



Caribou Vital Sign Annual Report for the Arctic Network Inventory and Monitoring Program

September 2021–August 2022

Natural Resource Report NPS/ARCN/NRR—2022/2484



ON THE COVER

Caribou in spring, south of Ambler, Alaska.

NPS / KYLE JOLY

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Executive Summary

Caribou (*Rangifer tarandus*) are an integral part of the ecological and cultural fabric of northwest Alaska. Western Arctic Herd (WAH) caribou roam over this entire region, including all 5 Arctic Network (ARCN) Inventory and Monitoring Program's National Park units. Conservation of healthy caribou populations are specifically mentioned within the enabling legislation (Alaska National Interested Lands Conservation Act or ANILCA) for 3 of these park units and is of importance to subsistence hunters. Caribou are, by far, the most abundant large mammal in northwest Alaska and are famous for their long-distance migrations and large population oscillations. For these reasons, the ARCN parks chose WAH caribou as a Vital Sign for long-term monitoring.

This report documents the monitoring results of this Vital Sign during its 13th year (September 2021–August 2022) of implementation. Results from the previous years of monitoring are also included for ease of comparison. Periodic syntheses of these data will be performed and reported on as appropriate. National Park Service (NPS) monitoring of the WAH is done in conjunction and cooperation with the Alaska Department of Fish and Game (ADFG). Thanks to a 2015 data sharing agreement, the report includes data funded by the ADFG dating back to September 2013. That particular year was chosen as it represents when ADFG started deploying a substantial number of GPS collars on an 8-hour relocation schedule.

Monitoring of the herd relies heavily on the use of Global Positioning System (GPS) radio telemetry collars that are capable of transmitting location data to a satellite. Given the extremely remote area that the WAH inhabits, this system provides the most efficient and accurate means to track individual caribou. These data are utilized to monitor the timing and location of migrations, as well as seasonal distributions of WAH caribou. Monitoring movement and the phenology of movement is perhaps the simplest means to track the influence of climate change, natural perturbations, development, and other potential impacts on a species—an analysis of which is outside the scope of this current report.

This report also documents the NPS commitment and involvement with the WAH Working Group. The group is composed of important stakeholders including representatives for rural villages, sport hunters, conservationists, hunting guides, hunting transporters, and reindeer herders. In addition, all the agencies charged with managing the WAH, including the ADFG, NPS, FWS and BLM, serve as advisors to the group. Information gathered by the Caribou Vital Sign monitoring program are intended to supplement and complement existing data streams gathered by the other cooperating agencies and will be important in future management decisions.

Acknowledgments

The ADFG, BLM, FWS, and students of the regional high schools helped with collar deployments over the years. We thank the NPS GIS Team for the comprehensive technical database and GIS assistance that made this report possible over the past 13 years. Monitoring a herd that ranges over a vast and remote landscape provides numerous challenges, and we thank ADFG biologists Alex Hansen, Christie Osburn, Nicole Edmison, and others for their continued assistance and collaboration. We thank Alex Hansen, Mat Sorum, and Eric Wald for reviewing drafts that improved this report.

List of Acronyms

ADFG: Alaska Department of Fish and Game

ANILCA: Alaska National Interest Lands Conservation Act

ARCN: Arctic Network Inventory and Monitoring Program

BELA: Bering Land Bridge National Preserve

BLM: Bureau of Land Management

CAKR: Cape Krusenstern National Monument

FWS: US Fish and Wildlife Service

GAAR: Gates of the Arctic National Park and Preserve

KOVA: Kobuk Valley National Park

NOAT: Noatak National Preserve

NPS: National Park Service

WAH: Western Arctic Herd

Introduction

This report is the latest in a series of annual reports documenting long-term monitoring of the Western Arctic Herd (WAH). Caribou (*Rangifer tarandus*) were chosen to be a Vital Sign of the National Park Service's (NPS) Arctic Network (ARCN) Inventory and Monitoring Program because they: (1) are an extremely important subsistence species that occur within all ARCN park units (Gates of the Arctic National Park and Preserve (GAAR); Noatak National Preserve (NOAT); Cape Krusenstern National Monument (CAKR), Kobuk Valley National Park (KOVA) and Bering Land Bridge National Preserve (BELA)); (2) are specifically identified in the enabling legislation (Alaska National Interest Lands Conservation Act [ANILCA]) of GAAR, KOVA and NOAT to be managed for natural and healthy populations; (3) directly impact reindeer and reindeer herders in BELA; (4) are considered good indicators of the condition of park ecosystems because they consume lichens and fungi (which derive their nutrients from the atmosphere and thus are sensitive to pollutants) making them good bio-indicators of environmental toxins; (5) are of great importance to park visitors because of the opportunities to view caribou in Alaskan parks; (6) are an example of the ever more rare natural phenomenon of long-distance migration of a large land mammal; (7) are an integral part of the ecology and social fabric of northwest Alaska; and, (8) can be compared with national and international caribou datasets across the Arctic region to gain insight into the ecology of the WAH or Arctic ecology in general.

Of the 4 Alaska Arctic caribou herds, only the WAH regularly utilizes all 5 ARCN park units (Figure 1). WAH caribou are of great importance to people for both consumptive and non-consumptive purposes, and to the ecosystem as a whole. At an estimated population size of over 490,000 animals in 2003 (Dau 2007), the WAH is a significant ecological force in northwest Alaska. The herd rather steadily declined from its 2003 apex to 164,000 in 2022 (Alex Hansen, *personal communication*, 2022). More robust measures may be needed to help slow or reverse this nearly 20-year decline. The heritage and traditions of Alaska Natives in approximately 40 subsistence-based communities in the region have been shaped by the availability of these caribou (Western Arctic Herd Working Group 2019). The availability of the WAH also affects the economy of this region. The presence and relative abundance of WAH caribou have substantial impacts on the populations of wolves, bears, and wolverines in the area. Caribou integrate regional environmental conditions in northwestern Alaska because of their migratory nature. Caribou may have substantial effects on plant and lichen communities and by extension to wildlife communities, either directly through browsing and grazing, or indirectly through biogeochemical cycling. While the primary objectives of monitoring will be to track the distribution and migrations of caribou, a variety of ancillary data (e.g., survival) will be obtained in the monitoring process that are likely to have great value for park and wildlife management, ungulate research, and evaluating long-term changes in the WAH.

This report documents the results of ARCN caribou monitoring for the 13th year (September 2021–August 2022) of the program. The caribou monitoring protocols contain the detailed methodology employed to obtain the results presented here (Joly et al. 2012). Periodic syntheses of these data will be performed and reported on as appropriate.

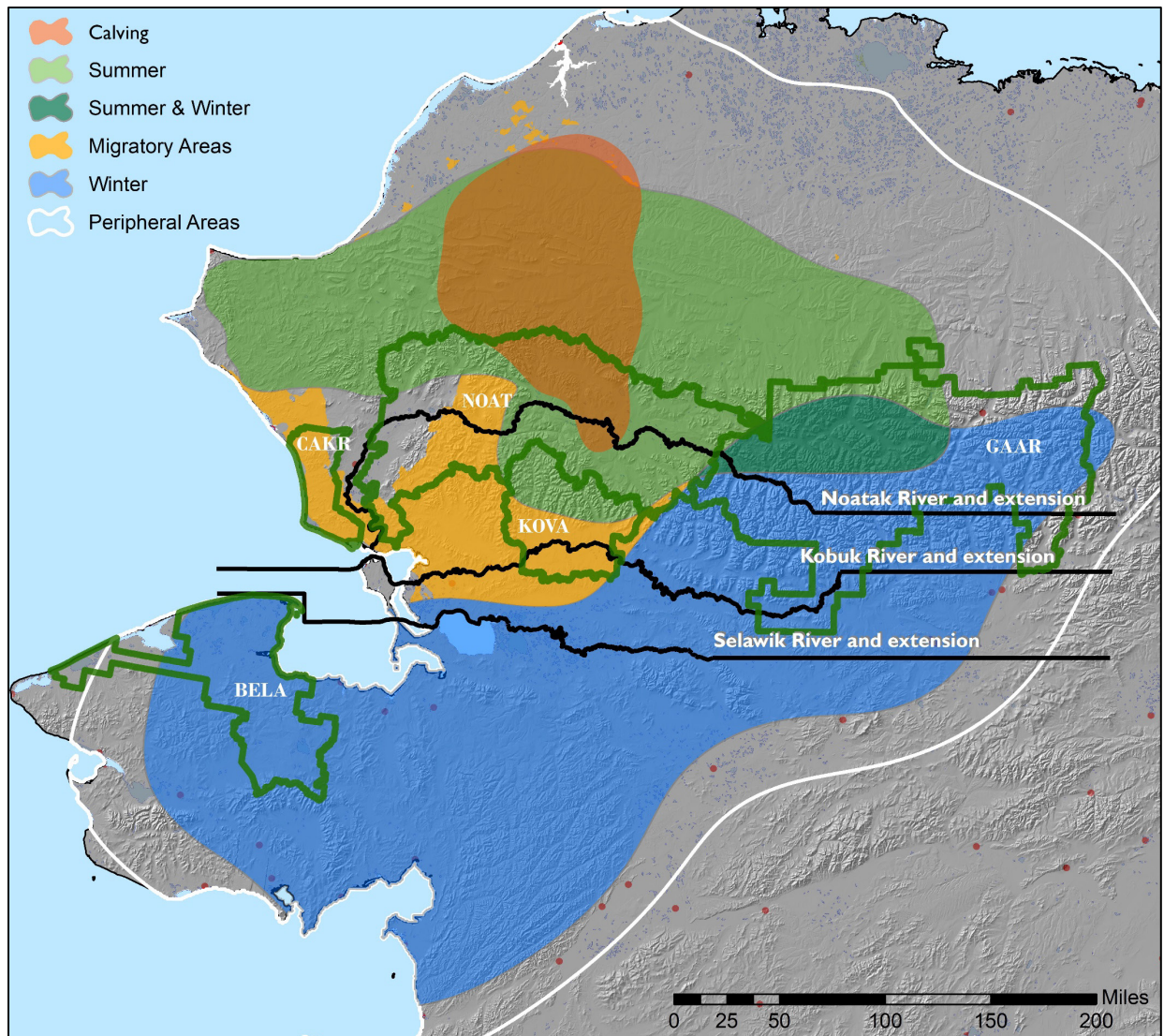


Figure 1. Study area and the range of the Western Arctic Herd. Generalized range data courtesy of the Alaska Department of Fish and Game. The red dots indicate villages and towns. Black lines depict key rivers. These rivers have been artificially extended to the east to help track the timing of caribou migratory movements. Green polygons are NPS units.

Measurable Objectives – Core Program

- Capture and radio-collar WAH caribou to maintain a sample size of 30–40 GPS collars.
- Obtain frequent ($>2/\text{day}$) location data via GPS-satellite telemetry.
- Membership, attendance and activity on the WAH Working Group Technical Committee.
- Attendance and involvement at WAH Working Group meetings.
- Obtain herd and environmental condition data by radio tracking.
- Define seasonal ranges (i.e., calving, insect relief, summer, winter).
- Define migratory corridors.
- Detect changes in range distribution over time.
- Detect changes in adult survivorship over time.
- Detect changes in migration routes and movement phenology over time.
- Detect changes in the location and timing of calving (using GPS data).

Methods

The methods outlined here are provided to give the reader a brief summary of the methods and analyses that were conducted to monitor the WAH. Detailed methodologies used to develop this report can be found in the ARCN Caribou Vital Sign Protocol (Joly et al. 2012, available at <https://www.nps.gov/im/arcn/caribou.htm>).

Collar Deployments

For decades, all WAH collars had been deployed at Onion Portage, KOVA, from early September to early October. Caribou were captured by hand using motorboats to intercept animals as they swim across the Kobuk River. However, because only a total of 7 collars were deployed in 2017 and 2018 combined, due to fewer caribou migrating, additional collars have been deployed using net gun techniques starting in April 2019. Both river and net gun captures used protocols approved by a State of Alaska Institutional Animal Care and Use Committee (IACUC). NPS collars were only deployed on adult (> 2 years old) female caribou. Capture operations are led by ADFG, in conjunction and cooperation with the NPS. Every collar is equipped with GPS technology that can transmit position data to satellites that can regularly be downloaded in an office setting. Collars are programmed to collect locations at least every 8 hours throughout the year (i.e., 1095 relocations per caribou per {non-leap} year for the 8-hour interval). For collars collecting relocations more frequently than every 8 hours, the data were subsampled to 8 hours for this report to provide consistency among individuals.

Year One Survivorship

Survivorship reported here merely represents how many caribou that were collared in this reporting period (i.e., September 2021–August 2022) remained alive through the end of the monitoring year (i.e., August 2022). The number that survived plus the number that died will equal 100% (i.e., collar malfunctions are not included). Survivorship of collars deployed in the spring, via netting, is not directly comparable to the survivorship of collars deployed in the fall, using motorboats.

Seasonal Range Use

Both 50% and 95% utilization distribution kernels (Worton 1989) were produced using ArcGIS and ArcGIS tools developed by the NPS (see Joly et al. 2012). Kernels were developed for the year (September 1–August 31) and for the following seasons: winter (December 1–March 31), calving period (May 28–June 14), insect relief (June 15–July 14), and late-summer (July 15–August 31). Kernels were created for individual caribou each season and then compiled so that individuals, regardless of the number of relocations per individual, were weighted evenly (i.e., normalized to a common scale). Results from every year of monitoring are also included for ease of comparison. The Least Squares Cross Validation (LSCV) smoothing parameter (Worton 1989) was utilized for all kernels (Joly et al. 2012). In fall, all collars were deployed at Onion Portage in KOVA, while in spring, collar deployments were clustered in areas relatively near aviation bases. As a result, their initial distribution was not considered representative of the entire herd. At calving, the collared caribou were considered mixed with the herd based on the distribution of collars deployed in

previous years (Prichard et al., in press). Range use and distribution analyses only considered collared caribou that were mixed with the rest of the herd.

Distribution and Movements

The GPS radiocollar data were used to determine what percentage of GPS-collared caribou were found in each ARCN park unit during summer (June, July and August), fall (September, October and November), winter (December, January, February and March) and spring (April and May). ArcGIS was used to determine distances and velocities between successive GPS relocations. Annual distance moved was the sum of the distances between successive GPS relocations.

Migration Phenology

ArcGIS was used to analyze the GPS data to determine when individual caribou crossed the Selawik, Kobuk and Noatak Rivers on their northward (“spring”; typically, between April 1–June 15) and southward (“fall”; typically September 1–November 30) migrations. The percentage of GPS-collared caribou that crossed each specified river, and the average date they crossed were calculated.

Migration Routes

A histogram of the longitudes at which the collared caribou crossed the Noatak River (the first major river crossed) heading southward was developed as a visual aid to understand the geographic distribution of the fall migration. Categories of longitudes are based on equal numbers of river miles rather than equal distribution of longitudes to account for the primarily north-south direction of the river at its mouth. The minimum distance, and its date of occurrence, between individual GPS-collared caribou and the villages of Noatak, Shungnak and Selawik, and Onion Portage, were calculated using ArcGIS for spring (April 1–May 31) and fall migrations (September 1–November 30).

Results

Collar Deployments

With continued late migrations and relatively few caribou crossing the Kobuk River in fall, we again relied upon net gunning to deploy collars. Thirty-three (33) GPS collars were deployed via net gunning in the upper Kobuk River drainage from April 1st through the 2nd, 2022. Since the inception of this project, over 800,000 GPS locations have been gathered at an 8-hour interval (Table 1). It is expected that about 12–15 NPS collars will need to be deployed annually to maintain an adequate sample size due to mortalities and the lifespan of GPS collars (~8 years). We do not collect females with calves at heel data during spring captures.

Table 1. Collar deployment overview. Number and survivorship (%) of GPS-satellite collars deployed on adult (>2 years old) female caribou, number of collared caribou that appeared to be accompanied by a calf, and number of GPS locations acquired at an 8-hour interval.

Monitoring Year	Deployment Season	Collars Deployed	Survived 1st Year (%)	Died (%)	Collar Failures (%)	With Calf (%)	# Collars W/ Complete Year of Data	Total GPS Locations
2021–2022^a	Combined	33	–	–	–	–	56	90,619
2021–2022	Spring	33	32 (100 %)	0 (0 %)	1 (3.0 %)	NA	–	–
2021–2022	Fall	0	–	–	–	–	–	–
2020–2021^a	Combined	48	–	–	–	–	50	79,517
2020–2021	Spring	48	38 (79.2 %)	10 (20.8 %)	0 (0.0 %)	NA	–	–
2020–2021	Fall	0	–	–	–	–	–	–
2019–2020^a	Combined	42	–	–	–	–	70	79,161
2019–2020	Spring	0	–	–	–	–	–	–
2019–2020	Fall	42	35 (85.4 %)	6 (14.6 %)	1 (2.4 %)	18 (42.9 %)	–	–
2018–2019^a	Combined	33	–	–	–	–	32	52,044
2018–2019	Spring	30	18 (90.0 %)	2 (10.0 %)	10 (33%)	6 (20 %)	–	–
2018–2019	Fall	3	3 (100 %)	0 (0%)	0 (0.0 %)	2 (66.7 %)	–	–
2017–2018^a	Fall	4	3 (75.0 %)	1 (25.0 %)	0 (0.0 %)	3 (75.0 %)	52	63,277
2016–2017^a	Fall	25	22 (88.0 %)	3 (12.0 %)	0 (0.0 %)	19 (76.0 %)	77	86,651
2015–2016^a	Fall	38	35 (92.1 %)	3 (7.9 %)	0 (0.0 %)	28 (73.7 %)	79	76,284
2014–2015^a	Fall	35	28 (80.0 %)	7 (20.0 %)	0 (0.0 %)	24 (68.6 %)	52	62,076
2013–2014^a	Fall	25	19 (76.0 %)	6 (24.0 %)	0 (0.0 %)	11 (44.0 %)	46	55,971
2012–2013^a	Fall	12	8 (66.7 %)	4 (33.3 %)	0 (0.0 %)	7 (58.3 %)	34	42,965
2011–2012^a	Fall	14	10 (76.9 %)	3 (23.1 %)	1 (7.1 %)	10 (71.4 %)	36	46,706
2010–2011^a	Fall	15	13 (86.7 %)	2 (13.3 %)	0 (0.0 %)	10 (66.7 %)	39	48,892
2009–2010^a	Fall	39	31 (81.6 %)	7 (18.4 %)	1 (2.6 %)	25 (64.1 %)	31	39,086
Total		363	–	–	–	157 (62.3 %)	654	823,249

^a Bold text indicates row containing an entire year's worth of data.

Year One Survivorship

Survival of the caribou collared in spring 2022 through the end of August was 100%. Spring capture cohorts only have to survive 6 months to reach the end of the reporting year, as opposed to 12 months for fall captures, thus, one would expect survival of spring capture cohorts to be greater than those of fall capture cohorts. The survival rate for this monitoring rate, nevertheless, is the highest reported and highest possible. It also is an increase from previous spring capture results (Table 1). For the past 13 years of monitoring, there are over 650 datasets that contain a complete year of locations.

Seasonal Range Use

The 50% and 95% utilization distributions (kernels) are depicted for the following ranges: 2021–2022 annual range (Table 2; Figures 2a and 2b; only for caribou collared from 2009–2021; however most caribou collared before 2015 dropped their collars prior to the end of the reporting year and were not used), 2021–2022 winter range (Table 3; Figures 3a and 3b; only for caribou collared from 2009–2021), 2022 calving grounds (Table 4; Figures 4a and 4b), 2022 insect relief areas (Table 5; Figures 5a and 5b), and 2022 summer range (Table 6; Figures 6a and 6b). The 50% kernels are also referred to as “core areas”. CAKR, GAAR, KOVA, and NOAT were utilized by collared WAH caribou during this reporting period, but BELA was not. The annual distribution was fairly different than most years but perhaps most similar to 2012–2013. It was by far the smallest area covered by an annual distribution. The core area was primarily just south of the village of Ambler, where much of the herd wintered. The 2021–2022 winter distribution also covered the least amount of area for any monitoring year. This was due to the tight cluster of collared animals just south of Ambler. During calving, collared caribou were primarily north of park units and in the general calving grounds. The calving distribution was similar to a number of other years, including 2020, 2011, and 2010. The 2022 insect relief area was generally consistent with past years, with the distinction that the herd did not move into the Brooks Range during this period and remained along the western coast near Cape Lisburne. Caribou distribution during late summer was broadly dispersed across the western portion of North Slope and Brooks Range, relatively similar to previous years except for 2020.

Table 2. Annual range areas of Western Arctic Herd caribou (95% and 50% kernels for September 1–August 31).

Year	Sample Size	95% kernel area (km2)	50% kernel area (km2)
2021–2022	51	32118	1081
2020–2021	51	102321	4468
2019–2020	37	174149	16045
2018–2019	32	129884	5523
2017–2018	52	129123	5758
2016–2017	55	100312	2493
2015–2016	44	101094	6387
2014–2015	22	48860	3375
2013–2014	25	46678	1618
2012–2013	34	72778	2169
2011–2012	36	125906	4374
2010–2011	26	136415	6058

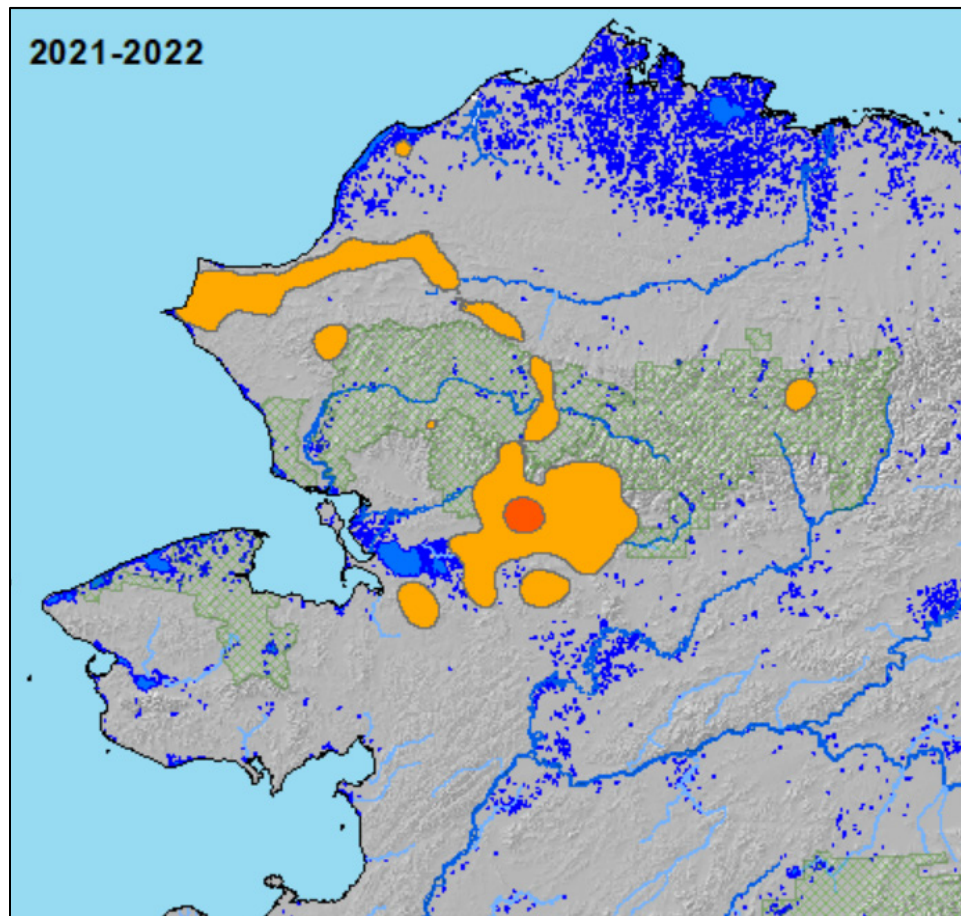


Figure 2a. 2021–2022 annual (September 1–August 31) range use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are NPS units.

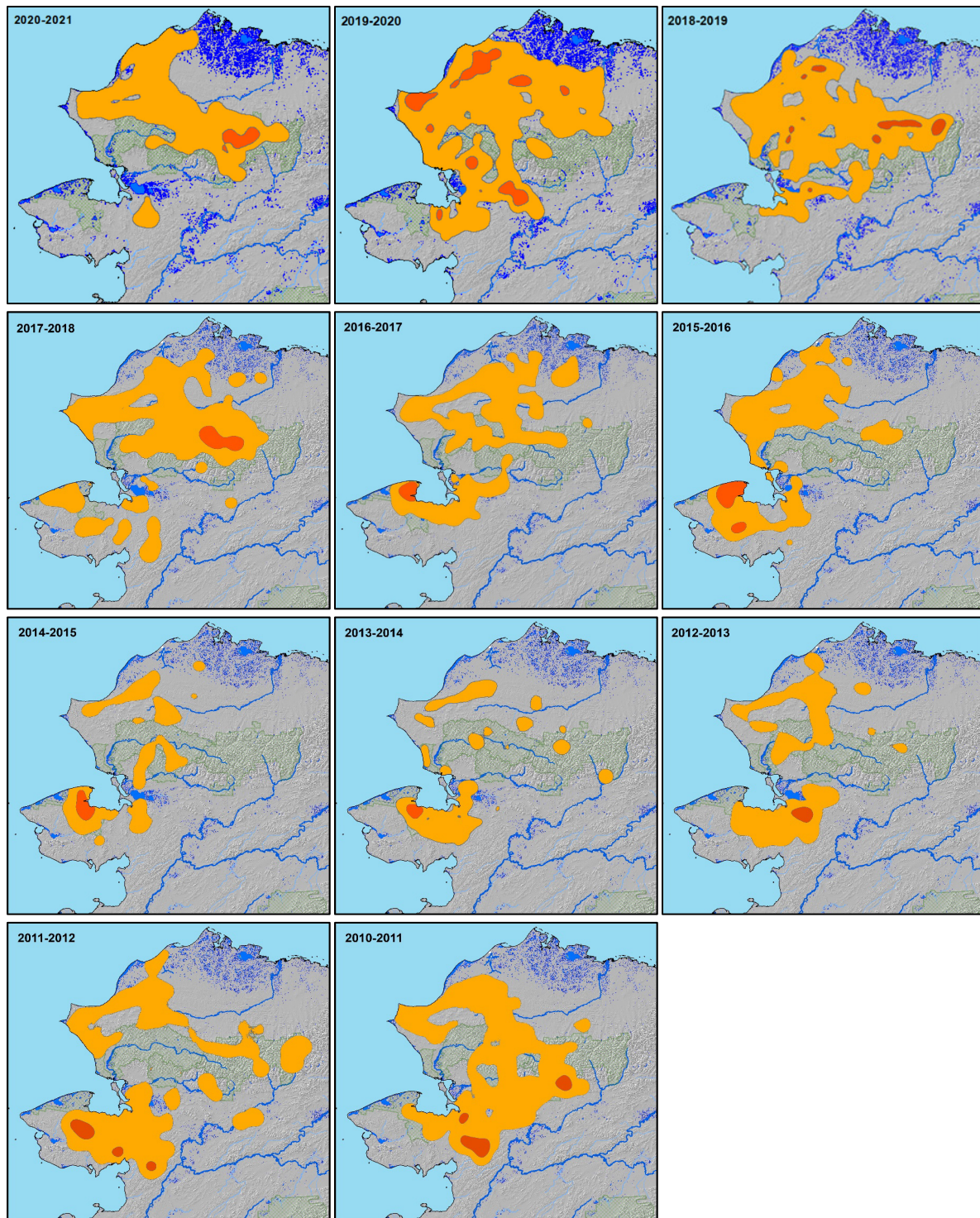


Figure 2b. 2010–2021 annual (September 1–August 31) range use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are NPS units.

Table 3. Winter range areas of Western Arctic Herd caribou (95% and 50% kernels for December 1–March 31).

Year	Sample Size	95% kernel area (km2)	50% kernel area (km2)
2021–2022	68	1913	82
2020–2021	58	5002	23
2019–2020	40	11757	274
2018–2019	40	8191	84
2017–2018	63	9814	67
2016–2017	67	10321	538
2015–2016	48	6210	151
2014–2015	36	5386	133
2013–2014	35	4338	105
2012–2013	30	5801	131
2011–2012	40	3933	86
2010–2011	27	9170	274

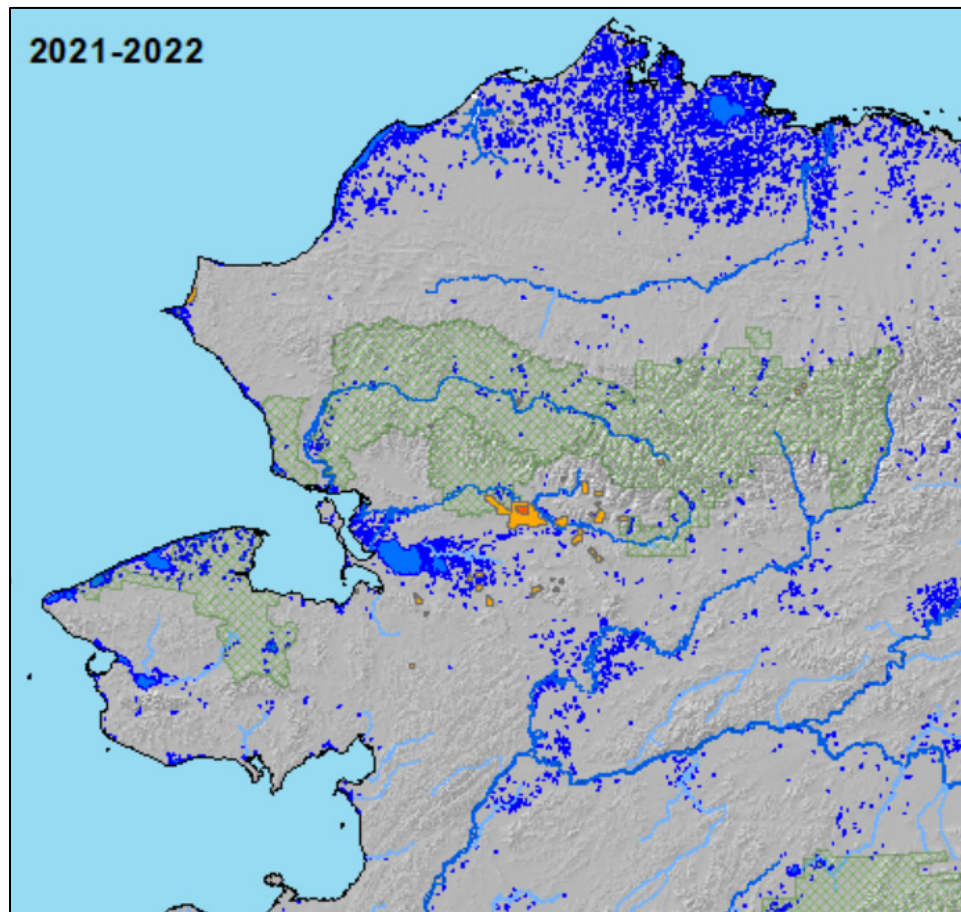


Figure 3a. 2021–2022 winter (December 1–March 31) range use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units.

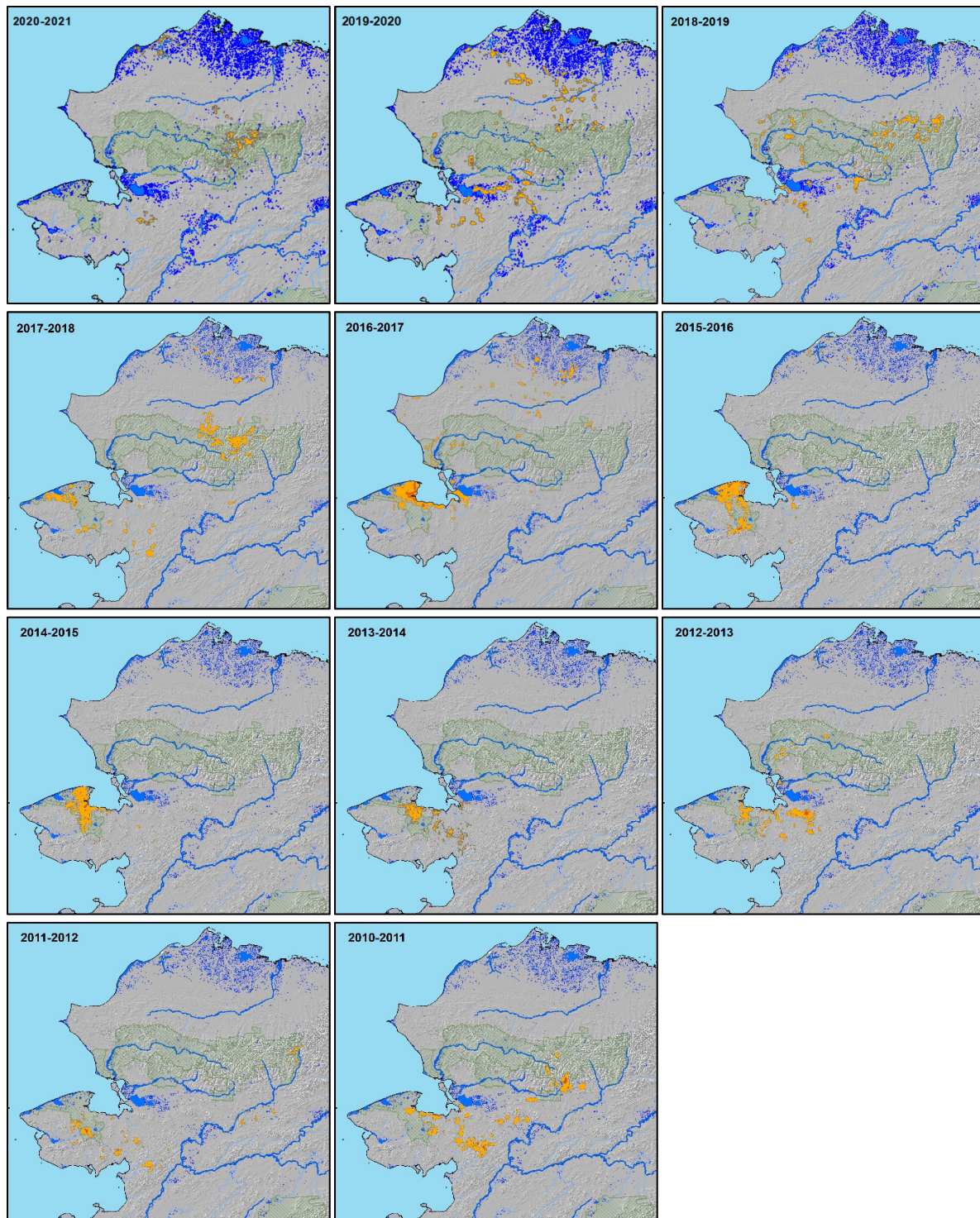


Figure 3b. 2010–2021 winter (December 1–March 31) range use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units.

Table 4. Calving period areas of the Western Arctic Herd (95% and 50% kernels for May 28–June 14).

Year	Sample Size	95% kernel area (km2)	50% kernel area (km2)
2022	101	13660	460
2021	78	8654	505
2020	70	14370	651
2019	58	4712	355
2018	54	9996	375
2017	84	7511	364
2016	82	6790	806
2015	54	5127	193
2014	56	4514	111
2013	40	21870	749
2012	38	31219	2118
2011	42	11429	291
2010	33	18362	707

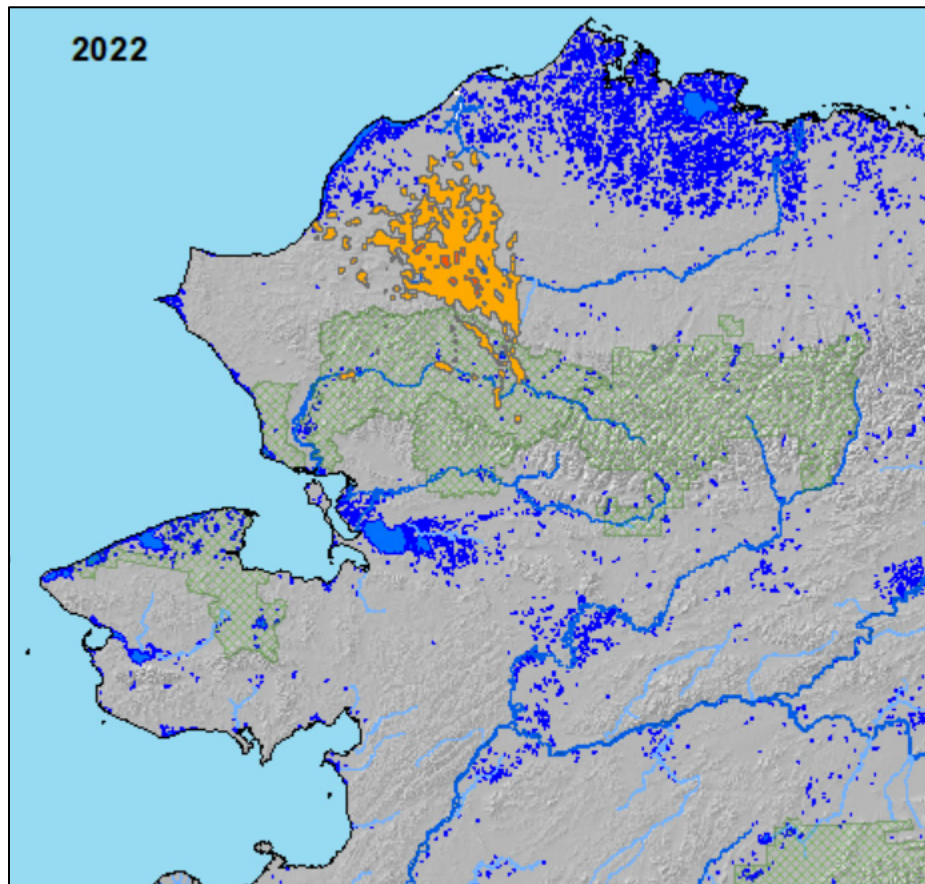


Figure 4a. 2022 calving period (May 28–June 14) area use by Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units. These kernels include all (both parturient and non-parturient) GPS-collared cows.

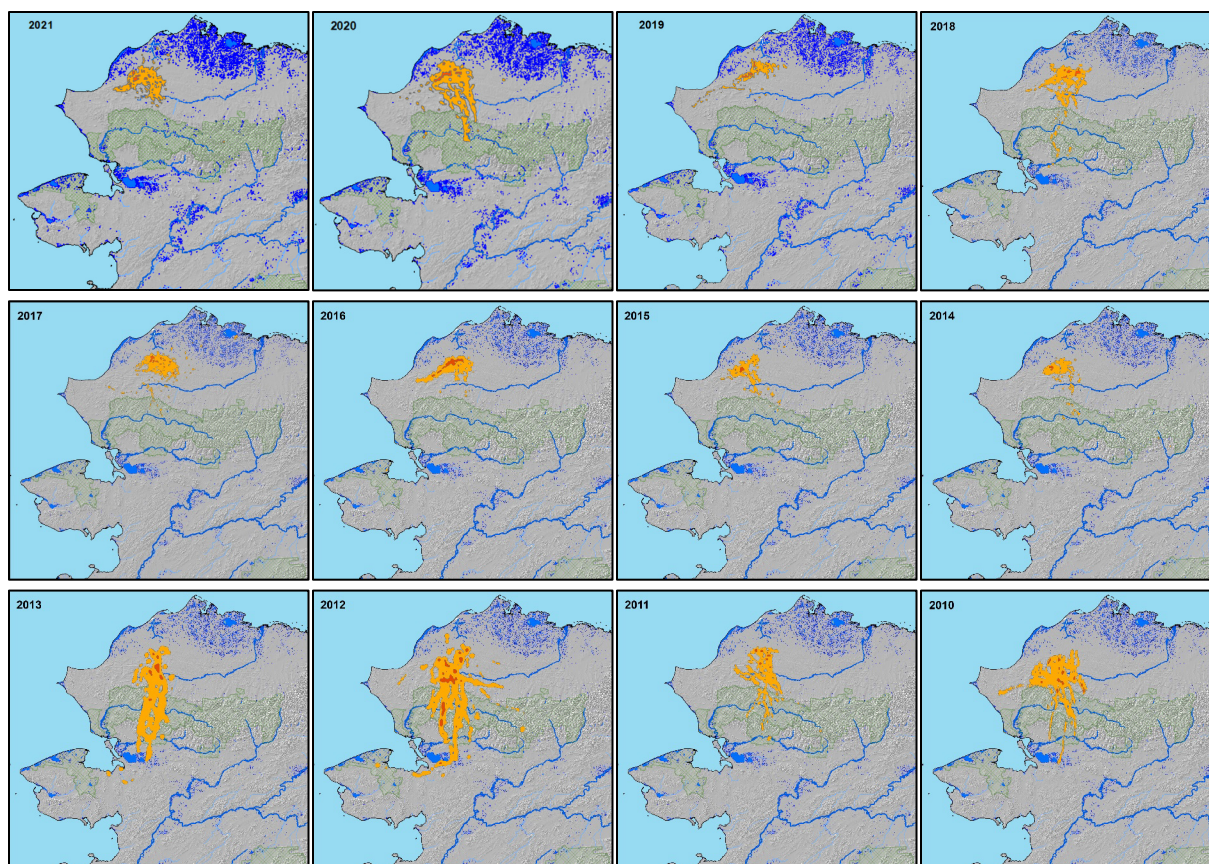


Figure 4b. 2010–2021 calving period (May 28–June 14) area use by Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units. These kernels include all (both parturient and non-parturient) GPS-collared cows.

Table 5. Insect relief areas of Western Arctic Herd caribou (95% and 50% kernels for June 15–July 14).

Year	Sample Size	95% kernel area (km2)	50% kernel area (km2)
2022	98	18256	3241
2021	77	19924	3616
2020	70	16457	1938
2019	57	19746	3465
2018	54	22787	6033
2017	80	25874	4858
2016	82	24722	7190
2015	52	20537	3834
2014	47	17214	4226
2013	36	22043	3688
2012	38	24476	5505
2011	40	20734	2737
2010	33	31142	3468

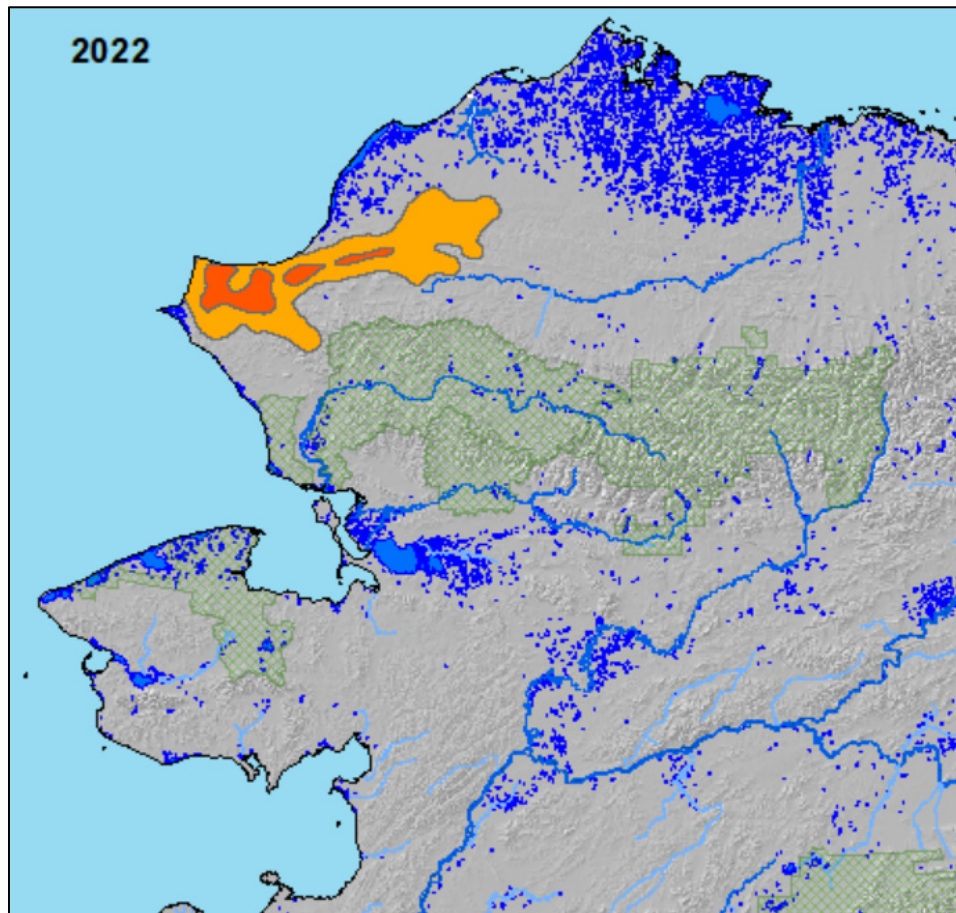


Figure 5a. 2022 insect relief (June 15–July 14) area use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units.

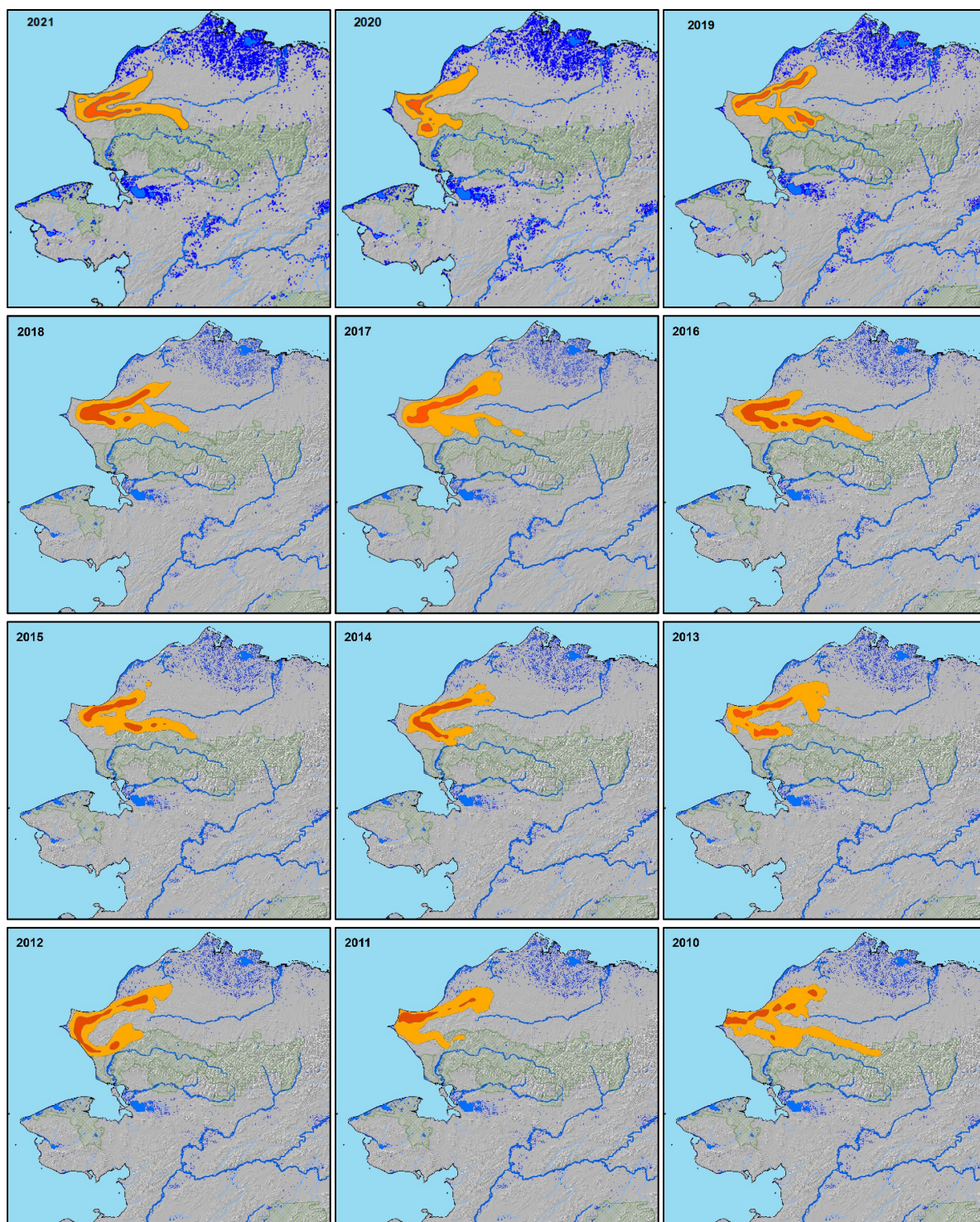


Figure 5b. 2010–2021 insect relief (June 15–July 14) area use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units.

Table 6. Late-summer areas of Western Arctic Herd caribou late-summer (95% and 50% kernels for July 15–August 31).

Year	Sample Size	95% kernel area (km2)	50% kernel area (km2)
2022	88	41671	2368
2021	72	46120	936
2020	68	19945	1104
2019	53	27437	243
2018	52	32126	432
2017	78	58281	4807
2016	81	47168	937
2015	51	44808	888
2014	46	53809	2687
2013	36	35253	359
2012	38	49736	2236
2011	39	64807	4373
2010	31	43859	2914

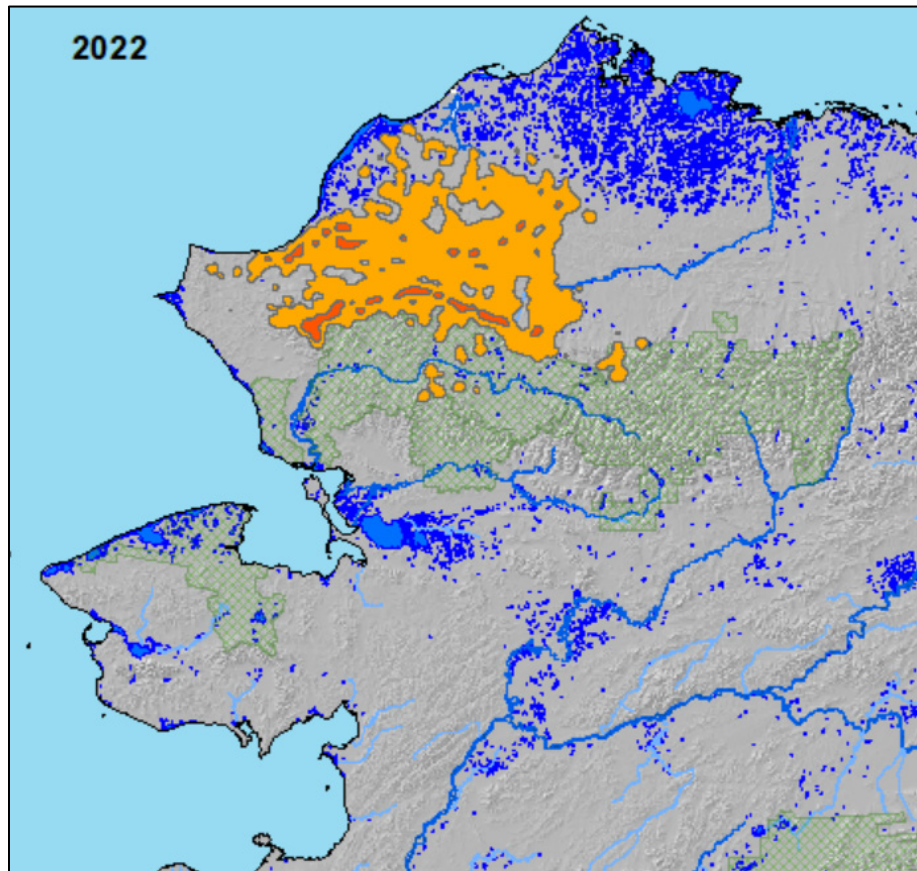


Figure 6a. 2022 late-summer (July 15–August 31) range use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units.

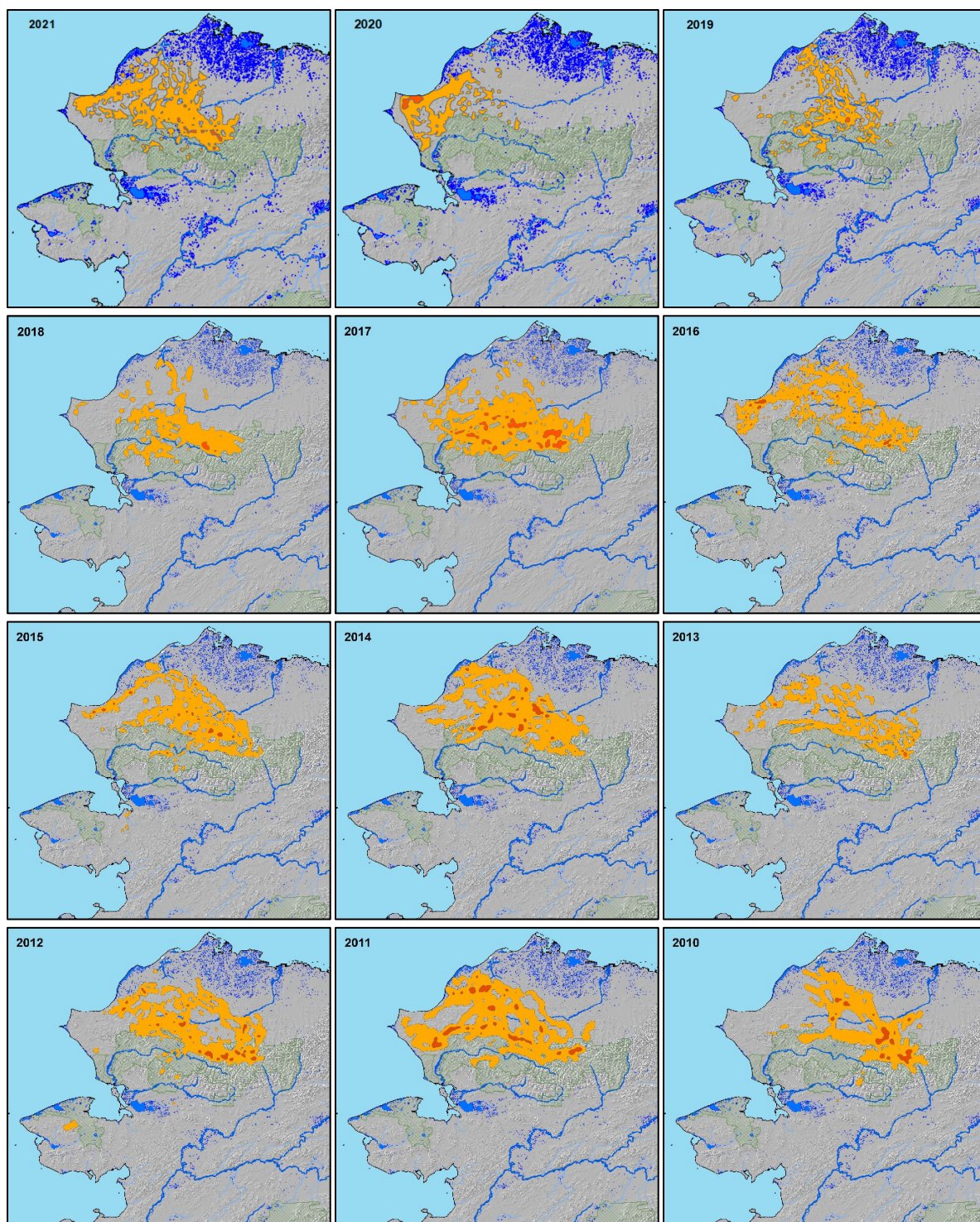


Figure 6b. 2010–2021 late-summer (July 15–August 31) range use of Western Arctic Herd caribou. Light orange depicts the 95% kernel and dark orange the 50% kernel. Green hatched areas are Park units.

Distribution and Movements

Usage of the 5 ARCN Parks is detailed in Tables 7a and 7b. For the 4th year in a row, no collared caribou entered BELA. NOAT again recorded the highest percentage of use compared to other Parks in fall, summer, and spring. While fall use of KOVA was lower than NOAT in 2021, it was the highest use of KOVA in fall ever reported. While migration was later than normal (see Table 9a, below), this finding reveals that the distribution of the herd in fall was more similar to the early years of this monitoring program than more recent years. In early November, 1 caribou moved northward nearly to the town of Utqiagvik (formerly known as Barrow): this is the farthest north any GPS collared WAH caribou has been found since monitoring began. In perhaps the most unusual result for distribution and movements, KOVA recorded the highest use during the 2021–2022 winter, with more than 40 times the previous long-term average use. After no reported winter use of KOVA in the first 8 monitoring years, the winter of 2021–2022 was the 4th consecutive year caribou used the Park. Nearly all the collars within KOVA during winter were in the southeast corner of the Park. NOAT had the highest use in spring 2021. KOVA had the next most use, which was more than double its previous long-term spring average. Summertime use of all 5 ARCN Parks were below to the long-term averages: it was the second lowest reported use of GAAR and the third lowest for KOVA and NOAT, as caribou stayed further north and west than most other summers. WAH caribou continued to exhibit some of the longest migrations and movements of any terrestrial mammal. After 6 straight years of decline, the mean annual distance traveled by all collared caribou this reporting year increased for the second year in a row. It was the greatest amount of movement since the 2015–2016 monitoring year (Table 8). Caribou movements have been shown to be significantly impacted by the Delong Mountain Transportation System (DMTS, commonly referred to as the Red Dog Road; Wilson et al. 2016). Ten collared caribou were in the vicinity of the DMTS during the fall of 2021. The deflection of caribou movement by the road was readily apparent (Figure 7). Only 2 of these 10 individuals eventually crossed the road. Of the 8 that stayed north of the Brooks Range for winter, 3 (37.5%) died, while both that migrated south survived until the end of the monitoring year.

Table 7a. Percent of Western Arctic Herd (WAH) collars that entered different Park units, including Bering Land Bridge National Preserve (BELA), Cape Krusenstern National Monument (CAKR), Gates of the Arctic National Park and Preserve (GAAR), Kobuk Valley National Park (KOVA), and Noatak National Preserve (NOAT). Fall (September, October, and November) and winter (December, January, February, and March). Averages are for all years.

Season	Sample Size	BELA	CAKR	GAAR	KOVA	NOAT
Fall 2021	88	0.0	9.1	15.9	69.3	79.5
Fall 2020	70	0.0	0.0	65.7	22.9	74.3
Fall 2019	52	0.0	13.5	1.9	25.0	38.5
Fall 2018	52	0.0	17.3	40.4	32.7	73.1
Fall 2017	82	15.9	20.7	35.4	41.5	58.5
Fall 2016	77	42.9	11.7	10.4	45.4	63.6
Fall 2015	50	70.0	22.0	4.0	58.0	60.0
Fall 2014	46	82.6	8.7	19.6	50.0	71.7
Fall 2013	35	0.0	8.6	20.0	57.1	88.6
Fall 2012	38	26.3	7.9	10.5	36.8	84.2
Fall 2011	39	12.8	28.2	33.3	33.3	46.2
Fall 2010	29	3.6	0.0	51.7	62.1	89.7
Fall Average	55	21.2	12.3	25.7	44.5	69.0
Winter 2021–2022	79	0.0	1.3	16.5	41.8	6.3
Winter 2020–2021	65	0.0	0.0	70.8	1.5	4.6
Winter 2019–2020	46	0.0	2.2	17.4	2.2	4.3
Winter 2018–2019	47	0.0	2.1	46.8	4.3	25.5
Winter 2017–2018	72	23.6	6.9	33.3	0.0	12.5
Winter 2016–2017	72	47.2	11.1	5.6	0.0	11.1
Winter 2015–2016	47	74.5	0.0	0.0	0.0	0.0
Winter 2014–2015	43	72.1	0.0	4.7	0.0	2.3
Winter 2013–2014	35	60.0	0.0	8.6	0.0	0.0
Winter 2012–2013	36	30.6	8.3	0.0	0.0	11.1
Winter 2011–2012	31	16.1	0.0	35.5	0.0	0.0
Winter 2010–2011	28	7.1	0.0	32.1	0.0	0.0
Winter Average	50	27.6	2.7	22.6	4.2	6.5

Table 7b. Percent of Western Arctic Herd (WAH) collars that entered different Park units, including Bering Land Bridge National Preserve (BELA), Cape Krusenstern National Monument (CAKR), Gates of the Arctic National Park and Preserve (GAAR), Kobuk Valley National Park (KOVA), and Noatak National Preserve (NOAT). Spring (April and May) and summer (June, July and August). Averages are for all years.

Season	Sample Size	BELA	CAKR	GAAR	KOVA	NOAT
Spring 2022	73	0.0	1.4	11.0	53.4	86.3
Spring 2021	57	0.0	0.0	73.6	0.0	38.6
Spring 2020	41	0.0	2.4	17.1	22.0	43.9
Spring 2019	41	0.0	0.0	41.5	2.4	46.3
Spring 2018	62	25.8	0.0	32.3	12.9	51.6
Spring 2017	66	31.8	4.5	3.0	34.8	63.6
Spring 2016	46	76.1	0.0	0.0	19.6	84.8
Spring 2015	33	63.6	3.0	6.1	21.2	87.9
Spring 2014	35	45.7	0.0	8.6	14.3	88.6
Spring 2013	30	13.3	0.0	0.0	66.7	70.0
Spring 2012	29	17.2	0.0	27.6	31.0	48.3
Spring 2011	28	3.6	0.0	35.7	42.9	82.1
Spring Average	45	23.1	0.9	21.4	26.8	66.0
Summer 2022	102	0.0	0.0	2.9	2.9	79.4
Summer 2021	97	0.0	0.0	57.7	4.1	86.6
Summer 2020	70	0.0	14.3	0.0	0.0	60.0
Summer 2019	59	0.0	0.0	18.6	15.3	93.1
Summer 2018	55	0.0	0.0	67.3	29.1	94.5
Summer 2017	86	0.0	0.0	46.5	11.6	90.7
Summer 2016	80	1.3	0.0	36.3	10.0	96.3
Summer 2015	53	3.8	0.0	50.9	9.4	96.2
Summer 2014	57	0.0	0.0	43.9	0.0	80.7
Summer 2013	41	0.0	0.0	51.2	31.7	87.8
Summer 2012	39	2.6	0.0	59.0	20.5	92.3
Summer 2011	40	0.0	0.0	37.5	10.0	65.0
Summer 2010	30	0.0	0.0	90.0	10.0	100.0
Summer Average	62	0.6	1.1	43.2	11.9	86.4

Table 8. Annual distance (September 1–August 31) moved by GPS-collared Western Arctic Herd caribou cows. Average is for all years.

Monitoring Year	Sample Size	Mean Distance (SD)	Maximum Distance
2021–2022	51*	3039 (358) km	3833 km
2020–2021	50	2722 (322) km	3416 km
2019–2020	37	2538 (312) km	3138 km
2018–2019	32	2540 (362) km	3126 km
2017–2018	47	2854 (432) km	3820 km
2016–2017	55	2932 (523) km	3756 km
2015–2016	35	3110 (488) km	3827 km
2014–2015	22	3238 (521) km	4076 km
2013–2014	24	3392 (521) km	4404 km
2012–2013	34	3071 (304) km	3636 km
2011–2012	36	3085 (485) km	3758 km
2010–2011	39	3045 (323) km	3747 km
2009–2010	31	3254 (237) km	3724 km
Average	38	2986 (263) km	3712 km
Total	493	–	–

* Five caribou had 5-month long data gaps so were not included.

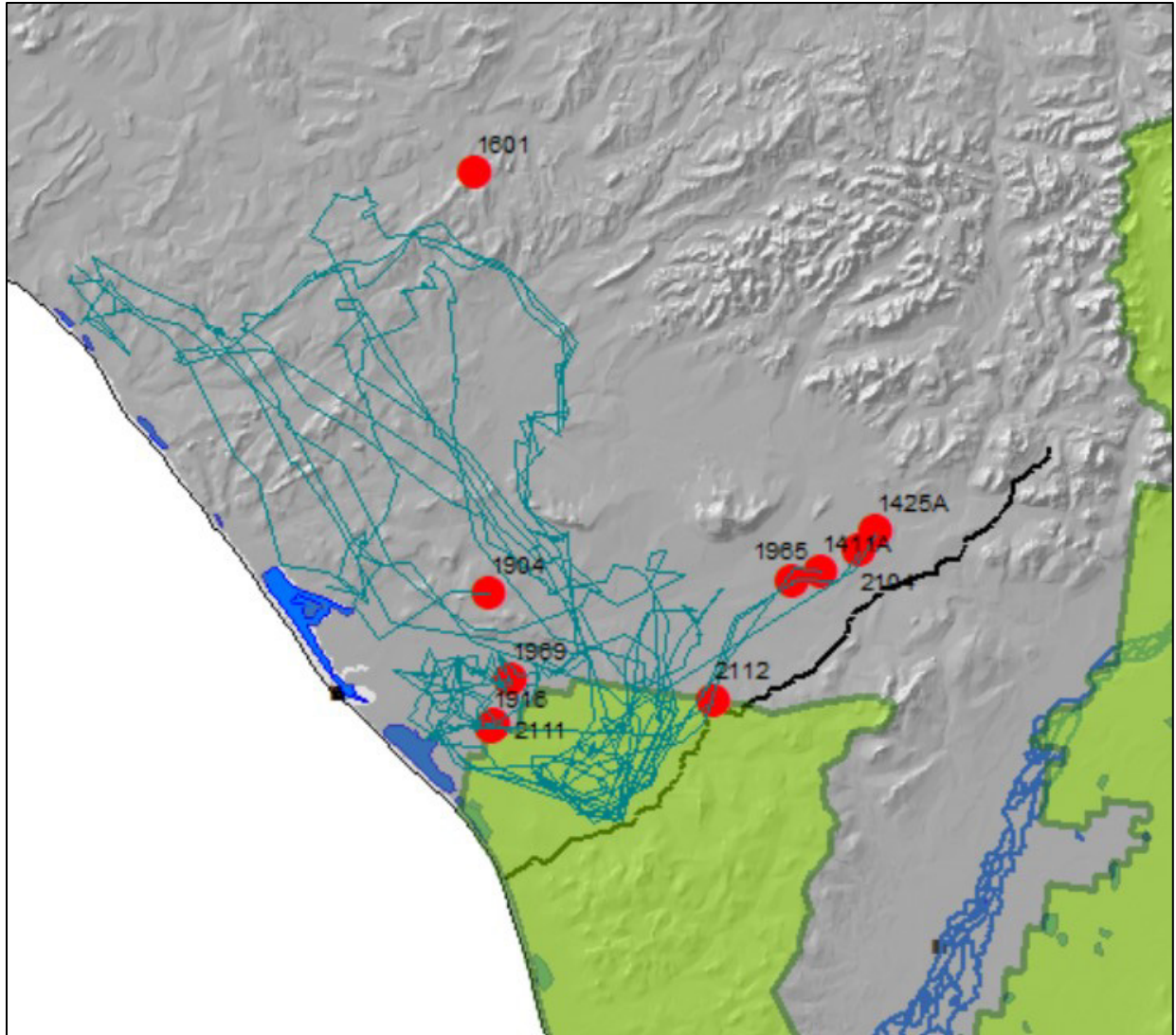


Figure 7. Caribou movements near the Delong Mountain Transportation System. Locations (red dots) of GPS collared female caribou on November 1, 2021 and their movements (blue-green lines) for the prior 30-day period. The black line represents the Delong Mountain Transportation System (commonly known as the Red Dog Road). Caribou were reluctant to cross the road; only 2 of the 10 collared caribou eventually crossed the road.

Migration Phenology

The results for when and how many GPS-collared caribou crossed the Noatak, Kobuk and Selawik Rivers on their annual ‘spring’ and ‘fall’ migrations are detailed in Tables 9a and 9b. The timing of the fall 2021 migration was mixed. The average crossing date of the Noatak was earlier than the long-term average, but this was heavily influenced by several individuals that crossed in summer. These crossings do not appear to be associated with fall migration. Meanwhile, the crossing of the Kobuk was near average. However, it was later than any of the first 7 years of monitoring yet relatively early compared the past few years (which have been extremely late). Notably, the first collared caribou crossed the Kobuk River on October 1st. This was the second latest first crossing ever; only the record late crossing of 2020 was later. The crossing of the Selawik River (November 13) was the latest ever reported. After 6 years in a row that the percentage of collared caribou crossing the Noatak had declined, that percentage increased for the second year in a row for the fall of 2021. For the Kobuk River, fall of 2021 had the highest percentage (73%) of collared caribou crossing since 2015. For comparison, from 2016–2020, an average of only 34% of collared caribou crossed the Kobuk River. While a doubling of the recent average, this percentage was still lower than the proportion of the herd that crossed from 2010–2015. The percentage crossing the Selawik River was the second lowest on record, exceeding only fall of 2020. Overall, there is a general trend of less caribou crossing all these key rivers in fall over the last 12 years, reflecting a shift away from the southernmost winter ranges by the herd. The duration (the number of days between the average date of crossing the Noatak and Selawik Rivers) of the fall 2021 migration was the longest on record (58 days). The average fall migration duration for the last 5 years (2017–2021) was 46 days while only being 18.4 days for the 7 years spanning 2010–2016. Spring migration across the Selawik and Kobuk Rivers, in contrast, was fairly consistent with near average timing.

Table 9a. Fall migration timing and prevalence of river crossing events by Western Arctic Herd caribou. Reported results are average date (standard deviation in number of days); percentage of collared cows crossing; and sample size results for generally southward 'fall' migration. Dates are for the first crossing if the individual re-crosses. Duration is the number days between Noatak and Selawik River crossings. Average (Avg) is for all years.

Year	Noatak River			Kobuk River			Selawik River			Duration
	Crossing Date (SD)	% Crossed	N	Crossing Date (SD)	% Crossed	N	Crossing Date (SD)	% Crossed	N	
2021	Sept 16 (24.2)	85.7%	84	Oct 16 (14.8)	73.2%	82	Nov 13 (12.8)	10.0%	80	58
2020	Sep 26 (23.0)	63.9%	72	Nov 3 (1.0)	5.6%	72	Nov 9 (0.6)	5.6%	72	44
2019	Sept 6 (42.7)	46.8%	47	Oct 16 (13.3)	36.2%	47	Oct 25 (14.4)	27.7%	47	49
2018	Oct 13 (28.6)	56.0%	50	Nov 3 (23.2)	20.0%	50	Nov 7 (16.1)	16.0%	50	25
2017	Sep 17 (40.0)	65.9%	82	Oct 30 (22.5)	48.1%	81	Nov 10 (18.2)	42.3%	78	54
2016	Sept 15 (21.1)	73.3%	75	Sep 24 (12.7)	58.1%	74	Oct 2 (15.4)	52.1%	73	17
2015	Sep 22 (29.5)	85.7%	49	Oct 1 (22.3)	85.4%	48	Oct 5 (21.0)	85.4%	48	13
2014	Sep 12 (19.9)	88.9%	45	Oct 1 (15.8)	84.8%	45	Oct 7 (15.6)	86.4%	44	25
2013	Sep 26 (16.9)	100%	35	Oct 7 (17.4)	91.4%	35	Oct 12 (16.4)	88.6%	35	16
2012	Oct 8 (20.8)	84.8%	33	Oct 11 (17.7)	78.8%	33	Oct 14 (18.1)	70.0%	33	6
2011	Sep 27 (37.2)	74.4%	39	Oct 13 (27.0)	71.8%	39	Oct 19 (27.4)	61.5%	39	22
2010	Sep 24 (16.4)	96.7%	30	Oct 12 (17.6)	76.7%	30	Oct 24 (11.7)	62.1%	29	30
Avg	Sep 23 (26.7)	76.8%	53	Oct 14 (17.1)	60.8%	53	Oct 22 (15.6)	50.6%	52	30

Table 9b. Spring migration timing and prevalence of river crossing events by Western Arctic Herd caribou. Reported results are average date (standard deviation in number of days); percentage of collared cows crossing; and sample size results for generally northward 'spring' migration. Dates are for the first crossing if the individual re-crosses. 'Spring migration' is not limited to the months of April and May as some cows cross the Noatak in early June. These later crossings are included in the results. Duration is the number days between Noatak and Selawik River crossings. Average (Avg) is for all years.

Year	Noatak River			Kobuk River			Selawik River			Duration
	Crossing Date (SD)	% Crossed	N	Crossing Date (SD)	% Crossed	N	Crossing Date (SD)	% Crossed	N	
2022	May 21 (14.3)	87.0%	69	May 8 (8.5)	54.2%	72	May 4 (7.3)	18.1%	72	17
2021	Apr 18 (27.1)	26.3%	57	May 9 (8.3)	8.8%	57	May 7 (6.7)	7.0%	57	NA
2020	May 19 (5.8)	45.9%	37	May 12 (5.3)	37.8%	37	May 3 (5.6)	27.0%	37	16
2019	May 12 (10.8)	34.1%	41	May 10 (7.4)	21.4%	42	Apr 25 (14.4)	23.3%	43	17
2018	May 24 (7.4)	36.1%	61	May 18 (8.8)	37.7%	61	May 10 (6.8)	38.1%	63	14
2017	May 11 (4.6)	65.1%	63	May 2 (10.0)	61.9%	63	Apr 25 (5.3)	59.4%	64	16
2016	May 7 (8.4)	84.8%	46	Apr 28 (8.3)	84.8%	46	Apr 24 (8.6)	84.8% ^a	46	13
2015	May 18 (6.5)	84.4%	32	May 9 (6.2)	81.8%	33	May 3 (4.4)	82.3%	34	15
2014	May 8 (7.3)	91.2 %	34	Apr 27 (4.1)	88.2%	34	Apr 23 (3.6)	88.2%	34	15
2013	May 31 (6.2)	93.1%	29	May 26 (8.1)	79.3%	29	May 21 (10.2)	79.3%	29	10
2012	June 7 (26.7)	74.4%	43	May 29 (26.4)	69.7%	43	May 26 (27.5)	69.7% ^b	43	12
2011	May 18 (11.8)	96.3%	27	May 15 (5.8)	70.4%	27	May 9 (5.8)	55.5%	27	9
Avg	May 17 (11.4)	68.2%	45	May 11 (8.9)	58.0%	45	May 5 (8.9)	47.8%	46	14

^a One caribou ('1529') did not migrate north and stayed on the Seward Peninsula.

^b One caribou ('1108') did not migrate north and stayed on the Seward Peninsula.

Migration Routes

A histogram (Figures 8a and 8b) of where caribou crossed the Noatak River provides a visual depiction of the geographic spread of the fall migration. Crossings of the Noatak continue to be variable. The 2021 migration was distributed very similarly to 2020. The bulk of the caribou crossing the Noatak River did so towards the central portion of the river.

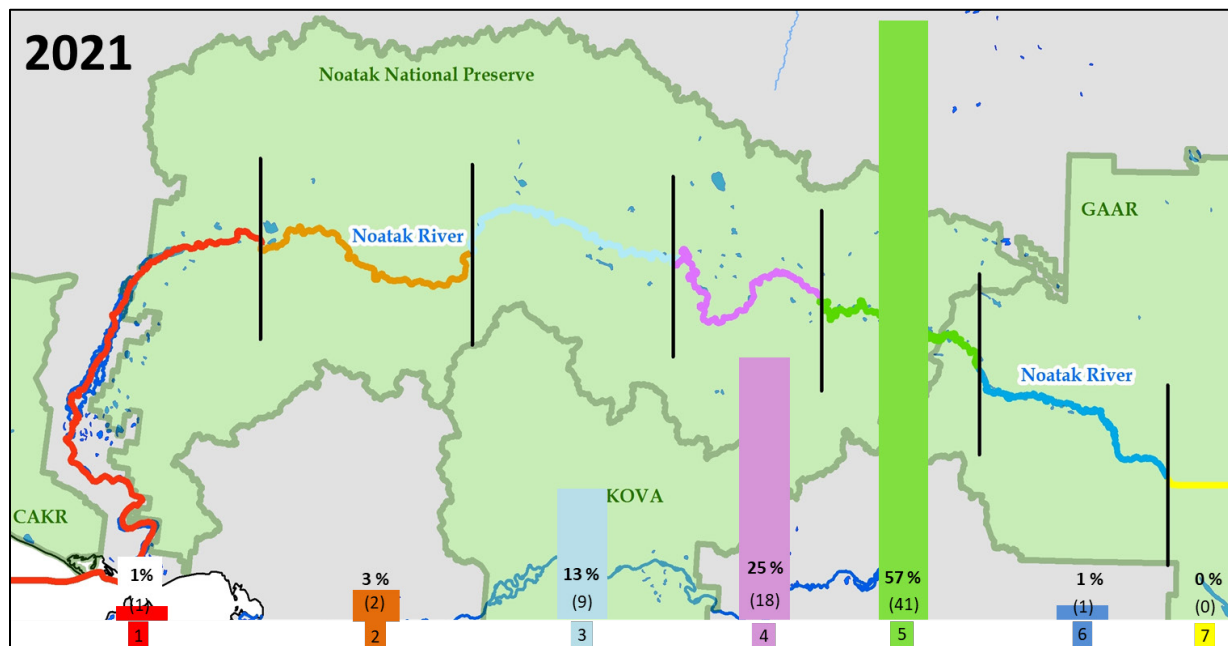


Figure 8a. 2021 distribution of caribou crossing the Noatak River during fall. This histogram depicts where collared female caribou crossed the Noatak River, generally from north to south, on their fall migration. Relative percentages (top number) and absolute number (middle number) of caribou are provided. The river is divided into seven (lowest number) color-coded segments which are displayed in the background. The middle five segments are 100 river kilometers long, while the westernmost segment (red) is 200 km (before extending into the Chukchi Sea) and the easternmost (yellow) runs as far east as WAH caribou are known to migrate.

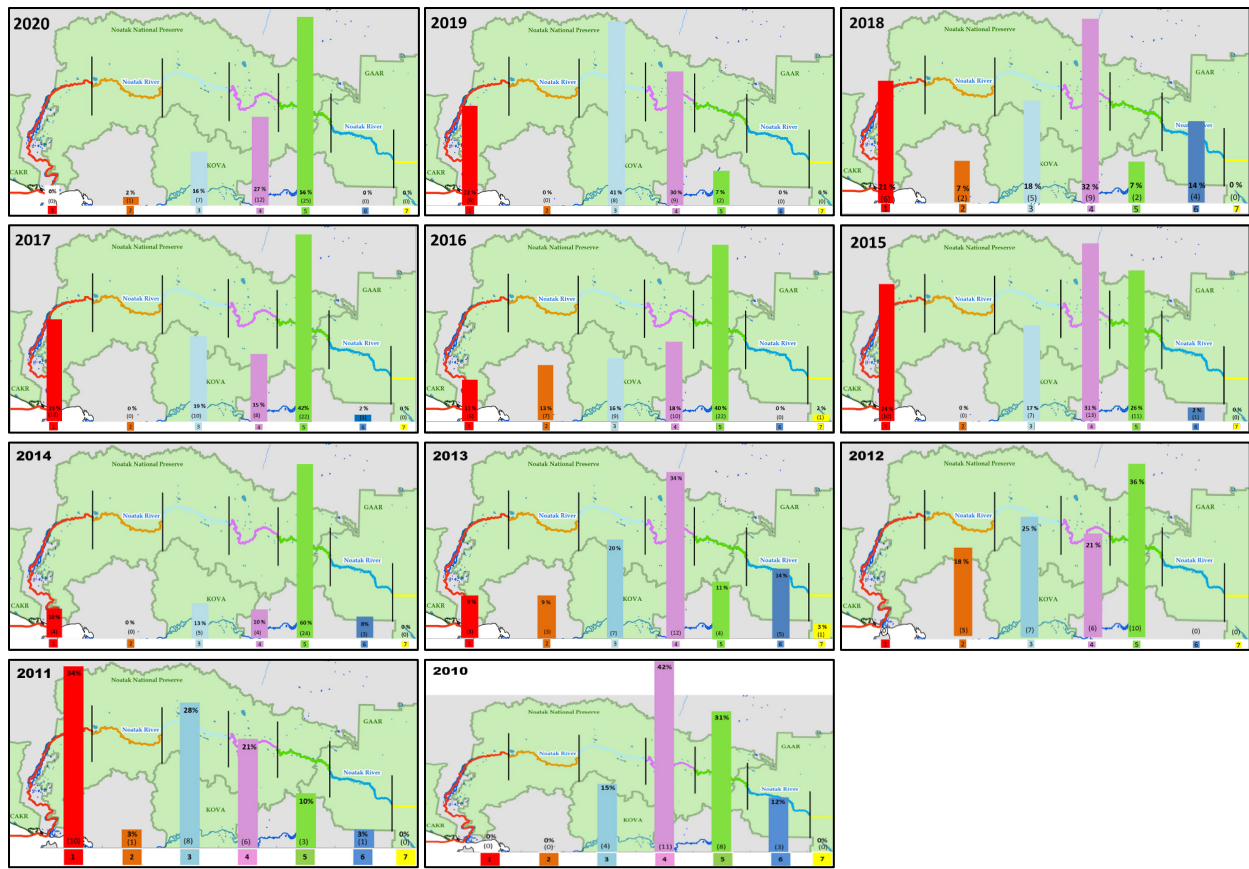


Figure 8b. 2010–2020 distribution of caribou crossing the Noatak River during fall. This histogram depicts where collared female caribou crossed the Noatak River, generally from north to south, on their fall migration. Relative percentages (top number) and absolute number (middle number) of caribou are provided. The river is divided into seven (lowest number) color-coded segments which are displayed in the background. The middle five segments are 100 river kilometers long, while the westernmost segment (red) is 200 km (before extending into the Chukchi Sea) and the easternmost (yellow) runs as far east as WAH caribou are known to migrate. Historic records dating back to the inception of vital sign monitoring.

The timing and minimum distance GPS-collared caribou were to the villages of Noatak, Shungnak and Selawik as well as Onion Portage on their annual ‘spring’ and ‘fall’ migrations are detailed in Tables 10a and 10b. Onion Portage, which has been used as a Kobuk River crossing by caribou for more than 10,000 years, is frequently utilized both during the fall and spring migrations (Anderson 1968). While the fall 2021 minimum distance and timing to Noatak was close to average, the distances to Shungnak, Selawik, and Onion Portage were some the shortest ever reported. However, it was the latest ever that caribou came their closest to Shungnak and Selawik and the 3rd latest for Onion Portage. With migration not getting far south, the minimum distance in spring was a record low for Onion Portage and the 2nd lowest for Shungnak. The spring timing was early for Shungnak but near average for the other key locations.

Table 10a. Fall season minimum distance and date that collared Western Arctic Herd caribou passed the northwest Arctic villages of Noatak, Shungnak, and Selawik, and the historical caribou river crossing location of Onion Portage, KOVA. Reported results are average distance in kilometers (standard deviation); average date (standard deviation); and sample size. Results are for generally southward, fall (September–November) migration. Average is for all years.

Year	n	Noatak		Shungnak		Selawik		Onion Portage	
		Distance (SD)	Date (SD)	Distance (SD)	Date (SD)	Distance (SD)	Date (SD)	Distance (SD)	Date (SD)
2021	73	144.2 (67.6)	Oct 4 (19.5)	60.1 (90.6)	Nov 9 (16.6)	90.0 (83.5)	Oct 26 (16.2)	54.5 (79.5)	Oct 19 (18.2)
2020	65	118.0 (54.4)	Sept 11 (17.8)	148.8 (101.9)	Oct 11 (20.8)	181.6 (85.0)	Oct 10 (21.7)	126.4 (92.9)	Oct 7 (16.2)
2019	46	155.5 (92.6)	Sept 27 (21.5)	169.1 (101.9)	Nov 4 (23.7)	178.4 (132.6)	Oct 16 (27.5)	145.2 (108.5)	Oct 24 (27.7)
2018	46	116.0 (85.1)	Oct 6 (27.2)	142.7 (73.0)	Oct 25 (31.9)	135.1 (82.7)	Oct 17 (34.4)	117.0 (65.1)	Oct 17 (32.8)
2017	69	135.9 (103.9)	Oct 5 (31.6)	138.6 (81.0)	Oct 30 (27.6)	138.9 (94.7)	Oct 25 (32.0)	115.5 (81.0)	Oct 27 (29.9)
2016	73	137.5 (88.3)	Oct 21 (33.4)	139.9 (100.6)	Oct 7 (28.5)	123.8 (107.5)	Oct 8 (23.6)	110.2 (97.4)	Oct 4 (26.6)
2015	49	132.7 (64.3)	Oct 23 (30.0)	132.0 (103.9)	Oct 3 (26.8)	86.3 (88.3)	Oct 6 (24.0)	93.2 (101.8)	Oct 2 (26.0)
2014	46	165.8 (76.5)	Oct 16 (26.9)	80.1 (88.2)	Oct 7 (23.6)	96.4 (95.7)	Oct 8 (18.8)	62.8 (87.6)	Oct 1 (22.5)
2013	35	146.8 (69.7)	Oct 14 (25.9)	83.8 (53.2)	Oct 11 (19.1)	63.9 (59.3)	Oct 15 (17.1)	60.4 (52.4)	Oct 9 (20.0)
2012	34	155.0 (61.1)	Oct 22 (31.7)	78.1 (87.1)	Oct 16 (19.9)	81.6 (49.9)	Oct 24 (20.0)	58.5 (71.6)	Oct 13 (19.8)
2011	39	123.8 (83.6)	Sep 30 (28.1)	140.0 (106.5)	Oct 19 (27.1)	118.4 (117.7)	Oct 12 (29.4)	122.8 (96.9)	Oct 14 (27.0)
2010	29	176.8 (54.2)	Oct 7 (17.6)	36.6 (37.3)	Oct 8 (15.5)	86.1 (53.1)	Oct 20 (12.7)	32.6 (32.7)	Oct 3 (14.6)
Average	50	142.3 (75.1)	Oct 8 (25.9)	112.5 (85.4)	Oct 17 (23.4)	115.0 (87.5)	Oct 15 (23.1)	91.6 (80.6)	Oct 11 (23.4)

Table 10b. Spring season minimum distance and date that collared Western Arctic Herd caribou passed the northwest Arctic villages of Noatak, Shungnak, and Selawik, and the historical caribou river crossing location of Onion Portage, KOVA. Reported results are average distance in kilometers (standard deviation); average date (standard deviation); and sample size. Results are for generally northward, spring (April and May) migration. Average is for all years.

Year	n	Noatak		Shungnak		Selawik		Onion Portage	
		Distance (SD)	Date (SD)	Distance (SD)	Date (SD)	Distance (SD)	Date (SD)	Distance (SD)	Date (SD)
2022	63	182.3 (50.7)	May 20 (13.2)	80.2 (96.0)	Apr 26 (17.9)	127.5 (77.4)	May 2 (15.6)	63.1 (86.6)	May 6 (14.5)
2021	57	222.1 (58.2)	May 17 (11.5)	181.7 (84.0)	May 1 (15.3)	238.8 (84.9)	May 7 (13.2)	172.3 (72.6)	May 5 (13.5)
2020	37	203.9 (87.3)	May 18 (11.8)	177.4 (105.0)	April 29 (18.5)	190.5 (133.0)	May 5 (16.1)	152.0 (106.8)	May 5 (17.4)
2019	36	167.2 (65.7)	May 6 (18.1)	173.1 (63.4)	Apr 23 (15.6)	184.3 (89.1)	Apr 28 (16.4)	149.6 (57.4)	Apr 27 (14.9)
2018	53	189.0 (78.2)	May 21 (6.7)	149.8 (54.6)	May 4 (17.9)	149.9 (122.9)	May 8 (12.9)	131.0 (60.6)	May 7 (15.8)
2017	61	167.8 (97.2)	Apr 30 (17.6)	164.2 (103.3)	May 1 (16.5)	126.4 (145.1)	Apr 28 (16.5)	129.5 (107.6)	May 5 (15.2)
2016	46	103.6 (78.0)	May 5 (9.6)	180.7 (68.1)	May 1 (12.7)	82.6 (107.8)	Apr 29 (12.7)	136.9 (71.2)	May 2 (12.4)
2015	37	124.4 (69.6)	May 9 (13.7)	162.9 (71.7)	May 5 (13.6)	69.5 (104.0)	May 2 (13.4)	120.7 (77.5)	May 7 (14.0)
2014	35	117.1 (81.1)	May 5 (8.5)	143.1 (28.7)	Apr 27 (7.8)	53.2 (85.5)	Apr 26 (8.3)	102.6 (45.9)	Apr 29 (7.4)
2013	30	138.5 (52.4)	May 23 (14.1)	123.9 (57.5)	May 18 (17.2)	58.3 (68.9)	May 11 (20.0)	79.4 (57.0)	May 19 (17.5)
2012	29	178.2 (97.2)	May 26 (7.7)	142.1 (69.4)	May 22 (10.3)	117.0 (116.7)	May 22 (9.8)	117.0 (72.5)	May 23 (10.3)
2011	27	202.3 (40.7)	May 20 (9.8)	74.5 (46.7)	May 9 (12.0)	110.3 (97.4)	May 12 (7.78)	64.8 (60.3)	May 15 (8.2)
Average	43	166.4 (71.4)	May 14 (11.9)	146.1 (70.7)	May 4 (14.6)	125.7 (102.7)	May 5 (13.6)	118.2 (73.0)	May 7 (13.4)

Western Arctic Herd Working Group

Several NPS employees, including ARCN's Caribou Vital Sign Monitoring Lead, attended and presented information at the December 2021 meeting, which was held via teleconference due to COVID-19 safety protocols. The Caribou Vital Sign lead acted as the NPS representative on the Technical Committee and contributed to the 'Caribou Trails' newsletters. NPS, through GAAR and Western Arctic Parklands, contributed financially to support the Western Arctic Caribou Herd Working Group and the Western Arctic Caribou Herd Technical Committee meeting.

New Products Completed Prior to the End of Reporting Period

Information on the WAH was disseminated in several mediums in the current monitoring year (see below). Most of the following products can be found on ARCN's Caribou Vital Sign webpage, which is located at <https://www.nps.gov/im/arcn/caribou.htm>: use the "Find all articles, report, and data here" link.

Technical Reports

Joly, K. and M. D. Cameron. 2021. Caribou vital sign annual report for the Arctic Network Inventory and Monitoring Program: September 2020–August 2021. Natural Resource Report NPS/ARC/NRR—2021/2335. National Park Service, Fort Collins, Colorado.
<https://doi.org/10.36967/nrr-2288517>.

Scientific Journal Articles

Cameron, M. D., J. M. Eisaguirre, G. A Breed, K. Joly, and K. Kielland. 2021. Mechanistic movement models identify continuously updated autumn migration cues in Arctic caribou. *Movement Ecology* 9 (54). DOI: 10.1186/s40462-021-00288-0.

Joly, K., A. Gunn, S. D. Côté, M. Panzacchi, J. Adamczewski, M. J. Sutor, and E. Gurarie. 2021. Caribou and reindeer migrations in the changing Arctic. *Animal Migrations* 8: 156–167. DOI: 10.1515/ami-2020-0110.

Outreach

Provided caribou information at grade school educational programs as well as multiple media outlets, and public presentations. A one-page handout about delayed fall migration for the herd was made for ARCN parks. An article about caribou population oscillations was produced for an online journal whose target audience is aspiring middle school science students. The article is located at: <https://kids.frontiersin.org/articles/10.3389/frym.2021.631372>.

Discussion

GPS collars were deployed in the WAH for the first time in 2009. Since then, over 820,000 relocations have been collected during the first 13 years of vital sign monitoring. During this reporting period (September 2021–August 2022), 33 additional GPS collars were deployed. Due to the trend of lowered percentage of collared caribou crossing the Kobuk River and late migration, net gunning was used to deploy collars in April 2022. Our successful spring capture efforts highlight how effective helicopter deployments can be and we expect the need to continue employing this method as long as fall migration remains irregular and unpredictable for the WAH. Collaboration with the ADFG continues to be an integral part of achieving Vital Sign objectives and greatly improves the capacity of the program.

All the caribou that were collared in the spring of 2022 survived through end of August, which was in contrast to the low survival rate of the spring 2021 cohort. As part of the Caribou Vital Sign's periodic review, a comprehensive review of mortalities has been initiated. Lower adult female survival has the potential to slow herd growth or even contribute to population declines. The last photo-census (2022) completed by the ADFG revealed a decrease in the population to 164,000 caribou (Alex Hansen, *personal communication*, 2022). A reduction in cow harvest has the potential to help slow the herd's decline.

Range use by GPS-collared cows during this reporting period was restricted, primarily due to the very few collared animals moving south of the Selawik River for winter. Both the annual and winter area distributions were the smallest on record. In winter, collared animals were clustered along and just south of the Kobuk River near the villages of Ambler, Shungnak, and Kobuk. Interestingly, despite the overall smaller range use, the average annual movement (3039 km) increased and was the highest it has been since the 2015–2016 monitoring year.

WAH caribou continued to use NOAT more consistently, over the course of the year, than other park units. This is likely due to its strategic location in relation to spring and fall migration routes as well as containing summer habitat. For the first time since GPS monitoring began, a plurality (42%) of the herd overwintered in KOVA, which exhibited the greatest use of all Park units in winter. For comparison, during the first 8 years of monitoring, no collared caribou wintered in KOVA and use had always been < 5%. For the fourth year in a row, no collared caribou used BELA this monitoring year (use was reported in all 8 previous monitoring years) or even entered the Seward Peninsula. This is a remarkable turnaround from 6–7 years ago, when the Seward Peninsula represented a major winter area for the herd and 72–75 % of collared caribou wintered in BELA.

About 10 collared caribou came within the vicinity of the Red Dog Mine and the Delong Mountain Transportation System this monitoring year. The movements of these caribou displayed obvious deflections (Figure 7). Only 2 of these caribou eventually crossed the road, with the remainder staying north for the winter. Both individuals that made it across the road and migrated south survived until the end of the monitoring year (September 2022). Three of the 8 (37.5%) that did not cross the road, and wintered north of it, died before the end of winter. These observations support previous findings (e.g., Wilson et al. 2016) that the road is impacting the fall migration of the WAH,

yet the underlying causes of what road-related factors are acting as a barrier to movement remain unknown at this time.

This monitoring year had the highest percentage of collared caribou crossing the Kobuk River since 2015. From 2016–2020, an average of only 34% of collared caribou crossed the Kobuk River, but in 2021, 73% of the collared caribou cross the Kobuk River. While a doubling of the recent average, this percentage was still lower than the average number (82%) that crossed from 2010–2015. Despite the relatively high percentage of caribou crossing the Kobuk River in the fall of 2021, the migration largely stalled out at this point and only 10% of collared caribou crossed the Selawik River, which was the second lowest on record. While the average timing of the Kobuk River crossing in 2021 was near the overall average, it was later than all 7 of the first years of monitoring. The first crossing of the Kobuk River was the second latest on record. Similarly, fall of 2021 was the latest average crossing of the Selawik River.

The root causes of these changing migratory and range-use patterns are unknown. Climate change is leading to snow and cold temperatures occurring later in fall, which may contribute to the delayed migration patterns we have been documenting (Cameron et al. 2021). Another potential factor in reduced and later migrations is the smaller size of the herd (Joly et al. 2021). After nearly 20 years of population decline, the herd is less than half that of its peak (490,000 individuals) in 2003. Smaller populations use less space than larger ones, thus smaller populations tend to have shorter migrations than larger ones.

These delayed migration patterns have important implications for subsistence users of caribou: later migrations can coincide with rapidly decreasing temperatures and pan ice running in the river, which can prevent hunting and travel difficult. Moreover, later arrival of caribou in fall can mean they arrive in some hunting areas during the rut, when the meat of males is unpalatable. This can increase harvest pressure on females. This has the potential to put additional downward pressure on the herd.

Two scientific journal articles on caribou migration were published. We were able to confirm and quantify the impacts of accumulating snow and decreasing temperatures on fall migratory movements that subsistence hunters have long known about (Cameron et al. 2021). The second paper was a review of the factors that affect caribou migrations, including climate, habitat productivity, and development (Joly et al. 2021). These research papers have important management implications. We also produced an article about caribou population oscillations for an online journal dedicated to middle school science students. Further research is ongoing and hopefully additional papers will be available for the next annual report. A large number of products and presentations, including these 2 scientific papers, have been developed in conjunction with monitoring this Vital Sign; most of which are available on-line at <https://www.nps.gov/im/arcn/caribou.htm>.

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