U.S. Fish & Wildlife Service

# Nunivak Island Reindeer and Muskoxen Survey—2009

**Yukon Delta National Wildlife Refuge Technical Report Series Number 2009-01**

**Eric J. Wald[1]**

Photo by: Eric J. Wald/USFWS.

[1]Yukon Delta National Wildlife Refuge
807 State Hwy., PO Box 346
Bethel, AK 99559
(907) 543-3151
December 2009

*Suggested Citation:*

Wald, E. J. 2009. Nunivak Island reindeer and muskoxen survey—2009. U.S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge, Technical Report Series Number 2009-01. Bethel, Alaska.

*Keywords:*
caribou, *Rangifer tarandus*, Yukon Delta National Wildlife Refuge, population estimate, photography, Alaska, muskoxen, *Ovibos moschatus*.

*Acknowledgments:*
The author would like to thank pilot Kevin Fox, observer Gary Ivanoff, Nuniwarmiut Reindeer and Seafood Products manager Moses Whitman, liaison Henry Ivanoff, Alaska Department of Fish and Game assistant area biologist Patrick Jones, reviewers Bryce Lake and Refuge staff. Without their commitment and contributions this project would not have been successful.

*Disclaimer:*
The use of trade names of commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

# Nunivak Island Reindeer and Muskoxen Survey—2009

Eric J. Wald

## ABSTRACT

Reindeer were introduced to Nunivak Island in 1920 and over the last 80 years have fluctuated significantly in population size. Past surveys varied by time of year, survey platform, and survey effort and resulted in variable estimates. This survey was completed August 26-28, 2009 under acceptable weather conditions. A Cessna 206 aircraft with two observers was used as the survey platform. The island was divided into 15 subunits with complete coverage and search effort averaging 56.6 minutes per subunit. A total of 16.3 hours was spent surveying and flying between units. A total of 1192 reindeer were counted in nine groups. All reindeer encountered were located on the western half of the island during this survey. Two groups (1070 and 87 reindeer) required photographing in order to get an accurate count. No attempt was made to classify reindeer into sex or age classes. Results indicate that the reindeer herd is under the current management objective of 2000 animals. Although this survey was mainly designed for reindeer, muskoxen (385 animals) were counted incidentally when encountered. Groups were distributed throughout most of the island with more concentrating along the south and west sides. The Alaska Department of Fish and Game completed a muskoxen-specific survey September 21-24, 2009 and counted 567 animals. This disparity in estimates highlights the difference in search effort and technique for each species. Recommendations are discussed.

## Introduction

Wild caribou (*Rangifer tarandus*) inhabited Nunivak Island until the late 1800s (Murie 1935). Caribou populations were once estimated to be 25,000 animals (Swanson et al. 1986); however, by 1904 the population had crashed and was extirpated due to starvation in severe winters and overhunting (Miller 1931). In the early part of the 20th century, Nunivak Island was considered open range and in 1920, reindeer were first introduced to the island by Lomen and Company from Nome, Alaska (Palmer 1938). In 1929, Nunivak Island Reservation was established by executive order for the purpose of conducting experiments on hybridizing reindeer and caribou (originally started in 1925; Palmer 1926), as well as propagating muskoxen for introductions elsewhere in Alaska. In 1940, congress changed the name to Nunivak Island National Wildlife Refuge. Lastly, in 1980 it was incorporated within the comprehensive boundaries of the newly created Yukon Delta NWR. However, the purposes of Nunivak Island largely remained the same. Over the last 90 years, changes in state and federal agency administrations and herd ownership have created an environment for mismanagement and allowed the reindeer population to exceed the island's carrying capacity.

Renewed concern for the island's environmental integrity was set forth in the mid to late 1980s with the completion of a range survey by the US Department of Agriculture, Soil Conservation Service and the cooperative development by all stakeholders of a management plan. The "Nunivak Island Reindeer and Muskox Management Plan" was finalized and signed in 1992 and outlined herd objectives and responsibilities for each party, including: 1) maintain a baseline reindeer population of 2000 animals, 2) maintain a baseline muskox pre-calving population of 500 animals, 3) restore critical lichen habitats to good or better range condition classes, 4) establish a program to monitor habitat carrying capacity, condition and trend, and 5) maintain an opportunity for a source of income for local residents through commercial reindeer sales (USFWS 1992).

Fixed wing aerial surveys have been utilized since the 1970's on Nunivak Island with the goal of systematically covering the entire island in 1-2 days and counting or photographing each reindeer group. In 2001, the village of Mekoryuk was contracted to conduct a ground count of the reindeer and muskoxen populations. Data were recorded over a 5 day period with multiple observation teams working each census area on the island. It is unknown if all animals were located or if double counting occurred. The Refuge continued to contract Nuniwarmiut Reindeer & Seafood Products (NRSP) to complete these late winter snowmobile censuses, but tried to increase the data quality so that results would be more comparable to aerial surveys. The last cooperative survey was conducted by snowmobiles in March 2006 and the 3250 animals counted were more than 60% over the herd objective (NRSP files; Moses Whitman 2009, pers. comm.).

Historically, most reindeer surveys (fixed-wing and snowmobile) on Nunivak Island have been typically conducted in March. However, at this time of year reindeer are highly scattered throughout the island in smaller groups making them more difficult to observe (Hinkes 1988). Additionally, it is difficult to fly this time of year due to short day length

and adverse weather. Therefore, conducting this survey in July or August before the breeding season is a preferred alternative. July and August have longer day lengths, better flying conditions, and are warm and buggy which causes reindeer to bunch together and move into prevailing winds in order to find relief from insects. As a result, most reindeer will be in a few large aggregations and will be easier to find, count and photograph giving a more accurate population estimate.

## Objectives

1. Survey Nunivak Island and count all reindeer.
2. Survey Nunivak Island and count muskoxen incidentally to reindeer.

## Methods

Logistics and budgeting are listed in Appendix 1.

*Study Area:*
Nunivak Island is approximately 4452 $km^2$ (1.1 million acres; 1719 $mi^2$) in size. It is 115 km (70 mi) by 80 km (50 mi) at its widest points and is located 30 km (20 mi) offshore in the Bering Sea.

*Survey Units:*
The island was divided into 15 subunits with boundaries delineated by geographical features such as rivers, mountains and shorelines (Figure 1). These boundaries were originally hand-drawn on topographical maps and used for navigation. Subunit division was used when several aircraft were simultaneously surveying the island and allowed for safe operations as well as a systematic survey method. Geographic subdivision worked well in the past without the aid of current navigation capabilities such as GPS units, tracklogs and mapping software; however, these technological advances were employed for this survey. Old topographic maps with hand-drawn subunits were recreated by hand digitizing boundaries using ArcGIS 9 v9.2 with the topographic module TOPO! Pro for ArcGIS v.2.3. New digital boundaries were converted to a shapefile (metadata in Appendix 2), which was uploaded to a handheld Garmin GPSMap 276C unit using the DNRGarmin v.5.02.0025 ArcGIS extension. The shapefile was converted and uploaded as an active tracklog on the GPS unit. Once uploaded to the GPS unit, the shapefile (converted tracklog) can be downloaded into Garmin's MapSource software for easy GPS uploads in the future. The GPS unit, with its real time tracklog activated, is then used by the pilot to navigate through the survey unit. This technology enables the pilot to verify his exact position at all times and to assess whether complete coverage has occurred. In this way, both survey efficiency and accuracy are maximized.

Each subunit was surveyed by flying parallel transects approximately 1.6 km (1.0 mi) apart and ranged from 1.3-2.4 km (0.8-1.5 mi) apart depending on terrain and visibility.

Flight altitude was approximately 30.5 m (1000 ft) above ground with a ground speed of 80 kts (92 mph). This provided observers excellent visibility out to 800-900 meters and good visibility between 900-1200 meters from the center of transect on both sides. Observers could visually cover the farthest edge twice on subsequent transects. The pilot (Kevin Fox) plus one observer (Gary Ivanoff) in the front right seat and another (Eric Wald) in the back left seat behind the pilot completed the survey.

The pilot was responsible for flying and navigating the plane and making incidental observations. Observers were responsible for continuous observations on their respective sides of the plane. When animals were encountered, the observer notified the pilot and he would circle the group. Observers counted all animals and recorded locations on the data form (Appendix 3). All reindeer groups were circled for accurate counts while muskoxen were not circled because they were not the focus of this survey and were incidentally counted. The active GPS tracklog and waypoints of each group helped to eliminate double counting. The survey team spent approximately 45 minutes to 1.5 hours in each subunit depending on size of unit, terrain and visibility. Depending on herd cohesiveness, groups of more than 50 reindeer were photographed and later counted to maximize accuracy (Hinkes 1988, 1989).

*Photography:*
We used a Nikon D200 digital camera with a 17-35 mm, 1:2.8D AF-S Nikkor lens to photograph reindeer groups. The camera was mounted on a bracket on the floor at the back of a Cessna 206 on wheels and images were shot through an access port. The camera was connected to a laptop computer running Nikon's Capture Control software to control camera operations. The camera was set at 30 mm focal length, aperture f8 and shutter speed 1/1000 seconds with an automatic exposure every 2.5 seconds to ensure complete overlap and group coverage. Flight altitude while photographing was 50 m (1500 ft) above ground level. Images were reviewed in flight to verify coverage and clarity. If more or better images were needed, extra over-flights were performed.

All images were stored on a laptop computer and were later analyzed digitally on a desktop computer. Images were imported into ArcGIS 9 v9.2 for analysis. The images were imported into ArcMap and an empty point shapefile was created for each image. The editor tool was used for creating points on individual reindeer for enumerating. The image was zoomed in and out to help identify all reindeer in the image. Other image processing or manipulations such as changing color bands can be used to enhance differentiation between individual reindeer. Once all reindeer were identified and marked with a point, the shapefile's attribute table was opened and the number of records (each point represents a record) was indicated the number of reindeer in the photo. Each photo was counted by two observers for quality control. The digital analysis provided a permanent and easily stored record of the count (Figure 2).

When smaller groups of reindeer were encountered, the floor mounted camera was removed and hand-held images were shot at an oblique angle out a side window while flying at a lower altitude (213-305 m). This was much faster to set up and execute compared to the belly port photos. Animal distribution and shadowing has to be

considered when photographing at oblique angles. Since larger groups (>200) are more difficult to reliably photograph at oblique angles, shooting straight down through the belly port is the preferred method for photographing larger reindeer groups.

## Results and Discussion

*Weather:*
Weather conditions during August 26-28, 2009 ranged from clear to overcast, winds 15-20 kts gusting at times to 26 kts, and temperatures from 7° C to 11° C. These were acceptable conditions, but at times the wind was a little breezy. While turbulence was not a significant factor, wind speed did make flying harder for the pilot and decreased his observation time.

*Reindeer Survey:*
Starting on August 26th, we surveyed the east and southeast portions of the island. The second day was spent in the northern and western portions of the island and the last day was spent surveying the central region. Historical data (Scott 1984) and satellite collar data (Figure 3) indicate that reindeer mostly congregate in the western portions of the island during this time of year. Our survey transects were slightly wider apart in the eastern region which has terrain conducive to longer observation distances compared to the western region.

A total of 849 minutes (14.15 hours) was spent in the 15 survey units. Survey times ranged from 40 to 79 minutes with an average of 56.6 minutes per subunit. Another 2.15 hours were spent flying between survey units and refueling in Mekoryuk.

A total of 1192 reindeer were counted in nine groups. All reindeer encountered were located in the western half of the island. Subunits 2C, 4B, 3A, 3B and 7B all had reindeer in them. Nearly 99% of all reindeer were west of Nash Harbor and 91% of all reindeer were located in subunit 3B (Figure 4; Appendix 3).

One large group (1070 reindeer) in subunit 3B required photographing using the belly port method. Two photographic passes were completed on this group at an altitude of 50 m (1500 ft). The first pass utilized a focal length of 25 mm and the second used a 30 mm focal length, which worked better. Using the camera's intervalometer, up to 20 photos were captured for each pass. The entire group was photographed in two frames with 99% of the group captured in one frame. Another smaller group (87 reindeer) in subunit 7B was photographed using the hand-held oblique angle method (Figure 5). This group was small enough with adequate spacing of individuals and appropriate shadowing to photograph the herd. Flight altitude was 24-30.5 m (800-1000 ft). Several photos were taken in order to capture the correct angle to minimize shadowing. All animals were captured in one photograph. No other group required photographing.

In February 2007, satellite collars were attached to two reindeer. The collars are a cooperative effort between the Natural Resources Conservation Service (NRCS),

University of Alaska Fairbanks-Reindeer Research Program (UAF-RRP), Nuniwarmiut Reindeer and Seafood Products (NRSP) and US Fish and Wildlife Service (USFWS) in order to determine range usage by reindeer and encourage active herding practices. Because one of these animals died in March 2008, the island had only one animal with an active satellite collar. We were able to cross reference our locations of reindeer with the satellite collar to determine whether it was part of one of the groups. Despite a lack of visual confirmation of the collar, its coordinates were 2.4 km (1.5 mi) away from the large herd the day of the survey. Given that the herd was moving away from this location when we flew over, it is likely the satellite collared animal was in the large group.

Survey results indicated that the herd is currently at one of its lowest population points and is below the 2000 animal herd objective outlined in the 1992 management plan (Figure 6).

*Muskoxen Survey*:
This survey was not intended to get a complete count of muskoxen on the island because the added flight time and cost was prohibitive and the Alaska Department of Fish and Game had scheduled a muskoxen survey at a later date. Muskoxen were counted and recorded incidentally from existing transects and located groups were not circled to increase count accuracy.

A minimum of 385 muskoxen were on the island. There were 102 groups ranging in size from 1 to 14 animals with an average of 4 muskoxen per group. Groups were distributed throughout most of the island with more concentrating along the south and west sides (Figure 7). Sand dunes on the south side have traditionally been highly utilized as well as cliffs on the west edge (Rearden 1982, 1983; Miller 1995). Subunits 5B, 6A and 3B had the most muskoxen; 80, 78 and 54 respectively.

Alaska Department of Fish and Game's intensive muskoxen survey occurred September 21-24, 2009. They used a Husky aircraft with one observer in addition to the pilot. They surveyed the entire island and flew a total of 19.5 hours. Their survey methodology was similar to ours. However, they did not fly within subunits and flew transects across (north to south) the island at a lower altitude and circled every muskoxen group to ensure complete counts (Jones 2009, pers. comm.).

Their count was 567 muskoxen. There were 132 groups ranging in size from 1-17 animals with an average of 4 muskoxen per group. Groups were distributed throughout the island. Additionally, two bull muskoxen were stranded on Triangle Island on the northeast side of Nunivak Island and one bull on Abaramiut Island on the north central side of Nunivak Island. The two bulls on Triangle Island looked to be in good health while the one bull on Abaramiut Island appeared severely malnourished. There were originally 7 muskoxen stranded on Triangle Island and 3 on Abaramiut Island with some of these being legally harvested through a special permit earlier in the summer (Jones 2009, pers. comm.). The 1992 management plan has a pre-calving herd objective of 500 muskoxen. The current count is post-calving and included 98 calves. The pre-

calving estimate of 469 animals is slightly below management objective. The population has been stable for nearly 50 years (Figure 8).

The Alaska Department of Fish and Game muskoxen count is significantly higher because they took the time to fly over each muskoxen group. This allowed them to count all animals in the group, including the calves, which can be difficult to see at a distance when they are encircled by the adults and counted incidentally while not leaving reindeer survey transects. Additionally, they spent more time circling rocky volcanic craters and bluffs where muskoxen tend to bed and be more cryptically hidden. Reindeer are not as likely to utilize these areas (Jones 2009, pers. comm.).

## Recommendations

Surveying reindeer during summer (July/August) by aircraft is the preferred method and time of year. Surveys in late winter (February/March) by either snowmobiles or aircraft can be plagued with problems such as adverse weather, animals in smaller and more dispersed groups, and considerably fewer daylight hours increasing the length of a survey by days, which increases the probability of double counting (Morgart 1996, 1998, 1999). Surveys during and after the breeding season (September/October) are also less preferred because reindeer are scattered into much smaller groups (average= 27 reindeer/group; range = 1-115 reindeer/group; Jones 2009, pers. comm.) which increases the probability of missing animals.

Flying over flat homogenous (visually noncryptic) habitat with 1.6 to 2.4 km (1.0 to 1.5 mi) transect separation seemed to provide adequate coverage. However, adhering to 1.6 km (1.0 mi) or less separation is highly recommended to make the survey more robust in all terrains/habitats. Broken habitat that is more visually cryptic as well as hills or mountainous features make 2.4 km (1.5 mi) transect separation inadequate.

Future reindeer management would be enhanced by obtaining herd composition data because the herd seems to be heavily biased toward bulls. Knowing bull:cow and calf:cow ratios is required to effectively meet management goals.

Surveying muskoxen would be enhanced by utilizing the ADFG procedure of flying over each group and more intensively surveying rocky, volcanic craters and bluffs. Surveying the island with two planes working together to simultaneously survey reindeer and muskoxen would maximize efficiency. Surveys should be completed minimally every two years.

## Literature Cited

Bos, G. N. 1967. Range types and their utilization by muskox on Nunivak Island, Alaska: a reconnaissance study. M.S. Thesis, University of Fairbanks, Fairbanks, Alaska.

Hinkes, M. 1988. Progress report, Nunivak Island reindeer/muskox inventory—a status report of muskox and reindeer populations on Nunivak Island. USFWS, Yukon Delta NWR, Bethel, Alaska.

Hinkes, M. 1989. Progress report, Nunivak Island reindeer/muskox inventory—a status report of muskox and reindeer populations on Nunivak Island. USFWS, Yukon Delta NWR, Bethel, Alaska.

Jones, P. 2009. Personal Communication. Assistant Area Biologist, Alaska Department of Fish and Game, Division of Wildlife Conservation, Bethel, Alaska.

Kovach, S. 2003. Summary of Nunivak Island reindeer and muskox census data. US Fish and Wildlife Service, Yukon Delta NWR, Bethel, Alaska.

Miller, G. 1995. Nunivak Island annual muskox/reindeer survey, Yukon Delta National Wildlife Refuge, Alaska—1994. US Fish and Wildlife Service, Yukon Delta NWR, Bethel, Alaska.

Miller, W. B. 1931. Nunivak Island reindeer-caribou roundup 1930. Memo to Mr. Palmer dated May 25, 1931; US Department of Agriculture, Bureau of Biological Survey. Veteran's Hospital, Walla Walla, Washington.

Morgart, J. R. 1996. 1996 annual aerial reindeer and muskox census on Nunivak Island. USFWS, Yukon Delta NWR, Bethel, Alaska.

Morgart, J. R. 1998. 1997 annual aerial reindeer and muskox census on Nunivak Island. USFWS, Yukon Delta NWR, Bethel, Alaska.

Morgart, J. R. 1999. 1998 annual aerial reindeer and muskox census on Nunivak Island. USFWS, Yukon Delta NWR, Bethel, Alaska.

Murie, O. J. 1935. Alasaka—Yukon caribou. North American Fauna Series 55:1-93.

Palmer, L. J. 1926. Progress of reindeer grazing investigations in Alaska. U.S. Department of Agriculture, Department Bulletin No. 1423, Washington, D.C.

Palmer, L. J. 1938. Management of muskox and reindeer on Nunivak Island, Alaska. U.S. Bureau of Biological Survey, Project Report 25 pages.

Perry, P. 2005. Unit 18 muskox management report. Pages 1-12 *in* C. Brown, editor. Muskox management report of survey and inventory activities 1 July 2002—30 June 2004. Alaska Department of Fish and Game, Juneau, Alaska.

Rearden, M. B. 1982. Report on 1982 winter muskox census on Nunivak Island. USFWS, Yukon Delta NWR, Bethel, Alaska.

Rearden, M. B. 1983. Report on 1983 winter muskox census on Nunivak Island. USFWS, Yukon Delta NWR, Bethel, Alaska.

Scott, D. O., Jr. 1984. Nunivak reindeer count - 9-21-84. US Bureau of Indian Affairs, Bethel, Alaska.

Swanson, J. D., D. Lehner, and J. Zimmerman. 1986. Range survey of Nunivak Island, Alaska. U.S. Department of Agriculture, Soil Conservation Service, Anchorage, AK. 67 pages.

USFWS. 1992. Nunivak Island reindeer and muskox management plan. US Fish and Wildlife Service, Yukon Delta NWR, Bethel, Alaska.

Whitman, M. 2009. Personal Communication. Manager, Nuniwarmiut Reindeer and Seafood Products, Mekoryuk, Alaska.

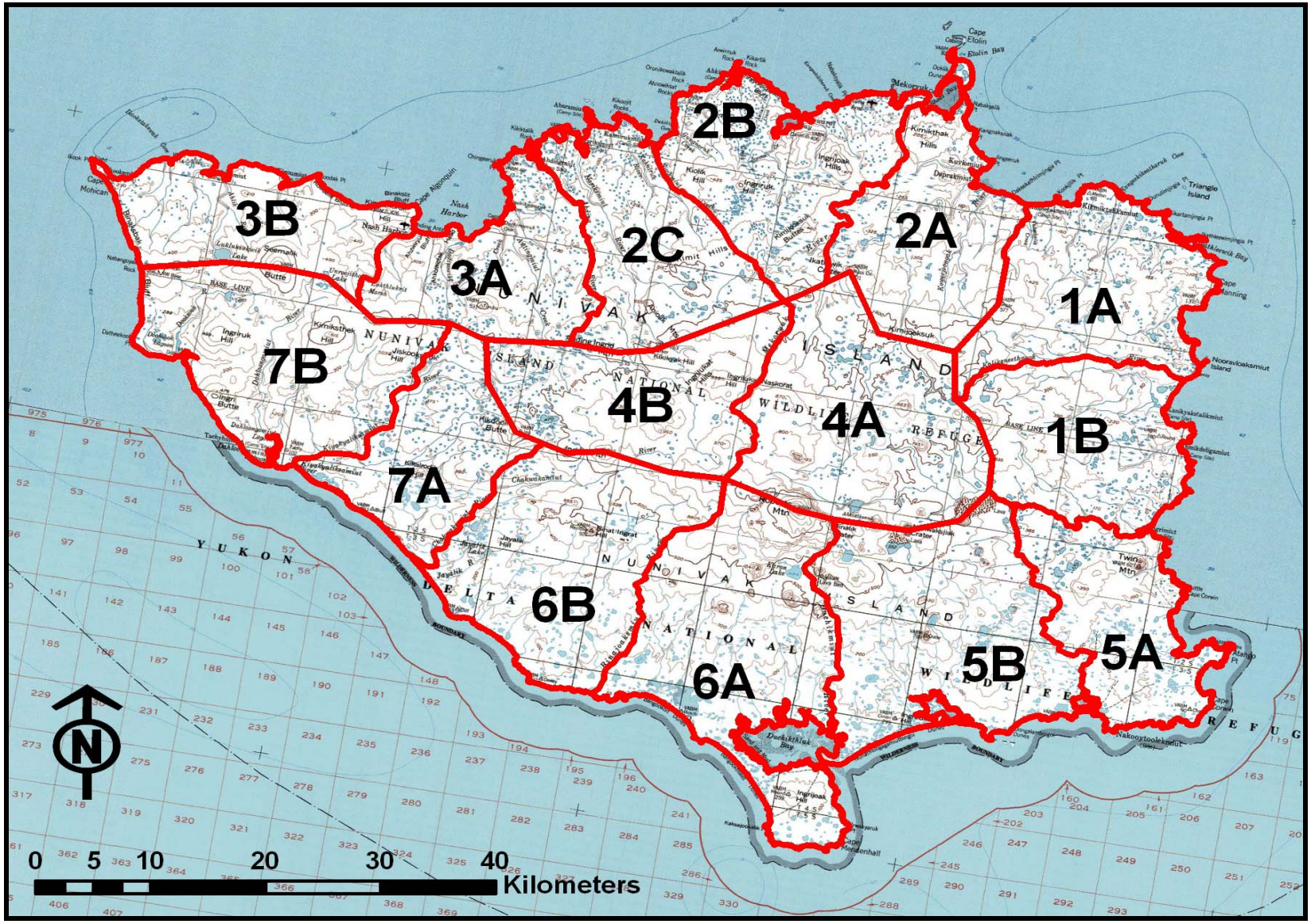


**Figure 1.** Census subunits on Nunivak Island.

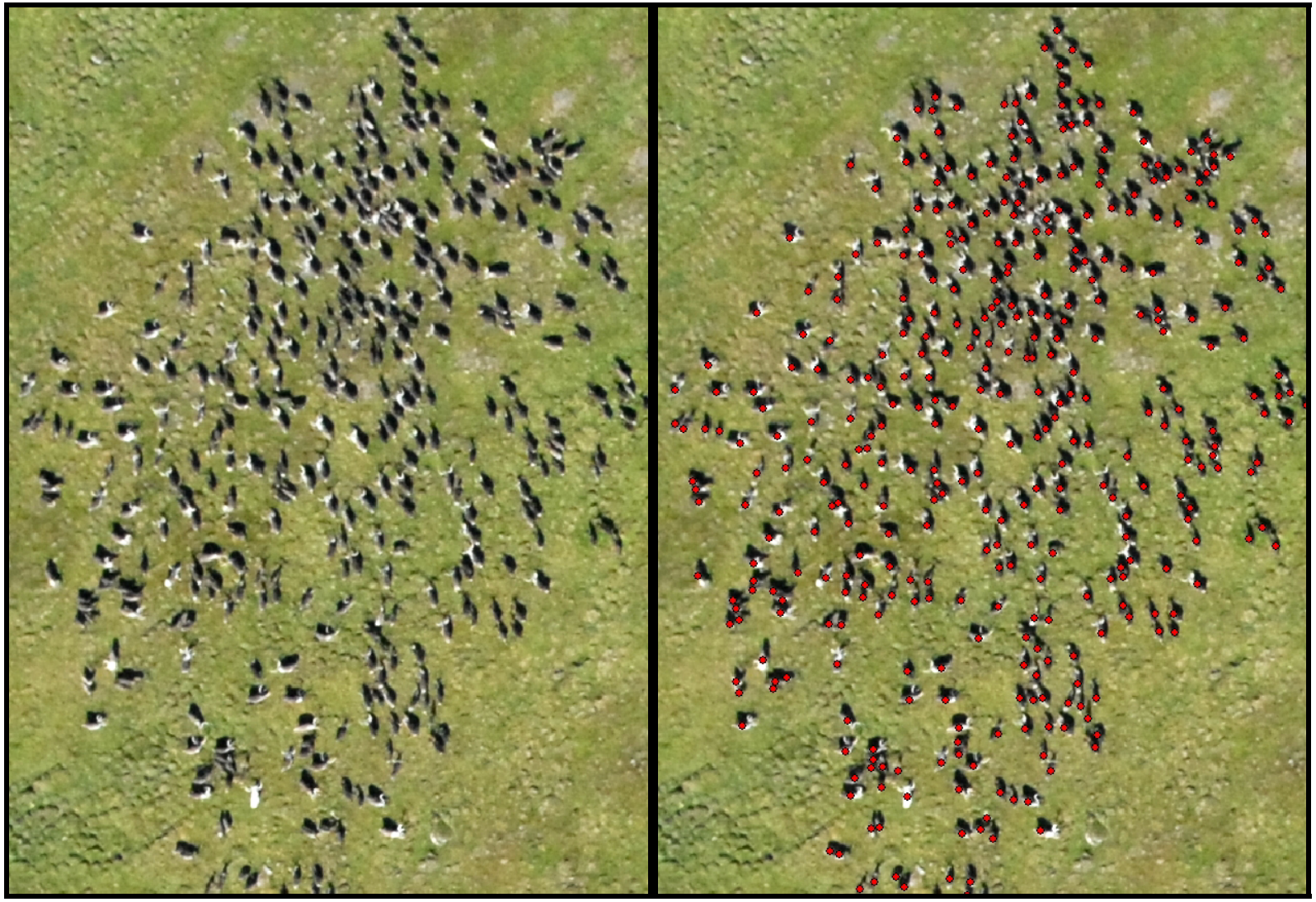

**Figure 2.** Magnified image of digitally counted reindeer in ArcGIS by using a point shapefile and enumerating the points (red dots). Image photographed from a C-206 belly mounted camera. This is the preferred method to enumerate large groups.

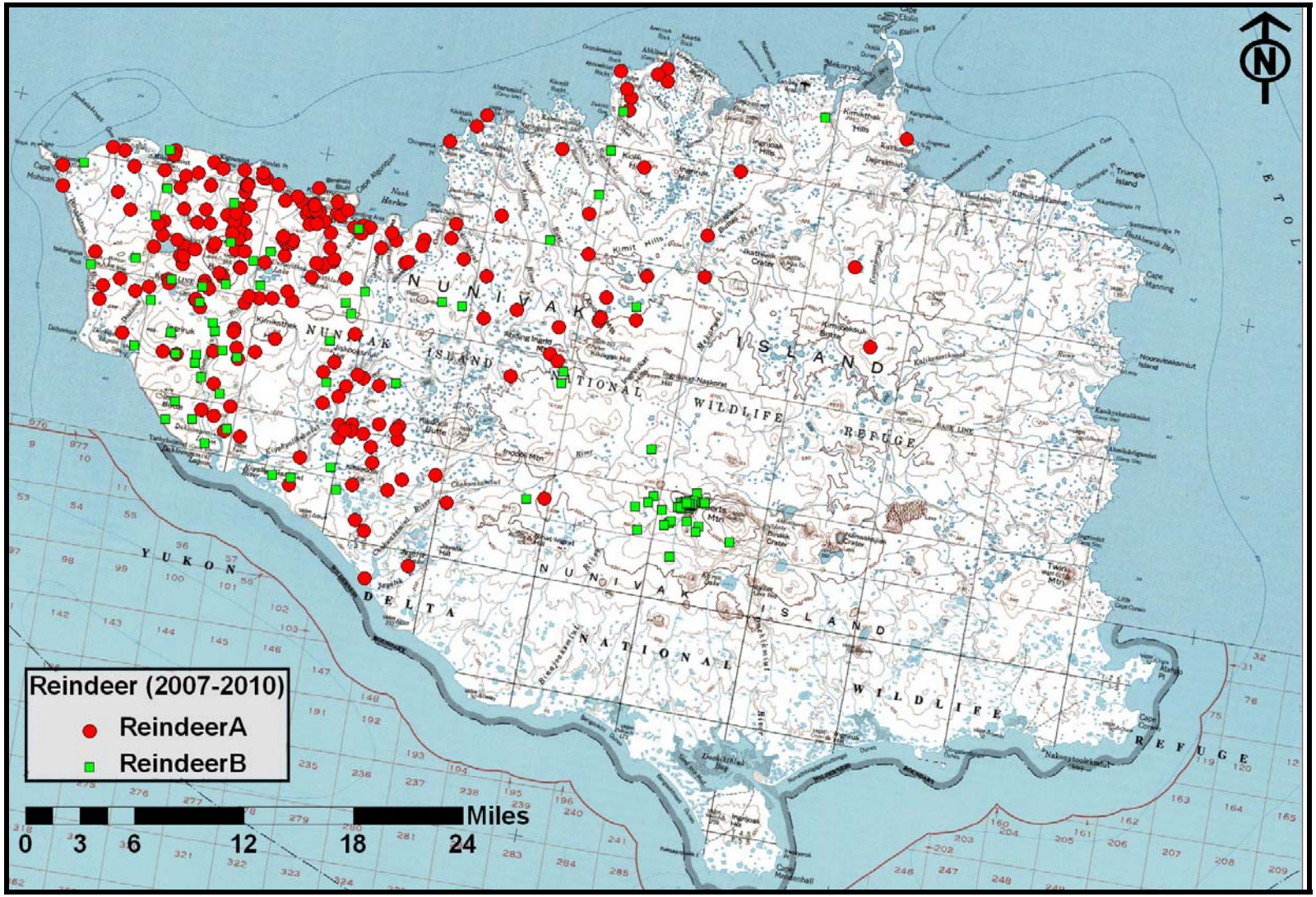


**Figure 3.** Satellite collar locations for 2 reindeer on Nunivak Island for the period 2007-2010. ReindeerB died near Robert's Mountain around March 2008. Satellite collars are a cooperative effort between the Natural Resources Conservation Service, University of Alaska Fairbanks—Reindeer Research Program, Nuniwarmiut Reindeer and Seafood Products, and the USFWS to better understand range usage by reindeer.

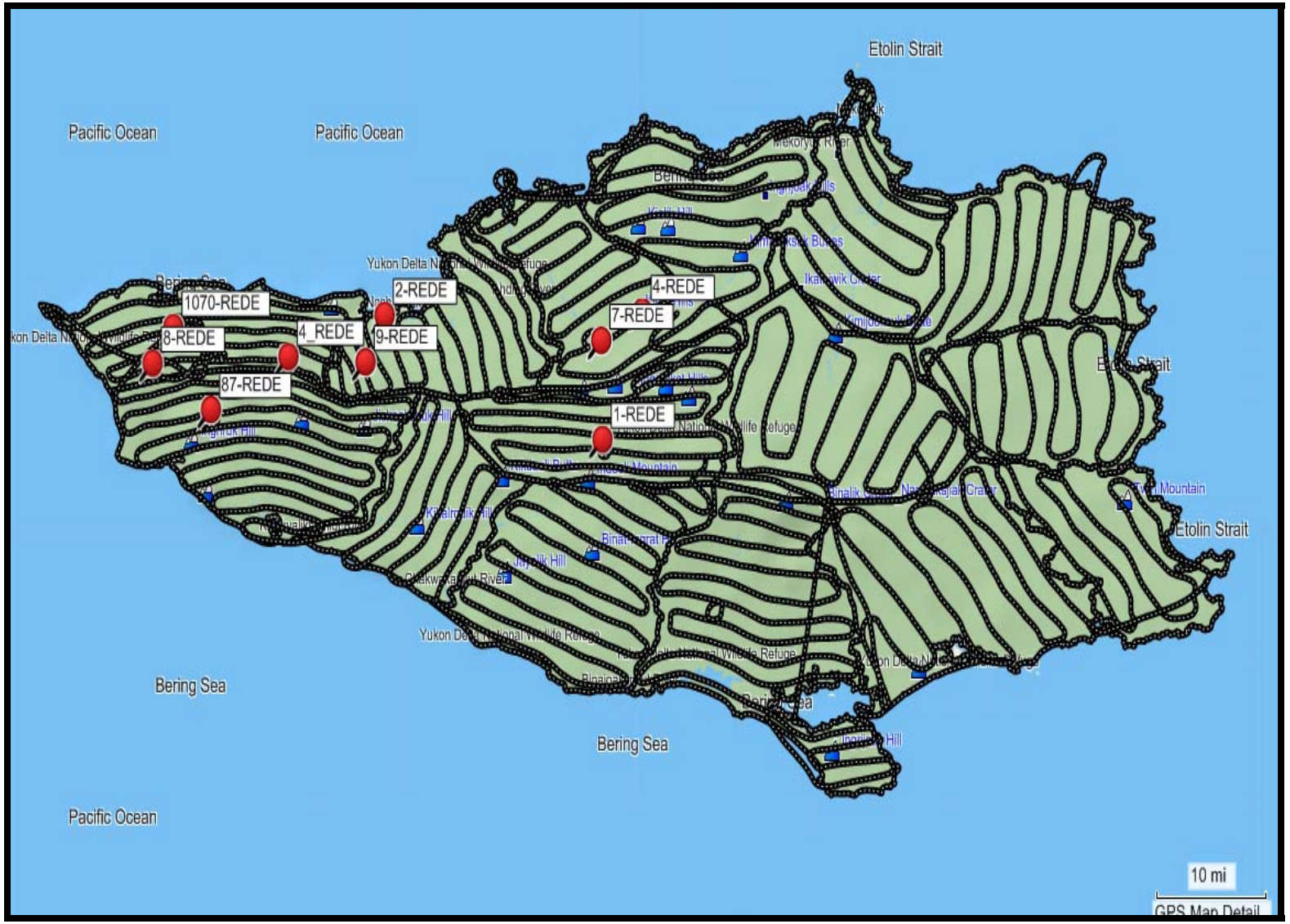


**Figure 4.** Survey track logs, locations, and number of reindeer in each group observed August 26-28, 2009. Map derived from Garmin MapSource.

**Figure 5.** Image photographed from hand-held camera at an oblique angle out the window of a C-206. Small groups are easier to photograph in this way. Multiple frames are taken in order to get a good image with reduced shadowing.

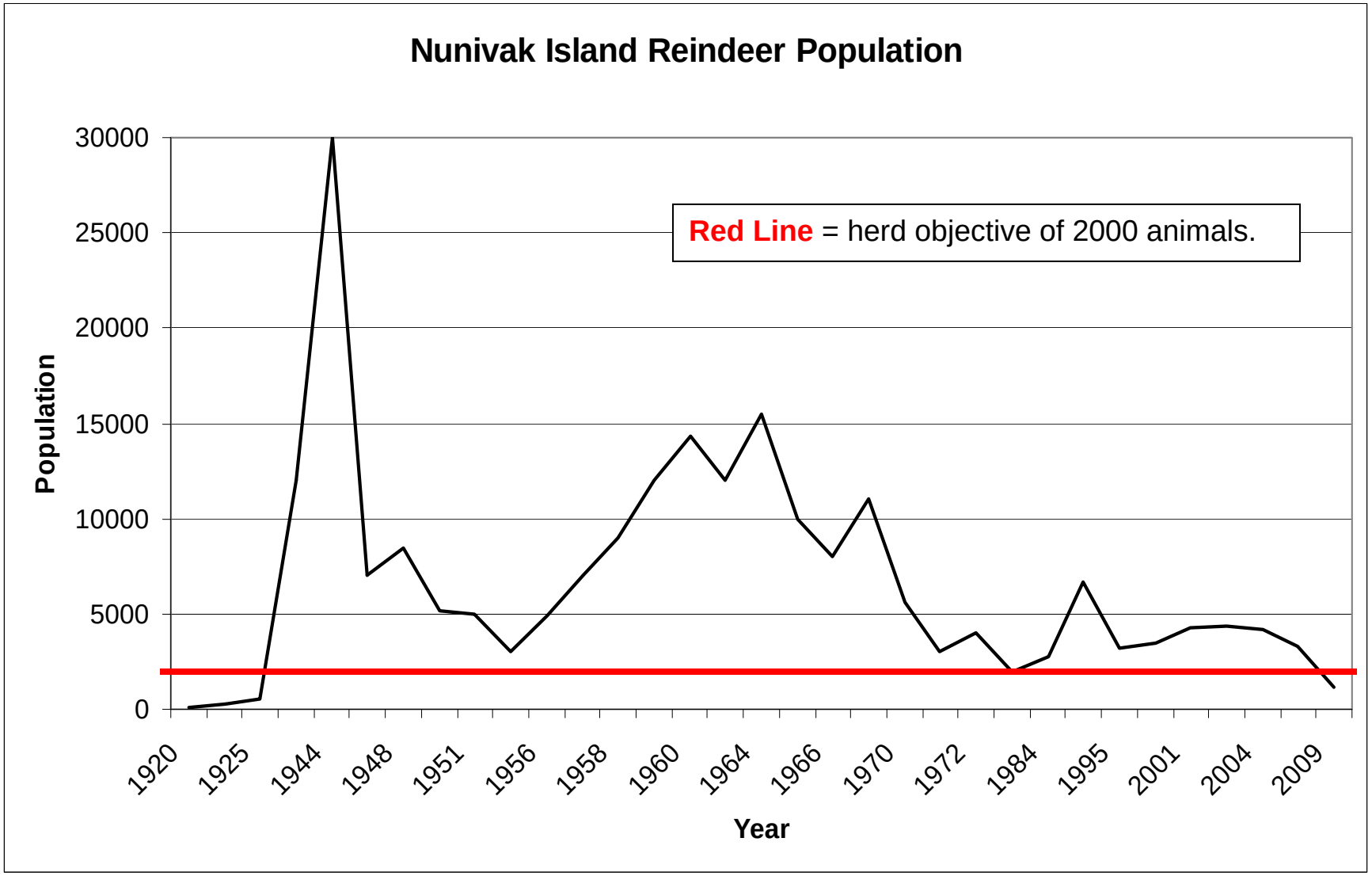


**Figure 6**. Reconstruction of reindeer population data on Nunivak Island, Alaska, 1920-2009 (Bos 1967; Kovach 2003-YDNWR files; Whitman 2009-NRSP files; and current survey).

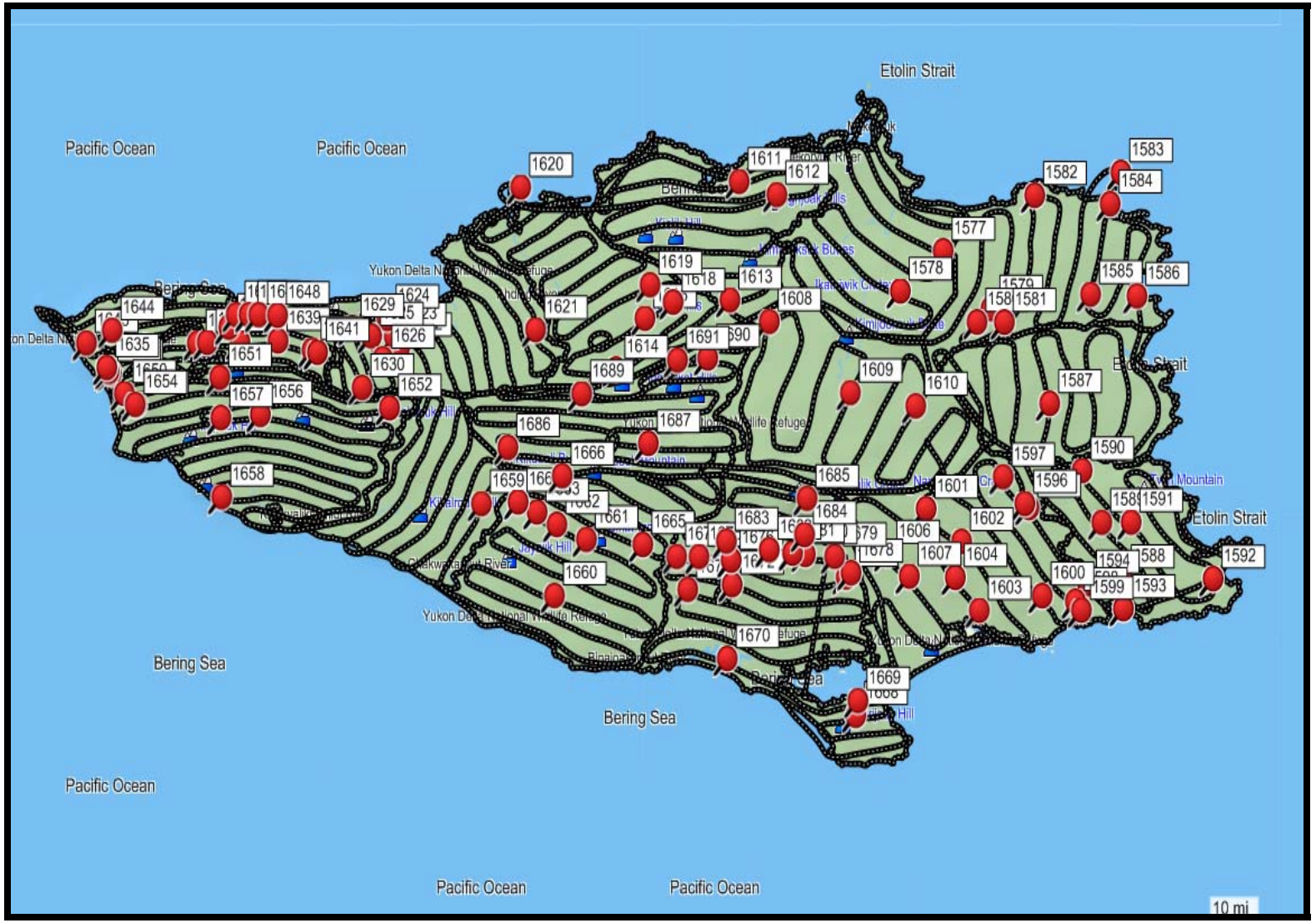


**Figure 7.** Survey track logs and waypoint locations for each muskoxen group observed August 26-28, 2009. Waypoints are sequential numbers and not the number of muskoxen in each group. Refer to datasheet for numbers. Map derived from Garmin MapSource.

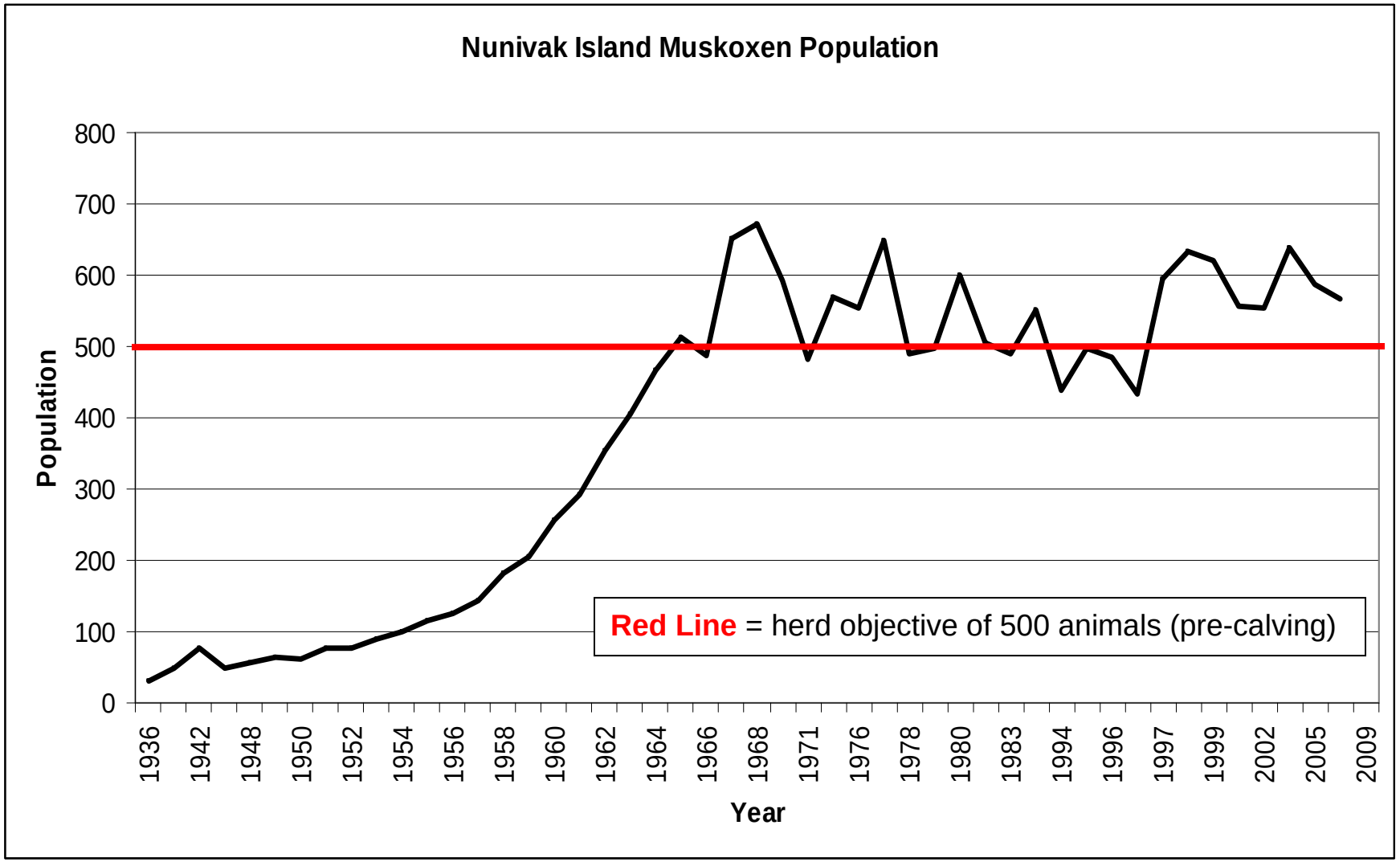


**Figure 8**. Reconstruction of muskoxen population data on Nunivak Island, Alaska, 1936-2009 (YDNWR files-Kovach 2003; Perry 2005; and Jones 2009, pers. comm.).

**Appendix—1**: *Logistics and Budget*

The Mekoryuk marine boat harbor is too busy for float plane access and it is located away from a safe fuel cache. Salt water also increases corrosion on aircraft. Therefore, we used a Cessna 206 on wheels to avoid corrosion problems, a busy boat harbor, fluctuating tides, and to have easy access to fuel.

We obtained a special use permit, including a $100 fee, from the Alaska Department of Transportation (DOT) to store fuel barrels on the airstrip apron. Fuel barrels had to be on pallets, lashed together, and have impermeable material underneath to prevent contamination in the event of a spill. The DOT permit can be valid for up to 120 days if you specify this time period. Processing time is a minimum of three weeks. DOT contact person is Robert Holbrook (airport leasing specialist 907-268-0450).

We shipped six fuel drums via Northern Air Cargo (NAC; 907-543-4155). We also shipped a hand fuel pump, hose with nozzle, an in-line aviation fuel filter, and containment material inside of a large polymer overpack container.

We asked to collaborate with Nuniwarmiut Reindeer and Seafood Products (NRSP) and to have them provide a survey observer. Gary Ivanoff was selected as an observer and manager Moses Whitman (907-827-8015) is the NRSP contact person.

Due to weather and airplane logistics we did not start the survey on schedule. Fuel was delivered to the airstrip as scheduled, so I flew to Mekoryuk and hauled the fuel drums to the USFWS' facility to store them indoors until we were able to return and initiate the survey. I utilized a four-wheeler and trailer to haul 3 drums at a time. The USFWS facility was used as a bunk house during the survey.

Aircraft Management Directorate (AMD) regulations require that a plane flying over open water (e.g., Bering Sea) carry an inflatable survival raft and that the pilot has an emersion suit. Passengers are not allowed, so the observer has to fly commercially.

| *Budget:* | |
|---|---|
| C-206 ($155/hr) Ferry time =1.3 to and 1.5 hrs from. Total=19.1 hrs. | $ 2,961 |
| Av Gas ($6/gal X 55gal/drum X 6 drums=330 gallons) | $ 1,980 |
| New fuel drums ($125/drum) | $ 750 |
| Sealing drums ($10/drum) | $ 60 |
| Fuel shipping (northern air cargo) | $ 2,829 |
| Fuel storage permit (through DOT) | $ 100 |
| Food | $ 200 |
| Transportation for biologist via commercial= grant aviation | $ 406 |
| Mics. = tools, rope, fuel filter, gas for 4-wheeler, travel | $ 200 |
| | |
| **TOTAL** | **$ 9,486** |

**Appendix—2**: *Geographical Information System Metadata*

The following steps create the subunit boundary shapefile:

1). Use an existing exterior boundary for Nunivak Island in the form of a polyline shapefile. This boundary had a coordinate system of:

GCS_North_American_1927
Datum: D_North_American_1927

2). Edit the polyline shapefile to add the digitized subunit boundaries to the existing exterior boundary. The original coordinate system remains the same.

3). Once all the subunits are created, transform the polyline shapefile into a polygon shapefile in order to add attributes to the table for labeling (i.e., subunit names). The polygon shapefile retains the original coordinate system (i.e., GCS_N.A._1927).

The extension TOPO! Pro for ArcGIS v.2.3 has a default coordinate system of:
GCS_North_American_1983
Datum: D_North_American_1983

4). The new polygon shapefile was named “ReindeerSurvey_subunits.shp” and was made compatible with the topographical map layer by reprojecting the shapefile to:

Projected Coordinate System: Alaska_Albers_Equal_Area_Conic
Projection: Albers
Central Meridian: -154
Geographical Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983

This allowed the boundary layer to be overlaid and displayed on the topographic map within ArcMap.

All data files, GIS data, Garmin MapSource waypoint and tracklog files, photographs and survey information are located in a file folder named “Nunivak_2009” on the big game wildlife biologist’s computer.

**Appendix—3**: Data form for August 26, 2009.

| **Nunivak Reindeer Survey** | | | | Pilot: Kevin Fox | | Observers: | | Aircraft: C-206 | Prop time: 5.6 hrs |
|---|---|---|---|---|---|---|---|---|---|
| **Date: 8-26-09** | | Time: 2:15 pm | | Sky condition: | | G. Ivanoff | | Temp: 44 F | Flight Elevation: 1000 ft. AGL |
| Waypoint Datum: hddd.ddddd; datum WGS 84 | | | | partly cloudy, overcast | | E. Wald | | Wind: 15-20 mph | 80 kts ground speed |
| Group | WyPt | Muskox | Reindeer | SubUnit | plot start | plot end | Lat | Lon | Comments |
| 1 | 1577 | 2 | | 2A | 2:20 PM | 3:08 PM | N60.26691 | W166.03213 | 48 minutes |
| 2 | 1578 | 1 | | 2A | | | N60.22619 | W166.09960 | |
| 3 | 1579 | 8 | | 1A | 3:08 PM | 4:03 PM | N60.20814 | W165.95694 | 55 minutes |
| 4 | 1580 | 1 | | 1A | | | N60.19470 | W165.97895 | |
| 5 | 1581 | 6 | | 1A | | | N60.19456 | W165.93591 | under plane on last transect |
| 6 | 1582 | 2 | | 1A | | | N60.32328 | W165.88805 | |
| 7 | 1583 | 2 | | 1A | | | N60.34639 | W165.75239 | Triangle Island (1 animal is smaller) |
| 8 | 1584 | 2 | | 1A | | | N60.31474 | W165.76923 | |
| 9 | 1585 | 2 | | 1A | | | N60.22285 | W165.80015 | one smaller animal |
| 10 | 1586 | 1 | | 1A | | | N60.22114 | W165.72700 | |
| 11 | 1587 | 5 | | 1B | 4:03 PM | 4:50 PM | N60.11216 | W165.86439 | 48 minutes |
| 12 | 1588 | 2 | | 5A | 4:55 PM | 5:35 PM | N59.93428 | W165.75006 | 40 minutes |
| 13 | 1589 | 4 | | 5A | | | N59.99143 | W165.78250 | |
| 14 | 1590 | 6 | | 5A | | | N60.04396 | W165.81333 | back on river; saw from unit 1B |
| 15 | 1591 | 3 | | 5A | | | N59.99157 | W165.73629 | > 0.5 mile out |
| 16 | 1592 | 1 | | 5A | | | N59.93426 | W165.60714 | |
| 17 | 1593 | 1 | | 5B | 5:38 PM | 6:36 PM | N59.90393 | W165.74843 | 58 minutes |
| 18 | 1594 | 1 | | 5B | | | N59.92921 | W165.80491 | |
| 19 | 1595 | 2 | | 5B | | | N60.00639 | W165.89723 | |
| 20 | 1596 | 11 | | 5B | | | N60.01051 | W165.90357 | |
| 21 | 1597 | 1 | | 5B | | | N60.03768 | W165.93791 | along river >0.5 mile away |
| 22 | 1598 | 10 | | 5B | | | N59.91145 | W165.82389 | |
| 23 | 1599 | 3 | | 5B | | | N59.90239 | W165.81455 | |
| 24 | 1600 | 6 | | 5B | | | N59.91701 | W165.87631 | edge of lake |
| 25 | 1601 | 10 | | 5B | | | N60.00521 | W166.05907 | |
| 26 | 1602 | 7 | | 5B | | | N59.97212 | W166.00320 | |
| 27 | 1603 | 8 | | 5B | | | N59.90219 | W165.97530 | |
| 28 | 1604 | 3 | | 5B | | | N59.93559 | W166.01304 | |
| 29 | 1606 | 6 | | 5B | | | N59.95941 | W166.11914 | |
| 30 | 1607 | 11 | | 5B | | | N59.93685 | W166.08556 | |
| 31 | 1608 | 2 | | 4A | 6:45 PM | 7:36 PM | N60.19531 | W166.30592 | 51 minutes |
| 32 | 1609 | 5 | | 4A | | | N60.12306 | W166.17832 | >0.75 miles away |
| 33 | 1610 | 3 | | 4A | | | N60.10964 | W166.07547 | |

**Appendix—3 (continued)**: Data form for August 27, 2009.

| **Nunivak Reindeer Survey** | | | | Pilot: Kevin Fox | | Observers: | | Aircraft: C-206 | Prop time: 7.6 hrs |
|---|---|---|---|---|---|---|---|---|---|
| **Date: 8-27-09** | | Time: 10:45 am | | Sky condition: | | G. Ivanoff | | Temp: 46 F | Flight Elevation: 1000 ft. AGL |
| | | | | clear below 12,000 ft. | | E. Wald | | Wind: 15-18 knots | 80 kts ground speed |
| Waypoint Datum: hddd.ddddd; datum WGS 84 | | | | | | | | gusting 26 kts | |

| Group | WyPt | Muskox | Reindeer | SubUnit | plot start | plot end | Lat | Lon | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1611 | 1 | | 2B | 10:45 AM | 11:31 AM | N60.33728 | W166.35340 | 46 minutes |
| 2 | 1612 | 2 | | 2B | | | N60.32394 | W166.29408 | ~0.5 miles on hill top |
| 3 | 1613 | 1 | | 2B | | | N60.21718 | W166.36805 | |
| 4 | 1614 | 4 | | 2C | 11:31 AM | 12:19 PM | N60.14680 | W166.54730 | 48 minutes; <0.5 mile near border |
| 5 | 1615 | | 7 | 2C | | | N60.17451 | W166.56024 | |
| 6 | 1616 | 12 | | 2C | | | N60.19854 | W166.50177 | Broken/busy habitat in this plot…made transects |
| 7 | 1617 | | 4 | 2C | | | N60.20161 | W166.49425 | closer together to make sure we covered good… |
| 8 | 1618 | 2 | | 2C | | | N60.21493 | W166.45734 | sunshine and shadows… |
| 9 | 1619 | 3 | | 2C | | | N60.23254 | W166.49378 | |
| 10 | 1620 | 1 | | 2C | | | N60.33155 | W166.69735 | Small Island on north west side; sick looking. |
| 11 | 1621 | 6 | | 3A | 1:17 PM | 2:10 PM | N60.18697 | W166.67396 | 53 minutes |
| 12 | 1622 | 2 | | 3A | | | N60.16964 | W166.88778 | |
| 13 | 1623 | 1 | | 3A | | | N60.18019 | W166.89651 | |
| 14 | 1624 | | 2 | 3A | | | N60.19830 | W166.90753 | |
| 15 | 1625 | 1 | | 3A | | | N60.18060 | W166.93236 | |
| 16 | 1626 | 8 | | 3A | | | N60.15748 | W166.91448 | |
| 17 | 1628 | | 9 | 3A | | | N60.15421 | W166.93827 | |
| 18 | 1629 | 1 | | 3A | | | N60.18895 | W166.96268 | |
| 19 | 1630 | 5 | | 3A | | | N60.12833 | W166.94725 | same as 1627 only closer point |
| 20 | 1631 | | 4 | 3B | 2:11 PM | 3:21 PM | N60.15914 | W167.06181 | 70 minutes |
| 21 | 1632 | | 8 | 3B | | | N60.15310 | W167.27954 | |
| 22 | 1633 | 8 | | 3B | | | N60.14287 | W167.34238 | Really Good area for seeing far in this plot!! |
| 23 | 1634 | 1 | | 3B | | | N60.14454 | W167.34572 | |
| 24 | 1635 | 2 | | 3B | | | N60.14859 | W167.34906 | |
| 25 | 1636 | 8 | | 3B | | | N60.17325 | W167.20674 | Some trailing evidence in this plot |
| 26 | 1637 | 2 | | 3B | | | N60.17415 | W167.19106 | |
| 27 | 1638 | 2 | | 3B | | | N60.17415 | W167.13945 | |
| 28 | 1639 | 6 | | 3B | | | N60.17552 | W167.07953 | Good transect spacing in these plots…!! |
| 29 | 1640 | 8 | | 3B | | | N60.16629 | W167.02581 | |
| 30 | 1641 | 1 | | 3B | | | N60.16401 | W167.01742 | |
| 31 | 1642 | 2 | | 3B | | | N60.18944 | W167.15699 | |
| 32 | 1643 | 2 | | 3B | | | N60.17346 | W167.38130 | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 33 | 1644 | 2 | | 3B | | | N60.18641 | W167.34084 | |
| 34 | 1645 | 6 | | 3B | | | N60.20216 | W167.14545 | Really Good area for seeing far in this plot!!! |
| 35 | 1646 | 2 | | 3B | | | N60.20214 | W167.12523 | |
| 36 | 1647 | 1 | | 3B | | | N60.20210 | W167.10991 | |
| 37 | 1648 | 1 | | 3B | | | N60.20160 | W167.08026 | |
| 38 | 1649 | | 1070 | 3B | count completed | | N60.18660 | W167.24636 | belly-port air photos = approximate location |
| 39 | 1650 | 7 | | 7B | 3:21 PM | 4:40 PM | N60.12212 | W167.32155 | 79 minutes |
| 40 | 1651 | 1 | | 7B | | | N60.13870 | W167.17129 | |
| 41 | 1652 | 9 | | 7B | | | N60.10771 | W166.90396 | Turbulence…!!!!!! |
| 42 | 1653 | 2 | | 7B | | | N60.11124 | W167.30231 | |
| 43 | 1654 | 1 | | 7B | | | N60.11108 | W167.30439 | |
| 44 | 1655 | | 87 | 7B | count completed | | N60.10934 | W167.18607 | oblique photos-hand held; #'s 50-57 |
| 45 | 1656 | 5 | | 7B | | | N60.10095 | W167.10739 | |
| 46 | 1657 | 2 | | 7B | | | N60.09781 | W167.16954 | |
| 47 | 1658 | 2 | | 7B | | | N60.01740 | W167.16811 | |
| 48 | 1659 | 1 | | 7A | 4:40 PM | 5:25 PM | N60.01043 | W166.75916 | 45 minutes |
| 49 | 1660 | 1 | | 6B | 5:25 PM | 6:30 PM | N59.91725 | W166.64426 | 65 minutes |
| 50 | 1661 | 1 | | 6B | | | N59.97415 | W166.59406 | |
| 51 | 1662 | 2 | | 6B | | | N59.98930 | W166.64044 | |
| 52 | 1663 | 1 | | 6B | | | N60.00203 | W166.67172 | |
| 53 | 1664 | 7 | | 6B | | | N60.01218 | W166.70157 | |
| 54 | 1665 | 8 | | 6B | | | N59.96897 | W166.50506 | |
| 55 | 1666 | 1 | | 6B | | | N60.03878 | W166.63201 | |

**Appendix—3 (continued)**: Data form for August 28, 2009.

| **Nunivak Reindeer Survey** | | | | Pilot: Kevin Fox | | Observers: | | Aircraft: C-206 | Prop time: | 3.1 hrs |
|---|---|---|---|---|---|---|---|---|---|---|
| **Date: 8-28-09** | | Time: 10:13 pm | | Sky condition: | | G. Ivanoff | | Temp: 51 F | Flight Elevation: 1000 ft. AGL | |
| | | | mostly cloudy; broken at 1900 | | | E. Wald | | Wind: 15-20 kts | 80 kts ground speed | |
| Waypoint Datum: hddd.ddddd; datum WGS 84 | | | | overcast at 2400 | | | | gusting 21 kts | | |
| Group | WyPt | Muskox | Reindeer | SubUnit | plot start | plot end | Lat | Lon | Comments | |
| 1 | 1668 | 5 | | 6A | 10:37 AM | 11:55 AM | N59.79575 | W166.16987 | 78 minutes | |
| 2 | 1669 | 4 | | 6A | | | N59.81066 | W166.16630 | | |
| 3 | 1670 | 8 | | 6A | | | N59.85330 | W166.37224 | >0.75 miles away. | |
| 4 | 1671 | 2 | | 6A | | | N59.92347 | W166.43441 | | |
| 5 | 1672 | 5 | | 6A | | | N59.92818 | W166.36454 | | |
| 6 | 1673 | | | 6A | | | N59.94043 | W166.44517 | repeat of 1671; running fast to us. | |
| 7 | 1674 | 1 | | 6A | | | N59.95682 | W166.45179 | | |
| 8 | 1675 | 4 | | 6A | | | N59.95676 | W166.41657 | | |
| 9 | 1676 | 1 | | 6A | | | N59.95319 | W166.36600 | lying down | |
| 10 | 1677 | 2 | | 6A | | | N59.93611 | W166.18495 | | |
| 11 | 1678 | 4 | | 6A | | | N59.94035 | W166.17735 | | |
| 12 | 1679 | 2 | | 6A | | | N59.95690 | W166.20306 | Really good terrain for seeing far on this plot..! | |
| 13 | 1680 | 3 | | 6A | | | N59.95895 | W166.24929 | | |
| 14 | 1681 | 14 | | 6A | | | N59.96022 | W166.26945 | | |
| 15 | 1682 | 6 | | 6A | | | N59.96373 | W166.30616 | | |
| 16 | 1683 | 2 | | 6A | | | N59.97245 | W166.37362 | | |
| 17 | 1684 | 8 | | 6A | | | N59.97902 | W166.25050 | | |
| 18 | 1685 | 7 | | 6A | | | N60.01589 | W166.24665 | | |
| 19 | 1686 | 1 | | 4B | 11:59 AM | 1:04 PM | N60.06754 | W166.71757 | 65 minutes | |
| 20 | 1687 | 1 | | 4B | | | N60.07161 | W166.49636 | | |
| 21 | 1688 | | 1 | 4B | | | N60.08102 | W166.55813 | lone bull running. | |
| 22 | 1689 | 5 | | 4B | | | N60.12193 | W166.60143 | | |
| 23 | 1690 | 5 | | 4B | | | N60.15824 | W166.40286 | older reindeer trailing along ponds in this plot. | |
| 24 | 1691 | 2 | | 4B | | | N60.15612 | W166.45057 | | |