CARIBOU USE OF THE GREATER KUPARUK AREA, NORTHERN ALASKA, 2018–2019

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Greater Kuparuk Area
Anchorage, Alaska

Prepared by
ABR, Inc.—Environmental Research & Services
Fairbanks, Alaska

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FINAL REPORT

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EXECUTIVE SUMMARY

- This study investigated the distribution, abundance, and calf production of Central Arctic Herd (CAH) caribou in 2018–2019 between the Colville and Kuparuk rivers in northern Alaska, including caribou distribution and movements in the vicinity of the Alpine pipelines between the Colville River and Kuparuk CPF-2.
- Telemetry data from 1 November 2017 to 31 October 2019 were used to examine movements by individual collared caribou in the vicinity of the Kuparuk oilfields and Alpine pipelines.
- The spring of 2018 was colder than average but the timing of snowmelt was close to average with substantial snowmelt occurring during the first week of June. Temperatures were below average for most of June, above average in mid- and late July, generally below average in August, and near average in September.
- The spring of 2019 was warmer and snow melted earlier than average with most snow melting prior to the early June survey. July temperatures were warmer than average and mosquito and oestrid fly harassment was predicted to be high during that month. August temperatures were close to average and early September temperatures were far above average.
- Eight different collared CAH caribou crossed the Alpine pipelines 30 times between December 2017 and November 2018. Ten different collared CAH caribou crossed the Alpine pipelines 57 times between December 2018 and November 2019.

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ACKNOWLEDGMENTS

This study was funded by ConocoPhillips Alaska, Inc. (CPAI) and the Greater Kuparuk Area Unit owners, and was administered by Robyn McGhee, Environmental Studies Coordinator for CPAI, for whose support we are grateful. Beth Lenart and Lincoln Parrett of the Alaska Department of Fish and Game, Division of Wildlife Conservation, generously shared unpublished information. Support during data analysis and report production was provided by ABR employees Pam Odom, Chris Swingley, Matt Macander, and Dorte Dissing. The report was improved through reviews by Adrian Gall of ABR and Robyn McGhee of CPAI.

INTRODUCTION

Four herds of barren-ground caribou (*Rangifer tarandus granti*) inhabit Arctic Alaska north of the Brooks Range. The herds differ in their use of calving, insect-relief, and winter ranges (Murphy and Lawhead 2000, Caikoski 2015, Dau 2015, Lenart 2015a, Parrett 2015a). The Central Arctic Herd (CAH) is the primary herd using the oilfield region on the central Arctic Coastal Plain, whereas the ranges of the neighboring Teshekpuk Caribou Herd (TCH) and Porcupine Caribou Herd (PCH) are located west and east of the oilfields, respectively. The Kuparuk and Alpine oilfields are on the periphery of the TCH range. The Western Arctic Herd (WAH) is the westernmost herd in northern Alaska.

The CAH typically calves in two broad areas of the coastal plain between the Colville and Canning rivers, uses coastal areas for insect relief, and winters in the central Brooks Range, primarily in the southern foothills in recent years (Arthur and Del Vecchio 2009; Lenart 2015a, Nicholson et al. 2016). Calving occurs both between the Colville and Kuparuk Rivers in the area of the Kuparuk and Milne Point oilfields and east of the Sagavanirktok River in an area with limited oil development (Murphy and Lawhead 2000, Arthur and Del Vecchio 2009).

The CAH was first identified as a separate herd in the 1970s. From the early 1970s to 2002, the CAH grew at an overall rate of 7% per year (Lenart 2015a). The herd grew rapidly from ~5,000 animals in the mid-1970s to the early 1990s, reaching a count of 23,444 caribou in July 1992 before declining 23% to 18,100 caribou in July 1995. By July 1997, the herd size had increased and was estimated at 18,824 animals. The herd continued increasing, reaching 66,666 caribou in July 2008 (Lenart 2015a), representing a mean annual increase of 13% since 2002. A photocensus in July 2010 produced an estimate of 68,442 caribou, demonstrating that herd growth had slowed (Lenart 2015a). The herd subsequently declined to an estimated 50,753 caribou by July 2013 (Lenart 2015a) and 22,630 caribou by July 2016 (Lenart 2017), but increased to 30,069 caribou by July 2019 (Lenart 2019). The magnitude of the decline from 2013 to 2016 may have been affected by emigration of some CAH animals to the PCH and TCH, with which the CAH often intermixes on winter range.

The TCH typically calves primarily near Teshekpuk Lake, ~130 km (80 mi) west of Kuparuk, and uses coastal habitats and areas around Teshekpuk Lake for relief from insect harassment during summer. The TCH usually winters on the Arctic Coastal Plain (Person et al. 2007). However, in some years, large portions of the herd have wintered in the central Brooks Range or with the Western Arctic Herd (WAH) on and near the Seward Peninsula, and an unusual excursion to northeast Alaska occurred in the winter of 2003–2004 (Carroll 2007, Parrett 2009, Bieniek et al. 2018).

Similar to the CAH, the TCH has also varied in abundance over the past 40 years. The TCH increased substantially in size from the mid-1970s to an estimated peak population size of 68,902 animals in July 2008 (Parrett 2015a). The herd subsequently declined at least 19% to an estimated 55,704 animals by July 2011 and then dropped at least 30% further to an estimated 39,172 animals by July 2013 (Parrett 2015a). The herd then increased in size to 41,542 animals in July 2015 and 56,255 animals in July 2017 (Parrett 2015b, Klimstra 2018). A new, higher-resolution camera was used for the photo censuses in 2017, and the improvement in photograph quality may have been partially responsible for higher caribou counts for the TCH and CAH in that year (Lenart 2018).

The PCH calves in the northeastern corner of Alaska in the Arctic National Wildlife Refuge (ANWR) and in the adjacent Yukon in Canada, moves into the Brooks Range during the summer insect season, and winters in the northern Yukon and the eastern Brooks Range in Alaska (Walsh et al. 1992, Caikoski 2015). The PCH decreased steadily from an estimated population of ~178,000 animals in 1989 to ~123,000 in 2001, but subsequently increased to ~169,000 animals by July 2010 and ~197,000 animals by July 2013 (Caikoski 2015), and 218,457 animals by July 2017 (Caikoski 2017).

The WAH is currently the largest herd in Alaska. The WAH peaked at ~490,000 animals in July 2003, and then declined by 52% to 234,757 animals by July 2013 (Dau 2015). The herd continued to decline to 201,000 animals by July 2016, but improving demographic parameters suggested the herd size was beginning to recover at that time (Parrett 2016) and was estimated to be ~259,000 animals in July 2017 (ADFG 2018). The annual range of the WAH does not include the North Slope oilfields. WAH caribou calve in the Utukok uplands north of the western Brooks Range, move into the Brooks Range during the insect season, and most animals in the herd migrate south long distances in the fall to winter in western Alaska (Dau 2015).

The Kuparuk oilfield and surrounding area (known as the Greater Kuparuk Area, or GKA) is located on the outer coastal plain (Figure 1) in the western portion of the summer range of the CAH. Beginning in 1978, shortly before development of the Kuparuk oilfield, considerable interest has focused on the use of the oilfield and surrounding area (particularly the Milne Point Unit) by the CAH during calving. The Kuparuk–Milne Point area is one of two locales (the other being the area between the Sagavanirktok and Canning rivers, east of the Prudhoe Bay oilfield) that consistently host concentrated use during the calving season since the late 1970s (Whitten and Cameron 1985, Lawhead and Cameron 1988). Studies by ADFG reported local avoidance of oilfield facilities and human activities by cows with young calves in the Kuparuk–Milne area during the calving season (Dau and Cameron 1986, Cameron et al. 1992). From 1978 through 1992, ADFG conducted aerial transect surveys of caribou distribution annually during the latter portion of the calving season (usually 10–15 June). After 1992, however, that annual effort was cut back due to budget constraints and ADFG conducted only two more transect surveys, in June 1997 and June 2000. Funded by CPAI and its heritage companies, ABR has conducted similar transect surveys of the calving grounds of the western segment of the CAH every year since 1995 and also conducted calving surveys in the region in 1983, 1984, 1987, and 1993.

The data from the surveys described in this report complement the data from radio-telemetry studies by ADFG and other entities, including CPAI. Since 1992, ADFG survey efforts have focused primarily on tracking radio-collared female caribou, following a known-age sample of 60–80 cows annually (Arthur and Del Vecchio 2009, Lenart 2015a). A small sample of 10-month-old CAH females is outfitted annually with conventional VHF radio collars by ADFG (Lenart 2015a) and some animals are recaptured and recollared 4–6 years later. Satellite (Platform Terminal Transmitter, or PTT) collars have been deployed on small numbers of bulls in recent years (Lenart 2015a). Additional PTT satellite collars and satellite-linked Global Positioning System (GPS) collars have been deployed since 2001 on female CAH caribou by ADFG biologists for several cooperative studies involving the North Slope Borough (NSB) Department of Wildlife Management, the federal Bureau of Land Management (BLM), and CPAI, to study the distribution and movements of the CAH throughout the year (Arthur and Del Vecchio 2009, Lawhead et al. 2015a, Nicholson et al. 2016).

The study reported here was conducted under contract to CPAI to monitor the distribution and abundance of caribou in and near the Kuparuk oilfield in 2018–2019. In addition, beginning in 2016 (Prichard et al. 2017), this study incorporates information covering the Alpine pipelines that previously was addressed in a separate report (Lawhead et al. 2015b and references therein). The State of Alaska's Right-of-Way Lease/Grant Stipulation 2.6.1 states that the pipeline systems carrying liquids between the Alpine Development Project and the Kuparuk Oilfield "…shall be maintained to avoid significant alteration of caribou and other ungulate movement patterns. The Commissioner may require additional measures to mitigate impacts to ungulate movements." This report addresses that stipulation by summarizing data on caribou distribution and movements from radio telemetry data from the period November 2017–October 2019 in the area traversed by the Alpine pipeline corridor, which comprises three adjacent pipelines sharing the same support structure between the Alpine Central Processing Facility (CPF) on the central Colville River delta and Kuparuk CPF-2.

Although the impetus for this study was caribou research, ongoing research in the area for other projects provided an opportunity to record data on the distribution and abundance of other large mammals as well, most notably muskox (*Ovibos moschatus*) and brown bear (hereafter, grizzly bear; *Ursus arctos*).

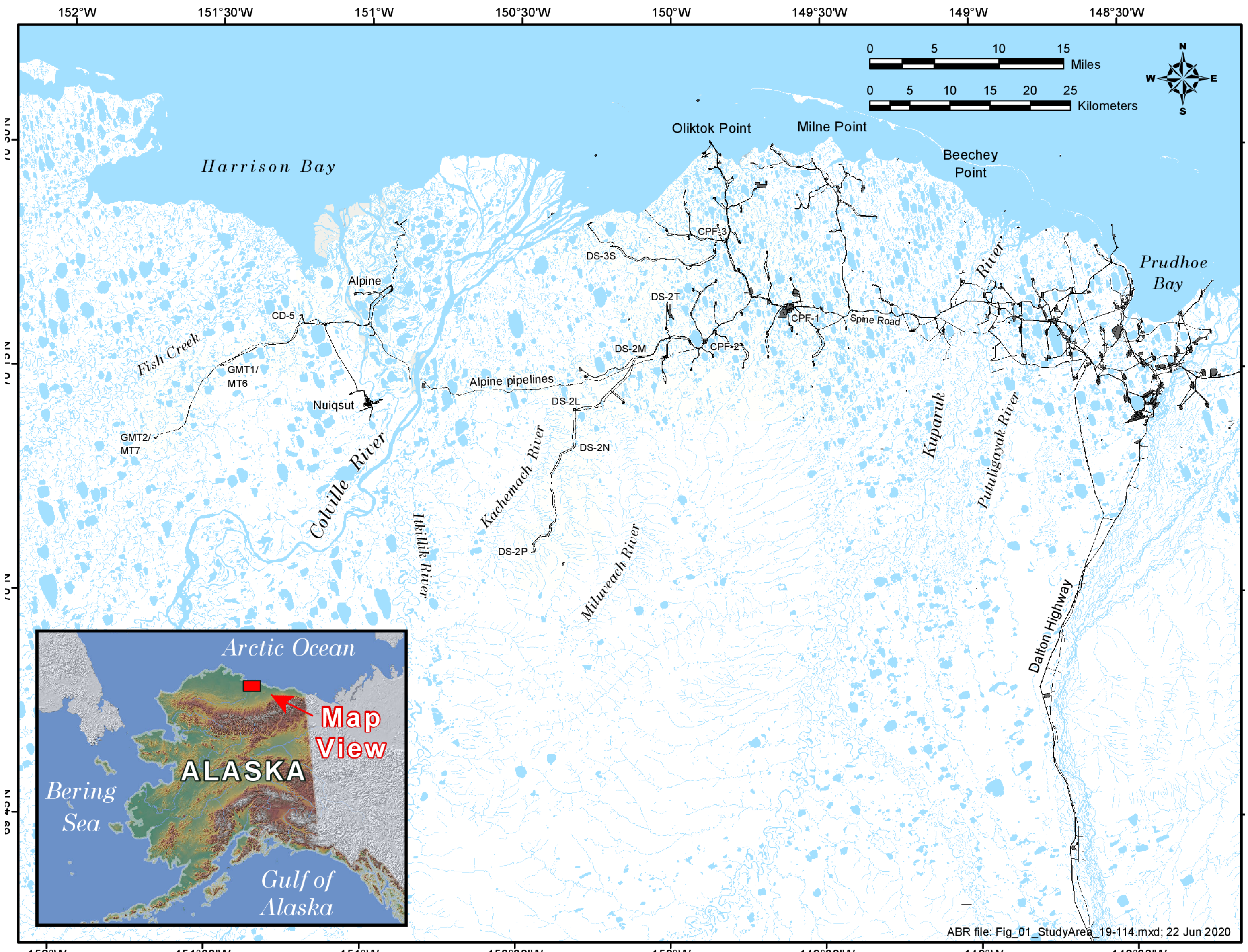

Figure 1. The Greater Kuparuk Area, North Slope, Alaska, 2019.

The 2018–2019 study had 3 objectives:

- Document the distribution and abundance of caribou in the region between the Kuparuk and Colville rivers during different life-history seasons;
- Summarize data on caribou distribution and movements from radio telemetry in the area crossed by the Alpine pipeline corridor; and
- Record the distribution and abundance of other large mammals encountered incidentally during research conducted in the Kuparuk–Colville region.

STUDY AREA

The study area extended east from the Colville River delta to the Kuparuk River and north from 70º N to the Beaufort Sea coast (Figure 1). This area encompassed the entire Kuparuk oilfield, the Alpine pipeline corridor between the Kuparuk oilfield and Colville River delta, the Milne Point oilfield, and the westernmost portion of the Prudhoe Bay oilfield (west of the Kuparuk River). Constructed in the winter of 1998–1999, the Alpine pipeline corridor extends 55 km (34 mi) from the processing facilities at the Alpine CD-1 pad to those at Kuparuk CPF-2.

The landscape in the Kuparuk–Colville region slopes gently downward from upland, moist tussock tundra in the upper reaches of the Sakonowyak, Ugnuravik, Kalubik, Miluveach, and Kachemach river drainages to moist and wet tundra near the sea coast. The study area terrain is characterized by permafrost-related features, such as oriented thaw-lakes, drained-lake basins, beaded streams, and pingos. The physiography, vegetation, and climate of the central Arctic Coastal Plain were described by Walker et al. (1980).

METHODS

WEATHER AND INSECT CONDITIONS

Spring weather influences the location of calving (Carroll et al. 2005; Dau 2015) and the availability of highly nutritious early-emerging forage (Kuropat 1984, Johnstone et al. 2002, Johnson et al. 2018). Summer weather conditions can be used to predict the occurrence of harassment by mosquitoes (*Aedes* spp.) and oestrid flies (warble fly *Hypoderma tarandi* and nose bot fly *Cephenemyia trompe*) (White et al. 1975, Fancy 1983, Dau 1986, Russell et al. 1993, Mörschel 1999). To estimate spring and summer weather conditions in the area during 2019, we used meteorological data from National Weather Service reporting stations at Kuparuk and Nuiqsut. Thawing degree-day sums (TDD; total degrees Celsius above zero) were calculated using average daily temperatures at the Kuparuk airstrip. The estimated probability of mosquito activity was estimated based on hourly temperatures and wind speeds from Nuiqsut, using an equation developed by Russell et al. (1993). The estimated probability of oestrid-fly activity was calculated from average hourly wind speeds and temperatures recorded at Nuiqsut, using equations developed by Mörschel (1999).

TELEMETRY DATA ANALYSIS

Eight seasons were used for analysis of telemetry, based on mean movement rates and observed timing of caribou life-history events (adapted from Russell et al. 1993 and Person et al. 2007): winter (1 December–30 April); spring migration (1–29 May); calving (30 May–15 June); postcalving (16–24 June); mosquito harassment (25 June–15 July); oestrid fly harassment (16 July–7 August, a period that also includes some mosquito harassment); late summer (8 August–15 September); and fall migration, a period that includes the breeding season, or rut (16 September–30 November).

We analyzed telemetry data from 695 collar deployments on 537 caribou (Table 1). Telemetry data used for this analysis were collected between 1990 and October 2019 for the TCH and 2001–October 2019 for the CAH. This included 185 satellite (PTT) collar deployments on 165 TCH animals, 304 GPS collar deployments on 221 TCH animals, 24 satellite collar deployments on 24 CAH animals, and 182 GPS deployments on 127 CAH animals. A total of 79% of TCH deployments and 96% of CAH deployments were on female caribou. Telemetry data were provided through a data sharing agreement with ADFG, Bureau of Land Management, and the North Slope Borough and additional GPS collars were funded by CPAI and deployed by ADFG.

Table 1. Number of TCH and CAH radio-collar deployments and total number of collared animals that provided movement data for the Colville South caribou study.

Herd [a] / Collar Type	Years	Female		Male		Total Deployments
		Deployments	Individuals	Deployments	Individuals	
Teshekpuk Herd						
Satellite collars	1990–2019	97	86	88	79	185
GPS collars	2004–2019	289	207	15	14	304
Central Arctic Herd						
Satellite collars	2001–2004	10	10	2	2	12
Satellite collars	2012–2015	6	6	6	6	12
GPS collars	2003–2019	182	127	0	0	182

[a] Herd affiliation at time of capture.

We used fixed-kernel density estimation (KDE) to quantify the spatial distribution of CAH and TCH caribou by season. Because most collared CAH caribou were females, we only conducted separate analyses by sex for the TCH. Caribou in northern Alaska are sexually segregated during some seasons, especially calving, so our results during these time periods may not represent the distribution of male CAH caribou during some seasons.

To conduct KDE, we calculated the average latitude and longitude of each caribou for every two day period of the year (all years combined). We used the *ks* package for *R* (Duong 2017) and the plug-in method to calculate the bandwidth of the smoothing parameter to create KDE utilization distributions of relative caribou density for each herd for each two day period. We then averaged the resulting utilization distributions together for each combination of herd, sex (TCH only), and season to get the final seasonal kernels. This method allowed us to capture caribou movements during a season without biasing the results towards individual animals with many locations.

During the period from 1 November 2017 through 31 October 2019, telemetry data were available from 25 GPS-collared female CAH caribou, 122 GPS-collared female TCH caribou, 14 GPS-collared male TCH caribou, and 16 PTT satellite-collared TCH caribou (13 males and 3 female). Funding for these collars was provided through the collaborative efforts of ADFG, NSB, BLM, and CPAI, and all collars were deployed by ADFG biologists. In previous years, most CAH caribou were collared in the central Brooks Range during late winter (usually April). Beginning in 2017, CAH animals were collared in late June on the coastal plain, primarily west of the Sagavanirktok River. No collars were deployed on CAH caribou in 2018, but in 2019, 10 GPS collars were deployed on CAH females (3 previously uncollared and 7 previously collared animals). In all years, the TCH collars were deployed by ADFG biologists in that herd's summer range, centered on Teshekpuk Lake >50 km west of the GKA study area. In 2018, 31 GPS collars were deployed on TCH females (20 previously uncollared and 11 previously collared animals), and 1 was deployed on a previously uncollared TCH male. Additionally in 2018, PTT collars were deployed on 2 previously uncollared TCH males and 1 previously collared TCH female. In 2019, GPS collars were deployed on 36 TCH females (19 previously uncollared and 17 previously collared) and 9 TCH males (5 previously uncollared and 4 previously collared). All deployments for both herds and years took place during 19–26 June.

RESULTS AND DISCUSSION

WEATHER AND INSECT CONDITIONS

Spring 2018 was colder than the 35-year average (1983–2017) but the timing of snowmelt at the Kuparuk airport was near average (Figure 2). Spring temperatures and the sum of thawing degree days were primarily below average from May until the first week in July and 2018 average daily temperatures remained below freezing until mid-June (Figure 2, Appendix A). Snow depth at the Kuparuk airstrip was above average in April and May, even after 12 and 13 May when temperatures above freezing resulted in a 15 cm decrease in snow depth (Figure 2, Appendix A). Snow depth remained greater than 15 cm until 31 May, and then melted rapidly. Temperatures and the sum of thawing degree days remained below

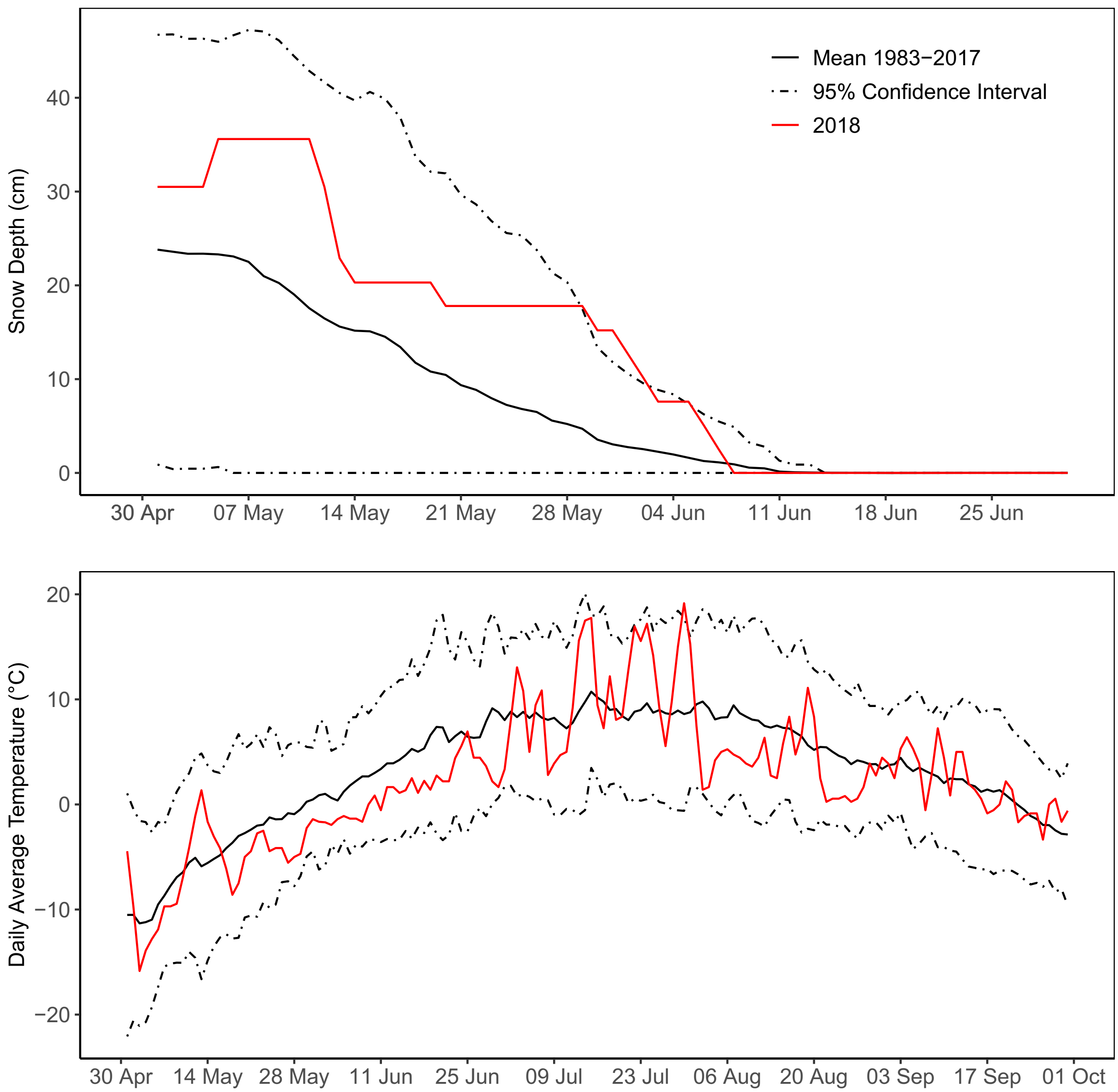

Figure 2. Snow depth and average daily temperature at the Kuparuk airstrip during 1 May–15 June 2018, compared to the mean and 95% confidence interval for 1983–2017.

average during the calving and postcalving seasons in early and mid-June (Figure 2, Appendix B).

During the summer insect season (mid/late June to mid-August), variability in weather conditions typically results in fluctuating insect activity levels and corresponding changes in caribou movements and distribution. Caribou move rapidly toward the coast in response to mosquito harassment and then move inland when mosquito activity abates, in response to cooler temperatures or higher wind speeds (Murphy and Lawhead 2000, Yokel et al. 2009).

The 2018 insect season started out with below average temperatures in late June, fluctuating temperatures in early July and temperatures often near or above the upper 95% confidence interval for most of mid- and late July (Figure 2). July was followed by a generally cool August and near-average temperatures in September. This resulted in 8 days with a high probability of mosquitos and 3 days with a high probability oestrid fly activity throughout the summer (>50% probability; Figures 2, 3). Average estimated mosquito and fly activity started out below average in June, increased to above average by late July, and was below average again for August (Appendix C, D).

Spring 2019 was warmer than average and snow melted earlier than usual at the Kuparuk airport (Figure 4, Appendix A). May temperatures were near or above the average with daily temperatures rising above freezing on 21–25 May. Snow depth at the Kuparuk airstrip remained below or near average until 20 May before completely melting by 23 May when temperatures warmed (Figure 4, Appendix A). Temperatures and the sum of thawing degree days were near average during the calving and postcalving periods in early and mid-June (Figure 3, Appendix A).

The 2019 insect season generally had average temperatures in late June, well above average temperatures in July, and August temperatures near the long-term average (Figure 4, Appendix B). This resulted in 16 days with a high probability of mosquitos and 2 days with a high probability oestrid fly activity (>50% probability; Figure 5), although both days of high oestrid fly probabilities were before expected emergence. Estimated mosquito and fly activity started out near average in June, increased to above average through July, and was near average for August (Appendices C, D). Early September temperatures were well above average.

TELEMETRY DATA ANALYSIS

SEASONAL DISTRIBUTION AND ABUNDANCE

KDE Analysis

CAH caribou winter primarily in the Brooks Range or in the foothills just to the north, with few caribou remaining near the oilfields (Appendix E; Arthur and Del Vecchio 2009, Lenart 2015a, Nicholson et al. 2016). CAH caribou move back onto the Coastal Plain and into the southern GKA during spring migration. The CAH then calve in two separate groups, one east of the Sagavanirktok River and one to the west of the river (Arthur and Del Vecchio 2009, Lenart 2015a, Nicholson et al. 2016). The areas of greatest calving activity for the western segment of the herd—in terms of both caribou distribution and density—are located consistently south or southwest of the Kuparuk oilfield, although the region of highest use by parturient caribou shifts somewhat from year to year (Prichard et al. 2018). Few caribou have used the Kuparuk–Milne concentration area (north of the Spine Road and east of the Oliktok Point Road in the Kuparuk Field survey area) for calving in recent years compared to the observations during ADFG surveys in 1979–1987 (Cameron 1994). CAH caribou that calve in the western area exhibit localized avoidance (within 2–4 km) of active roads and pads during and for 2–3 weeks immediately after calving (Dau and Cameron 1986, Cameron et al. 1992, Lawhead et al. 2004, Johnson et al. 2019, Prichard et al. 2019a).

Caribou distributions during the postcalving season are usually similar to the calving season (Appendix E). The CAH animals typically move through the oilfields to the Beaufort Sea coast during periods of mosquito harassment which generally begins in late June (White et al. 1975, Dau 1986, Prichard et al. 2019a). Once mosquito harassment subsides, caribou then tend to disperse inland during the oestrid fly season and select areas with oestrid fly relief, such as gravel bars and gravel roads (Pollard et al. 1998, Prichard et al. 2019a). They remain inland for the late summer

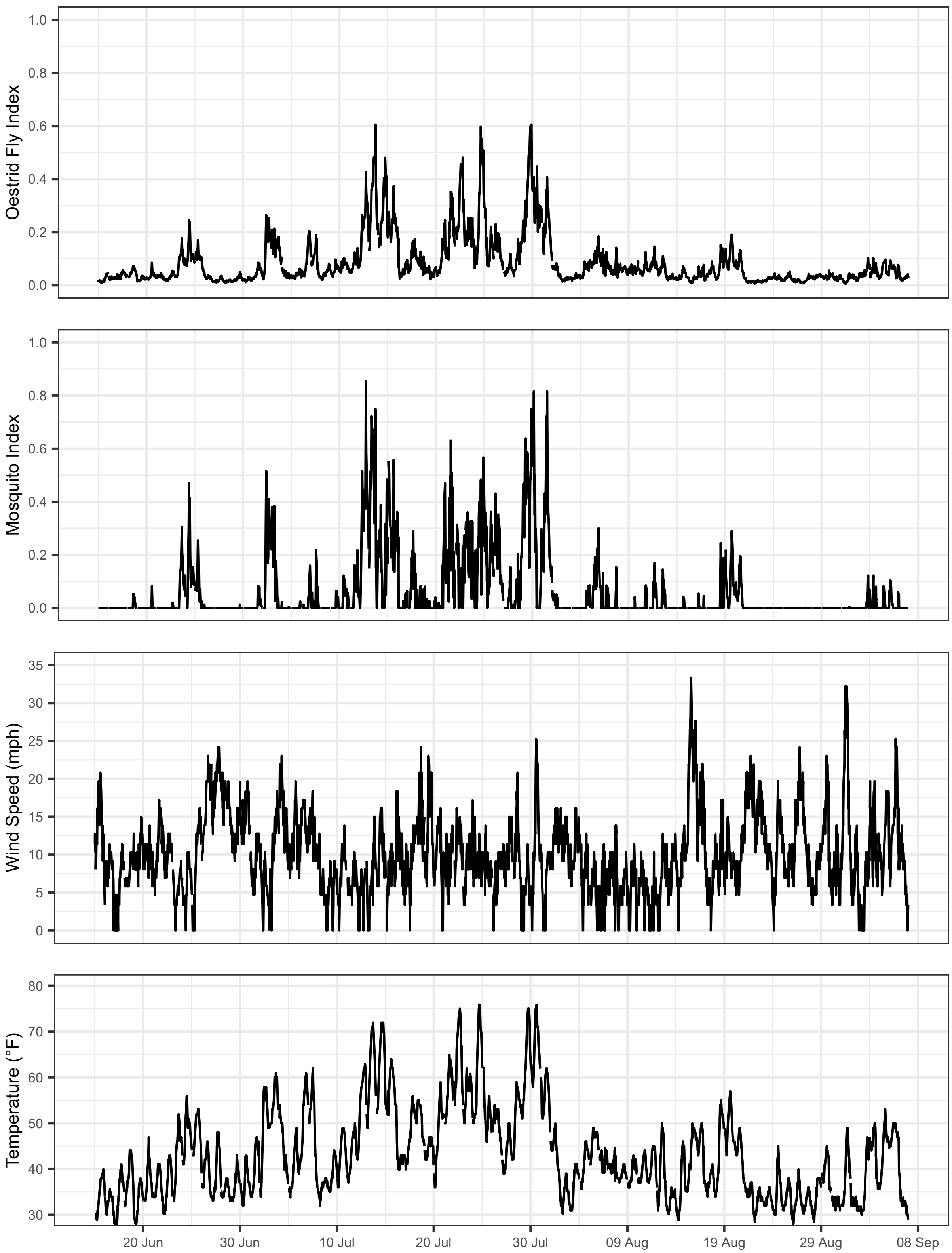

Figure 3. Probability of mosquito and oestrid fly activity (Russell et al. 1993, Mörschel 1999) in summer 2018 based on hourly wind speed and temperature data recorded at the Nuiqsut airstrip.

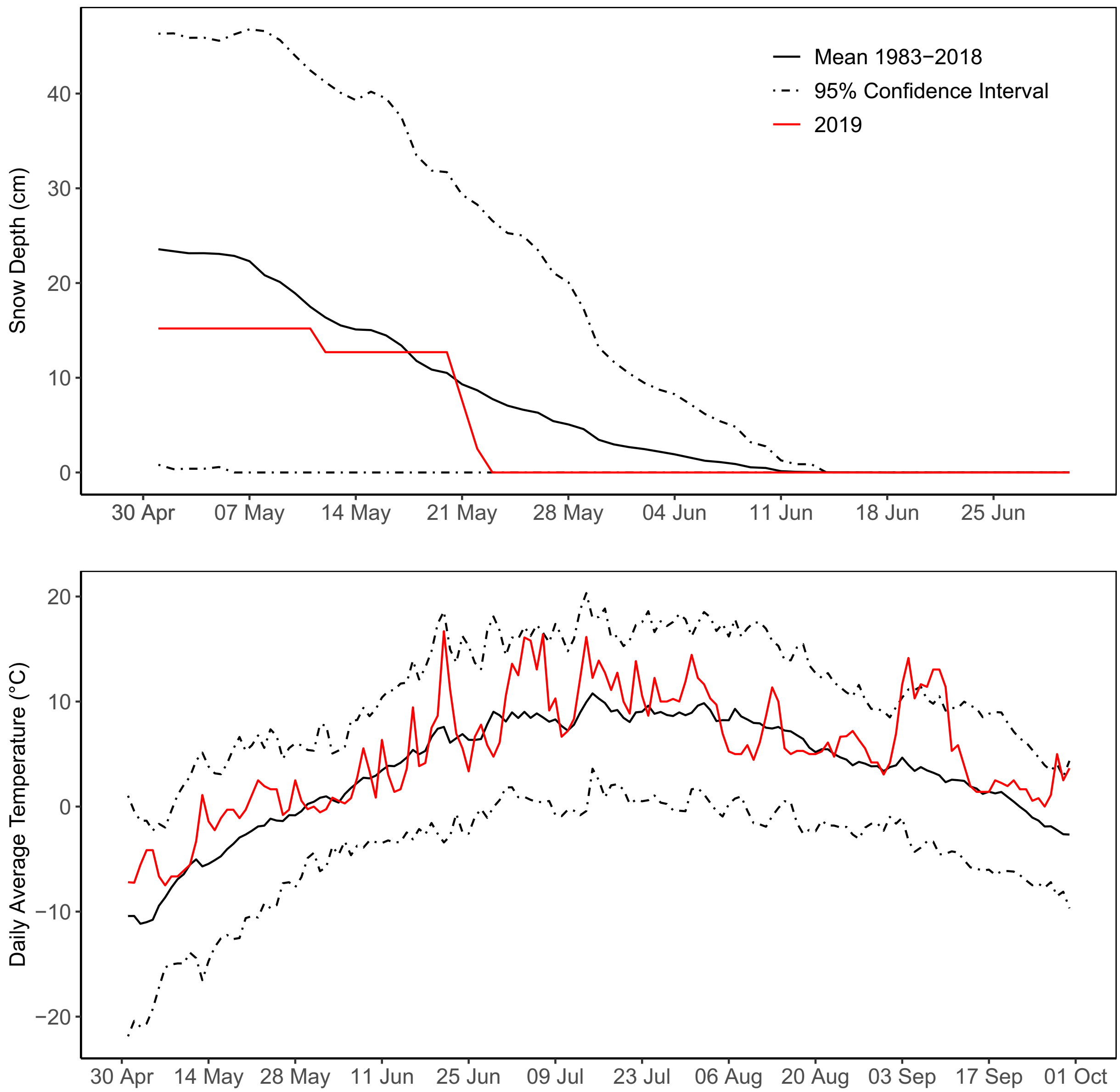

Figure 4. Snow depth and average daily temperature at the Kuparuk airstrip during 1 May–15 June 2019, compared to the mean and 95% confidence interval for 1983–2018.

season and then migrate to their wintering grounds in the fall.

The KDEs for the TCH indicate low to no use of the GKA for both males and females (Appendices E–F). TCH caribou rarely move east of the Colville River, although mixing with the CAH is quite common and can lead to dispersions into the CAH herd (Prichard 2016). The seasons when TCH caribou are most likely to be in the GKA area are spring and fall migration.

CPAI Collared Caribou

We mapped the movements of 17 female CAH caribou with active CPAI-funded GPS collars from December 2018 through November 2019 (Figures 6–8). The detailed movement tracks of 14 different female CAH caribou fitted with CPAI-funded GPS collars and active in 2018 were previously reported (Prichard et al. 2019a). An additional 9 new caribou were collared around the oilfields in June 2019.

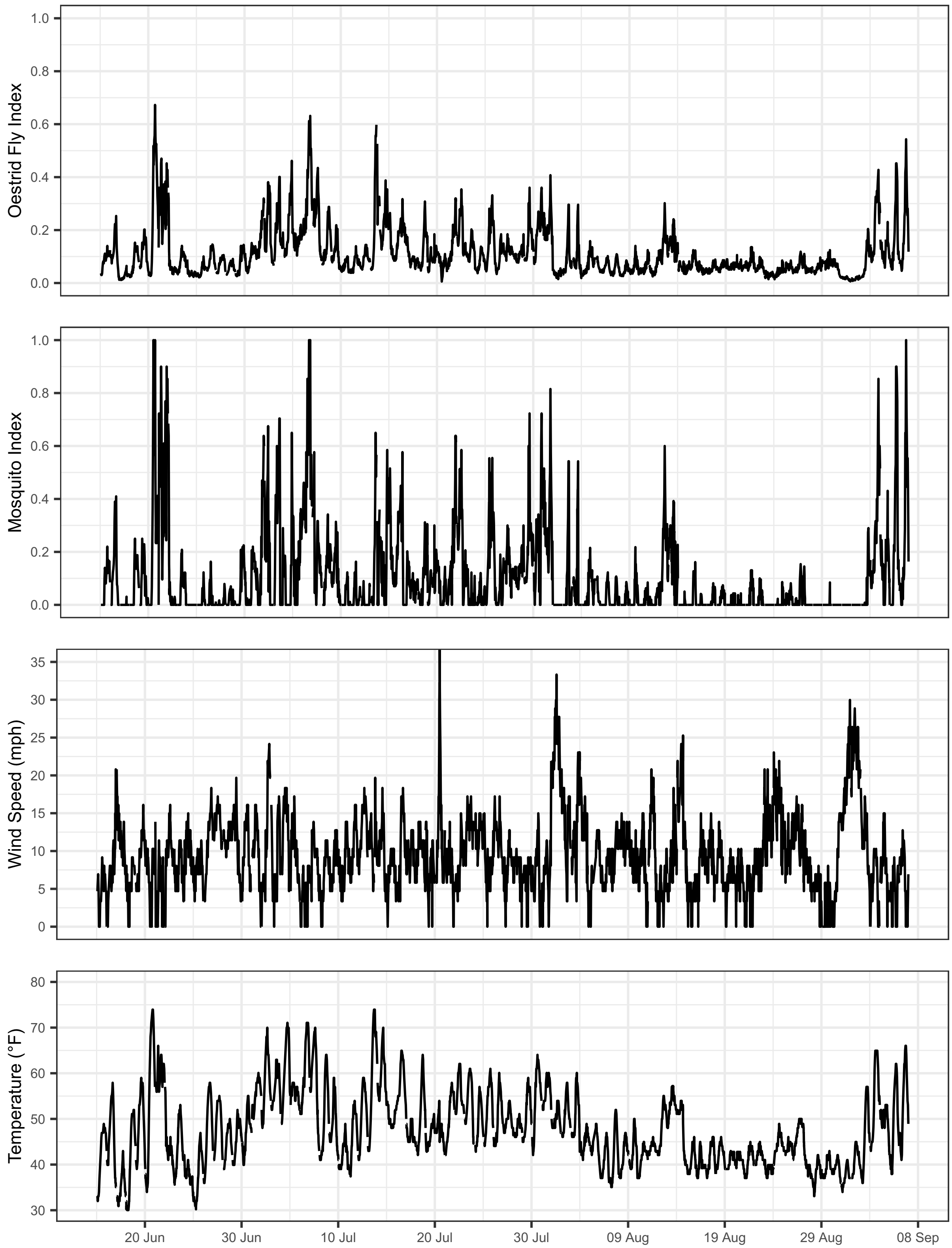

Figure 5. Probability of mosquito and oestrid fly activity (Russell et al. 1993, Mörschel 1999) in summer 2019 based on hourly wind speed and temperature data recorded at the Nuiqsut airstrip.

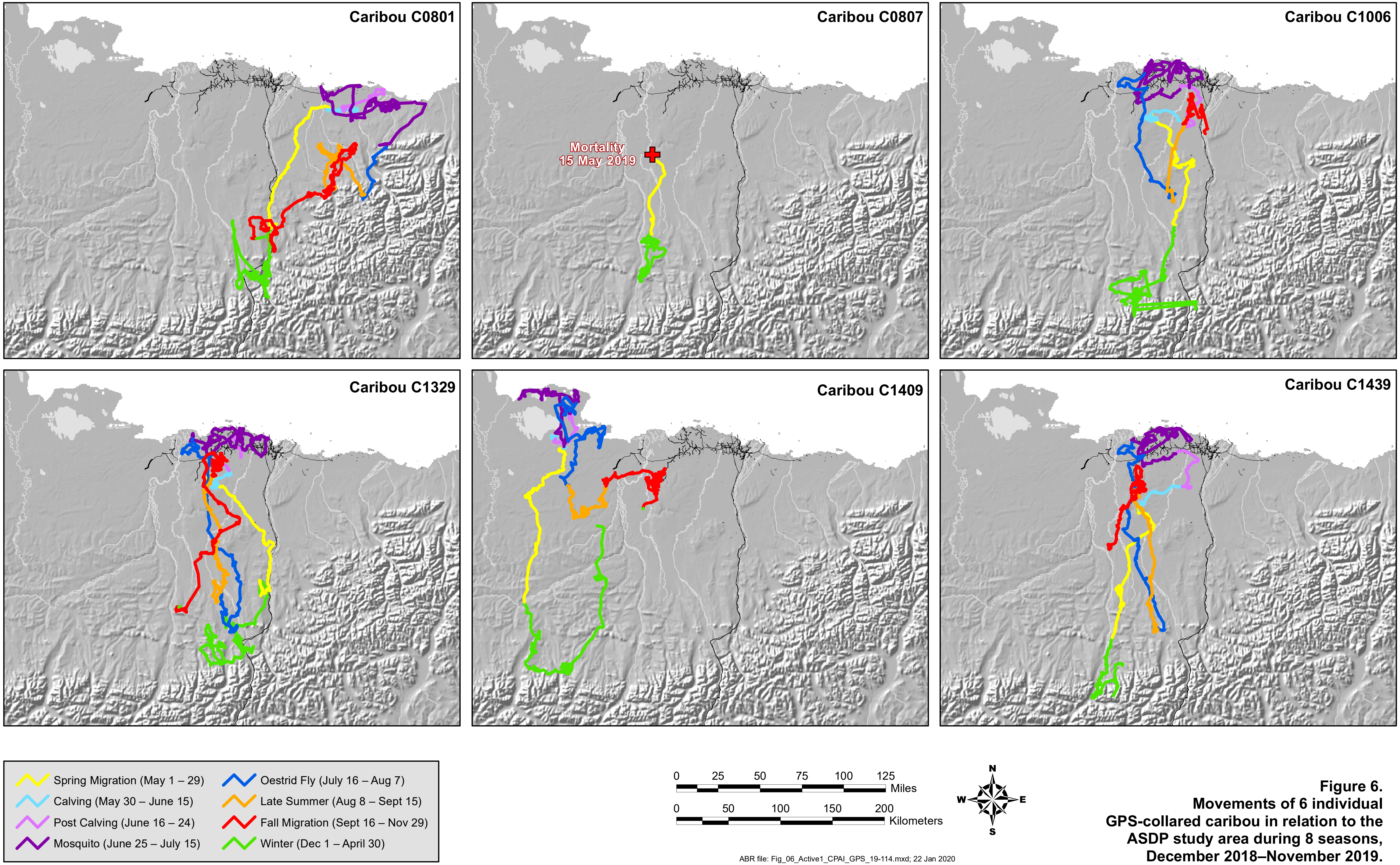

Figure 6.
Movements of 6 individual GPS-collared caribou in relation to the ASDP study area during 8 seasons, December 2018–November 2019.

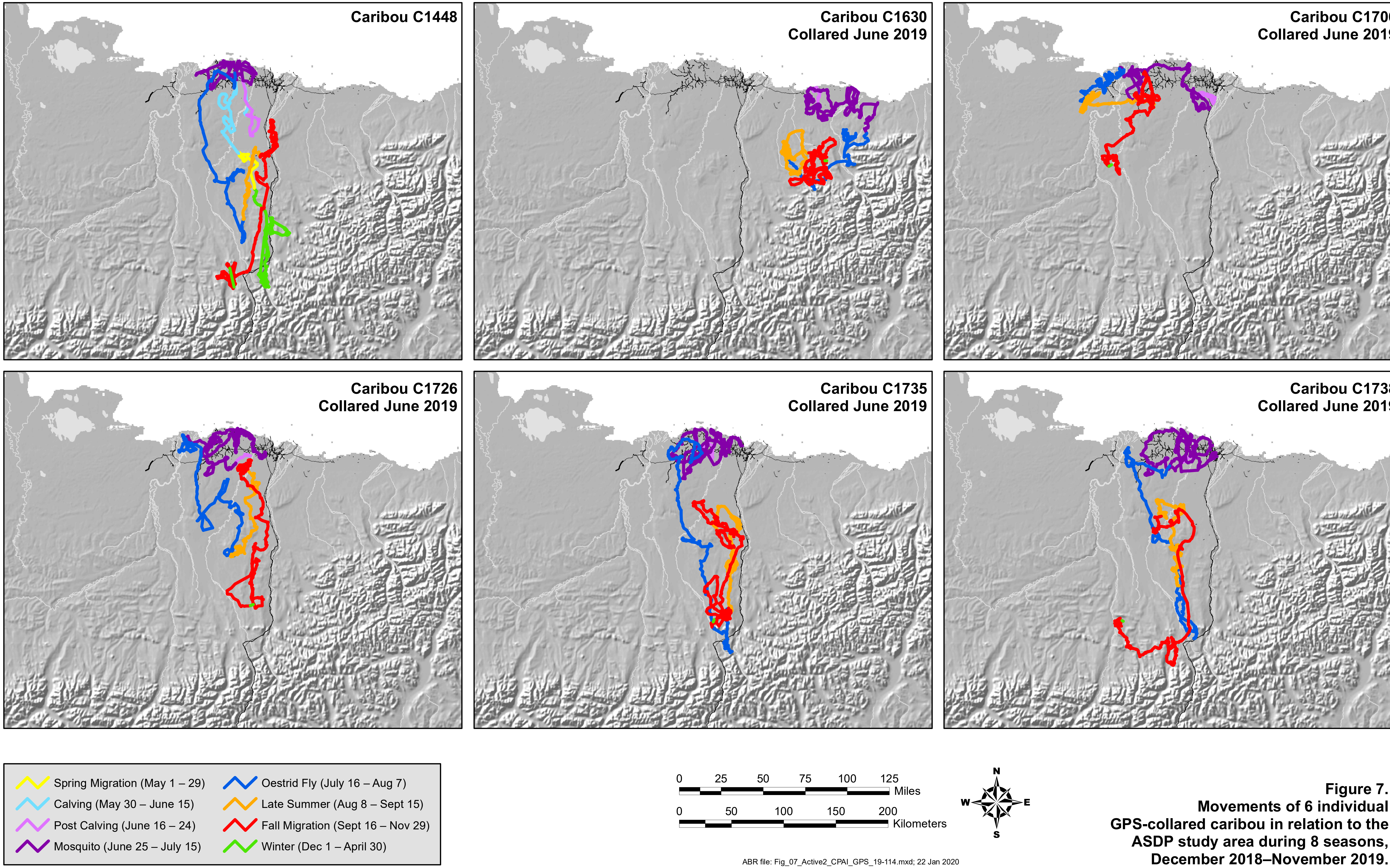

Figure 7.
Movements of 6 individual GPS-collared caribou in relation to the ASDP study area during 8 seasons, December 2018–November 2019.

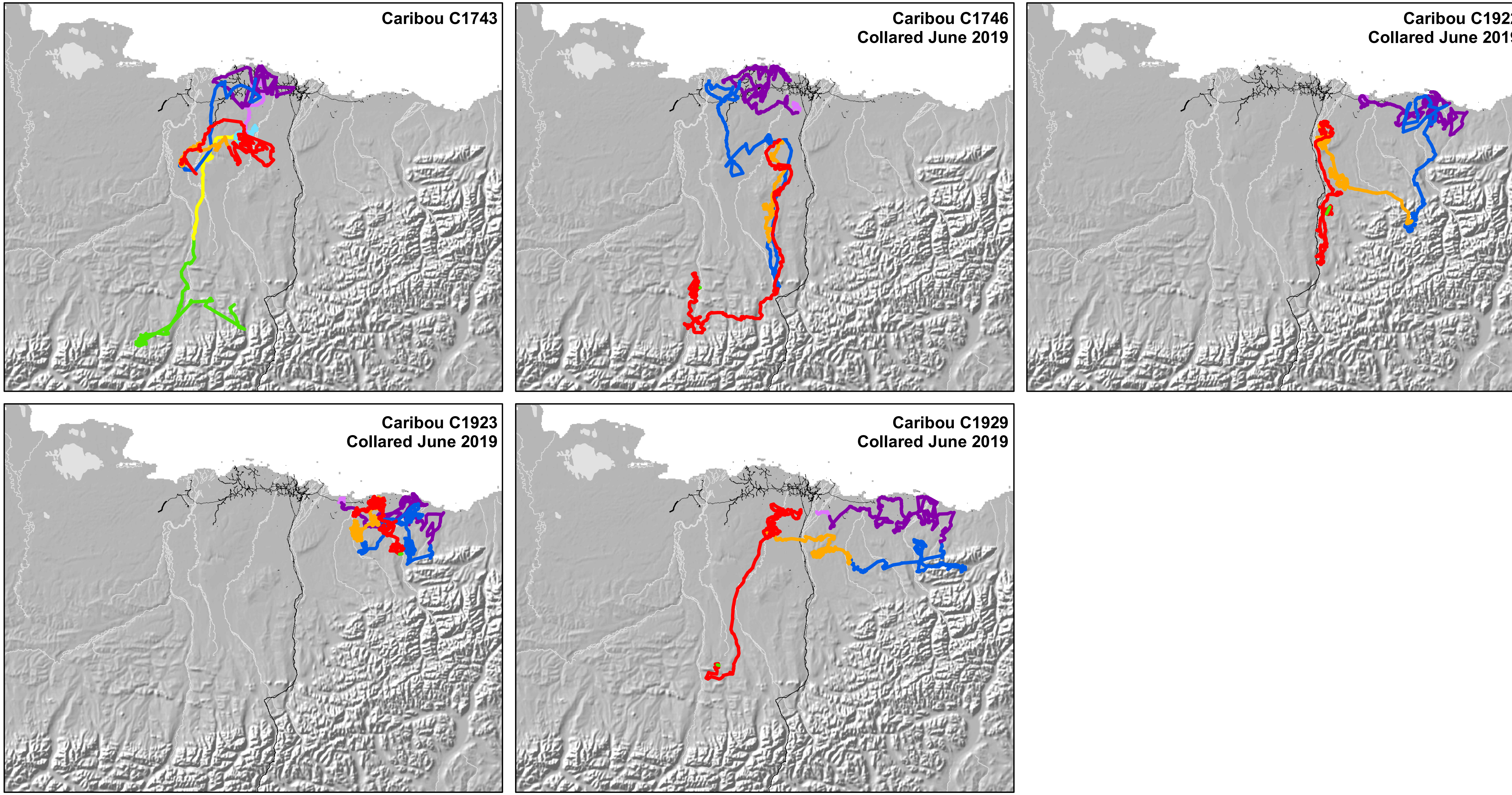

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Figure 8.
Movements of 5 individual GPS-collared caribou in relation to the ASDP study area during 8 seasons, December 2018–November 2019.

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One caribou died in 2019; caribou C0807 died on 15 May along the Itkillik River (Figure 6). One caribou (C1409) spent the entire year in typical TCH range: it wintered west of the Anaktuvuk River in the foothills during the winter of 2018–2019, migrated to Teshekpuk Lake during calving, spent the insect seasons near the area between Teshekpuk Lake and the Beaufort Sea coast, and spent the summer inland west of the Colville River (Figure 6). It did move east of the Colville River during the fall migration season and was in the vicinity of the Meltwater Road at the end of the time period, but numerous TCH caribou were also in that area during that period suggesting it was still with the TCH. The remaining 15 collared caribou spent the majority of 2019 within the normal annual range of the CAH (Figures 6–8).

Ten caribou spent the calving and postcalving season on the west side of the Sagavanirktok River and 5 were on the east side during this period. All caribou except 1 remained on the same side of the Sagavanirktok River throughout the summer. Caribou C1929 was collared east of the Sagavanirktok River during the postcalving season and remained on that side until late summer when it crossed the river and spent the remainder of late summer and the early fall migration season along the Kuparuk River (Figure 8). It then moved south into the foothills of the Brooks Range.

We also mapped the movements of collared CAH caribou in the GKA area during December 2017–November 2019 (Figures 9–15). Similar to previous years, there were few collared CAH caribou in the study area during winter in 2018 or 2019 (Figure 9). CAH caribou began to arrive in the study area in spring of both years, but most caribou remained south of the oilfields during that season (Figure 10). Numerous CAH caribou were in the study area south of the oilfields during calving and postcalving with more use of the eastern side of the area in 2019 compared to 2018 (Figure 11). In both 2018 and 2019, there was heavy use of the Kuparuk oilfields during the mosquito season (Figure 12). The collared CAH caribou remained closer to the coast during the 2019 mosquito season compared to 2018, possibly reflecting more sustained mosquito activity in 2019.

There were also numerous caribou moving through the oilfields during the oestrid fly season during both years (Figure 13). In 2019, four collared CAH caribou were on the Colville River delta during the late mosquito season and the oestrid fly season (Figures 12–13). Multiple collared CAH caribou remained in the GKA during late summer (Figure 14) and fall (Figure 15). There is some indication that CAH caribou are remaining north longer in recent years, possibly as a result of later onset of sea ice and warmer fall temperatures and later snow cover (Wendler et al. 2014).

MOVEMENTS OF COLLARED CARIBOU NEAR THE ALPINE PIPELINES

CAH Collars

The movements of GPS-collared caribou near the Alpine pipelines before November 2017 were described in previous reports (Prichard et al. 2018 and references therein). Twenty of the 25 female CAH caribou with GPS collars active between November 2017 and October 2019 moved into the study area near the Alpine pipeline corridor (Figures 9–15). Eight different collared CAH caribou crossed the Alpine pipelines 30 times between December 2017 and November 2018. Ten different collared CAH caribou crossed the Alpine pipelines 57 times between December 2018 and November 2019 (Table 2).

In 2018, no caribou crossed the Alpine pipelines during the winter, or spring seasons. One caribou crossed the Alpine pipelines twice during the calving and postcalving seasons, 8 caribou crossed the Alpine pipelines 27 times during the mosquito and oestrid fly seasons, and one caribou crossed the Alpine pipelines during late summer (Table 2).

In 2019, no caribou crossed the pipeline during the winter, spring migration, calving, postcalving seasons, or late summer seasons. During the mosquito and oestrid fly seasons when most of the crossings occurred, 10 caribou crossed the pipeline a total of 49 times, all these crossings occurred during 1–20 July. Two caribou crossed the Alpine pipelines 8 times during the fall season (Table 2).

From 2004 to 2013, most collared CAH caribou moved eastward out of the GKA area after the onset of mosquito harassment (Lawhead et al 2015a), but in 2014–2019 many animals from the CAH western segment remained in the GKA area

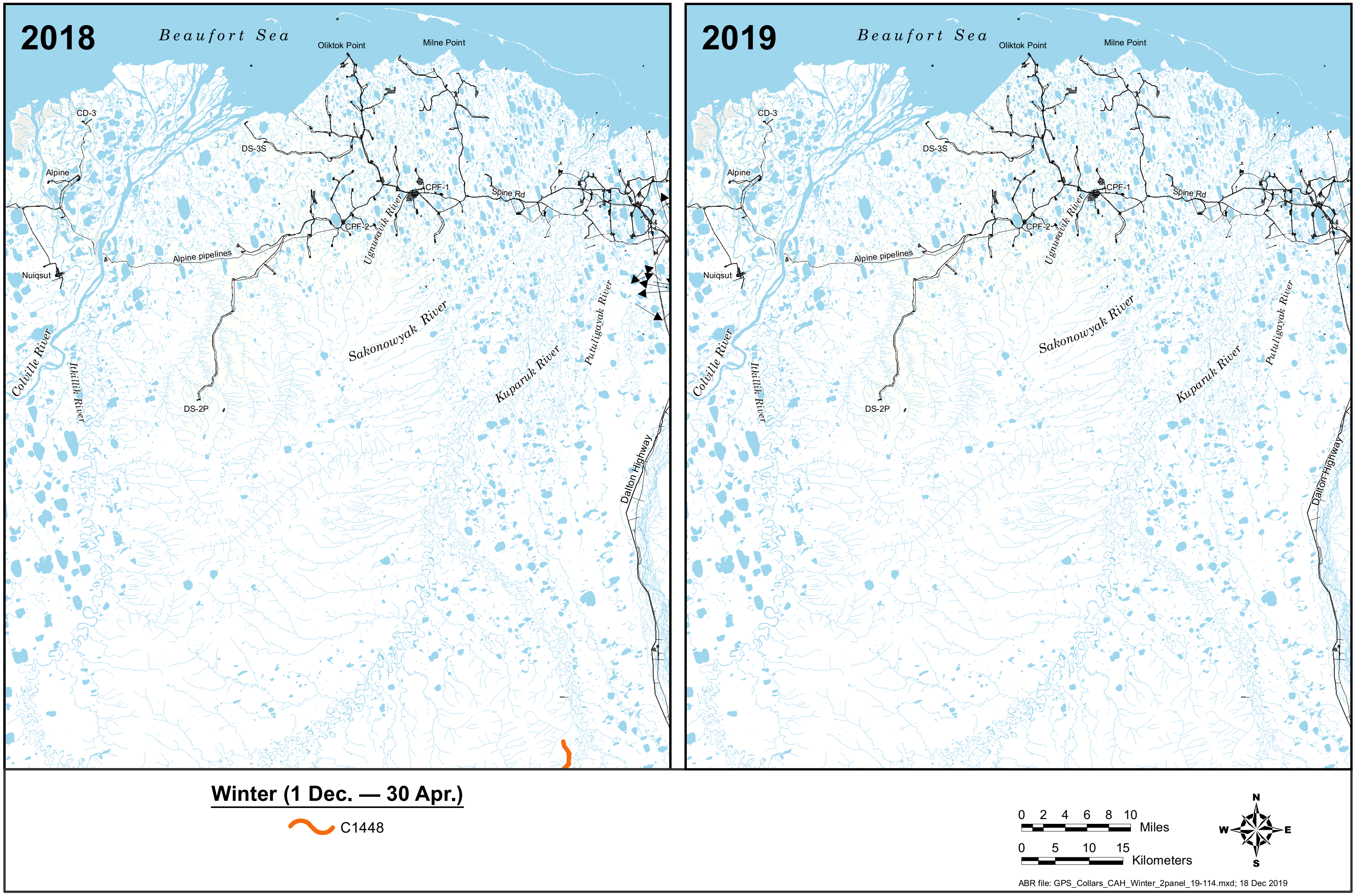

Figure 9. Movements of GPS-collared female caribou of the Central Arctic Herd in the Greater Kuparuk Area during winter, 2018 and 2019.

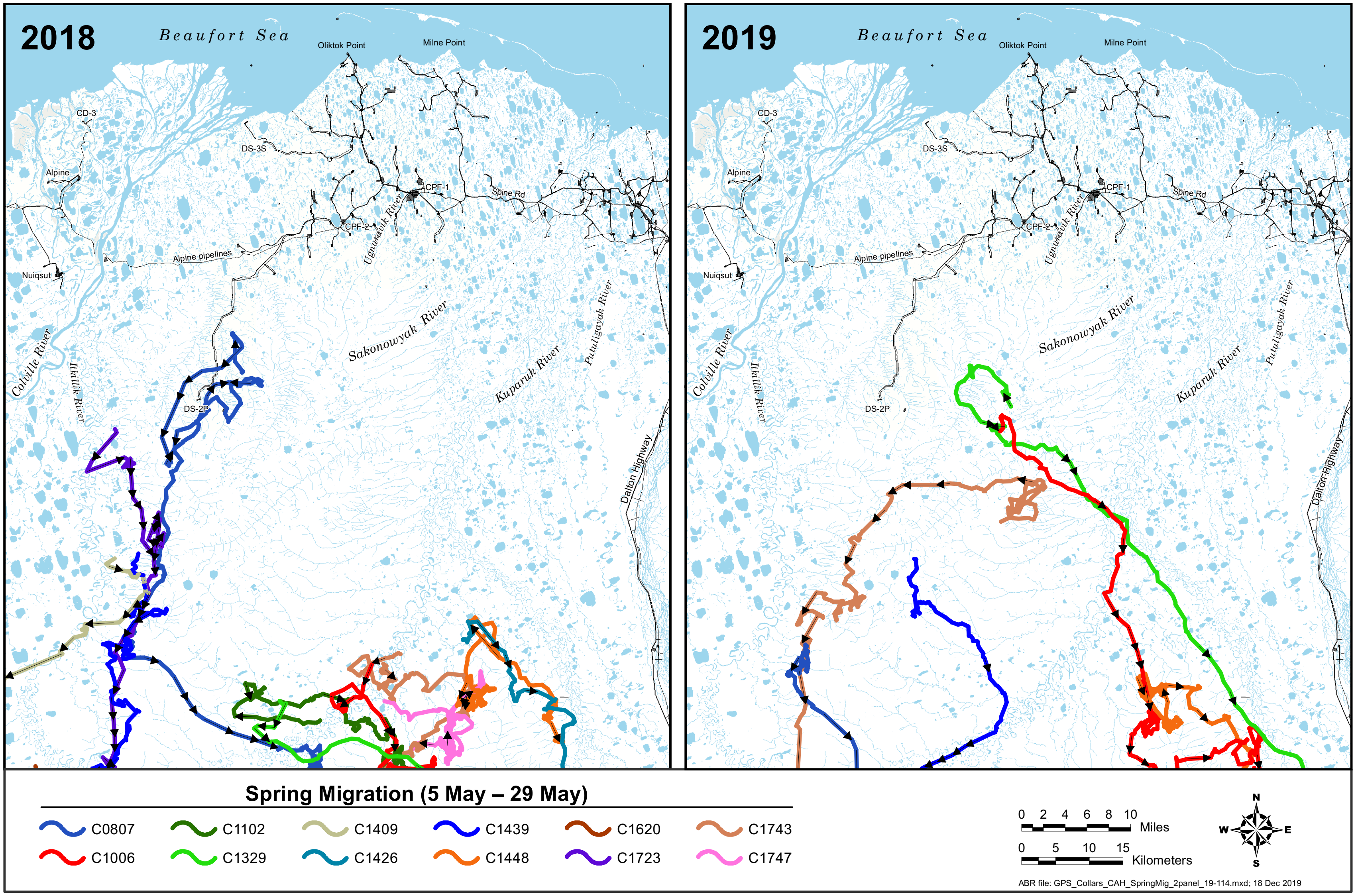

Figure 10. Movements of GPS-collared female caribou of the Central Arctic Herd in the Greater Kuparuk Area during spring migration in 2018 and 2019.

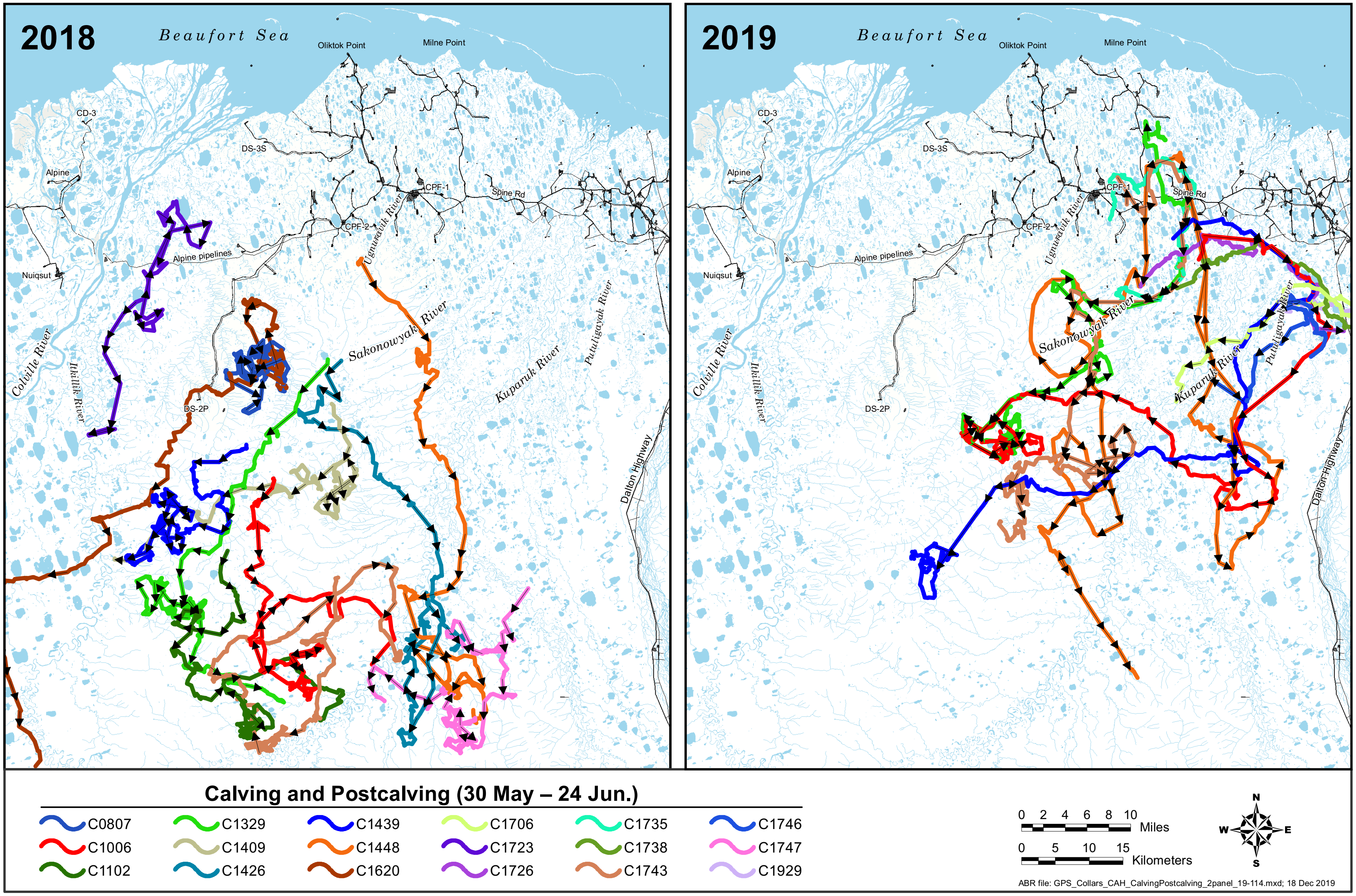

Figure 11. Movements of GPS-collared female caribou of the Central Arctic Herd in the Greater Kuparuk Area during the 2018 and 2019 calving and postcalving seasons.

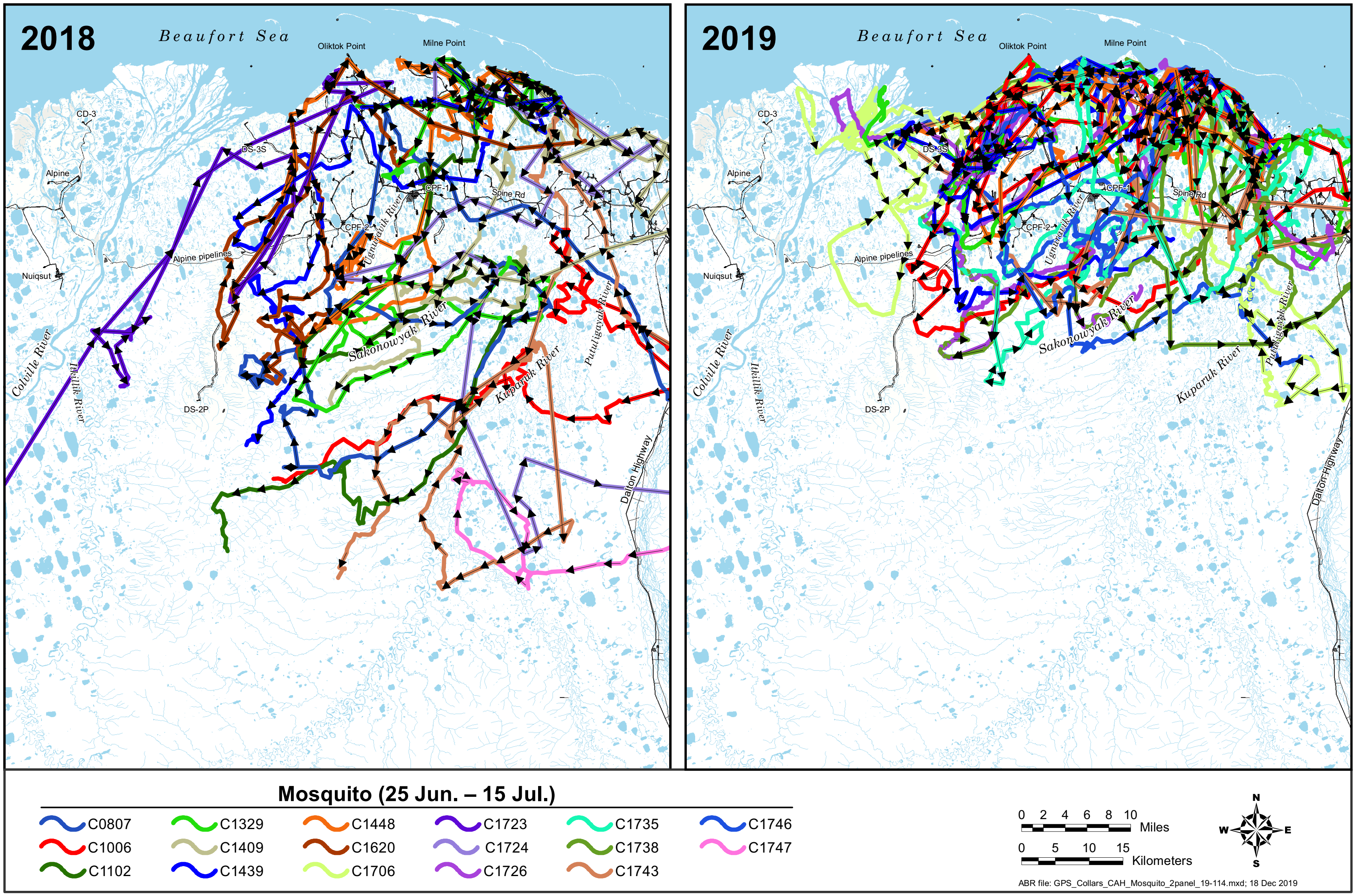

Figure 12. Movements of GPS-collared female caribou of the Central Arctic Herd in the Greater Kuparuk Area during the 2018 and 2019 mosquito seasons.

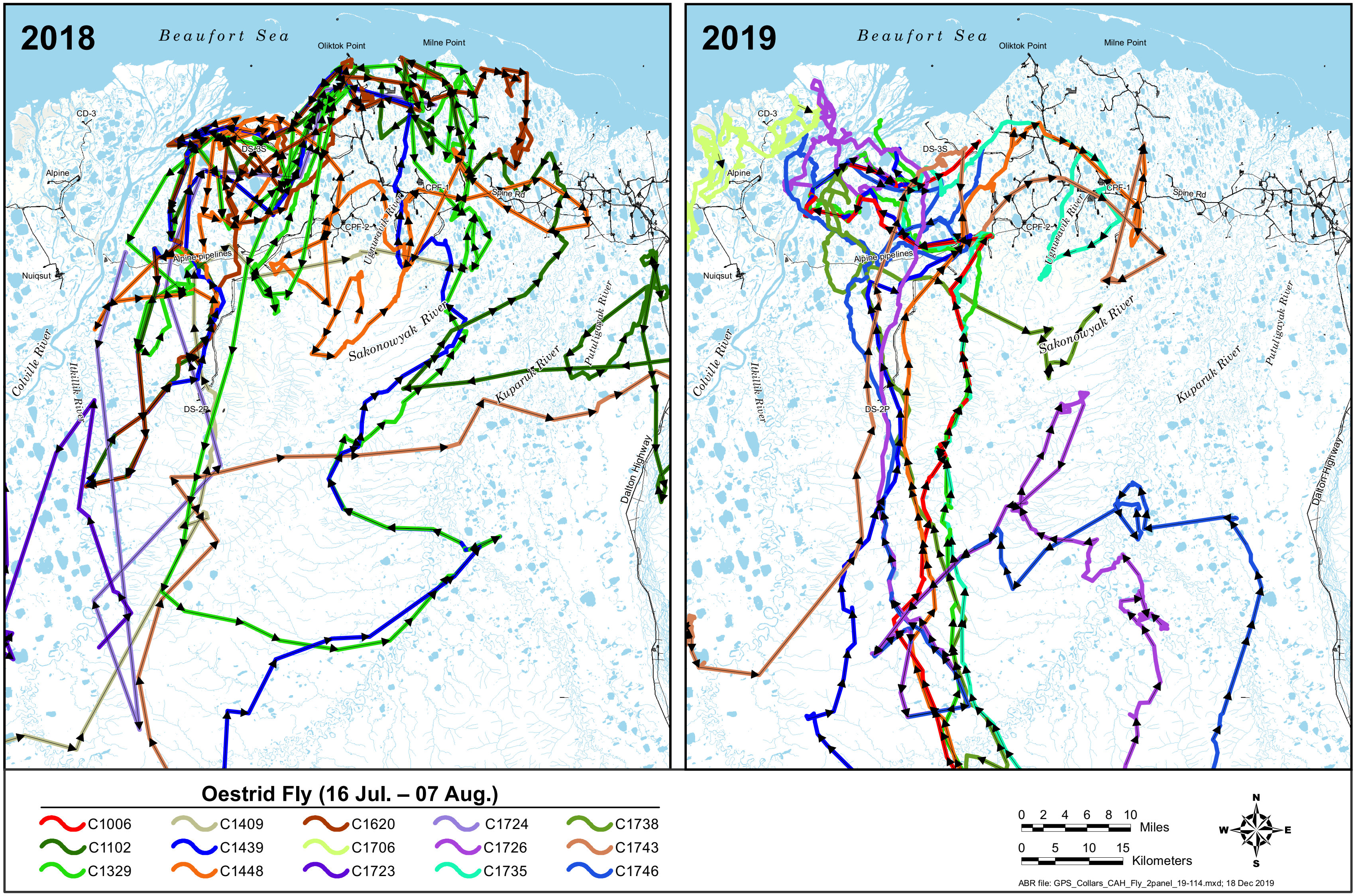

Figure 13. Movements of GPS-collared female caribou of the Central Arctic Herd in the Greater Kuparuk Area during the 2018 and 2019 oestrid fly seasons.

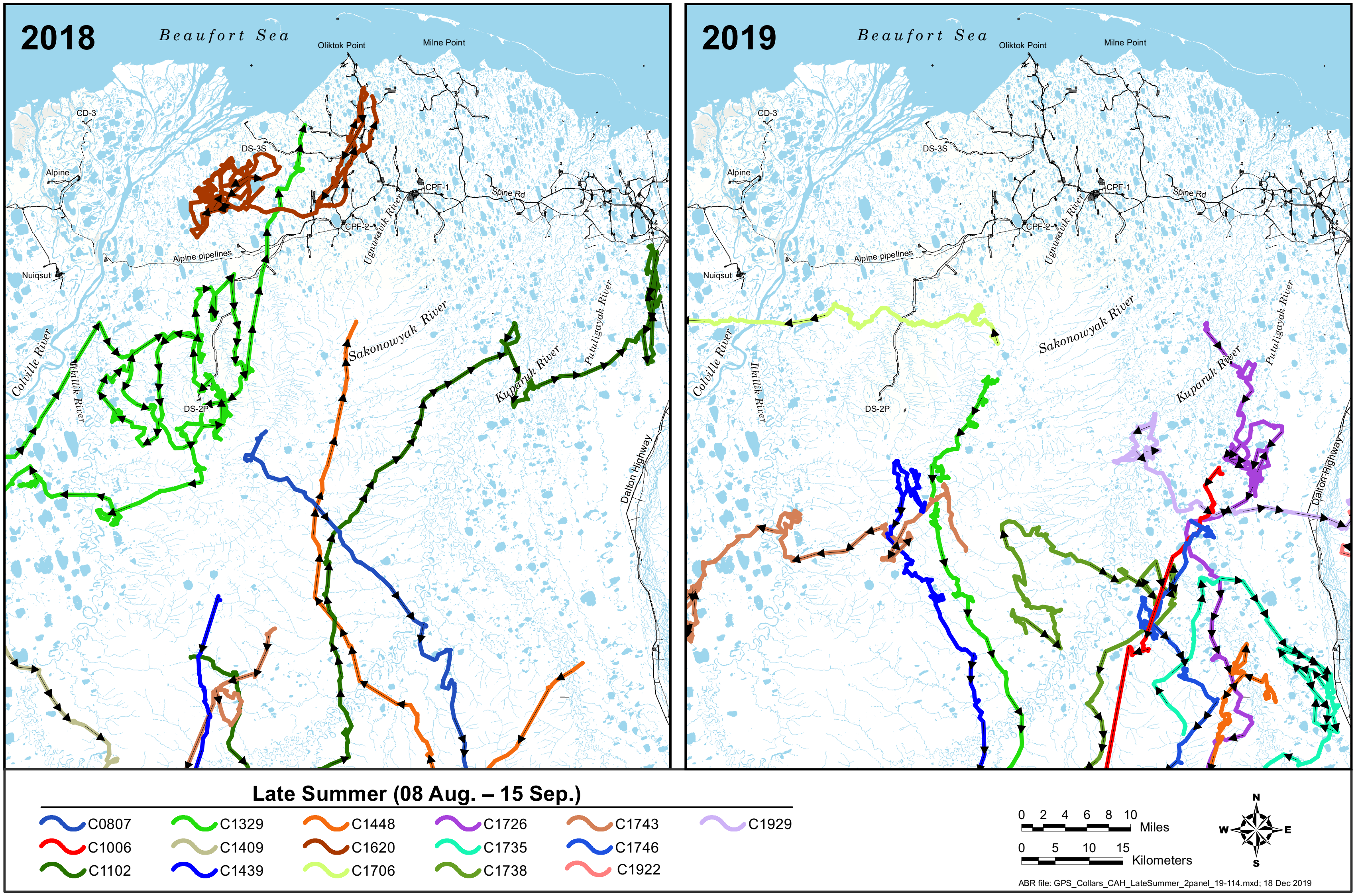

Figure 14. Movements of GPS-collared female caribou of the Central Arctic Herd in the Greater Kuparuk Area during late summer in 2018 and 2019.

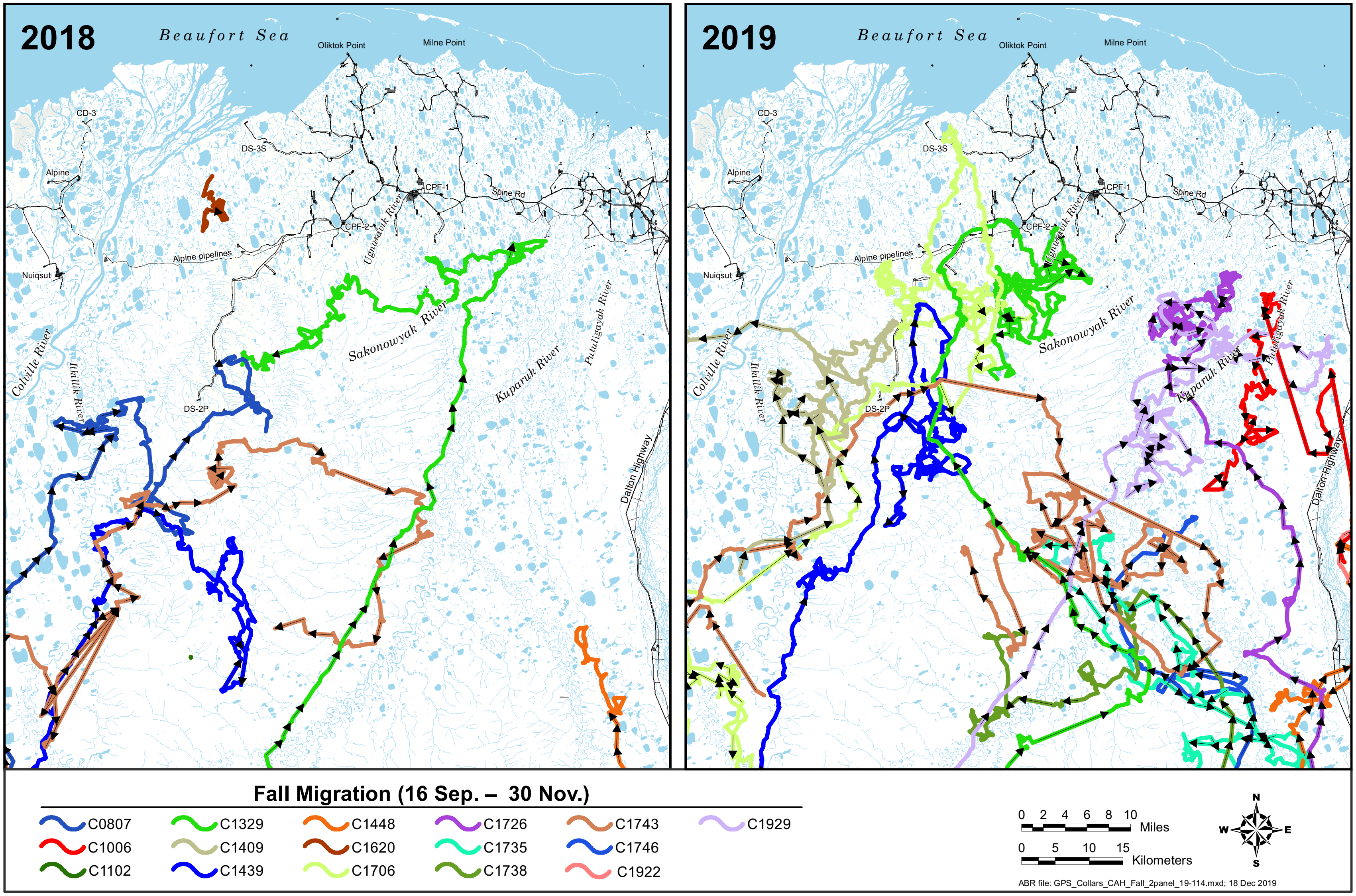

Figure 15. Movements of GPS-collared female caribou of the Central Arctic Herd in the Greater Kuparuk Area during fall migration in 2018 and 2019.

Table 2. Number of CAH radio-collared caribou crossing the Alpine pipelines between 1 December 2017 and 30 November 2019 based on straight line distances between locations.

Year	Season	Caribou ID	Times Crossed	Dates
2018	Calving an Postcalving	C1723	2	6, 16 June
	Mosquito and Oestrid Fly	C1620	5	2–21 July
		C1329	5	18 July–5 August
		C1102	2	19, 21 July
		C1439	3	3–21 July
		C1723	4	2–14 July
		C1724	2	18, 22 July
		C1448	4	19–26 July
		C1409	2	17–18 July
	Late Summer	C1329	1	10 August
	Total	8[a]	30	
2019	Mosquito and Oestrid Fly	C1439	2	1, 19 July
		C1448	7	1–19 July
		C1006	4	1–19 July
		C1743	4	1–20 July
		C1738	5	1–19 July
		C1726	2	1, 20 July
		C1329	9	11–19 July
		C1706	2	14 July
		C1735	7	1–19 July
		C1746	7	1–19 July
	Fall	C1329	2	16–17 October
		C1706	6	6–20 October
	Total	10[a]	57	
Total		18	87	

[a] Number of unique individuals in a year.

throughout the summer, similar to the pattern of use seen in the 1980s and 1990s. These animals typically make repeated crossings of infrastructure while moving between coastal mosquito-relief habitat and inland foraging areas (Murphy and Lawhead 2000).

TCH Collars

The movements of collared TCH caribou near the Alpine pipelines before November 2017 were described in previous reports (Prichard et al. 2018 and references therein). From November 2017 through October 2019, 152 TCH caribou were collared (136 with GPS collars and 16 with PTT satellite collars), but only 16 of those animals entered the GKA study area (Appendices H–N), consistent with the typical distribution of the TCH west of the Colville River. Only one of the caribou crossed the Alpine Pipeline, FY1701 crossed the pipeline 2 times, once on 11 October and once on 12 October, 2019 (Appendix N). During fall 2019, there was an unusually large number of TCH caribou to the southwest of the Meltwater (DS-2P) pad (Appendix N).

OTHER MAMMALS

Observations of other large mammals were recorded by ABR biologists at widely scattered locations during wildlife surveys in 2018 and 2019 (Figure 16). Because no aerial surveys for caribou were conducted in the GKA in 2018 or 2019, most other mammals were observed on the Colville River delta during research for other projects or while commuting to and from Deadhorse for surveys.

GRIZZLY BEAR

In 2018, we observed bears on the Colville River delta and west of the Colville River, but no bears were observed in the GKA (Figure 16). In 2019, a pair of adult bears was located south of Kuparuk in June (Figure 16).

MUSKOX

In 2018, 2 groups of muskoxen were observed while commuting from caribou aerial surveys. One group of approximately 20 muskoxen with an unknown number of calves was observed along the Colville River southeast of Alpine on 24 June. The other observation was of 3 muskoxen on 1 August on the Kuparuk River. In 2019, 2 groups of muskoxen were observed along the Colville River east of Alpine; a single adult was observed on 11 June and a group of approximately 12 muskoxen was observed on 30 July. It was unclear how many calves were present in that group, but later on 27 August, a group of 8 adults and 4 young were observed along the Colville River south of Nuiqsut and east of Ocean Point. This was potentially the same group that had moved further inland. Additionally, a group on 9 muskoxen (8 adults, 1 calf) was observed along the Kuparuk River on 30 July. In recent years, two mixed-sex groups of muskoxen generally have been seen during surveys for other species, one along the Colville River and delta and the other between the Kuparuk River delta and Milne Point (Prichard et al. 2018, 2019b).

The muskox population on the North Slope of Alaska has declined since 1999, evidently due to a combination of predation by grizzly bears, human interactions, disease, and unusual mortality events such as drowning (Reynolds et al. 2002, Shideler et al. 2007, Lenart 2015b). The decline was noted first in the Arctic National Wildlife Refuge but later was documented farther west on the central coastal plain. Population surveys by ADFG in late winter (April) found 216 muskoxen in 2006. Since then, the population on the central North Slope has remained relatively stable at approximately 190–200 animals (Lenart 2015b, Arthur and Del Vecchio 2017). Predation by grizzly bears was the most common cause of death, responsible for an estimated 58% of calf mortalities and 62% of adult mortalities when a cause of death could be determined (Arthur and Del Vecchio 2017).

MOOSE

In 2018, 2 individual moose were observed during aerial surveys; one moose was observed on 31 July and one moose was observed on 29 August. Both moose were observed in or near the southern border of the Colville South survey area (Figure 16; Prichard and Welch 2020). In 2019, another single moose was observed on 30 September in the same region. Moose north of the Brooks Range are concentrated in areas with tall shrubs along riparian corridors where their preferred willow forage is most abundant (Lenart 2018).

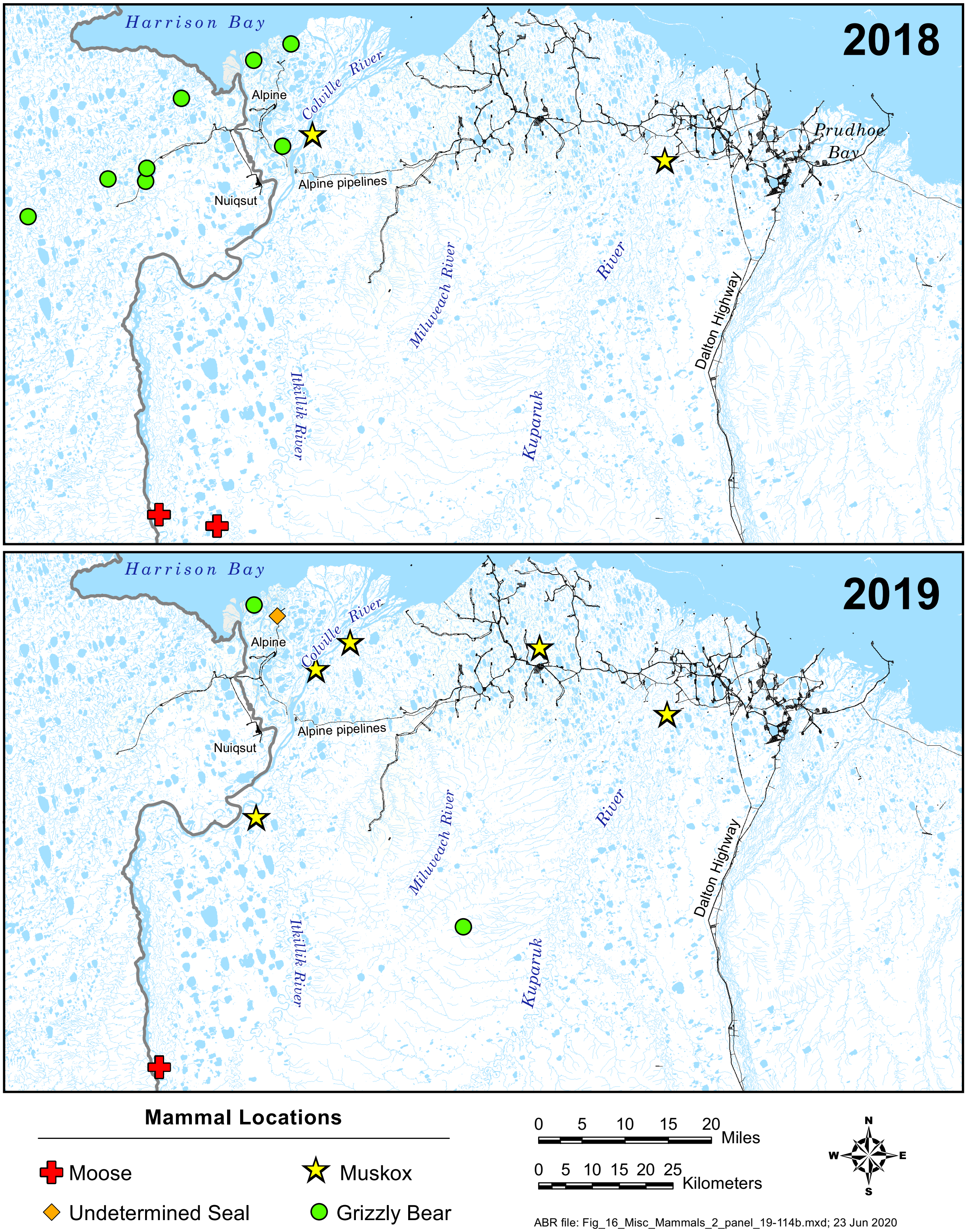

Figure 16. Distribution of other large mammals observed during aerial and ground surveys in the Greater Kuparuk Area, April 2018–October 2019.

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Appendix A. Snow depth (cm) and sum of thawing degree-days (TDD; ºC above freezing) at the Kuparuk airstrip, 1 April–15 June 1983–2019.

	Snow Depth (cm)			Sum of TDD (ºC)		
Year	April 1	May 15	May 31	May 1–15	May 16–31	June 1–15
1983	10	5	0	0	3.6	53.8
1984	18	15	0	0	0	55.6
1985	10	8	0	0	10.2	18.6
1986	33	20	10	0	0	5.0
1987	15	8	3	0	0.6	6.7
1988	10	5	5	0	0	16.6
1989	33	–	10 [a]	0	5.6	20.5
1990	8	3	0	0	16.1	39.7
1991	23	8	3	0	7.8	14.4
1992	13	8	0	0.3	20.3	55.1
1993	13	5	0	0	8.6	33.6
1994	20	18	8	0	4.4	49.3
1995	18	5	0	0	1.1	59.5
1996	23	5	0	8.1	41.7	86.1
1997	28	18	8	0	20.8	36.1
1998	25	8	0	3.6	45.8	74.2
1999	28	15	10	0	1.4	30.3
2000	30	23	13	0	0	36.6
2001	23	30	5	0	0.8	51.8
2002	30	trace	0	4.2	30.2	57.7
2003	28	13	trace	0	10.8	23.6
2004	36	10	5	0	9.0	26.3
2005	23	13	0	0	2.4	14.0
2006	23	5	0	0	23.3	93.4
2007	25	46	5	0	0	46.6
2008	20	18	0	0	32.8	71.7
2009	36	13	0	0	16.8	71.8
2010	41	43	13	0	1.4	53.4
2011	25	18	0	0	28.0	12.4
2012	48	53	2	0	1.7	26.8
2013	33	18	2	0	4.2	79.2
2014	33	0 [b]	0 [b]	11.1	4.2	28.6
2015	38	18	0	1.4	46.4	78.1
2016	25	0	0	15.6	12.4	63.7
2017	36	14	0	0	12.1	5.2
2018	40.6	20.3	15.2	1.4	0	6.6
2019	22.9	12.7	0	1.1	11.9	31.1
Mean	25.5	14.5	3.2	1.3	11.8	41.5

[a] Value for 1 June.
[b] Kuparuk airstrip station reported no snow after 8 May 2014, whereas other weather stations nearby reported snow until 31 May and patchy snow was present in the GKA survey areas into early June. Therefore, if accurate, the airport information was not representative of the study area.

Appendix B. Sum of thawing degree-days (ºC above freezing) at the Kuparuk airstrip during five periods of the insect season, mid-June through August 1983–2019.

Year	June 16–30	July 1–15	July 16–31	August 1–15	August 16–31	Total
1983 [a]	66.2	74.8	103.9	100.1	50.7	395.7
1984	75.3	122.8	146.4	99.6	59.8	503.9
1985	92.9	84.8	99.5	100.0	70.8	447.8
1986	100.9	112.3	124.7	109.6	54.4	501.8
1987	61.3	112.2	127.9	93.1	109.3	503.7
1988	78.0	108.5	143.0	137.7	52.3	519.3
1989	109.5	214.7	168.1	215.8	133.9	842.0
1990	132.2	145.0	150.0	82.5	72.8	582.5
1991	127.6	73.3	115.0	70.7	54.5	441.1
1992	85.2	113.9	166.1	104.2	96.2	565.5
1993	94.4	175.9	149.8	96.1	78.0	594.2
1994	51.6	149.7	175.8	222.2	92.4	691.6
1995	87.5	162.9	106.9	83.4	83.6	524.1
1996	121.1	138.9	168.1	95.8	34.7	558.6
1997	109.7	101.7	177.8	194.2	97.8	681.1
1998	135.0	158.9	184.4	174.4	123.1	775.8
1999	67.8	173.3	81.1	177.6	69.8	569.5
2000	169.8	113.4	127.2	118.6	53.6	582.5
2001	72.2	79.8	183.9	131.7	32.5	500.0
2002	70.2	92.3	134.5	106.2	90.7	493.8
2003	77.4	140.0	144.7	91.9	54.9	508.8
2004	185.7	148.0	151.5	153.4	123.2	761.7
2005	78.3	67.5	79.5	176.8	44.5	446.5
2006	153.2	82.3	186.2	109.6	36.9	568.1
2007	81.8	115.2	138.9	134.4	103.5	573.7
2008	138.9	172.3	132.5	86.0	73.9	603.5
2009	44.5	142.7	126.5	133.7	95.0	542.3
2010	51.1	126.7	168.8	149.2	115.2	610.9
2011 [b]	103.0	122.4	171.6	142.8	83.7	623.3
2012 [b]	137.3	140.2	194.1	142.9	166.3	780.7
2013	131.7	112.8	185.5	185.4	52.9	668.3
2014	82.0	127.2	102.3	67.9	112.0	491.2
2015	197.2	117.9	95.7	108.8	51.4	571.0
2016	131.2	174.7	130.8	98.1	132.7	667.4
2017	121.3	173.4	174.5	150.5	74.7	694.3
2018	47.7	137.0	195.9	63.6	57.4	501.6
2019	108.5	180.3	181.3	118.0	85.6	673.7
Mean	102.1	129.5	145.8	125.0	80.4	582.7

[a] Some missing values estimated by interpolation.
[b] Estimated by averaging data from Nuiqsut and Deadhorse while Kuparuk airstrip was closed for paving (Lawhead et al. 2013).

Appendix C. Average index values of mosquito activity[a] (adapted from Russell et al. 1993) during June–August 1983–2019, based on daily maximum temperatures at the Kuparuk airstrip.

	June			July			August		
Year	Early	Late	Total	Early	Late	Total	Early	Late	Total
1983	0.28	0.31	0.30	0.28	0.42	0.35	0.43	0.15	0.29
1984	0.26	0.37	0.31	0.60	0.68	0.64	0.46	0.20	0.33
1985	0.08	0.48	0.28	0.42	0.45	0.44	0.52	0.31	0.42
1986	0.01	0.46	0.24	0.62	0.54	0.58	0.53	0.21	0.37
1987	0	0.22	0.11	0.52	0.47	0.49	0.33	0.42	0.38
1988	0.04	0.32	0.18	0.50	0.64	0.57	0.73	0.19	0.46
1989	0.01	0.58	0.29	0.90	0.74	0.82	0.84	0.59	0.72
1990	0.17	0.69	0.43	0.68	0.62	0.65	0.30	0.21	0.25
1991	0.01	0.58	0.30	0.35	0.48	0.42	0.27	0.27	0.27
1992	0.29	0.36	0.33	0.49	0.77	0.63	0.48	0.42	0.45
1993	0.13	0.42	0.28	0.80	0.66	0.73	0.37	0.26	0.32
1994	0.23	0.18	0.21	0.73	0.77	0.75	0.97	0.37	0.67
1995	0.28	0.36	0.32	0.83	0.35	0.59	0.30	0.36	0.33
1996	0.44	0.54	0.49	0.72	0.69	0.70	0.46	0.14	0.30
1997	0.07	0.50	0.28	0.41	0.82	0.62	0.84	0.33	0.58
1998	0.30	0.55	0.43	0.72	0.81	0.76	0.70	0.46	0.58
1999	0.11	0.28	0.19	0.84	0.29	0.56	0.82	0.20	0.51
2000	0.11	0.82	0.47	0.50	0.47	0.49	0.59	0.27	0.43
2001	0.25	0.33	0.29	0.32	0.75	0.54	0.60	0.05	0.32
2002	0.25	0.30	0.28	0.43	0.61	0.52	0.40	0.36	0.38
2003	0.10	0.39	0.24	0.65	0.58	0.62	0.45	0.09	0.27
2004	0.04	0.89	0.47	0.72	0.65	0.68	0.70	0.44	0.57
2005	0.01	0.34	0.18	0.29	0.28	0.28	0.82	0.11	0.46
2006	0.49	0.73	0.61	0.33	0.81	0.57	0.50	0.06	0.28
2007	0.14	0.38	0.26	0.56	0.55	0.56	0.60	0.41	0.51
2008	0.31	0.71	0.51	0.85	0.59	0.72	0.22	0.22	0.22
2009	0.32	0.11	0.22	0.60	0.53	0.56	0.56	0.36	0.46
2010	0.22	0.14	0.18	0.56	0.74	0.65	0.61	0.43	0.52
2011[b]	0.05	0.48	0.27	0.54	0.71	0.63	0.61	0.28	0.44
2012[b]	0.07	0.64	0.35	0.67	0.80	0.73	0.67	0.67	0.67
2013	0.40	0.72	0.56	0.50	0.83	0.66	0.82	0.13	0.48
2014	0.11	0.35	0.23	0.61	0.33	0.47	0.14	0.52	0.33
2015	0.43	0.87	0.65	0.52	0.34	0.43	0.47	0.16	0.31
2016	0.30	0.70	0.50	0.77	0.55	0.66	0.37	0.60	0.49
2017	0.01	0.55	0.28	0.71	0.76	0.72	0.65	0.16	0.45
2018	0	0.14	0.07	0.62	0.79	0.71	0.15	0.19	0.17
2019	0.12	0.49	0.31	0.85	0.81	0.83	0.45	0.19	0.32
Mean	0.17	0.47	0.32	0.59	0.61	0.60	0.53	0.29	0.41

[a] Average Mosquito Index: if daily maximum temperature <6 °C, then index = 0; if daily maximum temperature >18 °C, then index = 1; otherwise, index = 1 – [(18 – daily maximum temperature)/13].

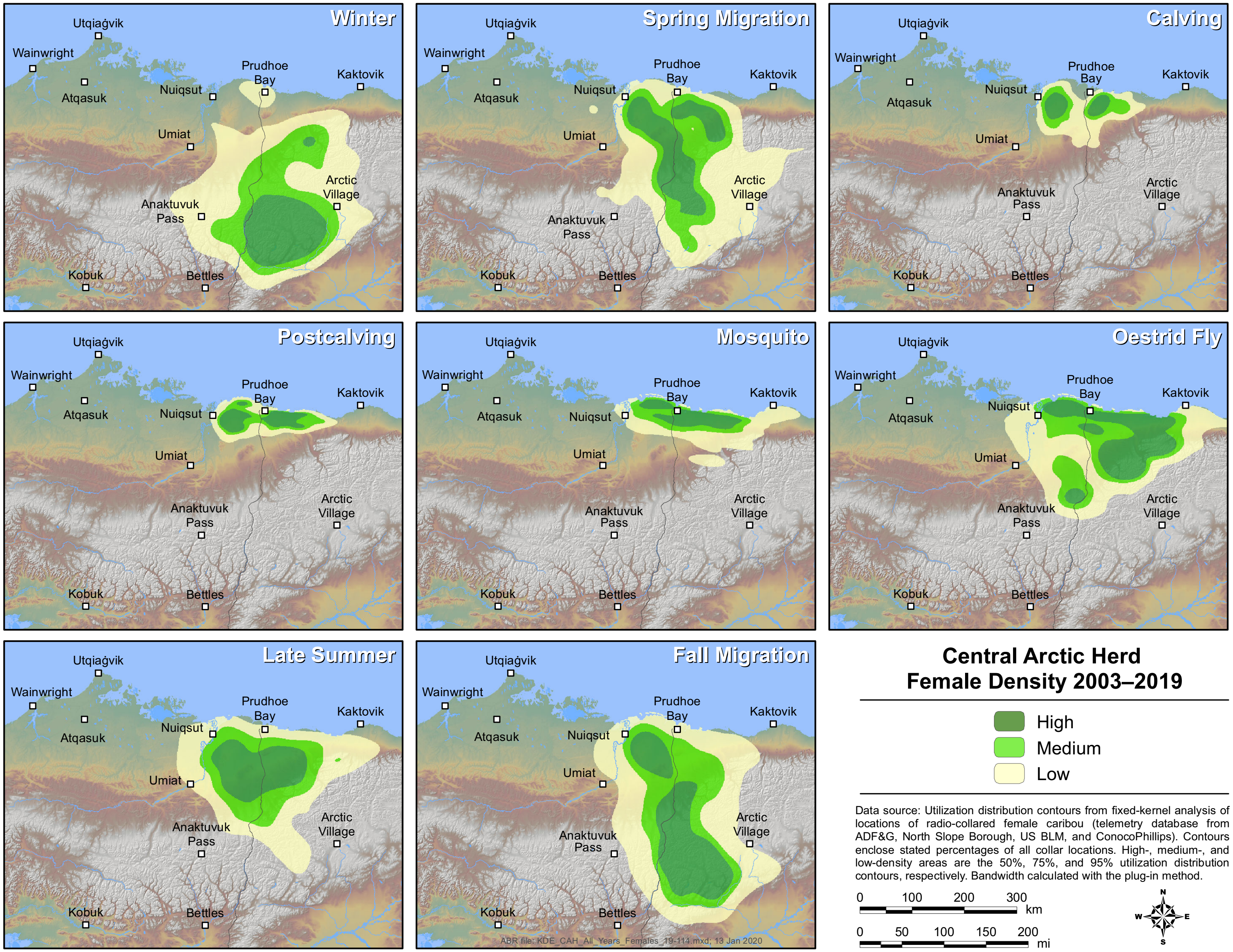
[b] Index values for late June through August were estimated by averaging data from Deadhorse and Nuiqsut while Kuparuk airstrip was closed for paving (Lawhead et al. 2013).

Appendix D. Average index values of oestrid fly activity[a] (adapted from Russell et al. 1993) during June–August 1983–2019, based on daily maximum temperatures at the Kuparuk airstrip.

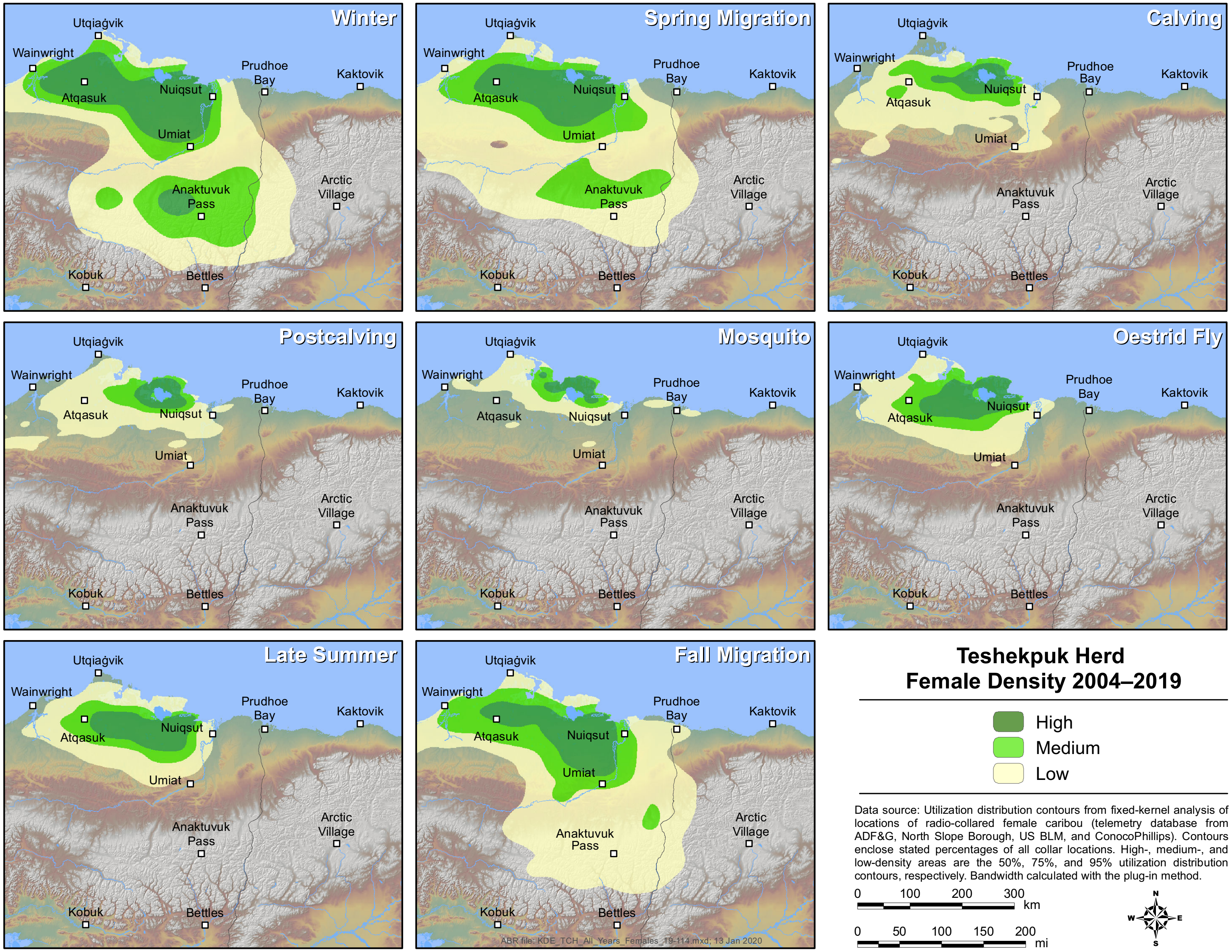
	June			July			August		
Year	Early	Late	Total	Early	Late	Total	Early	Late	Total
1983	0	0.10	0.05	0	0.30	0.16	0.08	0	0.04
1984	0.03	0.13	0.08	0.25	0.50	0.38	0.21	0.03	0.12
1985	0.01	0.16	0.08	0.24	0.23	0.24	0.26	0.15	0.20
1986	0	0.26	0.13	0.40	0.20	0.29	0.23	0.01	0.12
1987	0	<0.01	<0.01	0.22	0.25	0.24	0.01	0.10	0.06
1988	0	0.03	0.01	0.19	0.30	0.25	0.47	0.12	0.29
1989	0	0.32	0.16	0.80	0.59	0.69	0.69	0.40	0.54
1990	0	0.41	0.20	0.60	0.44	0.52	<0.01	0.02	0.01
1991	0	0.41	0.20	0.17	0.25	0.21	0.09	0.09	0.09
1992	0.15	0.09	0.12	0.27	0.55	0.42	0.26	0.18	0.22
1993	0	0.32	0.16	0.61	0.31	0.46	0.19	0.11	0.15
1994	<0.01	0.09	0.04	0.46	0.66	0.56	0.93	0.15	0.52
1995	0.09	0.09	0.09	0.62	0.24	0.42	0.06	0.13	0.09
1996	0.28	0.44	0.36	0.54	0.51	0.53	0.26	0	0.12
1997	0	0.23	0.12	0.31	0.61	0.47	0.64	0.08	0.35
1998	0.06	0.40	0.23	0.40	0.56	0.48	0.39	0.15	0.27
1999	0	0.01	<0.01	0.64	0.14	0.38	0.54	0.03	0.28
2000	0.02	0.68	0.35	0.28	0.27	0.27	0.38	0.15	0.26
2001	0.17	0.05	0.11	0.19	0.55	0.37	0.26	0	0.13
2002	0.10	0.15	0.12	0.13	0.37	0.25	0.25	0.14	0.19
2003	0	0.16	0.08	0.27	0.39	0.33	0.29	0	0.14
2004	0	0.75	0.38	0.50	0.41	0.45	0.59	0.27	0.42
2005	0	0.21	0.10	0.02	0	0.01	0.71	0	0.34
2006	0.34	0.58	0.46	0.11	0.65	0.39	0.16	<0.01	0.08
2007	0	0.17	0.08	0.27	0.18	0.22	0.27	0.01	0.14
2008	0.09	0.42	0.26	0.61	0.38	0.49	0	0	0
2009	0.06	<0.01	0.03	0.26	0.30	0.28	0.39	0.18	0.28
2010	0.05	0	0.03	0.29	0.47	0.38	0.51	0.13	0.31
2011[b]	0.03	0.22	0.13	0.17	0.39	0.29	0.29	0.01	0.15
2012[b]	0.01	0.42	0.22	0.35	0.61	0.48	0.30	0.47	0.39
2013	0.22	0.45	0.34	0.24	0.62	0.44	0.73	0.01	0.36
2014	0	0.21	0.11	0.24	0.14	0.19	0	0.28	0.14
2015	0.25	0.71	0.48	0.38	0.11	0.24	0.14	0.05	0.09
2016	0.18	0.50	0.34	0.51	0.36	0.43	0.20	0.43	0.32
2017	0	0.32	0.16	0.50	0.50	0.50	0.50	0	0.20
2018	0	0	0	0.47	0.58	0.53	0	0	0
2019	0	0.18	0.09	0.68	0.52	0.60	0.11	0	0.06
Mean	0.06	0.26	0.16	0.36	0.39	0.37	0.31	0.10	0.20

[a] Average Fly Index: if daily maximum temperature <13 °C, then index = 0; if daily maximum temperature >18 °C, then index = 1; otherwise, index = 1 – [(18 – daily maximum temperature)/5].

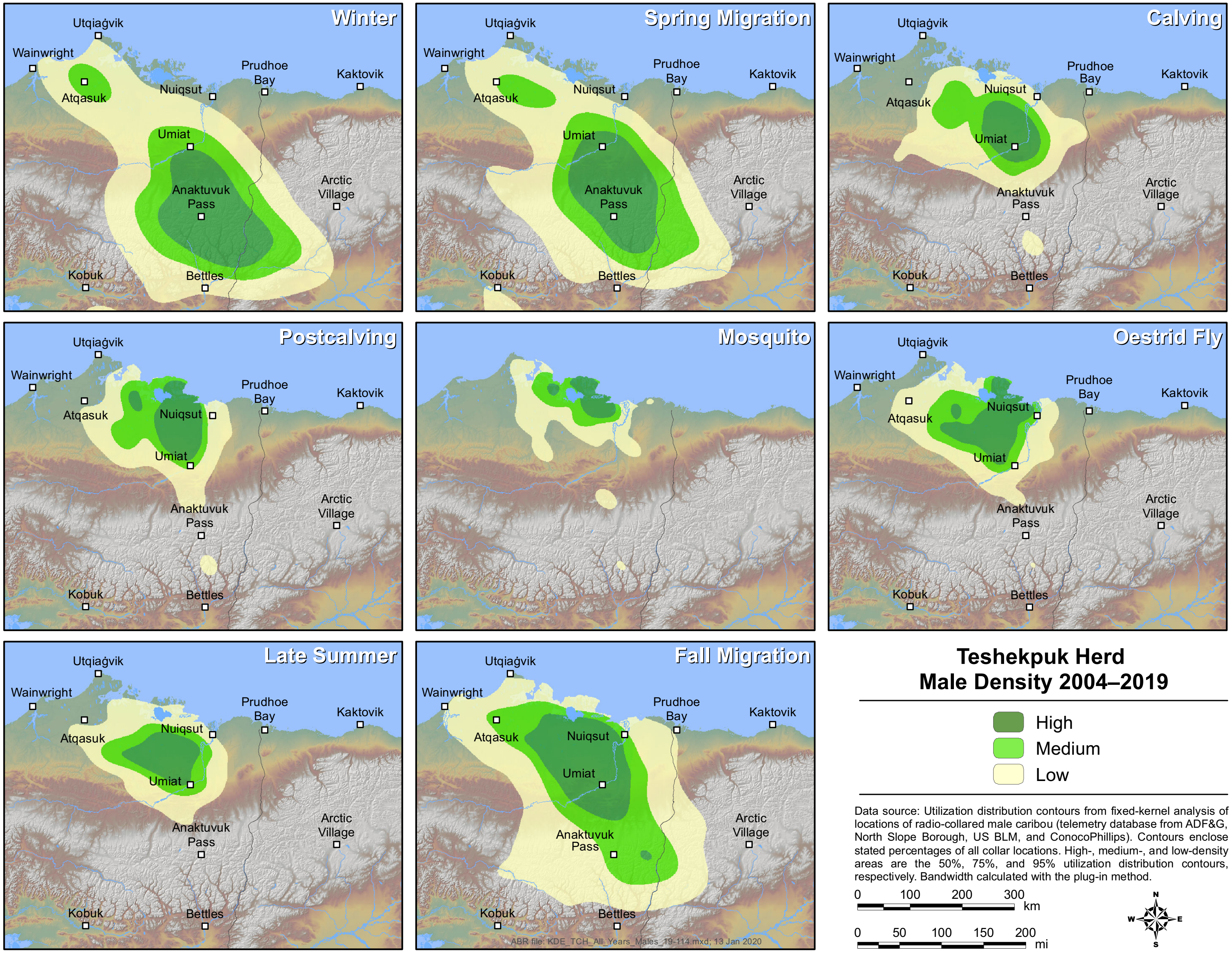
[b] Values for late June through August were estimated by averaging values from Deadhorse and Nuiqsut while Kuparuk airstrip was closed for paving (Lawhead et al. 2013).



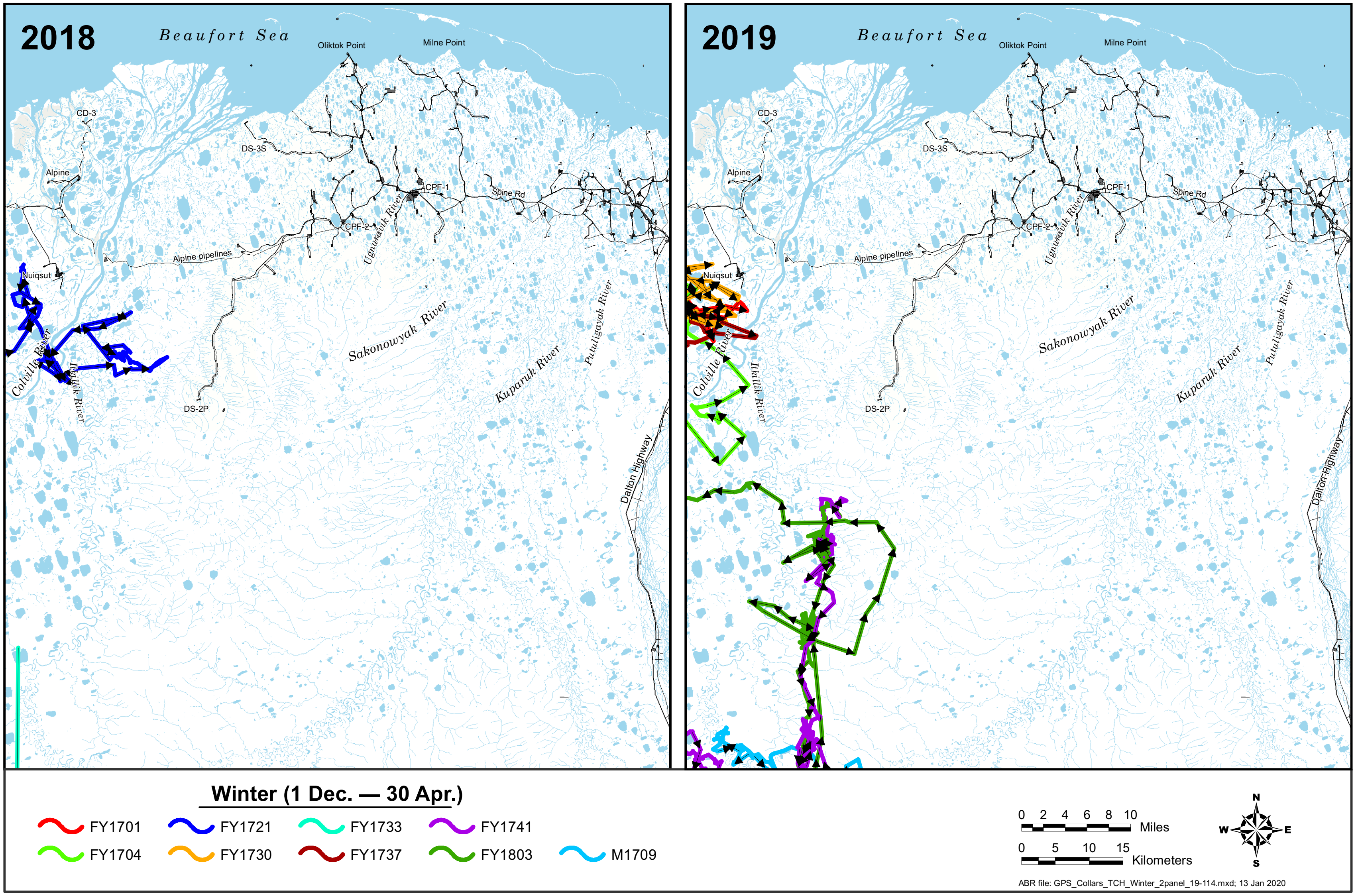
Appendix E. Kernel Density Estimates of seasonal distribution of female caribou from the Central Arctic Herd.



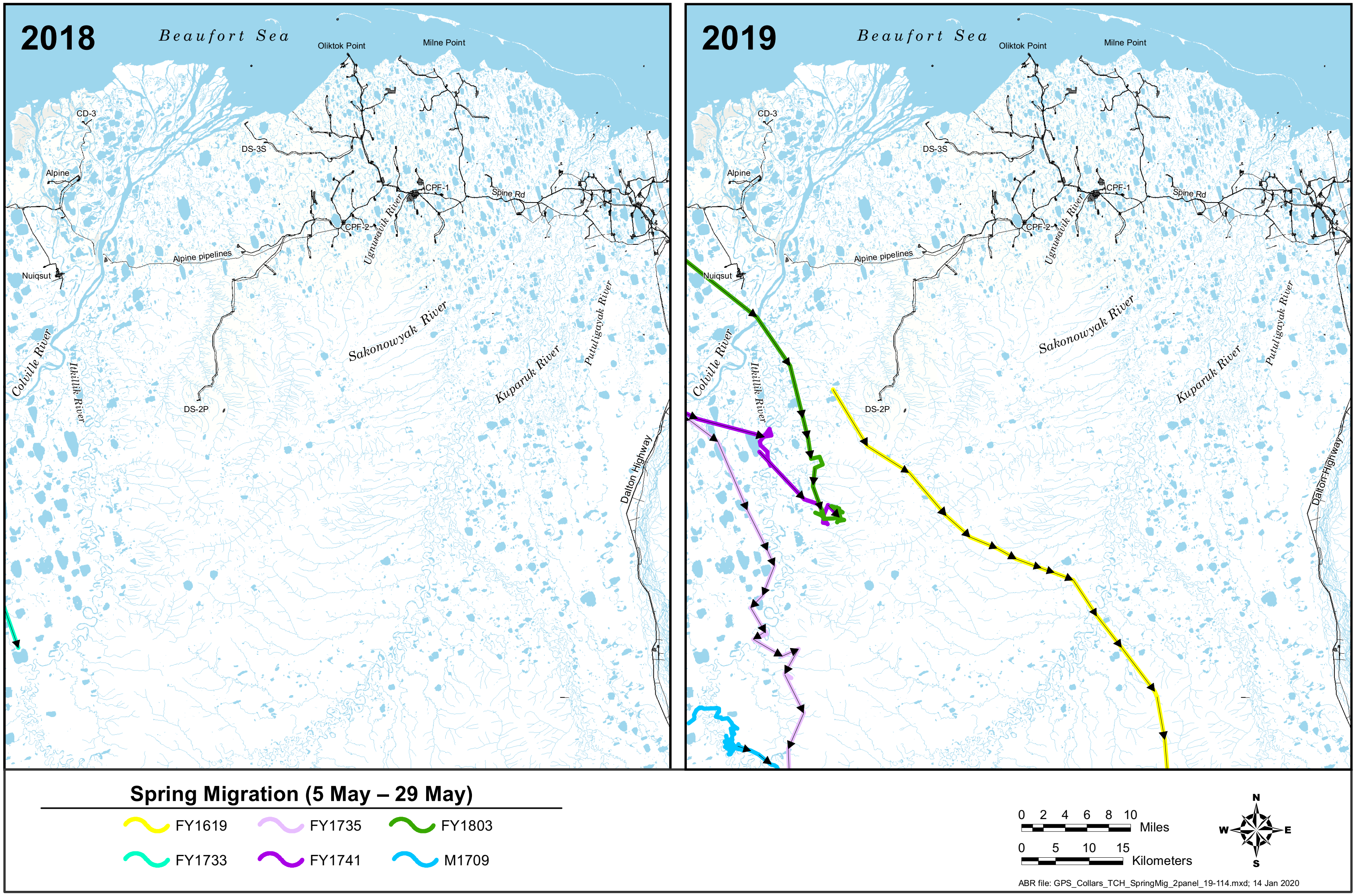
Appendix F. Kernel Density Estimates of seasonal distribution of female caribou from the Teshekpuk Caribou Herd.



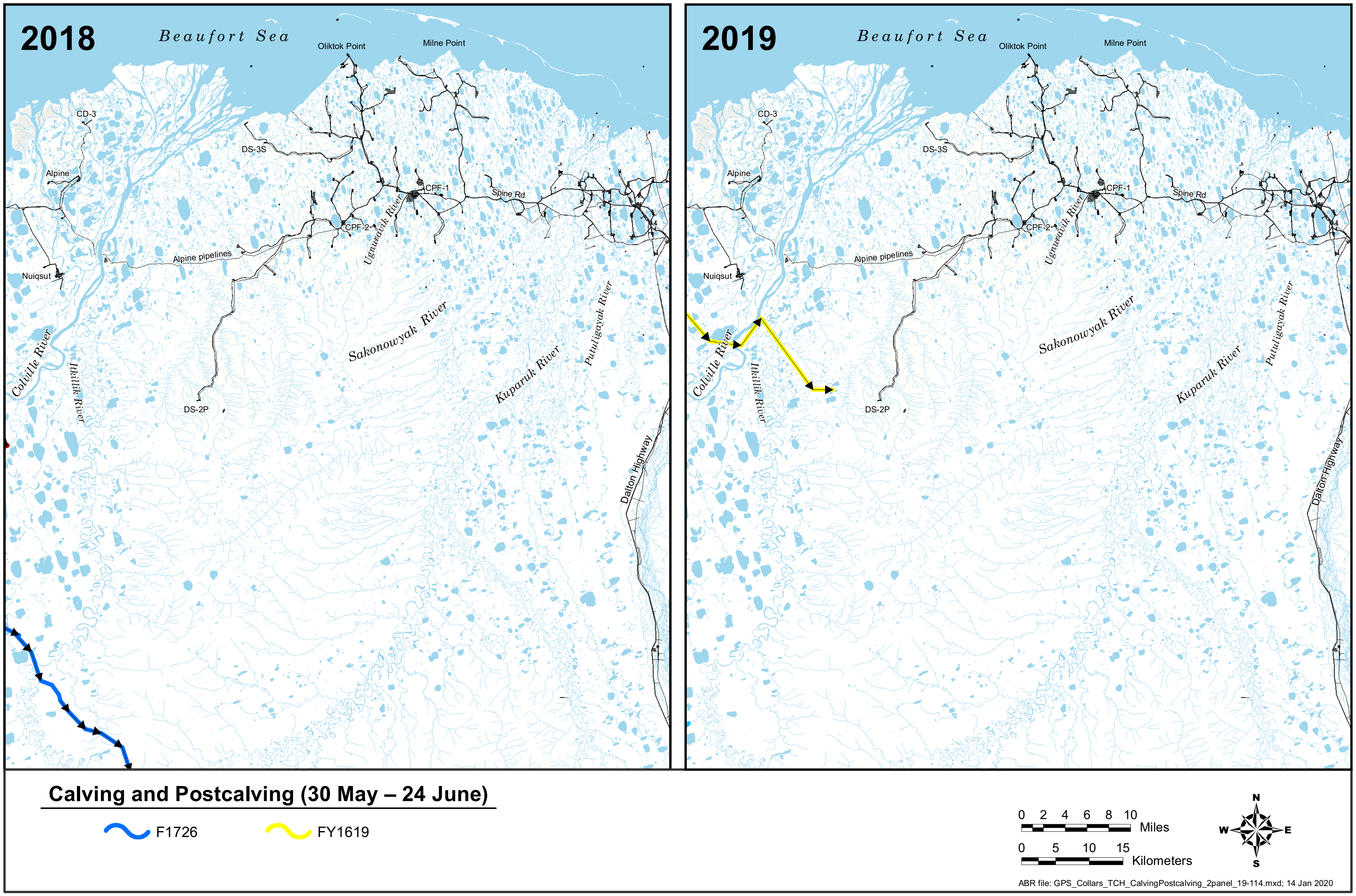
Appendix G. Kernel Density Estimates of seasonal distribution of male caribou from the Teshekpuk Caribou Herd.



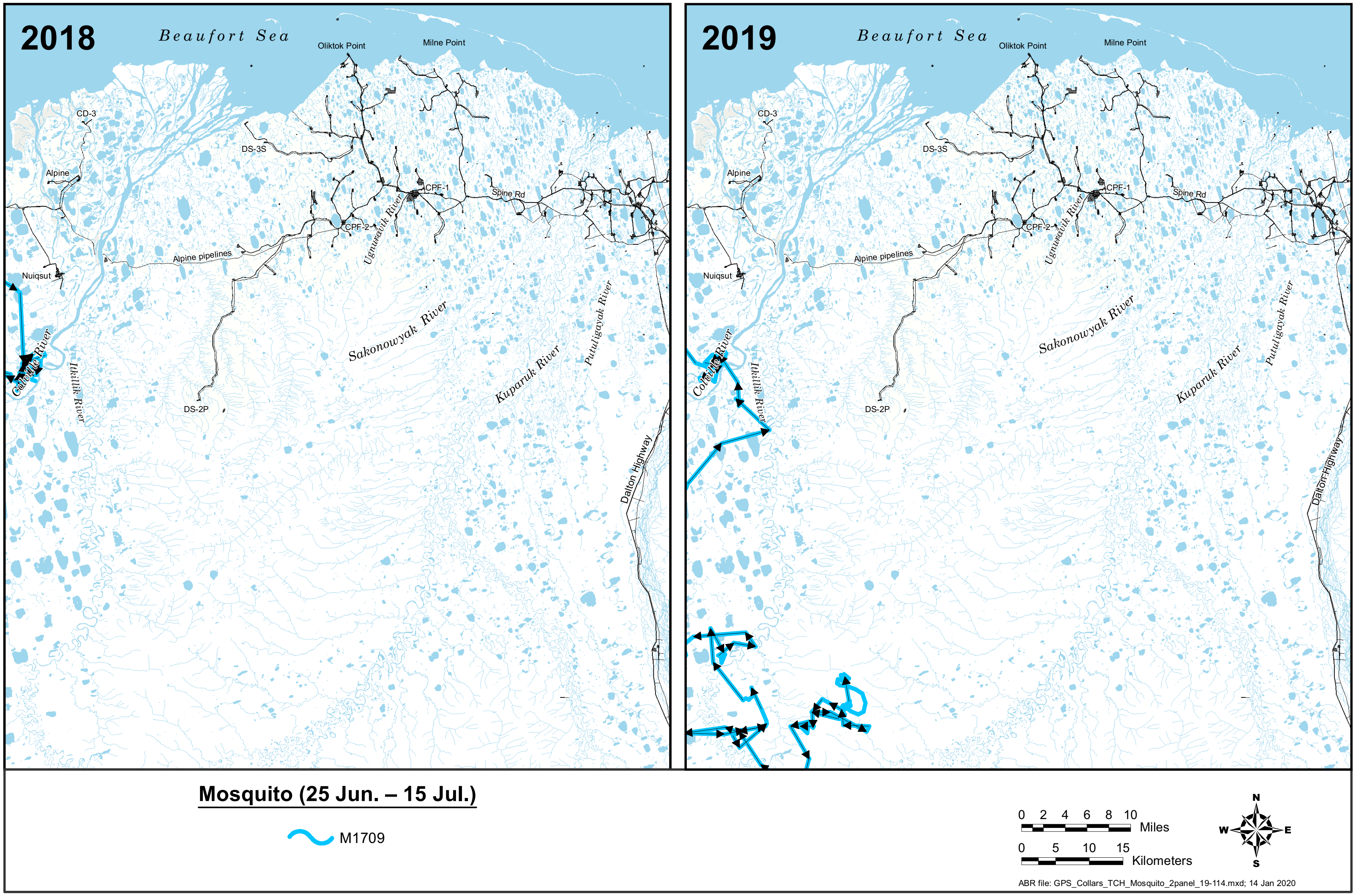
Appendix H. Movements of GPS-collared female caribou of the Teshekpuk Caribou Herd in the Greater Kuparuk Area during winter, 2018 and 2019.



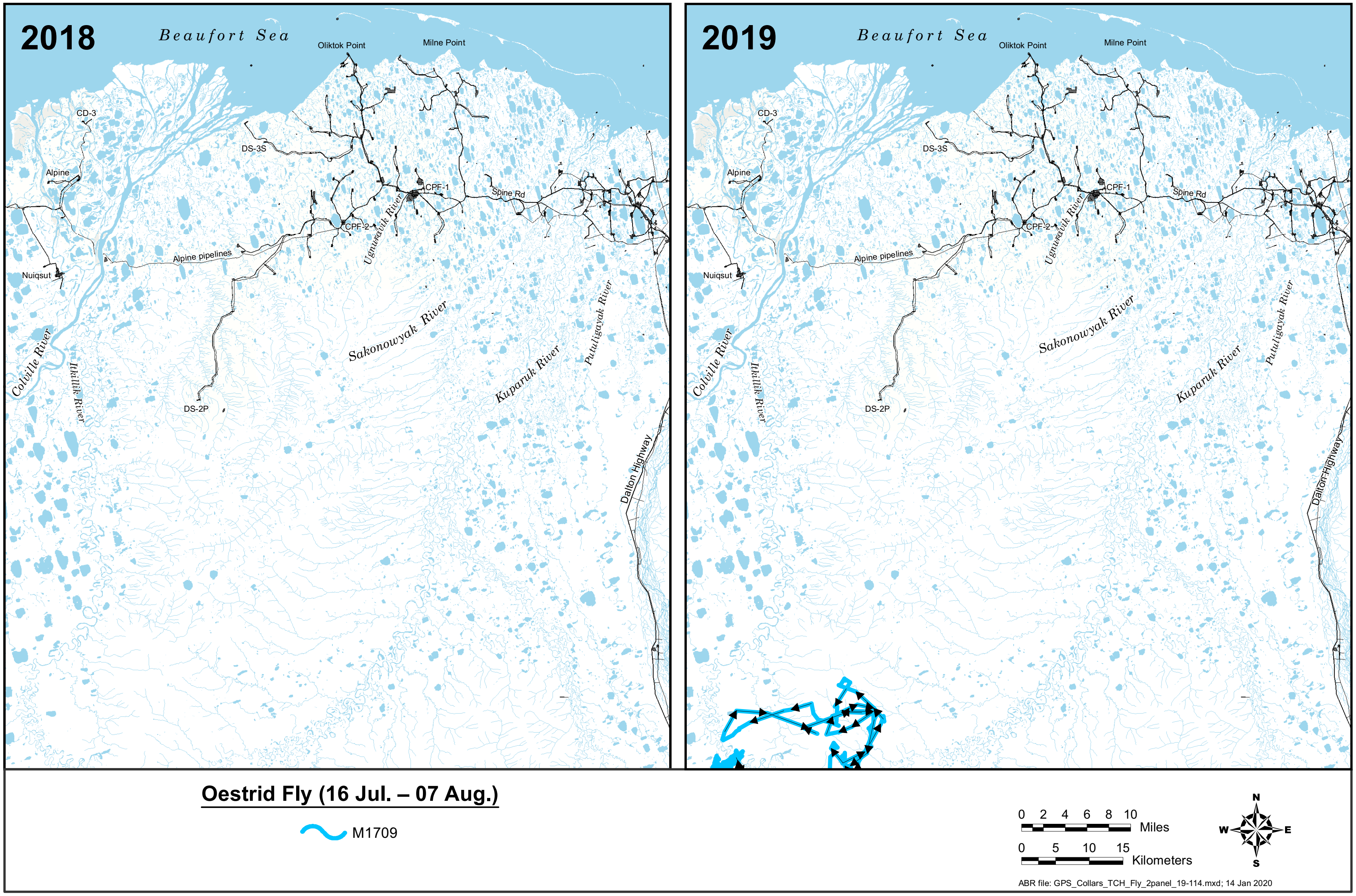
Appendix I. Movements of GPS-collared female caribou of the Teshekpuk herd in the Greater Kuparuk Area during spring migration in 2018 and 2019.



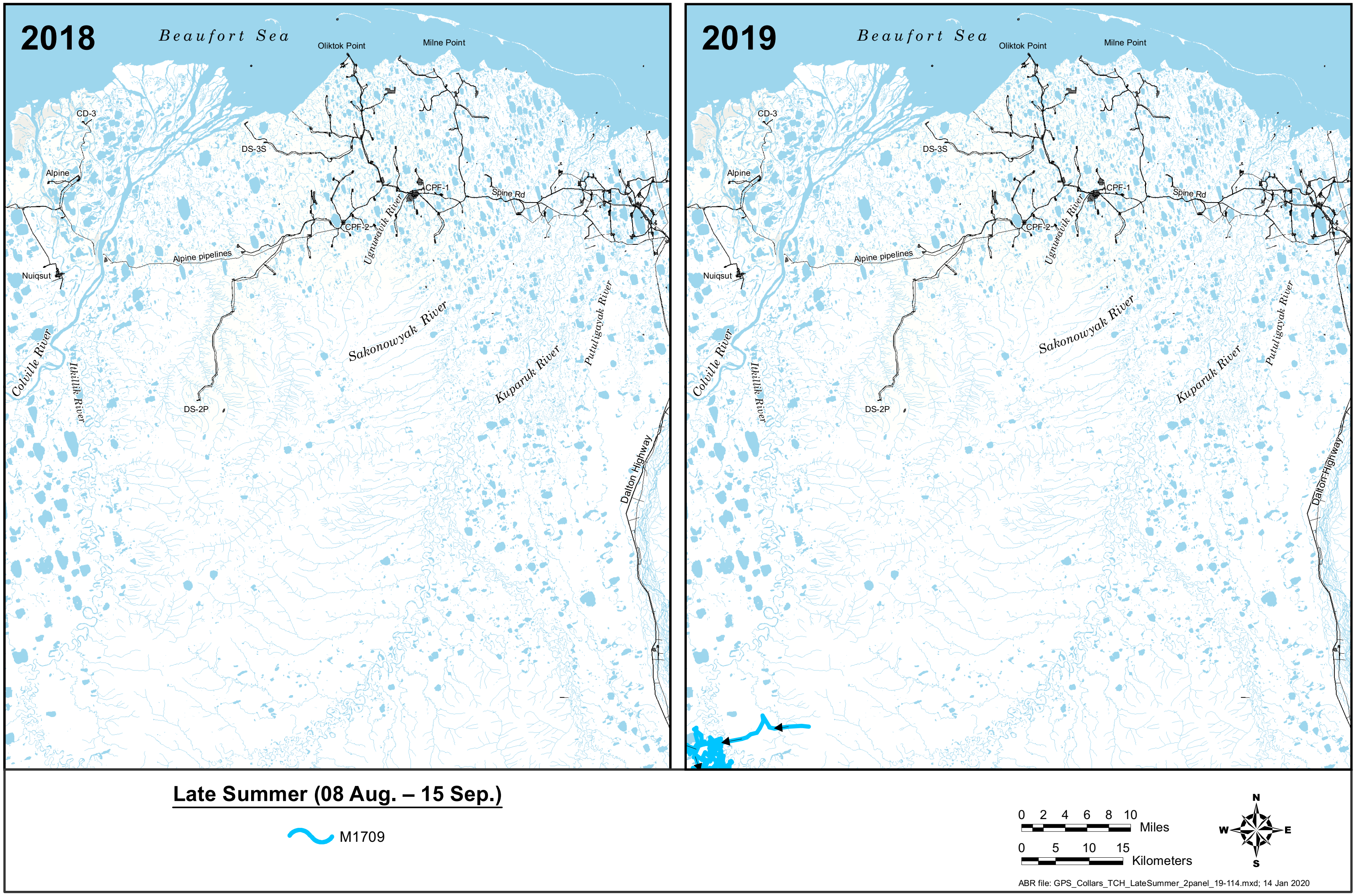
Appendix J. Movements of GPS-collared female caribou of the Teshekpuk Herd in the Greater Kuparuk Area during the 2018 and 2019 calving and postcalving seasons.



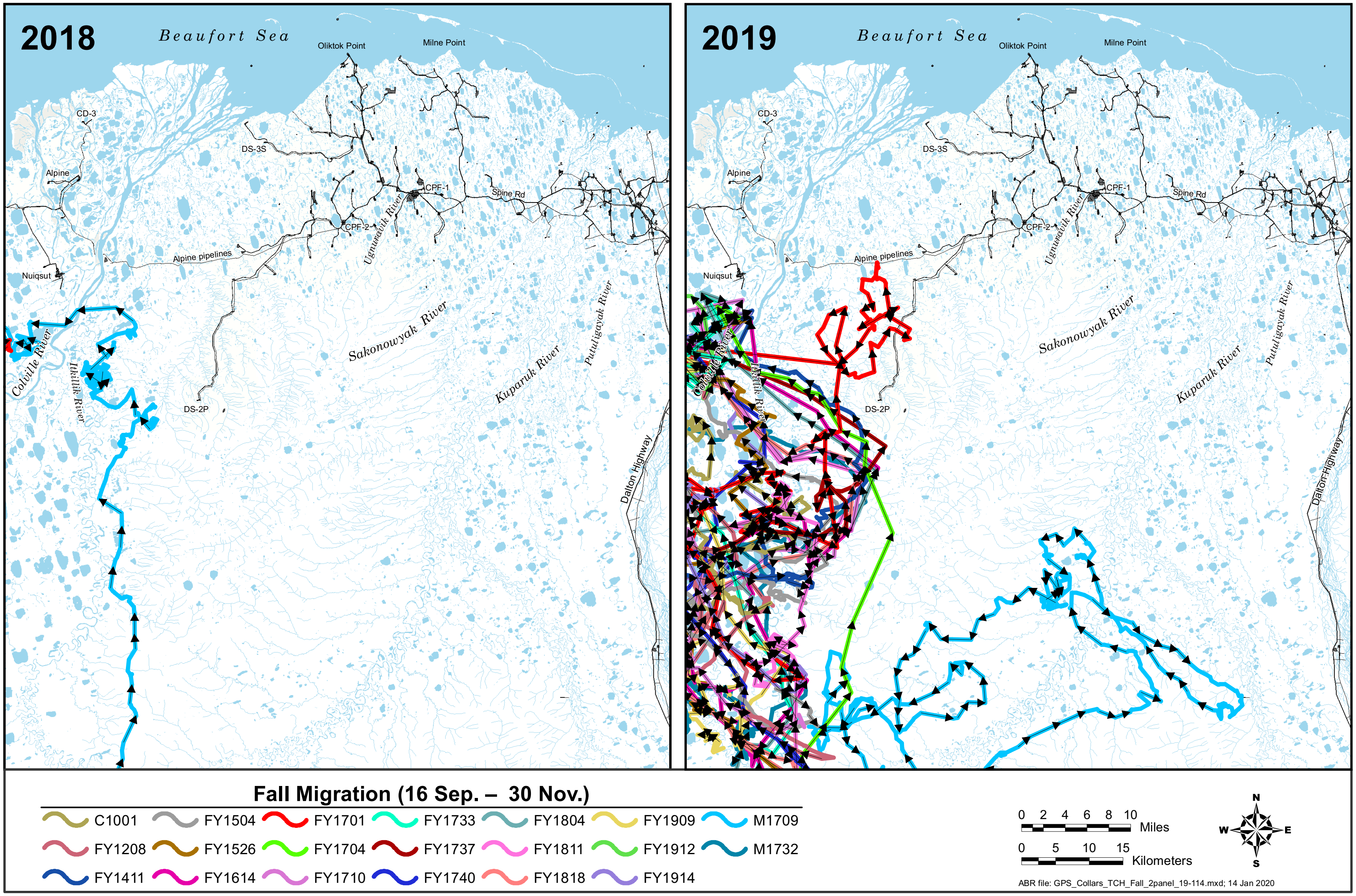
Appendix K. Movements of GPS-collared female caribou of the Teshekpuk Herd in the Greater Kuparuk Area during the 2018 and 2019 mosquito seasons.



Appendix L. Movements of GPS-collared female caribou of the Teshekpuk Herd in the Greater Kuparuk Area during the 2018 and 2019 oestrid fly seasons.



Appendix M. Movements of GPS-collared female caribou of the Teshekpuk Herd in the Greater Kuparuk Area during late summer in 2018 and 2019.



Appendix N. Movements of GPS-collared female caribou of the Teshekpuk Herd near the Greater Kuparuk Area during fall migration in 2018 and 2019.