caribou management report of survey and inventory activities that was previously produced every 2 years.

I. RY12–RY16 Management Report

Management Area

The Teshekpuk caribou herd (TCH) is primarily found in northwestern Alaska in Units 23, 24, and 26 (Fig. 1). This area extends from the Seward Peninsula along the coast to just east of the Colville River, including the coastal plain to the western and central Brooks Range. The topography of summer range is extremely flat and contains approximately 20% surface water with numerous shallow lakes. Vegetation is dominated by wet and moist sedge meadows (Parrett 2007). Summer climate is cool. Daily averages in Utqiaġvik (formerly known as Barrow), at the northern extent of the summer range, were all less than 5°C (41°F) during June, July, and August 1981–2010. Topography and climate of wintering areas can vary from the low relief, windswept coastal plain with shallow, dense snow to extremely high relief mountains in the central Brooks Range that are nearly snow free, to forested habitats south of the Brooks Range with deep snow and extreme cold (<−40°C, <−40°F).

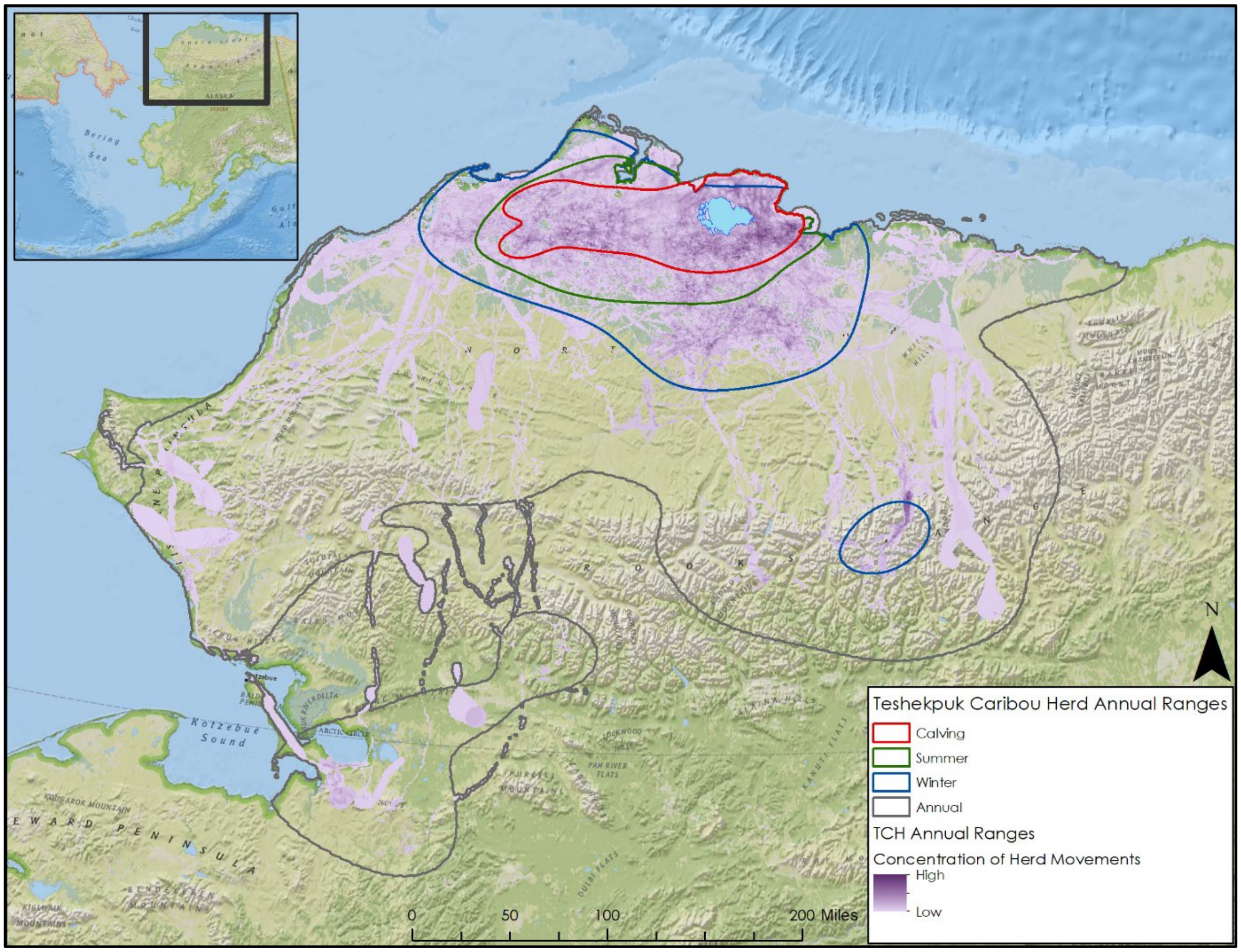


Figure 1. Teshekpuk caribou herd overall extent of range, 2012–2017, showing calving grounds, summer range, and frequently used wintering range in Alaska. This herd displays a diversity of migratory strategies, as indicated by the large extent of annual range (gray line), but in many years the bulk of the herd can be found on the North Slope year-round. Broad seasonal distribution shapefiles were created by ADF&G staff using ArcGIS™ software (Esri, Redlands, California) by aggregating more discrete seasonal distributions summarized by ABR Inc. (see Figure 7).

Summary of Status, Trend, Management Activities, and History of the Teshekpuk Caribou Herd in Units 23, 24, and 26

Teshekpuk Lake was an important area for caribou based on archeological and traditional knowledge. These sources of information suggest that caribou have been abundant near Teshekpuk Lake for at least the last 400 years (Silva et al. 1985). TCH was first identified as a distinct herd in 1978 (Davis and Valkenburg 1978). Aerial counts between 1978 and 1982 indicated that approximately 4,000 caribou used the area near Teshekpuk Lake during postcalving aggregations (Davis et al. 1979, Reynolds 1981, Silva et al. 1985). In 1984, a minimum population of 11,822 was estimated using postcalving aggregation photography (Davis et al. 1979, Carroll 1992). Growth continued through 2008, when TCH was estimated at over 68,000 caribou (Parrett 2011). The exponential growth rate was 7.0% between 1984 and 2008, based on minimum count estimates (Table 1). After the peak abundance of 68,000 observed in 2008, TCH began to decline. Abundance estimates based on postcalving aggregation photography indicated a decline of over 50% between 2008 and 2013. Other metrics confirmed the source and magnitude of the observed decline.

Table 1. Population estimates and exponential growth rates of the Teshekpuk caribou herd, 1978–2017, Alaska.

Year	Minimum population estimate	Population estimate (RSE)[a]	r (%)[b]
1978–1982	3,000–4,000[c]	–	–
1984	11,822[d]	18,292 (44%)	–
1985	13,406[c]	–	–
1989	16,649[d]	19,724 (32%)	6.8%
1993	27,686[d]	41,800 (26%)	12.7%
1995	25,076[d]	32,839 (34%)	−5.0%
1999	28,627[d]	–	3.3%
2002	45,166[d]	51,783 (9%)	15.2%[e]
2008	64,106[d]	68,932 (8%)	5.8%
2011	52,673[f]	59,391 (6%)[g]	−5.0%
2013	32,629[f]	39,172 (17%)	−16.7%
2015	35,181	41,542 (8%)	5.3%
2017[h]	56,255	55,614 (5%)	5.6%

Note: En dash indicates data unavailable.

[a] Population estimate derived only from photographed groups that included radiocollared caribou, with expansions to account for missing collars and groups of caribou with no marked caribou as described by Rivest et al. (1998); in some years the data was not collected in such a manner as to allow an estimate. Relative Standard Error (RSE) is shown as a percentage of the abundance estimate (SE/Abundance ×100), i.e., in 2017, the SE is 5.2% of the abundance estimate, or 2,909.

[b] $r = (\ln(Nt2) - \ln(Nt1)/t$, where t = number of years between censuses, N = population estimated at time t.

[c] Derived from visual estimate.

[d] Derived using aerial photocensus minimum count.

[e] It is unlikely that the herd increased at this rate. The 1999 count was probably an underestimation, and the herd had increased since 1995.

[f] Minimum count includes an unknown number of CAH caribou.

[g] This estimate is based on the number of caribou estimated using only collars deployed prior to 2011. An estimated 3,687 CAH caribou can be removed, post-hoc from that estimate, resulting in an estimate closer to 56,000.

[h] This survey was conducted outside of the reporting period, which ended 30 June 2017.

Adult female mortality rates (defined as females ≥1 year of age) showed a consistent increase over the past 25 years. Some acute increases in mortality were also observed, particularly 2 exceptionally high mortality rates in 2012 and 2013. Decreasing calf production and falling short-yearling recruitment rates also accompanied the declines. More recent data indicates that that the population is increasing.

TCH is an important subsistence resource. For the past few decades, this herd appears to have sustained some of the highest known harvest rates in Alaska (>6%), almost exclusively by Alaskan residents, and local residents in particular. Currently, this herd serves as the primary terrestrial resource for 5 communities on the North Slope numbering approximately 6,000 people in addition to providing occasional opportunity to other users in northwestern Alaska. In recent years the average per capita harvest of caribou by North Slope communities within the TCH range was estimated at 0.9 caribou per person, indicating a high reliance on caribou. Most of the caribou harvest within the area are TCH animals (Parrett 2013); although harvest from the Western Arctic caribou herd constitutes a portion of that harvest, even within the primary range of TCH.

Management Direction

Existing Wildlife Management Plans

There are no existing Wildlife Management Plans related specifically to TCH.

Goals

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

2. Ensure that adequate habitat exists to maintain the Teshekpuk caribou herd.

3. Provide for viewing and other uses of caribou.

Codified Objectives

Amounts Reasonably Necessary for Subsistence Uses

There is a positive customary and traditional use finding for TCH by the Alaska Board of Game. The amounts reasonably necessary for subsistence uses (ANS; 5 AAC 99.025) in this herd is unusual in that it is combined with the adjacent Western Arctic herd (WAH), and therefore the relationship between harvestable surplus and subsistence allocation is largely driven by the much larger WAH. The combined ANS range for the Western Arctic and Teshekpuk caribou herds is 8,000–12,000 caribou.

Intensive Management

The Teshekpuk caribou herd is recognized as an intensive management (IM) population. The board established the IM population objective for TCH at 15,000–28,000 caribou, and the harvest objective at 900–2,800 caribou (Title 5, Alaska Administrative Code 5 AAC 92.108). Unlike ANS, IM objectives are independent of WAH.

Management Objectives

1. Encourage cooperative management of the herd and its habitats among state, federal, and local entities, including all users of the herd (Goals 1, 2, and 3).
2. Develop a better understanding of relationships and interactions among North Slope caribou herds (Goals 1 and 2).
3. Monitor herd characteristics and population parameters (on an annual or regular basis) (Goals 1, 2, and 3).
4. Attempt to maintain a minimum population of 15,000 caribou, recognizing that caribou numbers naturally fluctuate (Goals 1, 2, and 3).
5. Maintain a harvest level of 900–2,800 caribou using strategies adapted to population levels and trends (Goal 1).
6. Maintain a population composed of at least 30 bulls per 100 cows (Goals 1 and 3).
7. Minimize conflicts between resource development and TCH (Goal 2).

Management Activities

1. Population Status and Trend

ACTIVITY 1.1. Determine the population size and trend of the herd a minimum of 2 times over a 5-year period (Objectives 3, 4, and 5).

Data Needs

Population estimates and trends are integral components of management, particularly to estimate harvestable surplus. The board established a population objective of 15,000 Teshekpuk caribou as part of the intensive management program (5 AAC 92.108).

Methods

DWC staff currently use the Aerial Photo Direct Count (APDC) minimum count photocensus (Davis et al. 1979) along with an abundance estimate derived using distribution of radiocollared caribou among photography groups (Rivest et al. 1998). APDC counts require good weather during a short window of time when caribou are aggregated, making it challenging to obtain successful counts. Therefore, to achieve an average of 2 estimates every 5 years, we need to monitor herd distribution annually during July. Appropriate conditions are typically preceded by 2 consecutive days with temperatures averaging >60°F, and winds <10 mph. Objectives for precision of the estimate are a 95% confidence interval half-width of 20% or less. To achieve this level of precision, the number of active collars should be greater than 70, and the number of collars in postcalving aggregation photography should exceed 2.5 per group (B. Taras, biometrician, DWC, ADF&G, Fairbanks, unpublished data). In order to adequately describe the statistical distribution of collared individuals, it is necessary to optimize for both aggregation quality and a sufficient number of collared caribou. To evaluate trends in abundance, we calculated exponential growth rates between point estimates (Johnson 1994).

If an abundance estimate was unavailable through postcalving aggregation photography, we used a stochastic population model to estimate abundance (A. Prichard, biometrician, ABR Inc., Fairbanks, unpublished Microsoft Excel spreadsheet model). This spreadsheet model was originally created specifically for TCH by ABR, Inc. under contract by the U.S. Bureau of Land Management (BLM). The model runs 1,000 iterations, drawing parameter values from a normal distribution based on a 95% confidence interval (CI) of the point estimates. Based on our knowledge of the availability and strength of the parameters used, ADF&G staff simplified the model. Aspects of seasonality and geospatial variation were removed from the model. Variability in sources of mortality was simplified to 2 causes (natural and hunting) and the model was changed from a 4-stage model to a 3-stage model (calves, yearlings, and adults). In addition, some parameters, which are infrequently estimated, or estimated with either poor or no precision, were adjusted to use long-term averages as parameter estimates. Initial age structure was fitted by allowing the population model to run with approximated vital rates until ADF&G staff were able to replicate observed growth rates from 1984 through 2002. Long-term average estimates were used for the following parameters: adult bull mortality rates, calf survival rates, rates of hunting mortality, and age and sex ratios in the harvest. Yearling males were assumed to survive at the same rate as yearling females. Standard errors (SE) for long-term estimates were conservatively estimated using the average SE from individual years. Parameters that were updated annually include estimates of parturition, adult and yearling female survival rates, and associated standard errors. When projecting abundance estimates into the future, we used the average of the 3 most recent years for each parameter.

Results and Discussion

During 2012–2017, the management objective of maintaining a population of at least 15,000 caribou was met. Abundance declined from 68,932 (±16%, 95% CI) in 2008, to 59,391 (±12%, 95% CI) in 2011, and 39,172 (±35%, 95% CI) in 2013. Abundance then appeared to stabilize through 2015, followed by an increase to 55,614 (±10%, 95% CI) in 2017 (Table 1). The 2011 and 2013 estimates included an unknown number of Central Arctic herd (CAH) caribou; ad hoc removal of those additional caribou is discussed in unpublished survey memoranda associated with those surveys (Lincoln Parrett, Caribou Biologist, ADF&G, Fairbanks, 2011 Teshekpuk Caribou Herd Photocensus Results, 30 January 2012; Lincoln Parrett, Caribou Biologist, ADF&G, Fairbanks, 2011 Teshekpuk Caribou Herd Photocensus Results, 17 March 2014). Management following the 2013 estimate was based on the minimum count of 32,629 caribou, rather than the abundance estimate. This decision was made for 2 reasons; first, the 2013 abundance estimate failed the assumption of randomness (Rivest et al. 1998); and second, due to uncertainty about the ultimate fate of caribou that were missing at the time of the photocensus. This uncertainty was primarily due to extensive mixing of TCH and WAH at the time of the photocensus (20% of the active collars). Although it is common for emigration from TCH to WAH to occur, both temporary and permanent (Prichard et al. 2020), in 2013 all of the collared caribou associated with WAH died by the time the estimate was finalized, implying that although missing at the time of the photocensus, the large number of caribou represented by those collars were unlikely to ever be a part of the TCH population again. As a result, we felt that the best representation of the hunted population was the minimum count, although the Rivest estimate at the time of the photocensus was the better representation of the ecological population. Abundance estimate results indicated a decline of approximately 50% from 2008 to 2013, followed by a relatively abrupt rebound. The observed changes in abundance were accompanied by vital rates (adult female mortality rates, productivity, and recruitment) that would be consistent with the observed changes in abundance with one exception in 2013–2015. Abundance estimates from 2013–2015 indicated slow growth (5% annually); however, that period also saw some of the highest mortality rates ever observed (Table 2).

Table 2. Annual survival of adult female radiocollared Teshekpuk Caribou, 1990–2017, Alaska.

Collar year[a]	Sample size[b]	Mortalities[c]	Survival rate[d] (%)	95% Binomial confidence
1990–1991	13	2	85	58–96%
1991–1992	21	3	86	65–95%
1992–1993	21	3	87	65–95%
1993–1994	30	4	87	70–95%
1994–1995	29	5	83	65–92%
1995–1996	31	4	87	71–95%
1996–1997	25	6	76	57–88%
1997–1998	28	4	86	68–94%
1998–1999	39	3	92	80–97%
1999–2000	37	5	86	72–94%
2000–2001[e]	45	5	89	76–95%
2001–2002	40	7	83	68–91%
2002–2003	36	4	89	75–96%
2003–2004	52	13	75	62–85%
2004–2005	46	8	83	69–91%
2005–2006	43	4	91	78–96%
2006–2007	60	5	92	82–96%
2007–2008	55	10	82	70–90%
2008–2009	61	8	87	76–93%
2009–2010	65	10	85	74–91%
2010–2011	68	13	81	69–89%
2011–2012	66	8	88	77–94%
2012–2013	65	21	68	55–79%
2013–2014	67	19	72	59–82%
2014–2015	60	11	82	70–90%
2015–2016	66	6	91	81–97%
2016–2017	77	7	91	82–96%
Average	46	7	85	–

[a] Collar year is defined as 1 July–30 June (e.g., collar year 1991–1992 = 1 July 1991–30 June 1992).

[b] Sample size is defined as the total number of active radio collars at the beginning of a collar year.

[c] The number of radiocollared caribou that died during the collar year.

[d] Survival rate = known survivors / number of active female collars.

[e] Beginning in collar year 2000–2001, caribou that were collared with Platform Transmitter Terminals (PTT), Global Positioning System (GPS), or very high frequency (VHF) radio collars were used in the analysis. Before 2000–2001 only VHF-collared caribou were used.

Recommendations for Activity 1.1.

Continue with modifications.

- When a declining trend is detected, conduct a photocensus either annually or at least 3 times (rather than 2 times) every 5 years. This approach will occasionally require conducting a photocensus to take advantage of good conditions, even though an estimate was produced the prior year.
- As needed, explicitly estimate the effects of mixing during a photocensus with adjacent herds by incorporating modifications to Rivest et al. (1998) that allow for estimation of the proportion of the estimate that is composed of missing and immigrant caribou, along with associated precision (B. Taras, biometrician, DWC, ADF&G, Fairbanks, unpublished memorandum, 15 July 2014).
- Document previous work done through simulations and post-hoc evaluations of the relationships between aggregation quality, sexual segregation, and group definitions on photocensus quality (requires biometric support).
- Quantify historic levels of herd interchange by collared caribou and seasonal range overlap (requires biometric support).
- Discontinue use of the stochastic population abundance model. This model has several faults; it is extremely data intensive, requiring inputs that are rarely available, and is incapable of dealing with paradigm shifts such as that observed between 2013 and 2017, when the population rebounded. A less complicated model that simply predicts the probability of decline may be more appropriate and could use only those metrics that are consistently collected and shown to be highly correlated with changes in abundance such as adult female survival rates.

ACTIVITY 1.2. Estimate harvestable surplus based on abundance, trend in abundance, and other demographic context (e.g., composition, age structure; Objective 3).

Data Needs

The board established an IM harvest objective for TCH of at least 900 caribou. Estimating harvestable surplus is critical for managing the hunt and evaluating the harvest relative to sustained yield.

Methods

Harvestable surplus was based on the most recent abundance estimate if less than 2 years had passed since that estimate. If a recent abundance estimate was unavailable, the stochastic population abundance model was used to estimate abundance. When abundance fell below 40,000, harvest rates were applied separately to cows and bulls. When abundance was above 40,000, we applied a 6% harvest rate to calculate the harvestable surplus. Based on observations of historical realized harvest rates that appeared to be sustainable, when abundance fell below 40,000, we calculated the harvestable surplus of bulls as 20% of a growing population and 15% of a stable or declining population. Given rates of adult bull mortality (Parrett 2013), and presumed age structure of harvested bulls (e.g., Dau 2013), this rate is likely largely compensatory. In contrast, given the presumed age structure of harvested cows (e.g., Dau 2013) and rates of adult cow mortality (Parrett 2013), cow harvest is largely additive. As a result, harvest rates applied to cows are much lower – up to 2% of a growing population that is exceeding the upper limit of the intensive management objective, and less than 1% of a population that is below management objectives. Cow harvest is an important component of the subsistence harvest, so hunt management focuses on reducing the additive component of overall harvest during times of reduced abundance.

Results and Discussion

During 2012–2017, we believe that the management objective of providing for a harvest of at least 900 caribou was met, although there is uncertainty about the number of caribou harvested (see Activity 2.1).

Harvestable surplus was calculated based on the decline in population that had been occurring since 2008, using a 15% harvest rate for bulls and a 1.5% harvest rate for cows starting in RY11. The harvestable surplus in RY11 and RY12 was 2,950 caribou based on the 2011 abundance estimate. The harvestable surplus in RY13 and RY14 was 1,715 caribou based on the abundance estimate from 2013. Lacking a recent estimate in 2015, we used the stochastic population abundance model to predict an abundance of 17,000 caribou; based on this abundance estimate, the harvestable surplus estimate was 900 caribou.

ADF&G area managers presumed that the harvestable surplus of 900 caribou was being exceeded in 2015. Based on patterns in harvest over the past 15 years (Braem 2013), ADF&G staff estimates that harvest was approximately 2,350 per year during RY12 through RY17 (see Harvest Monitoring and Regulations, Activity 2.1). With no mechanisms for controlling harvest in place (i.e., seasons and bag limits remained liberal and were unrestricted by quota) ADF&G managers were preparing for potential regulatory action.

There was a great deal of uncertainty regarding harvest, abundance, and the appropriate approach for estimating harvestable surplus in RY13–RY15. Hindsight provides several points worth mentioning: the stochastic population model[1] was in error, predicting an abundance of only 17,000; this may have been the result of an underestimate in 2013 (variance was relatively high for this survey), or a function of adult female survival not being reflective of the overall rate, and instead reflecting the deaths of older collared females. In addition, it is worth pointing out that even if harvest was exceeding harvestable surplus as calculated, the deaths of some 2,350 caribou were a small portion of the overall mortality happening at the time and may have had a substantial compensatory fraction. Lastly, the population demographics quickly turned around in a manner that the stochastic population model[1] could not have anticipated, and by 2015, vital rates would suggest growth was already occurring, although this was not apparent during discussions regarding potential regulatory actions at the time.

[1] A. Prichard, biometrician, ABR Inc, Fairbanks, unpublished Microsoft Excel spreadsheet model.

Recommendations for Activity 1.2.

Continue. Relying heavily on the predictive output of the stochastic population model would have resulted in regulatory action that was too restrictive. As suggested in Activity 1.1, relying on the stochastic population model as part of the calculation of harvestable surplus between abundance surveys should be reconsidered.

Although relying heavily on predictive outputs of abundance models to inform regulatory actions needs to be done with utmost caution, examining the potential effects of different harvest regimes on the caribou population using a demographic model to predict abundance and sex-age structure could be helpful. For example, additional work is needed to evaluate harvest consequences and increase transparency regarding decisions that consider current exploitation at the expense of long-term sustainable harvest levels (requires biometric support).

I recommend additional research to better evaluate additive mortality versus compensatory mortality (across sex and age classes) in a declining herd (requires biometric and research support).

ACTIVITY 1.3. Monitor calf production by tracking radiocollared female caribou annually (Objectives 1, 2, and 3).

Data Needs

The Teshekpuk caribou herd was recognized by the board as an intensive management population. Estimates of TCH productivity are an index of population-level and general health. Parturition rates are also a parameter used to model herd abundance during years that we are unsuccessful in conducting a photocensus. Changes in parturition rates may also provide context when evaluating future trends in abundance (Activity 1.1).

Methods

Parturition rate was estimated by observing radiocollared females ≥3-years old from a fixed-wing aircraft during the first half of June. Caribou observed with calves, hard antlers, or distended udders were classified as parturient (Whitten 1991). We typically visit each cow every other day until the end of the survey period unless the cow is observed with a calf at heel or is obviously growing velvet covered antlers. An additional metric termed “calving success” is defined as the proportion of all collared females with a calf at the end of the monitoring period (typically 11 or 12 June) and allows for evaluation of a longer-term trend because Whitten’s methods were not fully adopted until 2001. Parturition rates are estimated for 3-year-old cows and older. During this reporting period we compared age-specific parturition rates to evaluate the utility of monitoring 3-year-olds as a sensitive index to nutritional status (Boertje et al 2012). We also compared parturition rates during and outside the period of declining abundance (2009–2013). To evaluate the potential for reproductive pauses as a strategy to increase future productivity (e.g., Cameron 1994, Boertje et al. 2019), we compared the sequence of 2 years of parturition status for caribou that are age 4 and older. Differences in frequencies of caribou that were parturient in a given year and either parturient or nonparturient the prior year were tested using a 2 × 2 contingency table and Fisher’s exact test.

Results and Discussion

Parturition rates for TCH are among the lowest in Alaska (Parrett 2013, Lenart 2013, Dau 2013, Gross 2013). During 2013 through 2017, parturition rates of females ≥3-years old averaged 65% (range 28–83%; Table 3) compared to an average of 70% during 2001 through 2012. Note that the 2014 parturition rate was the lowest observed since 1990 and appears to be among the lowest ever observed in Alaska (28%; Table 3). Parturition rates in the adjacent CAH herd averaged 88%, and ranged from 61–97% during 1997–2014 (Lenart 2015). Parturition averaged 67% and ranged from 58–79% for WAH during 1997 to 2014 (Dau 2015). The perennially low parturition rates in this herd are indicative of an overall pattern of low productivity (Table 3; Parrett 2013) and presumably poor body condition (Cameron and Ver Hoef 1994). Specific management thresholds or precision objectives related to parturition rates have not been developed for this herd. Boertje et al. (2012) proposed a 55% parturition rate among 3-year-olds as a threshold to consider in regulations that limit growth particularly if density-dependent productivity is suspected. From 1997 through 2017 parturition rates estimated for 3-year-olds (69%; n = 91) did not significantly differ from 4-year-olds (67%; n = 64) and the long-term average was above 55%. Median age of first reproduction was 3-years old wherein 56% of females first gave birth as 3-year-olds, 25% as 4-year-olds, and 18% were 5-years old or older. Two-year-old cows had a much lower parturition rate (3%; n = 38) but were also inconsistently observed. In general, rates for all ages greater than 2-years old were similar (Fig. 2) and appear to be depressed compared to Interior and other Arctic herds (Boertje et al. 2012, Lenart 2015, Caikoski 2015). Pooling caribou data for age 3 and older showed them to be significantly more likely to be nonparturient during the years of declining abundance. The estimated average parturition rate during the decline phase was 63% (n = 217, 95% CI 55–69%) compared to 72% during the remaining years (67–76%; n = 426). Three-year-old caribou by themselves were estimated to be parturient 62% of the time

Table 3. Teshekpuk caribou herd calving and short-yearling survey results, 2013–2017, Alaska.

	Calving surveys (June)			Short-yearling surveys (April)			
Year	Cows observed	Parturition[a] (%)	Live calves[b] (%)	n	Short yearlings: 100 adults	Short yearlings (%)	95% confidence limits[c]
2013	36	61	44	3,153	13	12	10–13%
2014	32	28	13	2,279	15	13	9–17%
2015	24	71	65	1,025	15	13	10–18%
2016	33	81	75	1,243	29	22	22–31%
2017	49	83	69	3,099	18	15	13–16%
Average	35	65	53	2,650	17	14	–

Note: Data from 1990–2012 included in previous reports; see Parrett 2013.

[a] (Number of collared cows with calf + collared cows with no calf but hard antler or udder) / number of mature collared cows observed.

[b] Number of collared cows with live calves at the end of calving surveys / number of mature collared cows observed.

[c] Calculated based on Cochran's cluster sampling method (1977).

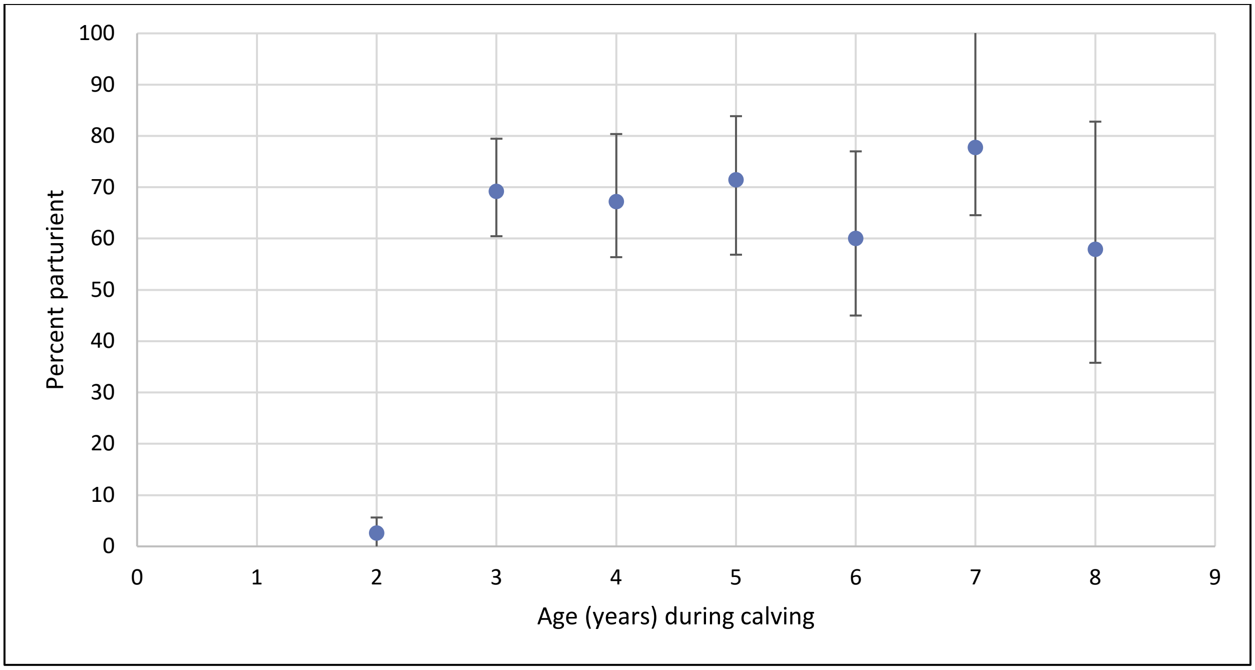


Figure 2. Age specific parturition rates for known-aged Teshekpuk caribou 2–8 years of age, Alaska. Sample sizes range from 19 (8 years of age) to 91 caribou (3 years of age). Sample sizes for ages 9–12 years old were all 10 caribou or less and are not included as a result.

during the decline phase in abundance (95% CI 42–79%; n = 29) and 72% of the time outside of that period (95% CI 60–83%; n = 62) with no statistical significance. This suggests that 3-year-old caribou parturition rates do not provide a metric any more sensitive than those obtained when pooling caribou aged 3 and older possibly due to smaller sample sizes. There was no evidence of reproductive pauses. Caribou aged 4 and older were not statistically more likely to be parturient following years when they did not produce a calf (69%) compared to years when they did (62%; n = 140 caribou-years, P-value = 0.48). Even if monitoring 3-year-old parturition rates were useful, they would need to be estimated precisely for multiple years which is logistically unfeasible (i.e., would require substantial effort to capture more than the typical 15–20 yearlings). The lack of difference in parturition rates between 3- and 4-year-old Teshekpuk caribou compared to Interior Alaska herds may speak to differences in ecological pressures that they endure and a life history that puts greater emphasis on producing calves as a strategy for dealing with challenging and highly variable environmental conditions. In general, parturition rates appeared to be subject to a great deal of individual variation and annual stochasticity. There was evidence that parturition rates were depressed during the herd's decline pointing to poor nutrition as a likely component of the cause of declining abundance from 2009 through 2013.

Current annual sample sizes of all adult females are likely to produce estimates with relative precision ranging from 10–20% given the moderate parturition rates that are typically observed. A potential goal may be to detect a 10% change in 5-year average parturition rates. A significant change in parturition rates may provide some indication that trends in abundance are likely to change.

Recommendations for Activity 1.3.

Continue. Evaluate environmental factors that influence parturition rates. The low parturition rates observed in this herd may imply that calf production is more of a limiting factor in this herd compared to other herds, where adult and calf survival are the predominant drivers of abundance (e.g., Walsh et al 1995, Boulanger et al. 2011, Belanger et al. 2018). This potentially unique aspect of TCH ecology could be more formally evaluated; the results could inform IM feasibility in terms of the potential to effect demographic changes through management actions if calf production is a limiting factor. Even if parturition rates are not limiting, they may still be useful as a predictive index for estimating potential change if they are correlated with changes in abundance.

ACTIVITY 1.4. Conduct fall composition surveys to determine age and sex ratios at least once every 2 years (Objectives 3 and 6).

Data Needs

The 6th management objective is to maintain a population composed of at least 30 bulls per 100 cows (23% of the adult population). Sex ratios are also needed to estimate harvestable surplus. From a biological perspective, changes in bull-to-cow ratios are potentially indicative of patterns in recruitment over a long timespan, as well as in the short term (through classification of relative age in bulls). The need for monitoring bull-to-cow ratios increases during time periods when we are more closely tracking harvestable surplus; for example, during declines when abundance falls below 40,000, and particularly when approaching biologically limiting bull-to-cow ratios.

Methods

In fall of 2012, 2013, and 2016, sex and age composition was estimated from an R-44 helicopter by classifying caribou near peak of rut to take advantage of the presumed mixing of bulls, cows, and calf caribou. Using previously estimated median calving dates and backdating by 228 days (gestation), we estimate that median breeding takes place around 21 October in most years. We scheduled fall composition surveys in October to coincide with this date.

Caribou groups were located by radiotracking very high frequency (VHF) radiocollared caribou from a fixed-wing aircraft (typically Cessna 182 or Bellanca Scout). Sampling was conducted by helicopter (R-44) using a focal-animal cluster design (Cochran 1977), classifying approximately 200 caribou within a 5-mile radius of each radio collar found during the survey. This technique approximates the cluster sampling design described by Cochran (1977), with the exception that the cluster sampling design described by Cochran assumes 100% sampling of each cluster. To encourage wider spatial distribution of the sample, we limited the sample to 200 if needed. This was often unnecessary as clusters are typically small and relatively well defined in this herd. Caribou were classified as either male calf, female calf, cow, small bull, medium bull, or large bull. Data was recorded using a voice recorder.

Percentages and standard errors of each sex and age class were estimated using a cluster-sampling scheme (Cochran 1977) and converted into ratios with cows as the denominator (i.e., bulls:100 cows).

Results and Discussion

In 2012 and 2013 we met our management objective of maintaining a population of at least 30 bulls per 100 cows. Bull-to-cow ratios were 39:100 in both 2012 and 2013 (including proportions and respective variance; Table 4). In 2016, the bull-to-cow ratio was 28:100 (22% of the adult population), which was slightly below the objective. We intended to attempt an additional survey in 2017 to confirm that bull abundance had dropped; however, other trends in abundance, productivity, and survival led to decreased concern. The large-bull-to-cow ratio ranged from 10:100 to 14:100 over that period, and calf-to-cow ratios ranged from 29:100 to 48:100.

Table 4. Teshekpuk caribou herd fall composition counts, 2010–2017, Alaska

	Helicopter surveys (October)							
Date	Bulls: 100 cows	Bulls (%)	Calves: 100 cows	Calves (%)	Cows (%)	*n*	% Calves 95% CI (%)	% Bulls 95% CI (%)
2010	46	26	29	17	57	3,308	16–18	23–28
2011	–	–	–	–	–	–	–	–
2012	39	23	35	20	57	5,010	19–21	22–24
2013	39	24	31	19	58	2,449	17–21	22–26
2014	–	–	–	–	–	–	–	–
2015	–	–	–	–	–	–	–	–
2016	28	16	48	27	57	2,551	22–27	19–26

A 2014 survey attempt was unsuccessful, primarily due to weather delays. Despite the lack of helicopter survey data prior to 2009 to help establish trend relationships, recent composition results are corroborated by observations by hunters and indicate that the decline in abundance, reduced adult survival, and reduced recruitment led to proportionally fewer bulls in the population, as mature bulls appear to suffer a higher mortality rate than adult cows.

Given the infrequent and contemporary nature off all calf-to-cow ratio data for this herd, it is difficult to draw many conclusions. Calf-to-cow ratios for the range observed in this herd are typically considered to be indicative of a stable or growing population in Interior herds (e.g., Bergerud et al. 2008, Boertje et al. 2012), however differences in timing of calf mortality and magnitude of over-winter mortality (ADF&G unpublished data; Boertje et al 2000) imply that for this herd, fall calf-to-cow ratios are not a good indicator of recruitment. In the adjacent WAH, it appears that parturition rates and fall calf-to-cow ratios are not correlated, implying varying over-summer calf survival. If that also applies to TCH than the metric could prove useful in the future when evaluating over-summer calf survival.

While this assumption has not been formally evaluated, it appears that immediately after and sometimes during rut, sexual segregation can occur in the herd. Because fall composition surveys take place during migration, there can be substantial spatial variation within the results; therefore, caution is warranted in assuming that groups being sampled represent a true mixing of sexes.

Objectives for bull-to-cow ratios are typically based on human desire (i.e., hunting satisfaction). In herds managed for trophy hunting, very high bull-to-cow ratios can be desirable; even in areas where subsistence hunting patterns are predominant, hunters appear to prefer bull-to-cow ratios well above those needed for adequate reproduction. A biological concern with skewed sex ratios lies with reduced productivity. Information on caribou and other species (e.g., Mysterud et al. 2002) suggest that in tightly controlled situations, effects on fecundity, synchrony of calving, and calving date typically do not occur until ratios are quite low (<20 bulls:100 cows); however, effects on wild populations are largely unknown and may occur at different thresholds.

Recommendations for Activity 1.4

Continue with modifications.

I recommend that conducting fall composition surveys be primarily a response to declines in abundance, and because we will likely be calculating harvestable surplus differentially between sexes. When abundance is above 40,000, I recommend conducting a composition survey every 5 years. When abundance falls below 40,000, frequency of surveys should be gauged as follows: when the bull-to-cow ratio is >30:100, I recommend conducting a fall composition survey every other year; when the bull-to-cow ratio is <30:100, composition surveys should be conducted annually. I also recommend moving the bull-to-cow objective to a biologically critical value that is more likely to induce regulatory change. Additional research would be helpful in assessing observed ratios in relation to survey timing, spatial variation, and type of focal animal, and to develop techniques to evaluate bias in samples (e.g., representative sampling). These would be important advancements to understand the interpretation (applicability) of age-sex ratios under varying fall conditions observed in the herd. Precision objectives have not been developed for this metric. Evaluating sample size and effort to detect ratios that are within 20% of management thresholds may be a starting point for discussion (requires biometric and research support).

ACTIVITY 1.5. Capture and radiocollar 20 female yearling caribou annually, with additional recaptures as needed to maintain a sample of at least 70 known-aged, collared females, including at least 20 GPS-collared females, without the use of immobilizing drugs. Capture and radio collar 5–10 bull caribou annually to maintain a sample of at least 10 bull caribou (Objectives 1, 2, and 3).

Data Needs

Maintaining a radiocollared sample is essential for determining if Objectives 4 and 7 were met. Radiocollared caribou are used to allocate sampling effort are also important in 1) conducting a photocensus, 2) estimating parturition rates, 3) estimating calf-to-cow and bull-to-cow ratios in the fall, 4) estimating spring recruitment ratios, 5) estimating mortality rates, 6) evaluating body condition of yearlings, and 7) estimating distribution and seasonal range use. Because of their mobility, caribou are unique compared to other wildlife species in that biologists rely on having radiocollared individuals in the herd in order to allocate sampling effort and produce representative samples for all survey and inventory activities. In this relatively large and remote herd, the use of satellite radio collars is particularly important for allocating effort, allowing significant reduction in radiotracking effort, and producing high-quality locations for use in estimating distribution and habitat use (see Activity 1.9). Radiocollared bull caribou provide a means to evaluate sexual segregation during photocensus and composition counts.

Methods

During 2012–2017 we used helicopter based netgunning because local residents, who mostly harvest Teshekpuk caribou, are uncomfortable with the use of immobilizing drugs on animals in general and particularly on animals they eat. Caribou were captured using a handheld netgun from an R-44 helicopter. Hard chase times (the period when caribou are actively attempting to escape) were limited to 3 minutes. Any slight uphill can be used to slow caribou, but generally, we attempt to force the caribou to stop or make an abrupt turn that requires deceleration prior to shooting the net. The goal of capturing 20 female yearlings each year provides for a reasonable chance of having 10–15 collared 3-year-old caribou. This is necessary in order to estimate the parturition rate of that age class, as well as retaining a relatively large sample of each age class through approximately 8 years of age. Caribou are recaptured in 3- to 5-year intervals, depending upon the battery life of the collar they are carrying and their availability at the time of capture. We deployed VHF (very high frequency), GPS (Global Positioning System), and PTT (Platform Terminal Transmitters) transmitters on TCH caribou. All 3 transmitters operate using an electromagnetic signal that emits at a specified frequency which is detected by receivers tuned to the frequency. PTT and GPS also use orbiting satellites to receive and relay transmitter signals, resulting in automated tracking (Argos, Iridium®, and Globalstar satellite systems). Caribou were typically captured in late June when herd identity is more reliable. Recaptures in late spring would be logistically challenging and uneconomical due to wide distribution of the herd. Any recaptures in fall risk unpredictable weather, and new captures in either spring or fall risk capturing individuals from a different herd due to mixing of North Slope herds during these times.

Caribou were manually restrained with hobbles and blindfold/hood while measurements were collected, and radio collars were fitted. We recorded sex (male or female), approximate age (yearling or adult), the number of permanent incisiform teeth, presence of a calf, and lactation status of females. We also recorded the latitude, longitude, and general location of capture. Measurements taken at the time of capture include weight (for yearlings), jaw length, metatarsus length, and one-half heart girth. Samples collected from individual caribou included a canine from all unknown-aged animals, blood (collected from the jugular), hair, and feces. These samples were distributed among collaborators (primarily the North Slope Borough (NSB) and ADF&G Wildlife Health and Disease Surveillance Program) who investigate disease and parasites.

Results and Discussion

During 2012–2017, we maintained 71–103 radio collars annually, including an average of 22 GPS collars deployed each year (range 11–35). During 2012 through 2017, we either captured or recaptured a total of 209 caribou, including 89 female yearlings and 37 adult bulls, with 4 capture-related mortalities.

Of the various collar models that were active during this reporting period, we found that collars that used Iridium® satellites (n = 61) tended to outperform those using Argos (n = 66) and Globalstar (n = 9) satellite systems (98%, 59%, and 72% of expected locations, respectively). Complete collar failures prior to predicted battery exhaustion occurred 15% of the time among 79 satellite collars and were most common for the Telonics model TGW-4560 (Globalstar, 6 of 6) and the least common with the Telonics TGW-4570 (Iridium®, 2 of 53). Due to the high demand for frequencies across the North Slope, we deployed 25 coded VHF collars manufactured by Advanced Telemetry Systems, Inc. (ATS) in order to reduce the number of frequencies in use. These collars appear to have failed prior to expected battery life at a very high rate (>75%), and we have not deployed any VHF collars since 2015 in this herd.

Recommendations for Activity 1.5.

Continue, with potential modifications. ADF&G has been heavily dependent upon cooperating agencies, in particular the North Slope Borough and the U.S. Bureau of Land Management (BLM), to purchase satellite collars for TCH. The goals for deployment of various types of collars represent the minimum effort that should be expended by ADF&G in the absence of additional funding and participation by cooperating agencies. If ADF&G has to purchase the bulk of satellite collars, then reduce the duty cycle (e.g., GPS collars currently get a location every 2 hours, and send those locations back to the satellite every 2–7 days) to accommodate a longer collar life (i.e., 4–5 years). Geofencing options should be considered to balance the need for long collar life and interest in particular areas, e.g., near new infrastructure. I would anticipate that maintaining the current level of collaring effort would incur an additional cost of $50,000 annually if we lost the financial support of NSB or BLM.

Based on performance of the various Telonics satellite collars, I would recommend moving away from Argos and Globalstar-based systems, toward Iridium® systems. We should gradually move toward having the entire sample composed of GPS collars, as budgets allow, including long-battery-life GPS collars with reduced satellite schedules (both download and upload), as needed. I would not use coded adult collars produced by ATS; if budgetary demands require VHF collars, Telonics MOD600 are preferred due to their reliability.

Activity 1.6. Evaluate trends in body condition through yearling and neonatal calf weights (Objectives 3 and 4).

Data Needs

A sample of average annual yearling and neonatal weights are used to evaluate trends in body condition for the herd. This information has the potential to provide context for several decision frameworks regarding the evaluation of herd size, trend in abundance, and potential for growth (Activity 1.2) and improves our ability to manage adaptively rather than reactively. Assessing these 2 metrics in combination with parturition rates may also help to differentiate seasonality in nutritional limitations.

Methods

Female yearlings are captured in late June using methods described previously in Activity 1.5 and weighed using a 100 kg Pesola digital scale (i.e., weight includes collar and net). We attempted to weigh 20 yearlings annually during this reporting period. To account for within-year growth while assessing the potential for a long-term trend in yearling capture weight we first evaluated the relationship between Julian date and capture weight. To evaluate the value of capture weights in predicting fitness, we compared average capture weights between individuals that survived to the following year with those that died. Neonates were captured by approaching a cow-calf pair in an R-44 helicopter then exiting the aircraft and pursuing calves on foot. Once calves were captured, sex was determined, then age was estimated in 12-hour increments based on posture, hoof wear, and state of the umbilicus. Calves were then weighed with a 25 kg spring scale.

Results and Discussion

Female yearling weights in the past 5 years have averaged 47.3 kg (104 lbs; $n = 76$, SE = 1.3). The timing of capture each year could influence the detection of long-term annual differences in yearling weights. Starting in 2012, we observed a potentially confounding pattern where weights were decreasing but capture dates were also progressively occurring earlier. We investigated this by comparing the observed weights by the date that they were collected. A simple linear regression model indicated that weights tended to increase by 0.8 kg (1.8 lbs) per day between June 21 and July 9 (1997–2017). This time of year is presumed to be important for caribou weight gain and in previous years it appeared that animals captured later tended to be heavier. We also recognized that the sample sizes of weights collected later in time were less than those collected earlier, possibly creating a spurious result. Using only data collected between 21 June and 28 June (2007–2017), the trend of weight increasing with time persisted (0.5 kg/1.1 lbs increase per day; t-value = 2.35, P-value = 0.02); but weights were highly variable, and day of year explained little of the overall variation ($R^2 = 0.03$). As a result, we see no reason to include dates of capture into any long-term analyses of annual changes in weight at this time, although constraining future captures to a specified period is warranted.

The average of weights collected during 2009–2013 ($n = 57$), when the herd was declining in abundance, were slightly lower (2.3 kg/5.1 lbs, Fig. 3) than averages from other years ($n = 89$; P-value = 0.02). An overall trend in weights is not apparent, although the temporally imbalanced nature of the data precludes a more formal analysis. Capture weights of caribou that survived from 13 months of age to 25 months of age did not differ from those that died between 13 and 25 months of age ($n = 152$, 1991–2017, t-value = 1.2, P-value = 0.25). Similar analyses on neonates captured from 2011 through 2013 also indicated that capture weights had no relationship with survival to 3 weeks or 1 year of age (Lincoln Parrett, Caribou Biologist, ADF&G, Fairbanks, Spatiotemporal Patterns in Calf Survival in the Teshekpuk Caribou Herd, 2014, unpublished grant report, BLM-AK-NOI-L10AS00211; Grant #L10AC20353).

These observations do not necessarily imply that weight is not an important predictor of fitness, but rather that neonate and 13-month-old weights do not appear to be associated with future survival. Weights at other time periods (i.e., just prior to winter) might be more informative.

Neonatal female weights during 2013 through 2017 averaged 5.5 kg (11 lbs; $n = 135$, SE = 0.09) and were similar to female neonates weighed from 2006 through 2009 (6.0 kg/13.2 lbs, $n = 76$, SE = 0.2 kg). The more recent weights are among the lowest average weights observed among North American caribou (range 5.0–9.0 kg/11–20 lbs); e.g., CAH (Arthur and Del Vecchio 2009), Porcupine caribou herd (Griffith et al 2002), Fortymile and Delta herds (Boertje and Gardner 2000), multiple herds (Bergerud et al. 2008).

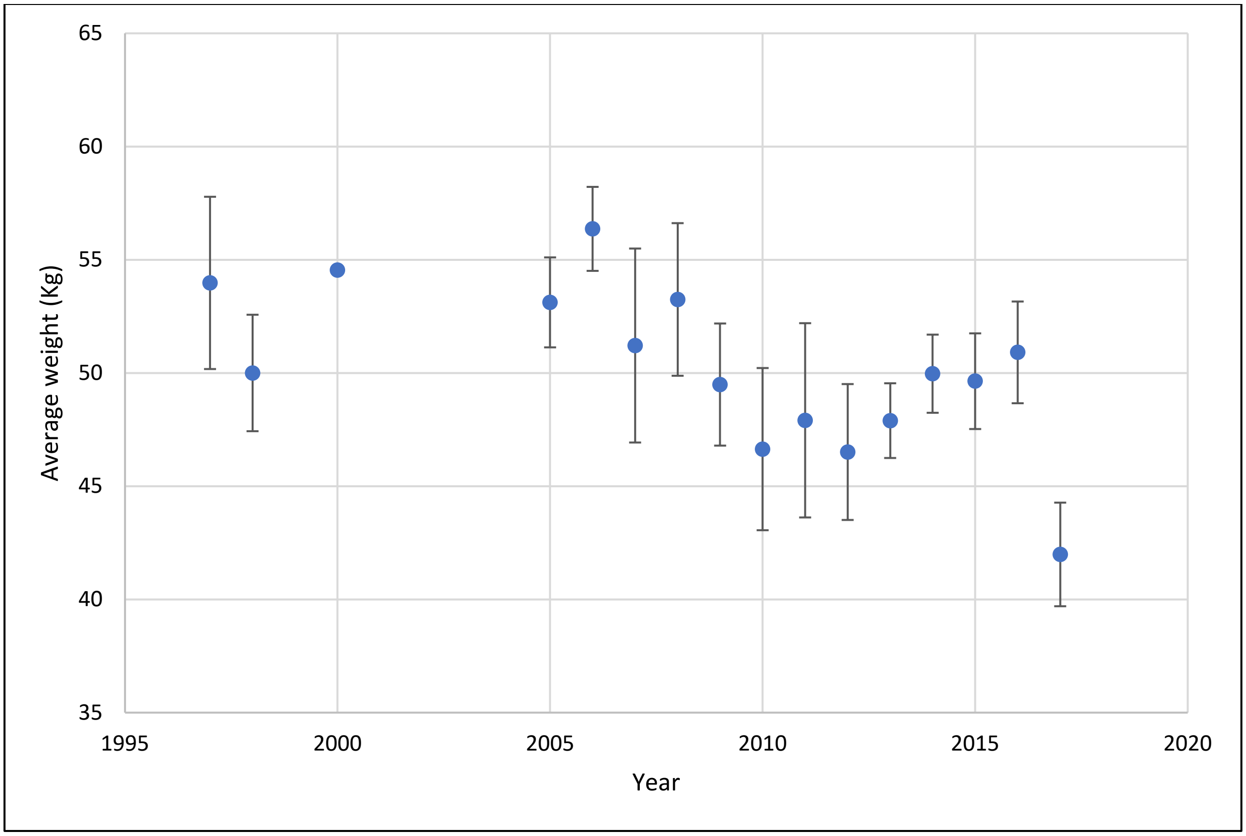


Figure 3. Average weights and 95% confidence limits of 13-month-old Teshekpuk caribou captured between 21 June and 9 July 1997–2017, Alaska.

We are unable to compare yearling weights to those in other herds due to the unique timing of captures in this herd. Calves are weighed at an age of 13 months in this herd whereas captures in other herds are typically conducted on 4-, 10-, or 11-month-old calves.

At this time neonatal weights and yearling weights do not appear to be strong indicators of individual fitness; both can be quite variable, and yearling weights can be subject to biases in selecting animals for capture. Although there are some weak indications that neonate and yearling weights decreased during the herd's decline in abundance, we do not know if adverse weather, density dependent range degradation, or a combination of the two led to the potential reduction in weight. Because change in range and movement are such extensive parts of caribou life history, it seems plausible that density-dependent effects may not be detected prior to observing effects on abundance.

Recommendations for Activity 1.6.

Consider eliminating this activity. Continued sampling of yearlings is likely due to our current protocol of maintaining a sample of known-aged, collared caribou. In order for weights to have the most utility for comparison with the current data set, captures should be consistently conducted during 21–28 June.

An issue with yearling captures is the potential bias resulting from targeting smaller yearlings in an effort to ensure that the captured animal is a yearling rather than a 2-year-old. If this issue is real, then changes in staff may have as much of an effect on variation in yearling weights as do natural processes. In the future, I would recommend that in the attempt to capture a sample of yearlings, a goal of incidentally capturing between 1 and 2 caribou that are age 2 would help to ensure that the entire spectrum of yearling weights is observed. Criteria for age confirmation include weights and tooth eruption patterns, with the expectation that 2-year-olds are likely to have all deciduous incisors replaced, with some light tooth staining. Weights that exceed 57 kg (125 lbs) should be viewed with skepticism, as that weight is in excess of 95% of putative yearling weights collected to date in this herd.

From the perspectives of cost and logistics, yearling weights are easy to obtain because the work coincides with captures that are already being conducted to maintain a known-aged sample of marked caribou. In contrast, collecting neonatal weights minimally costs anywhere from $7,000 to $10,000. This cost will be even higher when no other coincident helicopter work is planned during calving. Considering cost and the demonstrated lack of information provided, we see no obvious need or utility to collecting neonatal or yearling weights.

If monitoring body condition is deemed important, other metrics should be explored, including capture of calves at a different time of year (i.e., October), as yearling weights do not appear to be linked to fitness. At this time, the imperative to ensure that collared animals are from the Teshekpuk herd rather than a neighboring herd leads to a capture time in late June rather than October or March/April, when many other caribou captures tend to occur.

ACTIVITY 1.7. Evaluate the magnitude, sources, and timing of mortality in adult caribou via radio telemetry, monitoring of satellite collars, and field observations (Objective 3).

Data Needs

Understanding timing and sources of mortality is important for understanding demographic processes. Adult female mortality plays a critical role in ungulate population dynamics (e.g., Gaillard et al. 2000) and can be especially critical for caribou during declines in abundance (Crete et al. 1996). If collars are retrieved from mortalities close to the time of death, we can evaluate proximal causes of mortality (e.g., predation, drowning, etc.), which can be an important source of information when tracking population status and recommending regulatory changes. In addition, retrieving collars from mortalities in a timely fashion enables refurbishment of expensive satellite collars (e.g., reduces cost), allows retention and reuse of VHF frequencies, and reduces litter on the landscape.

Methods

Annual female (≥1-year old) mortality rate was estimated from the number of detected mortalities divided by the number of active collars on 1 July. This date corresponds to the beginning of a 12-month collar year (CY) aligned with the approximate date when new collars were deployed each year. VHF transmitters were tracked 10–15 times each year primarily during calving, the insect relief season, rut, and late winter prior to spring migration. Although we estimated seasonality of mortality for males, we did not estimate an annual mortality rate for VHF- and PTT-collared bulls due to the small sample size and a bias from selecting large bulls that are likely nearing the end of their natural lifespan.

Known-aged mortality rates for caribou 1–10 years of age were estimated from 1997–2017 using a Kaplan-Meier staggered entry procedure (Pollock et al. 1989). There was a total of 175 known-aged caribou captured as yearlings in most cases, and in a few cases as calves. We estimated mortality rates of yearlings compared to other adult age classes to evaluate whether yearling rates were significantly different from individuals greater than or equal to 2-years old and also individuals at age 2. This was investigated to establish whether pooling of yearlings and adults was warranted when estimating annual mortality rates. We also were interested in whether this relationship varied depending on which growth phase the herd was in.

Seasonality of mortality was estimated for 130 GPS-collared female caribou and 65 PTT-collared male caribou from 1990 through 2017. Mortalities due to capture or recapture were removed from the data set but hunting mortalities were included. For individuals where the date of death was unknown an approximate date of death was estimated. The estimate was the date corresponding to the second location in a continuous series of paired locations that were clustered in an area less than the potential error rate in location quality. Actual date of death may be up to 1 week earlier or later than estimated date of death due to collar duty cycles, particularly in winter when movement rates of living caribou are reduced. We grouped mortalities by 3-month seasons to examine broad patterns in seasonality of mortality and to establish baselines for comparison with other 5-year periods.

Mortality-site visits were accomplished in October, April, May, and June during 2012—2017. We used a helicopter or fixed wing aircraft as soon as logistics (especially daylight) and budgets allowed. Upon visiting a mortality site, we first looked for tracks in the vicinity (within 1 mile) from the air. After landing, we would locate the collar, look for evidence of violent death such as predator hair and feces, then assess the general disposition of the carcass. We assigned 3 categories to mortalities: 1) predation, 2) nonpredation (e.g., starvation, drowning, broken limb, etc.), and 3) unknown cause. Predation and nonpredation mortalities were further classified if possible.

We used tracks, scat, hair, and disposition of the carcass to assign predation-related deaths to predator type. Potential predators were Golden eagles, grizzly bears, wolves, lynx, and wolverine (e.g., Keech et al. 2011, Adams et al 1995). Wolverines occasionally cached the collar and portions of the carcass in rocks or in deep snowbanks. Predation mortalities were not assigned specifically to wolverines unless other predators could be positively eliminated because of the propensity for wolverines to scavenge.

Blood spatter on the collar and premortem hemorrhage were used to confirm that the death was attributable to predation rather than scavenging. We used the blood reagent luminol to detect latent bloodstains. Collar material that was soaked in blood or had clear and extensive spatter patterns were assumed to be predation mortalities. Collars with a small amount of blood were classified as unknown because of the potential for contamination during scavenging. Collars with no blood and a completely torn expansion section were assumed to have shed collars in absence of evidence to the contrary. This was particularly likely to occur for males during the rut.

Results and Discussion

Adult female survival rates during the 5-year reporting period ranged from 68–91% and included the 2 lowest survival rates observed since 1990 (72% and 68%; Table 2). Mortality during 2012–

2013 was very high and may have been related to exceptionally late phenology in spring of 2013. The effect was persistent as indicated by an exceptionally low parturition rate in 2014, possibly due to animals remaining in poor condition during breeding in autumn of 2013. During the decline phase (2009–2013), the female survival rate was 79% (331 collar years, 95% confidence limits (CL) 74–83%) compared to 86% outside of that phase (915 collar years; 95% CL 84–88%).

There is some indication that yearlings survive at a lower rate than 2-year-olds (83% survival for yearlings, 95% CL 76–89%, n = 154; 94% survival for 2-year-olds, 95% CL 89–97%, n = 82; Fig. 4). In general, yearling mortality rates appear to follow a pattern that is more extreme than adult age classes. Pooling data during the declining and increasing phases showed yearlings survived 66% of the time during the decreasing phase (n = 58, 95% CL 52–78%) and 94% of the time during the increasing phase (n = 117, 95% CL 88–98%). In contrast, adults survived more similarly across phases where survival was estimated as 79% during the decreasing phase (n = 273 caribou years, 95% CL 74–84%) and 85% during the increasing phase (n = 770 caribou-years, 95% CL 82–87%). This supports the hypothesis that a large proportion of the high mortality signal observed during the decline phase was due to yearling mortality. However, it is also important to recognize that the mortality rate of adults also increased and by the conclusion of the 2013–2014 collar year the oldest known-aged, collared female was 9-years old; and the average minimum age of collared caribou had dropped by over 2 years. If the collared sample was reflective of the age structure of the population, then the population was composed primarily of 3- to 8-year-old caribou by 2015; however, we did not evaluate age structure of the population during this period.

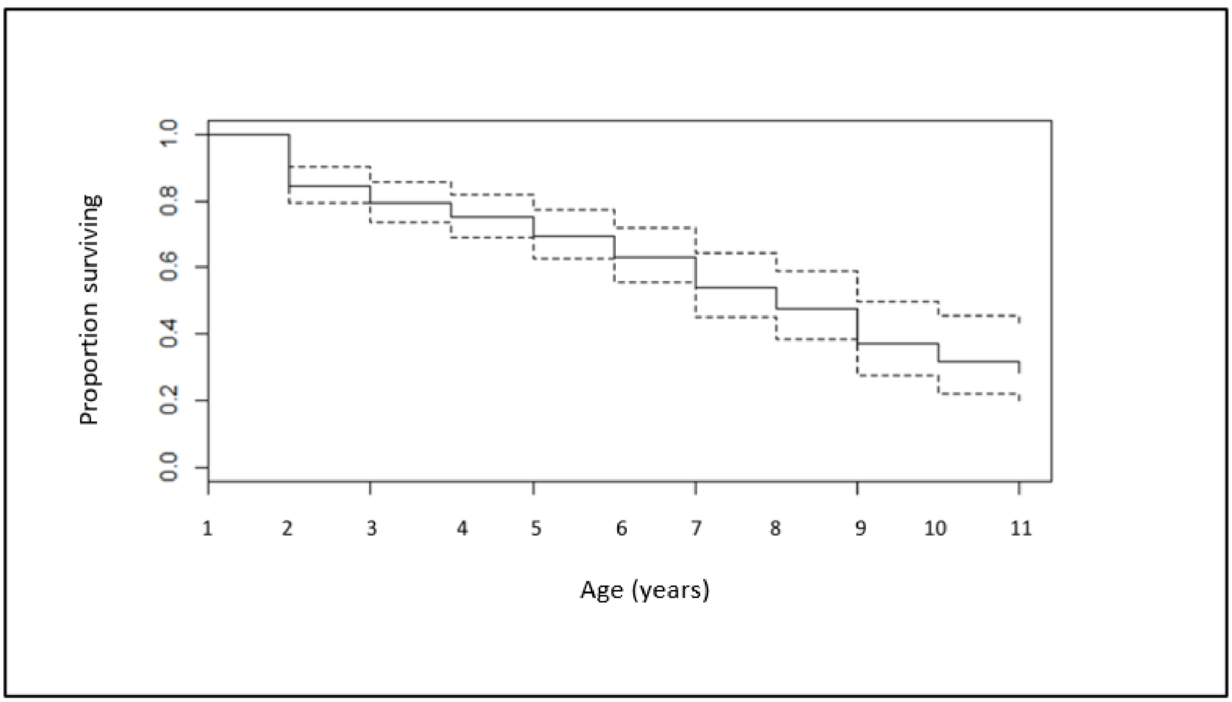


Figure 4. Kaplan-Meier survival estimates (solid) with 95% confidence intervals (dashed) for known-aged Teshekpuk caribou ages 1 through 11 years old, 1991–2017, Alaska. Sample sizes range from 175 yearlings to only 6 caribou (age 10). This herd's annual range is typically in northwestern Alaska, primarily in Game Management Units 23, 24 and 26.

Historically we have pooled ages to estimate annual mortality, but as yearling sample sizes increased in the last decade, it was unclear if this change was influencing the pooled mortality rate compared to prior decades, when the sample was composed primarily of older animals. It may be the case that yearling survival rates are generally lower than adults, but that relationship appears to vary depending upon how difficult environmental conditions are. Reevaluating this relationship as the sample of known-aged caribou increases may be required to fully discern any nuanced patterns in age-specific mortality. However, at this time we are assuming that pooling is unlikely to mask any relevant signals in temporal patterns of mortality.

Mortality of satellite-collared cows and bulls displayed seasonality that differed between the sexes. The highest female mortality occurred in spring (March–May; Fig. 5a) and the highest male mortality tended to occur in fall (September–November; Fig. 5b). Adult mortality was low in summer for both sexes. Although harvest is included, it is generally a small proportion of the mortality for both sexes. The high fall mortality in males was largely natural and tended to take place mostly following rut. Given the sampling bias toward collaring larger (breeding) bulls it is likely that the injuries and exertion associated with rutting activities contributed to the high mortality pattern observed in fall. Female mortality appeared to climb through the course of the year indicating that there may be a nutritional component to late-winter and spring mortality although predation was still identified as the proximal source of mortality in most cases where a cause of mortality could be identified.

We visited 83 mortalities from collar years 2012 through 2017. In broad categories, hunting was identified in 11% of the cases, nonpredation events (i.e., disease, injury, starvation) in 10% of the cases, and predation in 39% of the cases. Cause of death could not be determined for 40% of the individuals.

Precision for annual mortality estimates is generally low (e.g., 95% CI half widths averaged 10%, 2008 through 2017). Given the importance of adult mortality rates in predicting changes in abundance (Activity 1.1), and the impacts that small changes in rates can have on abundance, improved precision is desirable. Logistical and budgetary limits are likely to keep sample sizes near their current state; however, from an inferential standpoint, our ability to detect changes in mortality may be limited to detecting very high mortality years in contrast to long-term averages.

Recommendations for Activity 1.7.

Continue with potential modifications.

Like many metrics in this survey and inventory program, we can only make inferences by combining years (e.g., survival across broad time periods, or across broad age classes). Increased precision for annual survival estimates may be desirable to inform abundance estimation or may be useful to estimate probability of the herd increasing or decreasing (e.g., Hansen *In prep*). In the future we may need to evaluate sample size requirements for improving precision of estimates. Due to the large number of telemetry devices currently deployed on the North Slope, it may be logistically difficult to increase sample sizes due to limitations in the number of available frequencies.

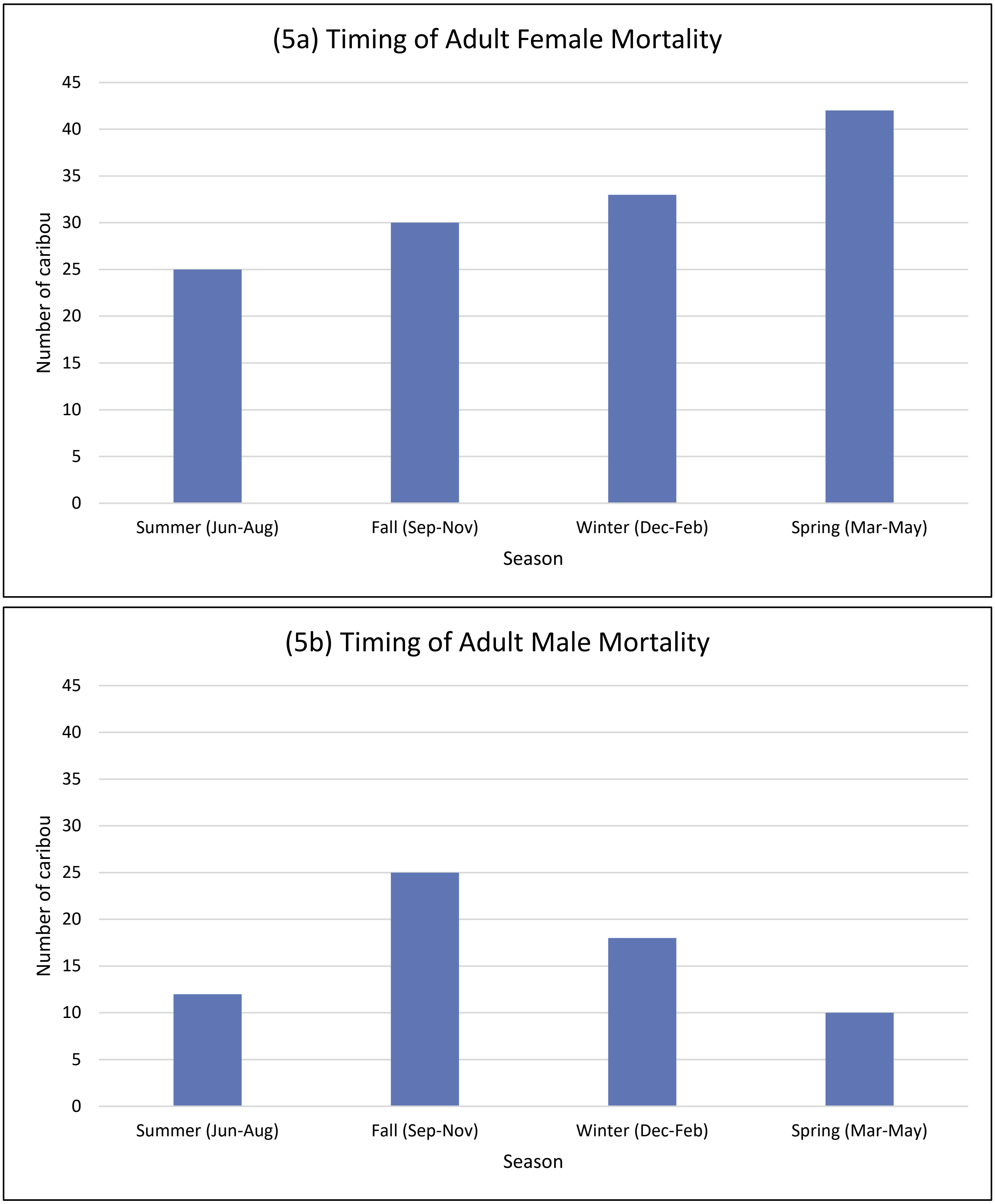


Figure 5. Number of Teshekpuk caribou herd mortalities by season for satellite-collared adult females (Fig. 5a, *n* = 130) and adult males (Fig. 5b, *n* = 65) from 1990–2017, Alaska. Capture mortalities are excluded, while harvest is included. Unknown mortality dates were estimated by using movement rates in relation to potential error in GPS or PTT collars to detect when caribou have stopped moving.

Some effort should be made to reevaluate age-specific mortality in the future to examine the concern that increased sample sizes of yearlings in recent years may be biasing herd-wise mortality rates upwards, which may negate the value and utility of trend analysis. Given our already limited sample size, separating yearlings from older animals may not be ideal (requires biometric and research support).

The level of effort required to quantify sources of predation depends on the need and amount of detailed information that result from shorter or longer intervals between detection and site visits. We were able to visit mortalities on a more frequent basis because of a concomitant calf survival research project in 2012 and 2013, which sometimes allowed making 5 separate trips in the spring. A reduced site-visit frequency to coincide with 3 regular field activities (fall composition, spring composition, and calving) may provide sufficient effort to identify proximal causes of most mortality events, but more complete knowledge requires substantially more effort.

ACTIVITY 1.8. Monitor short-yearling recruitment through rangewide spring radiotelemetry and composition surveys (Objective 3).

Data Needs

Spring composition surveys are conducted to estimate the recruitment rate of the population. This estimate of the proportion of the population made up of 10-month-old calves may provide context for abundance surveys and signal long-term trends in population age structure and future productivity. These surveys also contribute to our knowledge of animal fates because we are able to locate mortality sites that can be visited within the next few months (Activity 1.7). These surveys, which cover a large proportion of the winter range, also contribute greatly toward our ability to end the collar year with known-fates for most collared individuals. Such knowledge allows us to enter the photocensus season with a radiotracking list limited to active collars (Activity 1.1).

Methods

We used fixed-wing aircraft to locate radiocollared caribou in early to mid-April. Approximately 100 caribou within a 5-mile radius of each radio collar were classified to estimate herd composition. Total sample size objectives were 3,000 caribou, which typically results in a 95% confidence interval half width of less than 4% of the estimate. The proportion of the sample made up of yearlings was calculated using cluster sampling methods (Cochran 1977). The long-term trend in short-yearling recruitment rate was analyzed using simple linear regression.

Results and Discussion

Short yearling proportions ranged from 12–22% during 2013–2017 (Table 3). The average short yearling proportion from 1990–2012 was 15% (Parrett 2015). Short yearling proportions declined in this herd from approximately 20% in the early 1990s (Parrett 2011) to an average of 12% during 2009–2013, when the herd declined in abundance (Parrett 2015). The annual rate of decline in recruitment rate from 1990 through 2013 was low (−0.4% per year), but significantly different from zero (P-value = 0.001). In addition to the immediate effect that low recruitment has on abundance, we hypothesize that the gradual reduction in recruitment accompanied by relatively stable adult female mortality during 1990–2012 likely led to an older age structure in the population. This could have predisposed the population to significant mortality events as observed in 2013 and 2014. This is speculative as we cannot corroborate this hypothesis with actual age structure data from the population. We did observe that the age structure of the collared sample (Activity 1.7) appeared to consolidate around the prime ages of 3–8 years following the decline.

Recommendations for Activity 1.8.

I recommend continuing this activity because of favorable weather in the spring and the ability to complete this activity without helicopter support. In general, this is one of the most repeatable activities conducted on this herd. Some concerns exist regarding the limited inferences that are possible using the short-yearling proportions. The adult portion of the composition can change due to changes in sex and age ratios in the herd at large and may also be susceptible to short term fluctuations resulting from sex or age segregation.

Anecdotally, it would appear from conducting cluster samples near collared bulls that the calf proportion is substantially lower than samples drawn from collared females or collared calves. A more formal evaluation of this difference may help to quantify the difference between focal animal types. Although consistent helicopter-based sampling would be necessary to quantify the proportion of the denominator made up by males; and thereby clarify whether the proportion is more representative of calves in the population at large, or calves relative to adult females. I recommend conducting research on the extent to which sexual segregation and composition of the denominator influence this index, as it may improve the potential inference that can be made. An estimate of recruitment that provides a closer index of the survival of female calves in relation to adult female mortality would help to evaluate which growth phase the herd may be in and help to predict future fluctuations that result from unstable age distribution in the herd. Whether or not to include males as focal animals ultimately depends upon the question that is being asked (requires biometric and research support).

There is no numeric threshold established that would indicate the need for a change in management strategy. Although, based on WAH data, directly comparing this metric to adult female survival may provide insight into the associated growth phase of the herd (Dau 2013). The short-yearling index is currently used to provide context relative to adult female mortality rates and signal long-term trends in recruitment and putative age structure. The ability of this metric to further inform understanding of current age structure and growth phase should be investigated.

ACTIVITY 1.9. Use radiotelemetry and satellite-collar location data to identify seasonal ranges including calving, insect relief, fall and spring migration routes, and wintering areas. Estimate the extent of seasonal mixing that occurs between the Teshekpuk, Central Arctic, and Western Arctic herds (Objectives 1, 2, 5, and 7).

Data Needs

Data on seasonal distribution is useful for estimating herd overlap, harvest by herd, and informing the timing and spatial extent of regulatory changes. In addition, requests for data on spatial distribution for planning and mitigation of development occur on a regular basis. These products are useful for both the state and outside entities to inform comments on development plans and environmental impact statements, as well as plan for effective mitigation.

Methods

Estimation of calving distribution and winter distribution relies on a combination of locations provided by satellite and radiotelemetry that are inputs for fixed-kernel analyses. Estimates of spring and fall migratory routes have been limited to largely continuous data streams from satellite collared caribou (both PTT and GPS) and are based on cumulative estimates of individual Brownian bridge movement models (Horne et al. 2007, Sawyer et al. 2009). We estimated seasonal distributions with utilization distributions created for every other day. We then averaged across season dates for the 5-year reporting period. In addition, we averaged dynamic Brownian bridge estimates for individuals across the 5-year period. Currently, seasons are delimited using general knowledge of the timing of biological events including calving, insect avoidance, and both spring and fall migration (Person et al 2007).

Calving distribution—ArcMap (ESRI, Redlands, CA) was used to map calving period locations based on information collected during calving surveys. The location a cow was first seen with a calf was assumed to be the approximate calving location (Carroll et al. 2005). A cow's location nearest in time to the median calving date was used when cows were not observed with a calf. To document the historical use of calving grounds, we used calving locations documented from 1994 to 2012 to produce fixed-kernel utilization distributions for each year (Seaman et al. 1998, Griffith et al. 2002, Parrett 2007). Because annual sample sizes varied, we did not pool calving locations across years to produce a cumulative distribution. Instead, annual utilization distributions were produced using the same 5 km (3.1 mi) grid with least-squares cross-validation of bandwidth selection (Seaman et al. 1998). This allowed us to sum the observation densities at grid intersections across years and divide by the total number of years. This approach allowed us to produce a cumulative calving distribution that was unbiased with respect to annual sample size. Parturition rates in 2014 were so low (28%, Activity 1.3) that we did not estimate calving distribution for that year; the small sample suggested that it was similar to other distributions during the reporting period.

Spring and Fall migration—Estimates of migratory intensity were classified by categorizing the cumulative density of movement paths into 4 equal categories of increasing relative probability of use corresponding to low, moderate, high, and very high intensity use as in Sawyer et al. (2009). We delimited the series of locations used for estimating each individual's migratory path by using dates proposed by Person et al. (2007).

Postcalving, insect relief, late summer, and winter distribution—Distributions for these seasons were estimated using a cumulative kernel averaged across a fixed grid similar to the one used for estimating cumulative calving distribution. Individual locations from satellite telemetry were used to generate kernel estimates for every other day (to match the typical maximum location intervals). We estimated 50%, 75%, and 95% volume contours for the cumulative kernel density utilization distribution.

Results and Discussion

Calving distribution—In recent history (e.g., since 1990) calving has typically occurred near Teshekpuk Lake, specifically to the northeast, east, and south of the lake, with annual variation related to phenology (Carroll et al 2005). During 2013–2017 (Figs. 6a–f), calving occurred in areas consistent with the historical distribution unlike what was observed from 2010 through

2013 which was a deviation from the norm (Parrett 2015). From 2010 through 2013 very few caribou used the historical area of concentrated calving with many caribou calving west of the Ikpikpuk River. The causes of this temporary shift in calving ground use are unknown. While it is interesting that high fidelity areas near Teshekpuk Lake used consistently from 1990 through 2009 were temporarily abandoned, one of the areas that caribou shifted to (the lower Ikpikpuk) was reported to be one of the calving areas when TCH was first reported as a distinct herd (Reynolds 1981).

Summer distribution—Summer range is typically bounded by the Colville River to the east and southeast and extends to the southwest as far as a line from Umiat to Icy Cape. Coastal areas from Utqiaġvik (Barrow) to Cape Halkett are heavily used for insect relief from late June through early August particularly the area north of Teshekpuk Lake (Figs. 7c–g). Fidelity by TCH caribou to summer range is very high, although a few caribou will temporarily diverge from TCH and adopt the summer movement patterns of an adjacent herd, particularly after calving with them. Adopting summer movement patterns of an adjacent herd is less common than simply sharing a calving range for the period surrounding parturition. The portions of the summer range used for insect relief are typically the coastal areas within 1–15 km of the Beaufort Sea coast. See Wilson et al. (2012) for examples of summer range and habitats used when insect harassment is high or low.

Spring and fall migration—General patterns of seasonal movement used by TCH have been previously documented (Philo et al. 1993, Prichard et al. 2001, Carroll et al. 2005, Carroll 2007, Person et al. 2007). Spring migration routes are variable but similar to those seen in fall, which is expected for the return migration to the calving ground (Figs. 7b and 7h). A major difference in spring is that individual routes tend to be more direct but less consistent across individuals than routes chosen by individuals in the fall. This increased independence in individual movement along common routes results in population-level patterns that are more diffuse. In particular, caribou that migrated together along the coast in the fall were likely to move independently through the mountains and across the interior of the coastal plain in the spring.

Fall migration routes are variable and provide access to widely separated areas of winter range. Movements can be characterized into 3 broad categories. One category is intra-coastal plain movements that typically result in winter concentrations near Nuiqsut, Wainwright, and Atqasuk. Another is southeasterly movements toward wintering areas in the central Brooks Range. Lastly are southwestern movements along the Chukchi coast towards wintering areas in Unit 23. Other fall movements occur, but these 3 movement types are the most common (Fig. 7h).

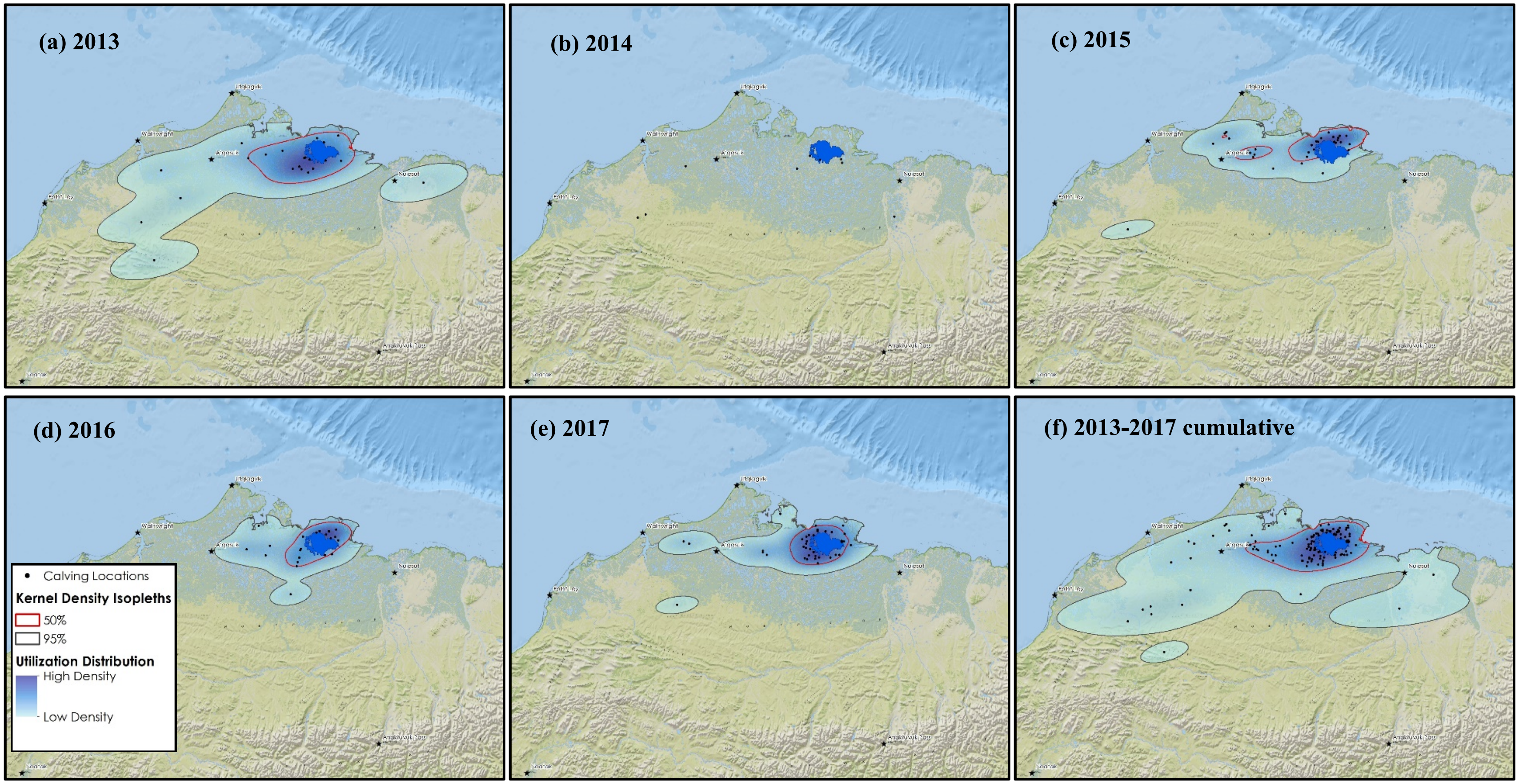
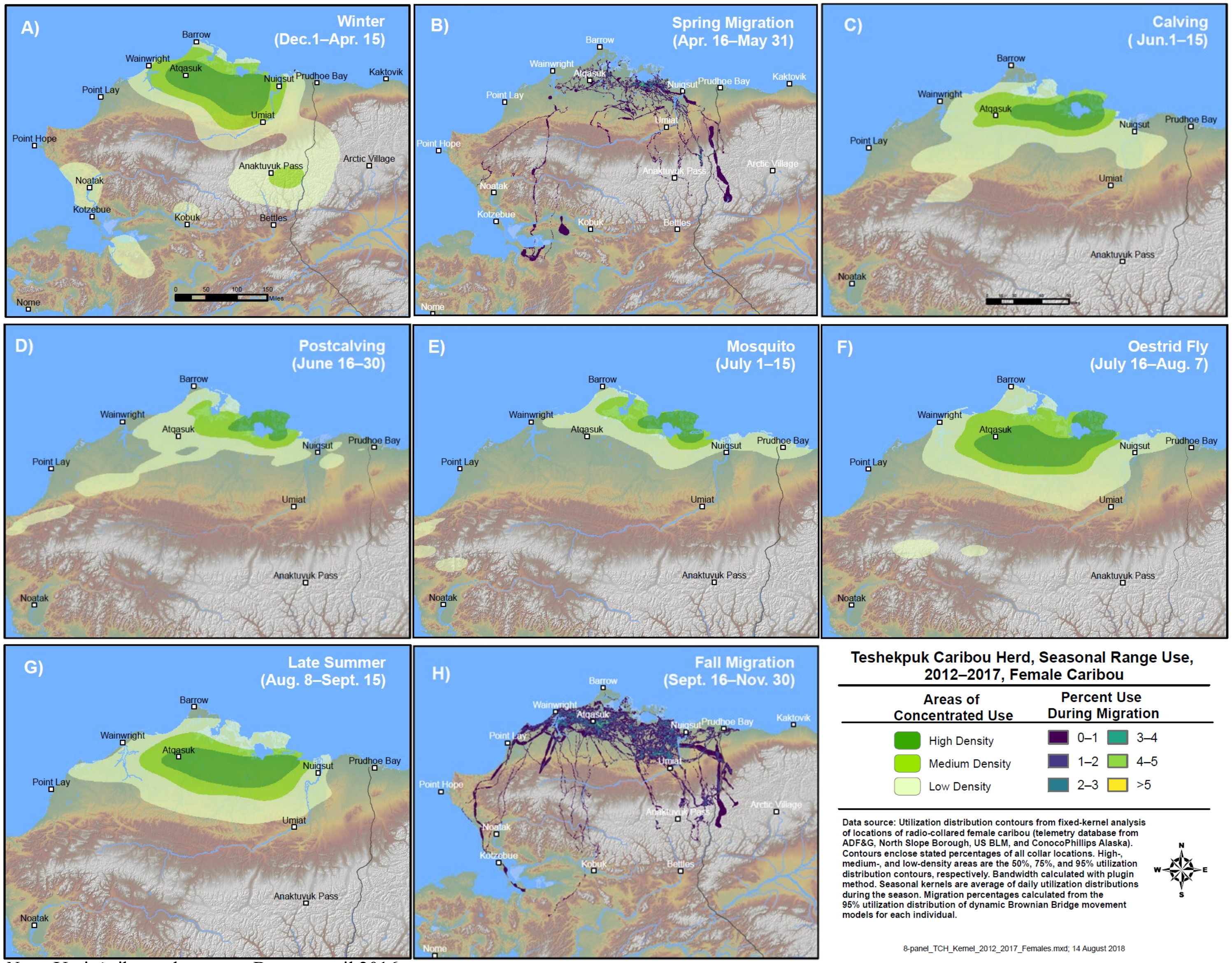


Figure 6a-f. Annual Teshekpuk calving distributions and cumulative calving distribution, 2013–2017, Alaska. Utilization distributions were estimated, and 50% and 95% kernel contours are displayed. Note that 2014 parturition rates were so low that an inadequate number of calving locations were obtained to estimate a utilization distribution, so only raw locations are displayed. These calving distributions are based on observations of parturient caribou, both VHF and satellite collared. In contrast, Figure 7c is all satellite collared females during the calving period, whether parturient or not.



Note: Utqiaġvik was known as Barrow until 2016.

Figure 7. Seasonal ranges, 2012–2017, for satellite collared female caribou of the Teshekpuk caribou herd, Alaska.

Winter distribution—The Teshekpuk caribou herd is unique among Arctic coastal plain calving caribou in that most years a substantial proportion of the herd remains on the coastal plain through the winter. There have been 4 relatively distinct wintering concentrations: 1) the coastal plain between Atqasuk and Wainwright, 2) the coastal plain west of Nuiqsut, 3) the central Brooks Range, and 4) the shared winter range with WAH in the Noatak, Kobuk, and Selawik drainages (Fig. 7a). Although winters of RY13–RY17 represent only a portion of the long-term satellite telemetry dataset, the winter range used in those 5 years was consistent with previous patterns (Philo et al. 1993, Prichard et al. 2001, Carroll et al. 2005, Carroll 2007, Person et al. 2007, Fullman et al. 2021).

Combined seasonal distribution—To summarize seasonal distributions in a single figure, we displayed 75% contours for calving, combined summer seasons, and winter with migratory routes connecting the seasonal ranges (Fig. 1).

Herd mixture—Seasonal sharing of ranges and mixture of caribou from multiple herds is common. Emigration rates tend to be low and directional, with larger herds tending to absorb caribou from smaller adjacent herds (Prichard et al. 2020).

Recommendations for Activity 1.9.

Continue. Quantitative methods for demarcating seasonality have not been broadly applied for this herd. One potential technique might include using a net distance squared model (Bunnefeld et al. 2011) to estimate migratory start and end. This technique requires calculating the squared net distance moved from an originating point. The originating point we would likely use would be the location of an individual caribou on 1 July. Directed movements away and toward that origin would result in a double sigmoid curve wherein its vertices demarcate the initiation and cessation of migratory movement periods.

Work to delimit other seasons between calving and fall migration may not be able to rely so explicitly on net-squared displacement models (e.g., Dau 2013), so other methods would need to be developed. For most purposes the dates outlined by Person et al (2007) are likely to be adequate.

2. Mortality-Harvest Monitoring and Regulations

ACTIVITY 2.1. Estimate caribou harvest. Work with the North Slope Borough and ADF&G, Subsistence Division to collect harvest information through community harvest surveys. Pursue harvest ticket and registration permit methods for estimating harvest (Objectives 1, 5, and 6).

Data Needs

Effective adjustment of regulations and evaluation of population and composition response to harvest requires knowledge of harvest patterns. Documentation of harvest levels is important for establishment, refinement, and comparison to administrative thresholds such as intensive management harvest objectives and amounts necessary for subsistence uses. The department does not currently have an efficient system in place, particularly for documenting harvest by local residents who hunt TCH caribou.

Methods

Previous analyses have shown that the hunter registration and reporting system was not effective in estimating caribou harvest in communities within the range of TCH (e.g., Georgette 2016). For at least the past 10 years, few hunters have registered with the department, and as a result no inquiries regarding harvest have been conducted using the registration system. Consequently, community harvest surveys have been used as an alternate method to quantify harvest; however, during this reporting period, no community harvest surveys were completed within the range of TCH. Lacking recent estimates, we instead used average harvests from communities located in the core TCH range. Because some communities have access to caribou from more than one herd on an annual basis, we used previously estimated proportional herd harvest from specific communities based on harvest in relation to caribou distribution where spatially referenced harvest data and satellite telemetry caribou location data were concurrent (Parrett 2013, Braem 2013). Additionally, harvest by nonlocal hunters was determined through harvest ticket reporting; proportional herd harvest was estimated using knowledge of caribou distribution at the time of reported harvest. This data was then used to evaluate the likelihood that harvest was from TCH or from an adjacent herd. As an approximation of what the range in harvest might be, we used the minimum and maximum per capita harvest rates from the primary communities that harvest TCH, average population sizes across the surveys, and estimated proportion of TCH in the harvest to calculate what minimum and maximum harvests might be.

Starting in RY17, a registration permit was put in place across the core ranges of TCH and WAH. We have yet to understand the level of participation and reporting rates that will occur, but active outreach efforts in preparation for the switch to this system began during this reporting period.

Season and Bag Limit

Harvest opportunity in Unit 26A, where most TCH harvest occurs, is outlined in the tables below.

Regulatory years 2012–2014

Unit and bag limits	Resident open season (Subsistence and general hunts)	Nonresident open season
Unit 26A Resident hunters: 5 caribou per day; cow caribou may not be taken 16 May–30 Jun	1 Jul–30 Jun	
Nonresident hunters: 5 caribou total; cow caribou may not be taken 16 May–30 Jun.		1 Jul–30 Jun

-continued-

Season and Bag Limit continued

Regulatory years 2015–2016		
Unit and bag limits	Resident open season (Subsistence and general hunts)	Nonresident open season
Unit 26A: Colville River drainage upstream from the Anaktuvuk River, and the drainages of the Chukchi Sea south and west of, and including the Utukok River Drainage (WAH range)		
Resident Hunters: 5 caribou per day, however calves may not be taken	Bulls: 1 Jul – 14 Oct 1 Feb – 30 Jun Cows: 15 Jul – 30 Apr	
Nonresident Hunters: 1 bull, however calves may not be taken		15 Jul–30 Sep
Unit 26A remainder (TCH range)		
Resident Hunters: 5 bulls per day, however calves cannot be taken	1 Jul – 15 Jul 16 Mar – 30 Jun	
5 caribou per day, 3 of which may be cows, calves may not be taken	16 Jul – 15 Oct	
3 cows per day, however calves may not be taken	16 Oct – 31 Dec	
5 caribou per day, 3 of which may be cows; calves may not be taken	1 Jan – 15 Mar	
Nonresident Hunters: 1 bull, however calves may not be taken		15 July – 30 Sep

Results and Discussion

Based on previously conducted community harvest data sets and harvest ticket data, we estimate TCH harvest has been approximately 2,350 caribou per year, from 2012 through 2017 (Braem 2013). Composition of harvest is estimated to be comprised of approximately 20% cows and 80% bulls (Braem et al. 2011). Local harvest is approximately 2,340 caribou; harvest by nonlocal residents and nonresidents is approximately 10 caribou per year in Unit 26A. An additional 20–40 can be harvested in Unit 26B by hunters traveling from the Dalton Highway in the spring, but this is dependent upon TCH distribution. More conservative regulations began in RY17 in Unit 26B which also may have had an influence on TCH harvest. Looking more generally at the average number of caribou harvested within 26A, proportional harvest by source herd yields an estimated 53% TCH, 46% WAH, and 1% CAH (Parrett 2013, Braem 2013)

The estimated harvest is likely to be a gross approximation, and we have no real sense of annual variability. Using minimum and maximum per capita harvest amounts corrected for the proportion of the harvest comprised of TCH caribou resulted in a potential harvest range of approximately 1,980–4,830 caribou (Table 5). One large source of potential variation is from Utqiaġvik (Barrow), where household surveys are difficult to accomplish, regardless of the entity conducting the survey. Harvest estimates from Utqiaġvik have varied by a factor of almost 5, and per capita harvest rates have varied by a factor of 4. Because the Utqiaġvik population is large and access to caribou can be very good, harvesting power is substantial. Consequently, understanding harvest from Utqiaġvik is essential to understanding Teshekpuk caribou harvest rates.

Table 5. Minimum and maximum predicted caribou harvests using the range of per-capita harvests, Alaska.

Community	Average community size (1990–2009)	Proportion TCH in Harvest	Per capita range	Minimum harvest	Maximum harvest
Anaktuvuk Pass	295	30%	0.7–2.6	62	230
Atqasuk	235	98%	0.7–1.8	161	414
Utqiaġvik[a]	4,300	97%	0.3–0.7	1,251	2,920
Nuiqsut	419	77%	0.6–1.9	192	607
Wainwright	525	60%	1.0–2.1	315	662
Total				1,981	4,833

Note: The range of per-capita harvest (Table 1, Braem 2013) has been corrected for the expected proportion of TCH caribou in the harvest.

[a] Known as Barrow until 2016.

Harvest by Hunters-Trappers

See Activity 2.1, Results and Discussion (above).

Permit Hunts

There were no permit hunts for TCH caribou prior to RY17.

Hunter Residency and Success

The total number of hunters participating in TCH hunts has not been quantified, so residency is generalized from harvest data. The majority of harvest (>99%) is by resident hunters. Nonresident hunters participate through harvest ticket hunts, and they take less than 0.5% of the annual harvest. Hunter effort is typically not quantified on community harvest surveys so there are no measures of success for hunters pursuing Teshekpuk caribou.

Harvest Chronology

Since the majority of harvest is by local residents in communities within the range of TCH, seasonal chronology of harvest is largely influenced by availability of caribou within traditional hunting areas used by the communities that harvest caribou. Annual variation in caribou distribution confounds the issue of availability; previous reports have described chronology of annual harvest (Parrett 2013).

Transport Methods

Transport methods have not been quantified for the vast majority of hunters participating in TCH hunts. A combination of boats, snowmachines, and ATVs are used by local residents, varying by season. In contrast, most visiting hunters use airplanes to get to their hunting location.

Alaska Board of Game Actions and Emergency Orders

Changes to regulations were passed by the Board of Game in March 2015 and took effect in RY15. These changes were precipitated by the declines that had been observed to date in both WAH and TCH. Local advisory committees crafted the changes to seasons and bag limits, which were presented to the board as potential amendments to Proposal 202, which was accepted as an agenda change request from the department. This would split Unit 26A into 2 hunt areas to reflect typical WAH and TCH distribution, reduce season lengths across the ranges of both herds, and reduce daily bag limits for cows within the TCH range.

In January of 2017, the Board of Game adopted proposal 2, which was a department proposal to begin using a registration permit in the majority of the TCH and WAH range (RC907). In 2016, the board adopted a proposal to change WAH regulations in Unit 22 to create an annual bag limit with a registration permit (RC800). The department's intent with proposing a registration permit in the remainder of the range of WAH and TCH was to provide increased flexibility in hunt management options, to increase participation in the reporting system, and provide a means for greater familiarity with ADF&G hunt management in the event that declines occurred in one or both herds that required harvest management. This permit does not include failure to report stipulations, where certain hunting privileges can be revoked as a consequence of not reporting permit results. The permit was first available in RY17. Considerable inperson efforts to inform the public and make permits widely available were undertaken in Units 23 and 26A. Analyses of permit acquisition and reporting will occur in the next reporting period (RY17–RY21).

Recommendations for Activity 2.1.

Continue. With the implementation of RC907 in 2017, we are beginning a new effort to see if a traditional permit system will gain any traction within the TCH range. Although changes that occurred during this reporting period signal a new regime in conservation through regulations, data is still expected to be of limited utility, at least initially. Regardless of the success of RC907, the department is interested in understanding what influences relative success, and what our best efforts to promote availability and use of the permit result in. It is possible that a new reporting system will also need to be developed if harvestable surplus appears to fall well below our gross understanding of harvest levels. What this might look like is highly dependent upon public involvement to develop an allocation and harvest reporting system that most closely achieves board intent, meets the needs of managers, and addresses the concerns of the hunting public.

I recommend encouraging local entities, particularly the North Slope Borough, to conduct more frequent community harvest surveys. Although locally driven efforts to collect harvest data might increase our ability to monitor harvest, they would not create the local infrastructure and habits that would be required for managing quota-based hunts.

3. Habitat Assessment-Enhancement

Logistical factors preclude effective treatment or cost-efficient application of habitat enhancement activities. Other than large scale climactic factors that could influence caribou habitat quality, the primary consideration for managing caribou habitat at this time is mitigating the risk of habitat loss that could occur through changes in caribou movement and habitat use patterns that could result from anthropogenic alteration of the landscape. An additional consideration is the reduction in population growth rates through hunting when necessary to avoid overgrazing; this is not always feasible in areas with difficult access, such as the TCH range.

ACTIVITY 3.1. Evaluate habitat conditions to understand sustainable density and the role of environmental factors in influencing population dynamics (Objectives 2 and 3).

Data Needs

Evaluating habitat condition in concert with evaluating caribou body condition (Activity 1.6) can provide context for several decision frameworks regarding the evaluation of herd size, trend, and potential for growth (Activity 1.2). This also increases our ability to manage adaptively, through identifying drivers of population change. Understanding the role of broad environmental factors in influencing population dynamics can be important for putting anthropogenic changes into context (i.e., new infrastructure or regulatory change). Direct evaluation of habitat also improves our understanding of the relationship between habitat and body condition.

Methods

During the end of the last reporting period and the beginning of this reporting period, we collected summer forage in collaboration with researchers from University of Alaska Fairbanks (UAF) and U.S. Geological Survey (USGS) in part to evaluate the potential for a long-term monitoring protocol. Detailed methods are reported elsewhere (Vansomeren 2014), but basic methodology included assessing 0.5 × 0.5 meter (1.64 × 1.64 foot) plots for total biomass in 4 areas within the summer range along a latitudinal gradient. Forage samples were collected from the plots to evaluate digestibility and nutrient concentration. Other than participating in this study, there was no monitoring of broad environmental changes, including weather, snow depth, lichen abundance, or diet composition.

Results and Discussion

Preliminary results suggest that forage biomass in the TCH summer range was similar to biomass values observed for the adjacent CAH, and much lower than values observed for WAH. Forage quality was highly seasonal, with digestible nitrogen declining to near zero in most forages by the end of the growing season. Predominant forage species in the TCH summer range tended to be low in digestible nitrogen, potentially implying nitrogen limitation. See Vansomeren et al. (2014) for more detailed results. Data collected as part of this study has been useful in refining the utility of remotely sensed vegetation indices (Johnson et al. 2018). It has also provided insight into nutritionally limiting factors that may be important to monitor in the future (Gustine et al 2017, Johnson et al 2018), particularly the length of the late summer and fall growing season and seasonal nitrogen availability.

Recommendations for Activity 3.1.

Continue collaborations that enable greater understanding of the forage-body condition-fitness dynamic in arctic caribou as opportunities arise.

Nonregulatory Management Problems or Needs

The fate of important caribou habitats and the future of resource development in the northeast National Petroleum Reserve in Alaska (NPR-A) continue to be very important management issues in Unit 26A. They will be determined through an ongoing process involving public input, agency recommendations, and executive decisions. ADF&G will play an important role in providing information relative to this process (e.g., Activity 1.9). Development continues to move westward into the NPR-A. During the next reporting period, it is expected that new infrastructure will be placed in areas that have an extensive pattern of historic use by TCH that is well documented through VHF and satellite collar data. This will provide an opportunity to examine caribou responses to new development with 20 years of predevelopment data. In addition to research on the effects of permanent infrastructure, the influence of aircraft on caribou movements is frequently raised as an issue within the ranges of the WAH and TCH. Relevant information on the topic could have implications for regulations (e.g., timing, extent, and efficacy of controlled use areas) and could be useful for planning and mitigation for industry.

Data Recording and Archiving

Recording

- Calving survey and general radiotracking datasheet.
- Calf weight datasheet.
- Capture datasheet.
- Photocensus radiotracking datasheet.
- Photo counting datasheet.
- Fall composition datasheet.
- Spring composition datasheet.
- Mortality event datasheet.

Data collection is being transitioned to tablet-based applications that can reference the primary database maintained by ABR, Inc. and provide immediate integration into the database when internet access is available. The first application was designed for collecting parturition data. Mortality event, photocensus, and fall composition data are the next applications to be developed.

Archiving

Data that is in digital form is stored in the network H drive, the Region V research coordinator's computer hard drive, and external hard drive backups are also regularly created and stored by the Region V research coordinator. Paper data collected since 2007 is stored in the file cabinets located in the Fairbanks, Region III caribou biologist's office. Paper data collected from 1990 through 2006 is stored in file cabinets located in the Utqiaġvik Area office; most of these data were also scanned and are stored in the Fairbanks Region III office. Additionally, all satellite telemetry data collected since 1990 are stored on a database server maintained by ABR, Inc. in Fairbanks, with annual backups saved to the Fairbanks network drives. That database is slowly being updated to include almost all TCH data, not just those associated with satellite telemetry. To date, historical parturition data, capture data, and composition data have been incorporated into that integrated, relational database. Efforts to improve project documentation and archiving data with metadata need to be made in the future.

Some additional data on serology and parasitology results are held by the DWC wildlife health and disease veterinarian in various digital formats. Integrating these data into a digital relational format would be helpful if an evaluation of the fitness effects of exposure and infection are to be evaluated in the future. Additional serology and parasitology data are held in databases maintained by the North Slope Borough, Department of Wildlife Management.

Agreements

A memorandum of agreement between ADF&G, NSB, and BLM was signed in 1991 to lay out a framework for cooperative data collection. The primary objectives were to estimate population size, recruitment, distribution and movements, harvest, develop working relationships with local communities, delineate calving grounds, and document sources of mortality.

There is a 2005 agreement regarding the sharing of telemetry data between ConocoPhillips, ADF&G, and ABR, Inc. that has expired as of 2015, but that is still referred to for guidelines regarding data sharing.

Permitting

- ADFG Animal Care and Use permits 2007-13, 2012-13 and 2015-16.
- A BLM permit for summer access to National Petroleum Reserve-Alaska lands has been acquired annually since 2011.

Research

Research conducted during this reporting period by the U.S. Bureau of Land Management (BLM) is important to note for the Teshekpuk caribou herd including "Timing and causes of calf mortality in the TCH, 2011–2013, Caribou Calf Mortality Study" (BLM-AK-NOI-L10AS00211; Grant #L10AC20353).

The primary objectives for this study are as follows:

1) Estimate the timing, causes and rates of calf mortality through 1 year of age.
2) Quantify the relationship between calving distribution, habitat selection, and calf survival.
3) Estimate the influence of birth weight on survival, recruitment rates, and subsequent recapture weights.
4) Quantify the relationship between calf survival and a spring index of recruitment.
5) Evaluate longitudinal patterns in forage biomass and quality; build pilot data for a potential long-term monitoring protocol.

Conclusions and Management Recommendations

During this reporting period, we met all of our population and harvest objectives to 1) maintain a population of at least 15,000 caribou, recognizing that caribou numbers naturally fluctuate, 2) provide a harvest of at least 900 caribou, and 3) maintain a population composed of at least 30 bulls per 100 cows. Although the latter metric was slightly below the objective at 28:100 in 2016, the average bull-to-cow ratio for the reporting period was well above the objective.

Abundance surveys indicated a sharp decline between 2008 and 2013. Changes in abundance were mirrored by demographic changes, particularly in adult female survival, and to a lesser extent in recruitment and productivity. If the decline was telegraphed at all, it was only through steadily declining recruitment, which may have manifested itself in an older age structure. It is unclear if severe environmental conditions precipitated what may have been an incipient decline. There were some years where spring timing was later than usual, around the time period of the decline, and over-winter survival of calves was particularly poor during the winters of 2011–2012, 2012–2013, and 2013–2014. A post-hoc analysis of weather, including summer weather, may shed some light on how much weather contributed to the sharp decline. Anecdotally, this decline appears to have been driven by factors at multiple temporal scales. Proximally, most caribou, particularly those that did not winter on the North Slope, were killed by predators. Starvation was the cause of death of approximately 20% of calves that wintered on the North Slope. In considering a longer timescale, it is unclear if those caribou were predisposed to mortality by factors such as severe winter or summer weather that was not conducive to building adequate reserves. At the longest scale, it appears that the age structure of the herd at large may have been predisposed to large scale mortality events. As is often the case with wildlife studies, and caribou in particular, establishing what happened is far easier than establishing why.

From a management perspective, our survey and inventory program is focused on monitoring this population with little or no active harvest management. The public appears unlikely to support regulatory changes unless harvestable surplus is clearly being exceeded and harvest is contributing to population declines. Being able to clearly establish and communicate this circumstance effectively will be important to achieve local support for regulatory change. This will require better knowledge of harvest than we currently have and is likely to require multiple corroborating lines of biological evidence. Monitoring abundance is by far the most important biological metric. Secondarily, monitoring adult female mortality rates provides the most robust ancillary evidence of demographic change. All other sources of data that we currently collect could be characterized as a second tier of data that is less directly involved in management and is primarily useful for putting other metrics into context. These include parturition rates, spring and fall composition, and sources of mortality. The public is often concerned with their role in mortality of caribou, particularly in comparison to natural factors. This provides additional impetus for collecting harvest data, as well as attempting to document the sources of mortality in collared caribou.

Fall composition data can be difficult and expensive to obtain. If the most recent decline had continued, we may have relied more heavily on fall composition to determine harvestable surplus. When the population is above 40,000, it is unlikely that harvest pressure will exert much influence on abundance or composition regardless of how liberal regulations are; therefore, increasing cow harvest to influence adult composition in favor of bulls is unlikely. It is more likely that cows would need to be protected during or following a decline. Bulls might also need to be protected if they were to approach biologically critical levels for breeding, and few circumstances would allow liberal cow harvest while protecting bulls. Understanding what these thresholds might be would require trial-and-error management, with close monitoring during critical periods, and simulation of harvest effects on demographics.

Because spring composition is typically less expensive and easier to collect, it is likely that this metric will continue to be collected for this herd. Its value could be reinforced if a predictive role could be established, perhaps either in combination or comparison with adult mortality rates.

Any future situation with reduced survey and inventory funding requires prioritizing activities, establishing how to make the best use of the current metrics, or abandoning them for alternatives. Assuming that estimating abundance remains the cornerstone of the program, the most likely candidates for elimination are calf and yearling weights, maintaining a known-aged sample, calving surveys, and fall and spring composition.

From a research perspective there are several themes that warrant attention in the future. The role of weather is not well understood in terms of influences on any of the metrics. The role of winter severity on newborn calf weights, the potential for summer insect harassment to influence caribou survival, and weight of yearlings are all potential relationships that could be investigated. The benefit of understanding these relationships is in being able to better explain fluctuations in the metric, and begin to separate the role of density dependence, anthropogenic change, and short-term weather effects. The shortage of spatially explicit weather and snow data have always been a limitation, but the potential to use remotely sensed or interpolated weather remains a possibility.

New industrial developments extending into areas that are regularly used by TCH present opportunities. Evaluating the influence of infrastructure and industrial activity and helping to refine effective mitigation practices remains a priority. The ability to effectively assess these anthropogenic influences is dependent to some extent on effective evaluation of the role of weather on movement, distribution, and demographics. Similarly, anticipating potential effects of a changing climate also depends on clarifying relationships between weather and demographic processes.

One new activity that should be considered is the monitoring or evaluation of the standing age structure of the population. Much speculation has been generated regarding the role of age structure in the declines of the WAH, TCH, and Mulchatna caribou herd. If unstable age structures resulting from changes in recruitment rates produce incipient declines and increases, this information could be useful both for putting demographic rates into context and for predicting changes between abundance estimates. Monitoring could take the form of sampling, modeling, or some combination of both. Exploration into the appropriate sample sizes, relevant questions, and analytical techniques are the next steps.

II. Project Review and RY17–RY21 Plan

Review of Management Direction

Management Direction

Management direction in this herd remains similar to previous years. Long-term conservation of this herd depends upon managing human impacts, including harvest, and mitigating the effects of oil development activities and infrastructure. We have modified our goals for this herd to reflect the need to increase public involvement in management during the decline, and to clarify goals related to understanding habitat requirements and population dynamics.

GOALS

Goals were modified as follows:

1. Ensure the long-term conservation of the Teshekpuk caribou herd and the ecosystem which it depends on for traditional and multiple uses of caribou by people now and in the future (new).

2. Provide for subsistence and other hunting opportunity on a sustained yield basis (no change).

3. Improve public engagement in the regulatory process, including harvest reporting (new).

4. Evaluate and increase the utility of biological metrics collected in this herd (new).

5. Build baseline data on caribou movements, distribution, and vital rates for the purposes of mitigating any adverse effects of resource development (new).

The following goals from the above 5-year report (RY12–RY16) have been removed based on limited effort devoted to habitat assessment and enhancement activities, and a lack of opportunity for the department to assess opportunities for viewing; although viewing is implied as a multiple use which is acknowledged in Goal 1:

- Ensure adequate habitat exists to maintain TCH (removed).

- Provide opportunities for viewing and other uses for caribou (removed).

CODIFIED OBJECTIVES

Amounts Reasonably Necessary for Subsistence Uses

It remains to be seen if the combined ANS (WAH + TCH = 8000–12,000 caribou) is a management issue for this herd. Because of the historically very low harvest by nonresidents of Teshekpuk caribou, the tendency for the larger WAH to drive the status of both herds relative to moving into Tier I is minimized from an allocation perspective. In contrast, the timing of when local demand exceeds harvestable surplus could be well out of sync with Tier II thresholds. Typical regulatory harvest allocation may not correspond with traditional harvest patterns, so development of harvest management systems that align with local desires while meeting subsistence law requirements will be ongoing challenges if allowable harvest falls below demand, independent of the status relative to ANS thresholds. Regardless of the independence of ANS values for these 2 herds, inability to track harvest in space and time with any precision remains an issue that complicates any ANS framework that could be applied.

Intensive Management

The current range in IM objectives for both abundance (15,000–28,000) and harvest (900–2,800) appear to be biologically viable objectives under most natural scenarios, based on past patterns of abundance and harvest. It should be recognized that the limited access to this herd and potential for user conflicts reduces the ability to increase harvest when available harvest is significantly greater than local demand, and thereby control growth rates during periods with increasing trend and abundance higher than the upper IM objective.

MANAGEMENT OBJECTIVES

Objectives have been reviewed and revised as follows:

1) Maintain a population of at least 15,000 caribou, recognizing that caribou numbers naturally fluctuate (Goal 1; no change).
    - This level of abundance is in concordance with the lower IM objective.
    - Previously listed as Objective 4 in the above 5-year report. Removed the wording “attempt to” maintain to strengthen the objective.
2) Provide a harvest of at least 900 caribou in a sustainable manner (Goal 2; revised).
    - This level of harvest is in concordance with the lower IM objective.
    - Previously listed as Objective 5 in the above 5-year report; shortened to reference the minimum IM harvest objective and to remove reference to methods (activities) in the objective statement.
3) Maintain a population with a range of 25–35 bulls:100 cows, depending upon population level (Goals 1 and 2; revised).
    - This change in objectives reflects the potential for reallocating harvest from cows to bulls and thereby reducing the bull-to-cow ratio. When total available harvest is inadequate to meet demand, managers are unlikely to protect bull-to-cow ratios beyond the lower limit that is biologically advisable, despite social desires for larger bull-to-cow ratios.
    - Previously listed as Objective 6 in the above 5-year report; revised from 30:100 to a range (25–35:100) to accommodate variable or flexible management regimes that target (if needed) bull-to-cow ratios being influenced by population fluctuations and population structures of the herd.
    - This change is recommended in Activity 1.4 in the above 5-year report.
4) Obtain harvest estimates with sufficient data such that a 15% change in annual harvest is detectable (Goals 1, 2, 3, 4, and 5; new).
    - This new objective recognizes the continued need for harvest data and sets a numeric threshold as a target for management.
    - This change is recommended in Activity 2.1 in the above 5-year report.

5) Develop regulations that have broad support among users and cooperating agencies (Goals 1, 2, and 3; new).

   - This new objective more closely matches the goal of improving public engagement in the regulatory process including developing methods and means to adequately estimate harvest. The following metrics could be used to assess whether or not this objective is being met:

      1. Advisory committees are generating proposals that are being adopted by the board.
      2. Public involvement is evident in voting records.
      3. Changes brought about by state or federal advisory committees are being adopted by their respective counterparts.
      4. Regulatory actions are associated with improved harvest reporting.

   - The previous Objective 1 to "Encourage cooperative management of the herd and its habitats among state, federal, and local entities, including all users of the herd. (Goals 1, 2, and 3)" has been incorporated into this new objective.
   - This change is recommended in Activity 2.1 in the above 5-year report.

6) Clarify the relationships between both abundance and vital rates with harvest, habitat, body condition, predation, seasonal mixture with adjacent herds, and immigration between adjacent herds (Goals 4 and 5; new)

   - This new objective focuses on the goal of using long-term data collected from this herd to evaluate both current and new monitoring tools.
   - The previous Objective 2 to "Develop a better understanding of relationships and interactions among North Slope caribou herds (Goals 1 and 2)" has been incorporated into this new objective.
   - This change is recommended in the Conclusions and Management Recommendations of the above 5-year report.

7) Monitor herd characteristics and population parameters (on an annual or regular basis). (Goals 1 and 4; no change)

   - This objective acknowledges the need for baseline data to understand long-term ecological relationships, herd characteristics, and the conservation status of TCH. Multiple organizations (CircumArctic Rangifer Monitoring and Assessment Network (CARMA), North Slope Science Initiative (NSSI)) have identified TCH as one of several herds with long-term data sets useful for evaluating large-scale environmental changes. Metrics to evaluate this objective are generated with the successful completion of survey and inventory activities.
   - Previously listed as Objective 3 in the above 5-year report.

8) Provide high-quality data on distribution, habitat preferences, and movement patterns to facilitate effective planning and mitigation of oil development and associated infrastructure. (Goals 1, 2, 3, and 5; revised)

   - This objective acknowledges that baseline data is required for planning within the range of TCH and particularly within the National Petroleum Reserve for future petroleum development. The previous Objective 7, to “Minimize conflicts between resource development and TCH (Goal 2)” has been removed because it is difficult to measure the success of this objective. The revised objective clarifies our primary responsibility relative to interagency planning efforts.

REVIEW OF MANAGEMENT ACTIVITIES

1. Population Status and Trend

ACTIVITY 1.1. Determine the population size and trend of the herd a minimum of 3 times over a 5-year period (Objectives 1, 2, and 7).

Data Needs

The Teshekpuk caribou herd was identified by the board for the intensive management of caribou with a population objective of at least 15,000 caribou. Population estimates and trends are integral components of management, particularly to estimate harvestable surplus.

Methods

We currently use the Aerial Photo Direct Count (APDC) minimum count photocensus (Davis et al. 1979) along with an abundance estimate derived using distribution of radiocollared caribou among photography groups (Rivest et al. 1998). APDC counts require good weather during a short window of time when caribou are aggregated making obtaining a successful count challenging. Therefore, to achieve an average of 3 estimates every 5 years, we need to monitor herd distribution annually during July. Appropriate conditions are typically preceded by 2 consecutive days with temperatures averaging >50F°, and winds <10 mph. Objectives for precision of the estimate are a 95% confidence interval half-width of 20% or less. To achieve this level of precision, the number of active collars should be greater than 70, and the number of collars in postcalving aggregation photography should exceed 2.5 per group (B. Taras, biometrician, DWC, ADF&G, Fairbanks, unpublished data). In order to adequately describe the statistical distribution of collared individuals it is necessary to optimize for both aggregation quality and a sufficient number of collared caribou. To evaluate trends in abundance we calculated exponential growth rates between point estimates (Johnson 1994).

Groups of caribou are photographed from a DeHavilland DHC-2 Beaver aircraft with a customized digital aerial camera system composed of 3 medium-format 100-megapixel cameras with 2 of the cameras oriented obliquely and one at nadir. Target altitude for photography is 1,500 feet above ground level (AGL). All cameras are contained within a rigid insert which is attached to a gyrostabilized mount. The system is instrumented with a differential GPS and inertial measurement unit (IMU) to record position (pitch, roll, and yaw) and altitude. Customized flight management software running on a laptop computer controls the cameras and navigation system and allows the pilot and camera operator to see footprints of the imagery in real time as well as inspect thumbnails of each image as they are captured.

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

Enumeration of caribou from image mosaics occurs within geographic information system (GIS) software and uses a customized tool which allows users to count and classify caribou by placing colored points on top of each animal. Point data are stored in file geodatabases and archived.

An estimate of abundance and a measure of uncertainty is conducted using a method described by Rivest et al. (1998). The estimator is based on a 2-phase sampling design. Phase 1 uses the distribution of collared caribou among groups of known size to estimate the number of caribou in groups without collared caribou. Phase 2 uses a Horvitz-Thompson estimator and the proportion of active collars detected to expand the herd size from phase 1 to account for caribou represented by collars that are not located during the survey. Rivest et al. (1998) describe 3 detection models for use in phase 2. Of these models, the homogeneity method has been most frequently applied (Couturier 1996, Patterson et al. 2004) and is best suited for our data. This model assumes that all active collars are identified in observed groups and that unobserved groups with collared caribou are missed because they are outside of the surveyed area. It is important to note that phase 2 calculations are not necessary if all collars are located and associated groups are counted. Also, the consequences of not meeting the assumptions of phase 2 are greatly mitigated when a high proportion of the active collars are detected, and associated groups counted. Finally, this estimator assumes a random distribution of collars among caribou; therefore, the number of collars in each group is approximately Poisson distributed. A score test to evaluate overdispersion in a Poisson model is provided to assess this assumption (Dean and Lawless 1989). If interherd mixture occurs during a photocensus, it is possible to explicitly estimate the effects of mixing during a photocensus with adjacent herds by incorporating modifications to Rivest et al. (1998) that allow for estimation of the proportion of the estimate that is composed of missing and immigrant caribou, along with associated precision (B. Taras, biometrician, DWC, ADF&G, Fairbanks, unpublished memorandum, 15 July 2014).

ACTIVITY 1.2. Estimate harvestable surplus based on abundance and trend in abundance, and other demographic context (e.g., composition, age structure; Objectives 1, 2, and 3).

Data Needs

The board established the IM harvest objective for TCH of at least 900 caribou. Estimating harvestable surplus is critical for hunt management and the evaluation of harvest relative to sustained yield.

Methods

Harvestable surplus will be based on the most recent abundance estimate. When abundance falls below 40,000, harvest rates will be applied separately to cows and bulls; when abundance is above 40,000, we will apply a 6% harvest rate across the herd to calculate harvestable surplus. Based on observations of historical realized harvest rates that appeared to be sustainable, when abundance falls below 40,000 we calculate harvestable surplus of bulls as 20% of a growing population, and 15% of a stable or declining population. Given rates of adult bull mortality (Parrett 2013), and presumed age structure of harvested bulls (e.g., Dau 2013), this rate is likely to be largely compensatory. In contrast, given the presumed age structure of harvested cows (e.g., Dau 2013) and rates of adult cow mortality (Parrett 2013), cow harvest is largely additive. As a result, harvest rates applied to cows are much lower; up to 2% of a growing population that is exceeding the upper limit of the intensive management objective, and less than 1% of a population that is below management objectives. Cow harvest is an important component of the subsistence harvest, so hunt management focuses on reducing the additive component of overall harvest during times of reduced abundance.

ACTIVITY 1.3. Monitor calf production by tracking radiocollared female caribou annually. (Objectives 1, 3, 7, and 8).

Data Needs

The Teshekpuk caribou herd was identified by the board for intensive management. Estimates of TCH productivity are an index of population-level and general health. Parturition rates are also a parameter used to model herd abundance during years when we are unsuccessful in conducting a photocensus. Changes in parturition rates may also provide context with which to evaluate future trends in abundance (Activity 1.1).

Methods

Parturition rate is estimated by observing radiocollared females ≥3-years old from a fixed-wing aircraft during the first half of June. Caribou observed with calves, hard antlers, or distended udders were classified as parturient (Whitten 1991). We typically visit each cow every other day until the end of the survey period unless the cow is observed with a calf at heel or is obviously growing velvet covered antlers. An additional metric termed "calving success" is defined as the proportion of all collared females with a calf at the end of the monitoring period (typically 11 or 12 June). This metric allows for evaluation of a longer-term trend because Whitten's methods were not fully adopted until 2001. Parturition rates are estimated for 3-year-old cows and older.

ACTIVITY 1.4. Conduct fall composition surveys as needed to determine age and sex ratios (Objectives 3 and 7).

Data Needs

The 3rd management objective is to maintain a population composed of at least 25–35 bulls per 100 cows (20–26% of the adult population). Sex ratios are also needed to estimate harvestable surplus. From a biological perspective, changes in bull-to-cow ratios are potentially indicative of patterns in recruitment over a long timespan, as well as in the short term (through classification of relative age in bulls). The need for monitoring bull-to-cow ratios increases during time periods when we are more closely tracking harvestable surplus. For example, during declines when abundance falls below 40,000, and particularly when approaching biologically limiting bull-to-cow ratios. Objectives for bull-to-cow ratios are typically based on human desire (i.e., hunting satisfaction). In herds managed for trophy hunting, very high bull-to-cow ratios can be desirable. Even in areas where subsistence hunting patterns are predominant, hunters appear to prefer bull-to-cow ratios well above those needed for adequate reproduction. A biological concern with skewed sex ratios lies with reduced productivity. Information about caribou and other species (e.g., Mysterud et al. 2002) suggests that in tightly controlled situations (e.g., semi-domesticated), effects on fecundity, synchrony of calving, and calving date typically do not occur until ratios are quite low (<20 bulls:100 cows); however, effects within wild populations are largely unknown and may occur at different thresholds. When abundance is above 40,000, a composition survey should be conducted every 5 years. When abundance falls below 40,000, the frequency of surveys should be gauged as follows: a fall composition survey should be conducted every other year when the bull-to-cow ratio is >30:100, and annually when it is <30:100.

Methods

Composition surveys take place near peak of rut to take advantage of the presumed mixing of bulls, cows, and calf caribou. Using previously estimated median calving dates and backdating by 228 days (gestation), we estimate that median breeding takes place around 21 October in most years. We schedule fall composition surveys in October to coincide with this date.

Caribou groups are located by radiotracking VHF radiocollared caribou from a fixed-wing aircraft (typically Cessna 182 or Bellanca Scout). Sampling is conducted by helicopter (R-44) using a focal-animal cluster design (Cochran 1977), classifying approximately 200 caribou within a 5-mile radius of each radio collar found during the survey. This technique approximates the cluster sampling design described by Cochran (1977), with the exception that the cluster sampling design described by Cochran assumes 100% sampling of each cluster. To encourage wider spatial distribution of the sample, we limit the sample to 200 if needed, although that is frequently unnecessary in this herd, as clusters are typically small and relatively well defined. Caribou are classified as male calf, female calf, cow, small bull, medium bull, or large bull. Data will be recorded with a voice recorder. Percentages and standard errors of each sex and age class are estimated using a cluster-sampling scheme (Cochran 1977) and converted into ratios with cows as the denominator (i.e., bulls:100 cows).

While this assumption has not been formally evaluated, it appears that immediately after rut, and sometimes even during rut, sexual segregation can be present in the herd. Because fall composition surveys take place during migration, large spatial variation can exist within results; therefore, caution is warranted in assuming that groups being sampled represent a true mixing of sexes.

ACTIVITY 1.5. Capture and radiocollar 20 female yearling caribou annually, with additional recaptures as needed to maintain a sample of at least 70 known-aged, collared females, including at least 20 GPS-collared females, without the use of immobilizing drugs. Capture and radiocollar 5–10 bull caribou annually to maintain a sample of at least 10 bull caribou (Objectives 1 and 3).

Data Needs

Maintaining a radiocollared sample is essential for determining if Objectives 1 and 3 were met. Radiocollared caribou are used to allocate sampling effort and are used in 1) conducting a photocensus, 2) estimating parturition rates, 3) estimating calf-to-cow and bull-to-cow ratios in the fall, 4) estimating spring recruitment ratios, 5) estimating mortality rates, 6) evaluating body condition of yearlings, and 7) estimating distribution and seasonal range use. Because of their mobility, caribou appear unique among most wildlife regarding the need to rely on radiocollared individuals to allocate sampling effort and produce representative samples. In this relatively large and remote herd, the use of satellite collars results in significantly reduced effort to find and locate animals when visual observations are desired, and multiple high-quality locations per day can be collected for movement and habitat studies without any flying at all (See Activity 1.9). Radiocollared bull caribou provide a means to evaluate sexual segregation during photocensus and composition counts.

Methods

We will use helicopter-based net gunning because local residents who mostly harvest TCH are uncomfortable with the use of immobilizing drugs on animals in general and particularly on animals they eat. Caribou will be captured using a handheld net gun from an R-44 helicopter. Hard chase times (the period when caribou are actively attempting to escape) will be limited to 3 minutes. Any slight uphill can be used to slow caribou, but generally, we will attempt to force caribou to stop or make an abrupt turn that requires deceleration prior to shooting the net. The goal of capturing 20 female yearlings each year provides for a reasonable chance of having 10–15 collared 3-year-old caribou. This is necessary in order to estimate the parturition rate of that age class, as well as retaining a relatively large sample of each age class through approximately 8 years of age to monitor age-specific mortality and evaluate other age-related life history traits (i.e., differences in migration, recruitment). Caribou will be recaptured at 3- to 5-year intervals, depending upon the battery life of the collar that they are carrying and their availability at the time of capture. Caribou are typically captured in late June when herd identity is more likely to be assured. This is because recaptures at other times of year are logistically challenging and uneconomical due to their wide distribution. Any recaptures in fall risk unpredictable weather and new captures in spring or fall risk capturing individuals from a different herd due to mixing of North Slope herds during these times.

Caribou are manually restrained with hobbles and blindfold/hood while measurements are collected and GPS-collars are fitted. We will record sex (male or female) and age (yearling or adult), the number of permanent incisiform teeth, presence of a calf, and lactation status of females. Latitude and longitude and general location of capture will be recorded. Weight (for yearlings), jaw length, metatarsus length, and one-half heart girth measurements will be taken at the time of capture. A canine from all unknown-aged animals, blood (collected from the jugular), hair, and feces will be collected from caribou. These samples will be distributed among collaborators (primarily NSB and ADF&G Wildlife Health and Disease Surveillance Program) who investigate disease and parasites.

ACTIVITY 1.6. Evaluate trends in body condition through yearling and neonatal calf weights (Objectives 3 and 4).

Data Needs

Average annual yearling weights are used to evaluate trends in body condition. This information has the potential to provide context for several decision frameworks regarding the evaluation of herd size, trend in abundance, and potential for growth (Activity 1.2); and improves our ability to manage adaptively rather than reactively. Assessing this metric in combination with parturition rates can help to differentiate seasonality in nutritional limitations.

Methods

Female yearlings are captured in late June using methods described previously in Activity 1.5 and weighed using a 100 kg Pesola digital scale (i.e., weight includes collar and net). We attempt to weigh 20 yearlings annually in the attempt to capture a sample of yearlings, a goal of incidentally capturing 1–2 two-year-olds will help to ensure that the entire spectrum of yearling weights is observed. Criteria for age confirmation includes weights and tooth eruption patterns, with the expectation that 2-year-olds are likely to have all deciduous incisors replaced with some light tooth staining. Weights that exceed 57 kg (125 lbs) should be viewed with skepticism, as that weight is in excess of 95% of putative yearling weights collected to date for this herd.

ACTIVITY 1.7. Evaluate the magnitude, sources, and timing of mortality in adult caribou via radio telemetry, monitoring of satellite collars, and field observations (Objectives 6 and 7).

Data Needs

Understanding timing and sources of mortality is important for understanding demographic processes. Adult female mortality plays a critical role in ungulate population dynamics (e.g., Gaillard et al. 2000) and can be especially critical for caribou during declines in abundance (Crete et al. 1996). If collars are retrieved from mortalities close to the time of death, we can evaluate proximal causes of mortality (e.g., predation, drowning, etc.), which can be an important source of information when tracking population status and recommending regulatory changes. In addition, retrieving collars from mortalities in a timely fashion enables refurbishment of expensive satellite collars (e.g., reduces cost), allows retention and reuse of VHF frequencies, and reduces litter on the landscape.

Methods

Annual female (≥1-year old) mortality rates are estimated from the number of detected mortalities divided by the number of active collars on 1 July. This date corresponds to the beginning of a 12-month collar year (CY) aligned with the approximate date when new collars were deployed each year. We do not estimate an annual mortality rate for collared bulls due to the small sample size and a bias toward selecting large bulls that are likely nearing the end of their natural lifespan.

Known-aged mortality rates from 1 through 10 years of age were estimated using a Kaplan-Meier staggered entry procedure (Pollock et al. 1989). We estimate mortality rates of yearlings compared to other adult age classes to evaluate whether yearling rates were significantly different from individuals 2-years old and older and individuals at age-2. This is investigated to establish whether pooling of yearlings and adults are warranted when estimating annual mortality rates. We are also interested in whether this relationship varies depending upon which growth phase the herd is in.

Seasonality of mortality is estimated for GPS-collared female caribou and GPS- and PTT-collared male caribou. Mortalities due to capture or recapture were removed from the data set but hunting mortalities were included. For individuals where the date of death was unknown, an approximate date of death was estimated. Mortality date would be assigned to the date corresponding to the second location in a continuous series of paired locations that were clustered in an area less than the potential error in location quality. For example, if locations began to consistently cluster within a 100 m (328 ft) distance of an initial point (GPS accuracy), we would assume the date of death as the second of those locations. Different types of collars had correspondingly different accuracies for locations. We frequently could only determine date of death within ±1 week of actual death due to collar duty cycles, particularly in winter when movement rates of living caribou are reduced. We group mortalities by 3-month seasons to examine broad patterns in seasonality of mortality and to establish baselines for comparison with other 5-year periods.

Mortality-site visits are typically attempted in October, June, and July. A helicopter or fixed-wing aircraft is used to access the site as soon as logistics (especially daylight) and budgets allow. Upon visiting a mortality site, we first look for tracks in the vicinity (within 1 mile) from the air. After landing, we locate the collar, look for evidence of violent death such as predator hair and feces, then assess the general disposition of the carcass. We assign the following 3 categories to mortalities: predation, nonpredation (e.g., starvation, drowning, broken limb, etc.), and unknown cause. Predation and nonpredation mortalities are further classified if possible.

We use tracks, scat, hair, and disposition of the carcass to assign predation-related deaths to predator type. Potential predators are considered to be Golden eagles, grizzly bears, wolves, lynx, and wolverine with reasons for attributing mortality to a given predator discussed in several publications (e.g., Keech et al. 2011, Adams et al 1995). Wolverines occasionally cache the collar and portions of the carcass in rocks or in deep snowbanks. Predation mortalities are not assigned specifically to wolverines unless other predators could be positively eliminated because of the propensity for wolverines to scavenge.

Blood spatter on the collar and premortem hemorrhage are used to confirm that the death was attributable to predation rather than scavenging. We use the blood reagent luminol to detect latent bloodstains. Collar material that is soaked in blood or has clear and extensive spatter patterns are assumed to be predation mortalities. Collars with a small amount of blood were classified as unknown because of the potential for contamination during scavenging. Collars with no blood and a completely torn expansion section are assumed to have been shed collars in absence of evidence to the contrary; this is particularly likely to occur for males during the rut.

ACTIVITY 1.8. Monitor short yearling recruitment through rangewide spring radiotelemetry and composition surveys (Objectives 6 and 7).

Data Needs

Spring composition surveys are conducted to estimate the recruitment rate of the population. This estimate of the proportion of the population made up of 10-month-old calves may provide context for abundance surveys and signal long-term trends in population age structure and future productivity. These surveys also contribute to our knowledge of animal fates because we are able to locate mortality sites that can be visited within the next few months (Activity 1.7). These surveys, which cover a large proportion of the winter range, also contribute greatly toward our ability to end the collar year with known fates for most collared individuals. Such knowledge allows us to enter the photocensus season with a radiotracking list limited to active collars (Activity 1.1).

Methods

We use fixed-wing aircraft to locate radiocollared caribou in early to mid-April. Approximately 100 caribou within a 5-mile radius of each radio collar will be classified to estimate herd composition. The total sample size objective is 3,000 caribou, which typically results in a 95% confidence interval half-width of less than 4% of the estimate. The proportion of the sample made up of yearlings is calculated using cluster sampling methods (Cochran 1977). The long-term trend in short-yearling recruitment rate will be analyzed using a simple linear regression.

ACTIVITY 1.9. Use radio telemetry and satellite collar location data to identify seasonal ranges including calving, insect relief, fall and spring migration routes, and wintering areas. Estimate the extent of seasonal mixing that occurs between the Teshekpuk, Central Arctic, and Western Arctic herds (Objectives 7 and 8).

Data Needs

Data on seasonal distribution is useful for estimating herd overlap, harvest by herd, and informing the timing and spatial extent of regulatory changes. In addition, requests for data on spatial distribution for planning and mitigation of development occur on a regular basis. These products are useful for both the state and outside entities to inform comments on development plans and environmental impact statements as well as plan for effective mitigation.

Methods

Estimation of calving distribution and winter distribution relies on a combination of locations provided by satellite and radio telemetry that are inputs for fixed-kernel analyses. Estimates of spring and fall migratory routes are limited to largely continuous data streams from satellite collared caribou (primarily GPS) and are based on cumulative estimates of individual Brownian bridge movement models (Horne et al. 2007, Sawyer et al. 2009). We estimate seasonal distributions with utilization distributions created for every other day and then averaging across the season dates, averaging across the 5-year reporting period, and averaging dynamic Brownian bridge estimates for individuals across the 5-year period. Currently, seasons are delimited using general knowledge of the timing of biological events including calving, insect avoidance, and spring and fall migration (Person et al 2007).

Calving distribution—ArcMap (ESRI, Redlands, CA) will be used to map calving period locations based on information collected during calving surveys. The location a cow is first seen with a calf is assumed to be the approximate calving location (Carroll et al. 2005). A cow's location nearest in time to the median calving date will be used when cows are not observed with a calf. Annual utilization distributions will be produced using a 5 km grid with least-squares cross-validation of bandwidth selection (Seaman et al. 1998). We will then sum the observation densities at grid intersections across years and divide by the number of annual distributions to produce a cumulative calving distribution that is unbiased with respect to annual sample size.

Spring and Fall migration—Estimates of migratory intensity are classified by categorizing the cumulative density of movement paths into 4 equal categories of increasing relative probability of use corresponding to low, moderate, high, and very high intensity use as in Sawyer et al. (2009). We will delimit the series of locations used for estimating each individual's migratory path by using dates proposed by Person et al. (2007).

Postcalving, insect relief, late summer, and winter distribution—Distributions for these seasons are estimated using a cumulative kernel averaged across a fixed grid similar to the one used for estimating cumulative calving distribution. Individual locations from satellite telemetry were used to generate kernel estimates for every other day (to match the typical maximum location intervals). We estimated 50%, 75%, and 95% volume contours for the cumulative kernel density utilization distribution.

Combined seasonal distribution—To summarize seasonal distributions in a single figure, we will display 75% contours for calving, combined summer seasons, and winter with migratory routes connecting the seasonal ranges.

2. Mortality-Harvest Monitoring

ACTIVITY 2.1. Estimate caribou harvest. Work with the North Slope Borough and ADF&G, Subsistence Division to collect harvest information through community harvest surveys. Pursue harvest ticket and registration permit methods for estimating harvest (Objectives 2 and 4).

Data Needs

Effective adjustment of regulations and evaluation of population and composition response to harvest requires knowledge of harvest patterns. Documentation of harvest levels is important for the establishment, refinement, and comparison to administrative thresholds such as intensive management harvest objectives and amounts necessary for subsistence uses. The department currently does not have an efficient system in place, particularly for documenting harvest by local residents who hunt TCH caribou.

Methods

Previous analyses have shown that the hunter registration and reporting system was not effective in estimating caribou harvest in communities within the range of TCH (e.g., Georgette 2016). Consequently, community harvest surveys have been used as an alternate method to quantify harvest. Lacking recent estimates, we use average harvests from communities located in the core

TCH range. Because some communities have access to caribou from more than one herd on an annual basis, we will use previously estimated proportional herd harvest from specific communities based on harvest in relation to caribou distribution where spatially referenced harvest data and satellite telemetry caribou location data are concurrent (Parrett 2013, Braem 2013). Additionally, harvest by nonlocal hunters will be determined through harvest ticket reporting. To evaluate whether harvest is from TCH or an adjacent herd, proportional herd harvest will be estimated based on caribou distribution at the time of reported harvest. As an approximation of what the range in harvest might be, we will use the minimum and maximum per capita harvest rates from the primary communities that harvest TCH caribou, average population sizes across the surveys, and estimate the proportion of caribou from TCH in the harvest to calculate what the minimum and maximum harvests might be.

Starting in RY17, a registration permit (RC907) was put in place across the core ranges of TCH and WAH. We have yet to understand the level of participation and reporting rates that will occur, but active outreach efforts began during the last reporting period (RY12–RY16). ADF&G staff intends to visit each North Slope community during each fiscal year to distribute permits and conduct outreach efforts. We also plan to maintain a license vendor in each of the North Slope communities. Analyses of permit acquisition and reporting patterns will occur in the next reporting period. If permit acquisition and reported harvest reach adequate levels, and they could be assumed to be an unbiased sample of hunters, then statistics related to hunter residency, success, chronology of harvest, and even sex of harvest could be estimated from permit reports Determining the adequacy of harvest reporting needed to estimate various harvest statistics, including total harvest, will need to be evaluated by staff moving forward. Currently, the primary source of data to estimate harvest patterns are historic community harvest survey data. Patterns in nonlocal harvest chronology, success, and transport methods are not tabulated as a matter of course, however regulatory proposals can prompt such analyses.

3. Habitat Assessment-Enhancement

No habitat enhancement activities are planned. Continue collaborations that enable greater understanding of the forage-body condition-fitness dynamic in Arctic caribou.

Evaluating habitat condition in concert with evaluating caribou body condition (Activity 1.6) can provide context for several decision frameworks regarding the evaluation of herd size, trend, and potential for growth (Activity 1.2), and increases our ability to manage adaptively, through identifying drivers of population change. Understanding the role of broad environmental factors in influencing population dynamics can be important for putting anthropogenic changes into context (i.e., new infrastructure or regulatory change). Direct evaluation of habitat also improves our understanding of the habitat-body condition relationship. Further research is needed to understand which types of monitoring might be useful, particularly if there are concerns about summer habitat. Lichen monitoring seems possible, albeit labor intensive, but understanding the metrics and type of sampling required for summer forage monitoring and linking those metrics to fitness is currently not possible.

Logistical factors preclude effective treatment or cost-efficient application of enhancement activities. Other than large scale climactic factors that could influence caribou habitat quality, the primary consideration for managing caribou habitat at this time is mitigating risk of habitat loss that could occur through changes in caribou movement and habitat use patterns that could result from anthropogenic alteration of the landscape. An additional consideration is the reduction in population growth rates through hunting when necessary to avoid overgrazing; this is not always feasible in areas with difficult access, such as the TCH range.

Nonregulatory Management Problems or Needs

There are currently 2 research projects involving TCH. The first is a collaboration with ABR, Inc., North Slope Borough, ConocoPhillips, and the Wilderness Society to characterize migratory behavior in TCH, including evaluating drivers of timing and destination. This will help to quantify variation in wintering areas and delineate important habitats and drivers for migration in a herd that is only partially migratory. The second is an evaluation of spatial patterns in caribou fecal stress hormones in relation to new and planned infrastructure. This effort will help to build a baseline understanding of caribou reactions and potential habituation to sharing winter range with ongoing development.

Data Recording and Archiving

Original raw data forms are stored at the Region III headquarters office in Fairbanks, Room 138, file cabinet "TCH Caribou". Digital data, including satellite telemetry, is archived in a database managed by ABR, Inc. and cooperatively supported by NSB and ADF&G.

Harvest data from harvest tickets and registration permits are stored on ADF&G's Wildlife Information Network database (WinfoNet, http:/winfonet.alaska.gov/index.cfm, under Harvest Information). Harvest data from community harvest surveys is archived by the ADF&G Subsistence Division, the North Slope Borough, and other entities involved in collecting that data.

Agreements

A memorandum of agreement between ADF&G, NSB, and BLM was signed in 1991 to lay out a framework for cooperative data collection. The primary objectives were to estimate population size, recruitment, distribution and movements, harvest, develop working relationships with local communities, delineate calving grounds, and document sources of mortality.

There is a 2005 agreement regarding the sharing of telemetry data between ConocoPhillips, ADF&G, and ABR, Inc. that has expired as of 2015, but that is still referred to for guidelines regarding data sharing.

Permitting

None.

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