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SR-18-03

Status of thinhorn sheep in Game Management Zone 7

2015-2016

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Key findings

- A broad-scale survey of thinhorn sheep in GMZ 7 was conducted during the summers of 2015 and 2016.
- Across all of GMZ 7, 3,112 thinhorn sheep were observed, 2,490 of which were non-lambs.
- Compared to the most recent comparable surveys in 2000 and 2009 for the western and eastern portions of GMZ 7, respectively, the thinhorn sheep population across GMZ 7 appears to be stable.
- Non-lamb numbers in the western portion of GMZ 7 were 655, compared to 640 in 2000.
- Non-lamb numbers in the eastern portion of GMZ 7 were 1,835 compared to 1,667 in 2009.
- Traditionally, thinhorn sheep management has been focussed on Game Management Subzones. Based on results from this survey, ten new thinhorn sheep management units were identified. Management units identified using this new approach form the framework for which future monitoring and management of thinhorn sheep across GMZ 7 should be considered.
- At the present time, licensed harvest in the western portion of GMZ 7 is mostly within recommended sustainable levels. Harvest levels in the Klukshu management unit (GMS 7-07) may be above sustainable levels as it is a small population.
- Licensed harvest in some thinhorn sheep management units inthe eastern portion of GMZ 7 is at recommended sustainable levels with a recent trend of increasing licensed harvest.

List of Abbreviations

BC-> British Columbia

CAFN -> Champagne and Aishihik First Nations

CTFN -> Carcross/Tagish First Nation

GMS -> Game Management Subzone

GMZ -> Game Management Zone

KDFN -> Kwanlin Dün First Nation

OA -> Outfitting Area

PHA -> Permit Hunt Authorization

TKC -> Ta'an Kwäch'än Council

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Contents

Introduction

Game Management Zone (GMZ) 7 in southwest Yukon (Figure 1) has some of the highest densities of thinhorn sheep in Yukon (Barichello et *al.* 1989a). Sheep in this area are the Dall's subspecies (*Ovis dalli dalli*) of thinhorn sheep (Sim et *al.* 2016). GMZ 7 is also adjacent to the highest human population in Yukon, centered on Whitehorse, leading to higher harvest pressure relative to many other areas in Yukon (Hoefs 1980). Westfall (2013) reported that GMZ 7 was the most popular zone for resident sheep hunting in Yukon. Increasing interest in harvesting sheep (Westfall 2013) coupled with increasing accessibility to sheep populations (e.g., Reid et *al.* 2013, Champagne and Aishihik Traditional Territory Fish and Wildlife Planning Team 2016), has led to concern regarding the sustainability of harvest here. Additionally, concerns have arisen regarding the shifting of harvest pressure westward following the placement of additional Game Management Subzones (GMSs) in eastern GMZ 7 on a Permit Hunt Authorization (PHA) in the early 2010s (Champagne and Aishihik Traditional Territory Fish and Wildlife Planning Team 2016). The Southern Lakes Wildlife Coordinating Committee (2012) recommended that adequate information be available to support sheep management decisions and to ensure the long term sustainability of sheep harvest. In 2015 and 2016, the Government of Yukon conducted a broad-scale survey of Dall's sheep to address their status across GMZ 7. The objectives of this survey were to assess abundance, population productivity (i.e., lamb production), adult sex ratio, and ram composition. An additional objective was to use this broad-scale survey data to help delineate biologically meaningful management units. This information will be used to assess the current sustainability of harvest across GMZ 7. The most recent comprehensive surveys of sheep in GMZ 7 were from 2000 in the west and 2009 in the east (Russell and Hegel 2011). Prior to this, the only other comprehensive surveys of GMZ 7 were in 1973 (OA 16 and 17) and 1980 (OA 18).

Figure 1. Distribution of Yukon's Game Management Zones. Game Management Zone 7 is shaded dark

Game Management Zone 7

GMZ 7 (Figures 1 and 2) located in southwest Yukon is one of 11 GMZs distributed across Yukon. It encompasses approximately 11,185 km² and is topographically dominated by the Coast Mountains. It is bordered to the north and south by the Alaska Highway and the Yukon-BC border, respectively. To the west and east, it is bordered roughly by the Haines Road and the South Klondike Highway, respectively. GMZ 7 is approximately bisected into a western and eastern portion by Kusawa Lake and the Takhini River. GMZ 7 is located in the traditional territories of Champagne and Aishihik First Nation (CAFN) , Carcross/Tagish First Nation (CTFN), Kwanlin Dün(KDFN), and Ta'an Kwäch'än Council (TKC) (Figure 2).

traditional territory of the TKC includes a small portion of GMZ 7 in the northern portion of the zone. Administratively there are 36 GMSs in GMZ7 (Figure 3). Category A and B First Nation Settlement Lands are distributed throughout GMZ7 (Figure 4). Kusawa Park is located in the center of GMZ 7, surrounding Kusawa Lake. Kluane National Park Reserve and the Kluane Wildlife Sanctuary are located adjacent to GMZ 7 to the west (Figure 2).

Currently there are two active Outfitting Areas (OA) in GMZ 7: OA 17 in the east and OA 16 in the west. There is no active OA in the southeast quadrant of GMZ 7 (Figure 3) and thus no non-resident harvest occurs there. GMZ 7 (east) is the primary region in Yukon where licensed harvest of sheep is limited under a lottery-based PHA. Other PHA areas outside of GMZ 7 include the Kluane Game Sanctuary, Pilot Mountain, and the North Richardson Mountains. Of the 36 GMSs in GMZ 7, six are closed to licensed harvest, 10 are under a PHA, and the remaining 20 are open to licensed harvest (Figure 3).

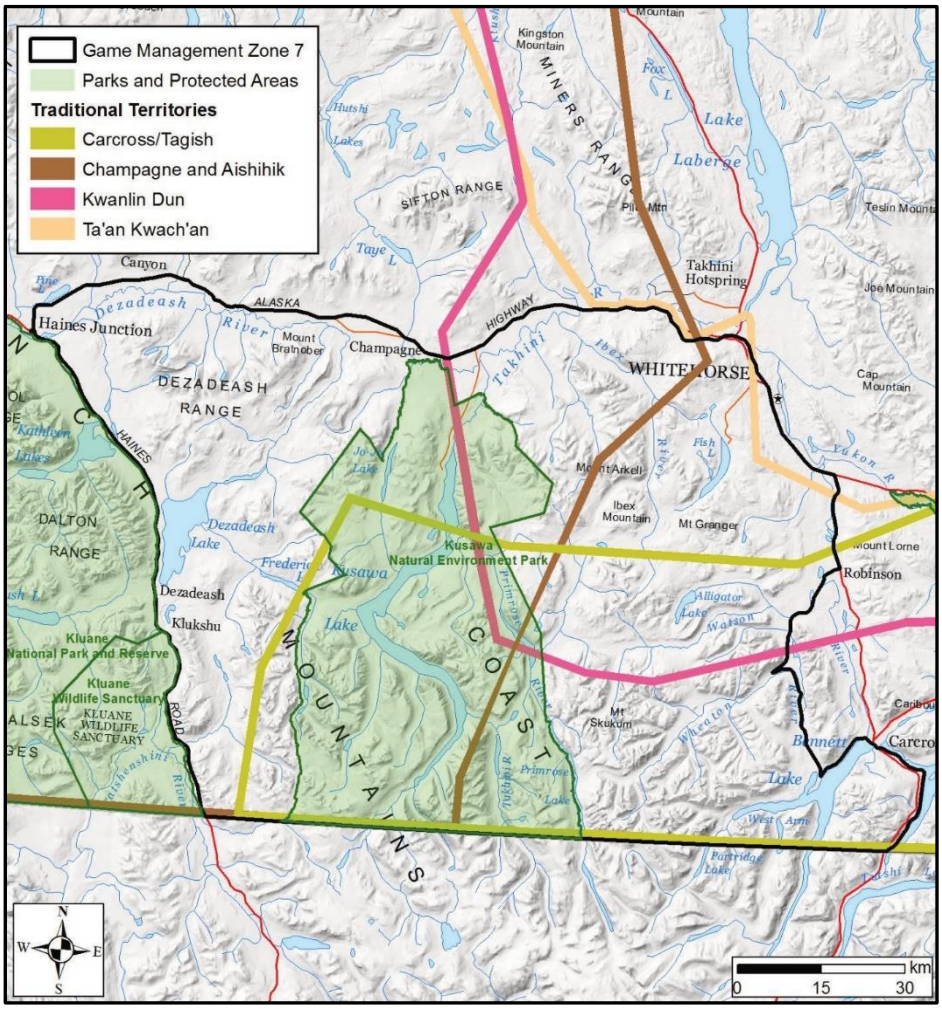

Figure 2. First Nation Traditional Territories, and parks and protected areas located in Game Management Zone 7.

Ecologically, GMZ 7 is located entirely within the Boreal Cordillera ecozone (Yukon Ecoregions Working Group 2004). The northern portion of GMZ 7 occurs within the Yukon Southern Lakes ecoregion while the southern portion lies within the Yukon-Stikine Highlands ecoregion. A small, narrow portion of GMZ 7 in its northwest corner lies in the Ruby Ranges ecoregion (Figure 5; Smith et *al.* 2004). The eastern three quartera of GMZ 7 is in the Yukon River watershed while the western quarter is in the Alsek River drainage. GMZ 7 maintains an intact multi-predator/multi-prey community with large mammals including moose (*Alces americanus*), mule deer (*Odocoileus hemionus*), grizzly bear (*Ursus arctos*) and black bear (*U. americanus*), and wolves (*Canis lupus*). Two Northern Mountain caribou (*Rangifer tarandus caribou*) herds, Ibex and Carcross, are found mainly in the eastern portion of GMZ 7 and mountain goats (*Oreamnos americanus*) are distributed in GMSs along the Yukon-BC border.

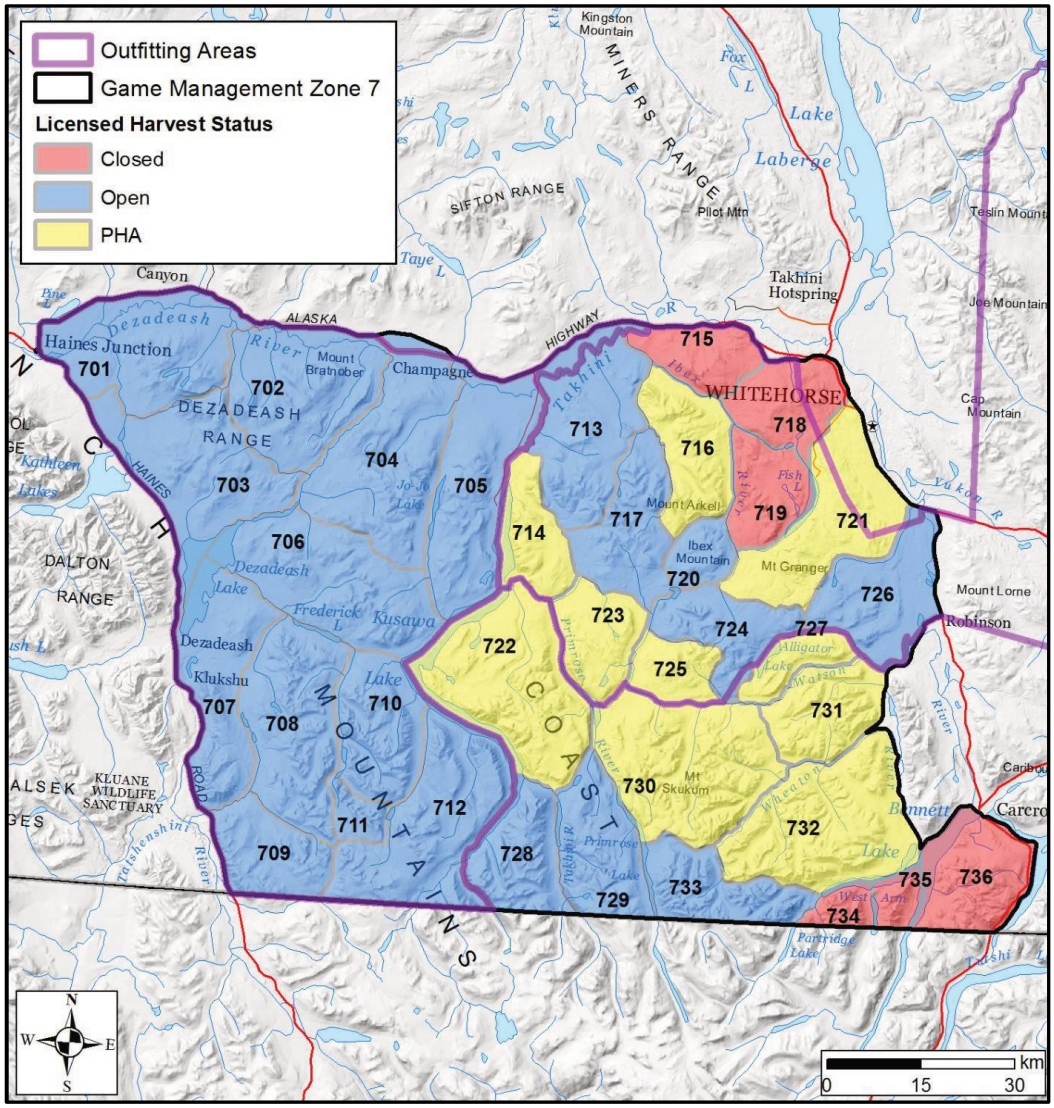

Figure 3. Current licensed harvest status of Game Management Subzones in Game Management Zone 7. OA16 is located in the western portion of GMZ 7 and OA 17 is located in the northeast quadrant.

As noted above, GMZ 7 is found within the Coast Mountains, with an average elevation of 1,238 meters above sea level (range: 564 to 2,518). Fires are generally uncommon throughoutGMZ 7 (Figure 6). While the periphery of GMZ 7 (with the exception of its southern edge) is within more intensive fire management zones (i.e., fires are generally extinguished), the majority of the zone is in a wilderness fire management area and natural fires are typically left to burn as per the 2003 Yukon Fire Management Zones Directive. The climate of GMZ 7 is generally arid with average precipitation of roughly 200 to 325 mm in the north and 300 to 500 mm in the south, and mean January and July temperatures of -21 to - 25°C and 12 to 14°C, respectively (Yukon Ecoregions Working Group 2004). Detailed descriptions of the vegetation, geology, and physiography of GMZ 7 can be found in Smith *et al.* (2004). Human land use disturbance in GMZ 7 is generally low and localized to a few key areas (Figure 7) such as GMSs 7-30 and 7-32. Apart from human settlement in and around Whitehorse, Carcross, and Haines Junction, the largest human footprint in GMZ 7 is located on Mount Skukum (GMS 7-30), where a previouslyoperating gold mine is located. Additional historical mineral development also occurred on Montana Mountain (GMS 7-36).

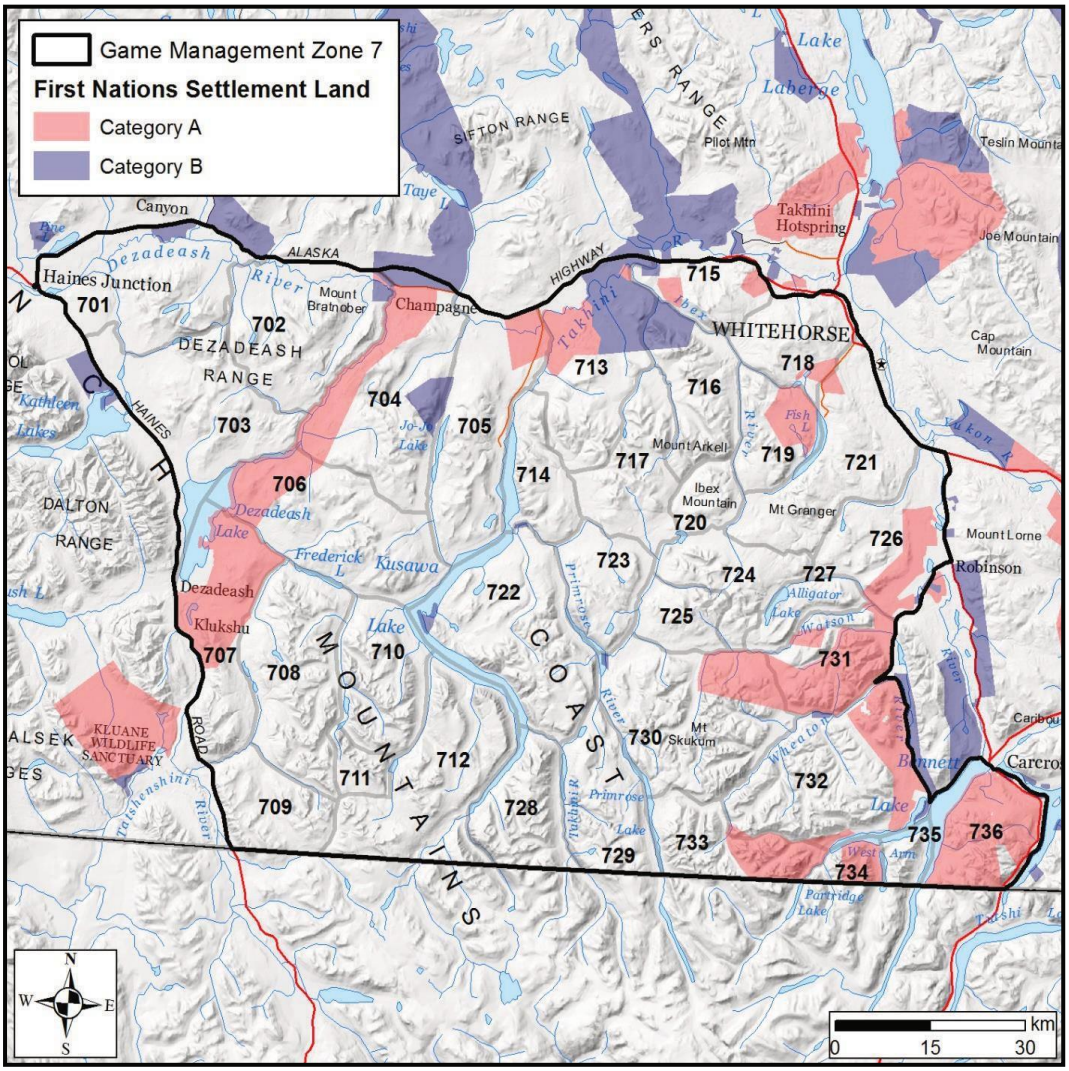

Figure 4. First Nation Settlement Lands in Game Management Zone 7.

Whitehorse, Carcross, and Haines Junction, the largest human footprint in GMZ 7 is located on Mount Skukum (GMS 7-30), where a previously operating gold mine is located. Additional historical mineral development also occurred on Montana Mountain (GMS 7-36). With respect to harvest, GMZ 7 was the first area to have PHAs implemented in Yukon in 1979 in GMSs 7-22, 7-23, 7-25, and 7-27 thru 7-36.

From that time to the present, various changes inlicensed harvest management have occurred leading to the current regime (Figure 3). Historically, three OAs operated in GMZ 7. Two, OA 16 and 17, are currently in operation (Figure 3). From 1999 to 2012, OA 17 was not operated and thus no non-resident harvest occurred there. Non-resident harvest in OA 17 began again in earnest during the 2014 hunting season.

The southeast quadrant of GMZ 7 was once an operating OA but was rescinded in 1979 and is no longer an outfitting concession. A number of key monitoring initiatives have occurred in GMZ 7 since the late 1970s. In the late 1970s and early 1980s, there was a proposed pipeline route that would have been located along the Ibex River valley. Due to potential impacts on sheep in GMS 7-15, substantial survey efforts took place in this area. Information from these surveys was a contributing factor to the closing of this subzone to licensed harvest (Hoefs 2009). Ultimately the pipeline was never constructed. Mining activities on Mount Skukum precipitated many years of monitoring during the 1980s and 1990s.

In the mid-1980s wolf numbers were actively reduced in GMZ 7 in an effort to increase moose numbers (Hayes *et al.* 1991).

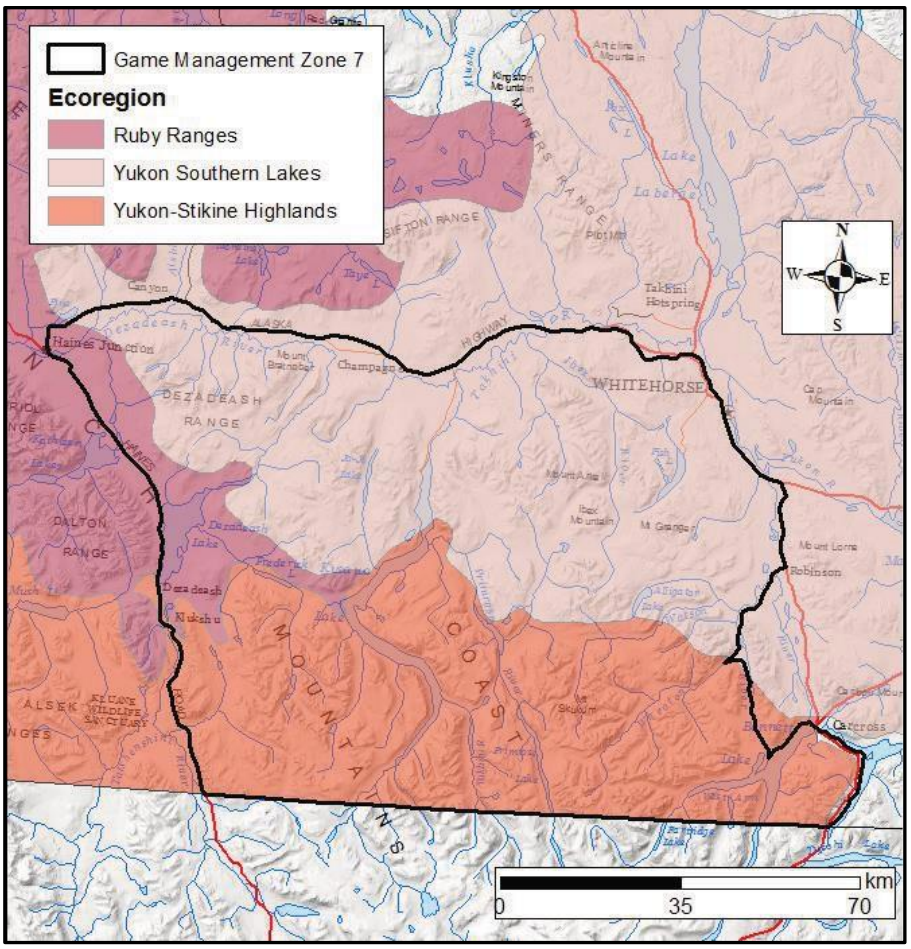

Figure 4. Ecoregions located within Game Management Zone 7.

Sheep in GMS 7-23 were monitored during the 1980s for any response to this wolf reduction. Barichello et *al*. (1989b) found these wolf removal actions had a minimal effect on sheep numbers, similar to findings in the Ruby Range of southwest Yukon (Hayes et *al*. 1991) and Alaska (Mitchell et *al*. 2015). Sheep in GMS 7-23 were also monitored as a control (i.e., no wolf removal) population during wolf removal activities in the Ruby Range in the 1990s (Hayes et *al*. 2003). In the 1950s, government sponsored wolf poisoning campaigns were initiated in the Coast Mountains until 1972 when poisoning was restricted (Smith 1981). Finally, sheep in GMZ 7 were believed to be significantly impacted, along with other ungulates, during the Klondike gold rush and the construction of the Alaska Highway (McCandless 1976, Hoefs 1980) due to increased subsistence and market hunting. However, the degree of those impacts is unknown as observations were anecdotal.

Methods

Aerial surveys

From 29 June to 17 July 2015, sheep in GMZ 7 were aerially surveyed via helicopter (Bell 206B [Jet Ranger]) following methods described by Hoefs and Barichello (1985). In 2016 (28 June to 8 July), some GMSs were resurveyed as there was indication that results from the 2015 survey may have been inaccurate based on observed sex ratios or compared to counts from previous surveys. The basic survey unit was typically a GMS (i.e., a relatively discrete mountain block) within which all high elevation habitat, typical Dall's sheep summer range (Hoefs and Cowan 1979, Roffler et *al*. 2016a), was surveyed in an attempt to achieve complete coverage. Surveys were designed to ensure geographic closure such that, when at all possible, a single GMS could be completed within one trip to reduce the chance of double-counting or missing animals that may have moved while the helicopter was out of the survey area. Three observers were present on all surveys with the helicopter "contouring" a mountain block in a counter-clockwise direction. Aircraft speeds typically ranged from 100 to 120km per hour, but this could vary depending on wind and terrain conditions. The altitude of the helicopter also varied depending on wind and terrain conditions. The same navigator/primary classifier was present on all surveys, with the same second observer present on roughly 75% of the surveys, to reduce observer bias and differences. When a sheep group was located, its total size was tallied and animals were classified. The survey method used here was a total minimum count, thus results are not corrected for sightability (Udevitz et *al*. 2006). Rams were classified based on their horn curl size into half, three quarter, or full curl categories. If present, younger quarter curl rams were also classified as such. While there is variability in the ages of rams having different horn curl sizes due to annual differences in horn growth (Hik and Carey 2000), roughly speaking quarter curl rams are ages 1 or 2, half curl rams are ages 3 or 4, three quarter curl rams are ages 5 or 6, and full curl rams are > 7 years of age (Barichello et *al*. 1987). The number of lambs was also recorded and yearlings, ewes, and young rams were classified as nursery sheep (i.e., ewe-like sheep). Young (quarter curl) rams are typically found in these nursery groups and are often indistinguishable from ewes when classified from the air and were not further distinguished to avoid added disturbance on these animals. Thus, the nursery sheep class does not represent solely reproductive females. Classifying nursery sheep in this manner is typical of management agencies elsewhere (e.g., Strickland et *al*. 1992, Marshall 2005, Mitchell et *al*. 2015).

Data from each GMS was summarized to include a total count of all animals, a count of non-lambs, a ram:nursery sheep ratio, and a lamb:nursery sheep ratio. Because quarter curl rams are typically found in nursery groups, all quarter curl rams observed in a GMS were included in the nursery sheep category to ensure consistency in the calculation of demographic ratios. The ram:nursery sheep ratio is an index (i.e., an indicator but not a true measure) of the sex ratio of the population. Because nursery sheep include young males, it

cannot be interpreted as a true sex ratio and will be biased low relative to the true population sex ratio.

Likewise, the lamb:nursery sheep ratio is an index of lamb productivity and is also biased low relative to, for example, a lamb:ewe ratio. Nevertheless, while these ratios do have biases associated with them (Festa-Bianchet 1992), they can still be useful for monitoring and comparative purposes.

Management units

One of the objectives of this survey was to identify biologically meaningful management units (Moritz 1994, Funk *et al*. 2012) on which management and monitoring decisions can be made (e.g., Zannèse *et al*. 2006). Historically, GMSs were typically used as the basic unit of management. However, in many situations a single GMS is not reasonable to consider as an appropriate management unit due to its small size, lack of geographic closure, or other knowledge of sheep movements. Two lines of evidence were used to identify management units: survey (i.e., demographic) data and geographic closure (i.e., terrain features) From a population perspective, we considered an appropriate management unit as one in which variability in sheep numbers was primarily driven by births and deaths, rather than immigration and emigration (Murray 2002, Turchin 2003). While recognizing that immigration and emigration among identified management units may occur, units were delineated such that this movement, and changes in population size arising from it, were assumed negligible relative to births and deaths. Recent genetic analyses from horn core samples from harvested sheep in GMZ 7 indicate low genetic differentiation across GMSs in GMZ 7, although there is some indication of genetic separation between sheep in GMZ 7 east and west (Z. Sim, University of Alberta, unpublished data). To begin, a GMS was considered the smallest unit and individual GMSs were not split. Adjacent GMSs were then assessed for possible grouping based on the lack of natural movement barriers across GMS borders (e.g., rivers, deep and long valleys; Roffler *et al*. 2016b), and based on observed ram:nursery sheep ratios and non-lamb survey counts. Historical data was also consideredin this assessment when available. Typical ram:nursery sheep ratios in unharvested sheep populations are >50 rams:100 nursery sheep (Hoefs and Mayer 1983), and lower (e.g., ~40 rams:100 nursery sheep) in harvested populations. Given lower survival and longevity of males (Toïgo and Gaillard 2003), there are generally always fewer males than females in ungulate populations. Thus, large departures from these typical ram:nursery sheep ratios indicates either rams or nursery sheep were missed, or a single GMS does not represent the population.

Examples of large departures from expected ram:nursery sheep ratios (i.e., ratios reflective of abiologically realistic management unit) include situations with >80:100, or conversely, situationssuch as <30:100.

To rule out sheep being missed during the survey, results from previous surveys were assessed to examine historical consistency, and a GMS was examined with respect to its degree of connectivity to adjacent GMSs. If a GMS was relatively isolated and previous surveys generally indicated higher sheep numbers, this could indicate that missed animals was the likely cause of this ram:nursery sheep ratio departure. When deemed appropriate to group GMSs, adjacent subzones with a high degree of connectivity were grouped and the ram:nursery sheep ratio and total count of non-lamb sheep recalculated. Non-lambs were used due to the high annual variability in lamb productivity and survival (Jorgenson 1992, Gaillard *et al*. 1998) making a comparison of non-lamb counts more comparable over time. These recalculated values were then compared to previous survey results from the grouped GMSs. If a group of GMSs yielded a biologically realistic ram:nursery sheep ratio and provided generally similar numbers of non-lamb sheep, recognizing that some degree of annual fluctuation in non-lamb numbers is expected, this group of GMSs was identified as a management unit.

An example of how this approach was applied is well demonstrated with the Alligator Lake management unit

(described below) which consists of three GMSs. Individually, none of the three individual GMSs have biologically realistic ram:nursery sheep ratios (i.e., 3:100, 1950:100, and 100:100 rams:nursery sheep, Table 23). However, once data from all three GMSs are pooled, the resulting ram:nursery sheep ratio is biologically realistic (40:100). The lack of any significant movement barriers among the three GMSs (Figure 23) provides further evidence that they should be considered as one management unit. Finally, non-lamb counts in the three GMSs have fluctuated considerably (Table 23), but when those counts are pooled across the subzones the fluctuations are dampened considerably, suggesting that animals were moving across GMS boundaries but not necessarily out of the overall management unit. While population fluctuations are expected over time, very large fluctuations (e.g., doubling of the non-lamb counts in a GMS) would not necessarily be expected, particularly if those levels of fluctuations were not observed in nearby areas. Management units were identified regardless of harvest management strategy or land tenure or administration. Survey results and harvest rates are presented by GMS and according to these newly identified management units, which are named based on local landmarks or features.

Harvest rates

Within each GMS and management unit, the average annual licensed harvest rate during 2011-2015 was calculated. A five-year period was used as it was deemed to represent current conditions while also accounting for annual variability in the number of sheep harvested and is consistent with recently updated thinhorn sheep management guidelines (Environment Yukon 2018). In cases where harvest regulations changed after 2011 (e.g. implementation of a PHA), a shorter time period was used to reflect the current regulatory situation. Harvest rates are based on the number of sheep harvested by licensed hunters divided by the non-lamb count (2015 survey) within a GMS or management unit. Non-lamb counts are used rather than total counts because of the high degree of annual variability in the lamb cohort size; there may also be considerable lamb mortality from the time of the survey to one year of age. Thus, non-lamb counts are a more stable indication of the size of asheep population. Harvest rates do not include First Nation subsistence harvest, for which reporting is not required.

Result

In 2015, all GMSs except for 7-34 to 7-36 were surveyed. In 2016, 7-36 was surveyed and 7-08, 7-12, 7-13, 7-14, 7-17, 7-22, 7-24, 7-25, 7-32, and 7-33 were resurveyed. GMSs 7-34 and 7-35 were not surveyed as there are no records of sheep being present in those subzones from either harvest data or previous surveys.

In 2015 and 2016, approximately 8,500 and 2,800 km of survey tracks (Figure 8) were flown during approximately 55 and 24 hours, respectively. Overall, 2,774 sheep were overserved in 2015, and 1,222 observed in 2016. A final minimum count of sheep based on the 2015 and 2016 surveys, accounting for repeated surveys insome GMSs in 2016 was 3,112 sheep. Broad-scale population ratios and composition are provided in Table 1. The most recent comparable survey in GMZ 7 west occurred in 2000 in which 853 sheep in total were observed, 640 of which were non-lambs. The most recent comparable survey in GMZ 7 east occurred in 2009 (Russell and Hegel 2011) when 1,959 sheep were observed in total, of which 1,667 were non-lambs.

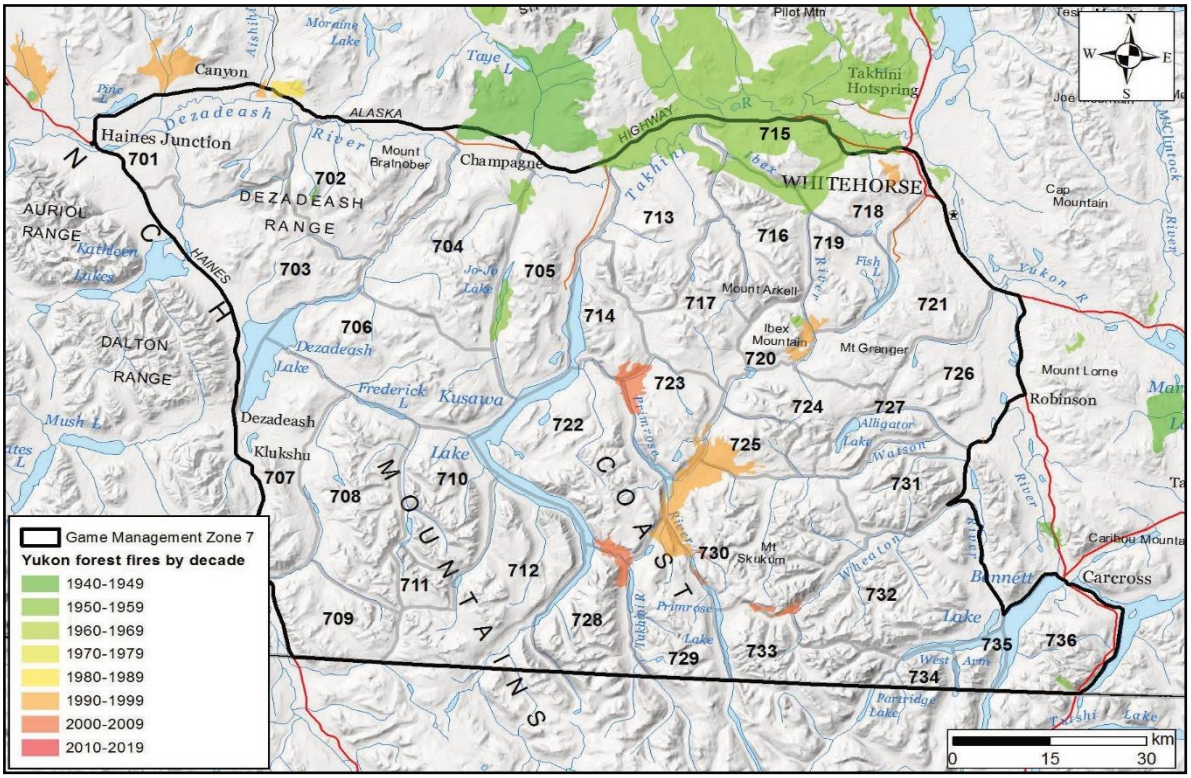

Figure 6. Distribution and ages of forest fires in Game Management Zone 7.

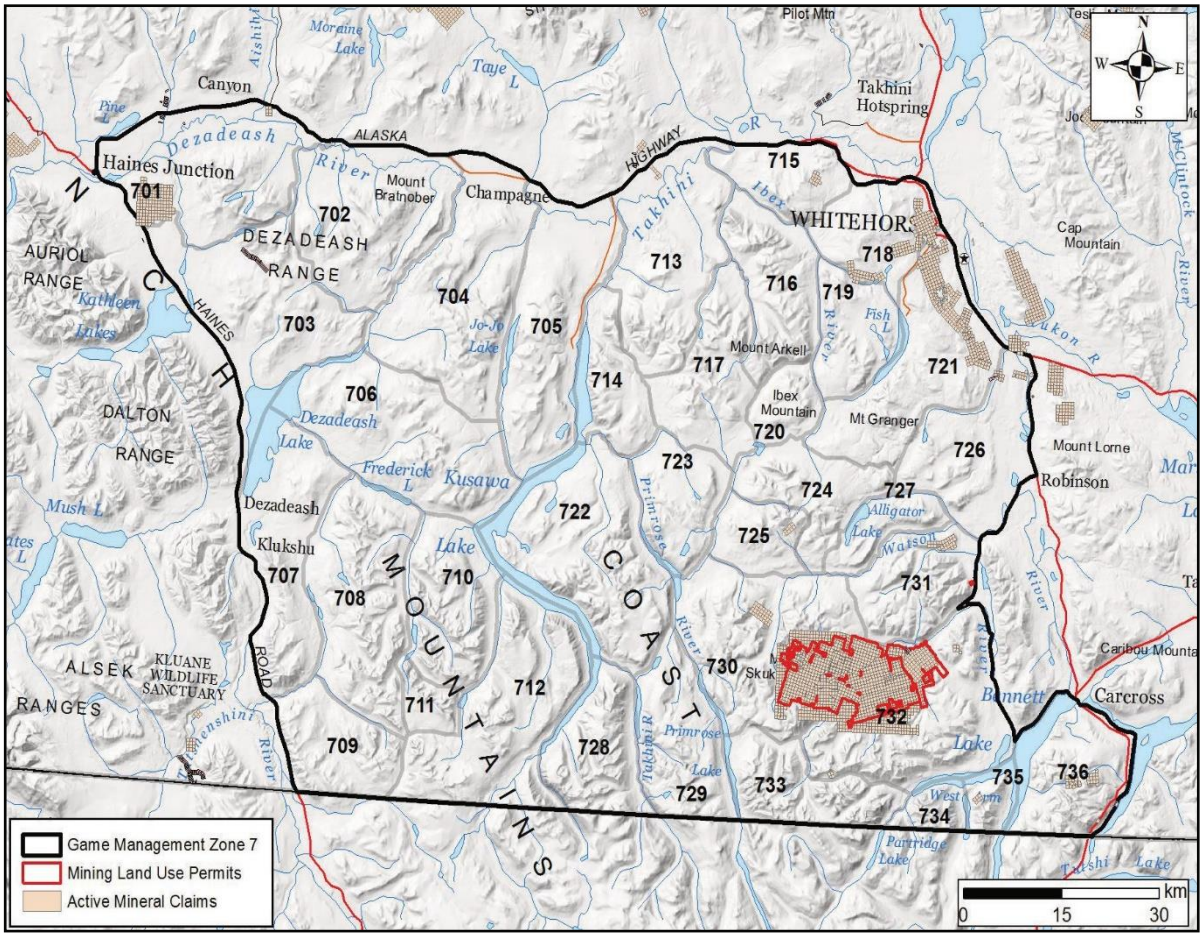

Figure 7. Distribution of mining land use permits and active mineral claims in Game Management Zone 7.

Table 1. Broad-scale Dall's sheep counts and population ratios for GMZ 7 (2015 and 2016).

Parameter	GMZ 7 West	GMZ 7 East	GMZ 7
Total Count	806	2306	3112
Non-lamb count	655	1835	2490
Lambs	151	471	622
Nursery Sheep	420	1229	1649
Rams	235	606	841
Lamb:Nursery Sheep Ratio	36:100	38:100	38:100
Ram:Nursery Sheep Ratio	56:100	49:100	51:100

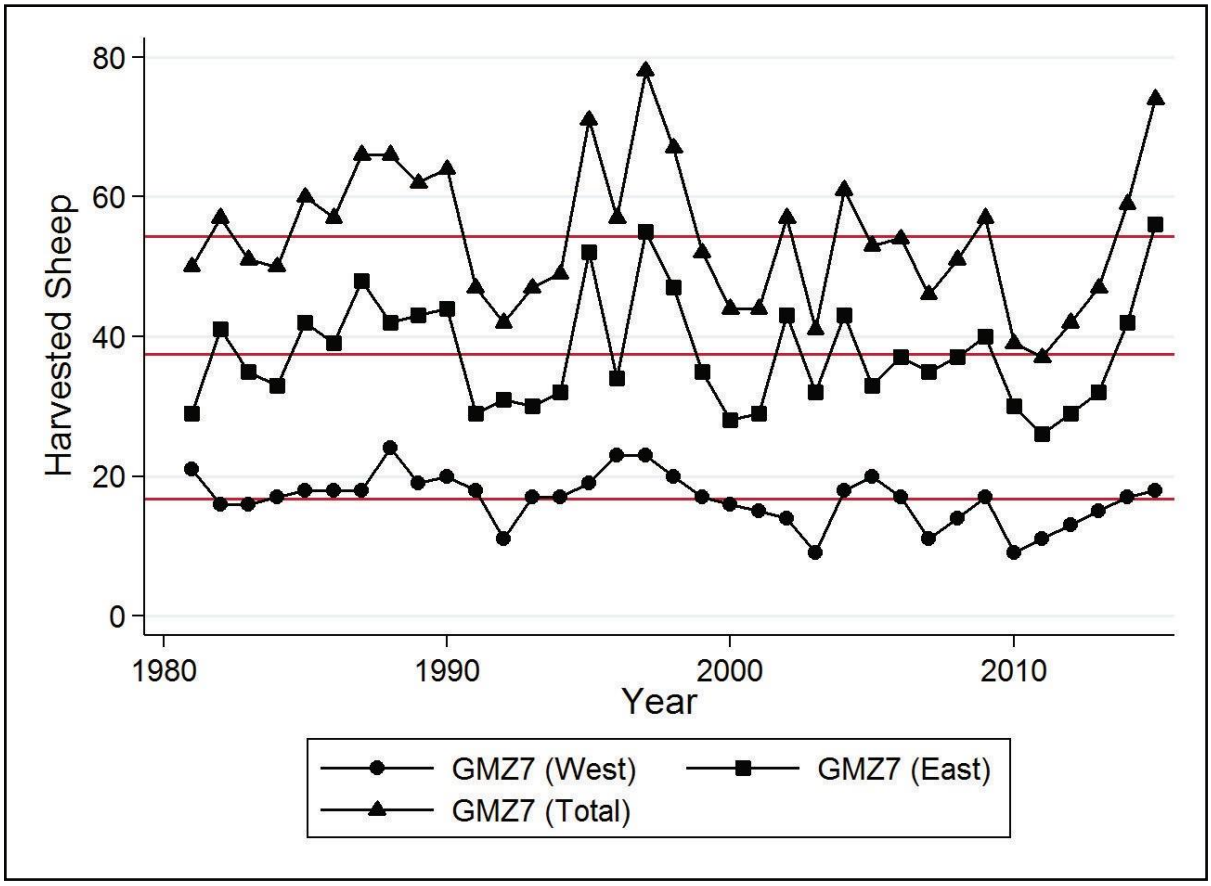

Figure 8. Long-term (1980 to 2015) licensed sheep harvest in GMZ 7. Red horizontal lines indicate long-termaverage harvest levels for, from the bottom to the top, GMZ 7 west, east, and overall.

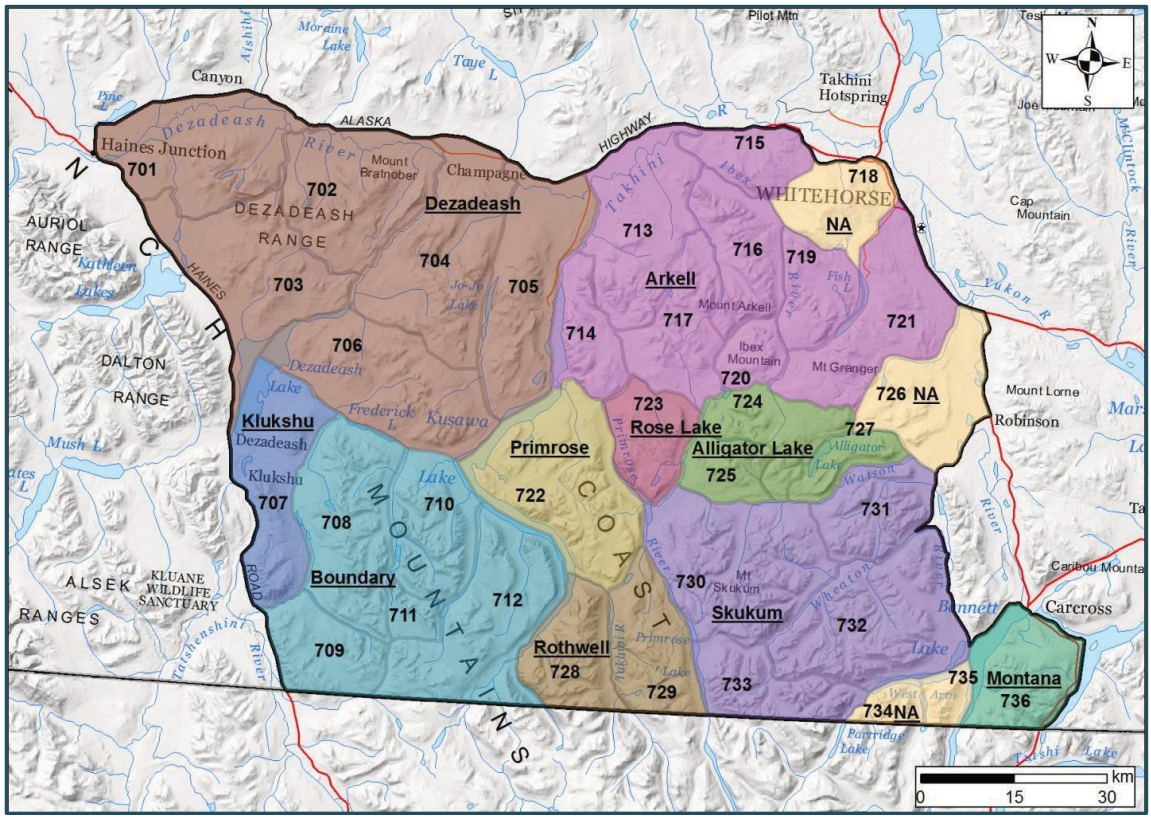

Figure 10. Ten identified management units in GMZ 7. NA indicates an area does not maintain sheep and is nota management unit. GMSs within each management unit are also labelled.

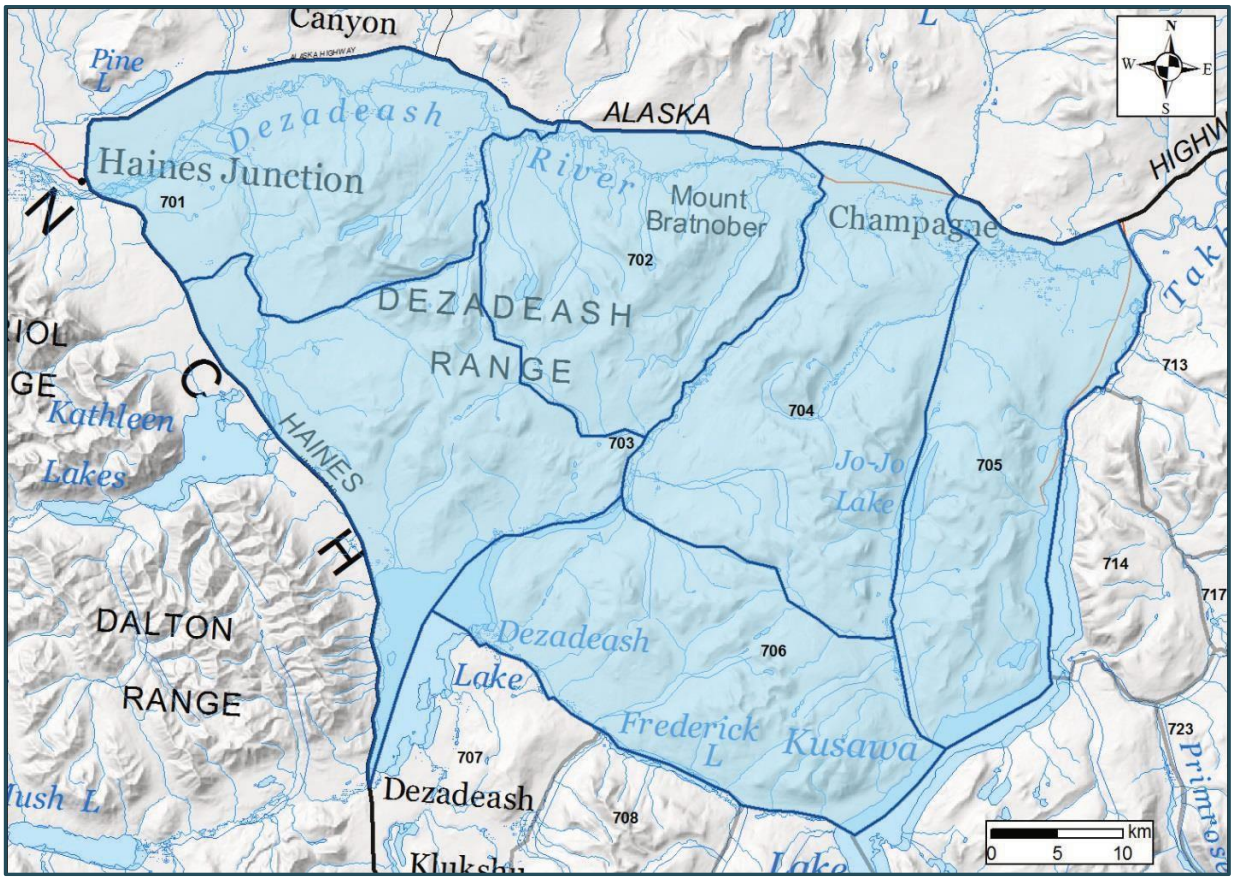

Figure 11. Location of the Dezadeash management unit.

Management units

Ten management units were identified across GMZ 7 (Figure 10). Four GMSs (7-18, 7-26, 7-34, and 7-35) were not assigned to a unit as there is little or no evidence that these subzones consistently maintain sheep. Detailed descriptionsof these units are described below.

Dezadeash (Game Management Subzones7-01 to 7-06)

The Dezadeash unit is dominated by the Dezadeash Range (Figure 11). The unit is bordered by the Haines Road to the west and the Alaska Highway to the north. The Takhini River and Kusawa Lake serve as an eastern border and the unit tapers to the south, reaching Dezadeash Lake, Frederick Lake and the Kluhini River in the south. The nearest communities are Haines Junction at the northwest corner of the unit and Champagne on the northern edge. Kusawa Natural Environment Park is located in the eastern portion of the unit (Figure 2). Mineral activity is limited in this area, and outside of likely sheep habitat, with two claim blocks: one placer and one quartz (Figure 7). CAFN settlement lands (category A and B) are located primarily in GMS 7-04 (Figure 4).

The most recent survey in this area was in 2000. The unit's current ram:nursery sheep ratio (Table 2) does not deviate from that expected for a relatively lightly harvested population, and historical non-lamb counts are comparable to that of 2015 (Table 3).

These six GMSs were grouped together largely due to the poor geographic closure among them, suggesting sheep movement among subzones in this group is likely (Table 3). For example, east of Granite Lake where GMSs 7-01, 7-02, and 7-03 meet, there is essentially no geographic closure.

Between GMSs 7-03 and 7- 04, sheep are found immediately east and west of the Dezadeash River, which may form a weak barrier to movement. Likewise, while Jo-Jo Lake likely does act as a strong barrier, Jo-Jo Creek to the south likely does not, with relatively easy movement occurring across the southern portions of GMSs 7-04 and 7-05, and 7-05 and 7-06. Finally, Undie Creek represents the only potential barrier to movement between 7-04 and 7-06, and sheep have historically been observed near it in both summer and winter. Coupled with the weak movement barriers across GMS borders, a review of previous non-lamb counts of these subzones (Table 3) suggests a high degree of movement across them, given by the highly variable counts. This variability is reduced when assessing those counts across all six subzones.

All subzones in this unit are currently open to licensed harvest (Figure 3). Licensed harvest numbers from 2011 to 2015 are provided in Table 4, with longer-term statistics (1981 to 2015) provided in Figure 12. Based on recent (past three years) harvest levels and results from this 2015 survey, the current average annual licensed harvest rate of the Dezadeash unit is approximately 2.1%. The numbers of harvested sheep in this unit has remained relatively stable, with a slight increase in numbers during the 1980s and mid-1990s and a recent increasing trend since 2010.

Table 2. 2015 survey results for the Dezadeash management unit.

	Non-lamb count	Lamb:nursery sheep ratio	Ram:nursery sheep ratio
GMS 7-01	49	31:100	26:100
GMS 7-02	129	45:100	39:100
GMS 7-03	17	54:100	31:100
GMS 7-04	189	28:100	52:100
GMS 7-05	55	34:100	34:100
GMS 7-06	101	32:100	46:100
Combined	520	35:100	45:100

Table 3. Historical summer survey results (non-lamb counts and ram:nursery sheep ratios) for the Dezadeashmanagement unit.

	Non-lamb count ratio				Ram:nursery sheep			
	2015	**2000**	**1994**	**1984**	**2015**	**2000**	**1994**	**1984**
GMS 7-01	49	97	81	55	26:100	49:100	50:100	2:100
GMS 7-02	129	145	64	118	39:100	36:100	68:100	15:100
GMS 7-03	17	25	76	17	31:100	32:100	111:100	6:100
GMS 7-04	189	72	86	208	52:100	33:100	100:100	79:100
GMS 7-05	55	51	70	99	34:100	183:100	127:100	57:100
GMS 7-06	101	72	47	94	46:100	24:100	42:100	31:100
Combined	540	462	424	591	45:100	44:100	80:100	39:100

Table 4. Harvested sheep (licensed) in the Dezadeash management unit (2011 to 2015)

	2015	**2014**	**2013**	**2012**	**2011**
GMS 7-01	4	5	0	4	2
GMS 7-02	2	3	2	3	2
GMS 7-03	0	0	0	0	0
GMS 7-04	1	2	5	1	3
GMS 7-05	2	5	2	4	2
GMS 7-06	2	0	1	0	0
Combined	11	15	10	12	9

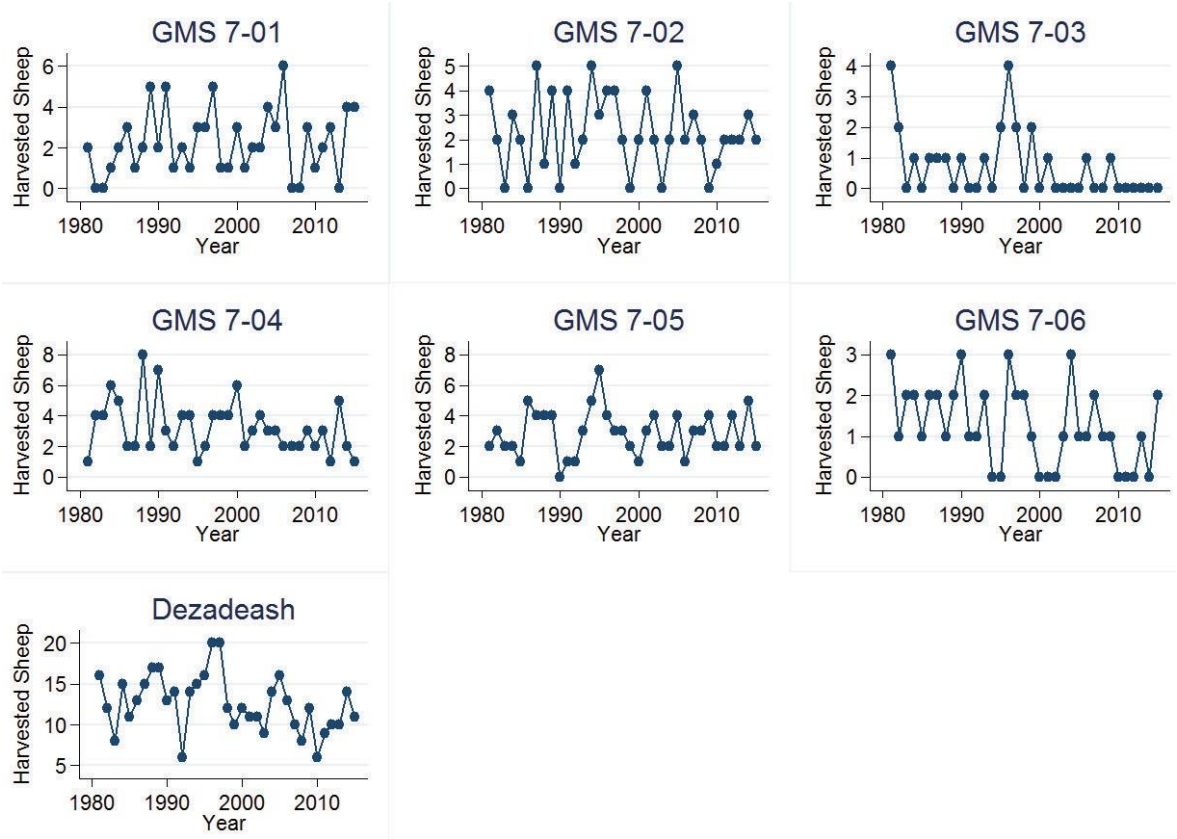

Figure 12. Long-term (1981 to 2015) licensed sheep harvest in the Dezadeash management unit. Harvest is reported by Game Management Subzone and summed across the entire Dezadeash managementunit.

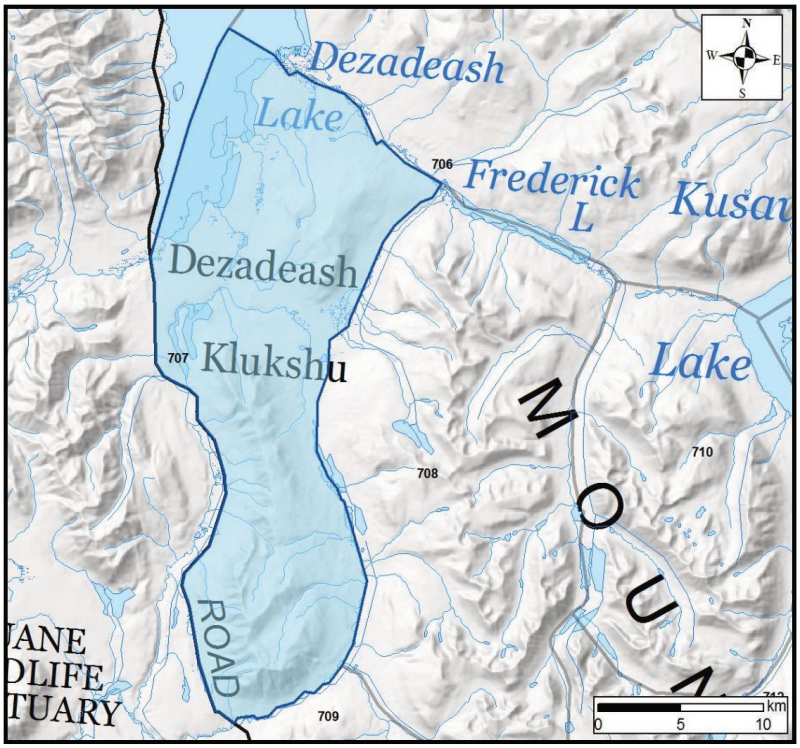

Figure 13. Location of the Klukshu management unit.

Klukshu (Game Management Subzone 7- 07)

Game Management Subzone 7-07 forms the Klukshu management unit (Figure 13). Sheep are distributed in the southern half of the GMS, with closure provided by the Haines Road and Howard Lake and the Takhanne River. This unit currently and historically has maintained a small population of sheep (Tables 5 and 6). The northern portion of the unit consists of CAFN category A Settlement Lands (Figure 4). Currently, there are no mineral exploration claims in the unit (Figure 7). Sheep in this unit have infrequently been monitored (Table 6). This unit is currently open to licensed harvest (Figure 3). Licensed harvest numbers from 2011 to 2015 are provided in Table 7, with longer-term statistics (1981 to 2015) provided in Figure 14.

Based on recent (past three years), harvest levels and results from this 2015 survey, the current average annual licensed harvest rate of the Klukshu unit is 4.2%. Given the small numbers of sheep available, the harvest of a single sheep hasthe potential to increase the harvest rate significantly and thus the age of harvested sheepshould also be considered. 10-year old sheep were harvested from this unit in 2012 and 2013 indicating older animals remain. The numbers of harvested sheep in this unit has remained relatively stable.

Table 5. 2015 survey results for the Klukshu management unit.

	Non-lamb	Lamb:nursery sheep ratio	Ram:nursery sheep
GMS 7-07	24	53:100	60:100

Table 6. Historical summer survey results (non-lamb counts) for the Klukshu management unit.

	Non-lamb count			Ram:nursery sheep ratio		
	2015	**2000**	**1973**	**2015**	**2000**	**1973**
GMS 7-01	24	24	8	60:100	50:100	N/A

Table 7. Harvested sheep (licensed) in the Klukshu management unit (2011 to 2015).

	2015	**2014**	**2013**	**2012**	**2011**
GMS 7-01	2	0	2	1	0

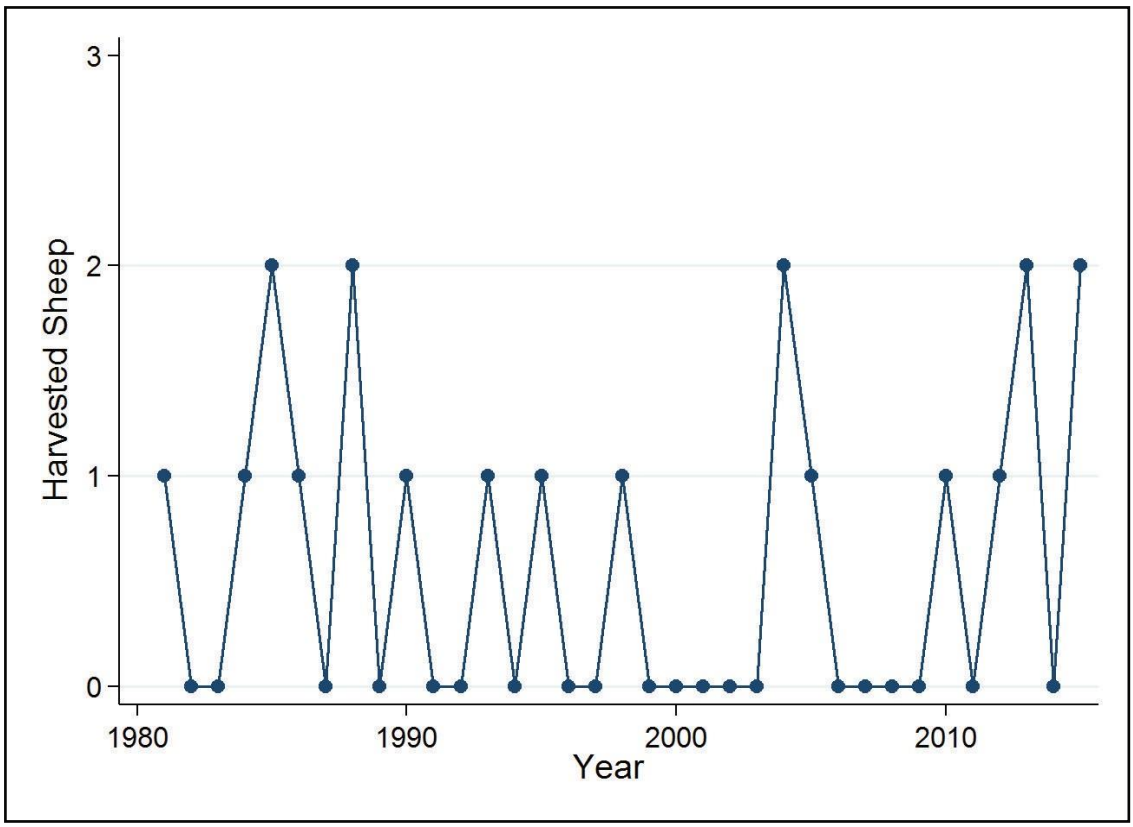

Figure 14. Long-term (1981 to 2015) licensed sheep harvest in the Klukshu management unit (GMS 7-07).

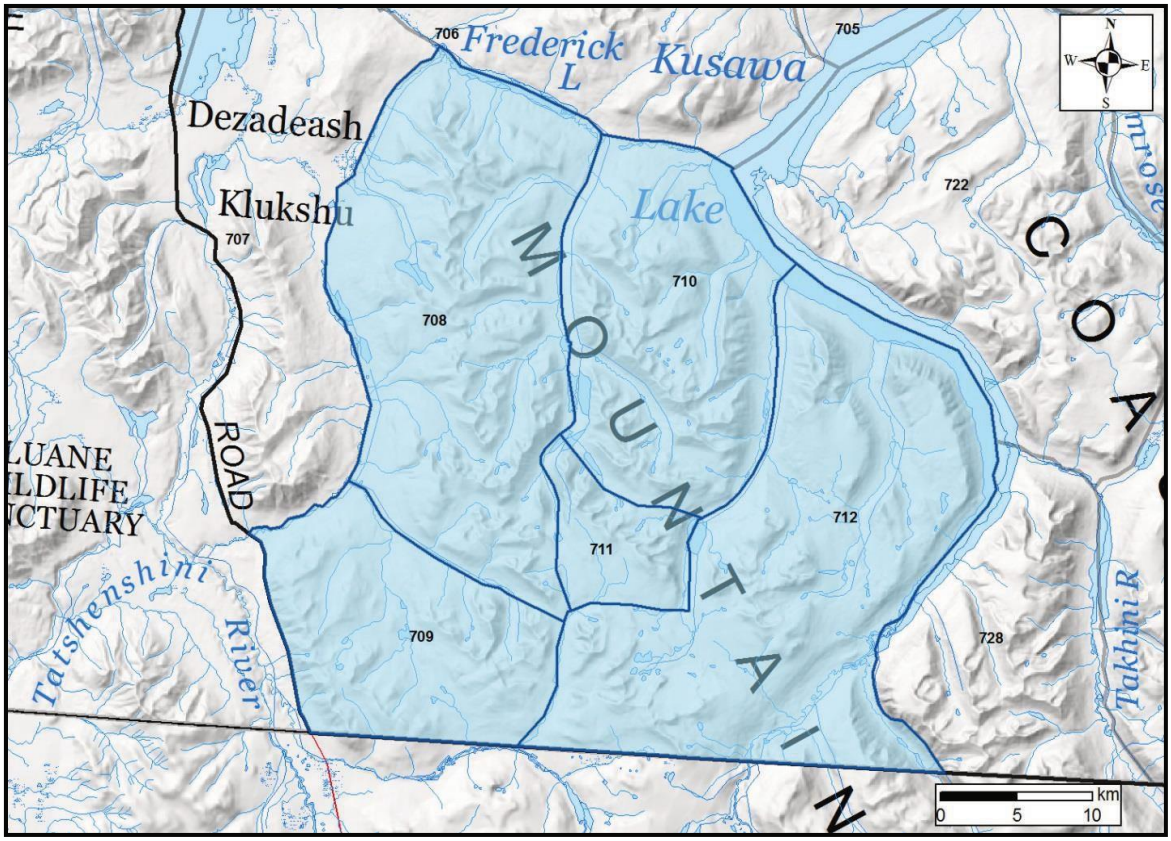

Figure 15. Location of the Boundary management unit.

Boundary (Game Management Subzones 7-08 to 7-12)

The Boundary management unit consists of the Boundary Ranges and is bordered to the south by the Yukon-BC border (Figure 15). The eastern half of this unit is located in Kusawa Natural Environment Park (Figure 2). There is very limited human activity in this unit (e.g., no active mineral claims – Figure 7). This unit is very rugged, generally high elevation, particularly in the central portion of the unit, and generally deemed marginal sheep habitat due to low forage productivity. GMSs 7-08 and 7-12 (Ark Mountain) hold the largest numbers of sheep in the unit, with a GMS 7-10 and 7-11 maintaining extremely sparse numbers (Tables 8 and 9). Sheep have never been observed in GMS 7-10 during formal surveys and 2015 was the first time sheep had been found in GMS 7-11. This is evidenced by the low numbers of sheep harvested in these subzones (Table 10, Figure 16). Among subzones 7-08 through 7-11, there is generally weak geographic closure, which is supported by current and historical sheep observations. Inclusion of GMS 7-12 in this unit was done somewhat tentatively. Sheep in GMS 7-12 (Ark Mountain specifically) appear to be somewhat isolated as Kusawa Lake likely forms an eastern barrier to movement and sheep are generally absent in the southern portion of the subzone. In February 2015, Jex (2015) surveyed the southern most portion of GMS 7-12 and did not observe any sheep in that area. However, observed ram:nursery sheep ratios from this survey and previous ones do not support treating GMS 7-12 as a discrete unit. Thus, until additional information (e.g., survey, sheep movement) becomes available, GMS 7-12 will be included within the Boundary management unit.

The southern portion of this unit corresponds to the northern portion of BC's "Mansfield" sheep population in Wildlife Management Unit 6-28. Thus, this unit in Yukon likely does not represent a"complete" population and is transboundary in nature. This is supported by the unrealistic ram:nursery sheep ratio (i.e., 141:100) observed in2015 and 2016 (Table 8). Marshall (2005) conducted a

survey of the Mount Mansfield area in July 2004, directly south of GMS 7-09, and counted 38 nursery sheep and no rams. These results and results from our survey (Table 8) lend credence to the possible sexual segregation of sheep in this area, with rams dominating the northern portion of the area in summer. These results also support the notion that Yukon sheep do not represent a complete population unit. While previous surveys of this unit have occurred (Table 9), the only comprehensive surveycovering this entire unit occurred in 2000. Non-lamb counts from 2000 to 2015/2016 have been stable. The average annual licensed harvest rate over the past five years is 2.7%. Annual harvest inthis unit fluctuates considerably and since 2010 there has been an increasing trend in the number of harvested animals (Figure 16).

Table 8. 2015/2016 survey results for the Boundary management unit.

	Non-lamb count	Lamb:nursery sheep ratio	Ram:nursery sheep ratio
GMS 7-08[a]	33	45:100	200:100
GMS 7-09	18	50:100	125:100
GMS 7-10	0	N/A	N/A
GMS 7-11	5	N/A	N/A
GMS 7-12[a]	55	33:100	104:100
Combined	111	39:100	141:100

a: Subzones were resurveyed in 2016. 2016 results are provided.

Table 9. Historical summer survey results (non-lamb counts) for the Boundary management unit.

	Non-lamb Count					Ram:nursery sheep ratio				
	2015/16	2000	1994	1992	1984	2015/16	2000	1994	1992	1984
GMS 7-08	33	60	45	-	40	200:100	131:100	81:100	-	186:100
GMS 7-09	18	21	-	-	-	125:100	5:100	-	-	-
GMS 7-10	0	0	-	0	-	N/A	N/A	-	-	-
GMS 7-11	5	0	-	0	-	N/A	N/A	-	-	-
GMS 7-12	55	33	-	72[a]	30	104:100	313:100	-	9:100	0:100
Combined	111	114	-	-	-	141:100	111:100	-	-	-

Table 10. Harvested sheep (licensed) in the Boundary management unit (2011 to 2015).

	2015	2014	2013	2012	2011
GMS 7-08	4	0	1	2	2
GMS 7-09	0	0	1	0	0
GMS 7-10	0	0	0	0	0
GMS 7-11	0	0	0	0	0
GMS 7-12	1	3	1	0	0
Combined	5	3	3	2	2

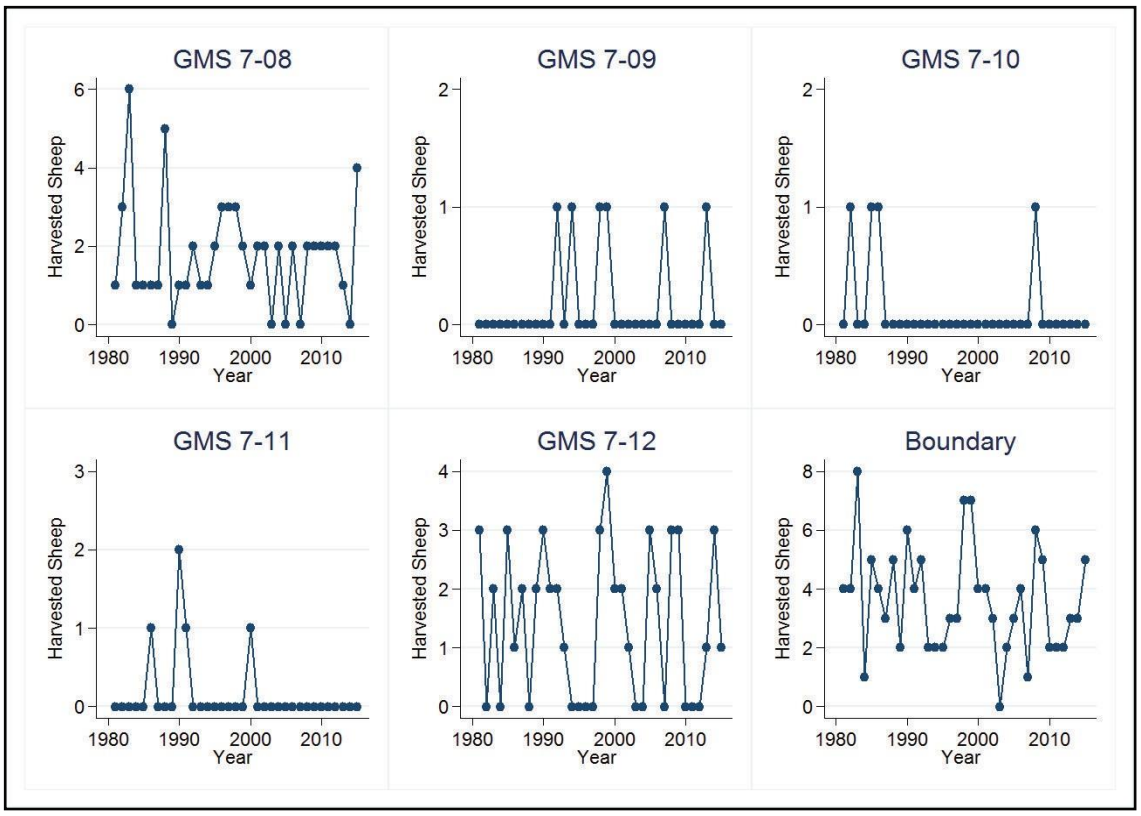

Figure 16. Long-term (1981 to 2015) licensed sheep harvest in the Boundary management unit. Harvest is reported by Game Management Subzone and summed across the entire Boundary management unit.

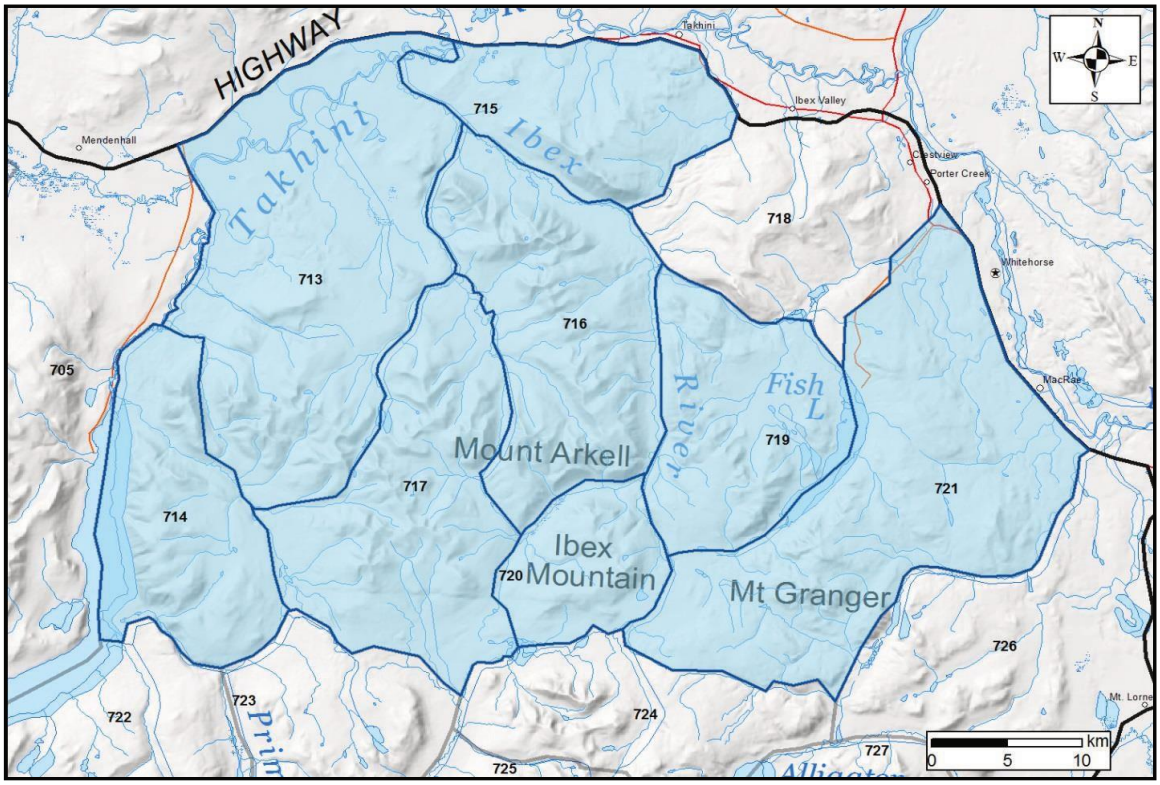

Figure 17. Location of the Arkell management unit.

Arkell (Game Management Subzones 7-13 to 7-17 and 7-19 to 7-21)

The Arkell management unit (Figure 17), named after Mount Arkell located roughly in the center of the unit, is the largest unit identified in GMZ 7. The size of this unit is largely due to the lack of geographic closure among GMSs. For example, there is essentially no closure between GMSs 7-13 and 7-14, 7-13 and 7-17, 7-16 and 7-17, 7-16 and 7-19, 7-19 and 7-21, 7-16 and 7-20, and weak closure between 7-15 and 7-16 (Figure 17). Furthermore, the ram:nursery sheep ratios in a number of individual GMSs in the Arkell unit are not biologically reasonable (Table 11), and historic counts (Table 12) of non-lamb numbers suggests movement across GMS boundaries (e.g., the high count in GMS 7-13 in 2000). Given these factors, it is challenging to identify smaller subsets of GMSs that are biologically reasonable. Sheep numbers (non-lamb) were found to be generally stable compared to previous surveys (Table 12). There is relatively sparse industrial development (Figure 7) in the Arkell unit, with one quartz mineral claim block at the south end of GMS 7-17 and a few claims distributed elsewhere and very limited forest fire occurrence (Figure 6). There are five First Nation Settlement Land blocks located in the unit: four category A and one category B (Figure 4). Human access into this unitis relatively high, with a number of well-used trails accessing sheep habitat. During the late-1970s and early-1980s, there was of significant concern in GMS 7-15 due to the proposed Alaska Highway Pipeline, which was not subsequently constructed. Within this unit, three GMSs are under a PHA, two are closed to licensed harvest, and three are open (Figure 3). From 1981 to 1998, this area was part of an operating outfitting area (OA 17) with non-resident sheep harvest occurring. From 1999 to 2012, the area was not operated and the only licenced harvest occurring was by residents. In 2013, non-resident harvest resumed, with the outfitter for the area operating under a sheep harvest quota for the entire area as of 2016. Non-resident harvest in the area began in earnest in 2014 which is one cause for the increase in sheep harvested beginning that year (Table 13). For licensed resident harvest, GMSs 7-14 and 7-16 became PHA areas for the 2012 hunting season with 15 permits issued annually in each subzone. Also in 2012, GMS 7-19 became closed to licensed harvest. GMS 7-15 has been closed to licensed harvest since 1979. Two permits are issued annually in GMS 7-21, which became a PHA zone in 1988. Changes in harvest regulations and outfitting operations make assessing the long-term trends in harvest numbers in this unit challenging.

The current average annual licensed harvest rate (2014 and 2015) in the Arkell unit is 3.3%. Beginning in 1999 (Figure 18), there is a clear decrease in licensed harvest across the unit as a result of the cessation of non-resident harvest. During the 2000s, resident harvest essentially “replaced” non-resident harvest, followed by a drop in harvest roughly around 2010. However, from 2010 to the present, the overall trend in harvest has been a rapid increase brought on by both the re-established non-resident harvest in the unit and increasing resident harvest. This has occurred even with GMS 7-19 being closed and GMSs 7-14 and 7-16 being placed on a PHA in 2012. The current quota for the outfitter in the area will likely stabilize non-resident harvest numbers, but if the current trend continues, resident harvest may increase in the open subzones.

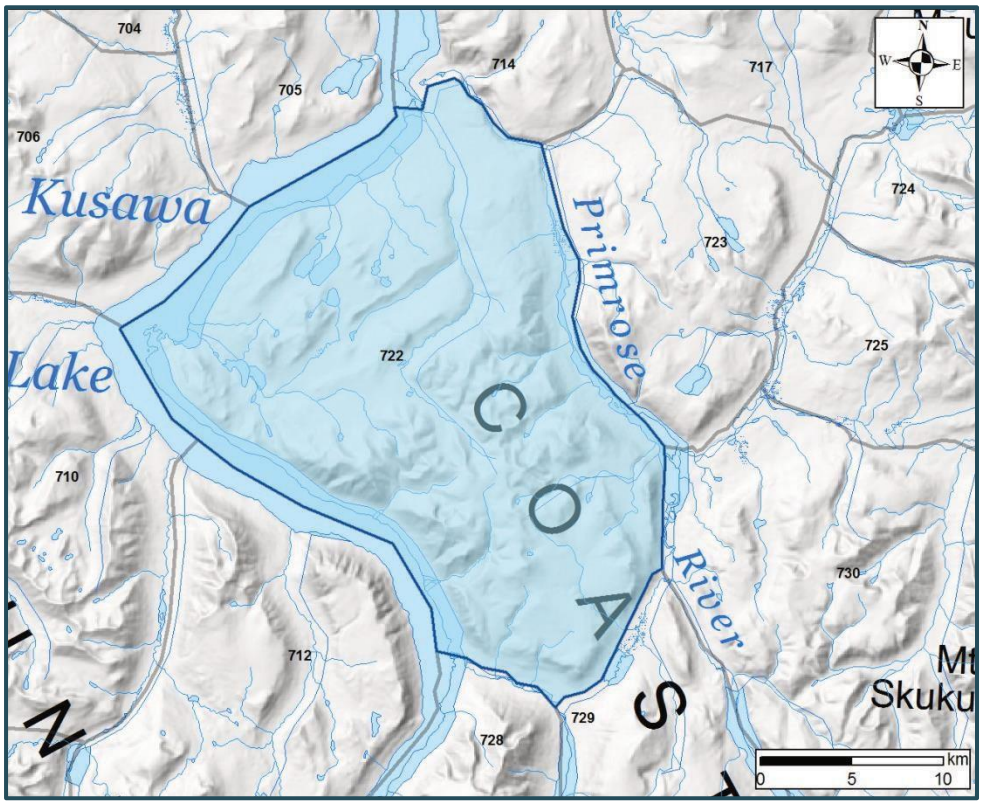

Figure 19. Location of the Primrose management unit.

Primrose (Game Management Subzone 7- 22)

Game Management Subzone 7-22 forms the Primrose management unit (Figure 19). It is a single large GMS with closure provided by the Takhini and Primrose rivers and Rose and Kusawa lakes. Sheep numbers are high in this unit (Tables 14 and 15). There is little human disturbance in the area (Figure 7) and the area has experienced a few forest fires (Figure 6), generally on its periphery in river valleys. There are two parcels of Category B First Nation Settlement Lands in theunit, outside of sheep habitat (Figure 4). Currently, the unit is outside of any outfitting area and licensed harvest is only available to Yukon residents (Figure 3). Since 1979, this area has been under a PHA with 20 permits issued annually. The current average annual licensed harvest rate in this unit is 1.9% (Table 16) and licensed harvest has been relatively stable (Figure20).

Table 14. 2016 survey results for the Primrose management unit.

	Non-lamb count	Lamb:nursery	Ram:nursery
GMS 7-07	24	53:100	60:100

Table 16. Harvested sheep (licensed) in the Primrose management unit (2011 to 2015)

	2015	2014	2013	2012	2011
GMS 7-22	9	5	5	8	6

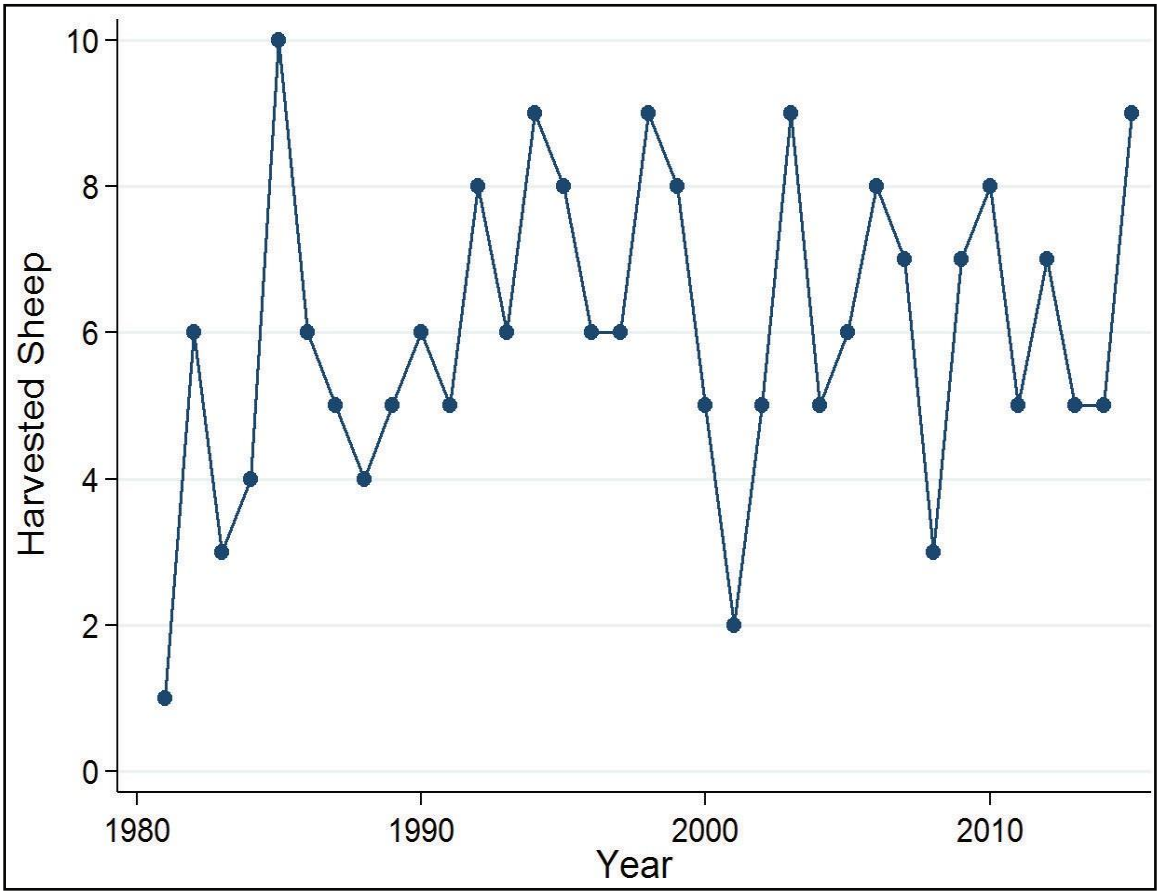

Figure 20. Long-term (1981 to 2015) licensed sheep harvest in the Primrose management unit (GMS 7-22).

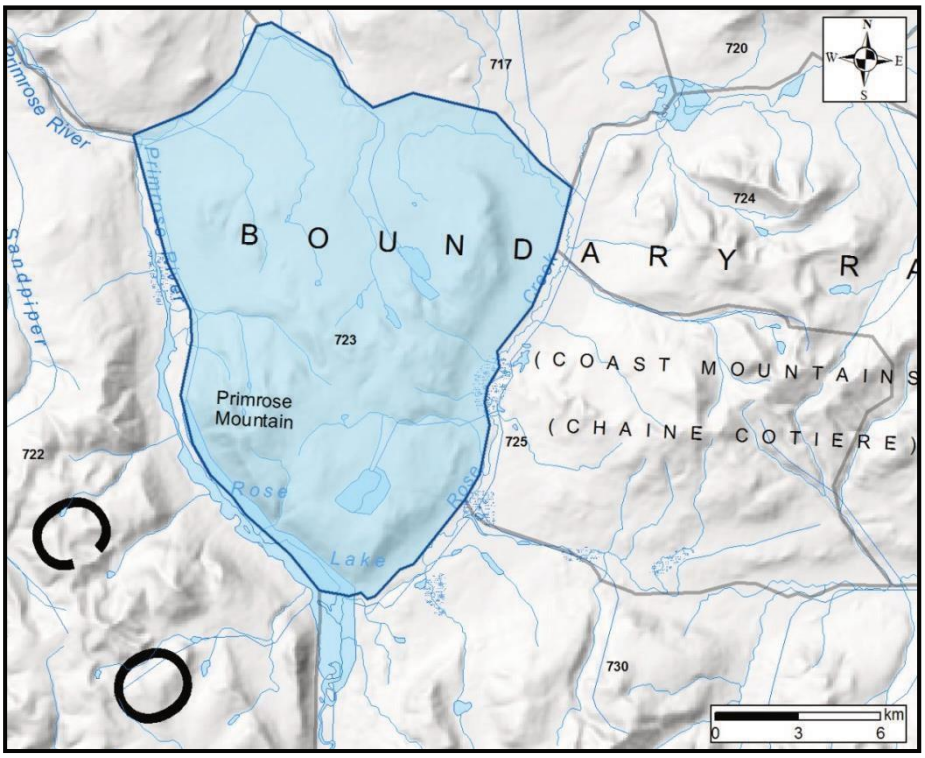

Figure 21. Location of the Rose Lake management unit.

Rose Lake (Game Management Subzone 7- 23)

The Rose Lake management unit (Figure 21, Table17) consists of a single GMS (7-23). Since the 1980s, this GMS has been identified as a discrete unit for sheep monitoring. The dominant physiographic features of this unit are Primrose Mountain and Rose Lake in the southwest portion of the unit. There is little landscape disturbance in the unit (Figure 7) with the exception of two forest fires that occurred along Rose Creek to the south and the Primrose River to the north (Figure 6). Geographic closure is provided by Rose Lake, the Primrose River and to a lesser extent Rose Creek. To the north of the unit lie lower elevation areas that do not provide sheep habitat. This unit has experienced some of the most frequent levels of monitoring among sheep populations in Yukon with surveys dating back to 1979 (Table 18). This area was a control area during the Aishihik wolf control program (Hayes et *al*. 2003) and its lamb productivity was compared to populations to the northwest where wolf control activities occurred. Monitoring also occurred during the 1980s during wolf control activities in the Coast Mountains (Hayes et *al*. 1991).

Sheep numbers in the Rose Lake unit were roughly double in size in the 1980s and 1990s compared to more recent survey data, but with little change between 2009 and 2015 (Table 18).The causes of this observed decline are unknown and it is unclear if environmental factors have led to it given the lack of decline elsewhere in GMZ 7.

Since 1979, GMS 7-23 has been under a PHA (Figure 3) for licensed resident harvest (7 permits issued annually) and a quota for non-residents (maximum of 2 per year after 31 August under the 1993 Commissioner's Agreement). The current average annual licensed harvest rate (2014 and 2015) for the Rose Lake unit is 4% (Table 19). Harvest started declined in the early 2000s but has recently increased (Figure 22).

Table 17. 2015 survey results for the Rose Lake management unit.

	Non-lamb count	Lamb:nursery sheep	Ram:nursery sheep
GMS 7-23	100	30:100	37:100

Table 18. Historical survey results (non-lamb counts and ram:nursery sheep ratios) for the Rose Lake Management Unit (GMS 7-23).

	Non-lamb count	Ram:nursery sheep ratio
2015	100	37:100
2009	119	21:100
1997	191	37:100
1996	206	36:100
1995	224	62:100
1994	169	82:100
1993	211	46:100
1992	153	61:100
1989	138	15:100
1986	106	63:100
1985	121	19:100
1984	262	43:100
1983	196	39:100
1982	186	42:100
1981	223	32:100
1980	203	28:100
1979	186	18:100

Table 19. Harvested sheep (licensed) in the Rose Lake management unit (2011 to 2015).

	2015	2014	2013	2012	2011
GMS 7-23	5	3	0	2	0

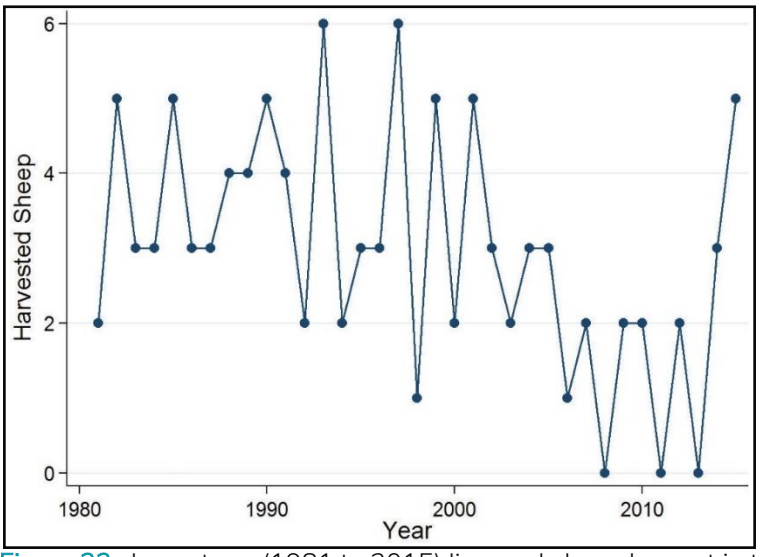

Figure 22. Long-term (1981 to 2015) licensed sheep harvest in the Rose Lake management unit (GMS 7-23)

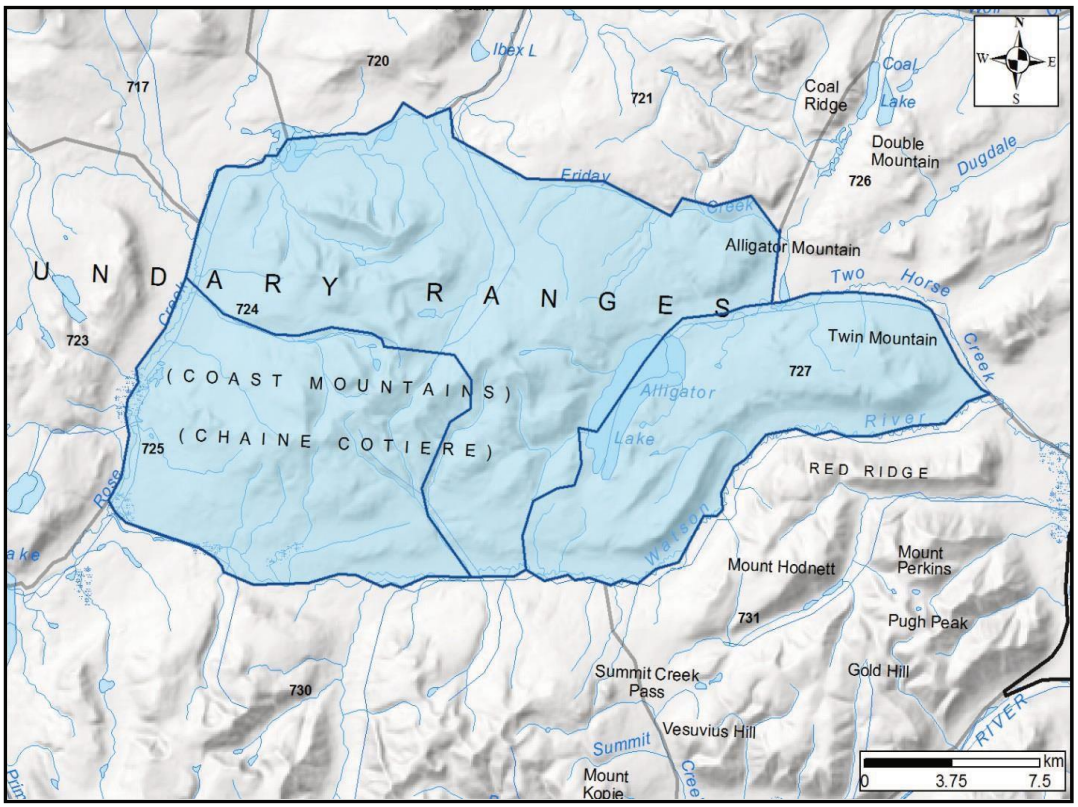

Figure 23. Location of the Alligator Lake management unit.

Alligator Lake (Game Management Subzone 7- 24, 7-25, and 7-27)

The Alligator Lake management unit consists of GMSs 7-24, 7-25, and 7-27 (Figure 23). The boundary between GMSs 7-24 and 7-25 is extremely permeable to sheep movement and provides essentially no geographic closure. GMS 7-27 is more challenging to assign to a management unit as on its own it is not at all consistent with representing a biologically reasonable population (Table 202). There is weak closure between GMSs 7-24 and 7-27 and we viewed the Watson River, between GMSs 7-27 and 7-31, as providing a stronger movement barrier, thus the decision to combine 7-27 with 7-24 and 7-25.

There are limited quartz mineral claims in GMSs 7-25 and 7-27 and an historic mining road accesses Alligator Lake from the east (Figure 7). The southwest corner of 7-25 has experienced forest fires but the rest of the unit is relatively undisturbed (Figure 6). The population in this unit has remained relatively stable since 1994, with slightly lower numbers compared to 1989 (Table 21). Both GMSs 7-24 and 7-25 are located within OA 17, while GMS 7-27 is not located in an OA. Both GMSs 7-25 and 7-27 are under a PHA for licensed resident hunters (Figure 3), with 6 and 4 permits issued annually, respectively. GMS 7-25 is under a quota for non-resident licensed harvest with a maximum of two sheep harvested per year and is managed according to a 1993 Commissioners Agreement. GMS 7-24 is currentlyan open subzone. Based on harvest data from 2014 and 2015 (Table 22), the average annual licensed harvest rate for this unit is 2.9%. Since 2011, all licensed harvest from this unit has come from GMSs 7-24 and 7-25 (Table 22). Harvest has been relatively stable in the unit (Figure 24).

Table 20. 2015/2016 survey results for the Alligator Lake management unit.

	Non-lamb count	Lamb:nursery sheep ratio	Ram:nursery sheep ratio
GMS 7-24[a]	123	43:100	3:100
GMS 7-25[a]	41	50:100	1950:100
GMS 7-27	28	14:100	100:100
Combined	192	40:100	41:100

a: Subzones were resurveyed in 2016. 2016 results are provided.

Table 21. Historical summer survey results (non-lamb counts and ram:nursery sheep ratios) for the AlligatorLake management unit.

	Non-lamb count				Ram:nursery sheep ratio			
	2015/16	**2009**	**1994**	**1989**	**2015/16**	**2009**	**1994**	**1989**
GMS 7-24	123	93	107	130	3:100	2:100	30:100	0:100
GMS 7-25	41	75	43	50	1950:100	108:100	1333:100	7:100
GMS 7-27	28	32	51	32	100:100	146:100	183:100	540:100
Comb.	192	200	201	212	40:100	43:100	95:100	50:100

Table 22. Harvested sheep (licensed) in the Alligator Lake management unit (2011 to 2015).

	2015	2014	2013	2012	2011
GMS 7-24	2	3a	1	2	2
GMS 7-25	3	3a	2	0	2
GMS 7-27	0	0	0	0	0
Combined	5	6	3	2	4

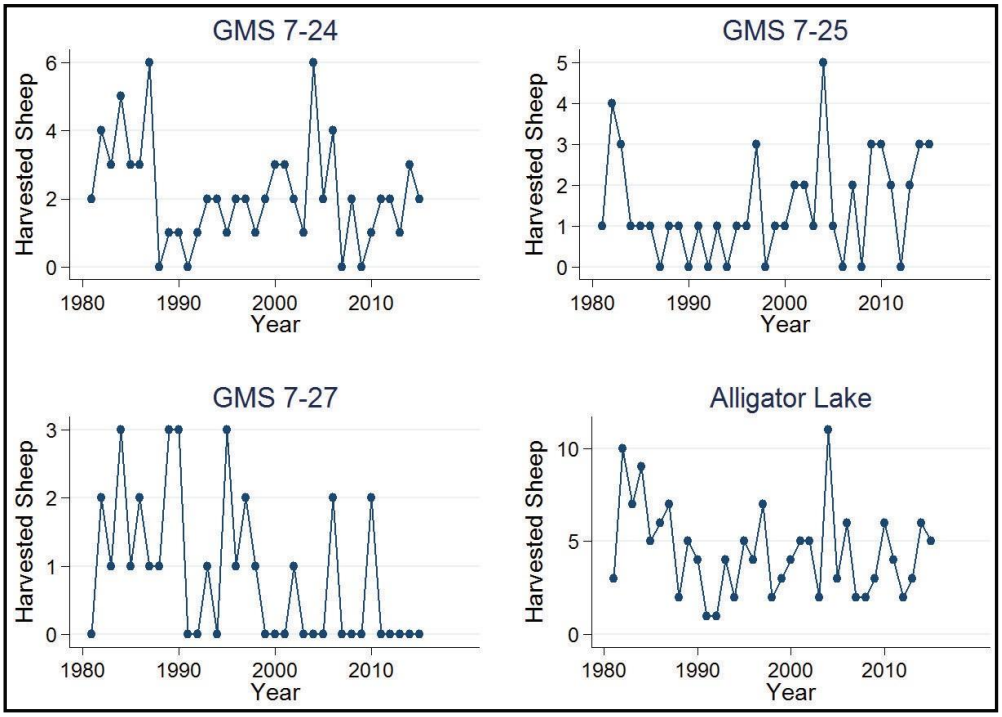

Figure 23. Long-term (1981 to 2015) licensed sheep harvest in the Alligator Lake management unit. Harvest is reported by game management subzone and summed across the entire Alligator Lake managementunit.

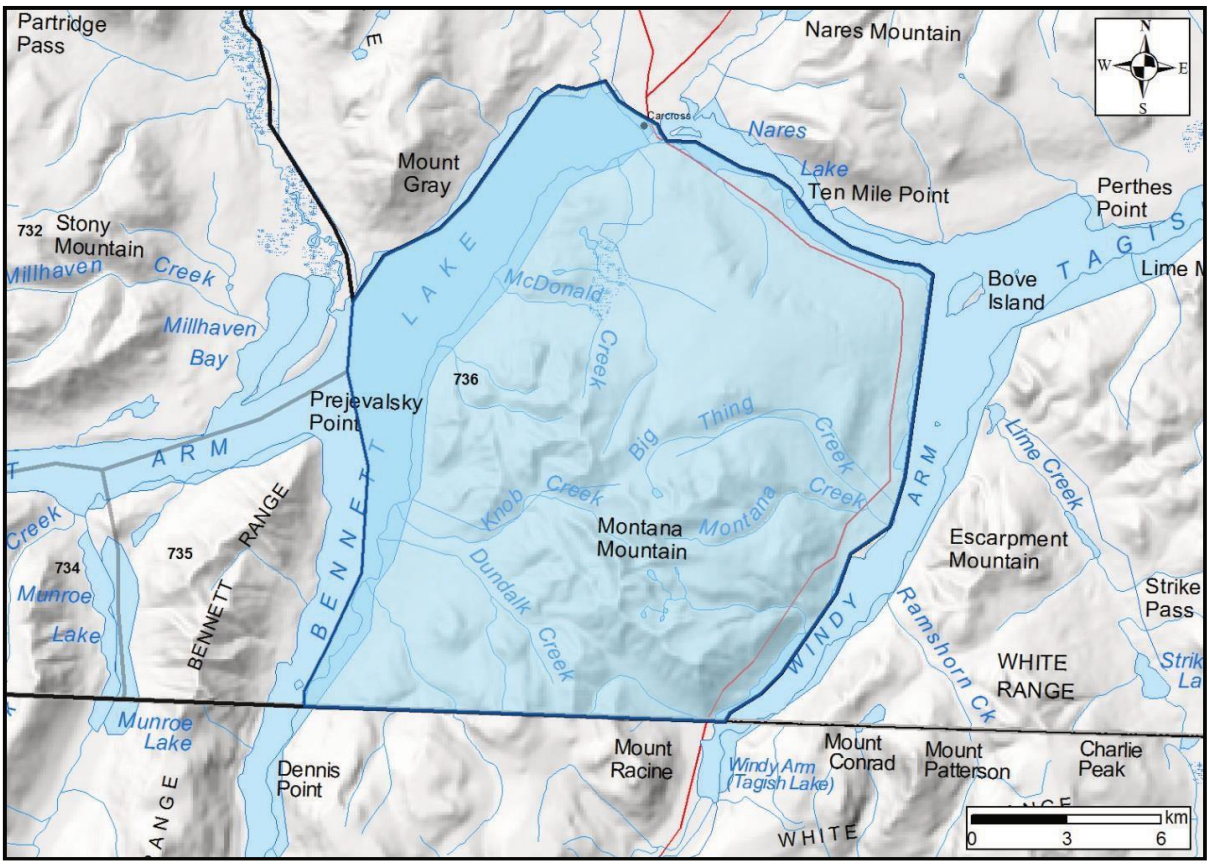

Figure 24. Location of the Montana management unit.

Montana (Game Management Subzone 7- 36)

The Montana management unit, consisting solely of GMS 7-36 (Figure 24), is located along the Yukon-BC border south of Carcross. Sheep are sparsely distributed within the unit (Table 23), which corresponds to the northern portion of BC's Tutshi population. Thus, sheep in the Montana unit likely do not represent a complete biological population as they are consistently biased to higher numbers of rams. Survey data for this unit are limited, however, based on data from 2016 and 2009 the numbers of sheep using this unit appear to be stable (Table 24).

The majority of the Montana management unit consists of CTFN category A settlement land (Figure 4), and has been closed to licensed harvest since 1980 (Figure 3). Historically the unit experienced significant mineral exploration and development (Figure 7), and currently it is the site of significant recreational use (e.g., mountain biking).

Table 23. 2016 survey results for the Montana mountain unit

	Non-lamb count	Lamb:nursery ratio	Ram:nursery ratio
GMS 7-36	22	0	633:100

Table 24. Historical survey results (non-lamb countsand ram:nursery sheep ratios) for the Montana management unit (GMS 7-36).

	Non-lamb count		Ram:nursery sheep ratio	
	2016	**2009**	**2016**	**2009**
GMS 7-36	22	16	633:100	1500:100

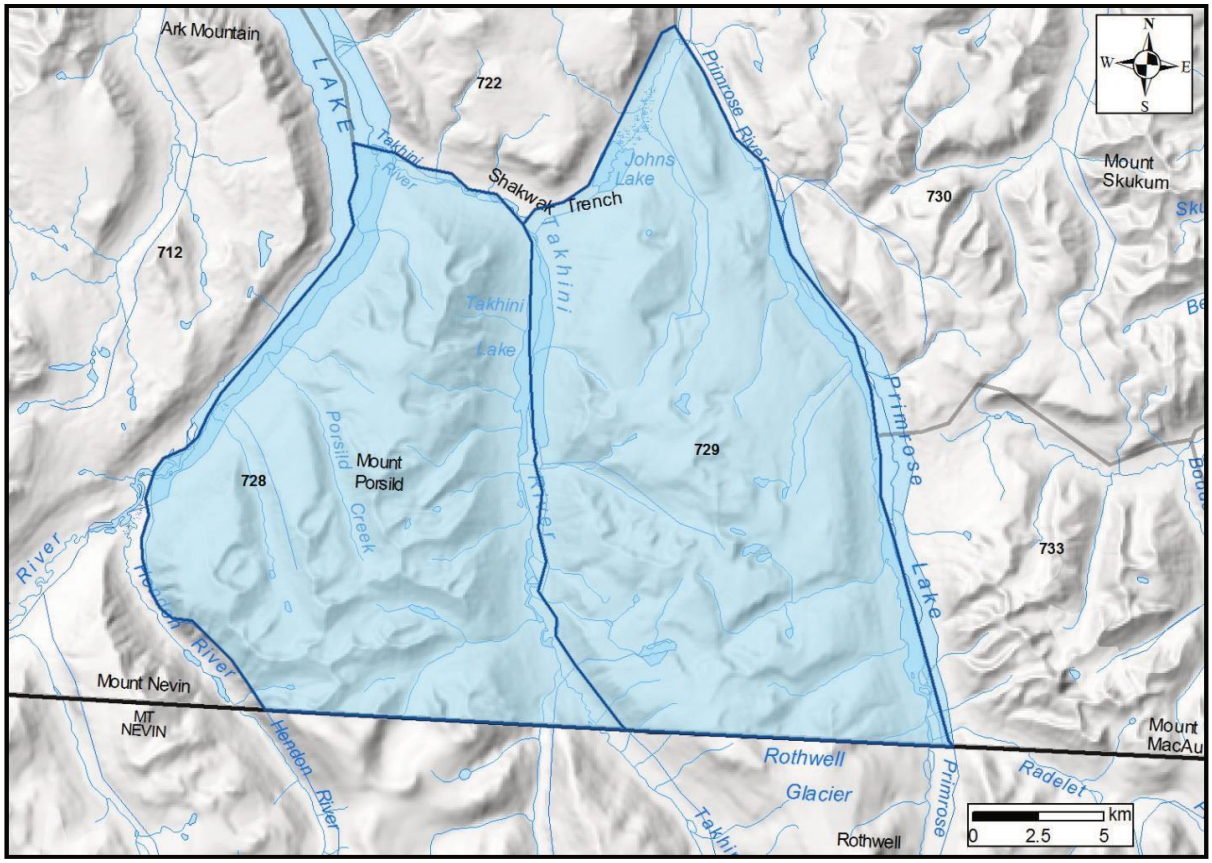

Figure 25. Location of the Rothwell management unit.

Rothwell (Game Management Subzones 7-28 and 7-29)

The Rothwell unit in the southwest corner of GMZ 7 (east) (Figure 25) consists of very high elevation rugged terrain with relatively low sheep numbers (Table 25). This unit corresponds to the northern portion of BC's Primrose population and sheep in GMSs 7-28 and 7-29 likely do not form acomplete biological population. Geographic closure of this unit is provided by Primrose Lake on the eastern side and the Hendon River and Kusawa Lake to the west. The Takhini River and Takhini Lake also likely provide a significant barrier to movement between GMSs 7-28 and 7-29; however, south of the Yukon-BC border, the connectivity for sheep movement becomes greater. In February 2015, Jex (2015) surveyed GMS 7-28 and areas in BC directly south of the border during his broader sheep survey in northwest BC. During that survey, he observed a total of 37 sheep, although no areas in GMS 7-29 were surveyed. Survey information across the unitis relatively sparse (Table 26), but current sheep numbers are generally similar compared to historic data.

This unit is relatively undisturbed from anthropogenic development (Figure 7), but its higher elevation results in low-productivity habitat and thus sheep numbers are expected to be low. The current average annual licensed harvest rate for this unit is 0.4% (Table 27) and has historicallybeen low (Figure 26). Both subzones in this unit are open to licensed harvest, with no non-resident harvest occurring (Figure 3).

Table 25. 2015 survey results for the Rothwell management unit

	Non-lamb count	Lamb:nursery sheep ratio	Ram:nursery sheep ratio
GMS 7-28	27	35:100	17:100
GMS 7-29	21	14:100	50:100
Combined	48	27:100	30:100

Table 26. Historical survey results (non-lamb counts and ram:nursery sheep ratios) for the Rothwell management unit.

	Non-lamb count					Ram:nursery sheep ratio				
	2015/16	**2000**	**1994**	**1992**	**1984**	**2015/16**	**2000**	**1994**	**1992**	**1984**
GMS 7-28	27	19a	27	34	-	17:100	N/A	59:100	31:100	-
GMS 7-29	21	-	-	-	14	50:100	-	-	-	N/A
Combined	48	-	-	-	-	30:100	-	-	-	

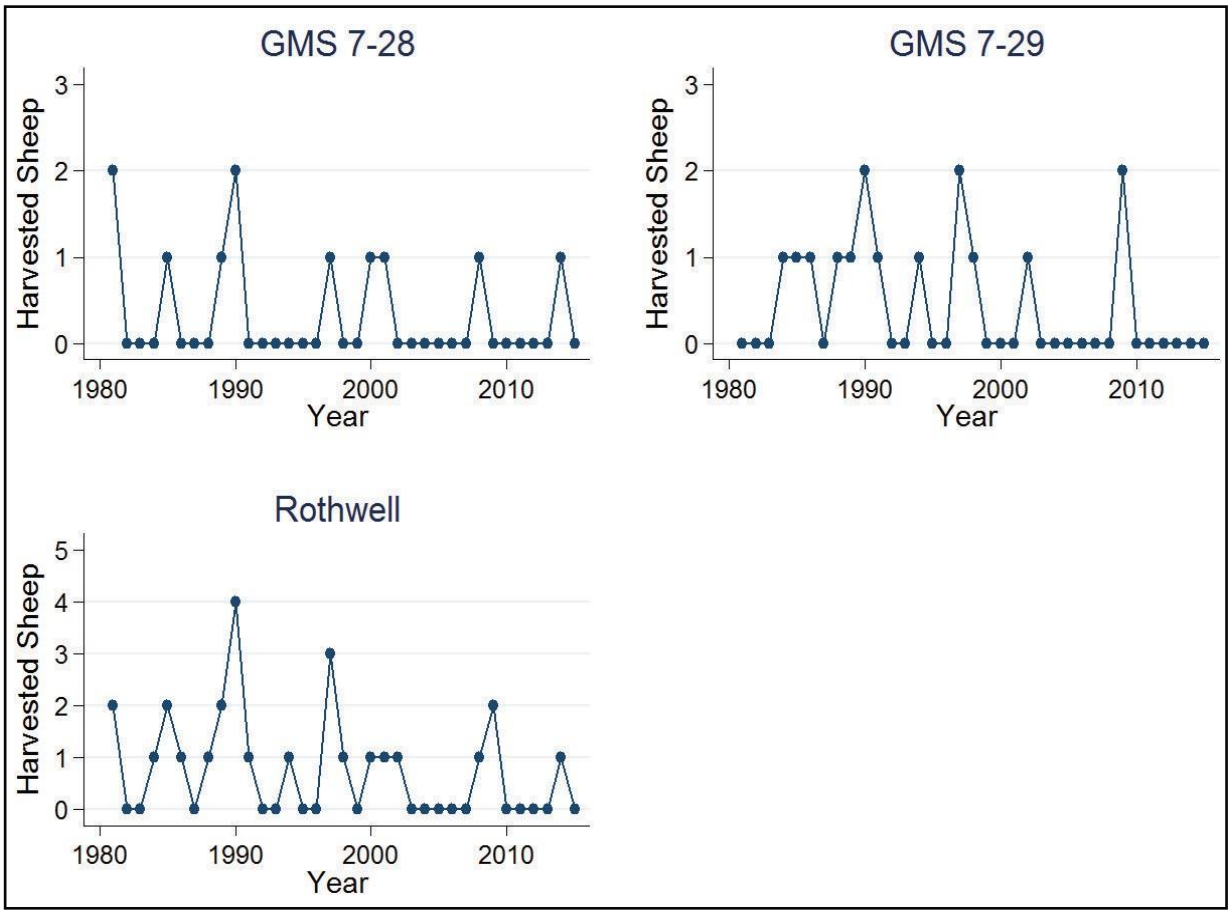

Figure 26. Long-term (1981 to 2015) licensed sheep harvest in the Rothwell management unit. Harvest is reported by Game Management Subzone and summed across the entire Rothwell management unit.

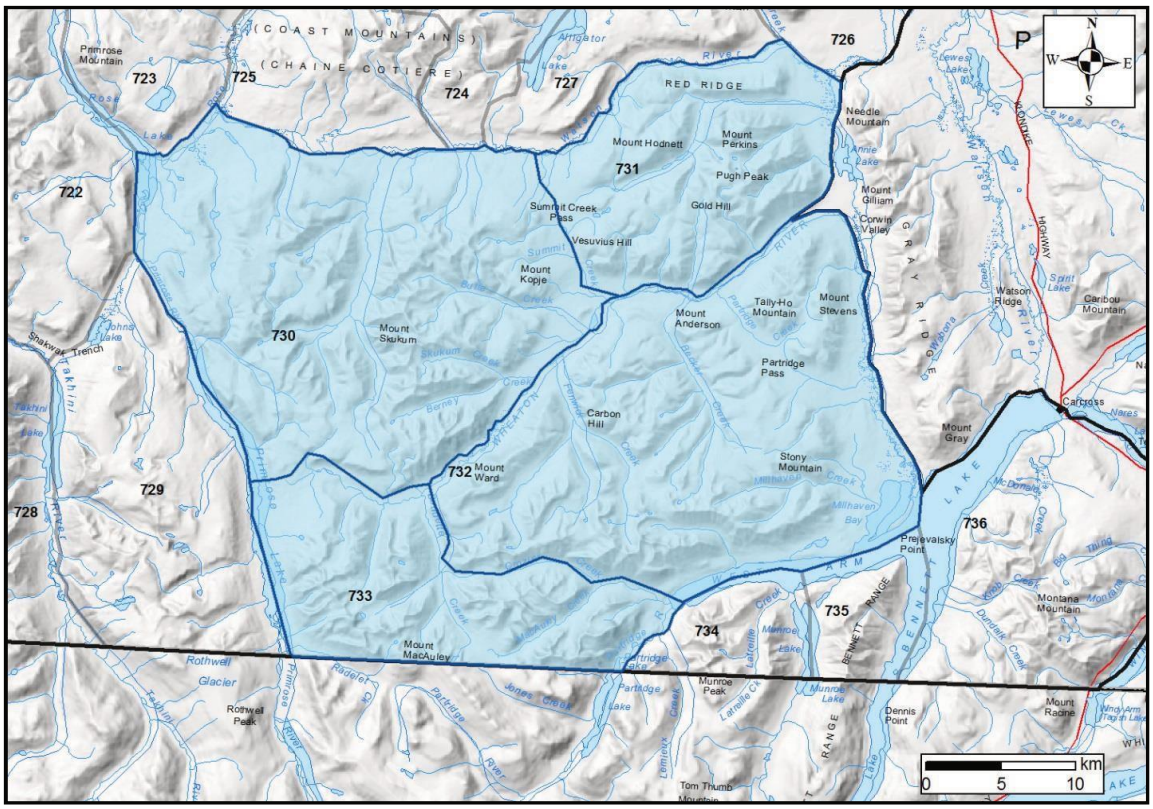

Figure 27. Location of the Skukum management unit.

Skukum (Game Management Subzones 7-30 to 7-33)

The Skukum management unit (Figure 27, Table 28), made up of GMSs 7-30 to 7-33, is dominated by Mount Skukum in the northwest, Gold Hill, Vesuvius Hill and Pugh Peak in the northeast, andCarbon Hill and Mount Ward in the southeast. Geographic closure for this unit is provided by the Primrose River and Primrose Lake, the Watson River, and the east arm of Bennett Lake. Most of GMS 7-31, the northeast corner of 7-30, and the east half of 7-33 are CTFN category A settlement land (Figure 4). This unit is one of the most heavily disturbed areas in GMZ 7 (Figure 7), primarily due to the previously operating gold mine on Mount Skukum. There are numerous quartz mineral claimblocks throughout the unit. It is accessed via the Annie Lake Road and there are numerous roads and trails crossing the unit, particularly in GMS 7-30.

GMS 7-30 is one of the most frequently monitored subzones (Table 29) in GMZ 7 largely due to the mining activities occurring there. Generally, sheep numbers (non-lamb) in GMS 7-30 have fluctuated around 250 animals. GMS 7-33 corresponds to the northern portion of BC's Primrose population, although sheep numbers in the corresponding area south of the Yukon-BC border are low (Jex 2015). Nevertheless, this unit may be transboundary in nature with the bulk of sheep occurring in Yukon. This could be the cause of the higher than expected ram:nursery sheep ratio (70:100) observed in the unit (Table 28), or nursery sheep were missed during the survey.

There is currently no non-resident harvest in the Skukum unit, with licensed resident harvest managed under a PHA since 1979 except for GMS 7-33, which is currently open but was under a PHA from 1979 to 1983 (Figure 3). Currently 15 permits are issued annually in GMS 7-30, 6 permits issued in 7-31, and 7 permits issued in 7-32. The current average annual licensed harvest rate is 1.8% (Table 30). Harvest has remained relatively consistent over time in the Skukum unit. However, there has been a slight increase in harvest over the past several years, primarily occurring in GMSs 7-30 and 7-32 (Figure 28).

Table 28. 2015/16 survey results for the Skukum management unit.

	Non-lamb count	Lamb:nursery sheep ratio	Ram:nursery sheep ratio
GMS 7-30	243	38:100	98:100
GMS 7-31	143	36:100	34:100
GMS 7-32	69	47:100	92:100
GMS 7-33	9	63:100	13:100
Combined	464	39:100	70:100

Table 29. Historical survey results (non-lamb counts and ram:nursery sheep ratios) for the Skukum management unit.

	Non-lamb count					Ram:nursery sheep ratio				
	GMS 7-30	**GMS 7-31**	**GMS 7-32**	**GMS 7-33**	**Comb.**	**GMS 7-30**	**GMS 7-31**	**GMS 7-32**	**GMS 7-33**	**Comb.**
2015/16	243	143	69	9	464	98:100	34:100	92:100	13:100	70:100
2009	204	60	116	36	416	69:100	51:100	29:100	21:100	48:100
1997	255	-	-	-	-	72:100	-	-	-	-
1994	317	-	-	-	-	82:100	-	-	-	-
1993	305	-	-	-	-	47:100	-	-	-	-
1991	470	-	-	-	-	32:100	-	-	-	-
1989	-	112	67	-	-	-	51:100	60:100	-	-
1987	251	-	-	-	-	54:100	-	-	-	-
1985	227	-	-	-	-	39:100	-	-	-	-
1984	251	-	-	-	-	63:100	-	-	-	-
1983	240	-	-	-	-	63:100	-	-	-	-
1982	325	-	67	2	-	51:100	-	63:100	N/A	-
1981	-	135	-	-	-	-	25:100	-	-	-
1973	101	-	-	-	-	34:100	-	-	-	-

Table 30. Harvested sheep (licensed) in the Skukum management unit (2011 to 2015).

	2015	2014	2013	2012	2011
GMS 7-30	9	3	6	4	4
GMS 7-31	0	2	0	1	0
GMS 7-32	4	2	3	2	0
GMS 7-33	0	0	2	0	0
Combined	13	7	11	7	4

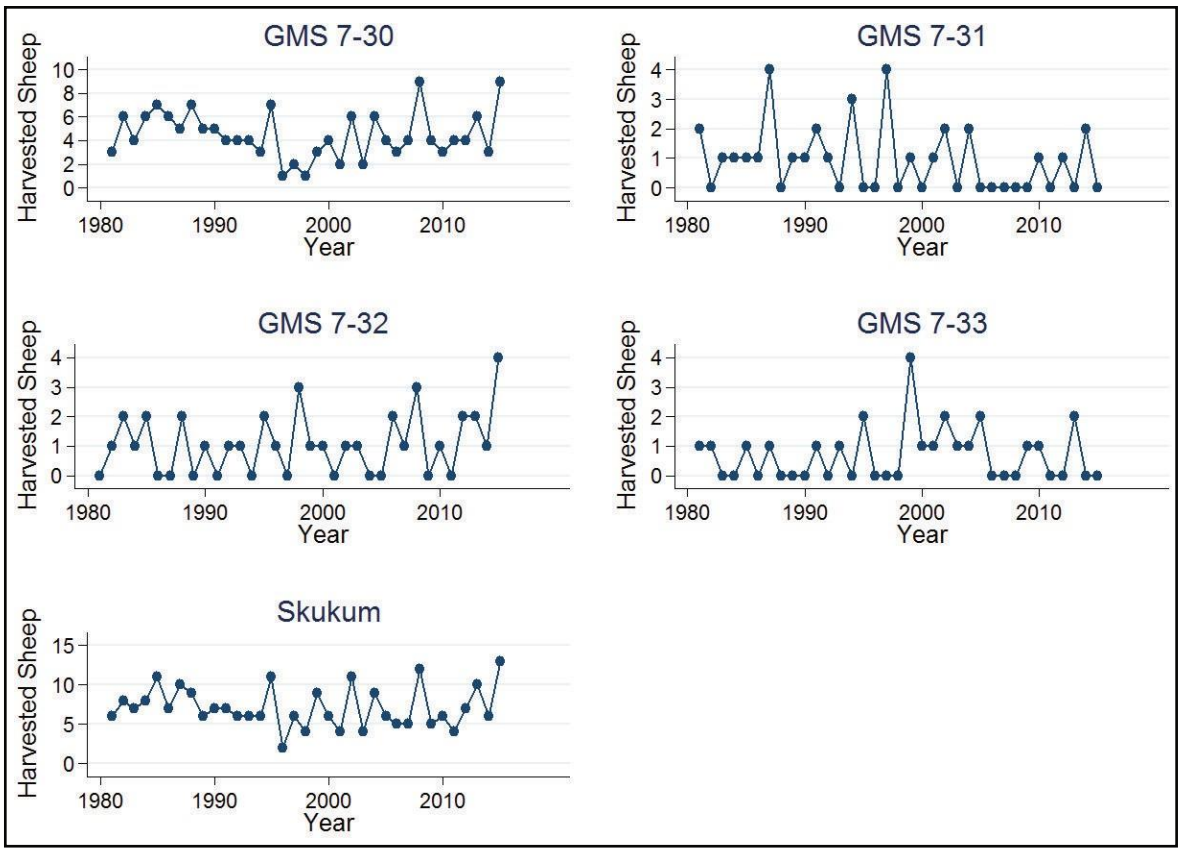

Figure 28. Long-term (1981 to 2015) licensed sheep harvest in the Skukum management unit. Harvest is reported by Game Management Subzone and summed across the entire Skukum management unit.

Discussion

Population status

In a broad sense sheep numbers in GMZ 7 have remained stable in the west and possibly have increased in the east. Non-lamb numbers in the western portion of GMZ 7 are remarkably similar to numbers observed during the last comprehensive surveys in 2000 and 1973 (640 in 2000 and 597 in 1973 compared to 655 presently). In the east, the most recent comprehensive survey in 2009 yielded a count of 1,667 non-lambs and in 1973/1980, 1,448 non- lamb sheep were observed (Hoefs and Barichello 1985) while the present survey yielded 1,846 non-lambs; an increase of 11% since 2009. Hoefs and Barichello (1985) reported a total number of non-lamb sheep observed across GMZ 7 in the 1970s at 2,045; roughly 500 less than our current estimate (Table 1).

The sheep counts presented here are interpreted as minimum counts (Caughley 1974). Hoefs and Barichello (1985) suggested a sightability rate of 90% in southwest Yukon could reliably be assumed based on survey work on unadjusted for missed animals and thus should be Sheep Mountain near Kluane Lake. Across the entire Territory, with differing terrain and habitat conditions, they recommended a sightability rate of 80 to 90%. This is similar to sightability trials conducted on Gray Ridge and Caribou Mountain which indicated sightability rates of ~85 to 95% (Government of Yukon, unpublished data). Thus,while we did not observe all sheep in GMZ 7 during this work, we likely observed a very high proportion of them and are confident in the results. Adjusting our observed numbers by a 90% detection rate would add an additional

312sheep (250 non-lambs) to the overall GMZ 7 estimate.

Among all identified management units, all have demonstrated to be relatively stable with the exception of Rose Lake (Table 18). Up to the 1990s there were roughly twice as many sheep in Rose Lake compared to both the current situation and that observed in 2009. The cause of this decline is unknown but Rose Lake stands out as an outlier in terms of long-term population status of management units in GMZ 7.

Harvest

Since the resumption of non-resident harvest in OA 17 in 2013, harvest levels in GMZ 7 have increased. Licensed harvest in 2015 was the second highest since 1980, with the highest level occurring in 1997 (Figure 9). Since 2011, there has been a sharply increasing trend in harvest in GMZ 7 east, with a more gradual increasing trend in GMZ 7 west. Current (2015) harvest in GMZ 7 west is consistent with its long-term harvest level whereas the current harvest in GMZ 7 east and overall is greater than their long-term averages. Historically there have been peaks and lows (e.g., 2010) in harvest, likely due to the availability of full-curl rams (Hik and Carey 2000). Whether or not the current harvest pattern is a continuation of this pattern or is reflective of a more consistent increasing trend remains to be seen. The recent increasing trend is occurring even with additional GMSs placed on PHA in 2012.

While the number of sheep harvested in GMZ 7 west has increased in the past several years, it remains within the typical long-term range (Figure 9). That is, there has not been a dramatic increase in the number of sheep harvested in GMZ 7 west following additional restrictions on licensed harvest in GMZ 7 east. Additionally, interest in sheep hunting appears to be increasing in Yukon as evident from the number of sheep seals purchased annually (Figure 29). While some hunters may have shifted their hunting areas farther west in recent years due to PHAs in GMZ 7 east (Figure 3), there are also increasing numbers of resident hunters purchasing sheep seals. Of note is that the Government of Yukon does not track where hunters plan to harvest and thus harvest pressure (i.e., number of hunters) could be increasing in GMZ 7 west without a concomitant increase in the number of harvested animals.

Current harvest management guidelines for thinhorn sheep recommend a harvest rate, based on the number of animals harvested per the number of non-lambs in a population, of no more than 4% for surveyed populations. If harvest rates approach 4 % (i.e., 3%-4%), additional information may be required to assess if harvest pressure is expected to increase over time (only full curl rams can be legally harvested; Environment Yukon 2018). This guideline is in place to ensure the harvest of rams does not adversely impact the age structure of sheep populations and was developed to account for not all individuals in a population being observed during surveys. Among identified management units in GMZ 7, only Klukshu and Rose Lake have harvest rates at or exceeding 4%, while Arkell is in the 3 to 4% range (Figure 30).

Klukshu is currently open to licensed harvest (Figure 3) and while the licensed harvest rate is high (4.2%), the absolute numbers of animals harvested is relatively small given the small size ofthe population and demonstrates significant annual variability (Tables 5 thru 7). The small population size means a single harvested animal can strongly influence the harvest rate.

Additionally, two of the rams harvested since 2012 were 10 years old, indicating older rams remain in the population.

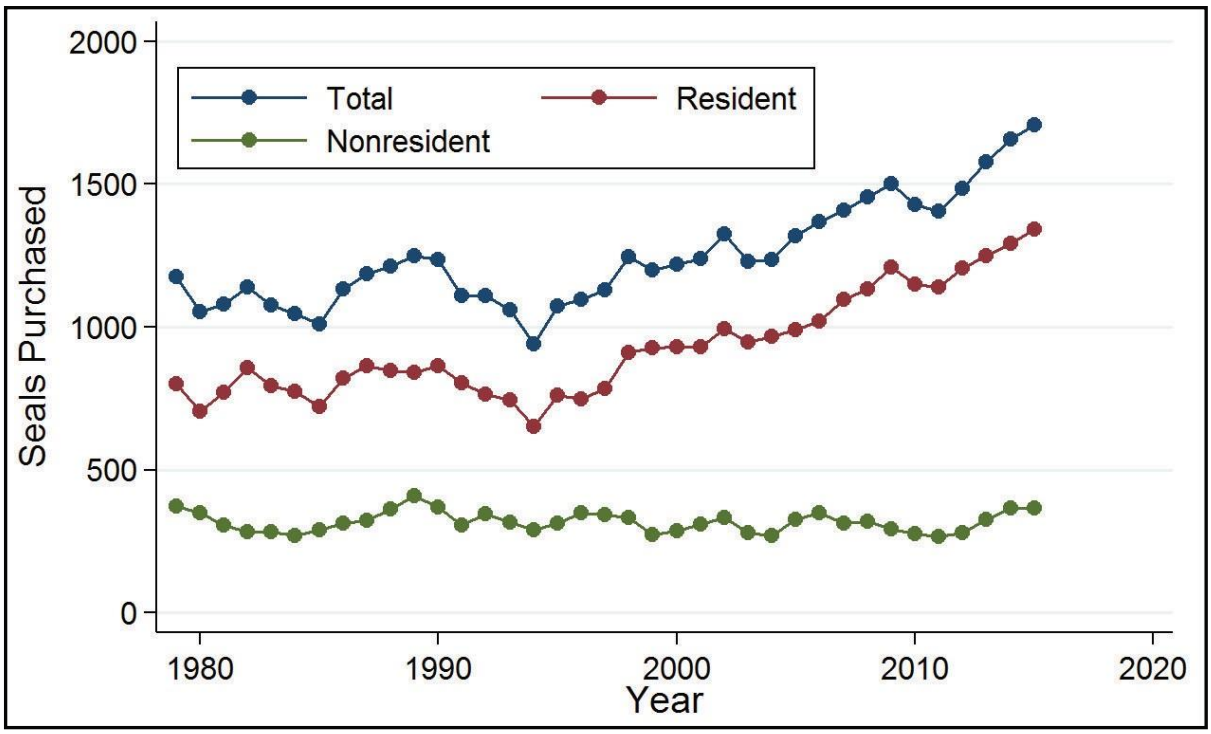

Figure 29. Annual Yukon sheep seals purchased (1979 – 2015).

The Rose Lake unit, currently under a PHA (Figure 3) with 7 permits issued annually, has a current licensed harvest rate of 4%. With the reestablishment of non-resident harvest in the Rose Lake unit, overall licensed harvest increased rapidly (Table 19, Figure 22). A non-resident quota is issued under the 1993 Commissioner's Agreement which dictates [Part 1. (b)] that non- resident harvest may only occur in GMS 7-23 after 31 August each year and:

- Where, in the previous year, 5 sheep are taken by resident PHA permit holders, the outfitter is assigned a maximum of 2 permits;
- Where, in the previous year, 6 sheep are taken by resident PHA permit holders, the outfitter is assigned a maximum of 1 permit;
- Where, in the previous year, 7 sheep are taken by resident PHA permit holders, the outfitter is assigned no permits.

This Agreement in essence forces the maximum number of sheep to be taken over a 2- year period to be 16 sheep if, for example, residents and non-residents take 7 and 2 sheep inyear 1, respectively, and in year 2 residents take 7sheep. Given the current non-lamb sheep numbers in Rose Lake, this would lead to an average annual harvest rate of 8%, double the recommended guideline. If we assume that over a longer period the maximum average number of sheep harvested is 7 per year (i.e., only by residents) this leads to a harvest rate of 7%. When the Commissioner's Agreement was developed, there was estimated to be roughly twice the number of sheep in the Rose Lake unit relative to today (Table 18).

The Boundary management unit currently has an average annual licensed harvest rate of 2.7%. Given the transboundary nature of that population and harvest in BC, working with BC would help obtain an estimate of the total population size and overall harvest rates. A similar collaborative approach would be useful for the Skukum unit.

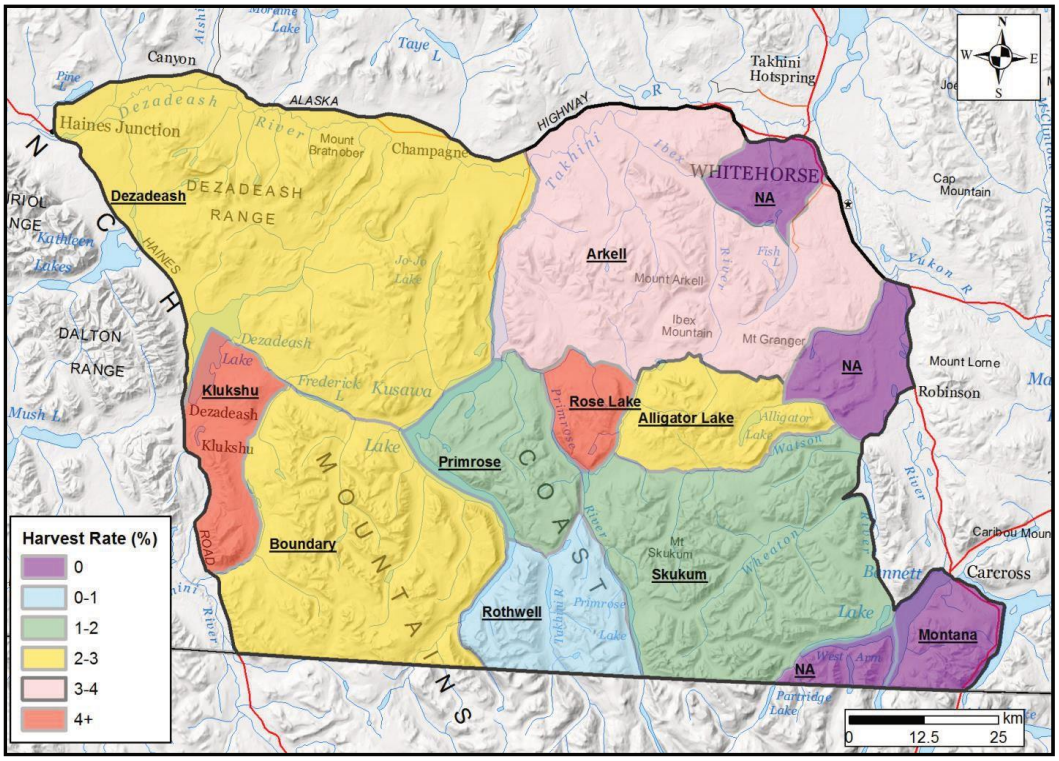

Figure 30. Current annual licensed harvest rates for management units in GMZ 7.

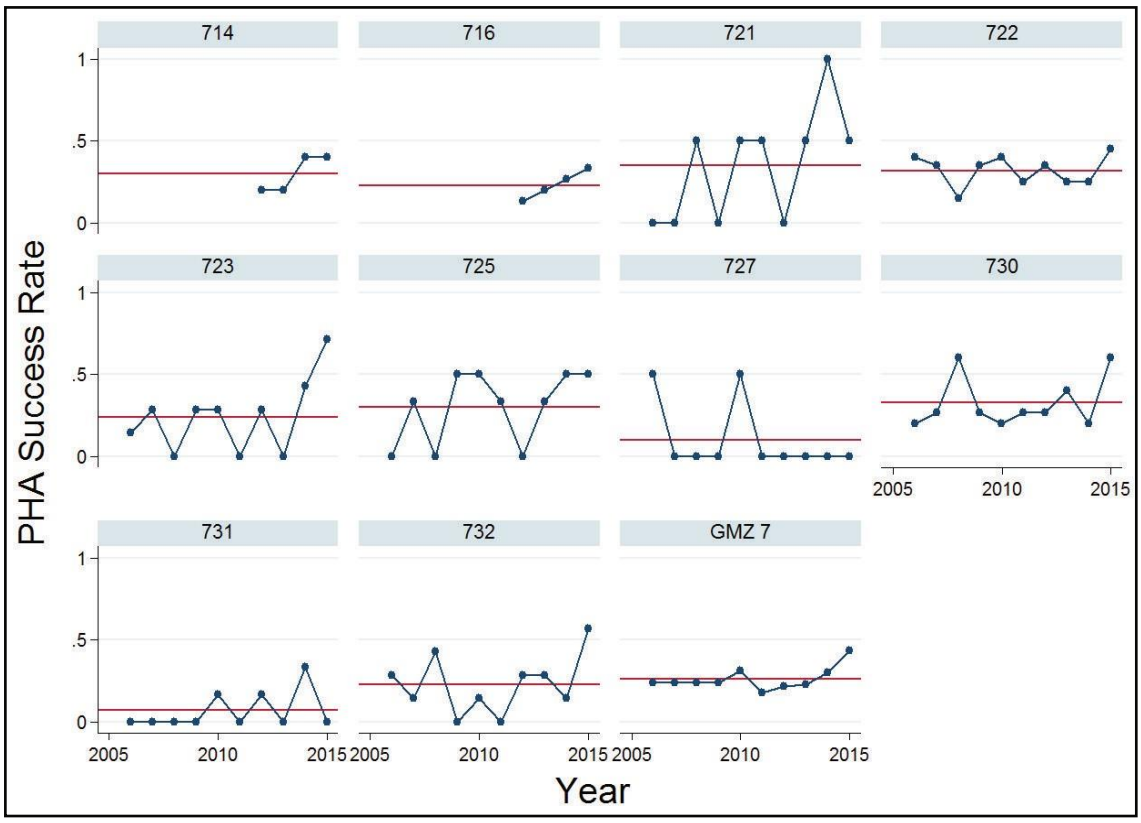

Figure 31. Success rates for PHAs in GMZ 7 (2006 to 2015). Success rates are provided for each GMS andsummarized across all of GMZ 7. Red horizontal lines indicate average success rates.

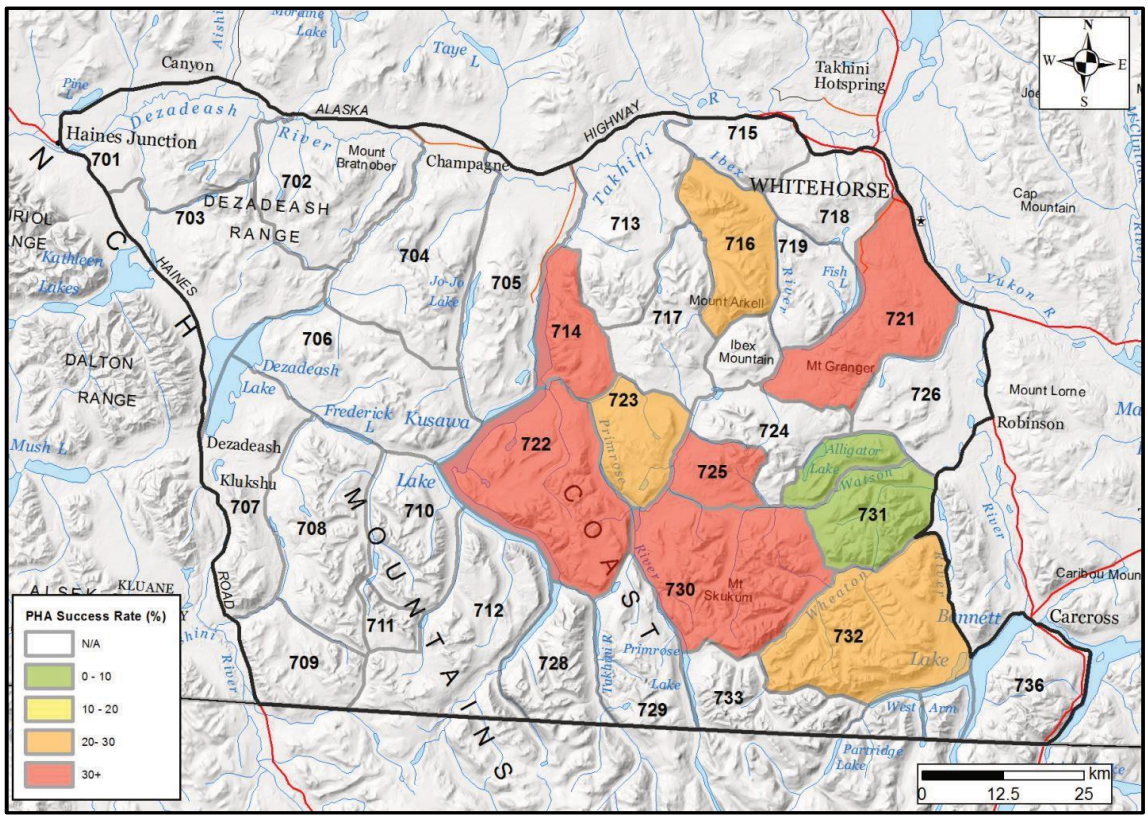

Figure 32. Average (2006 to 2015) permit success rates for those GMSs in GMZ 7 currently under a PHA.

The Arkell unit currently has a licensed harvest rate of 3.3% and the current harvest trend is increasing (Figure 18) even after additional limitations were implemented in 2012. Harvest management of the Arkell unit is complicated by the fact that some GMSs within the unit are undera PHA while others are open (Figure 3). A single comprehensive management approach to harvest in the Arkell unit would help ensure that harvest remains within sustainable limits and that higher harvest pressure is not localized within the open zones.

Ten GMSs in GMZ 7 are currently under a PHA for licensed resident harvest (Figure 3). From 2012 to 2015, 97 permits were issued annually among these subzones, and from 2006 to 2011, 67 permits were issued across eight subzones. From 2006 to 2015, the average success rate for these permits has been 26%, with annual success rates varying from 18% to 43% (Figure 31) and GMS-specific average success rates varying from 7% in 7-31 to 35% in 7-21 (Figure 32). The overall success rate (i.e., number of animals harvested per the number of permits) is generally consistent with the ~30% rate reported by Barichello and Hoefs (1984) for this area in the early 1980s when the PHA system was first implemented. The highest success rate (43%) within this 10-year period occurred in 2015. This success rate is based on the number of permits allocated to each GMS and not necessarily based on the number of hunters actually hunting (i.e., the number of permits does not equal effort). These success rates may be considered as part of any harvest management actions. subset of GMSs in GMZ 7, we would have missed relevant demographic patterns (e.g., ram:nursery sheep ratios). These newly identified management units should be considered dynamic and subject to change pending new biological information (e.g., sheep movement data).

Overall, sheep numbers in GMZ 7 appear to be stable over the past 15 years with non-lamb counts from this 2015 and 2016 survey generally consistent with the most recent comprehensive surveys in 2000 and 2009. From a longer term perspective, Rose Lake stands out as one area where sheep numbers appear to have declined by over half since the mid-1990s (Table 16). The cause of this decline is unknown but appears to be localized as this pattern generally wasn't observed elsewhere. Additionally, sheep numbers in adjacent GMSs (i.e., 7-14, 7-22, 7-25, 7-30) did not experience large changes in numbers (i.e., dueto, as an example, movement of large numbers of sheep in and out of 7-23).

Regarding harvest, most licensed harvest in GMZ 7 is within the recommended rate of 4% of the non-lamb population (Figure 30). There are two units where licensed harvest is at or exceeding this rate (Klukshu, Rose Lake). Harvest management in the Arkell and Alligator Lake units is complicated by the differing regulatory structure (i.e., open vs. PHA GMSs) within them. While the overall sustainable harvest level for a given management unit should be considered using sheep numbers from all GMSs within a unit, localized sheep numbers within a given unit vary and the PHA system allows for licensed harvest to be distributed across a unit such that one GMS does not receive a greater proportion of the harvest than its localized sheep numbers would reflect. That is, while an entire management unit should be under the same regulatory regime, harvest within that unit should be distributed across it based on allocated permits per GMS. This was one of the goals of the PHA system when it was first implemented (Barichello and Hoefs 1984).

Summary

Barichello et al. (1989a) estimated a total of 22,000 thinhorn sheep in Yukon. Assuming this number from 1989 is consistent with the present day, GMZ 7's sheep population represents roughly 11% of the total Yukon population. The management units identified here provide a new framework by which management and monitoring of sheep in GMZ 7 can proceed. This approach moves away from a GMS-specific one, in which sheep in a single subzone are considered a "population". Results from this regional survey demonstrate that in many areas across GMZ 7 this is not the case and that populations should be considered to occur across wider areas. Results from this survey highlight the utility of broad- scale surveys of wide geographic scope. If, for example, we would have focused on only a harvest within that unit can be distributed across it based on allocated permits per GMS. This was one of the goals of the PHA system when it was first implemented (Barichello and Hoefs 1984).

A further consideration in interpreting unit specific harvest rates is that those presented heredo not represent First Nation subsistence harvest.The level of First Nation harvest across GMZ 7 is unknown, and all harvest rates reported here should be considered to be biased low. The degree of this bias is unknown and may vary based on the level of accessibility of different units. Government of Yukon's recommended maximum harvest rate of 4% is for all harvest and human-caused mortality, not only licensed harvest. Thus, when determining if limitations are required or the number of permits requires adjustment, estimates of First Nation harvest in specific units are required to ensure overall harvest is within sustainable limits.

Licensed harvest rates across most of GMZ 7 are within sustainable limits (Figure 30), though recent patterns in both the number of residents purchasing sheep seals (Figure 29) and the numbers of animals being harvested across GMZ7 (Figure 9) could result in harvest rates increasing in some units.

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