Alaska Department of Fish and Game
Division of Wildlife Conservation
Federal Aid in Wildlife Restoration
Research Progress Report

Movement Patterns of the Porcupine Caribou Herd in Relation to Oil Development

by
Kenneth R. Whitten
Project W-23-2
Study 3.34
April 1990

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PROGRESS REPORT (RESEARCH)

State: Alaska

Cooperators: Larry Pank, U.S. Fish and Wildlife Service

Project No.: W-23-2 Project Title: Wildlife Research and Management

Study No.: 3.34 Study Title: Movement Patterns of the Porcupine Caribou Herd in Relation to Oil Development

Period Covered: 1 July 1988-30 June 1989

SUMMARY

Since March 1985 female caribou (Rangifer tarandus) in the Porcupine Caribou Herd (PCH) (n = 8-20) and Central Arctic Herd (CAH) (n = 2-12) have been successfully relocated several times per day by a satellite-tracking system. Movement patterns in relation to topographic features and broad habitat types will be determined and compared between the 2 herds. Movements in relation to petroleum production facilities and activities will be determined for CAH caribou, and these data will be used to predict effects of potential development on the PCH. Data are currently being collected and analyzed.

Key words: caribou, migration, Rangifer tarandus, satellite radio-tracking.

CONTENTS

BACKGROUND

The Porcupine Caribou (Rangifer tarandus) Herd (PCH) is composed of approximately 178,000 animals that migrate seasonally between wintering areas in the boreal forests of northwestern Canada and northeastern Alaska and the calving grounds on the arctic coastal plain within both the Yukon Territory and Alaska. Large-scale development of nonrenewable resources is planned throughout this resource-rich area. Concerns about the impact of development on the PCH have been expressed by numerous governmental agencies, environmental groups, and subsistence users. International concern is exemplified by efforts to develop an international agreement between the U.S. and Canadian governments to protect the PCH and its habitat.

Exploration for oil and gas is currently underway on the traditional calving grounds of the PCH and on the arctic coastal plain. It is highly likely that development will occur in the near future. The PCH wintering areas in the Ogilvie and Richardson Mountains in Canada and on Venetie tribal lands in Alaska are also subject to intensive oil and mineral exploration. A road has already been built between Dawson and the MacKenzie River Delta (Dempster Highway). Protection of habitats on calving grounds and key winter ranges and mitigation of the impacts of development require detailed knowledge of habitat use, movement patterns, and travel corridors.

The large size, remote location, and international movements of the PCH make it difficult and costly to study. Monitoring movements and habitat use through direct observation or by relocating caribou equipped with conventional radio collars has proven difficult. The feasibility of using satellite

radio collars to monitor daily movements of caribou in the PCH was tested in 1984. The prototype satellite radio collars (i.e., PTT's for "platform terminal transmitters") provided accurate and reliable data at a reasonable cost. A 2nd generation satellite transmitter was developed and deployed in 1985, and results have demonstrated a capability for describing migration routes and movement patterns in greater detail than had been previously possible. In particular, we noted extensive mid- and late-summer movements that had not been previously reported. Also, activity recorders in the PTT's have the potential to provide data on daily activity patterns of caribou. Collars on individual caribou were replaced as batteries or the satellite transmitters failed. Third-generation transmitters became available in 1986 and have been deployed on additional female caribou, raising current sample sizes to 20 PTT's in the PCH and 10 in the CAH. Collars on CAH females allow comparisons of relatively sedentary caribou with the highly migratory PCH and also provide an opportunity to describe caribou reactions to existing oil field development.

This study is 1 component of a cooperative program between the Alaska Fish and Wildlife Research Center (U.S. Fish and Wildlife Service) and the Alaska Department of Fish and Game. The overall goals of this cooperative study are to identify potential conflicts between caribou and oil development and to recommend measures for minimizing the impact of oil development on caribou and their habitat.

OBJECTIVES

To identify migration routes between summer and winter ranges and to determine movement patterns on the arctic coastal plain in relation to topographic features, broad habitat types, and existing or potential petroleum production and transportation facilities.

The U.S. Fish and Wildlife Service is the lead agency in determining habitat utilization and preferences as well as daily activity budgets. Objectives that are the primary responsibility of the U.S. Fish and Wildlife Service are not addressed in this report.

METHODS

Up to 20 adult female caribou from the PCH and 10 from the CAH are currently equipped with collars bearing both PTT and standard transmitters. Each PTT transmits 6 hrs/day, provides 2-5 locations daily, and functions for approximately 1 year. Each collared caribou is monitored as long as possible; that

is, until it dies or can no longer be located because of failure of both the PTT and standard transmitters. When a PTT expires or is near the end of its projected battery life, that caribou is located using the standard transmitter and recaptured; the old collar is reclaimed, and a new collar is attached. When a collared caribou dies, the collar is retrieved, refurbished as necessary, and placed on a different caribou.

Migration Routes

All PTT locations are plotted on digitized terrain maps. An attribute file for each fix is then automatically created that includes location, date, slope, aspect, vegetation type, ambient temperature, and activity of the caribou. Slope, aspect, and vegetation data are obtained from LANDSAT imagery, while temperature and animal activity are provided by sensors in the PTT. Migration routes and distances traveled each day can then be correlated with slope, aspect, and major geographical features. Satellite locations are supplemented by fixed-wing tracking of caribou with standard radio collars. Trail systems are noted during tracking flights as well as during general reconnaissance surveys of the migrations. Trails are clearly visible in snow, and fresh trails can also be distinguished along river bars and in tundra vegetation during summer and fall. In this way, data from satellite relocations can be compared with routes used by other members of the herd. Thus various migration paths can be compared for distances traveled, elevation changes, and rates of movement. Estimates of numbers, composition, and group sizes of caribou using various routes are then possible; these estimates could not have resulted from sole use of the PTT's.

Calving Areas

During calving, PTT locations are plotted on digitized terrain and habitat maps. Preference for calving sites will be determined by comparing use and availability of habitat types and terrain features. Time of calving for PTT-collared caribou is determined by observation from fixed-wing aircraft. Again, tracking of standard radio collars and general reconnaissance flights provide comparative data on numbers and composition of caribou using the calving grounds.

Insect Relief Habitat

Periods of severe insect harassment of caribou will be determined from (1) local weather records of wind and temperature conditions favorable to insect activity, (2) concurrent studies by U.S. Fish and Wildlife Service on insect activity and abundance in the Arctic National Wildlife Refuge, and/or (3) direct field observations.

PTT locations are plotted on digitized terrain maps and again compared with supplemental data from standard radio collars and general aerial surveys. Specific areas or types of habitats consistently used during insect harassment periods can then be compared, and any distinguishing characteristics such as vegetation type, elevation, temperature, and wind conditions noted.

RESULTS AND DISCUSSION

Capture dates, recaptures for collar replacement, and current status of satellite radio-collared caribou are summarized in Tables 1 and 2. PTT's in the CAH have been deployed so that some collared caribou are likely to frequently encounter oilfield facilities (i.e., captured in or near the Prudhoe Bay and Kuparuk Oilfields), while others are likely to encounter development only infrequently (i.e., captured in the Canning River/Sadlerochit Mountains area far east of the oilfield).

Data collected from radio-collared caribou are currently being analyzed relative to movements and habitat relationships. A number of manuscripts and technical reports, based wholly or in part on satellite transmitter data, were prepared during the current reporting period (Appendix A). A paper on winter range fidelity which has been submitted to the Canadian Journal of Zoology is included here as a representative sample of ongoing research and analysis (Appendix B).

ACKNOWLEDGMENTS

Valuable assistance to this project was provided by Cathy Curby, Steve Fancy, Gerald Garner, Larry Pank, Jim Greslin, and Richard Harris of the U.S. Fish and Wildlife Service.

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Table 1. Deployment data and current status of satellite radio collars (PTT's) on female caribou from the Porcupine Caribou Herd.

I.D. No.	Capture date	Recapture for collar replacement	Comments and current status (April 1988)
S8	4/85	3/86, 10/86, 10/87	Died of unknown causes 7/88; PTT retrieved
S9	4/85	3/86, 5/86	PTT failed 5/86; recollared with conventional transmitter 6/86; died of unknown causes 12/86
S10	4/85	3/86, 3/87, 4/88, 4/89	Still alive; PTT transmitting
S11	4/85	3/86, 3/87, 7/87, 4/88	PTT failed 5/87; died of unknown causes 7/88; PTT retrieved
S12	4/85	3/86	Died of unknown causes 12/86; PTT retrieved
S13	4/85	3/86, 10/86, 10/87, 9/88, 6/89	Still alive; PTT transmitting
S14	4/85	3/86, 10/86, 3/87, 4/88, 4/89, 6/89, 9/89	Still alive; PTT transmitting
S15	4/85		Killed by bear (along with calf) 6/85; PTT retrieved
S16	6/85		Killed by wolves 11/85; PTT retrieved
S17	3/86		Died of unknown causes 5/86; PTT retrieved
S18	10/86		Killed by wolves 2/87; PTT retrieved
S19	10/86	10/87	Died 6/88; PTT retrieved
S20	10/86	10/87, 9/88, 9/89	Still alive; PTT transmitting
S29	3/87		Died of unknown causes 3/88; PTT retrieved
S30	3/87		Died 4/87, apparent capture mortality; PTT retrieved
S31	3/87	4/88, 4/89	Still alive; PTT transmitting

Table 1. Continued.

I.D. No.	Capture date	Recapture for collar replacement	Comments and current status (April 1988)
S32	3/87	6/88	Died of unknown causes 11/88; PTT retrieved
S35	10/87		Killed by bear 6/88; PTT retrieved
S36	10/87	9/88, 9/89	Still alive;; PTT transmitting
S37	10/87	9/88	Still alive; PTT failed
S40	10/87		Died of unknown causes 7/88; PTT retrieved
S42	4/88	4/89	Still alive; PTT transmitting
S43	4/88	4/89	Still alive; PTT transmitting
S44	4/88		Died of unknown causes 4/88; PTT not retrieved
S45	4/88		Died 4/88, apparent capture mortality; PTT retrieved
S46	4/88	6/88	Died 6/88, apparent capture mortality; PTT retrieved
S47	4/88	4/89	Still alive; PTT transmitting
S48	4/88		Killed by wolves 4/88; PTT retrieved
S49	4/88		Died of unknown causes 4/88; PTT not retrieved
S50	4/88	4/89	Died of unknown causes 4/89; PTT retrieved
S51	6/88	4/89	Still alive; PTT transmitting
S53	4/89	9/89	Still alive; PTT transmitting
S54	4/89		Died 4/89, apparent capture mortality; PTT retrieved
S55	4/89		Still alive; PTT transmitting
S56	4/89		Still alive; PTT failed 5/89

Table 1. Continued.

I.D. No.	Capture date	Recapture for collar replacement	Comments and current status (April 1988)
S57	4/89		Shot 11/89; PTT retrieved
S58	4/89		Still alive; PTT transmitting
S59	4/89		Still alive; PTT transmitting
S60	4/89		Still alive; PTT transmitting
S61	4/89		Still alive; PTT transmitting
S68	9/89		Still alive; PTT transmitting

Table 2. Deployment data and current status of satellite radio collars (PTT's) on female caribou from the Central Arctic Caribou Herd.

I.D. No.	Capture date	Recapture for collar replacement	Comments and current status (April 1988)
S5	4/85	3/86	Presumed alive; PTT batteries exhausted 3/87 and standard transmitter failed. No longer trackable; collar not retrieved.
S6	4/85	3/86, 3/87	Died of unknown causes 6/87; PTT retrieved
S21	10/86	10/87	Died of unknown causes 10/88; PTT retrieved
S22	10/86	10/87	Died of unknown causes 2/88; PTT retrieved
S23	10/86	11/86, 3/87, 10/87, 9/88, 9/89	Still alive; PTT transmitting
S24	10/86	10/87, 10/88	Died of unknown causes 1/89; PTT retrieved
S25	10/86	10/87, 10/88	Died of unknown causes 11/88; PTT retrieved
S26	10/86	7/89	Still alive; PTT transmitting
S27	10/86	8/87	Died of unknown causes 10/87; PTT retrieved
S28	10/86	10/87, 10/88	Still alive; PTT failed, not retrieved
S33	5/87	4/88	Killed by wolves at capture site 4/88; PTT retrieved
S34	7/87	7/88, 4/89	Still alive; PTT transmitting
S38	10/87		Still alive; PTT failed 1/88
S39	10/87		Still alive; PTT transmitting
S41	10/87	9/88, 9/89	Still alive; PTT transmitting
S52	10/88	10/89	Still alive; PTT transmitting
S62	4/89		Still alive; PTT transmitting

Table 2. Continued.

I.D. No.	Capture date	Recapture for collar replacement	Comments and current status (April 1988)
63	4/89	9/89	Still alive; PTT transmitting
64	4/89		Still alive; PTT transmitting
65	7/89		Still alive; PTT transmitting
66	7/89		Still alive; PTT transmitting
67	7/89		Still alive; PTT transmitting
69	10/89		Still alive; PTT transmitting
70	10/89		Still alive; PTT transmitting

Appendix A. Manuscripts and technical reports prepared during the current reporting period.

Cameron, R. D., S. G. Fancy, and W. T. Smith. 1989. Caribou responses to development infrastructures and mitigation measures implemented in the Central Arctic Region. Pages 46-60 in T. R. McCabe, ed. Terrestrial research: 1002 area-Arctic National Wildlife Refuge. Ann. Prog. Rep. 1988. U.S. Fish and Wildl. Serv., Anchorage, Alaska. 168pp.

_____, W. T. Smith, and S. G. Fancy. 1989. Distribution and productivity of the Central Arctic Caribou Herd in relationship to petroleum development. Alaska Dep. Fish and Game. Fed. Aid in Wildl. Rest. Prog. Rep. Proj. W-23-1 and W-23-2. Juneau. 52pp.

Fancy, S. G., K. R. Whitten, R. D. Cameron, and R. B. Harris. 1989. Population dynamics and demographics of caribou in developed and undeveloped areas of the arctic coastal plain. Pages 1-11 in T. R. McCabe, ed. Terrestrial research: 1002 area - Arctic National Wildlife Refuge. Ann. Prog. Rep. 1988. U.S. Fish and Wildl. Serv., Anchorage, Alaska. 168pp.

_____, _____, D. E. Russell, F. J. Mauer, G. W. Garner, L. F. Pank, and R. F. Farnell. 1989. Fidelity of Porcupine herd caribou to winter ranges in Canada and Alaska. Can. J. Zoology. Submitted.

_____, R. B. Harris, D. C. Douglas, L. F. Pank, K. R. Whitten, T. R. McCabe, S. C. Amstrup, and G. W. Garner. 1988. Applications of satellite telemetry to wildlife research and management in Alaska. Ecologia Mediterrania. In press.

Whitten, K. R., R. B. Harris, S. G. Fancy, D. J. Reed, and T. J. Roffe. 1989. Effect of potential displacement of caribou from the 1002 area on mortality rates of calves. Pages 12-24 in T. R. McCabe, ed. Terrestrial research: 1002 area-Arctic National Wildlife Refuge. Ann. Prog. Rep. 1988. U.S. Fish and Wildl. Serv., Anchorage, Alaska. 168pp.

APPENDIX B

INFIDELITY OF PORCUPINE HERD CARIBOU TO PREVIOUSLY USED WINTERING AREAS

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Fancy, S. G., K. R. Whitten, D. E. Russell, F. J. Mauer, G. W. Garner, L. F. Pank, and R. F. Farnell. 1990. Infidelity of Porcupine Herd caribou to previously-used wintering areas. Canadian Journal of Zoology 67:000-000.

ABSTRACT:

We examined fidelity of individual caribou (n = 128) to previously-used wintering areas within the Porcupine Herd's traditional winter range during 1979-1988. Since 1979, most ($\bar{x}$ = 59%) of the Porcupine Caribou Herd wintered in the Richardson Mountains and the upper drainages of the Peel and Porcupine rivers in Canada. The location of concentration areas during winter varied annually. Little evidence of fidelity to previously-used wintering areas by individual caribou was found, and no sub-herds were identified. Localized human harvests should not interfere with traditional caribou movements through specific areas.

INTRODUCTION

Fidelity of individual caribou to specific wintering areas is particularly relevant to concerns regarding human harvest and industrial development. For example, the majority of the annual harvest of the Porcupine Caribou Herd (PCH; $\underline{n}$ = 165,000 in 1987) occurs near Arctic Village, Ft. McPherson, Old Crow, and along the Dempster Highway. If sub-herds exist and the same individuals return to the same areas each year, these sub-herds could be overharvested, and harvest activities could interfere with traditional range use patterns. The PCH is managed based on the assumption that sub-herds do not exist and that photographic counts of postcalving aggregations conducted at 2-5 year intervals reflect population trends. To assess potential effects of industrial development on the PCH and determine whether individuals habituate to development, it is important to know whether the same individuals will encounter the development repeatedly, or whether different caribou occupy areas where development will occur.

The PCH has received considerable attention since 1970 because of migration between the United States and Canada, its importance to subsistence hunters, and concerns about potential effects of roads and industrial development within its range. Annual surveys of PCH winter distribution and migration routes were begun in 1971 in relation to a proposed pipeline from northern Alaska to the lower 48 states via the MacKenzie River valley. In the mid-70's, additional studies of caribou winter range relationships and behavioral responses to the Dempster Highway were conducted (Kelsall and Klein 1979, Russell and Martell 1985). Since 1979, winter distribution surveys and monitoring of caribou using radio- and satellite telemetry have been conducted cooperatively by the U.S. Fish and Wildlife Service (USFWS), the Canadian Wildlife Service (CWS), the Alaska Department of Fish and Game (ADFG), and the Yukon Department of Renewable Resources (YDRR), to address concerns related to increased harvest along the Dempster Highway and potential oil and gas exploration and development on the PCH calving grounds.

Thompson and Roseneau (1978) compared data from 1971-1978 to historical accounts of caribou distribution within the range of the PCH and concluded that winter distribution patterns had changed little since the Franklin Expedition in 1826. In the 1970's, the primary wintering areas included the upper drainages of the Peel and Porcupine rivers in the Yukon Territory, and the Chandalar River valley in northeastern Alaska (Thompson and Roseneau 1978). The Canadian wintering areas were thought to have been used by $\geq$ 90% of the herd in 7 of 8 winters between 1971-1978. Thompson and Roseneau noted that distribution within these areas was highly variable, between and within winters. However, because there were no marked animals in the herd, and surveys often could not be flown because of darkness or poor weather, they did not obtain detailed winter movement data or determine if the same individuals returned to the same areas used in previous years.

We thank J. Carey, G. M. Lortie, L. D. Martin, M. A. Masteller, E. J. McDonald, W. A. Nixon, C. Smits and G. J. Weiler

for assistance with caribou capture and radio-tracking efforts. C. H. Curby, D. C. Douglas, J. C. Greslin, D. J. Reed and J. A. Venable assisted with computer programming and data analyses. D. L. Thomas and X. P. Quang assisted with statistical analyses. We appreciate critical reviews of the manuscript by W. B. Ballard, R. B. Harris, T. R. McCabe, F. L. Miller and W. L. Regelin. This study was supported in the United States by research and operational funds from the USFWS, administrative funds from the Pittman-Robertson Program, and funds from ADFG through Federal Aid in Wildlife Restoration Projects W-22-5 and W-22-6. In Canada, funds were provided by the Northern Oil and Gas Action Program, the Northern Roads and Airstrips Division, Indian and Northern Affairs Canada; the Polar Continental Shelf Project, Energy, Mines an Resources Canada; and research funds from the CWS and YDRR.

METHODS

We examined winter distributions and movements for radio- and satellite-collared PCH caribou over a 10-year period to determine whether the same individuals returned to wintering areas used in previous years. The range and seasonal movement patterns of the PCH were described by Garner and Reynolds (1986) and Fancy et al. (1989). Because caribou move continually and are capable of moving long distances at any time of year (Kelsall 1968, Skoog 1968), it is difficult to define a caribou's wintering area on a fine scale and determine if it is always loyal to that area in subsequent winters. We tested the hypothesis that individual caribou in the PCH returned to the same wintering area used in previous years by dividing the herd's winter range into only two areas, Canada versus Alaska, and determining fidelity of marked caribou to those areas. We would reject the fidelity hypothesis if no pattern of winter range use existed at this level of resolution.

We captured adult and yearling caribou on winter range using a helicopter and a net gun or an immobilizing drug fired from a Cap-Chur rifle (Palmer Chemical Co., Douglasville, Ga.), or during fall migration from a boat as they swam across the Porcupine River near Old Crow. Ninety-seven caribou were initially captured as 1-3 day old calves using methods described by Garner et al. (1985). Satellite transmitters (Fancy et al. 1988, 1989) were deployed on 34 adult female caribou between April 1985 and December 1987 to obtain daily locations.

Daily relocations of satellite-collared caribou were used to examine winter movements and distribution shifts. Satellite data were received monthly from Service Argos (Landover, Md.) and processed as described by Fancy et al. (1988, 1989). The satellite-transmitter package (Telonics, Inc., Mesa, Az.), which included a conventional radio transmitter to locate the caribou from an aircraft, weighed 1.6 kg and had a battery life of 1 year. Transmitters were programed to operate 6 hours/day, or 6 hours/2 days, and provided 3-4 locations/day with a mean location error of 829 m (Fancy et al. 1989).

We define winter from post rut in October to the beginning of spring migration in April or early May. Approximately 2-5 times

each winter, we conducted radio-tracking flights using fixed-wing aircraft to relocate collared caribou. During approximately half of the flights, we visually located collared caribou to obtain accurate locations and data concerning group size and composition, and habitat parameters. During the remaining flights we obtained only approximate locations and did not descend to visually locate the caribou. Based on the transmitting range and strength of the radio signals, the spacing of flight lines, and our experience locating thousands of transmitters from aircraft, we believe that approximate locations were within 25 km of the true location.

We assumed the distribution of radio-collared caribou reflected the distribution of the herd. Logistical and financial constraints have prohibited us from testing this assumption during winter. However, we have evaluated this assumption in summer by comparing numbers of caribou on various parts of the calving grounds as estimated from the distribution of radio-collars, to estimates based on helicopter and fixed-wing transects, ground counts, and photographic counts. The assumption appears to be valid when comparisons are made for large areas such as the PCH range in Canada versus Alaska (unpubl. data).

We used relocations of caribou between January and early April, when movements were relatively localized, to determine each caribou's wintering area. Because caribou were moving continually and many of the relocations were approximate, we assigned each winter relocation to an arbitrarily-selected grid system comprised of cells measuring 1 in latitude and 3 in longitude. These cells (ca. 112 x 126 km) correspond in size to a single United States Geological Survey map sheet for the general area of the PCH winter range. This grid system was used only to quantify the overall distribution of the herd, not to test for fidelity to specific cells.

For each year between 1979-1988, we used the proportion of collared caribou that wintered in Canada to determine the expectation that a particular caribou would winter in Canada. This was done because social interactions, weather patterns, and other factors influence herd distribution (Kelsall 1968, Skoog 1968), and we would not expect caribou to be evenly distributed between Canada and Alaska each winter. For 128 caribou that were located $\geq$ 2 winters (excluding the winter when a caribou was first captured), we compared the observed proportion of years that the caribou wintered in Canada to the mean proportion of collared caribou that wintered in Canada during the years for which the particular caribou was relocated. For example, if Caribou A wintered in Canada in 1979, 1980, and 1981, but wintered in Alaska in 1982, we would compare the observed proportion of years Caribou A wintered in Canada (0.75) to the mean proportion of all collared caribou that wintered in Canada during those 4 years (0.49). For each caribou with $\geq$ 2 winter locations, we then calculated the difference between the observed proportion of years in Canada and the expected proportion based on herd distribution. A positive difference would indicate that an individual wintered in Canada more than expected based on herd distribution, whereas a negative

value would indicate that the individual wintered in Alaska more than expected. We used the UNIVARIATE procedure of SAS (1985) to determine whether the combined differences deviated from a normal distribution (Kolomogorov D statistic) or were significantly different from zero (t-test).

RESULTS

Winter Distribution

Between 1978-1987, we captured 228 caribou and subsequently relocated them on winter range during 1 to 6 winters (Table 1). Weather and budgetary factors often prevented us from covering the entire winter range during aerial surveys, and some caribou were not located during surveys because of weak signals from transmitters. Expected battery life for radio-collars was 3-4 years, but many caribou died or their transmitters failed before they could be recaptured to replace their radio-collar.

The majority of the PCH (mean = 59%; Fig. 2) has wintered in Canada between 1979 and 1988, primarily south of 67 N and along the axis of the Richardson Mountains. The distribution of radio- and satellite-collared caribou in late winter during 1979-1987 (Fig. 3) indicated that the primary winter ranges of the PCH occurred in the upper drainages of the Peel and Porcupine rivers and in the Richardson Mountains in Canada, and in the upper drainages of the Chandalar, Sheenjek and Coleen rivers in Alaska.

Winter Movements

Caribou movements were relatively localized between December and March; the maximum distance between any two locations for each satellite-collared caribou during those months averaged 48 ($\pm$ 11 SD) km (Fig. 4). During October and November, however, caribou moved extensively. The maximum distance between any 2 locations of a satellite-collared caribou in October exceeded 100 km in 19 of 22 cases, and exceeded 200 km in 8 cases. In November, caribou were relocated more than 100 and 200 km between 2 locations in 12 and 2 cases, respectively. In contrast, for the months of December, January, February and March, only 8 of 86 distances were > 100 km, and none exceeded 200 km.

Fidelity to Wintering Areas by Individuals

Radio-collared caribou located in > 1 winter did not exhibit fidelity to a specific winter range ($t = 0.74$; $n = 128$; $P = 0.46$; Kolomogorov $D = 0.075$; $P = 0.07$). Only 2 of 20 caribou relocated in 5 or 6 winters (including winter locations where a caribou was captured) returned to either Canada or Alaska each year, and neither was relocated more than twice in the same grid cell (Fig. 3). Also, only 8 of 20 caribou wintered in the same country in all but 1 year, and these caribou used different areas within each country each year. Caribou captured together on winter range had no clear pattern of subsequent winter range use or long-term group association (unpubl. data).

DISCUSSION

Annual variation in winter range use by caribou has been reported for herds across North America (e.g., Kelsall 1968, Skoog 1968, Hemming 1971). Kelsall (1968) compared 10 years of winter distribution data for herds in the Northwest Territories of Canada, and concluded that only minor portions of winter range were used more frequently than 2 or 3 winters out of 10. Variation in winter range use has been attributed to annual variation in snow depth, density and hardness (Pruitt 1959, Kelsall 1968, Skoog 1968). The primary winter ranges used by the PCH in Canada occur in the snow shadows of the Ogilvie and Wernecke mountains, and in the Richardson Mountains where high winds redistribute snow to expose forage on ridges and mountain slopes (Russell and Martell 1985). Although learned behavior (traditions) appears to play a major role in the determination of a herd's long-term overall winter range, it appears that annual variations in weather and snow conditions override traditions in the finer selection of specific winter areas by individual caribou.

The relatively localized movements by PCH caribou in mid-winter also have been documented for other herds. Skoog (1968) reported that the usual pattern for the Nelchina Herd in Alaska was to become established on winter range by mid-January, as snow depths approach their maximum, and to remain there until early April. Skoog found, as we did, that extensive movements generally did not occur during that period, although considerable shifting by individuals occurred within the general region being utilized. For the PCH, locations of caribou obtained between early December and early April represent an individual's winter range and the winter distribution of the herd.

These findings have several obvious management and research implications. First, they indicate that sub-herds apparently do not exist in the PCH. The assumption that periodic counts of postcalving aggregations reflect overall herd status is probably valid. Second, at present densities, heavy, localized harvest should not interfere with traditional movements through an area because different caribou move through the area each year. Third, because of the lack of sub-herds or long-term group association, results obtained by collaring a group of caribou at the same location and then relocating them in subsequent winters should not differ from results obtained by capturing caribou in a random or systematic fashion throughout the winter range.

LITERATURE CITED

Fancy, S. G., Pank, L. F., Douglas, D. C., Curby, C. H., Garner, G. W., Amstrup, S. C., and Regelin, W. L. 1988. Satellite telemetry: a new tool for wildlife research and management. U.S. Fish Wildl. Serv. Resour. Publ. No. 172.

Fancy, S. G., Whitten, K. R., Pank, L. F., and Regelin, W. L. 1989. Seasonal movements of caribou in arctic Alaska as determined by satellite. Can. J. Zool. 67:644-650.

Garner, G. W., and Reynolds, P. E. (Editors). 1986. Final report baseline study of the fish, wildlife, and their habitats. U.S. Fish and Wildlife Service, Anchorage, AK.

Garner, G. W., Whitten, K. R., and Mauer, F. J. 1985. Methodology for studying neonatal mortality of caribou in remote areas. McGill Subarctic Res. Pap. 40:139-152.

Hemming, J. E. 1971. The distribution and movement patterns of caribou in Alaska. Alaska Dep. Fish Game, Game Tech. Bull. No. 1.

Kelsall, J. P. 1968. The migratory barren-ground caribou of Canada. Can. Wildl. Serv. Monogr. Ser. No. 3.

Kelsall, J. P., and Klein, D. R. 1979. The state of knowledge of the Porcupine Caribou Herd. Trans. N. Amer. Wildl. Nat. Res. Conf. 44:508-521.

Pruitt, W. O., Jr. 1959. Snow as a factor in the winter ecology of the barren-ground caribou (Rangifer arcticus). Arctic 12:159-179.

Russell, D. E., and Martell, A. M. 1985. The winter ecology of the Porcupine Herd, Yukon: Part I. Characteristics of the range. Unpubl. manuscr., available from Can. Wildl. Serv., 204 Range Rd., Whitehorse, Yukon, Canada, Y1A 3V1.

SAS Institute Inc. 1985. SAS User's Guide: basics, version 5 edition. SAS Institute Inc., Cary, NC.

Skoog, R. O. 1968. Ecology of the caribou (Rangifer tarandus granti) in Alaska. Ph.D. thesis, University of California, Berkeley.

Thompson, D. C., and Roseneau, D. G. 1978. Winter distribution of the Porcupine caribou herd in relation to the proposed Dempster lateral pipeline route. Available from Foothills Pipe Lines Ltd., 1600 - 205 Fifth Ave. SW, Calgary, Alta, Canada T2P 2V7.

Table 1. Sample size and number of caribou-winters for Canada and Alaska for radio-collared caribou relocated in 1 to 6 winters. Capture locations are excluded.

Years relocated	n	Winter location Canada	Alaska
1	100	69	31
2	56	77	35
3	48	71	73
4	13	29	23
5	9	25	20
6	2	4	8
Totals	228	275	190

FIGURE CAPTIONS

Fig. 1. Range of the Porcupine Caribou Herd.

Fig. 2. Proportion of radio- and satellite-collared caribou from the Porcupine Caribou Herd that wintered in Canada each year between 1979 and 1988. Sample sizes are shown in parentheses.

Fig. 3. Distribution of radio-collared caribou of the Porcupine Herd during winter (January - early April), 1979-1988. The number in each systematically-placed grid cell is the number of caribou-winters recorded for that cell. The figure excludes 93 caribou that were relocated in either Canada or Alaska, but for which a precise wintering location was not determined.

Fig. 4. Maximum distance (Means + 1 S.D.) between any two relocations of satellite-collared adult female caribou of the Porcupine Caribou Herd during winter (sample sizes are shown in parentheses).

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